

Oral Presentation Abstracts

1. Side-to-side vs. Pulvertaft Extensor Tendon Repair; Biomechanical Study

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Introduction: Extensor tendons can be coapted using a weave suture technique to provide tensile strength and repair surface overlap. Pulvertaft (PT) weave is the standard method of extensor tendon repair. However, recently, Brown and colleagues described a side-to-side (STS) tendon repair technique (one weave). This method may compare in speed of repair, while simpler, potentially less bulky and without the need specialized equipment while not compromising repair strengths and tensile properties. We hypothesize that STS is more practical than PT with matching biomechanical characteristics.

Materials and Methods: In a biomechanical study on 6 cadaver arms, we harvested 30 extensor tendons including four extensor digitorum communis (EDC) and one extensor indicis proprius (EIP). Three hand surgical fellows with similar backgrounds of training under the same conditions and precise standardized technique performed timed repairs (5 PT and 5 STS per surgeon). Following the repairs, the tendons were passed through a custom made graft sizing guide to determine bulk and the results were expressed as a repaired vs. native diameter ratio. The specimens were then tested for ultimate strength and fatigue properties (Instron Inc., Norwood, MA). Failure type and mechanical properties were recorded and compared to the native tendon portion.

Results: The STS technique demonstrated comparable time to repair (average tendon repair STS: 8.16 min vs. PT: 7.38 min; P=0.14). The average peak force to failure was 93 N for the STS and 51 N for PT group (P<0.001). Relative strength ratio (repair strength compared to native tendon strength) was 35.2% for the STS and 22.1% for the PT group (P=0.19). In the side-to-side group all failures occurred due to tissue failure; however, in the Pulvertaft technique suture failures occurred in 3 tendons prior to tissue failure. The mean bulk ratio of the repaired site vs. native tendon was +31% and +34% more for the STS and PT groups respectively (P=0.78). Furthermore, the bulk of the repaired site for the STS and PT groups was 4.2 and 4.9 mm respectively (P=0.098).

Conclusion: Side-to-side repair technique showed superior biomechanical properties while demonstrating comparable repair bulk and speed of tendon coaptation compared to the Pulvertaft weave.

2. Does Barbed Suture Repair Negate the Benefits of Peripheral Repair in Porcine Flexor Tendon?

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Introduction: Recent advances in suture materials and geometry have fueled interest in application of barbed sutures for flexor tendon repair. Theoretically, barbed suture tenorrhaphy offers benefits in better load distribution along the entire suture length, smoother gliding under pulleys with decreased cross-sectional area under load, and improved tendon blood flow by reduction of constricting forces. Studies have compared barbed suture to conventional non-barbed suture repair of flexor tendons, with varying suture patterns, loading properties, and tendon models. Some controversy exists on whether barbed tendon repair would benefit from supplementation by a circumferential stitch. Only one study to date has reported tensile strength of barbed suture repair in flexor tendons with additional peripheral repair, but findings were limited by an unconventional model resulting in substantially higher failure loads than previously published. The purpose of this study is to determine whether peripheral repair increases gap resistance in both conventional and barbed suture core repairs, to study if peripheral repair increases ultimate tensile strength, and to examine differences in failure sequence.

Materials and Methods: Porcine flexor tendons were harvested and assigned randomly into 4 groups (3-0 PDS or 3-0 V-loc 180 core with or without peripheral 5-0 Vicryl repair). Core repairs were performed using a modified 4-strand cruciate repair with 10 mm suture purchase and 4 mm cross-locks. Knotless repair was done using barbed suture, while a buried 6-throw square knot was done using conventional suture. An servohydraulic tester was used for biomechanical testing of linear 2 mm gap resistance and maximum tensile strength.

Results: The loads at 2 mm gap formation were 22.6 ± 3.8 N and 25.1 ± 4.0 N for conventional and barbed suture repairs respectively, while repairs with additional peripheral suture measured 61.7 ± 5.0 N and 76.4 ± 21.1 N. No significant difference was found between core suture types in gap resistance. No difference was found in maximum load to core suture failure among all groups. A statistically significant difference was found in maximum load to peripheral repair failure, which measured 57.8 ± 12.2 N in conventional repairs and 74.2 ± 20.4 N in barbed core repairs.

Conclusions: The addition of peripheral repair enhanced 2 mm gap resistance but not maximum core tensile strength in both conventional and barbed flexor tendon repairs. There may be a greater synergistic effect of peripheral repair with barbed over conventional core repairs. Barbed suture core repairs present a viable alternative to conventional repairs.

3. Anatomy of the Flexor Digitorum Profundus Insertion

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Introduction: Treatment of zone I flexor digitorum profundus (FDP) injuries requires reattachment of the tendon to the distal phalanx. Previous studies have evaluated the biomechanical strength of various repair techniques; however, none have described the anatomy of the FDP insertion or the proper location of an anatomic repair. We believe that correct placement of the tendon is essential to better restore native biomechanics and may improve clinical outcomes.

Methods: The FDP insertion to the index, middle, ring and little fingers were dissected in ten fresh-frozen cadavers. The FDP tendon was bluntly dissected off the volar plate, which was elevated from proximal to distal, before the distal phalanx was disarticulated. The distal phalanx was then inked and the FDP was sharply dissected off the bone (Figure 1). The insertion length, width, and distance from the joint of the insertion were measured and then the insertion surface area and centroid of the FDP insertion were calculated.

Results: The average insertion length and width were 6.2 mm (range 5.1-7.0) and 7.9 mm (range 6.9-8.4) respectively. The average surface area of the distal phalanx occupied by the FDP tendon, for all fingers, was 20.1% (range 15.0-26.5) (Table 1). The average distance from the most proximal insertion to the joint surface was 1.2 mm (range 0.4-2.1) with the intervening space occupied by the volar plate insertion, and the calculated distance of the centroid of the FDP insertion from the DIP joint was 3.6 mm (range 2.5-5.1) or approximately 20% of the phalangeal length (Tables 2 and 3).

Conclusions: The percentage of the distal phalanx occupied by the insertion of the FDP tendon into the distal phalanx, the distance of the most proximal FDP insertion from the joint, and the distance from the joint to the centroid of the insertion are fairly consistent in all fingers and not gender specific. Furthermore, the shape of the FDP insertion, widest proximally and tapering distally, was consistent amongst specimens. The findings of this study will allow for proper positioning of the FDP repair on the distal phalanx independent of the technique chosen. It remains to be seen whether this will restore the native biomechanics of the finger and improve patient outcomes.

Table 1.	FDP Insertion Measu	rements*			
		IF	MF	RF	LF
All	Length	7.0	6.7	6.1	5.1
	Width	8.1	8.4	8.4	6.9
	Surface Area (%)	21.6	20.3	20.3	17.9
Male	Length	7.5	7.5	6.6	5.0
	Width	8.0	8.3	8.2	6.9
	Surface Area (%)	22.2	20.3	20.3	17.0
Female	Length	6.2	5.6	5.3	5.2
	Width	8.1	8.7	8.7	6.8
	Surface Area (%)	20.7	20.4	20.5	19.2

Table 1. FDP Insertion Measurements*

*All data reported in millimeters (mm)

Table 2. FDP Insertion Related to DIP Joint*

	FDP to joint			Cer	Centroid to joint		
	Male	Female	All	Male	Female	All	
IF	1.1	1.5	1.2	4.3	3.4	3.9	
MF	1.5	1.3	1.5	4.1	3.1	3.7	
RF	1.1	0.9	1.1	3.9	3.0	3.5	
LF	1.0	1.2	1.1	3.1	3.0	3.1	

*All data in millimeters (mm)

Table 3. Centroid in Relation to Phalangeal Length

	Distance from Proximal Edge							
	Male	Female	All					
IF	23.0	20.1	21.6					
MF	20.5	19.1	19.8					
RF	19.1	17.8	18.4					
LF	17.7	18.8	18.2					

* Data expressed as percentage of phalangeal length from proximal bone



4. Relative Motion Flexion Splinting for Flexor Tendon Repairs: Proof of Concept

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Purpose: Early active motion protocols after flexor tendon repair have resulted in a better range of motion and decrease in flexion contractures, but still involve long periods of immobilization with interspersed sessions of motion, and activities of daily living are usually significantly impaired.

The principle of relative motion in extensor tendon repairs has allowed patients to regain a higher degree of hand function, while protecting the repair. The purpose of this study was to determine if the principle of relative motion could be a feasible method to protect a flexor tendon repair.

Methods: Four fresh frozen cadaver arms were used in this study. The flexor digitorum profundus (FDP) tendons of the middle fingers were dissected in the palm (zone 3) distally, while the muscles of the FDP and extensor digitorum communis were dissected proximally in the forearm.

Each arm was mounted on a testing apparatus with the wrist in 30 degrees of extension, and the MCP joints blocked to 70-80 degrees. A minimum of 11N was used to cyclically load the FDP and EDC tendons to maximum allowable flexion and extension for 25 cycles. Measurements of elongation of the tendons were obtained through the use of differential variable reluctance transducers (Lord Microstrain, Williston, VT). Following intact tendon testing, a tenotomy was made in the FDP tendon of the middle finger in zone 3 and immediately repaired with a single 6-0 nylon suture. Measurement of elongation was repeated with and without the relative motion splint. The tendon was visualized to determine if visible gapping was present after cycling.

Results: In all hands, elongation was restricted to less than 1.3mm in repaired tendon in the relative motion flexion splint compared to elongation >2mm in the non-splinted condition. Average elongation was 0.86mm (SD=0.45) Visual examination of the tendons demonstrated no gapping with the use of the relative motion splint in any of the hands (Fig 1). All repairs had suture breakage and repair rupture without the relative motion splint (Fig 2).

Conclusion: Relative motion splinting decreases elongation and eliminates tendon gapping and tendon rupture after flexion/extension cycling in a cadaver model. It provides proof-of-concept that relative motion splinting may be a viable protective mechanism for flexor tendon repairs, allowing for development of protocols that allow earlier tendon mobilization and less restricted hand function during the post-operative and rehabilitation phase.

Figure 1





5. Comparing Biomechanical Properties, Repair Times, and Costs of Common Flexor Tendon Repairs Aakash Chauhan, MD, MBA¹; Patrick Schimoler, BSE²; Mark C. Miller, PhD²; Edward Birdsong, MD¹; Matthew J. Schessler, MD¹; Bradley A. Palmer, MD¹ ¹Department of Orthopaedic Surgery, Allegheny General Hospital, Pittsburgh, PA; ²Orthopaedic Research, Allegheny General Hospital, Pittsburgh, PA

Introduction: Zone II flexor tendon injuries have numerous repair configurations, simple and complex, that range from 2 to 8 stranded repairs. Higher stranded repair configurations can be technically difficult but have been shown to be stronger. However there is significant variability across studies comparing the same constructs/suture with few studies presenting comprehensive biomechanical data across multiple configurations. The purpose of our study was to determine what the best repair configuration was in terms of biomechanical strength, repair time, and total repair value for popular Zone II flexor tendon repairs.

Methods: A total of 75 fresh-frozen FDS/FDP human cadaveric tendons were harvested from the index through small finger. They were randomized into one of five groups: 4-0 Polyester and 4-0 Braided Cross-Stitch Cruciate, 2-0 Bi-Directional Polypropylene Barbed Knotless Double Pennington (Modified Kessler), 4-0 Double-Stranded Braided Pennington (Modified Kessler), and 4-0 Braided Modified Lim-Tsai. All repairs had 1 cm of suture purchase and no epitendinous stitch was placed in order to assess the true core repair strength. Tendons were linearly loaded to failure at 30 mm/min. The 2 mm gapping load, max failure load, stiffness, and energy to cause 2 mm gapping were measured. In situ repairs were also performed on 6 FDP tendons and repair time was measured. The total repair value was calculated based on operating room costs, repair times, and suture costs. ANOVA and Tukey post-hoc analysis following any significant ANOVAs were used to statistically compare all data points.

Results: The braided cross-stitch cruciate was the strongest repair (p < 0.05) compared to all other repair groups in terms of max load to failure. (Figure 1) The braided cross-stitch cruciate required the most time for completion compared to all other repair times (p < 0.05), although average repair time differed at most by 2 minutes. (Figure 2) The total repair dollar value was highest for barbed cross-stitch cruciate (p < 0.05) compared to all other repairs.

Conclusions: The braided cross-stitch cruciate repair was the strongest in a series of commonly performed repair configurations, including a 6-stranded repair (modified Lim-Tsai). The 2 mm gapping and max load to failure approached similar historical strength of other 6 and 8 stranded repairs.

All repairs performed are adequate enough to start light active range of motion. This can be augmented with an epitendinous stitch.

Suture cost was negligible in the overall repair cost, and should not be a determining factor in choosing a repair.



Figure 1

Figure 2

6. Danger Zones For Flexor Tendons In Volar Plating Of Distal Radius Fractures

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Introduction: Flexor tendon rupture is a well-recognized complication after volar plating of distal radius fractures, with an incidence as high as 12%. Cadaver studies investigating the location of flexor tendons with respect to plate position are inherently flawed by the distortion of the position of the tendons after dissection. This study was undertaken using MR imaging to analyze the position of the flexor tendons "at risk" for rupture in a zone around the watershed line, and to define a 'danger zone' for flexor tendons in the region of volar plates.

Material and Methods: With institutional research board approval, we analyzed 40 MRIs of the wrist without distal radius pathology. The location of the FPL and index FDP (FDPi) tendons was recorded at 3mm and 6mm proximal to the watershed line of the distal radius. The distance between the volar margin and the FPL and FDPi tendons as well as the radial to ulnar position of the tendons with respect to proximity from the sigmoid notch were analyzed.

Results: At a point 3mm proximal to the watershed line, FPL and FDPi were located on average 2.6mm (+/-1.0mm) and 2.2mm (+/-1.1mm) anterior to the volar margin of the distal radius. This distance increased to 4.7mm (+/-1.4mm) and 5.3mm (+/-1.7mm) at a level 6mm proximal to the watershed line. FPL and FDPi were located 57% (+/-8%) and 42% (+/-8%) of the total width of the distal radius from the sigmoid notch at 3mm from the watershed, and 66% (+/- 8%) and 46% (+/-10%) at 6mm from the watershed. This corresponds to a high risk zone for FPL and FDPi ruptures (Figure 1).

Conclusions: Surgeons should be aware that the flexor tendons are at risk for rupture with volar plate placement within a zone that is more proximal and ulnar than previously appreciated. At a position 3 mm proximal to the watershed line, plate placement more than 2 mm anterior to the volar cortex or use of plates thicker than 2mm pose a high risk for directly contacting, irritating or causing attritional rupture. This distance nearly doubles at a point 6mm proximal to the watershed line.

Figure 1. Red zone represents the watershed line; the yellow and green zones represent the area where FPL and FDPi tendons are on average approximately 2.5 and 5mm volar to the distal radius, respectively.



7. Inpatient Status Drives Risk of Superficial Surgical Site Infection In Tendon Procedures

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Introduction: Post-operative superficial surgical site infections (SSSI) have been show to increase morbidity while lengthening hospital stay and increasing hospital cost¹. This study aims to identify risk factors implicated in surgical site infections in hand surgery.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database (ACS-NSQIP) was queried based on CPT code for patients who underwent hand surgery from 2005 through 2012. Cases identified were stratified into the following categories: "All Cases," "Fractures and Dislocations," and "Tendon Procedures." Univariate analysis was performed to identify the association between SSSI and potential demographic and medical risk factors, including: inpatient/outpatient status, surgical specialty, diabetes, smoking, alcohol use, hypertension, and intraoperative transfusion. Multivariate analysis was performed assessing the above risk factors as potential confounders.

Results: 2056 cases of hand surgery were identified and met inclusion criteria, which were further classified into the following subsets: "Fracture and Dislocations" (n=1129) and "Tendon cases" (n=927). Incidence for SSSI was largest in the "Tendon procedures" subset of cases (Table 1). Further analysis was performed on this subset to identify risk factors for SSSI.

Univariate analysis for risk factors associated with SSSI identified a significant association with inpatient status (vs. outpatient) and surgery performed by a Plastic Surgeon (vs. Orthopedic Surgeon). Multivariate logistic regression indicated that surgical specialty, as a risk factor, is not statistically significant when controlled for inpatient/outpatient status. Rather, inpatient/outpatient status is an independent risk factor when controlling for specialty as well as for age, gender, race, smoking, diabetes, previous cardiac surgery, hypertension, steroid use, and emergency case status (Table 2). Of note, tendon procedures performed on inpatients were significantly more likely to be conducted by plastic surgeons than by orthopedic surgeons (Table 3).

Table 1. Incidence of Superficial Su	rgical Site Infection	(Stratified by case type)
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Categories	n	Incidence of SSSI (% of total)
All Hand Cases	2056	17/2056 (0.83%)
actures & Dislocation	1129	7/1129 (0.62%)
Tendon procedures	927	10/927 (1.08%)

rocedures – Multivariate Analysis							
Risk Factor	Adjusted OR (95% CI)	Adjusted P-value					
tatus: Inpatient	11.94 (1.65-86.39)	0.014					
moking	3.83 (0.776-18.94)	0.099					
Direction Direction	4 67 (0 214 42 5)	0.171					

 Table 3. Inpatient/Outpatient Status o f Cases Performed by Plastic Surgery vs.

 Orthopedic Surgery

Inpatient/Outpatient Status (p=0.021)								
Surgical Inpatient Specialty (% of inpatient cases)		Outpatient (% of outpatient cases)	Total					
Orthopedics	20 (38.5%)	393 (55.0%)	413					
Plastics	32 (61.5%)	321 (45.0%)	353					
Total	52	714	766					

Conclusion: Inpatient status was identified as an independent risk factor for SSSI among hand tendon surgeries. While univariate analysis identifies surgical specialty as a risk factor, this difference is attributed to a significantly increased rate of inpatient hand surgeries performed by Plastic Surgeons.

References:

1. Vegas AA, Jodra VM, Garc'a ML. Nosocomial infection in surgery wards: a controlled study of increased duration of hospital stays and direct cost of hospitalization. Eur J Epidemiol 1993; 9:504.

8. Optimized Repopulation of Tendon Hydrogel: Synergistic Effects of Growth Factor Combinations and Adipoderived Stem Cells

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Background: Tendon-derived extracellular matrix (ECM) hydrogel has been shown to augment tendon healing *in vivo*. We hypothesized that reseeding of the gel with adipose-derived stem cells (ASC's) could further assist repopulation of the gel and that combinations of growth factors (GF) would improve the survival of these cells after reseeding.

Methods: Lyophilized decellularized tendons were milled and enzymatically digested. The resulting ECM solution was then supplemented with or without fetal calf serum (FCS) and varying concentrations of bFGF, IGF-1, and PDGF-BB, both individually and in combinations. The different gel conditions were then seeded with ASC's transfected with a GFP/luciferin construct. After 3 and 5 days in vitro, cell proliferation was determined using the MTT assay and histology. When the optimal condition for cell proliferation was established, gels were supplemented with the selected combination of GF, or no GF and injected into the back of immune competent Sprague Dawley rats. Bioluminescence of seeded gels was continuously followed up to 14 days after re-seeding *in vivo*. Histology and cell counts were performed after the gels were explanted at 14 days.

Results: There was enhanced proliferation of ASC's in gels supplemented with all individual growth factors *in vitro*. Among single growth factors, PDGF-BB at 100 ng/ml was the most efficient stimulator of proliferation. With multiple growth factors (combinations), the optimal concentration was determined to be 10 ng/ml bFGF, 100 ng/ml IGF-1, and 100 ng/ml PDGF-BB (increase 2.8-fold; p < 0.05). *In vivo*, bioluminesence showed an improved initial survival of cells in gels supplemented with the optimal concentration of GF compared with the control group (increase 10.6-fold at 8 days; p < 0.05). After 8 days a decline in cells was seen, and most replanted cells were not detectable by day 14. Cell counts of explants, however, showed a dramatic endogenous re-population of gels supplemented by GF+ASC's compared to both gels with GF but no ASC's (7.6-fold increase) and gels with ASC's but no GF (1.6-fold increase).

Conclusion: Synergistic effects of bFGF, IGF-1, and PDGF-BB can be used to improve cellular proliferation and repopulation of ASC's seeded to a tendon ECM gel. Reseeding with ASC's, with or without GF drastically stimulates endogenous repopulation of the gel *in vivo* and may be used to further augment tendon healing through this system.

9. Flexor Tendon Repair in an Ex-Vivo Model: An Established Knotless Bidirectional Barbed Suture Technique Does Not Withstand Cyclic Loading Necessary for Early Rehabilitation

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Introduction: In a dynamic ex-vivo model, a zone II flexor tendon laceration repaired with knotless, bidirectional barbed suture would provide equivalent resistance to gap formation during cyclic loading as a repair using conventional locking four-strand technique with braided suture of similar strength.

Methods: Flexor digitorum profundus tendons from fifteen fresh frozen cadaver hands were randomly assigned to one of three repair techniques: locking cruciate four-strand repair using braided suture (LC), three-strand repair with transverse passes using braided suture (TS), or three-strand repair with transverse passes using bidirectional barbed suture (BB). Flexor and corresponding extensor tendons were attached to a load generator. The fingers were cycled through a range of motion at a rate of 5.1 mm/s to a load of 5N per finger. Gap formation was assessed and recorded every ten cycles through 100 cycles, and at 100 cycle intervals through 1,000 cycles. Failure of repair was defined as gap formation of greater than 2mm. Tensile loading to failure was performed on each tendon, and the method of failure and required force were recorded.

Results: The BB and TS groups developed an average gap of 2.43 mm (SD 3.29) after 20 cycles, and 2.22 mm (SD 0.85) after 10 cycles, respectively. Over 1,000 cycles, the LC group demonstrated an average gap of 3.21mm (SD 1.51) compared with 9.12 mm (SD 2.80) in the BB group. Due to the consistently wide discrepancy between the cycles to failure between the BB and LC groups, the experiment was terminated at seven tendons per group. Using one-way ANOVA with Fisher LSD, post-hoc analysis was performed. We observed a significant difference in number of cycles until failure (p<0.001) between the LC and BB groups. There was no significant difference in force (N) required to induce catastrophic failure between the LC and BB groups; all repairs in this portion of the study failed by suture pullout.

Discussion and Conclusion: The BB group developed gapping early, with significant differences compared to the LC group at 1,000 cycles. As expected, the TS repairs failed rapidly. Barbed suture was inferior to a conventional repair technique in this low force, cyclic loading scenario, and the results do not support the use of bidirectional barbed suture in the repair of flexor tendons. Additional studies are needed to determine if modifications in techniques or suture materials would provide better resistance to gap formation due to cyclic loading forces encountered in early rehabilitation.

10. Glucocorticoids Differentially Inhibit Viability, Proliferation and Differentiation of Human Tenocytes

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Purpose: Glucocorticoid injections (GCI) are widely used to treat upper extremity tendinosis, including trigger finger, DeQuervain's tendinosis, and lateral epicondylosis. Despite such widespread use of GCI as a therapeutic treatment modality, the cellular and molecular response of human tendon to glucocorticoid injection is unclear. Although effective in ameliorating the pain response at low dose-frequency intervals¹, several case reports have noted tendon rupture after triamcinolone injection^{2,3,4}. We hypothesized that the mechanism of action of GCI on tendinopathy may, in actuality, be due to effects of glucocorticoids on the viability, proliferation and differentiation of tendon cells.

Materials & Methods: Human tenocytes were isolated from patients (ages 20-55) undergoing revision amputation for traumatic hand injury using IRB-approved protocols. Tenocytes were plated onto fibronectin-coated coverslips and treated with betamethasone (10⁻⁷ to 10⁻³ mol/L), triamcinolone (10⁻⁷ to 10⁻³ mol/L) or dexamethasone (10⁻⁷ to 10⁻³ mol/L) and harvested after one week. Viability was assessed using live/dead cell assay, proliferation assessed by cell counting, and differentiation assessed by immunofluorescence and RT-PCR of tenocyte molecular markers collagen I, tenomodulin and scleraxis.

Results: Treatment of human tenocytes with glucocorticoids at therapeutic doses (>1mM) resulted in decreased tenocyte viability and proliferation (Figure 1). Also, treatment of human tenocytes with triamcinolone resulted in decreased proliferation as compared to betamethasone and dexamethasone at all doses tested. Furthermore, treatment of human tenocytes with all glucocorticoids resulted in decreased expression of collagen I by immunofluorescence and RT-PCR.

Figure 1: Tendon cell proliferation is differentially supressed in a dose-dependent manner by glucocorticoids.



Conclusions:

- 1. Treatment of human tenocytes with glucocorticoids at therapeutic levels results in decreased cell viability, proliferation and differentiation.
- 2. Glucocorticoids do not have a uniform effect on tenocyte proliferation: triamcinolone causes decreased tenocyte viability, proliferation and differentiation in comparison to betamethasone and dexamethasone.
- 3. All steroids tested cause decreased tenocyte differentiation.
- 4. These results suggest that, in therapeutic doses at frequent intervals, glucocorticoid injections may cause tendon injury due to effects on cell viability, proliferation and differentiation.

References Cited

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11. Comparisons of Rabbit Flexor Tendon Stiffness via Acoustoelastic Ultrasound during Mechanical Testing and In vivo Loading

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Hypothesis: The purpose of this study was to investigate whether acoustoelastic (AE) ultrasound is able to detect stiffness differences between healing and normal rabbit tendons during mechanical testing.

Methods: Eighteen female New Zealand White rabbits (~2.5 kg) underwent transections and repair of left 3rd flexor digitorum profundus (FDP) tendons in zone II. 0, 3, and 7 weeks after repair, ultrasound video was recorded as the healing tendon was stretched. Each rabbit was sacrificed and the tendons harvested. The right 3rd digit served as the control. Each normal and healing tendon was submerged in a bath of saline and pulled to failure (Mark-10 ESM301 Copiague, NY) at a rate of 20mm/min with a 0.2N preload. Dynamic B mode ultrasound images of tendons were recorded during testing using a linear array transducer at 12MHz and GE LOGIQe ultrasound (General Electric, Fairfield, CT). The ultrasound videos were processed in an image analysis program (EchoSoftTM, Echometrix, Madison, WI) to compute the stiffness gradient index (SGI) of the healing and normal tendons. Additionally, ultimate load was recorded from the results of the mechanical test. Additionally we conducted a pull failure test of a transected and sutured 3rd digit FDP from cadaver New Zealand white rabbits (week 0) to serve as a sutured control.

Results: The SGI (normalized stiffness) values obtained from the ultrasound during the pull to failure tests appeared higher in control tendons than in the healing tendons (obtained through ultrasound *in vivo* and pull to failure; Figure 1). The stiffness obtained from the healing tendon *in vivo* and via *ex vivo* mechanical testing were generally similar. Figure 1 displays the most distinct differences between the different groups. Inconsistences obtained with AE ultrasound for other specimens could be due to the small size the of rabbit tendons. Stiffness of the healing tendons calculated from *in vivo* and *ex vivo* images appeared fairly similar, with some deviation. This deviation could be attributed to the different loading rates of the *in vivo* stretching and *ex vivo* pull to failure.

Summary:

¥ Tendon SGI quantified via AE *in vivo* appears similar to the stiffness quantified via AE ultrasound *ex vivo* (pull to failure)

¥ SGI of normal FDP tendons is greater than healing FDP tendons at week 7 obtained through AE ultrasound

<figure>

The ultimate load of the normal FDP tendon is higher than the healing tendon at week 3 and 7

12. Ultrasound Guided Percutaneous Annular Pulley Release for Trigger Finger

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Introduction: Trigger digit is a common cause of hand pain and loss of function. Treatment consists of hand therapy, splints, corticosteroid injections and finally open release of the constricting annular pulley. Our department piloted the use of ultrasound guided percutaneous annular pulley release, using a standard hypodermic needle bent at 2 points. Published by the senior authors in 2009, this technique allows visualization of the tendon and neurovascular bundle, and in a pilot study was found to be promising. This study aimed to evaluate the long-term use of this technique.

Methods: Retrospective case note review of all patients undergoing ultrasound guided A1 pulley release for trigger digit, between 2009 and 2014. All patients had first trialled conservative and corticosteroid treatments within the hand surgery department. Presenting symptoms, ultrasound findings and outcomes were evaluated.

Results: Following a pilot study of 35 patients, we present a case series of 200 patients, who underwent ultrasound guided percutaneous A1 pulley release between 2009 and 2014. We believe this is the largest series described thus far. In concordance with the original paper, up to 90% of patients had complete resolution of symptoms, with minimal complications (1%) and high patient satisfaction.

Conclusion: We support that A1 pulley release under ultrasound guidance for the treatment of severe triggering of the digit is a safe and effective procedure, well tolerated by patients and performed in an outpatient setting.

13. Simultaneous Closed Rupture of Flexor Digitorum Superficialis and Flexor Digitorum Profundus Tendons in the Middle Finger: A Case Report

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Closed tendon ruptures are uncommon as they represent the strongest link in the musculotendinous chain. Closed rupture of both flexor tendons of the same digit are rare and only a handful of cases have been reported in the literature. The diagnosis is clinical but can be supported by both ultrasound and magnetic resonance imaging which can provide additional information on tendon integrity, location of injury and the distance between tendon ends.

We report a case of a 20 year old left-handed man who injured his middle finger whilst playing rugby. Immediately he suffered pain but was able to complete the remainder of the game. Afterwards his finger had swollen and he was unable to bend it fully. On examination he was unable to flex the distal interphalangeal joint (DIPJ) and had very weak flexion at the proximal interphalangeal joint (PIPJ). Passive movement was maintained at the DIPJ but he had a restricted passive range of motion at the PIPJ. An initial diagnosis of a closed rupture of the FDP tendon was made.

Surgical exploration was performed and under anaesthesia tenodesis revealed no flexion at the PIPJ or DIPJ. Initially a Brunner's incision was performed opening the A5 pulley where a rupture of the FDP tendon was identified. It was not possible to milk the retracted FDP tendon so the initial incision had to be extended proximally to the A1 pulley revealing a complete rupture of the FDS tendon. The FDS tendon was not repaired and trimmed to facilitate repair of the FDP. The FDP tendon was threaded back through the residual pulleys and finally secured to the distal phalanx using a dorsal pull through technique. The patient was splinted in the Edinburgh position and commenced on an active range of motion protected with a dorsal splint. Unprotected movement of the finger was allowed from 8 weeks. He was reviewed in the outpatient clinic at four months where he had full movement at the PIPJ and an arc of 20 degrees to 70 degrees of flexion at the DIPJ. The patient reported a DASH score of 0 and he had successfully return to work and sport.

14. Linburg-Comstock Anomaly: Prevalence in a Racially Diverse Population and Effect on Hand Strength Nicholas Schraut, MD; David Mossad, BS; Olivia Wang, MD; Mark Gonzalez, MD, PhD *Orthopaedic Surgery, University of Illinois Chicago, Chicago, IL*

Introduction: The Linburg-Comstock anomaly is an anomalous tendinous connection between the flexor pollicis longus (FPL) of the thumb and the flexor digitorum profundus (FDP) of the index finger resulting in the lack of independent flexion of the thumb and index finger. There are few studies describing the effect of the anomaly on grip, key, chuck and tip pinch strength in racially diverse patient populations. The purpose of this study was to determine if there is a difference in the prevalence of the Linburg-Comstock anomaly among ethnically diverse patients as well as to determine the effect this anomaly has on grip, key, chuck and tip pinch strength.

Methods: 184 patients were recruited to participate in the study. The subjects were patients in clinic being seen for orthopedic problems not relating to the hand. Exclusion criteria included previous or current hand, wrist, or forearm injury, contractures or history of extensive arthritis in the hand. Information including race, gender, and hand dominance was collected for each patient. Each patient underwent examination for the Linburg-Comstock anomaly bilaterally and subsequently tested for grip, key, chuck, and tip pinch strength in kilograms using grip and pinch dynanometers. Statistical comparisons were made using Student's t-test and chi-square analysis for proportions with a significance level of 0.05.

Results: The anomaly was present in 25 of 184 subjects (13.6%), with 16 presenting bilaterally and 9 presenting unilaterally. The Hispanic population had the highest prevalence overall at 34.5% (10/29), significantly higher than African Americans (9/102, 8.8%, p<0.01) and all races combined (25/184, 13.6%, p<0.01) but not significantly higher than the individual cohorts of Caucasians (6/43, 14.0%, p= 0.08) or Asians/Indians (0/10, 0%, p=0.08). The male to female ratio for the group with the anomaly was 2 to 3. Of the patients presenting with the anomaly unilaterally, 8/9 were present in the right forearm. There was no difference in average grip (34.8 vs 30.5, p=0.12), key (8.3 vs 8.0, p=0.50), chuck (7.2 vs 6.7, p=0.43), or tip pinch strength (5.9 vs 5.5, p=0.39) between the group with the anomaly and the group without it.

Conclusion: The Hispanic population showed a significantly higher prevalence of the Linburg-Comstock anomaly compared to African Americans, and a higher but insignificantly different prevalence compared to Caucasians, Asians, and Indians. For those with the anomaly, grip, key, chuck, and tip pinch strength were not significantly different, suggesting this anomaly does not have an effect on hand functionality.

15. Functional Comparison of Hand Transplantation and Prosthetic Fitting in Below-Elbow Amputees

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Background: Composite tissue transplantation and improvements in the field of prosthetics have opened new possibilities in restoring hand function in upper limb amputees. These two concepts aim at restoring solid hand function, however, the indications, advantages and limitations for each treatment must be carefully considered depending on level and extent of amputation. Here we report our findings of a multi-center study comparing hand function in a cohort of transplanted and prosthetic hands.

Material and Methods: Seven male unilateral below elbow amputees fitted with prosthetic limbs and five male transplanted patients from Austria and Poland, 2 of them bilateral and 3 unilateral were tested. Hand function of all patients was tested with the Action Research Arm Test (ARAT), the Southampton Hand Assessment Procedure (SHAP) and the Disabilities of the Arm, Shoulder and Hand measure (DASH) and the results of both groups compared. In addition, in unilateral amputees, function was compared with that of the contralateral remaining limb.

Results: The transplanted patients achieved a mean ARAT score of 40.86 ± 8.07 out of 57 and an average SHAP score of 75 ± 11.06 points. In comparison, prosthetic patients achieved a mean ARAT score of 39 ± 3.61 out of 57 and an average SHAP score of 75.43 ± 10.81 points. No significant difference between transplanted and prosthetic hands in ARAT and SHAP could be identified. In unilateral patients, the transplanted hands could achieve 74.59 ± 17.09 % in SHAP and 70.76 ± 8.29 % in ARAT in relation to their healthy hand, the prosthetic patients 77.17 ± 10.9 % in SHAP and 68.42 ± 6.32 % in ARAT respectively.

Conclusions: Bilateral transplantation patients are forced users and definitely benefit from being totally independent in daily living. However, even though unilateral prosthetic users only gain a helping hand, the results of both groups show similar outcomes in hand function. Hand transplantation and prosthetic reconstruction are complementary and not competitive methods for functional reconstruction in transradial amputees, however the indication must be carefully weighed for each patient. Due to the significant side effects of immunosuppression the indication for allotransplantation must still be restrictive, the best being bilateral amputees. Considering the high quality of prosthetic hand function we therefore believe that unilateral amputees should be treated with prosthetic means.

16. Control of Upper Limb Prostheses By Activation of Motor Units in Targeted Muscle Reinnervated Patients Aidan Roche, MBBS, PhD¹; Hubertus Rehbaum, PhD²; Tamas Kapelner²; Ning Jiang, PhD²; Dario Farina, PhD²; Oskar C. Aszmann, MD, PhD¹

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Introduction: The control of commercially available active prostheses relies on very simple systems for recording and processing the electromyographic (EMG) signals of remnant muscles. In these applications, the only information used for control is the strength of the muscle contraction. Targeted muscle reinnervation (TMR) improves this scheme by surgically isolating intuitive muscle contractions for prosthetic control, yet existing signal processing algorithms do not take full advantage of the information available. We hypothesized that more detailed information extraction from muscle signals, at the level of individual motor units, would provide increased numbers of useable control signals for reliable use of prostheses without further surgical intervention.

Methods: Using a novel pattern recognition system for extracting control information from the global EMG signal, we have developed a technique that identifies individual motor unit behavior. This method relies on multi-channel EMG recording and decomposition of muscular electrical activity into the muscle fiber action potentials and the innervating nerve pulses. The nerve pulses can then be used to extract the patients' intent and thus identify the motor tasks they wish to execute. We applied this method to signals recorded from 3 glenohumeral patients who underwent TMR. Outcome measurements were recorded as percentage classification accuracy where the system's predictions were compared to patients' intent.

Results: While completing 8 (subject 1), 10 (subject 2), and 12 (subject 3) motor tasks of the arm, wrist and hand, the patients' intent could be correctly identified with an accuracy of >98% using this novel approach. The same tasks could only be classified with an accuracy of approximately 85% when using EMG activity as a global signal.

Conclusions: These results demonstrate the high accuracy of this novel approach based on motor unit behavior and are promising for improving pattern-recognition control of active prostheses in TMR patients.

17. WITHDRAWN

18. Complications following Upper Extremity Amputation or Replantation: A Review of 14,481 Cases Arjun Sebastian, MD¹; Rajaie Hazboun, BA¹; Amy Wagie, BA², Elizabeth Habermann, PhD²; Sanjeev Kakar, MD¹ ¹Department of Orthopedics, Mayo Clinic, Rochester, MN; ²Department of Health Sciences Research, Mayo Clinic, Rochester, MN

Background: Severe traumatic injuries to the upper extremity often require treatment with surgical amputation. Replantation can be successfully employed in select cases for limb and digit salvage. While the epidemiology and economics of upper extremity replantation and amputation surgery have been defined in the literature, the causes of injury, incidence of complications, and risk factors for complications are not well understood.

Methods: The Nationwide Inpatient Sample was used to identify 14,481 patients who underwent either amputation or replantation for upper extremity injuries between 2002 and 2011. ICD-9 procedure codes were used to separate patients into groups that underwent amputation or replantation. Data was collected regarding patient demographics, comorbidities, hospitalization characteristics, and postoperative complications. Univariate testing and multivariable logistic regression analysis was performed to identify predictors of complications.

Results: Of the 14,481 patients, 12,502 (86.3%) underwent upper extremity amputation and 1979 (13.7%) underwent replantation. The mean age of the cohort was 44.1 years with 86.5% of the patients being male. The most frequent causes of injury were machinery accidents (58.2%), motor vehicle accidents (10.7%), and crush injuries (9.0%). In the replantation group, 106 (5.4%) suffered a complication related to the reattached extremity or part. In the amputation group, 83 (0.7%) suffered a complication related to the amputation genory of complications following amputation or replantation were identified in univariate analysis including demographics, comorbidities, and admission characteristics. Independent risk factors for complications following replantation included peripheral vascular disease (OR 8.89, p < .001), recent weight loss (OR 8.51, p = .028), iatrogenic injuries (OR 5.29, p = .003), and admission to a trauma center (OR 3.67, p = .003). Independent risk factors for complications following amputation included discharge against medical advice (OR 7.10, p = .017), Medicare or Medicaid as a secondary payer (OR 5.28, p = .007), pulmonary circulation disorders (OR 4.79, p = .032), and renal failure (OR 3.50, p = .022). Of note, upper quartile hospital charges (OR .394, p = .021) and weekend admissions (OR .411, p = .009) were protective.

Discussion: Complications are significantly more frequent following replantation in comparison to amputation. In this cohort, patients with peripheral vascular disease were at significantly increased risk for complications following replantation. The importance of postoperative amputation care is highlighted by the increased complication rate in patients with unanticipated discharges. Further studies are needed to identify why certain payer status and admission characteristics were predictive of and protective against complications.

19. Cadaveric Study: Detailed Intra-flap Perforator Anatomy of the Dorsal Ulnar Artery Perforator Flap (Becker Flap)

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Introduction and Aims: The dorsal ulnar artery perforator flap (Becker flap) was first described by Becker and Gilbert (1988) and has then been reported to be ideal for soft tissue reconstruction of small to medium sized defects of the hand. Although this perforator flap is in current use, it is still raised without full application of the perforator paradigm. The Becker flap, anatomically, is a perforator flap but is still tend to be raised with fascia. The aim of this anatomical study sets out to establish the intra-flap anatomy of the key perforators, and to better define the pattern of arborisation into the subdermal plexus and to permit safe primary thinning during transfer. Additionally, the relative contribution of deep fascia to the vascular perfusion territory of the Becker flap will be assessed.

Material and Methods: 7 embalmed cadaveric Becker flaps were cannulated with latex dye and dissected to show the perforating branches of the dorsal ulnar artery. All flaps underwent tissue clearing using Spalteholz technique. Pictures were taken for each specimen and were analysed using Image J 1.46r. Several measurements of the flap and its respective perforators with regards to the entry points into the subdermal plexus were noted.

Results: The value of the means were as follows: Flap length = 11.1 ± 0.8 cm, Width = 4.1 ± 0.6 cm, number of dorsal ulnar artery perforators = 2, Perforator diameter = 1.1 ± 0.1 mm, Perforator length = 3.3 ± 0.4 cm. There are 2 major-branch distributions of the perforators and the perforators were noted to arborise in the subcutaneous tissue. The perforator entry points into the subdermal plexus were variable. Using the horizontal axis (pisiform towards medial olecranon), all perforators were located within 30-50% of this flap. They ascend proximally, giving off branches, mainly in the 45-60% region. Using the vertical axis (pisiform as mid-point), these branches enter the subdermal plexus within 30% of the mid point of this axis.

Conclusion: The axes are useful guides as it serves as a good surgical indicator as to where the danger zone (45 - 60%) is located. This cadaveric study on intra-flap perforator anatomy showed that deep fascia does not contribute to the vascular territory of the Becker flap.

20. Various Types of Superficial Circumflex Iliac Artery Perforator (SCIP) Flap for Hand Reconstruction: A Single Surgeon's Experience

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Introduction: Superficial circumflex iliac artery perforator (SCIP) flap was introduced by Koshima in 2004, which overcame shortcomings of groin flaps by dissecting out the superficial circumflex iliac artery (SCIA) further distally and designing the skin paddle lateral to the anterior superior iliac spine (ASIS). This allowed for longer pedicles and thinner flaps. Recently, we have successfully integrated nerves, muscles, bones, and fascia with the skin paddle. These advantages, combined with minimal donor site morbidity, make SCIP flap an ideal option for hand reconstruction.

Materials and Methods: From December of 2012 to July of 2014, 7 cases of hand reconstruction were performed by one surgeon (H. Y.) using SCIP flaps. The distribution of the defects were the thumbs and fingers in 6, and the palm in 1 case. In 6 cases, only the superficial branch of the SCIA was dissected. The deep fascia, perfused by the deep branch of the SCIA, was integrated with the skin paddle in one case. For palmar reconstruction, a skin paddle was elevated with the intercostal nerve for sensory recovery. A flow-through flap was elevated in one case in which only one digital artery existed.

Results: In 6 cases, flaps showed complete survival with satisfactory cosmesis. In one case, the flap was removed on postoperative day 10 by the patient, who had previous history of drug abuse. In cases with integrated nerves or fascia, satisfactory functional recovery was observed. In one case in which the intercostal nerve was coapted to the palmar branch of the median nerve, rapid sensory recovery (Semmes-Weinstein test result of 2.83 six months after the surgery) was observed. There were no complications at the donor sites.

Conclusions: The advantages of SCIP flaps for extremity reconstructions are as follows:

- 1) When compared with other free flaps, donor site morbidity is minimal; flap elevation does not require muscle or nerve dissection, resulting in no functional sacrifice and shorter operative time. It also leaves an inconspicuous scar, which can be hidden by underwear.
- 2) By designing the flap lateral to the ASIS, a thin flap with a pedicle longer than 10 cm can easily be obtained.
- 3) Vascularized fascia, iliac bone, nerve, or the sartorius muscle can be integrated with the skin paddle, allowing functional reconstruction.

Although dissection and anastomoses of the vessels require special techniques to some extent, SCIP flap has the potential to be a workhorse flap for hand reconstruction.



21. Lateral Arm Flap: A Detailed Quantitative and Qualitative Cadaveric Study of Intra-Flap Perforators Hui Qi Crystalline Lim, BSc¹; Sze Wei Justin Lee, MbChB¹; Quentin A. Fogg, BSc, PhD¹; Andrew M. Hart, MD, PhD, FRCS²

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Introduction and Aims: The lateral arm flap was first popularized by Katsaros (1984) and has been widely raised for the reconstruction of hand defects. One major drawback of this flap is the addition of excessive bulk to its recipient site, which requires a secondary defatting procedure. The aim of this study is to define the anatomical variations of intra-flap perforators and to establish the arborisation through the subcutaneous fascia within the subdermal plexus of the lateral arm flap, serving as a surgical guide for safe primary thinning.

Material and Methods: 10 embalmed cadaveric lateral arm flaps were cannulated with latex dye and dissected to show the perforating branches of the posterior radial collateral artery (PRCA). All flaps underwent tissue clearing using Spalteholz technique. Pictures were taken for each specimen and analysed using Image J 1.46r. Several measurements of the flap and its respective perforators were noted.

Results: The value of the means were as follows: Flap length = 9.8 ± 1.8 cm, Width = 4.3 ± 0.5 cm, number of PRCA perforators = 3 ± 1 , PRCA perforator diameter = 0.90 ± 0.19 cm, PRCA perforator length = 3.71 ± 1.55 cm. There are three different major-branch distributions of the perforators and the perforator locations were variable. Using the vertical axis (deltoid tuberosity towards lateral epicondyle), all perforators were distributed within 30 - 70% of the flap. The perforators ascend distally towards the lateral epicondyle, entering the subdermal plexus mainly in the lower 30% region.

Conclusion(s): These results show that it is crucial to use the vertical axis because it serves a good surgical guide as to where is the danger zone (30 - 70% in this study). Knowledge on intra-flap perforator anatomy allows the lateral arm flap to be raised and thin to the sub-dermal fascial plane.

22. Efficacy and Safety of Collagenase Clostridium Histolyticum Treatment for Dupuytren's Contracture: Effect of Delayed Finger Extension

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Introduction: Treatment of Dupuytren's contracture with collagenase clostridium histolyticum (CCH) involves a single injection of CCH into the cord of the affected joint, followed by a finger extension procedure. Current CCH labeling recommends that the finger extension procedure be performed 24 hours post-injection. In practice, the timing of the procedure may vary due to variability in physicians' clinic hours. The effect of varying time to finger extension was evaluated as part of a study of patients who received two concurrent injections of CCH to concurrently treat two affected joints of the same hand.

Materials and Methods: Patients with ≥ 2 contractures in the same hand caused by palpable cords participated in a 60day, multicenter, open-label phase 3b study. Patients received two CCH doses (each 0.58 mg) injected into one or two cords in the same hand during the same visit. Finger extension was performed 24, 48, or \geq 72 hours later. Changes in fixed flexion contracture (FFC) and range of motion (ROM), rates of clinical success (FFC \leq 5°), and adverse events (AEs), were summarized by time of finger extension (24, 48, or \geq 72 hours).

Results: The study enrolled 715 patients and 725 joint pairs were treated; among these pairs, 268 (37%) had finger extension at 24 hours, 299 (41%) at 48 hours, and 158 (22%) at \geq 72 hours. A total of 714 patients and 724 joint pairs were analyzed for efficacy. Improvement in FFC and ROM at 30 days post-CCH injection and clinical success rates (**Table 1**) and the percentage of subjects that experienced \geq 1 treatment-related AE (**Table 2**) were similar regardless of time to finger extension. The majority of AEs began on the day of injection or finger extension; most were mild to moderate and resolved without intervention.

Conclusions: The timing of the finger extension procedure did not affect the efficacy or safety of CCH, although numerically, the rate of lacerations appeared lower when finger extension was performed at 72 hours rather than at 24 or 48 hours. The ability to vary the time between CCH injection and finger extension may allow for greater flexibility for both physicians and patients.

	Finger Extension at 24 hours (n=268)	Finger Extension at 48 hours (n=298)	Finger Extension at ≥72 hours (n=158)
Total FFC, degrees			
Baseline, mean (SD)	96.9 (31.7)	97.9 (32.3)	98.4 (32.2)
Day 31 mean (SD)	27.0 (32.3)	26.7 (28.6)	28.8 (28.9)
Change, mean (SD)	69.9 (28.5)	71.2 (30.5)	69.6 (31.7)
% change, mean (SD)	75.2(25.2)	74.8 (24.5)	72.5(24.9)
Total ROM, degrees			
Baseline, mean (SD)	90.6 (31.6)	88.7 (32.8)	90.1 (33.9)
Day 31, mean (SD)	157.3 (33.0)	156.6 (29.8)	154.2 (31.1)
Change, mean (SD)	66.7 (31.3)	67.9 (31.9)	64.0 (32.3)
Clinical success (FFC ≤5°)			
Metacarpophalangeal (MP) joints treated, n	325	377	194
MP joints with clinical success, n (%)	213 (65.5)	237 (62.9)	129 (66.5)
Proximal interphalangeal (PIP) joints treated, n	211	219	122
PIP joints with clinical success, n (%)	62 (29.4)	70 (32.0)	26 (21.3)

AE, n (%)	Finger Extension at 24 hours (n=268)	Finger Extension at 48 hours (n=299)	Finger Extension at ≥72 hours (n=158)	
Any treatment-related AE	251 (93.7)	292 (97.7)	147 (93.0)	
Edema peripheral	188 (70.1)	255 (85.3)	117 (74.1)	
Contusion	125 (46.6)	194 (64.9)	108 (68.4)	
Pain in extremity	119 (44.4)	171 (57.2)	76 (48.1)	
Laceration	65 (24.3)	68 (22.7)	27 (17.1)	
Injection site pain	49 (18.3)	41 (13.7)	11 (7.0)	
Pruritus	39 (14.6)	61 (20.4)	8 (5.1)	
Blood blister	36 (13.4)	42 (14.0)	11 (7.0)	
Lymphadenopathy	33 (12.3)	46 (15.4)	17 (10.8)	

23. Efficacy and Safety of Xiaflex Injections for the Treatment of 1st Web Cords in Dupuytren Contractures F. Thomas D. Kaplan, MD

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Hypothesis: Clostridial collagenase histolyticum (CCH) is safe and effective for the treatment of 1st web space contractures in patients with Dupuytren disease.

Methods: Patients with Dupuytren contracture involving the 1^{st} web space caused by a palpable cord were prospectively enrolled. All patients received one dose of CCH (0.58mg) and were followed for 90 days. Radial and palmar abduction was measured both pre-injection and at follow-up evaluation at 10, 30, and 90 days post-injection. Adverse events were assessed at the same time points, and the Michigan Hand Questionnaire administered. Primary endpoint was the percentage of patients obtaining a >50% reduction in contracture 30 days after injection. Secondary endpoints were adverse events, change in Michigan Hand Questionnaire (MHQ) score, and patient satisfaction at 90 days.

Results: 7 patients with a 1st web space contracture received CCH injection and 6 returned for 30 day evaluation. One patient was seen at 10 days post-injection, but did not return for further visits. Five of six patients had a 50% or greater reduction in contracture of either palmar abduction (n=1), radial abduction (n=3), or both (n=1). One patient was evaluated at 10 days and had greater than 50% reduction of contracture of both palmar and radial abduction, but did not return for 30 or 90 day evaluation. All patients demonstrated improvement in MHQ score, and all patients were very satisfied with the results of their treatment. Adverse events were comparable to those seen in prior studies. No serious adverse events occurred.

Summary:

- CCH injection is effective in reducing contracture for 1st web space cords in a majority of patients.
- Patients successfully treated with CCH for 1st web space contracture show improvement in their MHQ scores, demonstrating hand function improves with increased thumb abduction.
- Adverse events are similar to those seen following CCH injection for metacarpophalangeal and proximal interphalangeal joint contractures

Patient / Age / Gender	Side	Baseline Motio	n		Motion 30 days a	fter Injection		Primary Endpoint (≥50 % reduction in Contracture 30 days after injection)	Patient Satisfaction		
		Radial Adduction/ Abduction	Palmar Adduction/ Abduction	MHQ	Radial Adduction/ Abduction	Palmar Adduction/ Abduction	MHQ				
1/65/F	L	0 /30	0 / 30	51	0 / 45	0 / 50	62.9	Yes - Both	Very Satisfied	Table 2: Descriptive table of adverse	e events
2/55/M	R	0/34	0 / 30	84.7	0 / 40	0 / 45	91.4	Yes - Palmar	Very Satisfied	Adverse event	Frequ
3 / 62 / F	L	0 / 40	0 / 65	58.6	0 / 75	0 / 70	59.2	Yes - Radial	Very	Bruising	7
4/54/M	L	0 / 35	0 / 45	59.9	0 / 55	0/45	95	Yes - Radial	Very	Edema	7
5 / 70 / 14		0/25	0.(25		**D 10.0 / 75	**D 10.0 / 75	880	** D 10	Satisfied	Itching	1
57787M	K	0735	0725	55.0	Day 10 0 / 75	Day 10 0775	10 71.4	Yes - Both			
6 / 69 / M	R	0 / 50	0 / 45	61.2	0 / 55	0 / 50	94.4	No	Very	Paresthesia	1
7/57/M	R	0/20	0/35	46.5	0/45	0/45	62.4	Ves - Radial	Verv	Nausea	1
				10.5	21012				Satisfied	Skin Tear	1

Table 1: Patient demographics, Baseline, and Post-Treatment motion and MHQ scores.

• Patient 5: Post-injection visit at Day 10

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24. Collagenase for Dupuytren's Disease in the U.K. N.H.S. - The Royal Orthopaedic Hospital Experience Eleonore E. Breuning, MBBCh, MD, FRCS; Elizabeth George, MD; Anuj Mishra, MD; Marianne Yousif, MD; Richard Pinder, MD; Claire Simpson, MD; Michael Craigen, MD; Subodh Deshmukh, MD; Michael Waldram, MD; Mark Brewster, MD

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Introduction: Collagenase injection is a new alternative to surgery in the management of Dupuytren's Disease (DD). We describe the results of our experience of its use in the NHS since its introduction in our unit in July 2012.

Methods: A prospective study of all patients who underwent Collagenase injections for DD was undertaken between July 2012 and December 2013. Degree of contracture was assessed pre-procedure, and at six weeks, three, six, and 12 months post procedure. Complications and side effects were noted. A visual analogue scale of patient satisfaction was assessed at 6 weeks.

Results: Over a seventeen month period 205 injections were performed in 157 patients (forty-three patients had more than one injection) with a mean age of 64 years. 86% were male. Five patients had a second injection for the same cord. 115 patients attended 6 week follow-up. Skin tear (23%), bruising (16%) and axillary discomfort (5%) were common complications. One patient had a localised allergic reaction after their third injection. Patient satisfaction was very high for the injections, and in comparison to surgery (VAS mean 9.1/10 & 8.3/10 respectively). Results for degrees of correction of contracture and % correction for 6 weeks, 3, 6 and 12 months are detailed in the table below.

Conclusion: Collagenase injection is a procedure with good results and well tolerated by patients. Average joint correction was good for both MCPJs and PIPJs, and was well maintained for 12 months in MCPJs. PIPJ correction was also well maintained with time, though there was a slight tendency towards recurrence of contracture between 6 and 12 months. Side effects of bruising and skin tear were common, but serious complications rare.

	MC	PJ PIPJ						
Time	n	Mean	Range	Mean %	n	Mean	Range	Mean %
following		change in	(deg)	change in		change in	(deg)	change in
injection		contracture		contracture		contracture		contracture
		(deg)						
6 weeks	61	31	20-70	76	53	36	0-80	64
3 months	33	37	0-80	77	30	38	-5-80	65
6 months	19	36	0-70	81	23	33	-65-	58
							70	
12	3	40	40-70	86	6	31	0-60	47
months								

25. Improved Outcomes With Injectable Clostridial Collagenase For Dupuytren's Contracture: A Single Surgeon's Experience

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Background: Historically, surgery has been the most effective treatment for Dupuytren's contracture, but this is fraught with disadvantages. In addition, not all patients with Dupuytren's contracture are appropriate candidates for surgery. Injectable collagenase Clostridium histolyticum (Xiaflex;Auxilium Pharmaceuticals, Inc, Malvern, PA) is a FDA-approved, office-based, nonsurgical treatment for adult patients with a palpable Dupuytren's cord. Several trials have evaluated the efficacy of Xiaflex. The CORD trials demonstrated that 44-66% of patients achieved the primary endpoint of less than 5 degrees of residual contracture. The results achieved may have been limited, by lack of use of local anesthetic for manipulations to rupture the Dupuytren's cords, limitation of injections sites, and lack of forceful manipulation of the digits.

Purpose of Study: The purpose of our study is to demonstrate superior efficacy at our institution than previously recorded in the CORD trials, based on use of local anesthetics to allow for more forceful manipulations and a more widespread injection approach. Adverse side effects within 30 days of injection was also evaluated.

Methods: Retrospective chart review of all patients who underwent Xiaflex by a single surgeon at a University Medical Center from 2010-present was performed. Factors evaluated included demographic information, extent of Dupuytren's disease, number of cords injected, response to injection, adverse side effects, and days to cord disruption. Outcomes measures included % joint correction and complications.

Results: 139 patients were identified, with an average age of 66. 63% of the patients were male. 32% percent of the patients had previous treatment for Dupuytren's, including Xiaflex, needle aponeurotomy and steroid injection. Fingers affected included: 60/139 small finger, 32/139 ring finger and 16/97 middle finger. The average MCP degree of contracture was 47 degrees, PIP 47 degrees, and DIP 40 degrees. Overall, patients had 3.8 joints affected, 2.9 joints injected and 3.7 joints manipulated. Post injection, all joints affected had 100% correction, including even some joints not originally injected. The average time between injection and manipulation was 2.8 days. All patients did have a minor complication, most commonly, ecchymosis in 100 patients (72%) and 69 (50%) had a minor skin laceration treated with local wound care. Five patients had an exposed tendon, which was also treated with local wound care only.

Conclusion: This study demonstrates improved results following several modifications of the FDA protocol, including digital block, forceful digital manipulation, and full-dose injection of Xiaflex. We achieved full extension on all joints manipulated, with minimal complications.

26. Predictors of Satisfaction with Hand Function In Patients Undergoing Limited Fasciectomy for Dupuytren's Disease

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Introduction: Knowledge of the determinants of satisfaction in patients with Dupuytren's disease may offer unique perspectives on the definition of therapeutic success. This study investigated which demographical variables, disease-characteristics, and functional outcomes predicted satisfaction with hand function in patients undergoing Limited Fasciectomy (LF) for Dupuytren's contracture.

Methods: In this multicenter prospective study, 236 patients undergoing LF completed the Michigan Hand Questionnaire (MHQ) at baseline and at varying time points in the first year after surgery. We derived satisfaction with hand function subscores, ranging from 0(completely dissatisfied) to 100(completely satisfied), from the most recently completed questionnaires. These scores were used to dichotomize patients into a satisfied and dissatisfied category according to a previously published anchoring method.

Baseline characteristics and functional outcomes assessed at the first follow-up time point were considered as possible predictors. Uni- and multivariable regression modeling was used to identify independent predictors of satisfaction. Receiver-operating curves assessed the discriminative ability of the model.

Results: At an average of 10 months (range, 6-12) postoperatively, 65% (N=153) of patients were satisfied with their hand function. Univariable analysis suggested that satisfied patients were more likely to be males, have milder PIP joint contractures and better self-reported hand function at baseline, and less residual joint contracture and better self-reported hand function after surgery. Clinically relevant factors that were not associated with satisfaction included the number of digits treated, whether the dominant side was treated or whether LF was a primary or revision procedure (Table 1).

After multivariable analysis, baseline self-reported overall hand function (p=0.024) and postoperative residual joint contracture (p=0.001) and hand appearance (p<0.001) remained as the only independent predictors, contributing to a model able to explain 75% of the variation in satisfaction response and distinguish satisfied from dissatisfied patients (Fig. 1).

Conclusion: Less residual joint contracture and better self-reported hand appearance after treatment predicted satisfaction with hand function in patients undergoing LF for Dupuytren's contracture.

As residual joint contracture is a modifiable predictor, this study highlights the importance of achieving complete contracture reductions at which LF might be more effective than its less-invasive alternatives.



27. Developing an Animal Model of Dupuytren's Disease by Orthotopic Transplantation of Human Fibroblasts into Athymic Rat

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Background: Dupuytren's disease (DD) is a slow, progressive fibroproliferative disorder affecting the palms of the hands. The disease is characterized by the formation of collagen rich- cords which gradually shorten by the action of myofibroblasts resulting in finger contractures. It is a disease that is confined to humans, and a major limiting factor in investigating this disorder has been the lack of a faithful animal model that can recapitulate its distinct biology. The aim of this study was to develop such a model by determining if Dupuytren's disease (DD)- and control carpal tunnel (CT)-derived fibroblasts could survive in the forepaw of the nude rats and continue to exhibit the distinct characteristics they display in *in vitro* cultures.

Methods: 1x10⁷ fluorescently labeled DD - and CT-derived fibroblasts were transplanted into the left and right forepaws of nude rats respectively. Cells transplanted to the forepaws were tracked at regular intervals for a period of two months by quantifying emitted fluorescent signal using an IVIS imaging system. After a period of 62 days rat forepaw connective tissues were harvested for histology and total RNA was isolated. Human-specific probes were used to perform real time RT-PCR assays to examine the expression patterns of gene products associated with fibrosis in DD. Rat forepaw skin was also harvested to serve as an internal control.

Results: Both CT- and DD-derived fibroblasts survived for a period of 62 days, but DD-derived cells showed a significantly greater level of persistent fluorescent signal at the end of this time than did CT-derived cells. mRNA expression levels of α -smooth muscle actin (α -SMA), type I- and type III- collagens were all significantly elevated in the forepaw receiving DD cord-derived fibroblasts in comparison to CT-derived fibroblasts. Masson trichrome stain confirmed increased collagen deposition in the forepaw that was injected with DD cord-derived fibroblasts.

Conclusion: In conclusion, for the first time we describe an animal model for Dupuytren's disease at the orthotopic anatomical location. We further show that gene expression differences between control (CT) and diseased (DD) derived fibroblasts persist when these cells are transplanted to the forepaw of the nude rat. These preliminary findings indicate that, with further refinements, this animal model holds promise as a baseline for investigating novel therapeutic regimens to determine an effective strategy in treating DD.

28. Prevalence of Palmar Fibromatosis with and without Contracture in Asymptomatic Patients Gustave Diep, BS; Julie Agel, MA; Julie E. Adams, MD *Department of Orthopaedics, University of Minnesota, Minneapolis, MN*

Introduction: Two distinct entities of palmar fibromatosis have been described in the literature: the typical and well-known Dupuytren's disease, which has a genetic predisposition and commonly results in progressive digital contractures and the more recently described atypical "Non-Dupuytren's palmar fascial disease", which is non-progressive and in which genetic predisposition does not seem to be an important contributor to pathogenesis. This current study documents the proportion of hand clinic patients presenting with palmar fibromatosis with and without contracture.

Methods: A retrospective study was performed of all "new" patients > 18 years presenting to a single surgeon's hand clinic over a 16-month period. Demographics and information regarding presence or absence of palmar fibromatosis, contracture, prior known diagnosis of Dupuytren's disease, and reason for presentation was abstracted from chart review. The percentage of asymptomatic patients with palmar fibromatosis was calculated.

Results: 827 patients (474 women (57%), 353 men (43%)) were included in the study, and 306 (37%) had palmar fibromatosis. Among all patients, 33% (n=118) of male and 40% (n= 188) of female patients had palmar fibromatosis. Only 26 (8%) had contracture (9 females and 17 males) while 280 (92%) had palmar fibromatosis without contracture. Among those who had contracture, 21 presented with a primary complaint of Dupuytren's disease (symptomatic contracture). Prevalence of palmar fibromatosis increased with increasing age.

Discussion: Palmar fibromatosis is a common condition (37% of this patients population study) and most patients (92%) with palmar fibromatosis do not have contracture and are asymptomatic; this suggests the possibility that most patients may not go on to develop contractures despite having Dupuytren's disease. Another possibility would be that the vast majority of these patients (92%) may have non-Dupuytren's fascial palmar disease, which would explain the absence of contracture. In contrast to prior studies, prevalence of palmar fibromatosis was similar between the genders, although the average age of female patients (50.4 years) was greater than males (46.0 years) as a confounding factor. In addition, there were more symptomatic males (65%) than females (35%), which indicate that although females have the same prevalence of palmar fibromatosis than males, they are also less likely to have contractures.

It is important to recognize that Dupuytren's palmar fibromatosis is common and often present without overt contractures, since surgical procedures performed for other reasons may worsen the condition and patients should be counseled appropriately.

29. Bupivicaine Extended-Release Liposome vs. Marcaine for Early Post-Operative Pain Control Following Wrist Operations: A Prospective Randomized Double-Blind Controlled Trial

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Introduction: The benefit of regional anesthesia in the setting of ambulatory procedures is well established. Options for continued local analgesia after discharge are limited, however. Bupivicaine extended-release liposome (Exparel) has recently emerged as a promising solution for post-operative pain, but rigorous studies demonstrating its efficacy are not yet available. In the setting of wrist arthritis procedures, carpometacarpal arthroplasty (CMCA) and proximal row carpectomy (PRC) are known to be particularly painful. In addition, the patient population that needs these operations is elderly, adding to the negative impact of narcotic side effects. We proposed that the use of Exparel would decrease post-operative pain scales, opioid use and opioid side effects; and that it may improve hand function long-term.

Materials and Methods: A double-blind randomized controlled trial was designed to compare pain outcomes in patients receiving either Exparel or Marcaine at the conclusion of CMCA or PRC. Patients were enrolled on the day of operation. Pain scales utilizing the Numeric Rating Scale (NRS), number of opioids taken, and Overall Benefit of Analgesia Scale (OBAS) were recorded at specific time points for the first 4 days post-operatively. QuickDASH scores were recorded preoperatively and at 2, 6 and 12 weeks after operation. A blinded observer collected data via phone calls to the patient in the morning and evening of each post-operative day. Primary outcomes included pain scales, opioids taken, OBAS and QuickDASH scores.

Results: Twenty-eight patients were enrolled, fourteen per arm. Pain scales reported on post-operative day 1 (p=0.0995) and number of opioids taken on day 1 (p=0.0976) were statistically significant for Exparel providing benefit over Marcaine. Pain scales on post-operative day 2 approached significance (p=0.1452). No differences were seen after post-operative day 2, though a consistent but insignificant decrease in number of opioids taken was seen. Side effects of opioids were similar between groups. QuickDASH scores were better at 3 months in the Exparel group, but this result did not reach significance.

Conclusions: Exparel provides better post-operative pain relief compared to Marcaine for wrist carpectomy procedures. This benefit is not as dramatic as expected; however, the arthritis population is particularly difficult to study with regards to pain assessments. Fewer opioids taken in the Exparel group as an objective measure of improved pain control was notable.

30. The Use of Liposomal Bupivacaine in the Treatment of Vaso-occlusive Symptoms in the Hand

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Purpose: To evaluate the use of a long acting liposomal bupivacaine in the salvage treatment and rescue of vascularly compromised upper extremity limbs that had failed other conventional treatment.

Methods: We have IRB approval to utilize 1.3% liposomal bupivacaine (Exparel) in an FDA off-label fashion for upper extremity treatment of limbs showing vascular compromise. The protocol allows us to use it when there is a limb threatening vascular emergency that has failed conventional treatment. An ultrasound-guided axillary block was performed with 3ml injected incrementally around the musculocutaneous, radial, median, and ulnar nerves. A total of 12mL of Exparel was used, corresponding to a total dose of 159.6mg. The patients are monitored in the block area 30 minutes after the procedure and placed on continuous telemetry monitoring for the remainder of their hospital stay.

Results: We have an ongoing case series of 7 patients that have had Exparel used to rescue hands showing evidence of vascular compromise. Photoplethysmography (PPG) studies were performed during hospital admissions, and the results illustrated increased flow in the effected digits on the PPG studies, even one week after the liposomal bupivacaine block. Several of these patients have had their extremities saved with this intervention, while others have required less to be amputated because of the improved vascular viability of the limb secondary to the block. Patients self reported improvement in their symptoms, even after the block had technically worn off.

Discussion: We describe the off label use of Exparel to induce sympathetically mediated blockade, resulting in marked improvement both objectively and subjectively of vaso-occlusive symptoms. We believe that the benefits of this treatment potentially outweigh the risks in these patients where conventional treatment has failed, or where no other options exist.

31. Quantification of Venous Pressures During Intravenous Regional Anesthesia

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Introduction: Intravenous Regional Anesthesia (IVRA) is utilized for upper extremity surgery. Higher tourniquet pressures and longer inflation time increase the risk of soft tissue injury. We investigated the duration and magnitude of elevated venous pressure during IVRA to assess the possibility of safely lowering the tourniquet pressure during surgery.

Materials & Methods: After IRB approval and informed consent, 20 adult patients scheduled for distal upper extremity surgery were studied. Two IV catheters were placed in the surgical arm: the hand for IVRA, and the antecubital fossa, which had a digital pressure transducer for monitoring venous pressure. The limb was elevated, exsanguinated with an Esmarch bandage, and then an upper arm tourniquet was inflated to 300 mm Hg. Local anesthetic (LA) was injected over two minutes (40cc in females, 50cc in males). Venous pressure was recorded prior to injection and every 30 seconds after injection of LA for twenty minutes or until the completion of surgery.

Results: All 20 subjects completed the study without complication. Group demographics were equivalent. No associations were discovered between venous pressures and systemic blood pressure, patients' height, BMI, or age. The mean tourniquet time was 21 minutes (range 16.5-41.5 minutes). Mean peak venous pressure was 75 mmHg, occurring at 1.5 minutes following LA injection. Peak venous pressure was 340 mmHg in one patient and lasted for less than 30 seconds. Mean venous pressure fell below systolic blood pressure after 4.5 minutes in all cases except one. This patient had elevated venous pressures (153-248 mmHg) for 24 of 25 minutes of tourniquet time exceeding systolic blood pressure by 30-130 mmHg. It took 11.5 minutes (range 0-20 minutes) for the mean venous pressure to fall below and remain below 40 mmHg.



Conclusions: Tourniquet pressures during IVRA are critical in the prevention of LA toxicity. We found that the mean peak venous pressure was below systolic blood pressure in only 14 of the 20 subjects, and the peak injection pressure exceeded 300 mmHg in one patient. Another patient's venous pressure remained above systolic blood pressure for 24 of 25 minutes of tourniquet time. Current precautions to prevent LA toxicity may be insufficient in some patients and attempts to lower tourniquet pressures to just above systolic blood pressures soon after IVRA injection may result in toxicity.

32. Osteoporosis: Survey of Hand Surgeons' Interest and Competency in its Management

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Introduction: Osteoporosis is a growing medical and economic burden on our society. The AAOS, among other organizations, has spent significant capital on the education of its membership on osteoporosis care. Hand surgeons are particularly well-positioned for the treatment of osteoporosis as they routinely see and manage upper extremity osteoporotic fractures. However, hand surgeons' understanding, interest, and comfort with osteoporosis diagnosis and management is not well understood.

Methods: An internet-based survey was e-mailed to all members of the ASSH, with the approval of the society. Data was collected anonymously and included demographics, knowledge-based questions, and practice management patterns. Statistical analysis included two-tailed significance bi-variate correlation analysis of over 105 variables.

Results: A total of 497 hand surgeons responded (82% Orthopaedic and 9.6% Plastic surgeons). Whether they routinely counsel patients about osteoporosis, 70% responded yes. Whether they would personally treat osteoporosis if they had dedicated training on the topic, 55% responded no. Even if they were financially penalized for not treating osteoporosis, 36% would still not treat it. Less than 2% believe that the treating surgeon should be responsible for treatment and 78% believe the primary care physician should treat osteoporosis. Reasons listed by more than 50% of the participants in the survey for not treating osteoporosis include no interest, unfamiliarity, inadequate training, and medico-legal liability. The correct response rate to the knowledge-based questions on vitamin and calcium dosing and drug mechanism of actions ranged between 40-70%. More than 25% or hand surgeons do not know the definition of osteoporosis based on T-scores.

Completion of orthopaedic training (p<0.05), being in practice less than 5 years (p<0.05), and practices with designated medical professionals that manage osteoporosis (p<0.05), all statistically correlated with correct knowledge of vitamin D and calcium requirements, and knowledge of osteoporosis diagnosis, testing, and treatment modalities.

Discussion: There is a wide disparity and relatively poor understanding of osteoporosis and its treatment within the hand surgical community. Hand surgeons with orthopaedic training and are recent graduates are more likely to have a better understanding of osteoporosis diagnosis and management. Regardless, even though the majority of the surgeons counsel patients regarding osteoporosis after fragility fractures, most have very low interest in managing their osteoporosis and refer patients to their primary care physicians. This deficit in knowledge and interest should be taken into account when advocating osteoporosis management by our community of surgeons.

33. Opportunistic Osteoporosis Screening: Gleaning Additional Information from Diagnostic Wrist CT Scans Joseph J. Schreiber, MD¹; Elizabeth B. Gausden, MD²; Paul A. Anderson, MD³; Michelle G. Carlson, MD¹; Andrew J. Weiland, MD²

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Introduction: Hounsfield Unit (HU) values can be easily obtained from diagnostic CT scans to calculate regional bone density. While correlations between HU and T scores, and even diagnosis of osteoporosis and osteopenia, have been established in the spine, the relationship between HU and fracture risk has yet to be investigated in the distal radius. As distal radius fractures tend to precede more devastating hip or vertebral fractures by ten to more years, these patients are an ideal target for osteoporosis screening. One means of increasing the currently low intervention rate for osteoporosis treatment could be through opportunistic diagnosis of metabolic bone disease via HU measurements from wrist CT scans. We hypothesized that HU values of the distal radius could be used to assess local bone quality and would be predictive of distal radius fracture risk, thereby allowing identification of patients in need of further management.

Methods: Bone density measurements were made in 100 patients using regional cancellous bone HU values of the distal radius, ulna and capitate (Figure 1). The HU values in 25 male and 25 female patients with an acute CT documented distal radius fracture were compared with age and gender-matched controls that had a CT scan obtained for other indications.

Results: In both male and female cohorts, age matched patients with a distal radius fracture had significantly lower regional bone density, as assessed with HU, at the distal radius, the ulnar head, and within the capitate as compared to non-fracture controls (P<0.0001, Figure 2). In females, a HU threshold of 218 in the distal radius optimized sensitivity (96%) and specificity (72%), and patients below this threshold were at increased risk of distal radius fracture (OR=3.4,P<0.001). In males, a HU value of 246 optimized sensitivity (88%) and specificity (84%) (OR=5.5,P<0.001). Control patients showed an age related decline in distal radius bone density (P<0.01), whereas fracture patients had low HU values regardless of age.

Conclusion: We found that patients with a distal radius fracture had significantly lower bone density, as assessed with HU, in the distal radius, ulna, and capitate. A distal radius HU value below 218 in females and below 246 in males was identified that is associated with a significantly increased risk for distal radius fracture. We suggest that patients with HU values below these thresholds, regardless of imaging indications, be considered for further metabolic bone disease work up, such as additional imaging, laboratory assessments, initiation of treatment, or appropriate referral.





34. The Effect of Limited Elbow Range of Motion on Gait Mechanics

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Introduction: Limited elbow range of motion can be functionally debilitating. Extensive research has been published on treatments to restore elbow motion, but few have discussed the clinical implications of limited elbow motion beyond the affected extremity.

Reciprocal arm swing in normal gait has been shown to increase stability/balance and reduce energy expenditure. The importance of arm swing in gait has been correlated clinically in patients with cerebral palsy, stroke and Parksinson's disease. However, no studies have reported the gait implications of an isolated upper extremity orthopedic injury or pathology.

Hypothesis: We hypothesized that limited elbow motion would result in an abnormal gait. We also hypothesized increased asymmetry of temporal distance footfall parameters in stiff elbow conditions compared to controls.

Methods: Forty healthy adult volunteers were recruited. Demographic data obtained included age, gender, height, weight and handedness. Each subject walked 25 times (five times per condition) on the Gaitmat II (EQ Inc, Chalfont, PA) which provided real-time analysis of temporal and distance gait parameters. Conditions tested were no brace (control), elbow brace unlocked (control), elbow brace locked in 30° flexion, locked in 90° flexion and locked in 120° flexion. The hinged elbow brace was applied to the dominant upper extremity by an occupational therapist to simulate the stiff elbow positions. Condition order was randomized for each subject.

After assessing normality (Shapiro) and group variance homogeneity (Levene's test), repeated measures analysis of variance (ANCOVA) was performed across the control and stiff elbow conditions (30° , 90° and 120°) for single variables and generalized estimating equation (GEE) for bilateral variables. Significance was set at p < 0.05.

Results: All three stiff elbow conditions demonstrated significantly decreased gait velocity, decreased stride length and increased single leg stance and double support times compared to control conditions (see Table). There was no statistically significant difference in cadence and no evidence of increased limb asymmetry (data not shown) between stiff elbow and control conditions.

Discussion: Despite the well-established functional limitations of elbow contracture patients and role of arm swing in normal gait, no research has been published on the impact of limited elbow range of motion on gait mechanics.

We have identified a direct impact of simulated elbow contracture in healthy subjects on gait mechanics. Specifically, data indicate significant differences in gait velocity, stride length, single leg stance and double support times. Future research will focus on joint kinematics, gait efficiency and energy expenditure in elbow contracture patients.

Gait analysis outcomes. ANCOVA with averages (standard deviations) and GBE. * denotes p < 0.05.								
	Velocit y	Cadence	Stride Length	Single Limb Stance Time	Double Support Time			
Brace 30	1_39 (0.026)*	114.22 (9.2)	1.46 (0.13)*	0.371*	0_127*			
Brace 90	1_39 (0.028)*	114.40 (9.0)	1.46 (0.13)*	0.371*	0_129*			
Brace 120	1_37 (0.028)*	114.03 (8_9)	1.45 (0.14)*	0_370*	0_128*			
Control	1.42 (0.026)	114.73 (8_9)	1.48 (0.13)	0.350	0.124			
P Value	0.001	0_33	0.001	0.01	0.02			

35. Subungual Melanoma: A Search for an Evidence-Based Treatment Plan

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Introduction: Subungual melanoma has historically been associated with a poor prognosis as a result of its frequent misdiagnosis and advanced disease on presentation. Amputation was felt to be the best means of preventing recurrence and deadly metatstasis, though; this was never based on scientific evidence. While cutaneous melanoma treatment has trended towards more conservative resections, aggressive amputation for subungual melanoma persists. In recent years, however, this dogma of amputating the digit involved with subungual melanoma has been challenged making the proper surgical treatment somewhat controversial.

Methods: A comprehensive review of the current literature regarding treatment and outcomes of subungual melanoma was undertaken. Surgical treatment was broken down into two groups: wide local excision (WLE) and amputation. Depth of lesion, previous treatment, stage of disease at presentation, adjunct therapy, local and distant recurrence, and survival were evaluated for the respective treatment groups. Direct comparison was performed to gain a better understanding of surgical trends, and to draw conclusions about the respective outcomes.

Results: Eight-hundred eighty-three cases of surgically treated subungual melanoma were analyzed. Eighty-six (9.8%) of the cases were treated with WLE and 69 of these (80.2%) had a defined depth of lesion on presentation. Conversely, 797 cases (90.2%) were treated by amputation of some kind; 705 (88.4%) of which were lacking a defined depth on presentation. In the amputation group, 11.4% presented with advanced disease (regional or distant recurrence), compared to 2.3% in the WLE group. Local recurrence rate for WLE and amputation were 11.6% and 5.8% respectively; regional/distant metastasis was comparable at 13.9% and 13.4%.

Conclusion: In the majority of articles, conclusions cannot be drawn due to a lack of comparable treatment groups, the strong presence of biases, and numerous co-founding factors. As a result, and based on this review, it seems as though amputation at the next joint level may be unwarranted, and WLE is justifiable. Among patients presenting with MIS, it is safe to perform a wide local excision with close follow up. The literature is in need of randomized, prospective, or comparative studies that would help elucidate whether amputation is superior to a more conservative, digit-sparing, approach.
36. Surgical Stabilization For Thumb Base Hyperlaxity; A Randomized Comparison Of The Dorsal And Volar Approach With A Cohort Of The Volar Approach

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Objective: Surgical stabilization for hyperlaxity of the carpometacarpal joint of the thumb was introduced by Eaton in 1987 using the flexor carpi radialis (FCR) tendon to reconstruct the beak ligament. However, evidence is scarcely available on the outcome for this patient group. In this study, we present the overall outcome of surgical stabilization in 57 thumbs. Within this group, we compared a volar approach with a dorsal approach in a small pilot RCT.

Methods: We followed all patients treated for chronic non-degenerative hyperlaxity of the thumb complaining of pain and impaired function due to pinch instability where conservative therapy failed. Sixteen of these patients were randomly assigned to either a variation of the volar technique by Eaton using the FCR to stabilize the beak ligament or a dorsal technique using the ECRL for stabilization of the intermetacarpal ligament. All patients received standard postoperative therapy. At baseline and at 3 months and 12 months after surgery we measured pain, strength, and ADL function using the Michigan Hand Questionnaire (MHQ) and the DASH. Generalized estimating equations statistics were used to compare repeated measurements over time in 2 groups.

Results: 54 Patients (57 thumbs) had a surgical stabilization of the thumb. We found a significant improvement in the visual analogue score for pain (mean \pm SD from 61 \pm 3 to 33 \pm 3 after 3 months and 23 \pm 6 after 1 year, p<0.001) and MHQ score (54 \pm 2 to 64 \pm 4 to 71 \pm 2, p<0.001). For secondary outcomes, the treatment improves after 1 year grip strength (22 \pm 1kg to 29 \pm 1kg, p<0.001) and key pinch strength 5.1 \pm 0.5kg to 7.0 \pm 0.6kg, p<0.001). The patients could return to work or activities within an average of 8(\pm 7) weeks.

The pilot randomized trial comparing the volar and dorsal technique was abandoned after including 8 patients in each group because of a significant increasement in pain in the dorsal group after 3 months (43 ± 8 compared to 26 ± 6 , p<0.003). The secondary outcome measurements after 1 year showed better function in the volar group (DASH) (35 ± 11 to 46 ± 8 in the dorsal approach compared with 38 ± 6 to 24 ± 7 in the volar group, p<0.124), higher grip strength (17 ± 2 to 22 ± 3 kg compared with 18 ± 3 to 29 ± 2 , p<0.199) and higher key pinch strength.

Conclusion: Surgical stabilization of the thumb base is an effective method for patients suffering from thumb hyperlaxity and results in pain relief, improved strength and improved function. The randomized controlled trial was abandoned because of significantly more pain in the dorsal group.

37. First CMC Arthritis - A Novel Staging System and Radiographic Analysis of Suture Button Suspension Ajul Shah, MD¹; Sarah Rizzo, BS¹; Anup Patel, MD, MBA¹; J. Grant Thomson, MD¹; John Safanda, MD² ¹Section of Plastic & Reconstructive Surgery, Yale University School of Medicine, New Haven, CT; ²Foundation Hospital, Kaiser Permanente, San Rafael, CA

Introduction: There are numerous approaches for the surgical treatment of thumb CMC joint arthritis. A newer method to reconstruct the beak ligament is suture button suspensionplasty. In this study, we perform a radiographic analysis to determine whether the thumb metacarpal remains suspended over time after suture button suspension. In doing so, we present a novel staging system for thumb CMC arthritis, and subsequently evaluate the proposed benefits of this procedure.

Methods: A retrospective chart review was performed. Pre-operative, 6-week post-operative, and 12 week post-operative x-rays were obtained. Patients were only included if 12 week post-operative x-rays were available. Radiographic analysis included pre-operative Eaton Stage, a novel staging system for CMC arthritis, maximum thumb metacarpal abduction angle, the angle of suspension, and the ratio of suture button height to the height of the index metacarpal. Pre-operative and post-operative results were compared, and statistical analyses were performed.

The novel staging system is shown, and will be described:



Figure 4. (0) Stage 0, (1) Stage 1, (2) Stage 2, (3) Stage 3-Failure/Impaction

Results: 100 patients underwent suspension, and 64 patients returned for 12-week post-operative x-rays. All patients underwent trapeziectomy. The average pre-operative Eaton Stage was 2.98. The novel stage improved from pre-operative to 6-weeks post-operative (0.38 and 0.20 respectively, p = 0.07), and worsened at the 12-week post-operative time point (0.38 and 0.40, p = 0.20). The novel stage was significantly different from 6 to 12 weeks post-operative (p = 0.008). The abduction angle increased from pre-operative to 6-weeks post-operative (20.7 to 34.2 degrees, p = 0.00000000005) and 12-weeks post-operative (20.7 to 33.0 degrees, p = 0.00000000001). The angle of suspension (146 and 149 degrees respectively, p = 0.08) and the ratio of the button height to the height of the second metacarpal (0.35 to 0.36, p = 0.33) did not significantly change between 6 and 12 weeks post-operative.

Conclusion: In this study, we present a radiographic analysis of suture button suspensionplasty. We present a novel staging system that is consistent irrespective of osteoarthritic changes or adduction contractures. We demonstrate that over a short period of time post-operatively, the thumb metacarpal subsides proximally. However, the procedure improves range of motion, as indicated by the increase in maximum abduction angle. These findings, in conjunction with future studies, will allow for further elucidation of the utility of suture button suspension.

38. Sensitivity and Specificity of Radiographs in the Diagnosis of Carpometacarpal Joint Injuries S. Hassan, MB, ChB, MRCS; A. Aziz, MRCS; T. R. C. Davis, MBChB, FRCS, MD; ND Downing, MA, BM, BCh, FRCS; R. W. Trickett, MBBCh, MSc, FRCS Department of Hand Surgery, Queen's Medical Centre, Nottingham, United Kingdom

Introduction: Injuries to the 4th and/or 5th carpometacarpal joints (CMCJs) are often described as rare injuries. These "fractures of frustration" can be missed at initial presentation due to misinterpretation of the radiographs, perhaps leading to an underestimation of the incidence. We aim to determine the sensitivity and specificity of standard hand radiographs in these injuries.

Materials & Methods: Four patients with confirmed 4th/5th CMCJ injuries were identified from our trauma theatre records. Four patients with normal hand radiographs were used as controls. All had undergone 4 radiographic views – anteroposterior, lateral, pronated oblique and supinated oblique. Radiographs were anonymised, duplicated and randomly ordered.

Radiographs were shown to 2 cohorts of higher orthopaedic trainees (n=17 and 11) in a timed "test". Test 1 showed the radiographs only and no clinical history; Test 2 described a history and clinical photograph consistent with the injury. Emergency Department Nurse Practitioners (ENP) viewed the same radiographs (as 8 individual cases) in an untimed test without clinical history (Test 3). Diagnoses for each radiograph/case were recorded.

Sensitivity, specificity, positive predictive value and negative predictive value were calculated for each radiographic view.

Results: The pronated oblique view had the highest sensitivity and specificity as well as yielding the most correctly interpreted radiographs. The supinated oblique view performed least well throughout. In test 3, the diagnosis was missed completely despite reviewing all 4 radiographs in 22% of cases. In no cases did the supinated oblique view correctly identify an injury when the other 3 views had been interpreted as normal.

Table 1: The calculated sensitivity (Sens), specificity (Spec), positive predictive value (PPV), negative predictive value (NPV) and total percentage correct for each of the radiographic views.

		Test 1	Test 3	Test 1 + 3	Test 2
		Timed, no	Untimed,	No history	History and
		history	ENP		clinical
					photograph
AP	Sens (%)	33.8	17.8	24.1	34.1
	Spec (%)	92.6	45.2	64.0	86.4
	PPV (%)	82.1	24.5	40.1	71.4
	NPV (%)	58.3	35.5	45.7	56.7
	Total correct (%)	63.2	31.5	44.0	60.2
LAT	Sens (%)	58.1	26.0	38.7	60.2
	Spec (%)	89.0	46.6	63.4	77.3
	PPV (%)	84.0	32.7	51.4	72.6
	NPV (%)	68.0	38.6	50.8	66.0
	Total correct (%)	73.5	36.3	51.0	68.8
PRO	Sens (%)	71.3	31.7	47.4	79.5
	Spec (%)	95.6	45.2	65.1	84.1
	PPV (%)	94.2	36.7	57.6	83.3
	NPV (%)	76.9	39.8	55.3	80.4
	Total correct (%)	83.5	38.5	56.3	81.8
SUP	Sens (%)	27.2	12.5	18.3	38.6
	Spec (%)	77.9	43.8	57.3	68.2
	PPV (%)	55.2	18.2	30.0	54.8
	NPV (%)	51.7	33.3	41.2	52.6
	Total correct (%)	52.6	28.1	37.8	53.4

Conclusions: The pronated oblique view offers the best chance of a successful diagnosis. A succinct history and examination aids diagnosis and suspected injuries should be referred on this basis. We recommend 3 views: anteroposterior, lateral and pronated oblique. Education is essential for correct interpretation.

39. Outcomes of Surgical Management Of Bilateral Rheumatoid Wrist Disease

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Introduction: Total Wrist Arthroplasty when compared to arthrodesis allows preservation of the function but may leave patient with a weaker wrist. Arthroplasty is considered for the patients with low demand activities or for the non-dominant side.

Objectives and Specific Aims: Aim of the current study was to identify a system of management for bilateral rheumatoid wrist disease.

Methods: This was a retrospective review of 32 patients at the tertiary hospital. There were two groups of patients; Group-1 had bilateral arthroplasty (n=10) and Group-2 had TWA on one side and fusion on the other side (n=22). The follow-up included; pain score, patient satisfaction, assessment of range of movements and function.

Results: The mean age for the patients in both groups was 60 years and follow-up was of 59 months. Post-operatively pain relief was achieved in 70% within 6 months and movements were preserved with mean dorsiflexion and palmarflexion of 19° . The mean DASH score for group-1 was 54.5, further; patients in group-2 who had arthroplasty also had similar DASH of 54. The DASH score was similar in arthrodesis patients. The PRWE score was also lower in patients with arthroplasty then arthrodesis. Complications of arthroplasty were; joint stiffness 10% (n=3), persistent wrist pain 13% (n=4) and revision arthroplasty in 6% (n=2).

Conclusion: Arthrodesis has been the gold standard for management of rheumatoid for predictable pain relief. Arthroplasty still remains an evolving procedure and the short to mid-term results are improving, longevity is yet to be established.

40. Basal Joint Arthroplasty Decreases Carpal Tunnel Pressure

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Background: There is a documented association between carpal tunnel syndrome (CTS) and thumb carpometacarpal (CMC) arthritis, and these conditions commonly coexist. We have observed that patients with who have previously undergone thumb basal joint arthroplasty (BJA) rarely develop CTS in the future. Our hypothesis is that the baseline pressure within the carpal tunnel in patients with CMC arthritis is higher than the general population, and that BJA decreases the pressure within the carpal tunnel.

Methods and Materials: Fifteen patients (3 with co-existent CTS) undergoing BJA were enrolled in the study. The pressure within the carpal tunnel immediately before and after BJA was measured using a commercially available pressure monitor device (Stryker STIC, Kalamazoo, MI). In patients with concomitant CTS undergoing both BJA and carpal tunnel release (CTR), the pressure was measured after BJA but prior to release of the transverse carpal ligament.

Results: The pressure within the carpal tunnel decreased in all patients. The mean pressure prior to BJA was 18.7 mmHg and decreased to 7.7 mmHg after BJA (p < .05). Patients with concomitant CTS had a mean pre-BJA pressure of 26.7 mmHg, which decreased to 6.0 mmHg after BJA (p < .05).

Conclusion: Patients with thumb CMC arthritis have a high baseline carpal tunnel pressure, which may in part explain the association between these conditions. BJA decompresses the carpal tunnel and decreases the pressure within. In patients with concomitant CTS, BJA alone decreases the carpal tunnel pressure. Further study is warranted on the need for discrete release of the transverse carpal ligament in patients undergoing BJA who have concomitant CTS.

41. Outcomes of Pyrolytic Carbon Hemiarthroplasty for Thumb Basal Joint Arthritis: A Single Centre Experience

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Purpose: The carpometacarpal (CMC) joint is a common site of degenerative osteoarthritis resulting in pain, swelling, and stiffness at the base of the thumb. When conservative measures fail, surface replacement is a surgical strategy to restore geometric articulation and range of motion. Pyrolytic carbon has been shown to be reliable biomaterial for joint surface replacement that is resistant to wear and inflammatory reaction, and it does not require additional bone cement for fixation. As a result, pyrocarbon implants have garnered interest for use in moderate stage (Eaton-Littler stage II-III) thumb basal joint arthritis. Given the paucity of clinical studies available, we present our center's experience with this surgical modality.

Materials and Methods: A retrospective chart review was undertaken for patients undergoing elective thumb CMC joint replacement from 2007 to 2014. All patients presenting with Eaton-Littler stage II-III thumb CMC osteoarthritis undergoing joint surface replacement with PyrohemisphereTM implant arthroplasty (Smith & Nephew | Ascension® Orthopedics Ltd., Austin, TX) were included in the study. Patients were followed-up until their final clinical visit when satisfaction with the outcome was reached. Patients were assessed for thumb range of motion, pain, sensory disturbances and overall hand function. In addition, patients were assessed for radiographic evidence of implant migration, subluxation, and failure.

Results: 45 patients (32F:13M) were included in the study. The mean age at the time of surgery was 60.6 ± 8.8 years (range 41 to 83 years). Average time to final follow-up was 5.2 ± 5.7 months. Mean post-operative thumb CMC radial and palmar abduction was $47.5 \pm 5.2^{\circ}$ and $40.0^{\circ} \pm 7.7^{\circ}$, respectively. 29 patients (64%) achieved functional thumb opposition. 32 patients (70%) expressed general satisfaction with the procedure, and 10 patients (21.7%) had the procedure repeated on the contralateral thumb. There was no radiographic evidence of implant failure or fracture. Two (4.3%) occurrences of implant subluxation were observed of which one required removal. 24 patients (52.2%) had persistent low grade discomfort at final follow-up but deemed tolerable by each patient. 5 patients (11.1%) experienced parasthesias of the dorsal radial sensory branch requiring desensitization therapy or neurolysis. 3 patients (6.6%) experienced persistent numbness in the hand. 2 patients (4.3%) developed post-operative infection.

Conclusions: Pyrohemisphere implants can be a useful modality for joint surface replacement. They can reduce pain and restore thumb range of motion in patients with low-to-moderate stage basal joint arthritis. However, patients must be counseled carefully about post-operative expectations.

42. Radiographic Analysis Of Simulated First Dorsal Interosseous And Opponens Pollicis Activation Upon Thumb CMC Joint Subluxation: A Cadaver Study

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Introduction: Therapy to treat thumb CMC arthritis includes selective strengthening of thenar muscles, particularly the 1st dorsal interosseous (FDI) and opponens pollicis (OP) to reduce subluxation of the joint, improve pain and decrease arthritic symptoms. Although there are now favorable clinical series, there are little biomechanical data available to support these techniques. This investigation describes the effect of selective activation of the FDI and OP muscles upon radiographic subluxation of the thumb CMC joint.

Methods: 11 fresh frozen cadavers were thawed and dissected to expose the FDI and OP and sutures placed for application of loads. The thumb CMC joint was dissected and capsulotomy performed such that the joint could freely subluxate with application of a 5 kg load to the metacarpal. Loads were applied to the FDI, the OP, and then concomitantly to both muscles at 0%, 25%, 50%, 75% and 100% maximal loads of 30 and 40 N respectively; at each point AP radiographs were obtained and assessed for subluxation of the joint (radial subluxation (RS) / articular width (AW) ratio).

ANOVA testing was used to compare mean RS/AW ratio across all loaded states. Chi-squared testing was used to evaluate reduction >50% v.s. reduction <50%.

Results: 7 complete and 4 partial sets of measurements were obtained as the OP were irreparably torn during testing in some cases. Selective activation of the OP, alone, improved the subluxation ratio across all loaded states. Increasing activation of the OP resulted in improved subluxation ratio in a dose dependent manner. Selective activation of FDI alone demonstrated minimal effects on RS/AW.

Concomitant activation of OP and DI lessened subluxation across all loading states. Subluxation ratios improved in a dose dependent manner with increasing activation with the lowest ratio at 100% of 0.10. Selective activation at 25% of DI and OP demonstrated the only ratio superior to loading of OP alone (0.341 vs 0.407). All other states demonstrated less improvement compared to OP alone, suggesting that the optimal combination of forces are 25% of maximal force of both FDI+OP. ANOVA testing for the test model demonstrated significance (p=0.001).

Conclusions: These data suggest that concomitant activation of the FDI and OP reduce subluxation of the thumb basilar joint. Therapy for strengthening programs likely function in part to encourage patients to activate the easily palpable FDI. Concomitant co-activation of the OP may be the major reducing force to elicit clinical and radiographic reduction of subluxation.

43. Volar Locking Plates Versus External Fixation and Adjuvant Pin Fixation in Unstable Distal Radius Fractures: A Randomized, Controlled Study - Clinical Outcomes at 5 Years

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Introduction: To determine whether volar locking plates are superior to external fixation with adjuvant pins in the treatment of unstable distal radius fractures.

Materials & Methods: A total of 111 unstable distal radius fractures were randomized to treatment with external fixation (EF) using adjuvant pins or with a volar locking plate (VLP). The mean age of the patients was 54 years (range 20 - 84). At 5 years (66 months) 22 patients were lost to follow-up and 89 were clinically assessed (80%), 76 women and 13 men. In the EF group there were 44 patients with 1 A2, 10 A3, 22 C1, 9 C2 and 2 C3 fractures. In the VLP there were 45 patients with 2 A2, 10 A3, 16 C1, 16 C2 and 1 C3 fractures (AO/ ASIF). The patients were assessed with a visual analog scale (VAS) pain score at rest and at activity (act), Mayo Wrist Score (MWS), Quick-Disabilities of the Arm, Shoulder, and Hand (QDASH) and range of motion. The QDASH score at 66 months was the primary outcome measure.

Results: The majority of the clinical outcomes varied insignificantly between the treatment groups and were good in both groups. MWS: EF 87 vs. VLP 90, P= .3. VAS rest: EF 4 vs. VLP 1, P= .2. VAS act.: EF 10 vs. VLP 6, P= .2. Flexion: EF 61° vs. VLP 64°, P= . 1. Extension: EF 63° vs. VLP 65° P= .3. Pronation: EF 83° vs. VLP 83°, P= .9.

The QDASH score was not significantly different between the groups at 66 months (EF 13 vs. VLP 10, P= .3).

The only statistically significant result favouring the VLPs was forearm supination (EF 81° vs. VLP 85°, P=.009).

In the VLP group 14 plates were removed, 12 (23%) of them due to plate-related complications. In the EF group 4 patients were operated with scar correction at the proximal radial scar and 2 patients still have some finger stiffness, in 1 due to CRPS.

Conclusions: There was no statistically significant difference between the groups for the QDASH score, and in general the clinical results were similar and overall good in both groups. A concern is that almost a quarter of the VLP patients needed plate removal due to surgical complications.

44. Intramedullay (Sonoma Wrx Distal Radius Nail) Versus Volar Locking Plate Fixation for Distal Radius Fractures: A Prospective, Randomized Controlled Study

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Aims of Study: Assess and compare the functional, radiological and cosmetic results as well as patient satisfaction in patients treated with the IMN Device Vs Volar Locking Plate

Method: All patients who presented to our institution with extra articular distal radius fractures and met the inclusion criteria were invited to take part in the study. The patients were randomly allocated to two groups, those who underwent intramedullary distal radius fixation using the Sonoma Wrx Distal radius nail and those who underwent fixation using a volar locking plate. The patients were then asked to follow up at 2 weeks, 6 weeks, 3 months, 6 months and 1 year. The radiological parameters, i.e radial height, inclination and tilt were compared as well as the functional outcomes by means of DASH score. Incision size and tourniquet times were recorded. Complications were reviewed.

Results: Currently we have included 21patients in the IMN group and 19 patients in the volar plate group. At 12 months the average DASH scores are 12.9 and 22.3 respectively. Tourniquet times are 29.5 and 37.8 minutes. The radiological parameters are statistically comparable. Scar sizes are 3.08 and 7.3cm respectively.

Conclusion: Intra medullary nailing of the distal radius seems to compare to volar plating in terms of radiological outcomes as well as functionally. The scar sizes are smaller DASH scores are lower for the intramedullary nail

45. Bridge Plating For Distal Radius Fractures: A Prospective Functional Analysis

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Introduction: Dorsal spanning distraction bridge plate fixation is used for surgical management of distal radius fractures in the setting of polytrauma, bilateral wrist injuries, and severely comminuted intra-articular distal radius fractures. It is currently unknown if placement of these plates for the duration of fracture healing has a long-term impact on wrist and hand function or kinematics. This study sought to determine the functional outcomes of patients following distraction bridge plate fixation of distal radius fractures.

Materials & Methods: The study population included all available adult patients over the age of 18 years who underwent treatment of a unilateral distal radius fracture with dorsal spanning bridge plate fixation from 2009 to December 2012. Patients greater than one year out from bridge plate removal were contacted for clinical follow-up for functional outcomes assessment. Wrist range of motion, composite finger flexion, grip strength, and wrist extension strength were measured and compared to the contralateral unaffected wrist. Patient also completed outcomes questionnaires (SF12, QuickDASH, PRWE).

Results: A total of 14 patients were available for follow-up and functional outcome assessment. The study group included nine men and five women with mean age of 60 (range 29 to 89). All patients had bridge plate removal within 5 months of the initial procedure. The mean grip strengths and extension torques were significantly decreased (85%, 80%) compared to the uninjured wrist. There was a significant decrease in grip strength (63 vs. 72 lbs, p = 0.002), wrist extension torque (88 vs. 102 lbs, p = 0.048), wrist flexion (44 vs 60 degrees, p=0.005) and ulnar deviation (24 vs. 30 degrees, p = 0.02). There was a trend towards decreased wrist extension (48 vs. 57 degrees, p = 0.10) and pronation (71.7 vs 74.1 degrees, p=0.182), that were not statistically significant. The mean DASH score was 12.3 and mean PRWE score of 10.8. There were no cases of infection, tendonitis, or tendon rupture.

Conclusions: Functional outcomes following distraction bridge plate fixation for distal radius fractures were similar to those published in the literature for volar plate fixation of similar distal radius fractures. There were minimal complications found in this cohort. Our findings suggest that this method is safe with minimal complications, and similar recovery to other methods of distal radius fixation is possible with rehabilitation.

46. Distal Radius Fracture Fixation Using a Specialized Threaded Pin John S. Taras, MD; Jason Saillant, MD; Peter Goljan, MD *The Philadelphia Hand Center, Thomas Jefferson University, Philadelphia, PA*

Introduction: This study presents the outcomes of extraarticular and simple intraarticular distal radius fractures stabilized with a specialized, threaded, cannulated device.

Materials & Methods: This is a prospective study of distal radius fractures treated with a specialized pin for distal radius fracture fixation. A minimum of 1 year of postoperative follow-up was required for inclusion in the study. The outcome data included wrist range of motion, grip strength, and lateral pinch strength. Radiographs obtained at each visit were analyzed to determine volar tilt and radial height. At the final follow-up visit, all patients completed the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.



Figure 1 (left); Preoperative PA radiograph of a typical extraarticular fracture amenable to fixation with the specialized threaded pin; (**right**) postoperative PA radiograph of a common pin placement pattern in which 2 pins are placed through a single incision at the radial styloid.

Results: A total of 24 patients with 24 distal radius fractures were included in this study. At an average of 2 years after surgery (range, 1 to 6 years), flexion was 89%, extension 96%, supination 99%, and pronation 100% of contralateral wrist motion. Grip strength was 93% (range, 40% to 137%) and lateral pinch strength was 99% (range, 48% to 130%) of the contralateral upper extremity. Preoperative AO fracture classification disclosed 6 type A2, 12 type A3, 4 type C1, and 2 type C2 fractures. One patient who admitted noncompliance with functional restrictions lost radial height of 6 mm from initial postoperative- to final follow-up radiographs. The average final DASH score was 4.4 (range, 0 to 35). Hardware was removed electively in 1 case and because of tenderness with wrist range of motion in 1 case. After hardware removal, neither patient expressed further complaints. No other complications or secondary surgeries occurred.

Conclusions: Specialized pin fixation offers stable, reliable fracture fixation for the treatment of extraarticular and simple intraarticular distal radius fractures. The intramedullary placement of the device and its minimally invasive approach diminishes postoperative soft tissue complications. The stability of the fixation allows patients to begin active range of motion early in their postoperative course.

47. A Clinical Decision Rule for the Use of Radiography in Acute Wrist Injury: Development and External Validation of the Amsterdam Wrist Rules

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Introduction: Wrist trauma is one of the most common Emergency Department (ED) attendances and in most hospitals, patients are routinely referred for radiography. There are no guidelines that indicate which patients require an X-ray of the wrist. A clinical decision rule that indicates if a patient requires radiography could avoid unnecessary exposure to radiation; decrease ED waiting times and reduce health care expenditure.

Methods: This cross-sectional study was conducted in the Emergency Departments of five Dutch hospitals: one academic hospital and four teaching hospitals. It consisted of two components: (1) development of a clinical prediction model; and (2) external validation of the model. We included all consecutive adult patients who presented at the ED with pain following wrist trauma. Patients were evaluated for 15 clinical variables including patient characteristics, mechanism of injury, physical examination and functional testing. The outcome measure was a fracture of the distal radius diagnosed on conventional x-rays at ED presentation. Data from the academic hospital were used to develop a prediction model. Subsequently, this model was validated in data from the other four hospitals to support general applicability.

Results: A total of 885 patients were analysed: 487 patients in the academic hospital and 398 patients in the other four hospitals. A clinical prediction model was developed that resulted in a model with the variables age; swelling of the distal radius; visible deformation; distal radius tender to palpation; painful ulnar deviation; dorsal flexion; palmar flexion; supination and a painful radioulnar ballottement test. This model showed an Area under the Receiver Operating Characteristics Curve (AUC) of 0.91 (95% CI: 0.89 - 0.94). The AUC of the external validation in the other four hospitals was 0.85 (95% CI: 0.81 - 0.89). From this model, a clinical decision rule was defined with a sensitivity and specificity of 97% (95% CI: 94% - 99%) and 30% (95% CI: 23% - 35%) for detecting fractures of distal radius.

Conclusion: The Amsterdam Wrist Rules provide an excellent tool in the Emergency Department to indicate which patients require an X-ray. If the Amsterdam Wrist Rules had been applied in the external validation cohort, an X-ray would have been requested for only 82.9% (330/ 398) of the patients instead of 100%. This is an absolute reduction of 17.1%. Applying the Amsterdam Wrist Rules to patients with wrist trauma in the Emergency Department could avoid a substantial number of unnecessary X-rays.

48. ORIF Distal Radius: Catastrophic Thinking Leads to Stiff Fingers

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Hypothesis There is debate whether patients that have greater pain and disability than expected after musculoskeletal injury have a distinct pathophysiological process (e.g. increased sympathetic nerve activity) or ineffective coping strategies such as excessive catastrophic thinking. This study aims to establish predictors of finger stiffness after distal radius fracture surgery. We hypothesize that there are no physical or psychological factors associated with finger stiffness measured by (1) range of motion and (2) distance to palmar crease at 8 weeks after surgical treatment.

Methods We prospectively enrolled 116 patients at the time of suture removal after volar plate fixation of a distal radius fracture. At inclusion we recorded patient's demographics, pain intensity, catastrophic thinking (Pain Catastrophizing Scale), symptoms of depression (Patient Health Questionnaire), health anxiety (Whiteley Index) and index through small fingers' motion and distance to palmar crease. Motion and distance to palmar crease were evaluated in 96 patients 5 weeks after enrollment (approximately 8 weeks after fracture). Seventeen percent (20/116) of the patients did not have a second evaluation: 8 sought follow-up care closer to home and 12 were missed by the research assistant when an appointment was rescheduled.

Results Age (r=-0.45, P<0.001), having another pain condition (pain condition 938° ±168° vs. no pain condition 999° ±99°, P=0.044), years of education (r=0.32, P=0.0017), catastrophic thinking (r=-0.42, P<0.001), health anxiety (r=-0.22, P=0.033) and pain score (r=-0.26, P=0.010) at enrollment were associated with range of motion 8 weeks after surgery. Age (beta=-3.2, 95%CI -4.6--1.8, P=<0.001), years of education (beta=10, 95%CI 3.1-18, P=0.006) and catastrophic thinking (beta=-6.3, 95%CI -9.8--2.8, P=0.001) were retained in the final model for range of motion (adjusted R²=0.35, P<0.001).

The same variables were associated with increased distance to palmar crease 8 weeks after surgery: age (r=-0.28, P<0.0053), having another pain condition (pain condition 3.9 ± 7.3 cm vs. no pain condition 1.3 ± 3.5 cm, P=0.031), years of education (r=-0.29, P=0.0042), catastrophic thinking (r=0.59, P<0.001), health anxiety (r=0.38, P=<0.001) and pain score (r=0.25, P=0.013). Years of education (beta=-0.32, 95% CI -061--0.040; P=0.026) and catastrophic thinking (beta=0.45, 95% CI 0.32-0.58, P = <0.001) were retained in the final model for increased distance to palmar crease (adjusted R²=0.37, P<0.001).

Conclusion A maladaptive coping response to pain (catastrophic thinking) leads to stiff fingers. Surgeons and therapists should acknowledge the counterintuitive aspects of recovery and help patients change mindset so that they feel healthy about using their sore arm and doing uncomfortable stretching exercises.

49. How Important is Cast Application to the Successful Management of Paediatric Distal Radius Fractures Robert W. Jordan, MBChB, MRCS; Gurdip Chahal, K. Srinivas; Gunaratnam Shyamalan *Trauma & Orthopaedic, Birmingham Heartlands Hospital, Birmingham, United Kingdom*

Introduction: Distal radial fractures are among the commonest skeletal injuries in childhood. For displaced fractures, closed reduction and cast immobilisation has been the mainstay of treatment in this population but high rates of redisplacement have been reported. Risk factors include initial displacement, imperfect reduction and the cast quality. The success of cast application has been measured using both cast and gap index. The aim of this study was to establish whether the cast or gap index are more successful at predicting the risk of redisplacement following manipulation for displaced paediatric distal radius fractures.

Methods: A retrospective analysis was carried out between September 2010 and April 2013 of all children under the age of 16 years old who underwent manipulation under anaesthesia for a distal third radius fracture at our centre. Open fractures, cases with associated dislocations and epiphyseal injuries were excluded from the study. Demographic data was collected from electronic records. Pre-operative radiographs were reviewed and initial severity of displacement graded according to Mani et al. Intra-operative radiographs were scrutinised to assess the success of closed reduction. The first post-operative radiograph was analysed with both the cast index and gap index measured. Clinic records and post-operative radiographs were reviewed to identify any redisplacement as described by Alemdaroglu et al.

Results: During the study period 107 patients underwent closed manipulation of their distal radial fractures. There were 63 boys (69.9%) and the mean age of 9.3 years (range 2 to 15). Mean duration of follow up was 32 days (range 15-70 days). 26 patients (19.7%) suffered a radiographic redisplacement although only 6 underwent further surgery. The redisplacement group had a significantly higher gap index (0.41 versus 0.27) than those with good radiographic outcomes. Although the cast index was higher in those suffering a radiographic redisplacement (0.84 versus 0.78) this did not reach statistical significance. Additional risk factors associated with a significant risk of redisplacement were initial grade of fracture displacement and a successful reduction intra-operatively.

Conclusion: The displacement of the initial injury, success of reduction and quality of cast are key factors in a successful outcome. Although both the cast and gap index are importance, the results from this study demonstrate the gap index to be more accurate in predicting risk of redisplacement. Therefore the authors endorse its use as an assessment of casting technique and one factor to consider when predicting redisplacement risk.

50. Obesity Increases Complexity of Distal Radius Fracture in Fall from Standing Height

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Introduction: Both obesity and fractures of the distal radius are epidemic conditions in the United States. The relationship between these two conditions has not been previously investigated. Our purpose was to investigate the relationship between patient body mass index (BMI) and severity of distal radius fracture. We hypothesized that increased BMI would correlate with increasing severity of distal radius fracture.

Materials & Methods: A retrospective chart review of 423 adult subjects with history of fracture of the distal radius resulting only from a fall from standing height was completed. Demographic data including age at the time of injury, gender, BMI, tobacco use, race, and diabetes was obtained. Wrist radiographs were then reviewed and classified by Arbeitsgemeinschaft für Osteosynthesefragen (AO) group (23-A, 23-B or 23-C). Distal radius fractures were categorized as simple (closed extra-articular (AO group 23-A) without an additional ipsilateral upper extremity fracture) or complex (intra-articular (AO groups 23-B and 23-C) or any open injury or with an additional ipsilateral upper extremity fracture). Descriptive statistics were calculated. Bivariate relationships between the demographic data and the outcome (simple or complex fracture) were evaluated using chi-square and t-tests. Logistic regression was used to model the probability of incurring a complex fracture given risk factors including BMI, age group, and gender.

Results: The average age was 53.8 years of age (range 18-98), with 64% of patients over age 50. Average BMI was 28.0 (range 13.6-59.5). 79% of patients were female. 244 patients (58%) suffered complex distal radius fractures by our criteria. Current smoking status and patient race were not significant predictors of complex injury. Obese patients (BMI > 30) demonstrated an increased risk of suffering a complex injury (p=0.0318). The probability of complex fracture varied based on gender and BMI (Figure 1), and ranged from 38% (female between 18 and 50 years, BMI <20) to 88% (male older than 50 years, BMI >50).

Conclusions: Obesity is clearly associated with more complex fractures of the distal radius, particularly in elderly patients. This relationship has not been previously reported and may have epidemiologic implications in an obese, aging population.



51. Changes in the Fracture Patterns of the Distal Radius in Patients Aged Between **51-89** Years Between **2006** And **2012**

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Introduction: Distal radius fractures are the most common fracture to be seen in emergency department. The incidence of these fractures is increasing. When considering the over-65-year group, distal radius fractures account for 18% of all fractures. The aim of the study was to investigate the change of fracture pattern seen in our elderly patient population (aged 51-89).

Methods: A retrospective comparison of fractures of the distal radius operated during the years 2006-7, and 2012-13. Information was obtained from the Orthopaedic Department discharge records. Patients aged 50 years or less and patients above the age of 89 were excluded.

During 2006-7, 136 patients aged 51-89 years had surgery for a distal radius fracture. During 2012-13, 118 patients aged 51-89 years were operated on for a distal radius fracture. Fractures were classified using the AO classification system.

Results: This study demonstrated an increase in the number of Type C fractures requiring treatment. The incidence of Type C fractures increased from 24.3% (n=33) in 2006-7, to 48.3% (n=57) in 2012-13. In the 2006-7 group 49.3% (n=67) of treated fractures were Type A; the number of this type of fracture reduced in the 2012-13 group to 44.1% (n=52). Over the same time period the number of Type B fractures treated saw a large reduction from 26.5% (n=36) to 7.6% (n=9).

Discussion: Over the last decade there has been an increasing trend toward surgical intervention for the treatment of distal radius fractures. It has not been shown as to why this trend is occurring – the authors argue could this be due to the increasing rates of complex distal radius fractures? The results presented above show an increase in the incidence of Type C fractures, within this group the incidence of Type C3 fractures also increased.

52. Are Distal Radial Fractures in Elderly Patients Best Managed by Percutaneous Wires or Moulded Cast – a Retrospective Comparative Study?

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Introduction: Distal radius fractures are common in the elderly population. The management remains controversial with recent publications reporting comparable functional outcomes between percutaneous wires and plate fixation despite worse radiographic measurements after wire fixation. Surgical intervention in elderly patients carries a risk and manipulation with cast treatment alone offers an alternative modality. Previous reports suggest that acceptable results can be expected after cast treatment even if mal-union occurs. This study aims to compare cast treatment with percutaneous wire fixation in terms of radiographic and functional outcomes in elderly patients.

Methods: A retrospective comparative study was performed of all displaced distal radius fractures presenting to our centre between April 2011 and March 2013. Patients over the age of 50 who were treated with either cast or percutaneous wire fixation were included. Displaced fractures were defined according to Sarmiento's modification of Lidstrom's scoring system. Patient demographics were recorded and the fracture was graded according to the AO classification. Measurement of radiographic outcome was performed at 10-12 weeks and included radial inclination, radial length and volar/dorsal angulation. Functional outcome was measured at a mean of 19 months (range 12 to 36) using the QuickDASH score. The need for further surgical intervention was recorded.

Results: A total of 161 patients were included in the study; 88 in cast group and 73 in wire group. Patient demographics and fracture type between the groups are demonstrated in Table I. Radiographic outcome was significantly better following percutaneous wire fixation with good or excellent results in 85% of patient compared to 55% in the cast group. However the functional outcomes were not significantly different between the groups. A higher proportion required further surgical intervention following cast treatment; 18.2% versus 5.5%. Despite this, no functional difference was demonstrated between the two groups with either intention to treat or per protocol analysis.

	Cast group	Wire group
Number	88	73
Age (years)	68.7	66.3
Female (%)	93.2	83.6
Type A fracture (%)	74.1	62.5
Type C fracture (%)	23.5	34.6

Table I – Demographics of the two study groups

Conclusion: Our results suggest that cast treatment alone can give comparable functional outcomes to percutaneous fixation in a high proportion of elderly patients. However radiographic outcomes are worse and 19% of cases have enough redisplacement to warrant further surgical intervention.

53. Economic Analysis of Implant Costs of Distal Radius Fracture

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Introduction: Over the past two decades, advances in volar plate implant technology for treating distal radius fractures has lead to a paradigm shift in their management towards open reduction internal fixation. There are a number of different implant choices for surgical treatment of distal radius fractures, with selection often determined by surgeon preference or availability. Although no one volar plate has emerged that demonstrates superior outcomes, there are significant but underappreciated differences in implant cost which are absorbed by hospitals and surgical centers where the implants are used. We aimed to characterize the economic implications of implant selection in the surgical management of distal radius fractures.

Methods: Implant costs of five volar locking distal radius plate systems with screws were obtained from a mid-size community hospital surgicenter. Medicare facility reimbursement rates for CPT code 25607, 25608, and 25609 were obtained from the same center, and private facility reimbursement rates estimated to be 280% of Medicare reimbursement, as described in the literature. Facility per case fixed and variable costs were estimated at \$900. Population distributions were derived from the US Census 2012 Population Estimates. Age and sex specific incidence of distal radius fracture were obtained from the literature. A unique stochastic decision tree model was built from derived probabilities and costs. A Monte Carlo simulation was performed with 100,000 iterations to achieve stable outcomes, and results analyzed with comparative statistics.

Results: Construct costs (distal radius plate with 3 locking screws and 3 non-locking screws) ranged from \$1,228.95 to \$2,029.00. Routine utilization of the lowest cost distal radius construct would result in operating surplus of \$131,996,896 (95% CI \$63,071,534 to \$200,877,339), while the highest cost construct would result in an operating surplus of \$66,725,459 (95% CI \$9,899,271 to \$124,474,700) annually in the US.

Discussion: In the universal effort to contain rising healthcare costs, value based purchasing are by necessity becoming integrated into clinical decision making by orthopaedic surgeons in the US. As a general rule, implant costs are included within facility reimbursement, therefore a positive operating margin is inversely related to implant cost. Utilization of lower cost plate and screw constructs can avoid a \$65,271,437 financial loss annually in the US. Arming the orthopaedic surgeon with the realities of the cost of implant selection in the operative management of distal radius fractures will lead to better value based decision making, substantial cost savings to the US hospital system, and ultimately payers and patients.

54. The Use of a Predictive Model in the Assessment of Distal Radial Fractures – Are We Being Too Conservative?

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Introduction: A number of methods of treating unstable distal radius fractures have been described; however, there is no accepted method for identifying these fractures in time to initiate appropriate treatment. A predictive model has been developed (Wristcalc, Edinburgh Orthopaedics) which prospectively identifies the radiographic outcome of wrist fractures using pre-defined prognostic factors; including age, fracture comminution and ulnar variance. Our aim was to assess the value of this tool by comparing the actual clinical outcome of distal radius fractures with the predictions made by this tool.

Methods: 80 patients with an extra-articular distal radius fracture were identified using a single institutions database. The probability of radiological malunion was calculated using the Wristcalc tool and this was compared to actual clinical outcome by using an observational study design; using patient records and standardized radiological follow-up examination.

Results: Patients managed operatively (Group A; n=40), had a 60.1%, mean probability of malunion, whilst patients managed conservatively (Group B; n=40) had a 61.3% mean predicted malunion (p>0.05). Mean number of pre-operative radiographs were 2.9(Group A) and 3.8(Group B) (p=0.005). This bears significance when mean ages of the groups were compared 57.8(Group A) and 76 (Group B) (p<0.001). Despite predicting a similar probability of malunion, the decision to operate on wrist was a clinical one, made at an earlier stage and was heavily influenced by external factors, such as age, comorbidities and level of function.

Conclusion: This tool may be a useful adjunct to predict the probability of malunion and therefore can be used to inform the surgeon's decision to operate. It's use early in the patients treatment may reduce number of pre-operative radiographs prior to making the decision to operate. Additionally, it may be used as a good primary learning tool to junior surgeons.

55. Intra-articular Fractures of the Sigmoid Notch of the Distal Radius: Analysis of Progression to Distal Radial Ulnar Joint Arthritis and Impact on Upper Extremity Function in Surgically Treated Fractures

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Introduction: Studies have established increased risk of radiocarpal joint post-traumatic arthritis (PTA) in patients with displaced intra-articular fractures of the distal radius, although this has yet to be evaluated in the distal radioulnar joint (DRUJ). We hypothesize that patients with displaced intra-articular fractures of the sigmoid notch would have a higher prevalence of DRUJ PTA and greater upper extremity dysfunction compared to fractures without sigmoid notch involvement.

Methods: A retrospective review was conducted on surgically treated patients with distal radius fractures with preoperative computed tomography (CT) scans. Patients were divided into those with and without involvement of the articular margin of the sigmoid notch. Within the sigmoid notch group, postoperative CT scans were used to measure sigmoid notch stepoff and diastasis in axial and coronal planes (mm), and volar or dorsal DRUJ subluxation (%). At final follow-up patients were administered Disabilities of the Arm, Shoulder, and Hand (DASH) scores and AP and lateral XRs were obtained to grade DRUJ PTA based on the Kellgren Lawrence (KL) scale.

Results: Thirty-three patients were included (19 with sigmoid notch involvement and 14 without) with an average radiographic follow-up of 6.4 years. DASH scores were available for all patients, and long-term radiographic follow-up was available in 24 patients. There was a trend towards poorer average DASH in those with sigmoid notch involvement (mean=53.4, SD=26.5) versus those without (mean=42.43, SD=22.9), but this was not statistically different (p>0.05). Similarly, there was a trend towards higher grade of DRUJ arthritis in those with sigmoid notch involvement (mean KL score=1.6, SD=1.1) versus those without (mean KL score=1.1, SD=0.8), but this was not significantly different (p>0.05). There were no significant correlations between sigmoid notch involvement there were poorer DASH scores in patients with coronal stepoff > 1.0-mm (mean=94.0, SD=15.6) versus those with stepoff \leq 1.0-mm (mean=49.4, SD=23.9, p=0.022).

Conclusion: Fractures involving the sigmoid notch did not appear to have a greater prevalence of DRUJ PTA in operatively treated patients at greater than 6 years of follow-up. Postoperative stepoff, diastasis and subluxation did not correlate with subsequent risk of DRUJ PTA. While overall there appeared to be a minimal effect of postoperative sigmoid notch stepoff, diastasis or DRUJ subluxation on postoperative upper extremity function, fractures with a coronal stepoff of > 1.0-mm had poorer upper extremity function.

56. Extensor Pollicis Longus Ruptures Following Distal Radius Osteotomy

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Introduction: Extensor tendon ruptures may occur from closed as well as open treatment of distal radius fractures. Although rare, surgical corrections of malunited distal radii with volar osteotomy may carry a potential risk of rupture of the extensor tendons, most commonly the extensor pollicis longus (EPL). To investigate the etiology and pathological process involved in these complications we had surgeons from multiple centers contribute cases for evaluation.

Materials and Methods: In this case series we included patients with EPL ruptures who underwent distal radius osteotomies performed through a volar approach. Data was pooled from multiple surgical centers and compiled. Demographics, initial injury parameters, imaging studies, pre and postoperative examination, intra-operative findings, surgical technique and patient outcomes were compared and analyzed. Pre and post-operative radiographs were evaluated and compared.

Results: Six cases from 5 surgeons in 4 institutions were evaluated. Length of follow up ranged between 1 to over 4 years. Initial injuries included intra and extra articular fractures. All patients were initially treated with cast immobilization. Every patient in the study had limitation of range of motion pre-operatively, most with primary loss of flexion. All malunions were healed in extension (20-60 degrees) and with shortening. During the reconstructive operation deformity correction in the sagittal plane was 25-55 degrees. All osteotomies were fixed with volar locking plates with autologous bone graft except one patient that received calcium phosphate based bone void filler. Postoperative xrays suggested prominent osteotomy resection edges, osteophytes, or dorsal bony prominence due to healed callous. Every osteotomy united during the follow up period. Average time from osteotomy to EPL rupture was 10 weeks [2-17 weeks]. Two patients initially refused to undergo tendon transfers. One was pleased with the outcomes despite the ruptured EPL. The other patient ruptured 2 other extensor tendons and then underwent tendon transfers with good results. One patient ruptured the transferred tendon as well after 2 months and underwent successful tendon grafting.

Conclusion: Although extensor tendon ruptures following distal radius volar osteotomies are rare they are a known complication of these corrective surgical procedures. In the absence of screw prominence, it is likely that dorsal callus, prominent osteotomy resection edges and osteophytes may attribute to attritional rupture of the EPL tendon.

57. The Long Term Outcome of Four Corner Fusion

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Four-corner arthrodesis with excision of the scaphoid is an accepted salvage procedure for scapho-lunate advance collapse (SLAC) and scaphoid non-union advance collapse (SNAC) and has been undertaken in our unit for over 20 years. We have undertaken a retrospective review of 116 of these procedures performed in 110 patients between 1992 and 2009. Fifty-eight patients attended for a clinical evaluation and 29 responded by postal questionnaire. Although the surgical technique was standard, various methods of fixation were used including k wires, staples, bone screws, but predominantly the Spider plate.

Follow-up was a mean of 9 years and 4 months, (range 3 - 19 years). All patients reported a significant improvement in pain relief and approximately 50% of flexion extension. Although only 30% of radio-ulnar deviation. Grip strength was again approximately 50% on the contralateral side. Most patients reported a significant improvement in function with 87% returning to work.

In addition, radiological evaluation identified 28 patients (31%) who demonstrated ongoing signs of non-union, particularly around the triquetrum. Fourteen of these (15%) who undergone a further procedure, generally with success.

Finally none of the patients demonstrated any arthritic changes in the lunate fossa on follow-up x-ray and all secondary procedures were undertaken within 2 years of the primary.

58. Four Corner Arthrodesis Using a Funnel Shaped Plate Allowing Multi-Planar Fixation

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Most four corner fusion plates provide fixation with screws in a single plane relying on the screw threads for bone stability. We have used a novel plate which provides multi-planar fixation via locking screws and autogenous bone grafting to address SLAC / SNAC wrists which provides fixation via screw threads and screw shaft divergence to enhanced stability.

Methods: A retrospective clinical and radiographic assessment was performed in a consecutive cohort of 15 patients who underwent a standardized four corner arthrodesis with a Titanium, funnel-shaped plate and distal radius bone grafting for a diagnosis of SLAC or SNAC wrist. Follow-up examination of all patients included VAS pain scores, VAS activity ratings, work status, PA/lat radiographs, grip strength, range of motion, and complications/re-operations was obtained on each patient.

Results: Average follow-up was 28 months (minimum = 2 years). Radiographs demonstrated union in all (100%) of cases, no screw breakage, carpal collapse, or unexplained severe pain. In addition, no evidence of secondary arthritic changes at the radiolunate joint were noted, with maintenance of joint height. No plates required removal. Range of motion averaged 58% of the uninjured side (avg. extension= 47° ; ave flexion= 34°). Grip strength averaged 82% of the uninjured side (45 kg vs 55 kg). The mean VAS pain and activity scores were 1.3/10 and 2.2/10.

Conclusions: The use of a novel funnel-shaped plate which allows fixation of the 4 corner region via both screw threads and screw shaft divergence in a locked rigid construct produced excellent and reproducible results in this consecutive series with direct follow-up examination. Importantly, the development of secondary arthritic changes at the radiolunate joint were not noted indicating a reasonable durability to the procedure.

59. Medium Term Outcomes of the Universal-2 Total Wrist Arthroplasty for Rheumatoid Arthritis K. Kailash, MCh, MRCS; A. Raza, MCh, MRCS; S. Mahalingam, MCh; SC Talwakar, FRCS; IA Trail, FRCS; R. Murali, FRCS; JK Stanley, FRCS *Wrightington Upper Limb Unit, Wrightington Hospital, Wigan, United Kingdom*

Introduction: Total Wrist Arthroplasty (TWA) for Rheumatoid Arthritis (RA) of wrist allows pain relief and preservation of the movements. Revision still remains a major issue in Total Wrist Arthroplasty (TWA) for Rheumatoid Arthritis.

Aims: The primary aim was to evaluate medium term outcomes of Universal-2 TWA at a tertiary centre. The secondary aim was to follow complications and revision procedures performed in the series.

Methods: This was a retrospective review of case notes of 93 Universal-2 total wrist arthroplasty procedures performed from 2003 to 2009 at our institute. The five patients who were lost to follow-up and two patients died at two and four years following TWA, due to un-related causes. Therefore study included 87 TWA procedures.

Results: The indication was RA in 83 wrists, three had severe osteoarthritis and one had post-traumatic arthritis following scaphoid fracture. Ten patients had bilateral wrist replacements. Mean age of the patients was 60 years (26 to 86 years) and mean follow-up was of 51 months (13 to 94 months). Post-operatively pain relief was achieved in 70% within 6 months and patient satisfaction in 85% of wrists. Movements were preserved, at the final follow-up the mean dorsiflexion was of 23° and palmarflexion was of 21°. An earlier interim study of 39 patients showed VAS pain score improved from 5.4 to 1.7 and DASH score improvement of 14 points. The complications included; joint stiffness (10.5%, n=9), wrist pain (10.5%, n=9) and superficial infection 2.5% (n=2). Major complications were revision total wrist arthroplasty in 3.5% (n=3) and 3.5% (n=3) had salvage arthrodesis, as unable to proceed with revision arthroplasty. The Kaplan-Meier probability of survival was 91% at 7.8 years (95% CI:7%).

Conclusion: Pain relief and patient satisfaction following wrist arthroplasty procedures were consistently high in our series. The incidence of the major complications was 7% in this study, compared to the available literature which shows rates of up to 12% for Universal-2 TWA and up to 50% in earlier Universal implant.

Universal-2 Wrist Arthroplasty is recommended for pain relief and preservation of function. Further studies are required particularly focusing on carpal component loosening and long term outcomes.

60. Clinical Outcomes Following Midcarpal Hemiarthroplasty Of The Wrist

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Introduction: Wrist hemiarthroplasty by means of proximal carpal row resurfacing is indicated for patients suffering from radiocarpal arthritis with a preserved distal carpal row. Compared to alternative procedures, such as total arthroplasty or arthrodesis, resurfacing the proximal carpal row preserves the anatomic centre of rotation and radial length without ligamentous disruption and maintains the natural coupled motion of the wrist at the midcarpal articulation.

Method: The KinematX prosthesis has been implanted into 20 of our patients. Further to our earlier results [1], data was collected prospectively with a mean follow up of 114.3 weeks (range 59-168 weeks). Data collected included; pre and postoperative Mayo and DASH scores with grip strength, range of movement and prosthetic complications.

Results: The KinematX prosthesis was implanted to 11 males and 9 females, with an average procedural time of 54 minutes. The operative side was dominant in 65% of cases. Indications included; scapholunate advanced collapse (eleven), osteoarthritis (five), Keinbock's (one) psoriatic (two) and inflammatory arthritis (one). Average wrist flexion-extension improved postoperatively from 63 degrees to 99.2 degrees. Preoperative assessment revealed an average Mayo wrist score of 34.1, and DASH score of 50.3. Postoperatively, the average Mayo wrist score improved to 64.5 and DASH score to 21.9. The average percentage grip strength of the operative compared to nonoperative hand increased from 66.3% to 96.3% postoperatively. Stiffness occurred in 4 patients who underwent manipulation under anaesthesia within 5 months of primary surgery. One patient underwent revision for aseptic loosening; otherwise there were no cases with radiographic evidence of loosening or capitolunate narrowing. At latest follow-up 76.9% of patients had returned to work.

Conclusion: Our data suggests the KinematX prosthesis is safe and reliable, however a larger population with longer follow-up will determine the durability and overall success of the implant.

The level of of evidence for this study is therapeutic level IV (case series).

61. Lunate Pyrocarbon[©] **Implant Arthroplasty: Analysis of Physical Function and Patient Satisfaction** Reinier Feitz, MD; Noortje J. Visser, MD, PhD; Harm Slijper, PhD; Thybout Moojen, MD, PhD *Xpert Clinic, Hilversum, Netherlands*

Background: Kienbock's disease is frequently discussed by different authors. However, the precise aetiology is still uncertain and the treatment remains controversial. A relatively new treatment is lunate implant arthroplasty using a pyrocarbon prosthesis. A literature study could not identify any outcome studies regarding this implant despite the implant being on the market since 2009. Apart from a recent paper from Mark Henry no outcome data have been published since the operative technique was first described in 2011. This study will document the first clinical outcomes.

Methods: Between 2010 and 2013 sixteen patients with Kienbock's disease stage III were treated by lunate pyrocarbon implant arthroplasty using a single tendon graft to stabilize the implant. Average age of patients was 38 years (range 16-53). Eight males and 8 females were included. Pre-surgical and post-surgical assessment was performed with a mean follow up of 14 months (range 3-34). Assessment included an interview, questionnaire (VAS-score and PRHWE-score), examination, X-ray and measurements (active range of wrist motion and grip strength).

Results: After surgery the levels of pain and function were improved in the majority of patients with a minimum follow up of one year. Average VAS-score improved from 5 to 2.6, average PRHWE-score from 58 to 24. The average flexion-extension arc and wrist deviation arc were decreased with a decline in flexion/extension of 16/12 degrees and a decline in ulnar/radial deviation of 12/3 degrees. Grip strength was not considerably changed after surgery with improvement of average Jamar-score from 23 to 29. Most patients were very satisfied about the operation. Seven patients rated the procedure as "excellent", 5 patient as "good", 2 scored "moderate" and 2 scored disappointing. Two patients would not undergo the same procedure again, 14 patients would undergo the same procedure again.

Conclusion: Lunate implant arthroplasty may be a solution in symptomatic patients with a Lichtman stage IIIB or stage IV. Our study suggests that a majority of patients benefit from this procedure. However, this study reports the first clinical outcomes of a small population with a limited maximum follow-up period of 3 years. Future prospective studies with larger patient samples have to be awaited. One advantage of this technique is that it does not elimintate other options, it can be revised with standard alternative options.

62. Revision Metacarpophalangeal Arthroplasty; 128 Consecutive Cases

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Purpose: Primary metacarpophalangeal (MCP) arthroplasty is an established treatment for MCP arthritis, and as with all total joint replacements, it is not unusual to require revision arthroplasty. There is a paucity of literature examining incidence, prognosis and outcomes following MCP revision arthroplasty. The objective of this study was to assess the results revision MCP arthroplasty, identifying factors associated with improved outcomes.

Methods: Utilizing the institutional Joint Registry Database, 128 revision MCP arthroplasties were performed in 64 patients at our institution from 1998 to 2012. The average age at surgery was 62.2 years, average BMI 31.5. There were 83 with patient's rheumatoid arthritis (RA) and 6 with Juvenile RA, while 46 patients were using prednisone and 31 methotrexate at the time of surgery. There were 50 were non-constrained (30 pyrocarbon and 19 metal-plastic) and 78 constrained silicone implants. Cement was used in 20 and bone graft in 9. 13 patients had a history of preoperative flexion contractures, while 8 had MCP instability.

Results: At an average 5.1 years of follow-up, there were 19 (15%) repeat revision surgeries performed. Reasons for revision surgery included: dislocation (11), pain with limited motion (4), silicone synovitis and bone resorption (2), infection (1), and metacarpal component loosening (1). The 2, 5 and 10 year survival rates were 89%, 80%, and 78%, respectively (**Figure 1**). Patients that had a history of DM and prior instability had an increased risk of implant failure (p<0.01). There were 3 intraoperative complications involving periprosthetic fractures, including 2 in the proximal phalanx and 1 in the metacarpal. Only 1 of the fractures required circumferential suture stabilization. There were 11 (9%) postoperative complications, including 8 MCP dislocations, 1 heterotopic ossification, 1 postoperative fracture and 1 infection. Furthermore, 31 (24%) developed flexion contractures. SRA implants (p<0.04) were associated with increased rates of infection, while implants in the dominant extremity (p<0.04) were associated with increased rates of postoperative dislocation were higher in female patients (p<0.04), smokers (p<0.02), and SRA implants (p<0.03).

Summary Points: Revision MCP arthroplasty is a challenging procedure with a 5 year survival of 80% and a relatively high rate of complications and flexion contractures. Worse outcomes are seen in in patients with a history of MCP dislocations, smokers, and SRA implants. With increasing use of MCP arthroplasty, there is a need for innovative strategies to optimize long-term outcomes in revision MCP arthroplasty.



63. WITHDRAWN

64. An Evaluation of Content and Accessibility of Hand Surgery Fellowship Websites

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Background: Hand fellowship programs compete for trainees in general, orthopedic, and plastic surgery residencies. These applicants use resources on the Internet to manage their fellowship applications. The purpose of this study was to evaluate the accessibility of information from commonly used databases and assess the content of HFWs.

Methods: Websites from eighty-one accredited hand surgery fellowships available during the 2014 academic year were eligible for study inclusion. Program lists from the Fellowship and Residency Electronic Interactive Database (FREIDA) and the Fellowship Program Directory of the American Society for Surgery of the Hand (ASSH) were assessed for program information and working links to HFWs. Available HFWs were evaluated for comprehensiveness in the domains of fellow education and recruitment. Website content was correlated with program characteristics. All statistical tests were two-tailed and P values less than 0.05 were considered significant.

Results: 15 plastic, 65 orthopedic, and 1 general surgery hand fellowships were analyzed. FREIDA had 12 working links to HFWs and ASSH had 34 (15% vs 42%, P<0.001). However, FREIDA had in-depth training statistics for 44 programs (54%), while ASSH had none. Links to HFWs did not vary by surgical specialty (p=0.655). Of the 81 accredited fellowships, 74 had HFWs (91%). 3 plastic and 4 orthopedic hand programs did not have an HFW (20% vs 6%, p=.118). As a whole, HFWs provided an average of 5.4 education and 4.9 recruitment variables. The majority of HFWs described commonly treated conditions (89%), affiliated sites (81%), academic conferences (69%), didactic instruction (68%), and journal clubs (64%). For recruitment, HFWs commonly had information on faculty (89%), eligibility (72%), application links (59%), fellows (42%), and previous graduates (34%). Orthopedic programs had more education content than plastic surgery programs (55% vs 44%, p=0.030). Programs in the South had more education content than programs in the Northeast (63% vs 47%, p=0.001), but not more than programs in the West or Midwest. Larger programs with more hand fellows had greater education content than those with only one fellow (57% vs 49%, p=0.042). Programs affiliated with highly ranked medical schools had less education content than their lower ranked counterparts (48% vs 56%, p=0.045). No differences existed in online recruitment content between programs.

Conclusions: Most accredited hand surgery fellowships lack readily accessible websites in commonly used databases. Furthermore, a paucity of online content suggests HFWs are underutilized as education and recruitment tools. Future opportunity may exist to utilize these resources more effectively.



65. The Diagnostic Value of MRI Ordered by Providers Prior to Referral to a Hand Surgeon: A Look at Efficiency and Quality of Imaging

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Background: Orthopaedic and plastic surgery residents receive unique hand surgery training, yet often compete for similar fellowships in hand surgery. This wide variation in training background has historically been viewed as a strength to the specialty, but recent interest has emerged to help unify the core of hand surgery training. The purpose of this study was to examine hand content on the In-Service Exam for Plastic Surgeons (IEPS) and compare it with content on its orthopaedic counterpart.

Methods: Score keys of six consecutive IEPS administrations were reviewed for questions related to the hand or distal forearm (2008-2013). Questions were categorized by taxonomic classification, anatomical location, diagnosis, and treatment. Keyed references were analyzed to determine the most frequently cited sources. Results were compared to a previously published study on the Orthopaedic In-Training Examination (OITE). Comparisons were made via Fisher's test. It was determined that our sample size was sufficient at a power of >80% to reveal significant p values.

Results: More questions addressed the hand and forearm on the IEPS compared to the OITE (20.3% versus 8.1%, p<0.001). Questions were similar by taxonomy classification, but focused on different anatomical locations. For example, questions on the IEPS more commonly addressed fingers (54.6% versus 33.0%, p<0.001), but questions on the OITE more commonly addressed the wrist (30.4% versus 15.5%, p=0.002). Furthermore, questions on the two exams tested different diagnoses and treatment modalities. Fractures were more common on the OITE (26.8% versus 13.0%, p=0.002), but wounds were more common on the IEPS (18.1% versus 6.3%, p=0.003). Similarly, therapy and rehab was more common on the OITE (7.1% versus 1.7%, p=0.022), but flaps and replants were more common on the IEPS (19.3% versus 10.7%, p=0.046). The focus of the referenced literature in support of the correct answers also differed by exam. The top 3 cited journals for the OITE were Journal of Bone and Joint Surgery, American; Journal of Bone and Joint Surgery, British; Clinical Orthopaedics and Related Research; whereas those for the IEPS were Journal of Hand Surgery, Update, and for the IEPS was Green's Operative Hand Surgery.

Conclusions: Hand curricula for orthopaedic and plastic surgery residents emphasize different diagnoses and treatment modalities. These results will assist educators quantify differences in exposure to hand surgery prior to hand fellowship, and help establish a benchmark for future modifications to the hand surgery curriculum.

66. A Comparison of Plastic and Orthopaedic Hand Surgery Curricula

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Introduction: Magnetic resonance imaging (MRI) is a valuable diagnostic tool for evaluation of upper extremity musculoskeletal pathology. As MRI has become increasingly available in communities, there appears to be increased frequency of ordering this expensive tool for screening rather than diagnostic evaluation or surgical planning. Based on observation and literature review, we hypothesized there is an abundance of unnecessarily ordered MRIs prior to referral to a treating hand surgeon. We also hypothesized community-ordered MRI is often of inadequate quality for appropriate evaluation of specific upper extremity pathology. To our knowledge, no previous study has prospectively assessed the efficiency and quality of MRIs ordered prior to referral to a hand surgeon.

Materials & Methods: Thirty-two patients presented over a five-month period with MRI obtained prior to referral to a hand surgeon. The population included all patients with previous MRI, regardless of referring diagnosis, previous treatment, gender, or age. A single experienced hand surgeon completed routine history and physical exam, and plain films were reviewed if available or completed if needed. After evaluation, the surgeon made a diagnosis and commented on whether MRI was needed for further evaluation or treatment. Only then were the previously obtained MRIs and any reports reviewed. The surgeon then commented on whether these results changed diagnosis or treatment. To assess the quality of prereferral MRIs, an experienced musculoskeletal radiologist at our institution reviewed all studies without having reviewed previous reports or diagnoses. The radiologist determined whether the studies were satisfactory for review of the anatomical area of concern, and then made diagnoses based on evaluation of the study provided.

Results: The attending hand surgeon would have routinely ordered MRIs to aid in the diagnosis or treatment for three patients. Based on these findings, we concluded 90.63 percent of studies were unnecessary. Evaluation of MRIs by the radiologist, found only 9.37 percent of studies to be "unsatisfactory" for assessment of the area of concern, but noted 53.12 percent of studies used a field of view, which was "too large" for the anatomy.

Conclusions: While MRI is a valuable diagnostic tool, it is being used inefficiently by referring providers prior to patient referral to treating hand surgeons. As MRI is expensive, this represents a large overutilization and expense waste in healthcare currently. Furthermore, studies performed in communities may be unsatisfactory for the proper evaluation of the anatomy of concern, which could result in duplicate ordering and further cost.

67. Is Smartphone Technology Reliable and Effective in Assessing Pediatric Elbow Trauma? Ebrahim Paryavi, MD, MPH; Brandon Schwartz, MPH; Joshua Abzug, MD

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Hypothesis: The use of mobile imaging has become increasingly prevalent in the clinical setting. Data are not available regarding the reliability of mobile phones in transmitting adequate images of radiographs for establishing a diagnosis and directing treatment. We hypothesized that diagnosis of pediatric elbow fractures from multimedia messaging service (MMS) images would demonstrate low reliability among pediatric orthopaedic surgeons and senior residents. Our secondary hypothesis was that the decision for operative treatment would not be affected by evaluation of images on a mobile device as opposed to standard picture archiving and communication system (PACS).

Methods: AP and lateral radiograph images of 50 pediatric elbow cases were evaluated by 2 pediatric orthopaedic surgeons and 2 senior orthopaedic residents. Raters were asked to classify the case as any of the following fractures/diagnoses: supracondylar humerus, lateral condyle, medial epicondyle, radial neck, posterior fat pad, or normal pediatric elbow. Additionally, raters were asked to choose operative or conservative treatment. After a temporal lag, pictures of the same images were taken from a standardized distance from a computer monitor with an iPhone 5 camera and transmitted by MMS to each rater. The same questions were again posed to raters. Inter and intra-observer reliabilities were calculated by Cohen's kappa statistics with bootstrapped 95% confidence intervals.

Results: Baseline inter-observer reliability of classification of injuries based on PACS images was excellent between residents and attendings with a kappa of 0.85 (95% CI 0.76-0.93). The inter-observer reliability of treatment decision between the two groups was also high with a kappa of 0.79 (95% CI 0.67-0.91). Intra-observer reliability of classification of injuries on PACS compared to MMS images was excellent, with kappa ranging from 0.89 (95% CI 0.80-0.95) to 0.94 (95% CI 0.87-0.99) for residents and attendings, respectively. The overall kappa was 0.91 (95% CI 0.86-0.95) when comparing ratings of all participants on PACS versus MMS. Treatment decision also demonstrated excellent intra-observer reliability (PACS versus MMS) with kappa ranging from 0.80 (95% CI 0.67-0.92) to 0.916 (95% CI 0.84-0.99) for residents and attendings, with an overall kappa of 0.86 (95% CI 0.79-0.93) for all raters.

Conclusion: The diagnosis of pediatric elbow injuries and treatment decisions can be made equally reliably based on either PACS or transmitted MMS images taken with an iPhone from a computer screen. As MMS images become increasingly prevalent in communication between physicians and staff, we have demonstrated that this practice can be effective in establishing a diagnosis and directing treatment.

68. The Attitude of Hand Surgeons Toward the Affordable Care Act: A Survey of Members of the American Society for Surgery of the Hand

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Background: Signed into law in 2010, the Affordable Care Act (ACA) commonly known as Obamacare will have significant effects on nearly every aspect of healthcare in the United States. This study aimed to examine the attitudes of hand surgeons toward the ACA.

Methods: An electronic survey was sent to the members of American Society for Surgery of the Hand (ASSH). The survey consisted of 31 questions and was sent twice at one-month intervals per ASSH guidelines.

Results: A total of 974 hand surgeons responded to the survey (33% response rate). The majority were male (89%), trained in orthopaedic surgery (81%), in private practice (75%), and with more than 15 years of experience (56%). Most respondents rated their knowledge of the ACA as average (41%). Only 15% reported that they received training on the expected healthcare changes related to the ACA. In general, respondents disagreed that the ACA would improve healthcare in the United States (median 2, mean 2.06, range 1-5, 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree), while agreeing that the ACA would decrease reimbursements specific to hand surgery (median 4, mean 4.11). They also disagreed that the ACA would improve access to emergent (median 2, mean 2.10) or elective (median 2, mean 2.30) hand surgery. Approximately 37% of respondents believed that implementation of the ACA would cause them to retire earlier than planned and 51% believed that they would alter their individual practice as a result of the ACA. Stratified analysis revealed that respondents in private practice had a more negative outlook on the ACA compared to their academic-practice contemporaries ($p \le 0.0013$ for all questions). Male respondents had a more negative outlook on the ACA to improve care quality (p 0.0021) and access (p 0.02) for hand surgery patients without affecting the surgeon's retirement timeline (p 0.007) or practice type (p 0.002).

Conclusion: The majority of responding hand surgeons had a fairly negative outlook on the ACA. Private-practice members were more pessimistic than their academic-practice contemporaries and male members were more pessimistic than their female colleagues. Notably, only a small percentage of respondents reported sufficient preparation for the coming changes related to the ACA. These findings indicate a need for increased education and advocacy from professional organizations, which could potentially improve hand surgeons' outlook on the ACA.

69. Current Climate of Hand Surgery Call: A Survey of ASSH Members

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Background: Hand injuries account for a significant number of emergency room encounters per year. Qualified hand specialists are needed to address emergent concerns though there exists a recognized shortfall in hand surgeons providing emergency coverage. The goal of this study was to survey all active members of the American Society for Surgery of the Hand (ASSH) to determine the current practices of members with respect to emergency call.

Methods: All active members of the ASSH were emailed a survey assessing hand call practices. The email survey was sent twice and responses were collected. Variables of interest included surgeon age, primary specialty, and scope of practice, as well as several detailed questions regarding Emergency Department (ED) call coverage and compensation.

Results: 865 of 2843 (30.4%) members completed the survey. 78% of respondents provide Emergency Department coverage for hand injuries irrespective of primary specialty or practice type. 58% of respondents perform emergency microsurgery or replantation. Plastic surgery respondents take the most emergency microsurgery call (70%) as compared to 52% of orthopedic surgeons and 53% of general surgeons. Academic hand surgeons are almost twice as likely (94%) as their counterparts in solo private practice (53%) to accept Medicaid. 42% of respondents that provide ED coverage are compensated for taking call, which is higher when taking microsurgery call, and in 95% of these cases the hospitals provide the compensation. Hand surgeons in private practice are more likely than those in academics to be compensated for taking call. The percentage of respondents taking emergency call decreases with age, with age of sixty years being the cutoff for most practices.

Discussion: The majority of respondents in this study provide hand surgery emergency care (78%). Survey results suggest that the amount of call declines with age and respondents report that when compensated, providing microsurgery coverage compensates at a higher rate than general hand call. With an imminent physician shortage, hand emergency care will need to be continually reevaluated and potentially restructured.

70. FDA Approval and Recall Trends for Orthopaedic Devices: A 21-year Analysis

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Introduction: The FDA utilizes two major pathways to approve medical devices. The first is the Premarket Approval Application (PMA) which requires clinical trials and safety data for a device to be approved. The second is the Premarket Notification 510(k) review, which requires no clinical trials if the product is shown to be substantially equivalent to an existing device. Recently, orthopaedic and hand surgery device manufacturers have experienced grand lawsuits for device recalls. Given the number of highly publicized recalls, we hypothesize that orthopaedic and hand surgery devices are more likely to be approved through the FDA's less regulated 510(k) review.

Methods: Using the FDA's public database, we aggregated PMA and 510(k) device approvals from 1992-2012 for all specialties, orthopaedics, and hand surgery. Device recalls were then obtained from the FDA's recalls database. We evaluated the top 20 companies contributing to recall from 2002-2012.

Results: From 1992 to 2012, PMA approvals for all medical specialties increased by 88 devices/year, while 510(k) approvals decreased by 96 devices/year (Figure 1). However, PMA approvals for orthopaedics decreased by 0.44 devices/year, while 510(k) approvals increased by 12 devices/year (Figure 1). Hand surgery devices followed the same 510(k) trend as orthopaedic devices. There were significant differences in PMA approval trends (P<0.001) and 510(k) approval trends (P<0.001) between all specialties and orthopaedics. Five of the top 20 companies contributing to recall from 2002-2012, including the top three, were orthopaedic and hand surgery device manufacturers, accounting for 44% of recall within these 20 companies (Figure 2). These five companies accounted for 15% of total recall during this 10-year period.

Conclusion: Over the past 20 years, while the medical device industry has shifted towards utilizing the safer PMA review, the orthopaedic and hand surgery device industry has been approving devices primarily via the 510(k) review. In the last decade, orthopaedic and hand surgery device manufacturers were the main contributors to recall. As healthcare providers, we are concerned that many orthopaedic and hand surgery devices are introduced without proper safety and efficacy data. There remain critical issues around device approval processes that must be addressed to provide better care.



71. A Chance "Mutation" - The Evolution of a Hand Therapy Regimen for Tupper Arthroplasty

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Introduction: The Tupper palmer plate interposition arthroplasty has been utilised as an alternative to implant arthroplasty for the management of metacarpophalangeal joint (MCPJ) osteoarthritis (OA). Post-operative rehabilitation guidelines following pyrocarbon arthroplasty are available, yet an optimal protocol following the Tupper arthroplasty is lacking. This preliminary report describes the evolution of rehabilitation following a "chance mutation" in protocol, as part of a continuous prospective audit of results.

Materials & Methods: Patients undergoing Tupper arthroplasty were historically managed in a standardized manner (Phase 1) this comprised of 2 weeks immobilization followed by restrictive splinting and cautious mobilization of the MCP joints. In attempt to improve the overall range achieved, Phase 2 patients were immobilized for 1 week followed by less restrictive splinting and MCPJ restrictions. An incidental "mutation" of therapy occurred when 2 consecutive patients were non-compliant with advice, mobilizing freely with minimal splint utilization (Phase 3). Ranges of movement and Numerical Rating Scores for pain were recorded. Patient feedback was also captured as part of routine physiotherapy care.

Results: Sixteen joints were evaluated, with mean follow-up of 62 months (1.6 to 53.9 months). Adjacent to the therapy reforms, a change in surgical technique was also instigated during Phase 1. Outcome measures are described in Table 1.

Table 1: Summary of Mean results of Phase 1, 2 and 3 Tupper arthroplasty patients

Therapy Phase	1	2	3
Number of joints	10	3	3
Age at operation (years)	71.8	59.3	73.3
Follow-Up (months)	30.2	17.8	4.6
Extension lag	11°	30°	13°
Maximal Flexion	52°	50°	73°
Arc of Movement	41°	13°	60°
Numerical Rating Score			
(Pain)	0.3	0.0	0.0

Unrestricted mobilization exhibited by the uncompliant patients did not demonstrate additional complications with regard to stability or pain.

Conclusion: Early results suggest that a more rapid approach to mobilization without restrictive splinting leads to a greater mean arc of flexion than a more protective regimen in patients undergoing Tupper arthroplasty.
72. MatOrtho Proximal Interphalangeal Joint Arthroplasy: Minimum Two-Year Follow-up Olivia Flannery, MD; Oliver Harley, MD; Ann Birch, MD; Mike Hayton, MD; Ian A. Trail, MD *Wrightington Upper Limb Unit, Appley Bridge, United Kingdom*

Introduction: The MatOrtho proximal interphalangeal replacement (PIPR) is a cementless cobalt-chromium metal-onpolyethylene mobile bearing surface replacement arthroplasty. It permits preservation of the collateral ligament attachments so that joint stability is not compromised. The aim of this study is to report the outcome and complications from the MatOrtho PIPR at a minimum of 2 years of follow-up from a single centre.

Materials and Methods: A retrospective case review was performed on all MatOrtho PIP joint replacements performed with a minimum of 2-year follow-up. Patient demographics, diagnosis, implant revision and other surgeries were recorded. Subjective and objective outcomes were evaluated at latest follow-up including pain scores, range of motion and radiographic assessment.

Results: 109 implants were inserted in 56 patients. Nine implants (6 patients) were lost to follow-up. Of the remaining 100 implants 75 were female, the average age at time of surgery was 64 years and the principal diagnosis was osteoarthritis in 77% of joints. The average follow-up was 46 months. The revision rate was 12%. The reasons for revision were soft tissue failure in 6 patients, stiffness in 5 patients and implant failure in 1 patient. Eight joints were revised to the NeuFlex (silicone rubber) prosthesis, 3 were converted to an arthrodesis and 1 had exchange of the MatOrtho prosthesis. Twenty-four joints (24%) required soft tissue release. There was no infection. There was a significant improvement in pain scores, with 62 out of 72 joints being pain free at rest. There was an improvement in functional scores post operatively but no improvement in range of motion. Nine percent showed some radiological periprosthetic lucency but no clinical loosening was observed.

Conclusion: The survival of the MatOrtho PIP joint arthroplasty was 88% at a minimum of 2 years follow-up. Patients can be advised that the procedure achieves good pain relief, improvement in functional scores but does not improve range of motion.

73. Can Computerized Tomography be Used to Predict Successful Non-Operative Treatment of Scaphoid Waist Fractures?

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Introduction: The purpose of this study was to determine whether computerized tomography (CT) could be used to predict success with non-operative treatment of scaphoid fractures and to determine if any predictors for delayed union could be identified.

Materials and methods: A radiology data base (2004-2013) was searched to identify a cohort of simple acute scaphoid waist fractures. Simple waist fractures were identified by excluding cases presenting >6 weeks from injury, or those with CT findings associated with nonunion/delayed union (displacement, humpback deformity, comminution and/or a sclerotic border). Cases that were not given a trial of non-operative management were excluded (n=23). The x-rays, CT scans and health records for each patient were reviewed to extract data on the injury, treatment course and outcome.

Results: A sample of 164 patients met inclusion criteria (133 males, 31 females). The mean age was 30 ± 16 years. Five patients had diabetes, 78 were smokers (47.5%), 36 were non-smokers (22.0%) and the smoking status was unknown in 50 patients (30.5%). Although all fractures were acute, 17 patients had evidence of cystic resorption along the fracture line on CT.

The union rate for this cohort of simple non-operatively treated scaphoid fractures was 99.4% (1 nonunion/164 subjects). The mean time to union was approximately 7.5 weeks (53 ± 38 days). Smoking did not affect union rates (p=0.17) or time to union (p=0.9), nor did energy of injury, age, gender, diabetes.

Cysts did not affect the non-union rate (p=0.73) but patients with cystic resorption along the fracture line required approximately 10 weeks for union (70.6 \pm 61.2 days) compared to 7 weeks (50.9 \pm 34.2 days) for those without cysts (p=0.04). A small percentage of patients required casting for greater than 3 months to achieve union (8%), with 4.9% requiring casting for greater than 4 months. There was a correlation between the number of days before the fracture was casted and the length of time needed to achieve union (r=0.27, p=0.001), however, once casted, the treatment delay was not correlated with a longer time to union (r=0.062, p=0.43) indicating that once treatment was initiated, the delay did not adversely affect union times.

Conclusions: Using CT to assess scaphoid fractures can help identify scaphoid fractures that can be expected to heal reliably (99.4%) within a short time frame (7 weeks), allowing us to focus operative resources on those with a higher likelihood of delayed union or progression to non-union.

74. Three-Dimensional Analysis of Acute Scaphoid Fracture Displacement

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Introduction: Scaphoid fractures are common, and internal fixation is the preferred treatment for displaced fractures. Quantification of the mode of displacement of the scaphoid fragments may aid in correct surgical management. Previous studies have described the relative movement between the scaphoid fragments in fractures with nonunion. The goal of this study was to analyze the movement of acute scaphoid fracture fragments and adjacent bones relative to a common coordinate system.

Methods: All CT scans diagnosed with an acute scaphoid waist fracture during the study period were evaluated using the developed 3D model (Amira Dev 5.3, Mercury Computer Systems, Chelmsford, MA). The fractures were divided into displaced and nondisplaced fracture groups and were compared to a control group with no injury. Three anatomical landmarks were labeled on each of the distal and proximal fragments of the scaphoid as well as the lunate and trapezium. Four landmarks were marked on the distal radius articular surface. Each set of labels formed a triangle representing the bone or fragment. Virtual reduction of the fracture was conducted in the displaced fractures. A coordinate system based on the radius distal articular surface was used as reference. The position of each bone or fragment was calculated, using 6 variables, representing lateral, volar and distal motion; pronation, flexion/radial deviation, and rotation of the bone or fragment.

Results: In the displaced group, compared with nondisplaced and control groups, the proximal scaphoid fragment showed significant extension (25.1° and 25.2° ; p<0.001), supination (7.1° and 7.5° ; p=0.006) and volar motion (0.9 and 0.6 mm; p=0.037). The lunate showed supination (4.6° and 5.2° ; p=0.058), similar to that of the proximal scaphoid fragment. The distal fragment and the trapezium showed no movement.

Conclusion: Measuring the displacement of the acute scaphoid fracture fragments and the adjacent bones relative to a common coordinate system revealed that the proximal scaphoid fragment is the one displaced, along with supination of the lunate. According to this data, concurrent reduction of the proximal scaphoid and lunate may be the more effective reduction maneuver.

The developed 3D method can be a tool in the evaluation of the quality of reduction of the scaphoid fracture as well as other aspects of wrist biomechanics.

75. Distal Radioulnar Joint Reaction Force After Ulnar Shortening: Diaphyseal Osteotomy vs Wafer Resection Colin D. Canham, MD¹; Michael J. Schreck, MD¹; Noorullah Maqsoodi, BS²; Mark Olles, PhD²; John C. Elfar, MD¹ ¹Department of Orthopaedic Surgery, University of Rochester, Rochester, NY; ²Department of Mechanical Engineering, Rochester Institute of Technology, Rochester, NY

Introduction: Prior studies have demonstrated ulnar shortening alters distal radioulnar joint (DRUJ) mechanics. In previous work, we developed a novel method of measuring joint reaction force (JRF) at the DRUJ that preserves periarticular soft tissues. Prior methods of measuring DRUJ JRF required disruption of these important stabilizing structures. The purpose of this study was to apply this method to compare how ulnar diaphyseal shortening and wafer resection affect DRUJ JRF. Our hypothesis was ulnar shortening osteotomy would increase DRUJ JRF more than wafer resection.

Methods: Based on pilot data, a sample size of 7 was required to detect a 30% increase in DRUJ JRF with 83% power. Eight fresh frozen human cadaveric arms were obtained. Under fluoroscopic guidance, a threaded pin was inserted into the lateral radius orthogonal to the DRUJ and a second pin was placed in the medial ulna coaxial to the radial pin. Each arm was mounted onto a mechanical tensile testing machine with the wrist in neutral rotation using a custom fixture. A distracting force was applied across the DRUJ while force and displacement were simultaneously measured, generating a force-displacement curve. Data sets were entered into a computer and a polynomial was generated and solved to determine the inflection point representing the JRF. Each ulna was then shortened by 3 mm using a standard ulnar diaphyseal osteotomy and fixed with a slotted compression plate that allowed for subsequent re-lengthening. JRF was determined as above. The ulnae were re-lengthened to their original length to re-establish normal anatomy and return JRF to baseline prior to performing wafer resection. Wafer resection was then performed with removal of a 3 mm wafer. JRF was again calculated. JRF between the 4 conditions (baseline, diaphyseal, re-lengthened and wafer) were compared using a linear mixed model with Bonferroni correction.

Results: Average baseline DRUJ JRF was 7.17 ± 2.52 N and 10.30 ± 2.66 N after diaphyseal shortening osteotomy, (p<0.0015). Average JRF after re-lengthening the ulna was 6.86 ± 2.24 N and 6.68 ± 1.87 N after wafer resection (p>0.05). There were no differences in JRF between baseline, re-lengthened, and wafer resection conditions. A representative force-displacement curve for the 4 conditions is shown in figure 1.

Conclusions: DRUJ JRF increases significantly after ulnar diaphyseal shortening osteotomy and does not increase after ulnar wafer resection.



Figure 1. Representative force-displacement curve for the 4 conditions. JRF is represented by the inflection point.

76. A Mixed-Methods Assessment of Patient Costs Following Hand Trauma

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Introduction: It is recommended that cost utility analyses have a societal perspective, including costs to the patient, health care system and third-party payers. These analyses are becoming more common in hand surgery yet a common limitation is patient cost reporting. The objective of the current study is to conduct the preliminary steps for developing a patient-reported outcome measure for accurate prospective assessment of patient costs following hand trauma.

Methods: This is a prospective, mixed-methods cost of illness study conducted at a level 1 trauma centre. All hospital and physician fees covered by the provincial health care plan. Following institutional research board approval and signed informed consent, upper extremity trauma patients were recruited within the four weeks of injury. Demographic and injury data were collected and a Hand Injury Severity Score (HISS) was calculated. Patients maintained a cost diary, and completed a narrative questionnaire between 4-8 weeks post-injury. Descriptive statistics and qualitative (grounded theory) analyses were performed to disaggregate and describe patient costs, which were then organized into cost categories. Recruitment was stopped upon reaching saturation in the qualitative thematic analysis.

Results: Fourteen participants (mean HISS = 15, range: 2-64) were included in the analysis reporting 8 cost categories (patient and caregiver lost income, rehabilitation costs, medications, travel, accommodation, food and adaptive devices) and 21 cost items. Direct income loss and indirect caregiver income losses were reported by 42% (n = 6) and 50% (n = 7), respectively. Direct income losses ranged from decreased work productivity to months of unemployment. The average out-of-pocket cost within 4 weeks of injury was \$521. Rehabilitation costs (hand therapy and splints) accounted for 61% of out-of-pocket costs (\$342) and were the most commonly reported (64%), followed by travel (56%).

Conclusions: Upper extremity trauma patients experience a wide range of costs with rehabilitation costs representing a major economic burden. Our understanding of their costs and resource use may formulate the basis for future cost assessments and practice and policy changes aimed at decreasing the economic impact for hand trauma and hand surgery patients. The findings of this study will provide the foundation for developing a patient-reported measure to prospectively capture these costs. Not only will this provide an outcome measure meaningful to patients, physicians and policy makers, but also allow for more robust cost analyses in the hand surgery literature.

77. Radiation Exposure and Hand Dominance using Mini C-arm Fluoroscopy in Hand Surgery

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Introduction: The mini C-arm is popular with hand surgeons for its portability and decreased radiation generation compared to large C-arms. There has been recent evidence that suggests the mini c-arm is still capable of generating considerable radiation exposure. Hand surgeons are particularly at risk for radiation exposure, as they cannot easily distance themselves from the radiation beam, frequently maintaining fracture reductions with their hands. Previous studies have looked at hand exposure in the dominant hand with mini C-arm. However we have noted the non-dominant hand to is used to maintain reduction placing it closer to the radiation beam.

Materials & Methods: Prospectively, two fellowship-trained hand surgeons wore ring dosimeters on both hands during surgeries involving bony work of the forearm and hand, involving mini C-arm fluoroscopy. The type of case, fluoroscopy time and fluoroscopy radiation output for each case were recorded as well as total radiation exposure to the hands measured from ring dosimeters. Given the ring's threshold in recording radiation of 30 mrem, at least 8 cases per ring was determined to be necessary to achieve measurable data.

Results: 4-ring dosimeters pairs (8 rings total) were worn during 8 cases each (32 cases total) and a second set of 2-ring dosimeters pairs (4 rings total) were worn during 16 cases each (32 cases total). This represents 6-ring dosimeter pairs worn during 64 cases, averaging 10.7 cases per ring. No ring met the minimal dose threshold of 30 mrem to record a numerical value. Each ring experienced an average of 413 seconds of fluoroscopy time and 66.3509 cGy*cm² of radiation output from the mini C-arm. See table for a breakdown of surgery type and location.

Case Characteristics

Total Cases = 64			
Hand =	Forearm		
37	= 27		
10	11		
4	7		
9	2		
6	0		
0	3		
s8	4		
	= 64 Hand = 37 10 4 9 6 0 \$8		

Conclusions: Assuming worst-case scenario: each ring measured 29 mrem (just below the threshold), the surgeon's hands experienced 2.7 mrem per case. This would allow a hand surgeon to perform 18,391 cases per year before exceeding the allowable annual hand exposure limit of 50,000 mrem set by the National Council of Radiation Protection (NCRP) & International Commission of Radiological Protection (ICRP). The results do not allow comparison of radiation exposure related to hand dominance.

78. Results of Arthroscopic Reduction Association of the Scapholunate Joint

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Introduction: The reduction association scapholunate technique was described as an open technique that creates a fibrous non-union between the scaphoid and lunate for treatment of scapholunate interosseous ligament tears; but, a more recent alternative technique includes the use of an arthroscope for fixation. We hypothesize that Arthroscopic Reduction Association of the Scaphoid and Lunate (ARASL) is an optimal technique for scapholunate ligament injuries that decreases wrist pain and improves function.

Materials & Methods: 18 patients with scapholunate injuries (including grade I SLAC) who had undergone ARASL by the senior author were included. Post-operative pain score, DASH, range of motion (ROM), grip strength and radiographic parameters were calculated. Statistical significance was calculated using a two-tailed t-test and the Fisher exact test.

Results: The average follow-up time was 3 years. Postoperatively there was noticeable reduction in average SL angle, SL joint diastasis and carpal height ratio. Postoperative average VAS was 2.5 and average DASH score was 8. The average postoperative grip strength difference was 15% less in the operative wrist compared to the nonoperative wrist. The average arc of postoperative range of motion was 103°. There were 8 complications (44%). 3 complications were attributable to technical mistakes. 5 patients had SL joint widening and 1 patient had windshield-wipering of the hardware. 2 patients underwent revision ARASL and 2 patients had a PRC. Overall survival was 78% of the index surgery.

In the patients without SLAC wrist, the SL angle, SL joint diastasis, carpal height ratio, DASH and VAS were not significantly improved. There was 1 complication (11%), which was asymptomatic SL gap widening. No patient required additional surgery and postoperative survivorship was 100%.

However, SLAC was a statistically significant risk factor for complications and revisions. Furthermore, a preoperative gap greater than 5mm was predictive of SL gapwidening and complications.

Conclusions:

- ARASL patients maintain a high average arc of wrist motion.
- Patients with SLAC had the majority of complications and all of the revision surgeries.
- SLAC was a statistically significant risk factor for complications and revisions.
- A preoperative gap greater than 5mm is predictive of SL gap widening and complications.
- Perfect technique is imperative for a chance at success for this procedure. Three of our complications were due to technical errors.
- Our complications offer insight into the technical aspects of ARASL.
- The ARASL technique is a very promising surgical option for well-selected patients with scapholunate injuries.

79. Does SLAC IV Exist? A Radiographic and Magnetic Resonance Imaging Analysis

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Introduction: The progression of scapholunate advanced collapse (SLAC) and scaphoid nonunion advanced collapse (SNAC) was originally described in three stages that spared the radiolunate joint. A fourth stage of the continuum which includes progression into the radiolunate joint has been proposed, however rigorous analysis of its prevalence has not been performed using standard or advanced imaging protocols. The purpose of our study is to evaluate the radiolunate joint on radiographs and cartilage sensitive MRI in a cohort of patients with SLAC or SNAC arthritis. We hypothesize that stage IV SLAC/SNAC arthritis exists due to degeneration of the radiolunate joint.

Methods: A retrospective cohort of 32 patients with SLAC or SNAC arthritis was studied with radiographs and cartilagesensitive MRI. Two board-certified hand surgeons and a board-certified musculoskeletal radiologist read the blinded radiographs and MRIs. The styloid-scaphoid, radioscaphoid, midcarpal, capito-lunate, and radiolunate (RL) joints were independently graded using the Kelgren-Lawrence scale and overall SLAC/SNAC grade was assigned to each patient. Depth of cartilage wear on the volar, middle and dorsal aspects of the radiolunate joint was graded on MRI.

Results: Both surgeons graded 3 of 32 wrists (9%) as SLAC/SNAC IV on radiographs. MRI identified 2 of the 3 patients as having deep or full thickness cartilage wear of the dorsal RL joint. MRI evaluation yielded grade 3 (deep wear) or grade 4 (full thickness) cartilage wear of the RL joint in 9 of 32 (28%) wrists, all of which was on the dorsal one-third of the joint only. No wrists showed a grade >2 (superficial wear) in the middle or volar aspect of the joint. 5 of 32 (16%) wrists had normal radiolunate joints radiographically and grade 3 or 4 cartilage loss on the dorsal one-third of the radiolunate joint.

Conclusion: Although mainly limited to the dorsal aspect, the radiolunate joint is involved in SLAC/SNAC wrists in approximately one out of four cases. We recommend MRI with cartilage sensitive sequencing in the workup of SLAC/SNAC arthritis to more accurately grade cartilage involvement as the findings and location of radiolunate cartilage loss may influence treatment decisions. The amount of radiolunate cartilage loss and its effect on clinical outcome is the subject of ongoing study.

80. The Utility of Ultrasound for Detecting Stener Lesions in Ulnar Collateral Ligament Injuries

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Introduction: Ulnar collateral ligament (UCL) injuries of the thumb result in an unstable metacarpophalangeal joint (MCPJ), particularly if the adductor aponeurosis interposes between ends of the ruptured ligament, preventing healing. Such 'Stener lesions' are an indication for surgical repair and ultrasound (US) is commonly used to investigate suspected UCL injuries prior to repair. We investigated the accuracy of ultrasound in diagnosis of UCL injuries and also whether a difference in the time between the injury and the scan affected the diagnostic accuracy.

Methods: Patients who underwent UCL repair in our hand surgery department were identified retrospectively and electronic and paper records and imaging reports were reviewed. The time between injury, US and surgery was calculated and the diagnostic accuracy of US was calculated using the surgical findings as the gold standard. The seniority of the radiologist was noted.

Results & Discussion: 82 patients underwent UCL repairs between July 2006 and June 2014, one of which was bilateral. From the data available, time from injury to US ranged from 0 to 124 days (median 4) and time from US to surgery ranged from 0 to 126 days (median 5). The overall diagnostic accuracy of US for diagnosing Stener lesions was 64.4%, which was higher in consultants (76.1%) than non-consultant grade radiologists (62.5%). Overall sensitivity was 82.8% and specificity 64.7%. Consultants were more specific but non-consultants had a higher sensitivity, which reflected perhaps lower confidence in negative diagnoses. Scans performed in under 7 days from the time of injury had an accuracy of 69.0%, whereas those performed at over 1 week had an accuracy of 46%. This may be due to scarring of the tissues in more chronic injuries.

Conclusion: US is a useful adjunct to clinical examination, being inexpensive and non-invasive. Our results suggest that US is useful in diagnosis but is best performed promptly by experienced musculoskeletal radiologists.

81. Dynamic External Traction Device for PIP Joint Fracture Dislocation: Which Is The Best Model? A Comparative Cadaveric Biomechanical Analysis

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Purpose: The ideal k-wire based external distraction device for fracture dislocations of the PIP joint has yet to be identified. To date, there are no direct comparisons between different types of distraction devices in the literature.

Using a cadaveric hand model, we performed a biomechanical analysis of two devices, using one as described by Suzuki *et al* and the other by Hynnes & Giddins. The effect of the devices on the intra-articular width and on the force of flexion of the PIP joint was measured.

Methods: Thirty-two cadaveric fingers were used to compare a pins and rubber system with 3 and with 5 elastics per side (3E and 5E), as well as a pin system that uses no elastics (2P). Articular distraction of each device was compared using x-ray imaging. The force of flexion required to pull on the flexor digitorum profundus to flex the PIP joint to 45° and to 90° with each group was also measured.

Results: The three study groups showed statistically significant (p<0.01) articular distraction from baseline. Intra-articular spaces were 3E-AP 199%, Lat193%; 5E-AP 217%, Lat 200%; and 2P- AP 241%, Lat 183% of the pretreatment measurement space. Articular widths were 3E-AP 1.29mm, Lat 1.18mm; 5E-AP 1.41mm, Lat 1.22mm; and 2P-AP 1.46mm, Lat 1.22mm (no statistical difference between groups). Forces of flexion at 45° was 3E- 3.97N, 5E- 4.17N, and 2P- 4.87N (no statistical difference) and 3E- 11.27N, 5E- 10.29N, 2P- 14.34N at 90°.

Discussion: The three devices have similar distraction effect on the PIP joint. Resistance to joint mobility was greatest for 2P despite not attaining statistical significance. Given that all devices are equally as effective to distract the joint, the choice of device should be based on the force of flexion, ease of placement, reliability, and simplicity. Based on this, we favor 3E and 5E given that it is easier to flex, simpler to obtain precise placement of the distraction pin, and did not spontaneously disengage over the course of the study as opposed to 2P. The use of 5E over 3E provides a greater joint distraction, no increased resistance to flexion, and is just as reliable and easy to place.

Clinical relevance: This study allows clinicians to better understand the biomechanical effects of each of these devices and allows physicians make an informed decision as to the best distraction device described.

82. A Prospective Randomized Crossover Study On The Comparison Of Cotton Vs Waterproof Cast Liners Phillip Tomas Guillen, MD; Corey B. Fuller, MD; Montri D. Wongworawat, MD; Barth Bishop Riedel, MD Department of Orthopaedic Surgery, Loma Linda University Medical Center, Loma Linda, CA

Introduction: Many fractures are regularly treated with closed reduction and casting to maintain alignment during fracture and ligament healing. Although Gore-Tex-based Procel cast liner (waterproof) has been compared to cotton liner and shown to be superior in the context of comfort variables and objective assessments, the Gore-Tex has been known for its difficult application and high costs. The purpose of this study is to compare newer generation waterproof liners from BSN Medical, DeltaDry, with traditional cotton liner. It is the first study to compare waterproof liner and cotton liner in a crossover model, allowing patients to swim in the pool with the cast and compare this new product with traditional cotton liner.

Materials & Methods: Twenty patients (ages 7-30) with upper extremity injuries were randomized to a waterproof-liner or cotton-liner casts made of fiberglass. Patients would switch cast-liners halfway between their treatments to fulfill crossover criteria. All fractures were within a 2-week period from original incident. Mean number of casting weeks was 4.6. At each clinic visit, patients and physicians completed questionnaires evaluating comfort and skin condition, respectively. They were also asked which cast-liner they preferred at the end of the study.

Results: Only one patient lost alignment and had to be manipulated; this occurred after being in a cotton-lining cast. There were no unscheduled cast changes. The waterproof –liner group had better scores for sweat (P=0.01), odor (P=0.04), and overall physician score (P=0.02). There was no significant difference in weight, itch, pain, irritation, fit and overall comfort, however seventy five percent of patients preferred waterproof casting to the cotton liner.

Conclusion: To our knowledge this is the first study to evaluate and compare comfort and effectiveness of cast liners in a randomized crossover clinical trial with this newer generation waterproof liner. In addition it is the first to allow patients to swim in a pool even with above elbow waterproof casts. When used for upper extremity injuries, waterproof cast liners, compared with cotton cast liners, had better sweat, odor and overall physician scores. The waterproof liners allow patients to rinse casts daily without risking skin maceration, rashes, or ulceration and the majority of patients prefer waterproof to cotton liner.

83. Outcomes of Radial Head Fractures in Patients Under 50 Years Old: What's Better ORIF or Arthroplasty? Sanmeet Singh, BS¹; Xuyang Song, MS²; W. Andrew Eglseder, MD²; Raymond Pensy, MD²; Joshua Abzug, MD² ¹School of Medicine, Howard University, Washington D.C, DC; ²Department of Orthopaedics, University of Maryland Medical Center, Baltimore, MD

Introduction: Arthroplasty has been recommended for radial head fractures with more than three articular fragments due to increased complications with ORIF, including nonunion and loss of forearm rotation. However, the active lifestyles of patients under 50 years of age may not be in line with replacement of their radial heads. The purpose of this study is to evaluate the outcomes of radial head fractures in patients under 50 years of age to determine which treatment may be more appropriate, replacement or ORIF.

Materials & Methods: A retrospective review of radial head fractures over a 6-year period from a level 1 trauma center was performed on patients aged 18-50 years. Data collected included patient demographics, age of patient at the time of surgery, the number of fragments, Mason classification, the presence of any associated soft tissue injuries, dislocations, or other fractures, the need for bone grafting, implant type if replacement was performed, and outcomes data including, range of motion (ROM), complications, and conversion to replacement.

Results: 35 patients were included in the study with an average follow-up of 8.5 months. 35% (13/35) had greater than three articular fragments. 85% (11/13) of this subset underwent open reduction and internal fixation, with only 15% (2/13) undergoing prosthetic replacement. The average postoperative ROM in the ORIF group was 67.8 degrees of pronation and 61.6 degrees of supination. None of the patients who underwent ORIF (0/11) went on to nonunion, malunion, or failure of the hardware. 36% (4/11) had removal of their hardware, capsulectomy, and excision of heterotrophic ossification to improve post-operative range of motion. No patients (0/11) in the greater than three fragment group that underwent ORIF required conversion to a radial head replacement.

Conclusions: The notion that "smashed" radial head fractures (those with more than 3 articular fragments) need to have a replacement performed may not be optimal for patients under 50 years of age. Treatment of young patients with ORIF of a "smashed" radial head can lead to excellent outcomes with a low complication rate. Better understanding of the specific fracture patterns that may occur as well as patient demands may help guide surgeons in choosing which treatment to perform for "smashed" radial head fractures in young patients.

84. Upper Extremity Injuries in Motor Vehicle Crashes Involving Partial Ejection; an Analysis of 20 years of NASS-CDS Data

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Introduction: Partial ejection remains a significant problem in motor vehicle collisions (MVCs). Upper extremity ejection can lead to severe injuries, but literature is limited to small case series. This study examines the occurrence, crash characteristics, and efficacy of restraint systems in partial ejections and upper extremity injuries in MVCs, and describes the relationship between upper extremity injuries and partial ejection. We hypothesize that partial ejection increases risk of upper extremity injury, especially severe soft tissue injuries, and is significantly associated with rollover.

Materials and Methods: Weighted data from the National Automotive Sampling System Crashworthiness Data System (NASS CDS) from 1993-2012 were used. The study population included belted outboard occupants in four-wheeled passenger vehicles, aged 14 and older. Upper extremity injuries were identified and characterized using Abbreviated Injury Score definitions. Descriptive and comparative statistics were employed in analysis, and logistic regression modeling was used to assess the relationship between partial ejection and side-curtain airbags.

Results (all figures are weighted estimates): Upper extremity injuries were the third most common injury in MVCs, with 920,000 from 1993-2012. There were 100,000 belted partial ejections. Partial ejection increased risk of upper extremity injury five-fold. The majority of severe soft tissue injuries were associated with partial ejection (61%) and rollover (67%, p < 0.0001). 63% of partial ejections occurred in rollover MVCs. Light truck vehicles had the highest rates of partial ejection (3.6%), but SUVs had the highest rate of upper extremity injury in partial ejection (59%). Logistic regression revealed an odds ratio (OR) of 3.9 (95% CI = 2.1 - 7.4) for partial ejection in vehicles without side-curtain airbags (SABs) compared to those with side-curtain airbags. The odds increased significantly with increasing deltaV (OR = 12.1; CI = 1.2 - 119.9 for deltaV > 30kph). Regression did not reveal a significant difference in upper extremity injuries with SABs (OR = 1.34; CI = 0.81 - 2.23). No severe soft tissue injuries occurred when SABs deployed. Window status (up or down) was not associated with partial ejection or upper extremity injury.

Conclusions: Upper extremity injuries represent a considerable portion of the trauma burden of MVCs. Partial ejection is associated with a five-fold increase in upper extremity injuries, and most severe soft tissue injuries occur in partial ejection during rollovers. Side-curtain airbags significantly reduce the risk of partial ejection, especially with increasing deltaV.

85. Simultaneous Bilateral Pollicization is Effective and Efficient

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Introduction: In patients with bilateral deformities of the hand indicating index finger pollicization on both sides, the surgeon must decide whether to perform the procedures simultaneously during one operation or separately in a staged fashion. No evidence-based guidelines exist in the literature regarding the advantages and disadvantages of simultaneous vs. staged pollicization. The purpose of our study was to compare functional outcomes of bilateral pollicization to those of unilateral pollicization and to evaluate relevant concerns including patient safety, family satisfaction, and cost-efficiency.

Methods and Materials: A retrospective chart review was performed to identify all patients who underwent index finger pollicization on one or both hands by a single surgeon at one institution between 1995 and 2012. Forty seven patients were identified, and of these patients, 24 agreed to return to the clinic for evaluation: 7 patients who underwent simultaneous bilateral pollicization (14 hands), 2 patients who underwent staged bilateral pollicization (4 hands), and 8 patients who underwent unilateral pollicization (8 hands). Functional assessments were carried out by a single occupational therapist and included the Humphry-Jewell assay, *Child Health Assessment Questionnaire*, pinch strength, grip strength, visual analog scales, and patient and parent satisfaction scores. Surgical data were obtained from charts, and cost data were obtained from hospital records. The results of simultaneous bilateral and unilateral pollicization were compared. Significance was determined by student's T-test.

Results: Average time between surgery and functional assessment was 4 years (ranging from 10 months to 9 years). There were no significant differences in functional outcomes between the simultaneous and unilateral groups in any domain (P=0.472). Average surgical time was 352 minutes and 175 minutes for the bilateral and unilateral groups, respectively. Average tourniquet time for each hand was 107 minutes and 111 minutes for the bilateral and unilateral groups, respectively (P= 0.752). There were no surgical complications in either group. Simultaneous bilateral pollicization was significantly less costly for the hospital than staged pollicization.

Conclusions: Simultaneous bilateral pollicization had equivalent functional outcomes when compared to unilateral pollicization. From a safety perspective, simultaneous surgery offers the advantage of a single anesthetic exposure. Additionally, simultaneous bilateral pollicization is more cost-efficient than staged pollicization and involves decreased total recovery time with a single rehabilitative period. For these reasons, we feel simultaneous bilateral pollicization is a safe and successful procedure and should be strongly considered as an option for patients with bilateral indications.

86. Anatomy and Natural History of the Elbow Joint in Obstetric Brachial Plexus Injuries

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Purpose: To date, there is a paucity of information within the published literature on the radiographic anatomy of the elbow, its long-term progressive changes and its relationship to elbow flexion contracture in patients with obstetric brachial plexus injuries (OBPI). The purpose of this study is to evaluate the radiographic anatomy of the elbow and its relation to elbow flexion contracture in patients with OBPI, as well as the natural history of the progressive radiographic changes of the elbow.

Methods: We examined all patients at our institution with OBPI who had radiographic evaluation of the elbow for a history of elbow flexion contracture. All patients had to have a recent radiograph as we aimed to determine whether bony abnormalities were underlying flexion contractures in OBPI patients. Radiographic evaluation was performed to determine the presence of bony abnormalities of the elbow and the presence of progressive arthritic changes over time. In addition, a detailed medical review was performed focusing on elbow range of motion and function, and past surgical interventions for elbow contracture.

Results: We identified 59 patients who fit our inclusion criteria. There were 35 (59%) females, with 33 (55%) of the injuries involving the right extremity. Every patient used their un-injured extremity as their dominant extremity. At an average clinical follow-up of 24 years (8-75), the average elbow range of motion was 32°-122° (total arc of 90°). All patients were treated with therapy and splinting for their elbow flexion contracture at some point in their lives, while 12 patients underwent attempt at surgical release. Although 62% of patients reported pain in their affected extremities, only 7% patients localized the pain to their elbow. Three patients had pathologies involving their ipsilateral elbows, including 2 radial head dislocations and 1 patient with ulnar nerve compression at the elbow. At an average follow-up of 16.5 (4-75) years, only 3 (5%) patients had radiographic evidence of moderate or severe elbow arthritis. 2 of these patients had congenital anterior radial head dislocations, while the other patient had an 85° flexion contracture and progressive elbow arthritis.

Summary Points: Patients with OBPI experience a high rate of flexion contractures. However, only 5% of patients with flexion contractures develop arthritis. This study adds an important to consideration for surgeons as they evaluate the need for bony procedures when treating flexion contractures for patients with OBPI.

87. Appropriateness and Adequacy of Splints Applied for Pediatric Fractures in an Emergency Department/Urgent Care Environment

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Introduction: Upper extremity fractures are common in pediatric patients, with emergency room physicians or mid-level practitioners performing most evaluations. These injuries are typically splinted. However, correct splinting techniques are necessary to prevent potential complications. Iatrogenic injuries from are a potential public health and legal problem that can lead to fracture malalignment, as well as severe complications. The purpose of this study was to evaluate all patients who presented in a splint to a pediatric orthopaedic practice, in order to assess both splint adequacy, and iatrogenic complications from improper application.

Materials and Methods: Consenting patients aged 0 to 18 years who presented to the pediatric orthopaedic clinic with a splint in place were prospectively enrolled. A total of 205 patients who had a mean age of 9 years (range, 0 to 18 years) were enrolled. A questionnaire was administered to either the patient or their accompanying parent to obtain information regarding demographics, type of splint, type of facility where the splint was applied, type of practitioner that placed the splint, and the amount of time from splint application until orthopaedic evaluation. Photographs were taken of each splint prior to removal, and the extremity was examined for any soft tissue complications. Two blinded members of the pediatric orthopaedic team evaluated the splint for functional position, length, and elastic bandage position. Splints were not removed in 31 patients who had undergone fracture reduction.

Results: Upper extremity slints were improperly placed in 93% (190/205) of cases, with improper joint immobilization in 51% (104/205) of cases. The splint length was inappropriate in 57% (117/205). The elastic bandage was applied directly to skin in 83% (170/205), with excessive distal edema present in 21% (36/170). Soft-tissue complications were observed in 35% (61/174) of patients who had their splint removed. Pressure points were observed on the skin in 16% (27/174) of patients, whereas pressure points overlying bony prominences were seen in 1% (2/174) of cases. Direct injury to the skin and soft tissue was seen in 4% (7/174) of patients.

Conclusion: Many practitioners in pediatric emergency departments and urgent care centers incorrectly apply splints. Factors contributing to iatrogenic injuries include an inadequate padding leading to excessive pressure, application of elastic bandage directly to the skin, inadequate fracture immobilization, and inappropriate splint length. Complications from poor splint placement include swelling, skin breakdown, and poor bone healing. Healthcare workers who treat pediatric fractures may benefit from more extensive education regarding proper splinting techniques.

88. Comparison of Ultrasound and MRI for the Diagnosis of Glenohumeral Dysplasia in Brachial Plexus Birth Palsy

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Hypothesis: Ultrasonography (US) for the diagnosis of humeral head subluxation and glenoid morphology will correlate with Magnetic resonance Imaging (MRI) findings in infants and toddlers with brachial plexus birth palsy (BPBP).

Methods: We performed a prospective investigation of 39 consecutive patients (14 male, 25 female) with BPBP at two separate institutions. All patients underwent both US and MRI for suspected glenohumeral dysplasia. The studies were obtained an average of 2 months apart (range 0 - 6 months). Patient age ranged from 6-53 months. Four blinded independent evaluators were given the entire US and MRI study of each patient and asked to perform measurements on the US and MRI for alpha-angle, percentage of humeral head displacement (PHHD), and glenoid version, as well as measurements only on the MRI for the percentage of humeral head anterior to the middle of the glenoid fossa (PHHA). Measurements were obtained on OsiriX software (Pixmeo Sarl).

Results: We found strong inter-rater reliability for alpha-angle on MRI, glenoid version on MRI, and alpha-angle on US (intra-class correlation coefficient, 0.83, 0.75, 0.78). Inter-rater reliability for PHHD on MRI and US was fair (0.70, 0.68), and inter-rater reliability for glenoid version on US and PHHA on MRI was poor (0.30, 0.57). A Bland- Altman analysis was used to evaluate measurement agreement between MRI and US in respect to each parameter. US was found to underestimate alpha angle and glenoid version by an average of 13 ± 23 degrees and 6 ± 17 degrees respectively. US was found to overestimate PHHD by 4 ± 12 degrees. There was a high degree of variability between measurements performed on MRI and US, which persisted despite modifications in measuring technique by the most senior author. This variability was maintained throughout all degrees of dysplasia.

Summary: We found both US and MRI measurements to be reliable and internally consistent. However, the poor correlation between MRI and US calls into question the validity of using US as a stand-alone examination for glenohumeral dysplasia in children with BPBP. To the author's knowledge, this is the first study to investigate the interrater reliability of ultrasound measurements in children over 1yr old and children with significant glenoid remodeling (Water's Type IV-V). Cartilage sensitive techniques on MRI remain the gold standard to fully evaluate the glenohumeral joint. The role of US may be as a screening tool for specific patient populations (Water's type VI) or as a way of evaluating glenohumeral joint reduction in real-time.

89. Epidemiologic Dynamics Contributing to U.S. Pediatric Wrist Fractures

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Introduction: In childhood, trauma to the distal upper extremity is frequent, and pediatric wrist fractures are commonly seen in the emergency department (ED). The purpose of this study was to explore and evaluate national epidemiologic trends and factors contributing to wrist fractures in children.

Methods: Over a 16-year period from January 1998 to December 2013, patients aged 0-17 years old with primary diagnosis of wrist fracture were identified and reviewed, as evaluated in U.S. EDs and chronicled by the National Electronic Injury Surveillance System (NEISS) database of the U.S. Consumer Product Safety Commission. Descriptive epidemiologic, bivariate, and chi-square analyses were conducted. Patients were categorized into age-defined subgroups (0-12 mo, 13-36 mo, 3-5 yrs, 6-10 yrs, and 11-17 yrs) and further stratified with regards to gender, race, location, and consumer product/activity associated with injury.

Results: There were 53,265 children evaluated in NEISS EDs (national estimate, 1,908,904) with wrist fractures from 1998-2013. Mean age was 10.9 (SD 3.8) years, with 64% male and 36% female. Most common locations of injury were place of recreation or sports (28%), home (23%), and school (13%). The top five consumer-product related injuries were associated with bicycles (10%), football (8%), playground activities (8%), basketball (6%), and soccer (5%). The highest associations were with beds or bedframes (19% of 0-12 mo), stairs or steps (14% of 13-36 mo), playgrounds (25% of 3-5 yrs and 15% of 6-10 yrs), and football (14% of 11-17 yrs). The greatest increase in fractures occurred between ages 0-12 and 13-36 months (1:3.8), with second-largest increase between ages 3-5 and 6-10 (1:2.2). There was a disproportionately higher number of females sustaining fractures in all groups under age 11, with increased males in the 11-17 group (18%, p<0.05).

Conclusions: It is essential to develop injury prevention and safety strategies as well as identify individual risk factors for fracture, including activity, gender, and key age transitions. Surveillance is imperative to advance our understanding of the epidemiologic basis for pediatric wrist fractures, and in the future may facilitate development of research prediction tools to anticipate or prevent injury.

Graphs:



90. Atypical Mycobacterial Infections of the Upper Extremity: Becoming More Atypical?

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Background: Atypical mycobacterial infections of the upper extremity are relatively uncommon, yet cause chronic indolent symptoms that frequently defy prompt clinical and laboratory diagnosis with consequent prolongation of disability for patients. Our institution on the Gulf Coast has successfully diagnosed and treated an increasing number of these infections, noting new uncommon patterns of infection with more aggressive mycobacterial strains. The purpose of this study is to review our experience with upper extremity atypical mycobacterial infections and verify the developing trends we are encountering in our patient population.

Methods: An IRB-approved retrospective chart review was performed at our institution for patients with positive non-tuberculous mycobacterial cultures of the hand, forearm, or elbow from 2000-2013. Patient demographics, source of transmission, symptom duration before diagnosis, mycobacterial strain, operative interventions, antibiotic treatments, and outcomes were recorded.

Results: We identified 33 patients with a mean age of 50 years (9-71years) that were equally distributed by gender. The mean symptomatic period before diagnosis was 9 months (1-60 months) and mean follow-up was 9 months (1-48 months). Forty-two percent had identifiable causes of immune dysfunction including solid organ transplants (heart, lung, liver), uncontrolled diabetes, HIV, rheumatoid arthritis, lupus, and asplenia. Fifty-eight percent appeared immunocompetent. Only 10 % were smokers.

Patients were infected most frequently by M. marinum (42%), M. abscessus (24%), M. fortuitum (21%), and other less common strains. Although only 12% of patients had a marine-related source of transmission, 75% of these grew M. marinum. Most patients had non-marine causes including lacerations, insect bites, animal bites, and tattoos as well as unidentifiable sources.

All patients required incision and drainage (100%), flexor/extensor tenosynovectomy (18%), or carpal decompression (6%). Clarithromycin was the most commonly used antibiotic for an average duration of 5 months. One symptom-free patient with myeloma remains on treatment indefinitely. Ninety-seven percent had complete resolution of disease. One patient died of unrelated causes.

Conclusion: Atypical mycobacterial infections have an indolent course that may be difficult to diagnose. Marine-related injury mechanisms may heighten clinical suspicion however the majority of infections in this study are not marine-related. While M. marinum remains the most prevalent strain, an increasing number of infections are from rapidly progressive M. abscessus and M. fortuitum, which may require earlier operative intervention and more prolonged courses of antibiotics. Atypical mycobacterial infections affect both immunocompromised as well as seemingly healthy individuals. Good outcomes are possible with accurate diagnosis and appropriate management.

91. Risk Factors Associated with Emerging Clindamycin Resistant MRSA in Hand Infections

Rick Tosti, MD; Asif Ilyas, MD Orthopaedics, Rothman Institute at Thomas Jefferson University Hospital, Philadelphia, PA

Purpose: Methicillin Resistant Staphylococcus Aureus (MRSA) is the most common pathogen identified in hand infections at urban centers. A number of oral agents including clindamycin are routinely utilized for empiric antibiotic management. However, concurrent clindamycin resistance in MRSA hand infections has also recently been reported to be on the rise. The purpose of this study was to identify risk factors for clindamycin resistance in acute hand abscesses caused by MRSA.

Methods: A retrospective review of 247 consecutive culture-positive hand abscesses from 2010-2012 was performed at an urban hospital. Demographic and laboratory data from patients with abscesses that grew MRSA with and without clindamycin resistance were compared in a multivariate analysis.

Results: MRSA grew on culture from 103 abscesses with a total incidence of 42%. Among these MRSA infections, 16% were resistant to clindamycin. Multivariate analysis showed that intravenous drug use (P=0.002) and nosocomial-acquired MRSA (P=0.04) were significant risk factors for concurrent clindamycin resistance. Patients with a history of intravenous drug use and nosocomial-acquired MRSA were respectively 8.4 and 3.6 times more likely to have concurrent clindamycin resistance. History of immunosuppression, prior history of MRSA, and human immunodeficiency virus were not identified as risk factors.

Conclusion: Patients with a history of intravenous drug use or recent contact with health-care facilities appear to be a reservoir for clindamycin resistant MRSA. When selecting empiric antibiotics for treatment of a hand abscess, clindamycin should be prescribed with caution in these groups.

92. New Resistant Strains of MRSA: Risk Factors Associated with Clindamycin-resistant MRSA in Hand Infections

Rick Tosti, MD; Asif Ilyas, MD Orthopaedics, Rothman Institute at Thomas Jefferson University Hospital, Philadelphia, PA

Purpose: Methicillin Resistant Staphylococcus Aureus (MRSA) is the most common pathogen identified in hand infections at urban centers. A number of oral agents including clindamycin are routinely utilized for empiric antibiotic management. However, new clindamycin-resistant strains of MRSA in hand infections has recently been reported to be on the rise. The purpose of this study was to identify risk factors for clindamycin resistance in acute hand abscesses caused by MRSA.

Methods: A retrospective review of 247 consecutive culture-positive hand abscesses over a consecutive three year period (2010-2012) was performed at an urban hospital. Demographic and laboratory data from patients with abscesses that grew MRSA with and without clindamycin resistance were compared in a multivariate analysis.

Results: MRSA grew on culture from 103 abscesses with a total incidence of 42%. Among these MRSA infections, 16% were clindamycin-resistant. Multivariate analysis showed that intravenous drug use (P=0.002) and nosocomial-acquired MRSA (P=0.04) were significant risk factors for concurrent clindamycin resistance. Patients with a history of intravenous drug use and nosocomial-acquired MRSA were respectively 8.4 and 3.6 times more likely to have concurrent clindamycin resistance. History of immunosuppression, prior history of MRSA, and human immunodeficiency virus were not identified as risk factors.

Conclusion: Patients with a history of intravenous drug use or recent contact with health-care facilities appear to be a reservoir for clindamycin-resistant MRSA. When selecting empiric antibiotics for treatment of a hand abscess, clindamycin should be prescribed with caution in these groups.

93. Predictors of Admission for Patients Who Present With Hand Cellulitis to the Emergency Department: A 13year Retrospective Review

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Purpose: To identify the variables associated with patient admission and discharge after presenting to the Emergency Department (ED) with hand cellulitis and to analyze factors associated with re-admission after failure of conservative treatment.

Patients and Methods: This is a 13-year retrospective review of patients who were diagnosed with hand cellulitis in the ED at the University Hospital of the Albert Einstein College of Medicine, Bronx, New York between 2000 and 2013. Patients were subdivided into three groups: 1. Patients discharged from the ED with oral antibiotic treatment (conservative); 2. Patients admitted for IV antibiotic treatment; 3. Patients who returned to the ER due to failure of conservative treatment. Using the Clinical Looking Glass system sociodemographics including sex, race-ethnicity, alcohol and intravenous drug use were recorded. Comorbidities such as congestive heart failure (CHF), diabetes mellitus (DM), HIV/AIDS, renal disease, liver disease, chronic obstructive pulmonary disease (COPD) were also analyzed. Laboratory findings such as white blood count (WBC) was also recorded. Univariate and multivariate analysis was performed in order to find a correlation between these variables and final outcomes.

Results: In a 13 year period, a total of 1543 patients were diagnosed with hand cellulitis. 560 patients were discharged and 983 patients were admitted. Of those discharged 268 (47.9%) were female and 292 (52.1%) were male. 546 of the 983 patients admitted were male. Univariate analysis showed that alcohol abuse (p=0.016) and IV drug abuse (p<0.001) were more common in patients who were admitted. HTN (p<0.001), DM (p<0.001), CHF (p0.001), COPD (p<0.001), liver failure (p<0.001) and elevated WBC (p0.001) were associated with admission. However, AIDS/HIV (p=0.107), and renal failure were not. Multivariate analysis showed that HTN (AOR: 1.837), rheumatologic disease (AOR: 2.666), coagulopathy (AOR: 2.714), IV drug abuse (AOR:8.756), DM (AOR:1.576) and elevated WBC (AOR:1.116) showed a significant correlation with admission for IV antibiotic treatment. Among the patients who were discharged (n=560), 113 (20.1%) returned to the ED. Significant variables associated with this group were: COPD (p=0.039) and IV drug abuse (p=0.035).

Conclusions: Hand cellulitis is one of the most common reasons for consultation in the emergency room for plastic surgeons. Clinical diagnosis is the gold standard for evaluation. This 13 year retrospective review shows that patients with multiple comorbidities should be evaluated more carefully before discharge. Risk factor identification, prompt evaluation and treatment and appropriate disposition should lead to improved outcomes, minimal resource utilization and reduced ED length of stay.

94. Pointing a Finger at Hospital Volume: Analysis of Digital Replantation Outcomes Using a National Database Patrick L. Reavey, MD, MS; Horatiu Muresan, MD; Marc Soares, MD; Vishal Thanik, MD Institute of Reconstructive Plastic Surgery, New York University Medical Center, New York, NY

Introduction: It has been argued that surgeons and hospitals with higher operative volume have improved outcomes in digital replantation. However, this relationship has not been specifically demonstrated. An analysis of a large, national database was performed to investigate the relationship of hospital volume to the success of finger and thumb replantation.

Materials & Methods: The National Inpatient Sample (NIS) of the Healthcare Utilization Project was queried to identify all patients that underwent a finger or thumb replantation from 2000-2010. Two authors (PR, HM) independently analyzed diagnosis and procedure code data for each patient to determine relevant peri-operative details as well as the success or failure of any replantation or revascularization. Hospital volume was a priori categorized into high (>10 cases per year), medium (5-10 cases), and low (<5 cases). The success or failure of replantation was analyzed on a per-finger basis across multiple patient-specific and hospital specific variables using R (Mac v.2.15.0, 2012).

Results: Over this 11-year period, the NIS recorded 2602 patients with 3049 digital replantations, performed at 556 unique hospitals. 510 (92%) of these hospitals are low volume, 26 (4.5%) medium volume, and 20 (3.5%) are high volume. 60% of hospitals performed an average of only 1 replantation per year. Collectively, low volume hospitals performed 43% of all operations. High and medium volume hospitals are more likely to be metropolitan (p=0.057), teaching hospitals (p<0.0001) relative to low volume hospitals.

After elimination of patients with inadequate data, 1944 patients with 2524 replantations and revascularizations were identified for analysis. The overall success rate for a reattached digit was 70.8%. Increased hospital volume was significantly associated with a better success of replantation – high 82%, medium 74%, and low volume 61% success, p<0.0001. High volume hospitals were more likely to operate on multiple digit injuries (54% vs. 43%, p<0.0001) and perform multiple replantations and revascularizations at the time of operation (46% vs. 35%, p<0.0001) relative to low volume hospitals.

Conclusions: The paper is the first to demonstrate that high-volume hospitals have improved outcomes in digital replantation. However, the majority of hospitals performing replantation procedures perform only one per year. This is likely due, in part, to disparities in the geographic distribution of high volume centers. Given the high patient and system cost associated with digital replantation, organization of resources in regional centers of excellence should be considered to optimize outcomes and care for patients.

95. Comparisons of Patient Smoking Status and Functional Recovery Following Peripheral Nerve Repair with Processed Nerve Allograft

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Introduction: Exposure to cigarette smoke has been associated to negatively impact recovery, as it constricts blood vessels supplying nutrients to damaged peripheral nerves inhibiting the regeneration process. In 2008, a national registry (RANGER[®]) was initiated to collect data on the use of processed nerve allograft (PNA), Avance[®] Nerve Graft, AxoGen, Inc. The resultant database allows for the analysis of patient populations, nerve injury epidemiology, and outcomes of processed nerve allografts. Here we report our findings from a subgroup analysis of patient smoking status and functional recovery following peripheral nerve repair with processed nerve allograft.

Materials & Methods: The registry database was queried for repairs with quantitative outcomes data from subjects reporting smoking status and medical history. This dataset was grouped into "Smokers" defined as subjects reporting a history of smoking and "Non-smokers" defined as healthy subjects reporting no history of smoking. Demographics and outcomes analysis were performed. Meaningful recovery was defined by the MRCC scale at S3/M3 or greater for sensory and motor function. Comparisons were made between the groups and historical data published in the literature.

Results: There were 70 subjects with 92 repairs reporting sufficient history and quantitative follow-up data. There were 25 subjects with 32 repairs in the "Smoking" group and 45 subjects with 60 repairs in the "Non-smoking group". Demographics were comparable between the two groups. Meaningful recovery for the total population was 86% with 81% and 90% reported in the "Smokers" and "Non-Smokers" groups respectively. See Table 1 for demographics and outcomes. A statistically significant difference was found between the groups for moving two-point discrimination (2PD), with greater recovery in the Non-Smoking group, (p<0.05). There were no reported adverse events.

Conclusion: Processed nerve allograft demonstrated meaningful recovery across both populations. While levels of meaningful recovery were comparable between the groups, a statistical difference was reported in moving 2PD, with greater recovery in the Non-Smoking group. These outcomes compare favorably to historical data in the literature for nerve autograft and exceed that of nerve tube conduit. Outcomes from this analysis provide further evidence that suggest smoking may contribute to decreased functional recovery. Data from this study should be considered when designing future studies. The RANGER[®] registry remains ongoing and additional clinical data collection will allow for further comparisons of these populations.

Table 1: Summary of Subject Demographics and Outcomes by Smoking Status				
	Subjects with History of Smoking	Subjects with No History of Smoking		
No. of Subjects	25	45		
No. of Repairs	32	60		
	Sensory: 24	Sensory: 48		
	Mixed: 6	Mixed: 10		
Nerve Type	Motor: 1	Motor: 2		
Average Age (years)	43 <u>+</u> 16 (18, 77)	36 <u>+</u> 14 (18, 70)		
Average Gap Length (mm)	21 <u>+</u> 12 (8, 50)	21 <u>+</u> 14 (5, 65)		
Median Time to Repair (days)	3 (0, 463)	6 (0, 2555)		
Average Follow-up	11 months	11 months		
Static 2PD	9+3 (4,15)	8+3 (2,15)		
Moving 2PD	10+4 (4-15) *	6+2 (2-10) *		
Meaningful Recovery	81%	90%		
* Statistically significant difference p<0.05				

96. Is Specialist Outpatient Follow-Up for Carpal Tunnel Decompression Necessary - A Patient Satisfaction Survey Piyush Mahapatra, MA, MB, BS, MRCS¹; Edmund Ieong, BSc, MB, BS, MRCS²; Harry Belcher, MS, FRCS³; Satish Babu BSc, MBBS, MRCS⁴

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Introduction: There is no consensus as to what is the optimum follow up period for carpal tunnel. This study aims to identify an optimum follow up regimen.

Materials & Methods: 2 follow up regimens were instigated: ad-hoc (no routine follow up) vs planned (routine follow up). Questionnaires were sent out to patients 4 months post operatively. The following subjective parameters were recorded: Details of Follow up, Complications, Satisfaction (with surgery and service), Functional Score, Pain and Tenderness, Appearance.

Results: 58 questionnaires (40 ad-hoc vs 18 planned) were sent. No significant differences found in complication rates or patient questionnaire results (Table 1).

	Ad Hoc	Planned	p values
			(Mann-Whitney U)
Number of Responses	36	14	
Age	64.1	55.8	0.118
Functional Score	1.75	1.79	0.873
Pain Score	1.97	1.79	0.344
Appearance Score	1.25	1.5	0.085
Composite Outcome	4.97	5.14	0.792
Surgery Satisfaction Score	1.39	1.36	0.663
Service Satisfaction Score	1.11	1.36	0.2
Composite Satisfaction	2.5	2.7	0.718

Table 1. Patient Survey Results (All values answers ranked 1-4 with 1 being the best result)

33% of patients in the ad hoc group arranged follow up themselves, 50% of that group seeing their GP with minor complications. However, 97% of all patients were happy to have been discharged post operatively without routine follow up.

Conclusions: With these findings, we propose a system of open appointments to empower patients post carpal tunnel decompression to arrange their own follow-up, on an ad-hoc basis. The obvious advantages include reduced waiting times, less pressure on hospital resources and lower costs.

97. Doctor-patient Visit Versus Internet Directive for Carpal Tunnel Syndrome Patients

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Introduction: 62% of patients would like their doctor to recommend a specific website to find health information, but only 3% of patients receive such recommendations. We investigate whether providing patients with an internet website link would improve patient knowledge and satisfaction. Our hypothesis is that directing patients to a reliable website would improve both.

Material & Methods: 60 patients with a new diagnosis of carpal tunnel syndrome (CTS) were prospectively randomized into two groups (Figure 1). 23 patients in the control group received a traditional doctor's visit with standard care for CTS. 37 patients in the handout group were directed to the ASSH webpage on CTS in addition to the doctor's visit. Patients later completed a 10-question true/false knowledge questionnaire and a 6-item satisfaction survey. Differences in scores were analyzed using two sample t-tests.

Results: Less than half of patients (48%) said they used the internet to learn more about CTS. Scores on the knowledge assessment (treatment: 6.84/10; control: 6.96/10), and the satisfaction survey (treatment: 4.64/5; control: 4.63/5) were similar for both groups (Figures 2 and 3). Patients who used the ASSH website scored similarly in knowledge to those who did not (ASSH: 6.89/10; non-ASSH: 6.97/10). Moreover, compared to patients who did not use the internet at all to learn about CTS, patients who used the internet scored 6.6% better (internet: 7.14/10; no internet: 6.70/10. p>.05). Regardless of internet usage, most patients scored well on knowledge and reported high satisfaction.

Conclusion: Whether the patient was given a handout, visited the ASSH or other internet websites, knowledge and satisfaction scores for all patients were similar. Since the physician was the common denominator in all the patient groups, results indicate that the patient-physician relationship may be more valuable to patient education than the internet. If the surgeon provides an internet link, then close to half of the patients will use it. Within those who use the physician-recommended website, 83% will actively seek knowledge using other internet sources.



Question	Overall	Treatment	Control	ASSH	Non-ASSH	Internet	Non-Internet
Explanations about the problem or condition	4.58	4.58	4.61	4.67	4.54	4.69	4.44
Concern for the patient's questions or worries	4.50	4.50	4.39	4.72	4.39	4.72	4.30
Efforts to include patients in the decisions about his/her treatment	4.52	4.52	4.48	4.61	4.45	4.59	4.41
Amount of time spent with the patient	4.27	4.27	4.30	4.39	4.20	4.41	4.15
Confidence as a care provider	4.65	4.65	4.61	4.94	4.51	4.90	4.37
Instructions given to the patient about caring for himself herself at home	4.28	4.28	4.18	4.47	4.18	4.32	4.16
Total patient satisfaction score	4.47	4,47	4.43	4.64	4.38	4.61	4.31
Figure 3. Patient Satisfaction Scores This table lists the average scores reported by study participants on a 5-point Likert scale for each of the six components of patient satisfaction. The six questions shown are verbatim from the actual survey read and responded to by all study participants.							

98. Positional Tension of the Ulnar Nerve After Decompression Procedures

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Introduction: The elbow is the most common site of ulnar nerve compression, likely due to the superficial location and inherent compressive anatomy of the ulnar nerve. While biomechanical studies have analyzed the effect of strain on nerve conduction, few have applied these principles to the various techniques of ulnar nerve decompression. The purpose of this study is to determine the amount of strain on the ulnar nerve in full flexion and extension of the elbow and determine if tension in full extension is increased after anterior transposition of the nerve.

Methods: Fifteen fresh cadaver upper extremities with intact shoulder girdles were tested. A differential variable reluctance transducer (DVRT) was placed in the ulnar nerve just proximal to the medial epicondyle and the distance between the mounting pins was measured and used as the initial gauge length. The strain was measured in full elbow flexion and extension. An in situ release, a sub-cutaneous transposition, and a submuscular transposition were performed sequentially with the strain being measured after each procedure in the full elbow flexion and extension positions. The strain was then averaged and compared for each procedure. A one-way analysis of variance was used to determine if any observed differences were significant ($p \le 0.05$).

Results: After the in situ release there was no statistically significant change in strain compared with the strain before the release in either flexion or extension (p=0.302). With a subcutaneous transposition there was a statistically significant decrease in strain in full elbow flexion (p=0.048) but not in extension. Similarly with a submuscular transposition there was a statistically significant decrease in strain in full flexion (p=<0.0005) but not in extension. There was not a statistically significant change in strain with medial epicondylectomy (p=0.051).

Conclusion: An in-situ release of the ulnar nerve at the elbow may relieve pressure on the nerve but does not address the problem of strain which may be the underlying pathology in many cases of cubital tunnel syndrome. Transposition of the ulnar nerve anterior to the medial epicondyle, as part of a subcutaneous or a submuscular transposition, does address the problem of pressure and strain on the ulnar nerve. In addition it does not create increased strain on the ulnar nerve with elbow extension.

99. Incidence of Ulnar Nerve Instability in Patients Considered for in Situ Ulnar Nerve Decompression Jonas Matzon, MD; Kevin Lutsky; C. Edward Hoffler, MD, PhD; Nayoung Kim, BS; Pedro Beredjiklian, MD *Orthopaedics, Rothman Institute at Thomas Jefferson University Hospital, Philadelphia, PA*

Introduction: The incidence of ulnar nerve instability in patients considered for in situ ulnar nerve decompression is unknown, and pre-operative risk factors for ulnar nerve instability necessitating transposition have yet to be identified. We hypothesized that a relatively high percentage of patients considered for in situ ulnar nerve decompression will require transposition secondary to ulnar nerve instability.

Methods: Using our surgical database, we retrospectively identified all patients undergoing surgical treatment of cubital tunnel syndrome by three surgeons over a five-year period. We included all patients who were candidates for in situ ulnar nerve decompression. Patients requiring ulnar transposition due to revision surgery, elbow arthritis, or elbow contracture were excluded. Three hundred sixty three patients met inclusion criteria. We collected demographic data including age, weight, height, and body mass index (BMI). Patients with pre-operative radiographs had measurements of ulnar groove and medial epicondyle morphology. We recorded the number of patients who underwent ulnar nerve transposition due to ulnar nerve instability, and we evaluated whether ulnar nerve instability was diagnosed pre-operatively, intra-operatively following decompression, or post-operatively. We performed unpaired t-tests to assess statistical differences between patients undergoing decompression and patients requiring transposition.

Results: Of the 363 patients who were considered for in situ ulnar nerve decompression, 76 patients (21%) required ulnar nerve transposition secondary to ulnar nerve instability. Twenty-nine patients (8%) were diagnosed with instability preoperatively, while 44 patients (12%) were identified with instability intra-operatively following in situ decompression. Three patients (1%) were not diagnosed with instability until post-operatively and subsequently underwent delayed transposition. Patients who required transposition due to instability were significantly younger (p<0.0002), taller (p<0.03), and had a lower BMI (p<0.05) than patients without instability. For those patients with pre-operative radiographs, height and width of the ulnar groove and slope of the inferior aspect of the medial epicondyle did not correlate with the need for transposition.

Conclusion: In situ ulnar nerve decompression is an acceptable treatment for cubital tunnel syndrome, but a relatively high percentage of patients will require transposition secondary to ulnar nerve instability. While patient age, height, and BMI correlate with the need for ulnar nerve transposition, further research is necessary to determine which patients are at greatest risk for ulnar nerve instability following decompression. Meticulous pre-operative evaluation for ulnar nerve instability is recommended to aid in appropriate patient counseling and surgical scheduling.

100. Prospective Evaluation of Sensitivity and Specificity of CTS-6 for Diagnosis of Carpal Tunnel Syndrome Brian H. Gander, MD; John R. Fowler, MD

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Introduction: Carpal tunnel syndrome (CTS) is a compressive neuropathy and accounts for 90% of all cases of compressive neuropathy. Current AAOS Clinical Practice Guidelines give a Grade of Recommendation B to the use of electrodiagnostic studies in the setting of positive clinical or proactive. Graham et. al published a clinical diagnostic criteria for CTS where he found six clinical criteria that were statistically significant in the probability of diagnosing CTS. Subsequently, Graham demonstrated that electrodiagnostic studies do not change the likelihood of diagnosing CTS secondary to the high probability that can be estimated with CTS-6. Our prospective study aims define the diagnostic validity of CTS-6 when compared to the reference standard of electrodiagnostic testing.

Methods: Eighty-five consecutive patients over a three month period whom were referred for electrodiagnostic studies were prospectively enrolled into the study. A blinded, certified electrodiagnostic technician performed all electrodiagnostic testing. A distal motor latency > 4.2 ms or distal sensory latency > 3.2 ms was considered positive. A hand fellow, not involved in the electrodiagnostic examinations and trained to independently examine patients calculated the CTS-6 score. A score of 12 or greater was considered a positive diagnosis of CTS and less than 12 was negative. Sensitivity and specificity were calculated using electrodiagnostic testing as the reference standard.

Results: Fifty five of 85 patients tested positive for CTS with EMG/NCS and of those 49 tested positive for CTS using CTS-6. Thirty patients found not to have CTS based upon electrodiagnostic studies and 24 of those tested negative using CTS-6. The calculated sensitivity and specificity of CTS-6 was found to be 0.89 and 0.80 respectively.

Discussion: Current AAOS Guidelines give a strong recommendation to proceeding with electrodiagnostic studies in the setting of clinical finding as a confirmatory test. Graham devised a new clinical diagnostic test that challenges the routine of electrodiagnostic studies when diagnosing CTS. No prospective studies have evaluated the diagnostic validity of CTS-6 when compared to electrodiagnostic studies as the reference standard. In our study we found CTS-6 to have similar sensitivities and specificities to other confirmatory imaging tests. An accuracy of 86% for CTS-6 is respectable, but likely not high enough to suggest that CTS-6 can replace EMG/NCS. The relatively low specificity of 80% means that CTS-6 does not function as well as EMG/NCS as a good confirmatory test. The high sensitivity of 89% means that it is a relatively strong screening test.

101. Does Pre-Operative Electrodiagnostic Testing Predict Time to Resolution of Symptoms After Carpal Tunnel Release

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Background: Previous studies have found weak or no correlation between pre-operative electrodiagnostic (EDX) studies and functional and/or subjective outcomes after carpal tunnel release (CTR). However, these studies examined outcomes at 6 months or 1 year, potentially missing early differences in recovery. Our anecdotal experience found that patients with mild carpal tunnel syndrome recovered more quickly than those with severe carpal tunnel syndrome. The purpose of this study is to determine if EDX studies predict time to resolution of symptoms after CTR.

Methods: 61 consecutive patients undergoing open CTR were prospectively enrolled. Preoperative presence of nocturnal symptoms and daytime numbness/tingling were documented. Preoperative EDX studies were reviewed and classified as mild, moderate, or severe. After open CTR, patients were contacted by phone within 48 hours, at 1 week, and then at 2-week intervals for up to 9 months or until both nocturnal and daytime symptoms had resolved. Kaplan-Meir survival curves were constructed and compared using the Wilcoxon and log rank test.

Results: Daytime numbness and tingling in patients with mild carpal tunnel syndrome resolved in a median of 0.4 (95% IQR 0.4-1.4) weeks, moderate carpal tunnel syndrome in a median of 0.4 (95% IQR 0.4-1.4) weeks, and severe in a median of compared to 4.0 (IQR 0.4-24.0) weeks, p = 0.002. Nocturnal symptoms resolved in a median of 0.4 (IQR 0.4-1.4) weeks for patients with mild CTS, median of 0.4 (IQR 0.4-1.4) weeks for patients with moderate CTS, and median of 0.4 (IQR 0.4-0.4) weeks for patients with severe CTS, p=0.3. All symptoms resolved in a median of 0.4 (IQR 0.4-1.4) weeks in patients with mild CTS, 0.4 (IQR 0.4-1.4) weeks in moderate CTS, and 4.0 (IQR 0.4-24.0) weeks in patients with severe CTS, p=0.3.

Conclusion: Patients with mild or moderate CTS, based on preoperative EDX studies, experience a faster time to resolution of daytime numbness and tingling when compared to patients with severe CTS. Nocturnal symptoms resolved quickly in both groups. The results of this study are in contrast to previous studies that found little to no value of EDX in predicting postoperative functional and subjective outcomes, likely due to the early time points used in the current study. This is not mean to be an indication to obtain EDX, but could be used to counsel patients if obtained for other reasons.

102. Early Active Motion Versus Protective Splinting Following Open Carpal Tunnel Release Surgery

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Introduction: Splinting after open carpal tunnel release remains a controversial issue, with significant variability in practice among surgeons. We carried out a single blinded, randomized controlled trial to assess differences in outcome and complication rates between splinted and non-splinted patients following open carpal tunnel release.

Materials & Methods: One hundred and sixty-two patients undergoing open carpal tunnel release by a single surgeon using a standardized technique were prospectively randomized to Protective Splinting (77 patients, splinted two weeks post-operatively) or Early Active Motion (85 patients, no splinting). Visual Analog Pain Scale, Boston Carpal Tunnel Questionnaire (BCTQ), and the Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire were completed pre-operatively, and at two, six, and twelve weeks post-operatively. Daily range of motion activities were prescribed for all patients throughout the study. Complications (pillar pain, scar sensitivity, surgical site infection, bowstringing of flexor tendons) were recorded at each follow-up appointment. Duration until return to modified and full duties at work was also recorded. Statistical analysis was performed using a repeated measures analysis of variance for continuous variables between groups and Pearson Chi-Square for binary outcome complication data. Return to modified and full duties at work was assessed using a Student's t-test. Significance was set at a p < 0.05 for all comparisons.

Results: There were no significant differences in post-operative pain (p=0.973), Boston Carpal Tunnel symptom severity (p=0.828), functional severity scores (p=0.773), or DASH scores (p=0.642) between the Protective Splinting and Early Active Motion groups. In addition, there were no significant differences in the occurrence of pillar pain (p=0.930), infection (p=.104), wound dehiscence (p=0.882), or scar hypersensitivity (p=0.465) between groups. Bowstringing of the flexor tendons was not observed in any patients in either group. There were no difference in return to modified (p=0.199) and full (p=0.471) duties at work between Protective Splinting (21.1 and 32.7 days, respectively) and Early Active Motion (16.7 and 36.3 days, respectively) groups.

Conclusions: No significant differences were identified in the subjective or objective outcome measures between patients in the Protective Splinting group and the Early Active Motion group. In addition, there was no significant difference in complication rate or return to work times between the two groups of patients. This data further suggests that there is no benefit to immobilization post-operatively following open carpal tunnel release surgery but also suggests that there was no detrimental effect of splinting as has been show in some previous studies.

103. Ultrasound Evaluation of the Median Nerve After Carpal Tunnel Release

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Introduction: Carpal tunnel syndrome is the most common entrapment neuropathy of the upper extremity, affecting 5.8% of women and 0.6% of men. Nerve conduction studies have long been used in the diagnosis of this condition, although recent reports have advocated the use of high-resolution ultrasound as a useful non-invasive alternative. The purpose of this study is to determine if there are measureable changes in the ultrasound cross-sectional area (CSA) of the median nerve following carpal tunnel release in a previously studied patient cohort that had undergone preoperative median nerve CSA measurement.

Materials and methods: 65 patients underwent ultrasound CSA measurement of the median nerve in our office as part of a previous study. A retrospective review of the patient records identified 30 patients who ultimately underwent carpal tunnel release. These patients were contacted and invited to undergo repeat ultrasound of the median nerve and CSA measurement. 10 patients agreed to participate in this study, and a median nerve CSA measurement of the operated side was performed in 11 wrists.

Results: Average age of returning patients was 58 years (range) and 30% were male. None of the respondents were affected with diabetes. Mean CSA of the median nerve prior to carpal tunnel release was 11.8 mm2. Average CSA post-CTR was 9.5 mm2. Seven wrists had a decrease in the median nerve CSA measurement following CTR, and one patient had no change in the CSA measurement.

Conclusions: Ultrasound examination of the median nerve at the wrist has been shown in previous studies to have comparable specificity and sensitivity to nerve conduction studies for diagnosis of carpal tunnel syndrome. The current study demonstrates that the CSA of the median nerve decreases after CTR in the majority of patients, but does not return to normal values in most patients. Larger prospective studies are necessary to characterize the role musculoskeletal ultrasound may have in monitoring the median nerve following carpal tunnel release.

Figure 1 – Median Nerve measurements

Wrist	t	US CSA (mm2) -
#	US CSA (mm2)	POST CTR
1	16	18
2	7	7
3	16	7.6
4	10	10.3
5	10	7.6
6	10	8.3
7	10	9.3
8	8	8.6
9	14	9.3

10	13	11
11	16	8
Mean	11.8	9.5

104. Cost Effective Analysis of Simultaneous Versus Staged Bilateral Carpal Tunnel Release Paul Phillips, MD; James Kennedy, MD; Tara Lee, MPH Department of Plastic Surgery, University of Tennessee College of Medicine, Chattanooga, TN

Background: As healthcare in the United States continues to find more efficient and cost effective methods of treatment, physicians must evolve modalities and habit. Carpal tunnel syndrome is the most common compressive neuropathy with 56-87% of patients experiencing bilateral symptoms. Simultaneous bilateral carpal tunnel release has been proven to be both safe and effective. Our aim is to conduct a cost analysis of simultaneous versus staged bilateral carpal tunnel release through a retrospective chart review.

Hypothesis: We hypothesize simultaneous bilateral carpal tunnel release is more cost effective and time efficient for both patient and surgeon than staged bilateral carpal tunnel release.

Specific Aims: Analyze the cost of simultaneous bilateral carpal tunnel release and staged bilateral carpal tunnel release by evaluating: patient cost, work time lost, number of follow-up visits required, and physician fees.

Methods: Retrospective review of 198 patients who had bilateral carpal tunnel release performed between August 2009 and March 2014 by a single surgeon. Simultaneous versus staged procedures were compared with respect to billed charges, fees collected, days until return to work (with and without limitations), and the number of post-operative visits.

Results: 198 patients had bilateral carpal tunnel release performed between August 2009 and March 2014 by a single surgeon. Simultaneous versus staged procedures were compared with respect to patient charges, patient amount paid, days until return to work (with and without limitations), and the number of post-operative visits. Mean amount billed and total fees collected were both significantly reduced in the simultaneous versus the staged procedures (\$4,312.09 vs. \$4,364.46 and \$733.87 vs. \$1,003.43, p<0.05). Days returning to work (with and without limitations) were significantly reduced in the simultaneous procedures relative to the staged procedure (13 and 21 vs. 27 and 45 days respectively, p<0.001). The numbers of post-operative follow up visits were also reduced in the simultaneous procedure when compared to the staged procedure (1.45 vs 3.46 visits, p<0.001).

Conclusions: It is evident simultaneous bilateral carpal tunnel release is more efficient and cost-effective than bilateral staged release. Simultaneous release is beneficial for the patient in terms of work days missed and cost. The surgeon benefits from fewer postoperative office visits are necessary and the remuneration per hour is increased. Overall, simultaneous bilateral carpal tunnel release benefits patients and surgeons in terms of cost-effectiveness and time efficiency when compared to staged release of bilateral carpal tunnel syndrome.

105. PEG-fused Allografts Produce Rapid Behavioral Recovery AfterSegmental Nerve Loss

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Introduction: Every year in the United States approximately 360,000 people suffer from peripheral nerve injuries and roughly 12% of operations performed for traumatic neuropathy involve patients with segmental nerve loss. Of these operations less than 50% show meaningful recovery. Presently, the most dependable method of repair for such major deficiencies is autologous nerve grafts. Substitutes to nerve autografting are being pursued due to donor site morbidity and limited functional recovery. Polyethylene Glycol (PEG) has demonstrated an ability to improve behavioral outcome after nerve transection as well as nerve autografting. We hypothesized that the previously established PEG therapy could improve functional outcome after nerve allografting.

Materials and Methods: In this experiment we used a segmental rat sciatic nerve injury model in which we restored a 0.8-1.0 cm gap with a 1.0 cm nerve segment from a separate rat (allograft) using microsurgical techniques. The experimental animals were treated with a combination of solutions including Plasmalyte A (calcium free saline), Methylene Blue, Polyethylene Glycol (PEG), and Lactated Ringers (calcium containing saline); control animals received all solutions except for PEG. Animals underwent weekly (1w-6w) behavioral assessments using the Sciatic Functional Index. At 6 weeks post-op animals were perfused and fixed for thick cross sections.

Results: Following removal of 0.8-1cm segments of rat sciatic nerves, we report that micro-sutured allografts treated with polyethylene glycol (PEG) rapidly and permanently restore axonal continuity within minutes as assessed by action potential conduction (p<0.001) and intracellular diffusion of dye (Fig 1). Behavioral functions are largely restored (80%) within 2-4 weeks as measured by the sciatic functional index (SFI) in PEG treated animals and are associated with increased number of axons in PEG-fused allografts (p<0.001).

Conclusions: Our data suggests that use of microsutures, allografts, and PEG-fusion procedures might produce a paradigm shift in the clinical treatment of traumatic injuries to peripheral nerves for which the current gold-standard for simple cuts is micro-suture of the severed ends.



Figure 1 – Control nerve (left) and PEG-fused nerve (right) loaded proximally with fluorescent intra-axonal dye (Texas-Red) immediately following in-vivo repair. White arrows indicate proximal site of nerve severance.

106. Chaining Nerve Grafts With An Additional Suture Line Has Limited Impact On Axonal Regeneration Ying Yan, MD, PhD; Amy M. Moore, MD;Daniel A. Hunter, RA; Xueping Ee, MD, MS; Susan E. Mackinnon, MD; Matthew D. Wood, PhD Division of Plastic and Reconstructive Surgery, Washington University School of Medicine, Saint Louis, MO

Introduction: In cases of limited donor supply, the end-to-end coaptation of multiple nerve grafts (autograft or acellular nerve allografts-ANAs) to repair long nerve gaps has been performed. In this study, we sought to evaluate the effect of an added suture line on nerve regeneration and functional return when using either an autograft or ANA "chained" together.

Materials & Methods: Rat sciatic nerve was transected and repaired with 2cm nerve grafts. Nerve grafts consisted of either isografts (2cm: single, or a 1cm segment repaired to a 1cm segment: chained) or ANAs (single or chained). At an endpoint of 8 weeks post surgery, EDL muscle force and mass was measured, and nerve was harvested for quantitative histology (histomorphometry). In a separate parallel study, the same procedures and groups were employed, where nerves were harvested 2 weeks following graft implantation to assess gene expression changes using qRT-PCR. Collagen I, CD31, Ang-2, Jag1, VEGF and Dll4 expression levels at the middle of the grafts were determined.

Results: Contractile extensor digitorum longus (EDL) muscle force production was comparable between nerve isografts and ANAs as well as between single or chained groups. EDL muscle mass recovery was significantly increased by using a nerve isografts compared to ANAs, regardless of using a coapted nerve chains. Myelinated axon numbers assessed in nerve distal to the grafts were comparable between single and chained isografts and the single ANA, not the chained ANA.

Assessment of axonal regeneration within the grafts revealed stark differences. Myelinated axon numbers in the distal graft and proximal graft were similar between isografts groups (single or chained). However, ANAs, either single or chained, demonstrated decreased myelinated axon numbers in the distal graft compared to the proximal graft. The ratio of myelinated axon numbers in the distal graft compared to the proximal grafts but ~55-68% in ANAs. Gene expression analysis within grafts is ongoing to determine (1) why ANAs decrease axonal regeneration within nerve grafts and (2) differences between single and chained grafts.

Conclusions: Minimal axonal loss and no functional deficit were identified with an additional suture line in an isograft repair. Axonal regeneration across an additional suture line in ANAs has a moderate effect on axonal regeneration. The need to coapt multiple isografts to achieve a desired length does not limit axonal regeneration over short distances and is advantageous compared to the alternative ANA.

107. Magnesium Microfilaments inside Traditional Nerve Conduits Improve Nerve Regeneration Characteristics Kevin J. Little, MD¹; Tracy Hopkins², Alex Heilman³; Meir Hershcovitch, MD⁴; David Hom, MD⁴; Sarah Pixley, PhD² ¹Department of Orthopaedic Surgery, Cincinnati Children's Hospital, University of Cincinnati, Cincinnati, OH; ²Department of Molecular and Cellular Biology, University of Cincinnati, Cincinnati, OH; ³School of Medicine, Vanderbilt University, Nashville, TN; ⁴Department of Otolarygology Head and Neck, University of Cincinnati, Cincinnati, OH

Introduction: The use of biomaterials for the reconstruction of long nerve gaps lacks clinical efficacy using current techniques. The placement of filaments inside traditional conduits has been proposed to provide physical support to guide cells across the gap. We have previously used magnesium (Mg) metal microfilaments as "cables" to act as physical support for nerve regeneration and as biodegradable implants that release Mg⁺⁺ ions. We now test the hypothesis that Mg metal microfilaments can assist nerve regeneration across longer nerve gaps.

Materials & Methods: Short or long (6 or 15 mm) nerve gaps were created in the sciatic nerves of 44 adult male Lewis rats. Poly(caprolactone) nerve conduits were sutured into the gaps and filled with Mg microfilaments (99.9% pure, 250µm diameter), titanium microfilaments (250µm diameter) or saline filler alone (empty). Groups were: 1) empty conduits (6 and 15mm, n=7 each), 2) Mg (6mm, n=7; 15mm, n=8), 3) titanium (6mm only, n=7), or 4) isograft nerve controls (donor rats, 15mm, n=8). After sacrifice (6 weeks for short, 14 weeks for long gaps), the reconstructed nerve was excised, fixed and imaged by micro computed tomography (microCT) to determine extent of Mg degradation. Gastrocnemius muscles were removed and weighed. After imaging, nerves were halved and treated with either osmium to enhance contrast and imaged by microCT or paraffin embedded, sectioned and stained with H&E or immunostained for axons (anti-NF200).

Results: Mg degradation (seen via microCT) appeared accelerated (gaps at 6 weeks and almost no metal at 14 weeks). This was thought to be due to metal fatigue from processing. With short nerve gaps, there was no difference in muscle recovery or anti-NF200 staining between empty, titanium or Mg groups. Titanium filaments did not degrade, but this inert physical support also did not appear to improve regeneration characteristics (p>0.05). In long gap experiments, use of Mg microfilaments showed improvement over empty controls in terms of greater cross sectional area of total regenerating tissues (3.7 vs 2.4 mm², p<0.001) and greater area of axonal (anti-NF200) staining (62000 vs 25000 pixels, p<0.05). Muscle regeneration was not improved with Mg or empty groups at 14 weeks, but was with isografts (p<0.001).
Conclusions: Mg microfilaments improved the histologic characteristics of nerve bud regeneration through conduits across long nerve gaps, but did not improve muscle recovery at 14 weeks. Further research will focus on decreasing Mg degradation and assessing the effects of Mg^{++} ions on nerve regeneration.

108. Bilateral Regenerative Peripheral Nerve Interface Function Correlates with Hind Limb Kinematics during Treadmill Locomotion

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Introduction: Regenerative Peripheral Nerve Interfaces (RPNIs) are neurotized autologous free muscle grafts equipped with electrodes to record myoelectric signals for prosthetic control. In vivo characterization of voluntary RPNI signaling is critical when designing prosthetic device controllers. RPNIs are known to reliably produce high fidelity electromyography (EMG); however, RPNI signaling has not been matched with joint movements during walking when foot flexor and extensor signals are provided by RPNIs. We seek to define the relationships between Control and RPNI group signaling using kinematics and joint gait analysis during volitional treadmill walking.

Methods: Three experimental groups of two rats were devised (Figure 1): **Control**, rat hind limbs remained intact; **RPNI**, rat left extensor digitorum longus and right soleus muscles were transferred to the ipsilateral thigh and reinnervated with the transected peroneal and tibial nerves, respectively; **Denervated**, rats underwent peroneal and tibial nerve transections. In all groups, bipolar wire electrodes were positioned on the muscles. Evaluations occurred 4-5 months post-surgery. Rats walked on a treadmill. A synchronized videography system was used to identify hip, knee, ankle, and toe joint angles bilaterally, with acquired EMG. Within each group, normalized joint angles and EMG were cross-correlated.

Results: Control and RPNI group EMG signals were periodic with gait. Control group hind limb movements were normal with normal EMG signal periodicity. RPNI and Denervated groups exhibited compensated gaits with marked inability to dorsiflex or plantarflex the left and right hind feet. RPNI signal periodicity had different timings from Control due to gait compensations (Figure 2). EMG was highly repeatable within rat and within left and right legs (Control: r=0.88; r=0.91) and (RPNI, r=0.75; r=0.79); but, RPNI signaling was of lower amplitude than controls. Cross-correlation of the EMG from Control and RPNI groups indicated RPNI signaling predicts peroneal and tibial nerve firing that is proportionally similar to Control. The Denervated group demonstrated low amplitude random signaling, unrelated to gait.

Conclusion: This study determined that in vivo EMG signaling of Control and RPNI rats is periodic and highly correlated with hind limb joint angles during walking. EMG signaling by RPNIs correctly matched with compensations during walking.



Denervated study groups. Bipolar myoelectric recordings originated from the soleus, with Figure 2. Average hind limb hip, knee, ankle and toe joint positions illustrated as a threereference on the ear. Similar interventions and recordings on the left leg involved the peroneal segment limb and EMG mean and one standard deviation for Control, and RPNI groups, time nerve and extensor digitorum longus muscle (not shown) **B.** Bony processes of the hip, knee, course normalized with respect to gait cycle, and separated into stance and swing phase. Note ankle and metatarsophalangeal articulation were marked and tracked throughout the that for the RPNI group, the surgical intervention eliminated hind limb dorsiflexion on the left videographed walking trials bilaterally using image processing methods. **C.** Joint angle rotations and plantarflexion on the right. Pearson's R values indicate a strong correlation between ankle joint position and EMG activity bilaterally, for both Control and RPNI.

109. Histomorphometric Evaluation of Median Nerve Injury in Wistar Rats Treated with GM1

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Background: The aim of this study was to compare the morphologic alterations between traditional neurorrhaphy and neurorrhaphy combined with intraperitoneal administration of GM1 after median nerve injury of Wistar rats, using histomorphometric analysis.

Method: Twenty-two male Wistar rats suffered microsurgical median nerve damage. Rats were further subdivided into two experimental groups: Group I (10 animals) treated with external epineurial neurorrhaphy and Group II (12 animals) treated with epineurial neurorraphy combined with intraperitoneal GM1.

Results: Microscopic analysis containing distal stumps revealed that Group II animals had more regenerated axons with slightly thicker myelin sheath than Group I animals and had a more homogeneous and organized regeneration pattern, with a looser endoneurium in the central nerve fiber. A significant difference (p=0.0056) in mean axonal diameter of the distal segment was observed. Group II had larger and more axons (28%) than Group I.

Comparison with existing method(s): Traditional axonal regeneration index, obtained by axon counting in both segments was added to the diameter of axonal myelin layer.

Conclusion: Since nerve regeneration depends upon the association between the number of regenerated axons and myelin sheath diameter, data indicates that Group II is more highly myelinated than Group I. There is strong evidence (p=0.0536) that GM1 used as an adjuvant in peripheral nerve surgery improves axonal regeneration pattern.

Keywords: GM1, median nerve, axonal regeneration, morphometry, rats.

110. Motion Deficits of Thumb Opposition and Circumduction Due to Carpal Tunnel Syndrome

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Introduction: Carpal tunnel syndrome (CTS) is associated with sensory and motor impairments resulting from the compressed and malfunctioning median nerve. These impairments affect the thumb which is indispensable to hand function and is required to move in multiple directions through coordinated articulations at its three joints. CTS sufferers often experience clumsiness while performing daily tasks, but the pathokinematics of the thumb associated with CTS remain unclear. The purpose of this study was to evaluate thumb motion abnormities associated with CTS. It was hypothesized that CTS would result in translational and angular motion deficits during thumb opposition and circumduction.

Methods: Eleven patients with CTS (49.5 ± 9.6 years) and 11 age- and gender-matched healthy controls (48.9 ± 7.6 years) participated in this study. Translational and angular motion of the thumb was obtained using marker-based video motion analysis during thumb opposition and circumduction tasks. Translational metrics included thumb tip path length and thumb tip position, normalized according to subject specific palm width (PW); angular kinematics were quantified by examining 6 angular degrees of freedom.

Results: Analyses revealed translational and angular motion deficits for patients with CTS. In comparison to control subjects, the path length traveled by the thumb tip for CTS patients was approximately 30% less during opposition and 25% less during circumduction (p < 0.001). Specifically, CTS patients were unable to reach a similar maximum ulnar position of their thumb tip during opposition, with an ulnar deficit of 0.3 PW (p < 0.05). The angular range of motion for the CTS group was 36-41% less for the metacarpophalangeal and interphalangeal joints in extension/flexion compared to the control group across both opposition and circumduction (p < 0.05). These kinematics abnormalities were present even though there was no difference in pinch strength between the two groups (53.1±18.1 N for patients with CTS and 57.2±18.1 N for controls, p = 0.56).

Conclusions: Motion deficits of the thumb are present for CTS patients while completing tasks of opposition and circumduction. Improving the understanding of thumb pathokinematics associated with CTS may help clarify the clumsiness in hand function related to CTS given the critical role of the thumb in dexterous manipulation. Furthermore, such advanced kinematic analyses may be used to assess functional improvement following median nerve decompression.

111. Reverse End-to-Side Anterior Interosseous Nerve to Ulnar Nerve Transfer for Severe Ulnar Neuropathy at the Elbow

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Introduction: Ulnar nerve injury or severe nerve compression at the elbow is a difficult clinical problem as decompression or repair at this level may result in variable reinnervation of intrinsic hand muscles. Distal reverse end-to-side nerve transfers (anterior interosseous nerve to ulnar motor fascicles) have been suggested to "supercharge" or augment intrinsic hand muscle recovery while axons regenerate from the level of the elbow and have a significant theoretical advantage. There is little published about the efficacy of this technique.

Materials & Methods: Consecutive patients presenting between June 2013 and December 2013 who had repair of an ulnar nerve injury or severe compressive neuropathy (McGowan Grade III) at the elbow were considered for reverse end-to-side AIN to ulnar nerve transfer at the wrist. Consenting patients underwent nerve transfer by a single surgeon and followed post-operatively with electrodiagnostic studies and clinical evaluation. Changes in MRC grade and evidence of early intrinsic muscle reinnervation (6 months) on EMG were evaluated. Pinch strength and intrinsic hand function were also evaluated. In addition, strength and neurophysiology changes were measured with the forearm in neutral position and pronation (simulating AIN function).

Results: Six patients were eligible for review. Four patients suffered an ulnar nerve laceration with microscopic repair at the elbow and two had a severe compressive neuropathy. Average time from initial injury to transfer was 37.5 months (2 - 120 months). All patients had no recruitable motor units on pre-operative EMG of hand intrinsic muscles. All patients had intrinsic muscle wasting pre-operatively, which persisted post-operatively. Fifty percent (3/6) had an improvement in MRC grade by 6 months. Eighty three percent (5/6) of patients showed evidence of intrinsic muscle reinnervation at a time earlier than expected for regeneration from the elbow level (< 6 months). Eighty three percent (5/6) showed improvement in needle EMG studies with nascent units recruited during active forearm pronation, suggesting contribution of the AIN to the ulnar nerve motor fascicles.

Conclusion: The timing of clinical and electrophysiologic recovery suggests the AIN to ulnar reverse end-to-side nerve transfer enhances the results of surgery for severe ulnar neuropathy at the elbow.

112. In-situ Decompression of Ulnar Nerve Entrapment: A Controlled Randomized Study Comparing Decompression using Two Small Transverse Incisions with Standard Open Decompression Ashraf N. Moharram, MD; Mostafa Mahmoud, MD; Ayman Mansour, MD; Ayman Shaheen, MD; Ahmed Afifi, MD Orthopedic Department, Cairo University, Cairo, Egypt

Introduction: Ulnar Nerve entrapment is the second most common nerve entrapment in the upper limb in adults. Many methods of treatment have been advised including transposition, in-situ decompression as well as endoscopic decompression.

Method: We performed in-situ ulnar nerve decompression for 60 patients with ulnar nerve entrapment who were randomized into 2 groups. In group I decompression was performed through basically 2 transverse incisions each less than 2cm long which were placed 4cm above and 3 cm below the medial epicondyle and centered on the course of the ulnar nerve which was decompressed and all potentially compressing structures were released from the medial intermuscular septum down to the 2 heads of the flexor carpi ulnaris muscle. In group II decompression was performed through a standard curvilinear approach averaging 8cm based anterior to the medial epicondyle.

Patients who had symptoms of ulnar nerve instability, cubitus valgus, elbow osteoarthritis or significant local scaring were considered to be indicated for ulnar nerve transposition and were excluded from the study.

Results: Outcome measures used included Visual Analogue Scale (VAS) for pain, time of return to work, Disabilities of the Arm, Shoulder, and Hand (DASH) score, Gabel and Amadio score, and grip and pinch strengths as well as local scar tenderness. At final follow up, which averaged 6.3 months (5-8.5months), there was no statistically significant difference in either the DASH score, the Gabel and Amadio outcome scores or grip and pinch strength between both groups. However group I showed significantly less pain on VAS scores, faster return to work, less scar tenderness and less disfiguring scar.

Conclusion: These results are similar to those of endoscopic release of the ulnar nerve but avoiding the need for special equipment and thus less added time and expense as well as a long learning curve.

113. Nerve Transfers to Restore Hand Function in Cervical Spinal Cord Injury: A More Appealing and Accessible Option for Patients

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Purpose: Restoration of hand function in people with cervical spinal cord injury (SCI) is critical to their independence and quality of life. Traditional surgeries (tendon transfers/tenodesis) are, however, remarkably under-utilized despite their well-established benefits. This study examines a series of SCI patients who underwent the relatively novel application of *nerve* transfers to improve hand function. The purpose was to investigate patient knowledge about treatment options and preliminary perceptions regarding nerve transfers.

Methods: A qualitative study design was used to assess five post-surgical cervical SCI patients 6-10 months after nerve transfer surgery. Asemi-structured interview was performed. Questions addressed access to health information, barriers to treatment, and perceptions of treatment options including nerve transfers.

Results: Patients reported that they received most of their health information from physicians and the internet. The major barriers to information about and access to care for upper extremity surgery were jargon and access to medical professionals. Only 3/5 reported even having previously heard about the traditional surgical treatments (tendon transfers/tenodesis). Limited post-operative downtime was the highest ranked advantage of the nerve transfer surgery. Reliability and perceived lower risk also made the nerve transfer surgery appealing. While 2/5 had at least one negative experience related to the surgery (paresthesias, transient donor site weakness), all patients reported they would have the surgery again, are considering surgery on the contralateral arm, and would recommend the surgery to others.

Conclusion: Tendon transfers and tenodesis are under-utilized options to improve hand function in SCI patients despite their benefits in improving independence and self-care. In our patient population, barriers to information regarding upper extremity surgery, including jargon and access to medical professionals, appear to contribute to this under-utilization. In comparing traditional options to nerve transfers, the lack of downtime and perceived increased reliability made nerve

transfers attractive. Moreover, despite being early in their recovery (it typically takes 12-18 months to see gain in function after nerve transfer surgery), all of the patients have a positive impression of the surgery. These data provide preliminary guidance for further prospective investigation of patient perceptions of surgery to improve hand function in the setting of cervical SCI. The long term goals of this work are better dissemination of information regarding treatment and patient/provider education in this setting.

114. Double Distal Nerve Transfer for Hand Reconstruction after Lower Brachial Plexus Injuries Zhongyu Li, MD, PhD *Orthopaedic Surgery, Wake Forest School of Medicine, Winston-Salem, NC*

Hypothesis: Lower brachial plexus injury (LBPI) remains a clinical challenge. Early distal nerve transfer may provide useful thumb and finger functional recovery.

Material & Methods: Four patients were treated with distal double nerve transfer for LBPI. There were 3 males and one female, 3 of them involved in the right side. The mean age at surgery was 22 (17-26) years old. The procedure includes transferring a pronator branch of the median nerve (PBMN) to the anterior interosseous nerve (AIN) and a supinator branch of the radial nerve (SBRN) to the posterior interosseous nerve (PIN). The mean time of delay from injury to surgery was 7.5 (5-13) months. The mean follow-up was 19 (6-36) months.

Results: The first 2 patients achieved M4 of EPL/EDC and M4 of FPL /FDP. The other two more recent patients showed signs of motor recovery 6-9 months after surgery. There was no functional loss of forearm pronation or supination after surgery.

Conclusion:

- Simultaneous double distal transfer of a PBMN to AIN and a SBRN to PIN is a reliable technique for patients with LBPI.
- The advantages of this procedure include: 1) transfers can be performed through one incision with minimal intraneural dissection; 2) the transferred nerves are very close to the targeting muscles; 3) there is no need for nerve graft; 4) both transfers are in-phase with ease in post-op therapy.

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115. Outcomes from an Ongoing Multicenter Registry Study on the Use of Processed Nerve Allograft as Compared to Contemporary Controls for Sensory, Mixed, and Motor Nerve Reconstructions

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Introduction: The RANGER registry is an active database designed to collect injury, repair, safety and outcomes data for processed nerve allograft (PNA), Avance[®] Nerve Graft, AxoGen, Inc. In 2013, a control arm (MATCH) was added to the registry to allow for comparisons of outcomes between conduit and nerve autografts. Here we report our cumulative findings from the ongoing registry on the safety and efficacy of processed nerve allograft with comparisons of outcomes to conduit and nerve autografts.

Methods: The RANGER registry is designed to continuously monitor and incorporate data using standardized data collection into a centralized database. For the control arm, a medical record review was conducted at participating centers to identify subjects repaired with conduit or nerve autograft according to the IRB approved protocol. Outcome measures were reported for the cumulative PNA dataset and then stratified for comparisons to controls. PNA repairs with gaps <30mm were compared to conduit and gaps >20mm were compared to the nerve autograft group. Meaningful recovery was defined by the MRCC scale at S3/M3 or greater.

Results: Quantitative outcomes data was available in 109 subjects with 152 PNA repairs. The mean age was 41 ± 16 (18-70). The mean gap was 21 ± 12 (5-65) mm. Recovery of meaningful sensory function was reported in 84% of the repairs (118 sensory/18 mixed). The mean static and moving 2PD was 8 ± 3 mm and 7 ± 3 mm respectively. Return to light-touch or greater was demonstrated in 47 of 65 repairs reporting SWMF scores. Recovery of meaningful motor function was reported in 68% of repairs (22 mixed/9 motor). There were 8-M3, 6-M4, and 7-M5. No related adverse experiences were reported. PNA was further stratified for comparisons to controls. Meaningful recovery was reported in 49% and 64% in the conduit and nerve allograft groups. See Table 1.

Conclusions: Outcomes from the registry continue to demonstrate the successful use of Avance[®] Nerve Graft in sensory, motor, and mixed nerve defects between 5 and 65mm. Meaningful recovery at MATCH sites for PNA exceed that of tube conduits and are comparable to nerve autograft. This study is currently in open; additional data incorporated into the registry and MATCH control arms will allow for continued analysis on the role of processed nerve allografts, tube conduit, and nerve autograft in the treatment algorithms for peripheral nerve injuries.

	Processed Nerve Allograft (Gaps ≤ 30mm)	Conduit	Processed Nerve Allograft (Gap ≥20 mm)	Nerve Autograft
Total Repairs	64	41	29	14
Sensory	61	36	21	5
Mixed	3	5	8	9
Mean Gap (mm)	16 ± 8 (5, 30)	18 ± 6 (10, 30)	30 ±11 (20, 65)	39 ± 14 (10, 60)
Mean FW-Up	11 months	13 months	11 months	18 months
Meaningful Recover (S3/M3 or greater)	v			
Meaningful Quantitative Outcomes	53/64	20/41	23/29	9/14
Recovery	83% *	49% *	79%	64%

AAHS/ASPN/ASRM Joint Outstanding Paper Session

AAHS #1 Patient Factors Associated with Complications within 30 days of Hand Surgery; an Analysis of 9,969 Patients Using the 2006-2011 ACS-NSQIP Datasets

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Introduction: The ACS-NSQIP database collects detailed and validated data on patient demographics, co-morbidities, and 30-day postoperative outcomes on patients undergoing operations in most subspecialties. This dataset has been previously used to delineate specific complication risks and risk factors in a number of surgical subspecialties, but has not yet been used for hand surgery. While the risk of early complications following hand surgery is generally believed to be low, it is important to define these risks quantitatively, and to identify patient groups who are at higher risk for complications so that preventive measures can be employed.

Materials and Methods: ACS-NSQIP data from 2006-2011 was queried using 293 hand-specific CPT codes. Descriptive statistics were calculated for the population, and potential risk factors and patient characteristics contained within the NSQIP database were analyzed for their association with complications in the 30-day postoperative period. The most common complications were identified, and significantly associated variables were determined.

Results: 204 hand-specific CPTs were represented in the data. Of these, 81 resulted in at least one complication. The overall 30-day complication rate for hand surgery was 2.7%. Women had fewer complications than men, and there were significant differences between races. Age and BMI did not correlate significantly with complication rates. Significant increase in complication rates were associated with insulin-dependent diabetes (10%), pre-operative dyspnea (5.4%), COPD (7.4%), hypertension (4.2%), peripheral vascular disease (14.9%), renal failure (44.1%), preoperative steroid use (10.5%), bleeding disorder (16.7%) and emergent surgery (10%). Increased surgical wound class was associated with increased rate of complications. Lower complication rates were associated with operations done under local or regional anesthesia. Decreased operating time and anesthesia time were significantly associated with decreased rate of complications. The most common complications were superficial and deep surgical site infections, urinary tract infection, unplanned intubation, sepsis, pneumonia, and wound disruption.

Conclusions: This study utilized a large, prospective national database to characterize the 30-day complication profile and risk factors for surgery of the hand. Overall, the incidence of complications is low, approximately 2.7%. However, rates are significantly elevated in certain sub-groups and with some perioperative conditions. The most common complications are listed and quantified. This information is valuable in counseling patients preoperatively, and in identifying groups of patients on whom risk reduction efforts should be focused.

AAHS #2 Can Platelet-rich Plasma Impact the Formation of Flexor Tendon Adhesions?

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Background: Because of its regenerative potential, platelet-rich plasma has been studied extensively. Chickens contain nucleated thrombocytes that contain many of the growth factors contained within mammalian platelets. We aimed to separate the thrombocyte-rich plasma (TRP) from avian whole blood, deliver this growth factor-rich concentrate to a traumatic flexor tendon laceration and evaluate its effect on flexor tendon healing - specifically the formation of peritendinous adhesions.

Methods: 9 chicken surgeries were performed on 18 digits (3rd, 4th digit). Prior to surgery, the digits were randomized to undergo laceration and repair - in an area homologous to zone two in the human hand -followed by the addition of thrombocyte-rich plasma (treatment) or closure without TRP (control). 5 cc of whole blood, separated via the Biomet GPS III system generated 1 cc of thrombocyte-rich concentrate. Post-operatively, all chicken feet were immobilized using a plaster cast. Three weeks later, subjects were euthanized and the tendons were examined histologically by five independent, study-blinded pathologists for the presence of connective tissue, peritendinous adhesion formation and the presence of a peritendinous space. These specimens were graded on a scale of 1 to 5 and a mean value for each specimen was calculated. The difference in severity of tendon adhesions between the treatment and control groups was calculated using a paired t-test.

Results: Mean adhesion score for the treatment group was 3.40 and mean adhesion score for the control group was 3.36 (p=0.90). Mean Olympic adhesion scores (highest and lowest score not included) for the treatment and control tendons were 3.40 and 3.44, (p=0.91) respectively. A score of 3 suggests moderate adhesions, peritendinous space preserved in more than 50 % of the circumference and a score of 4 denotes severe adhesions, peritendinous space obliterated in more than 50 % of the tendon circumference. Adhesion formation varied between hosts, but there were no differences between treatment and control groups or between digits 3 and 4.

Discussion: The efficacy and reproducibility of platelet-rich plasma delivery is controversial. Laboratory evidence suggests that the addition of platelet-rich plasma may aid in tendon healing, but thus far there is no literature detailing its effect on adhesion formation. Though we have shown no difference in adhesion formation between control and study tendons, there are two significant limitations to this study: our ability to reliably quantify the growth factors within the thrombocyte-rich fraction and to consistently deliver the same volume to the repair site.

ASPN #1 The Result of Contralateral C7 Spinal Nerve Transfer – a 28 Years of Experience

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Introduction: Total root avulsion of the brachial plexus remains to be a major reconstructive challenge. This study aims to evaluate the functional outcomes of brachial plexus patients with unilateral total root avulsion, who were reconstructed with CC7 spinal nerve transfer.

Method and Materials: 168 patients who suffered from total brachial plexus palsy, and underwent reconstruction with CC7 spinal nerve transfer from 1985 to 2013 were analyzed. We then selected and analyzed the characteristics and the achievements of the 10 patients who attained the best functional outcomes.

Results: The average age was 24.8 years old. 89 patients had their dominant upper limb affected. All but 4 had more than one body part injured, 21 % of them suffered from concomitant fractures in their affected upper limbs. 40 patients had vascular injuries on their affected limbs. The average time from injury to initial nerve reconstruction was 133.5 days and the average time from initial injury to CC7 transfer was 263 days.

Neither significant nor permanent donor site morbidity was noted. The average follow-up period was 5 years

For the 10 patients with best functional outcomes, no significant difference in their basic characteristic, their injury or their time from injury to initial nerve reconstruction was noted when compared with the other patients. A majority attained an education level of upper high school or above. They attended more follow-sessions with a longer average follow-up period of 8.2 years

6 patients had their CC7 transfer to both median and musculocutaneous nerves while 4 patients had their CC7 transfer to their median nerve only. This ratio is comparable to the remaining patients. 8 out of 10 patients underwent more than 1 surgery, which was significantly more than the rest of the patients. All patients with CC7 transfer to musculocutaneous nerve could achieve an elbow flexion motor grading of 4. 3 out of 4 patients with CC7 transfer to median nerve only had a finger flexion of grade 3. 9 patients had a finger flexion of at least grade 2. They all had protective finger sensation. Their self-perception improved post nerve reconstruction. They also had a significant improvement in DASH and Michigan Hand score.

Conclusion: CC7 is a good treatment option for patients with total brachial plexus injuries. Patients who are young and have high education status and motivation appear to achieve better functional results in the long term.

ASPN #2 A Quantitative Analysis of the Sensory and Motor Fibres of the Brachial Plexus in Man

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Introduction: Any surgical nerve reconstruction must take into account amount of individual nerve fibres at any given level of injury. To date, however, literature on qualitative and quantitative assessment of motor axons of the peripheral nerves of the upper extremity is scarce. Furthermore, none of these studies have depicted the topography of motor fibres along the entire course of these peripheral nerves. The aim of the present study is to present the total number of motor fibres of the brachial plexus from each root down to the level of its corresponding branches.

Material and Methods: Nerve samples have been harvested from 12 organ donors immediately after death. From 8 incisions ranging from the neck to the wrist a total of 36 nerve samples were gained per organ donor. A special immunohistochemical protocol was applied to visualize the specific structure of interest within the nerve cross section. Antibody against neurofilament served to determine the total amount of myelinated and unmyelinated axons. Antibody against choline acetyltranferase (ChAT) was used to detect cholinergic/motor fibres. Histology sections were then scanned and evaluated with a digital software program to allow quantification of each cross section. These numbers were cross checked in an animal model with standard retrograde tracing methods. Finally, the quality of this method was also cross checked with staining ventral and dorsal roots of organ donors at spinal cord level.

Results: As expected the majority of any given peripheral nerve contains afferent fibers. To our surprise, however, only around 10% of all axons in a mixed peripheral nerve are efferent fibers. In a "pure" peripheral motor nerve (thoracodorsal nerve) one third of the axons are cholinergic. In a pure cranial motor nerve the motor portion rises to about 60% (accessory nerve) but still has a significant afferent fibre population. The control experiments in a rodent animal model show good correlation between retrogradely labelled motor neurons with ChAT positive labels in the peripheral nerve section.

Conclusion: Here we present for the first time a quantitative analysis of all afferent and efferent fibres of the brachial plexus and its consecutive nerves. The surprising finding is that even "pure" motor nerves with a suspected high number of motor fibres (thoracodorsal nerve) only have a relatively small number of efferents. Since this ratio is relatively constant for motor nerves at different levels of the extremity these results challenge the traditional view of fiber distribution and innervation density in man.

ASRM #1 Evaluation of Viability and Structural Integrity after Whole Eye Transplantation

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BACKGROUND: Approximately 37 million people throughout the world suffer from blindness. Whole eye transplantation (WET) gives the opportunity to provide viable retinal ganglion cells and the entire optical system to recipients with vision loss and irreversible injury to the eye. A key obstacle to WET is the poor regenerative ability of the optic nerve. Recently, several groups have demonstrated optic nerve regeneration, showing promise for eye transplantation. There has been difficulty in establishing a consistent small animal model for basic science research in WET. We previously established and published a functional face transplant model in the rat, and have recently expanded our model to include the whole eye, optic nerve and its blood supply.

Methods: All syngeneic transplants were performed in Lewis (RT1¹) rats. The donor flap, pedicled by the common carotid artery and external jugular vein, is composed of all ocular tissue distal to the optic chiasm, a portion of the temporal bone, and the skin tissues of the eyelids and external ear. The recipient site was prepared by removing a similar region of skin tissue and the eye socket content, with the optic nerve cut at the base of the globe. A nerve apposition between the donor and recipient optic nerve was performed. Slit lamp examination and Optical coherence tomography (OCT) imaging of the cornea, lens and retina were performed weekly after transplantation. Histological sections of the eye were analyzed post-mortem.

Results: 6 out of 8 rats survived the surgical procedure while maintaining visual transparency of the anterior eye. All eyes were viable via slit lamp examination. OCT imaging confirmed transparency of the cornea and lens, preservation of the structural layers of the retina, and blood flow throughout the eye. Histology confirmed neovascularization of the cornea as well as preservation of the structural integrity of the retina, with the exception of degeneration of the retinal ganglion cell layer.

Conclusion: We have established a viable orthotopic model for vascularized whole eye transplantation in the rat. Maintenance of structural integrity and viability were confirmed by slit lamp examination, OCT, and histology. The model is ideal for examining viability, functional return and immunology in whole eye transplantation.

Figures



Fig. 1 WET graft. (ON: Optic Nerve; TB: Temporal Bone; TN: Trigeminal Nerve; ELG: External Lacrimal Gland; CCA: Common Carotid Artery; EJV: External Jugular Vein.)



Fig. 2 Recipient immediately after graft insetting, with optic nerve apposition.



Fig. 3 Retina vascularization with Doppler OCT on POD 7. A: Control retina; B: Transplanted retina.

ASRM #2 Implications of Intracranial Facial Nerve Grafting in the Setting of Facial Reanimation Bridget Harrison, MD; Khalil Chamseddin, MS; Gangadasu Sagar Reddy, MD; Shai Rozen, MD UT Southwestern Medical Center

Background: Most intracranial tumors involving the facial nerve are extirpated with nerve preservation, but when resected, and if feasible, intracranial facial nerve grafting is performed. Results likely depend on multiple factors such as age, anatomic location, pre-operative facial palsy, radiation, and gap-length. Results can vary from complete palsy to varying degrees of tonicity, synkinesis, effective motion, and ocular protection.

Purpose: Evaluate the varying degrees of facial reanimation by facial region after intracranial nerve grafting and identify implications for future facial reanimation and pre-operative consultation.

Methods: Between the years 1997-2012, twenty-seven patients underwent intracranial nerve grafting after tumor extirpation. Of the 26 candidates, 14 completed evaluations. All patients were prospectively evaluated by three physical therapists specializing in facial nerve rehabilitation and scored with Facial Disability Index (FDI), and two regional grading systems - Facial Nerve Grading System 2.0 (FNGS 2.0), and SunnyBrook Facial Grading Score (SFGS). Additionally, all patients underwent still photos and videography to assess quality of motion and tonicity in repose. Demographic and surgical variables were analyzed as to their possible effect on end results.

Results: The average age was 43 (22-66). The average time interval between nerve grafting to evaluations was 44 months (12-146). Average total FDI was 67.5% comprised of the Physical Function and Social/Well-Being portions averaging 62.8% and 72.6% respectively. Subdivisions of the physical function score with worst outcomes were eye dryness/tearing and difficulty speaking. Best outcomes were recorded in teeth brushing, eating, and drinking. FNGS 2.0 demonstrates best outcomes in Eye and Oral Commissure portions and worse in Brow and Nasolabial fold. Final FNGS 2.0 grade average was 4.3 (1-5) i.e. moderately severe dysfunction. The SFGS reveals 64.3% have oral resting symmetry, but only 28.6% resting symmetry in eye and nasolabial fold. Symmetry in voluntary movement revealed gentle eye closure and lip pucker as best – 3.6 and 3.0 respectively, while brow lift as worst - 1.0 and open mouth smile at 2.0 (5-25). Total synkinesis score averaged low at 3.6 (0-15).

Conclusion: Intracranial nerve grafting does not provide consistently good facial animation but may provide periocular protection, although not symmetry. It does afford good symmetry of the midface in repose, thus potentially improving results of midface reanimation surgery by providing improved baseline tonicity with minimal synkinesis. This information is important during patient discussions if intracranial facial nerve resection and grafting is anticipated or in the interim between nerve grafting and planned future facial reanimation.