Paper 01: Body Mass Index as a Continuous Variable in Shoulder Arthroplasty

Treatment, Surgical Technique, Patient Education, Prognosis/Outcomes, Shoulder and Arm, General Principles
Level 2 Evidence

Eric Wagner, MD
Matthew Houdek, MD
W. Scott Harmsen, MS
Robert Cofield, MD
John W. Sperling, MD, MBA
Bassem T. Elhassan, MD

Hypothesis
Morbid Obesity has been linked to increased rates of complications in lower extremity arthroplasty. There is a paucity of studies in the upper extremity and those few studies have examined the effect of BMI using specific ranges. The purpose of this investigation was to quantify rate of revision surgery and complications after shoulder arthroplasty using BMI as a continuous variable.

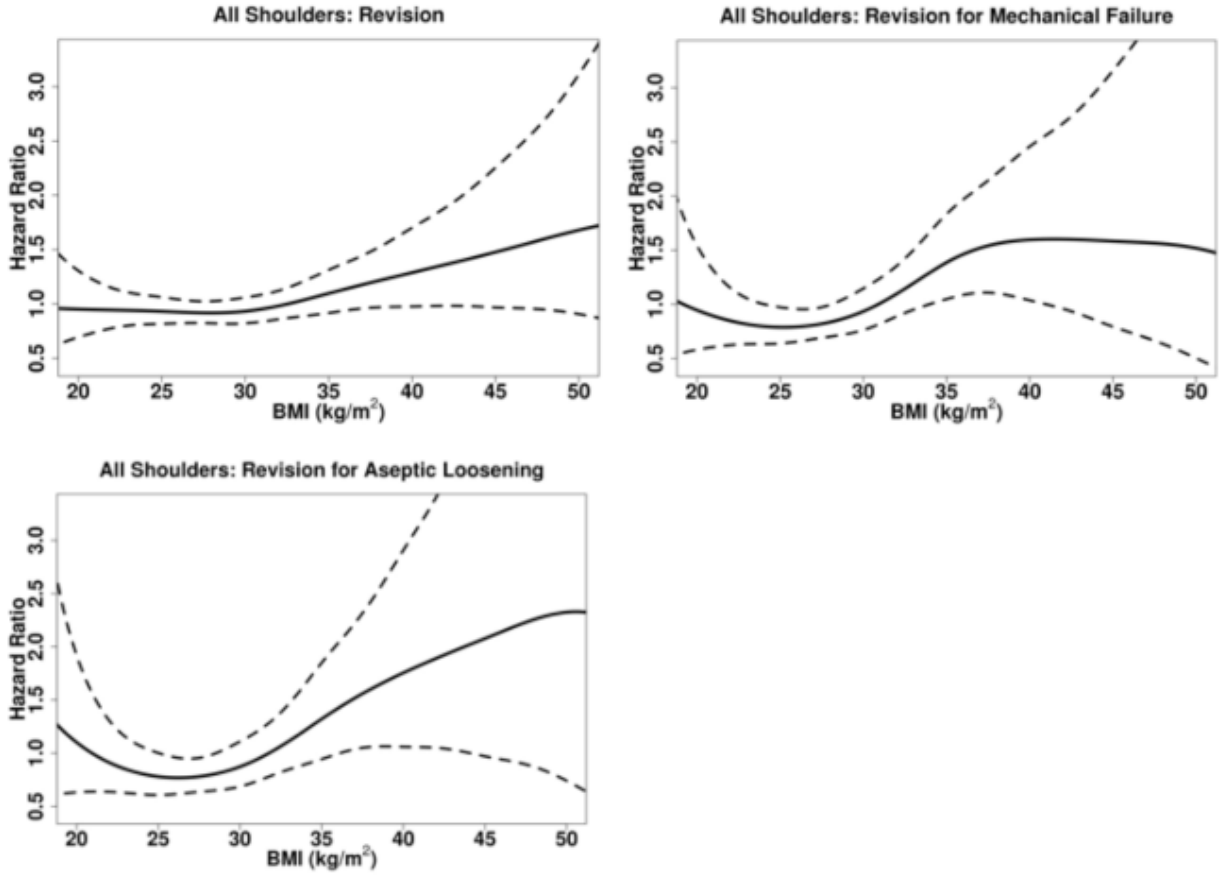
Methods
Using a single institution's total joint registry, 5,904 consecutive shoulder, treated with either hemiarthroplasty (1,388), anatomic (3,330) or reverse (806) shoulder arthroplasty from 1998-2013 were examined. The average BMI was 29.7 (14-66), with 1,622 (35%) shoulders with a BMI >30 and 297 (7%) with a BMI >40. BMI was parameterized using a smoothing spline model. The associations of patient factors with the risk of each complication were assessed using Cox hazard regression analysis, adjusting for correlated shoulders.

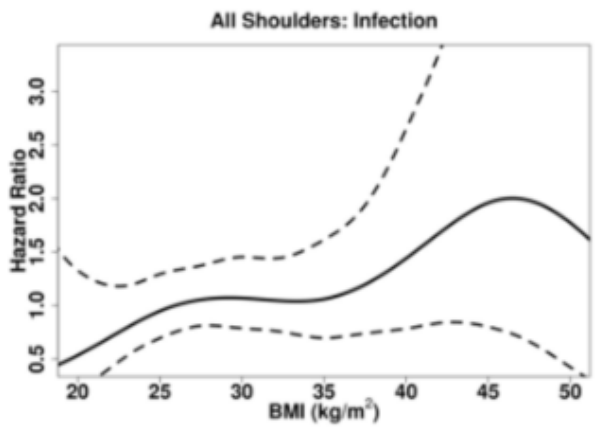
Results
Increasing BMI was associated with an increased risk of revision surgery, reoperation, revision for mechanical failure, superficial infection, and periprosthetic fracture. Risk of revision surgery increased in a linear fashion with increasing BMI (HR 1.05, or a 5% increased risk per unit of BMI, p=0.03). Subgroup analysis revealed BMI was also associated with an increased revision for mechanical failure (HR 1.05, p<0.01). Each unit increase in BMI was also associated with a 5% increase in the risk for reoperations (HR 1.05, p<0.02). In a multivariate model incorporating gender and primary diagnoses, revision surgery, revision for mechanical failure and reoperation

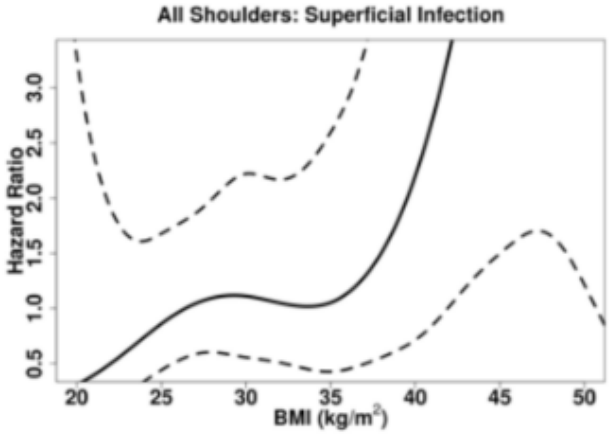
maintained statistical significance ($p<0.01$). The most striking correlation between increasing BMI and any complication in shoulder arthroplasty was its association superficial wound infection (HR 1.09, $p=0.03$). There also was an increased risk of deep and all infections, but not statistically significant. Increasing BMI as also associated with an increased rate of periprosthetic fractures (HR 1.12 per unit of BMI, $p=0.01$). Alternatively, rates of shoulder instability and thromboembolic events were not significantly associated with BMI. When examining each of these outcomes by specific types of arthroplasty, increasing BMI in hemiarthroplasty, anatomic, and reverse arthroplasty each individually were correlated with higher rates of revision surgery, reoperation, superficial wound infection, and periprosthetic fracture ($p<0.05$).

Summary Points

- Increasing BMI is strongly associated with increased rates of revision surgery and postoperative complications after shoulder arthroplasty.
- Many of these complications increases in a greater than linear fashion across the range of BMIs.
- The increased complications are demonstrated in a greater than linear fashion across most BMIs.




All Shoulders: Infection
Hazard Ratio
0.5
1.0
1.5
2.0
2.5
3.0
20
25
30
35
40
45
50
BMI (kg/m^2)


All Shoulders: Superficial Infection
Hazard Ratio
0.5
1.0
1.5
2.0
2.5
3.0
20
25
30
35
40
45
50
BMI (kg/m^2)

Paper 02: Attenuation of Robust Glial Scar Formation after Chronic Nerve Compression Injury Can Facilitate Functional Recovery

Basic Science, Hand and Wrist, Nerve
N/A - Not a clinical study

Minal Tapadia, MD, JD, MA
James Jung, BS
Diana Zhu, BA
Weiping Wang, PhD
Tahseen Mozaffar, MD
Ranjan Gupta, MD

Hypothesis

Early surgical management of chronic nerve compression (CNC) injuries often improves sensation but offers limited reversal of late motor atrophy. Spinal cord injury (SCI) models have shown formation of glial scar composed of chondroitin sulfate proteoglycans (CSPGs), degradation of which leads to improved functional outcomes. We hypothesized that persistent glial scar composed of CSPGs and other extracellular matrix (ECM) molecules such as laminin-a2, fibronectin, and collagen-IV might similarly account for poor motor recovery after decompression in later stages of CNC injury, and that digestion of glial scar would result in improved functional recovery.

Methods

CNC injury was created in C57BL/6 mice and Sprague Dawley rats by placing silastic tubing around the sciatic nerve. Mouse nerves were harvested after 2-weeks and 6-weeks while rat nerves were harvested at 4-months and 6-months. Electrophysiology was performed to confirm CNC injury. Western blot, PCR, and immunohistochemistry (IHC) were performed to determine levels of CSPGs including decorin, aggrecan, brevican, and versican, as well as of other ECM molecules including collagen-IV, fibronectin, and laminin-a2. A subset of mice were treated with either surgical decompression alone, or decompression coupled with intraneural injection of chondroitinase ABC (AMS Biosciences, 0.2 µg/uL) at 6-weeks.

Results

Aggrecan showed the greatest change in mRNA levels following rat CNC with marked bimodal increases of nearly 25-fold at 1 month and 18-fold at 5-months. IHC analysis for mouse collagen IV, laminin a2, and fibronectin showed perineurial scarring at 2-weeks. This correlated with

western blot data in mice at 2-weeks that showed 6-fold upregulation of fibronectin, 1.4-fold upregulation of laminin-a2, and 2-fold upregulation of collagen-IV. IHC and western blot for mouse decorin demonstrated minimal changes to expression in compressed nerves at 2-weeks but marked upregulation of expression by 6-weeks in epineurium and perineurium. Decompression with intraneural injection of chondroitinase ABC at 6-weeks resulted in marked attenuation of decorin expression.

Summary Points

- CNC injuries such as carpal and cubital tunnel syndromes result in demyelination and glial scar formation that cause patients significant morbidity despite optimal medical and surgical management.
- These data demonstrate that a progressive and significant upregulation of CSPGs and other ECM components contribute to the pathogenesis of compression neuropathies in murine models.
- Analogous to SCI, degradation of persistent scar can result in significant functional recovery. These data therefore present a potential novel therapeutic avenue for treatment of late-stage, irreversible compression neuropathies.

Reference 1: Tapadia M, Mozaffar T, Gupta R. Compressive neuropathies of the upper extremity: update on pathophysiology, classification, and electrodiagnostic findings. J Hand Surg Am. 2010; 35(4): 668-77.
Reference 2: Lee YS, Lin CY, Jiang HH, Depaul M, Lin VW, Silver J. Nerve regeneration restores supraspinal control of bladder function after complete spinal cord injury. J Neurosci. 2013; 33(26): 10591-606..
Reference 3: Barritt AW, Davies M, Marchand F, Hartley R, Grist J, Yip P, McMahon SB, Bradbury EJ. Chondroitinase ABC promotes sprouting of intact and injured spinal cord systems after spinal cord injury. J Neurosci. 2006; 26(42): 10856-867..
Reference 4: Zuo J, Neubauer D, Graham J, Krekoski CA, Ferguson TA, Muir D. Regeneration of axons after nerve transection repair is enhanced by degradation of chondroitin sulfate proteoglycan. Exp Neurol. 2002; 176:221-28.
Reference 5: James Jung, BS; Peter Hahn, MD; Bernard Choi, PhD; Tahseen Mozaffar, MD; Ranjan Gupta, MD. Early Surgical Decompression Restores Neurovascular Blood Flow and Ischemic Parameters in an in Vivo Animal Model of Nerve Compression Injury J Bone Joint Surg Am, 2014; 96(11):897-906.

Paper 03: Lateral Femoral Condyle Flap: Anatomic Dissections and Case Report

Surgical Technique, Anatomy, Hand and Wrist
N/A - Not a clinical study

Victor Wong, MD
Heinz K Burger, MD
Matthew L. Iorio, MD
James P. Higgins, MD

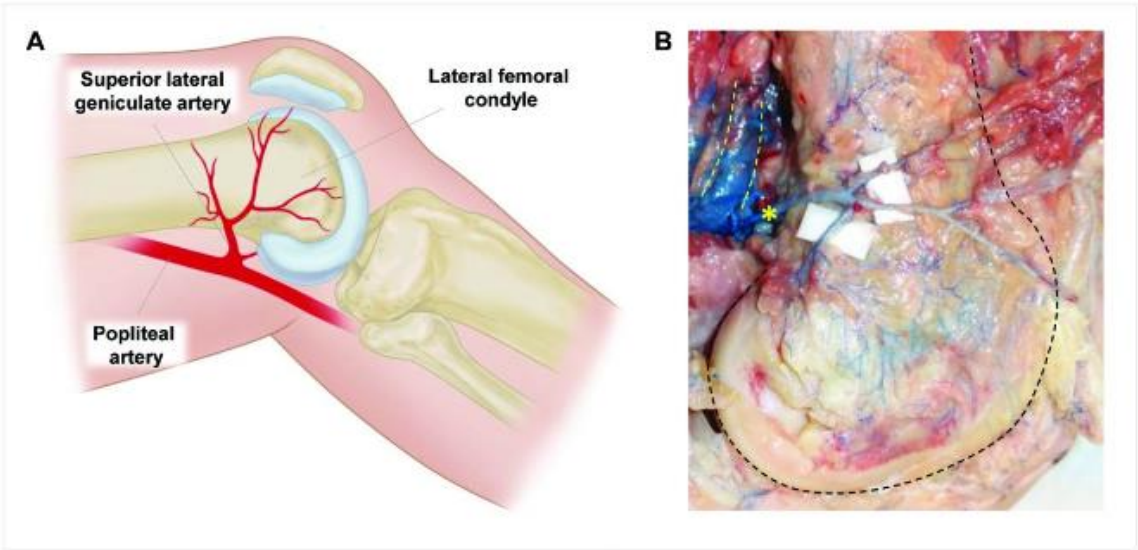
Hypothesis
Corticoperiosteal flaps from the medial femoral condyle (MFC) have been successfully utilized for reconstruction of complex carpal, long bone, tarsal, and craniofacial defects. Although not previously described, the lateral femoral condyle (LFC) can serve as a similar donor site for vascularized bone based on the superior lateral geniculate artery (SLGA) (Figure 1). An understanding of the periosteal vascular anatomy would provide guidelines for flap design.

Methods
Thirty-one fresh cadaveric limbs were evaluated. Subtraction angiography was utilized to define the vascular territory of the SLGA and intra-arterial injections of latex rubber were performed in 12 of the limbs. The vascular territory was traced from the SLGA to its distal branches and surrounding soft tissues were dissected. Additionally, a clinical case utilizing a LFC corticocancellous flap for scaphoid non-union reconstruction is presented.

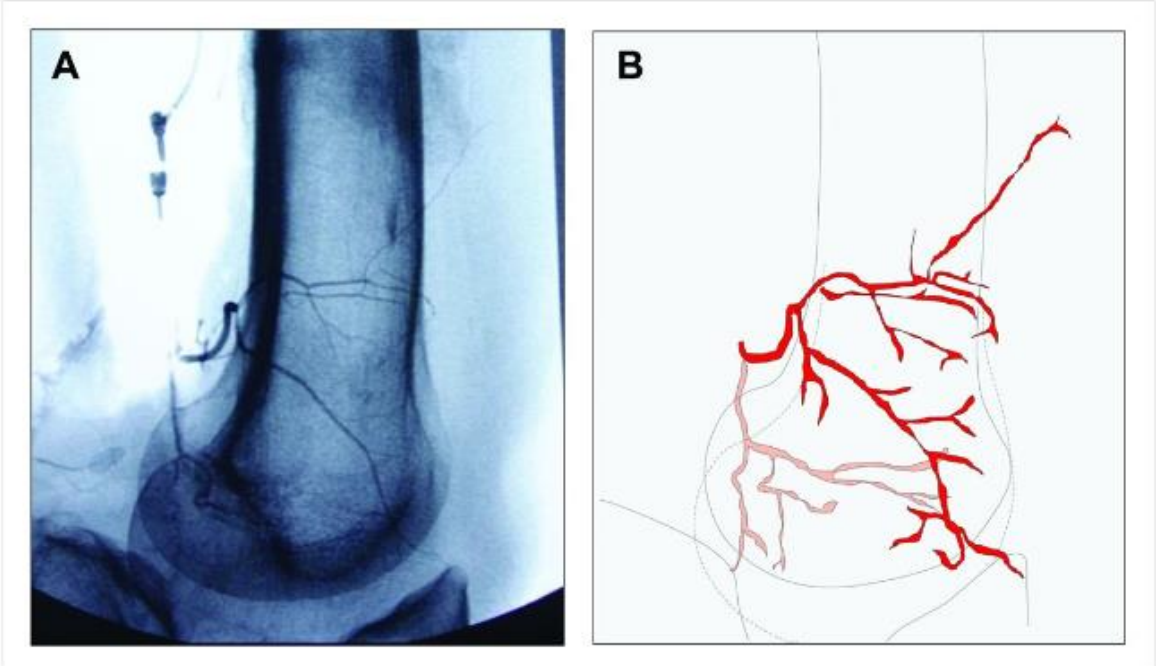
Results
The SLGA originated from the popliteal artery 4.9 ± 1.2cm (range 2.8 – 7cm) from the knee joint and its pedicle diameter was 1.8 ± 0.5mm (range 1 – 3mm). SGLA pedicle-specific fluoroscopic angiography demonstrated a dense filigree of vessels over the lateral distal femur and condyle (Figure 2). Arterial latex injections confirmed that the SLGA supplied the periosteum of the LFC and distal femur shaft. The proximal-most extent of periosteal perfusion was 11.7 ± 2.1cm (range 9.3 – 14.1cm) from the joint line. The average pedicle length of LFC osteoperiosteal flaps was 4.8 ± 0.9cm (range 3.5 – 6.3cm).

Summary Points
- The LFC flap consistently demonstrated an average of 12cm of femur-length perfusion based on the SLGA pedicle.

- The anatomy of this flap enables chimeric designs combining soft and osteocartilaginous tissues.
- The illustrative case demonstrated the successful use and clinical potential of the LFC flap in upper extremity reconstruction.



A. Schematic of vascular territory supplied by the superior lateral geniculate artery (SLGA). B. Cadaver dissection demonstrating latex perfusion of the SLGA and its branches to the lateral femoral condyle. Yellow dashes = popliteal artery, asterisk = SLGA origin.



A. Subtraction angiography via superior lateral geniculate artery (SLGA) pedicle demonstrating perfusion of the distal femur and lateral femoral condyle. B. Schematic of panel A demonstrating differential perfusion via superior and inferior branches of the SLGA.

Paper 04: Diagnosis of Occult Scaphoid Fractures: A Cost Effectiveness Analysis

N/A – Not a clinical study

John Karl, MD, MPH
Eric Swart, MD
Robert J. Strauch, MD

Hypothesis

The purpose of this study was to use formal cost effectiveness principles to evaluate the diagnostic scenario of a patient with a suspected scaphoid fracture in the setting of negative x-rays, comparing empiric casting with early follow-up to immediate advanced imaging. We hypothesized that the increased costs of advanced imaging would be offset by the future savings of decreased immobilization and less need for short-term follow-up.

Methods

A decision analysis model was created to evaluate three diagnostic strategies for patients with concerning history and exam but negative radiographs: (1) empiric cast immobilization with orthopedic follow-up and repeat radiography at two weeks post-injury, (2) immediate CT scan, or (3) immediate MRI. Prevalence of occult scaphoid fracture, sensitivity and specificity of CT and MRI, and risks and outcomes of missed fracture were derived from published clinical trials. Costs of imaging, lost worker productivity, and surgical costs of non-union surgery were estimated based on the literature (Table 1).

Results

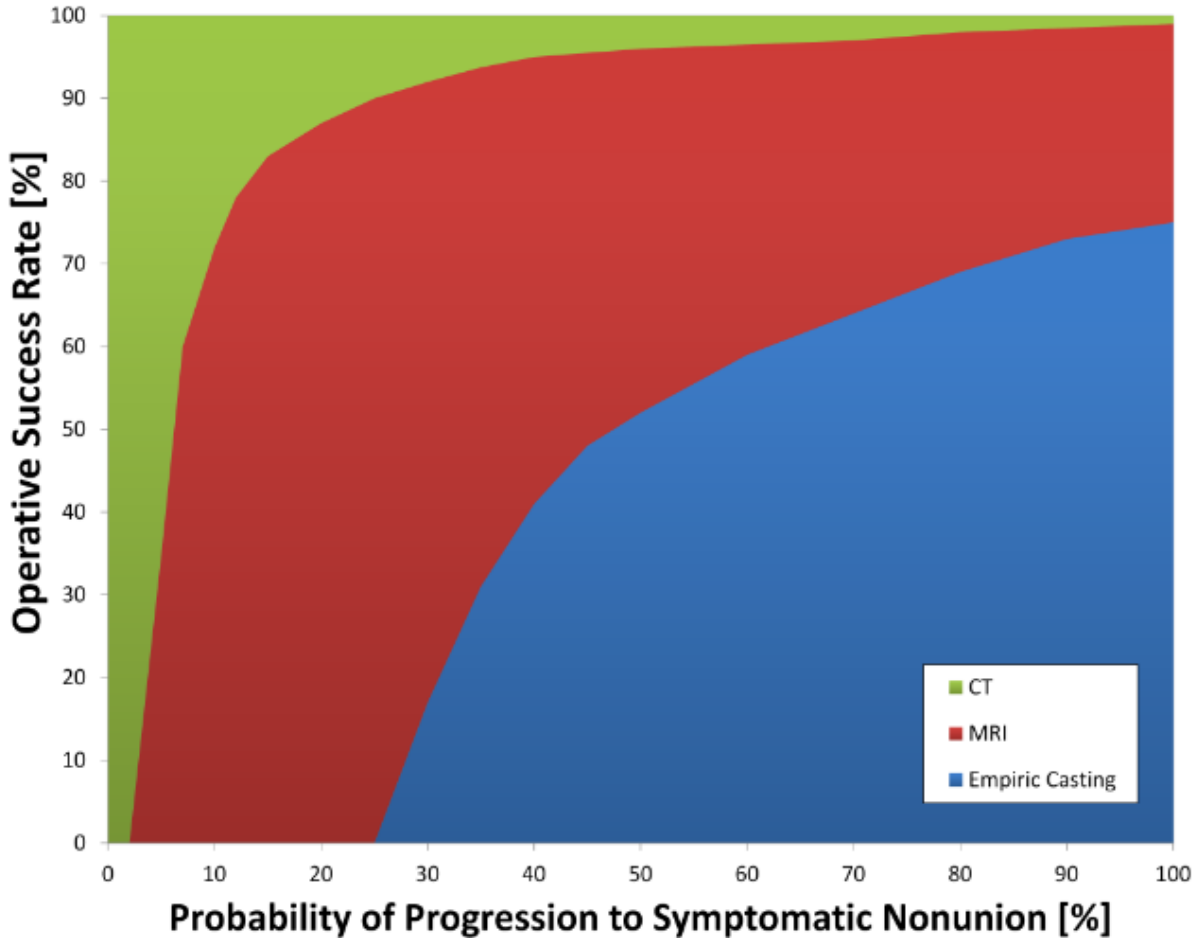
Advanced imaging was dominant over empiric immobilization with lower costs (savings of approximately $832 per case) and slightly better expected health outcomes. CT was more cost-effective than MRI based on average published diagnostic performance. However, if MRI was greater than 5% more sensitive than CT, or MRI was less than 17% more expensive, MRI would become more cost effective. Advanced imaging would have to increase in cost to over $2,000 or decrease in sensitivity to below 35-40% for empiric casting to be cost effective. The cumulative risk of both a) going on to nonunion and b) nonunion surgery failing needs to be greater than 14% for CT, and 25% for MRI in order for casting to be a cost-effective strategy (Figure 1).

Summary Points

- For patients with suspected scaphoid fractures but negative initial x-rays, immediate advanced imaging is dominant over empiric casting and follow-up radiography, resulting in lower costs and better health outcomes
- CT is more cost effective than MRI using the most commonly reported performance values
- The decision to use CT versus MRI is a function of individual institutional costs and test performance characteristics.

Table 1 – Input Values Used to Calculate the Cost-Effectiveness of Diagnostic Imaging for Occult Scaphoid Fractures

Description	Value		
	Base Case	Low	High
Costs [$]			
ED immobilization	115	50	150
Follow-Up clinic visit	165	60	280
X-ray of wrist	54	40	70
Scaphoid protocol CT	374	300	500
Scaphoid protocol MRI	521	350	600
Cost of ORIF for scaphoid nonunion	5,600	3,600	9,000
Value of a day of missed work	179	73	752
Missed work [days]			
Extra work missed if immobilized	5	1	10
Extra missed work after operation for scaphoid nonunion	45	30	45
Clinical probabilities			
Chance of scaphoid fracture given concerning exam, negative XR	0.15	0.05	0.26
Sensitivity of CT for acute scaphoid fracture	0.93	0.83	0.98
Specificity of CT for acute scaphoid fracture	0.99	0.96	1.00
Sensitivity of MRI for acute scaphoid fracture	0.96	0.91	0.99
Specificity of MRI for acute scaphoid fracture	0.99	0.96	1.00
Increased incidence of nonunion for missed, untreated fracture	0.15	0.02	0.25
Probability of success of surgical fixation of nonunion	0.90	0.90	1.00
Health Utility States			
Wrist arthritis	0.784	0.726	0.842
Short arm immobilization	0.759	0.697	0.821
Age of base case	30	25	50
Life expectancy	80	70	90


Operative Success Rate [%]
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Probability of Progression to Symptomatic Nonunion [%]
CT
MRI
Empiric Casting

Paper 05: A Novel Telemedicine System for Care of Statewide Hand Trauma

Evaluation/Diagnosis,Prognosis/Outcomes, Hand and Wrist, General Principles
Level 3 Evidence

John Bracey, MD
Mark Tait, MD

Hypothesis

Implementation of a telemedicine system for the care of hand trauma in Arkansas will improve patient care, decrease the number of unnecessary transfers and minimize costs.

Methods

In association with the Arkansas Trauma Communication Center (ATCC), a novel telemedicine system was instituted for the care of hand trauma in Arkansas. The Tele-hand program created a telemedicine call schedule including 7 fellowship-trained hand surgeons. Using a tablet computer, live audio-video feeds of hand injuries from 70 emergency departments across Arkansas were available via a secure internet connection. Relevant imaging was also available for review. The Tele-hand program allowed on-call physicians to evaluate injuries in real time and to make recommendations for patient care including local care, transfer for general orthopedic care, or transfer for hand specialist care.
Using the ATCC database, we reviewed hand trauma data from the first year of the program (2014) and compared it to data from the year prior (2013). Data collection from both years included the number of hand consults and need for transfer. From the 2014 data, we also recorded the use of telemedicine, type of transfer and time to disposition. A chi-squared test was used to compare the rate of transfer prior to and after starting the Tele-hand program.

Results

During 2013 (pre Tele-hand), there were 263 hand traumas identified in the ATCC database. 191 (73%) injuries required transfer to a higher level of care while 72 (23%) were managed locally. In the first year of the Tele-hand program, a total of 331 hand injuries were identified. 298 (90%) resulted in telemedicine consultation with 65% (195) utilizing live video encounters. The remaining 104 consults (35%) were managed by telephone only. After Tele-hand consultation, local management was recommended for 164 injuries (55%) while transfer was recommended for 134 (45%). 72 patients were transferred to a hand surgeon whereas 62 were transferred for general orthopedic care. The average time to disposition after consultation was 54 minutes.

After implementation of the Tele-hand program, there was a significant decrease in the rate of transfer for hand injuries ($p = 0.004$).

Summary

- The Tele-hand program was well utilized providing patients with access to fellowship trained hand surgeons including many regions where subspecialty care is not typically available.
- Using the Tele-hand program, there was a significant decrease in the number of unnecessary hospital transfers thereby minimizing cost.
- This data suggests that the Tele-hand program provided efficient patient disposition and care.

Paper 06: Postural Stability in Older Adults with a Distal Radius Fracture

Evaluation/Diagnosis, Therapy/Rehabilitation, Patient Education, Hand and Wrist
Level 3 Evidence

Craig Louer, MD
Sean Boone, BA
Andre Guthrie, BA
Ryan Patrick Calfee, MD
Lindley Wall, MD

Hypothesis

Falls are the most common cause of non-fatal injury and hospital admission in older adults with associated direct medical costs approaching $30 billion annually in the United States. While low bone mineral density is a recognized risk factor for distal radius fracture, the impact of impaired balance is poorly understood. The goal of this study was to compare postural stability between older adults with and without a prior distal radius fragility fracture.

Methods

This case-control study enrolled adults 65 years or older at a single tertiary institution. The case cohort was comprised of 23 patients treated for a low-energy distal radius fracture in the prior 6-24 months. Twenty-three age and sex-matched control participants, without prior fragility fracture, were selected from the same clinic population. All participants completed a validated balance assessment on the PROPRIO 5000. This device measures displacement of an individual's center of mass while they stand on its multi-directional moving platform. Dynamic Motion Analysis (DMA) scores ranging from 0-1440 are produced, with lower scores indicating better postural stability (less variation of a subject's center of mass). Participants also completed validated questionnaires for general health quality (EQ-5D) and physical activity (PASE), and comprehensive health and demographic information including treatment for compromised balance or osteoporosis. Statistical analysis compared data between cases and controls using either Student's t-test or Mann-Whitney U depending on each variable's distribution.

Results

There were no significant differences in age, sex, BMI, physical activity score, or perceived general health between participants with or without prior distal radius fracture (Table 1). The case cohort with prior fracture demonstrated poorer balance with higher DMA scores (933 vs. 790; P=0.008; Figure 1). The fracture group also reported more falls over the past 12 months (median: 1.0 vs. 0.0; P=0.04). Nineteen (83%) of patients in the fracture cohort reported having

DEXA scans in the last five years, while only two of them (9%) had ever been referred for balance training with physical therapy.

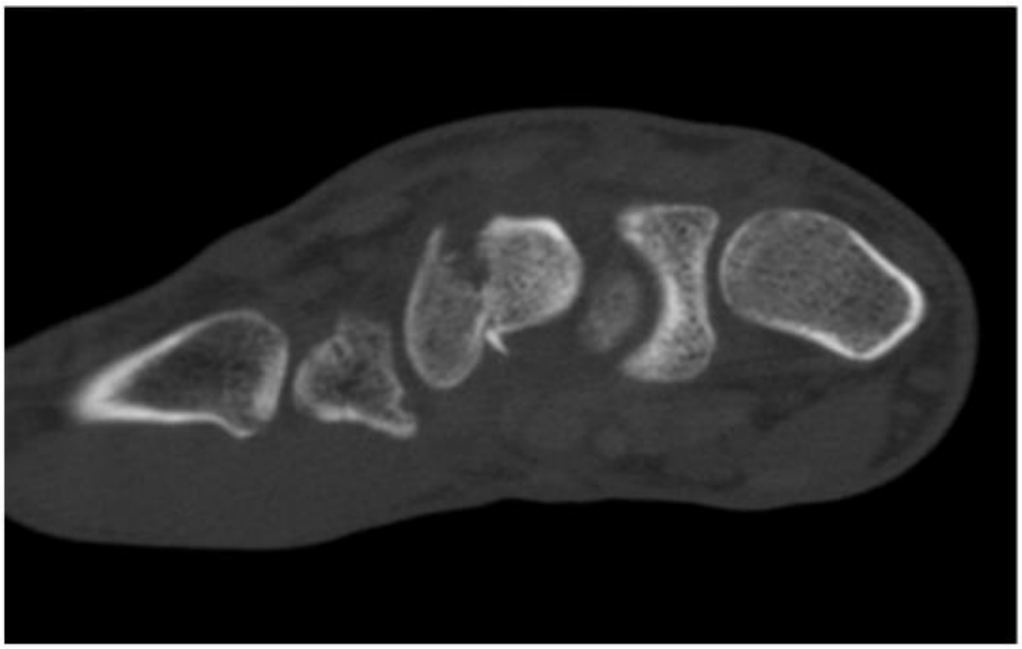
Summary Points

- Older adults who sustain low energy distal radius fractures demonstrate impaired balance and a higher incidence of falls compared to individuals of similar age that have not suffered fragility fractures.
- Following distal radius fracture, older adults may benefit from attempts to improving postural stability.
-

Grade (hands)	Hypoechoic lesions	Slightly Hyperechoic	Strongly Hyperechoic
Control(32)	32		
Normal(1)	1		
Mild (5)	2	3	
Moderate (25)	2	18	5
Severe (11)		3	8

Figure 1B

CT scan of the same patient showing displacement and increased intrascaphoid angle not recognized on initial radiographs



Reference 1: Stevens JA, Corso PS, Finkelstein EA, Miller TR. The costs of fatal and non-fatal falls among older adults. Inj Prev J Int Soc Child Adolesc Inj Prev. 2006;12(5):290-295.
Reference 2: Tromp AM, Pluijm SM, Smit JH, Deeg DJ, Bouter LM, Lips P. Fall-risk screening test: a prospective study on predictors for falls in community-dwelling elderly. J Clin Epidemiol. 2001;54(8):837-844.
Reference 3: Broglio SP, Sosnoff JJ, Rosengren KS, McShane K. A comparison of balance performance: computerized dynamic posturography and a random motion platform. Arch Phys Med Rehabil. 2009;90:145-150.
Reference 4: Cho YJ, Gong HS, Song CH, Lee YH, Baek GH. Evaluation of physical performance level as a fall risk factor in women with a distal radial fracture. J Bone Jt Surg Am. 2014;96:361-365.

Paper 07: The Vascular Anatomy Relevant to Distal Biceps Tendon Repair

Anatomy, Basic Science, Elbow and Forearm
N/A - Not a clinical study

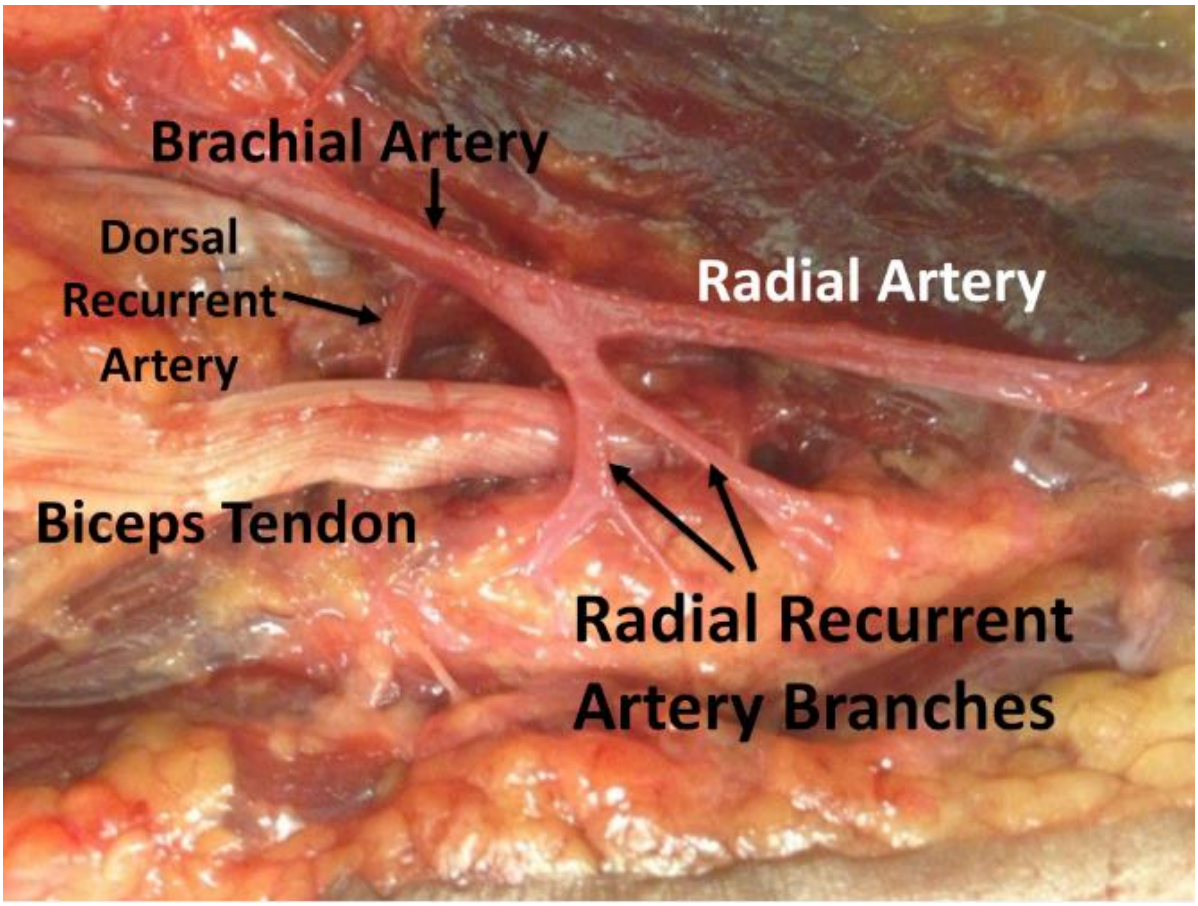
David Zeltser, MD
Robert J. Strauch, MD

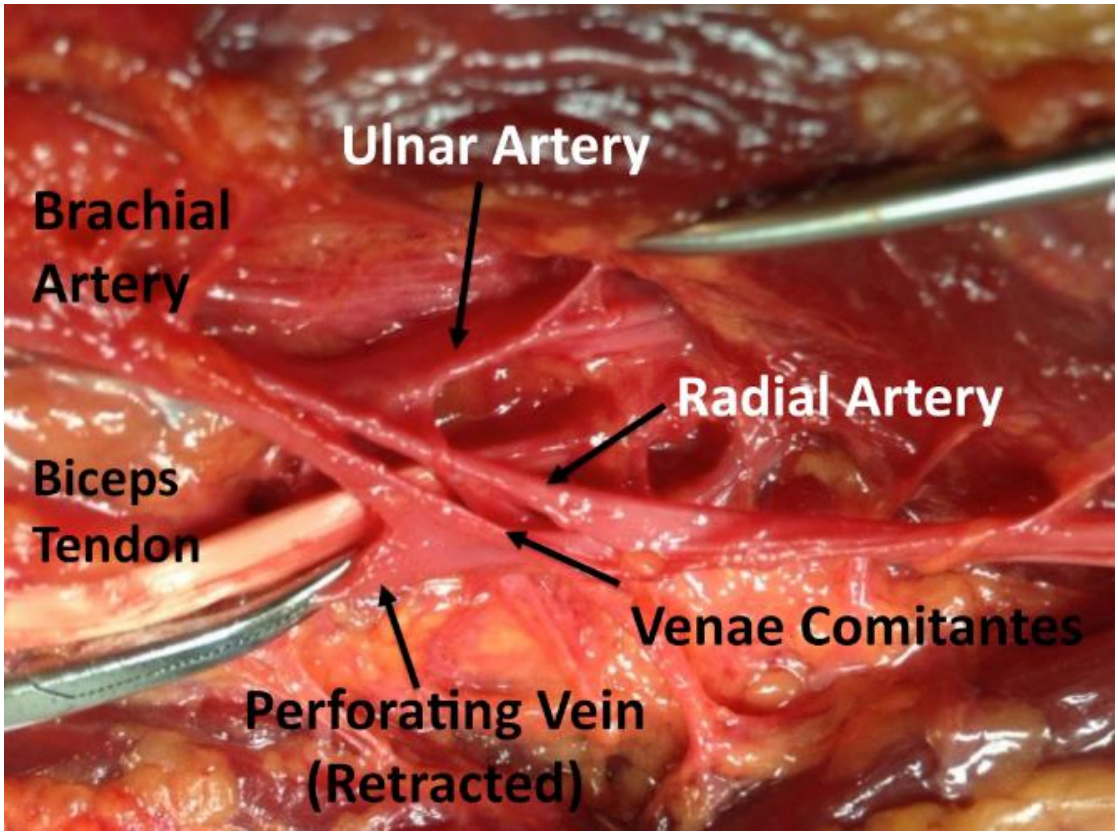
Hypothesis
The goal of this study is to describe the vascular anatomy relating to distal biceps tendon repair.

Methods
The antecubital regions of seventeen cadaveric upper extremities were dissected using 2.5x loupe magnification to identify the bicipital tuberosity of the radius, the brachial artery, the radial artery and its recurrent branches, and nearby venous branches traversing the distal biceps tendon. Ten were fresh-frozen, above-elbow specimens; the remainder were preserved specimens. Using digital calipers, we measured the position of each vascular structure relative to the most proximal aspect of the tuberosity along the proximal-distal axis as well as the volar-dorsal axis, with elbows extended and forearms supinated.

Results
The most common pattern (13/17 specimens) was a single radial recurrent artery (RRA) crossing volar to the tendon at a mean of 4 mm proximal to the bicipital tuberosity (range: 19 mm proximal to 4 mm distal) and positioned 15.4 mm (mean) volar to the tuberosity (range: 9.4-25 mm). The RRA bifurcated after 2 to 9 mm in six arms with a single RRA bifurcation. In the others, two or three RRAs were seen. In eight, an additional small recurrent branch originating from the brachial artery traveled beneath (dorsal to) the intact biceps tendon 16 mm (range 15.6-16.4 mm) proximal to the RRA.
The brachial and radial arteries were always ulnar to the tendon and the ulnar artery was ulnar and dorsal to the radial artery. The brachial artery bifurcation occurred 10.8 mm (mean) proximal to the tuberosity (range: 0-23 mm). Two arms demonstrated a high brachial artery bifurcation. In one, the main recurrent branch originated from the ulnar artery and anastomosed with a small branch off the radial artery.
The venae comitantes of the RRA's branches and radial and ulnar arteries formed a complex network with veins crossing volar to the biceps tendon and connecting to a perforating branch to the superficial veins. There were usually 3 (range 2-4) clinically significant transverse veins. Their average position was 0.2 mm proximal to the tuberosity (range: 18 mm proximal to 10 mm distal). Crossing veins were 16 mm (mean) volar to the tuberosity (range 10-24 mm). Although characteristically volar to the RRA, a dorsal crossing was identified in four cases.

Summary
The vascular anatomy relating to distal biceps tendon repair is important to surgeons performing acute or chronic distal biceps tendon repair. The vascular anatomy is variable and radial recurrent arteries occasionally travel dorsal to the biceps tendon.




Ulnar Artery
Brachial Artery
Radial Artery
Biceps Tendon
Venae Comitantes
Perforating Vein (Retracted)

Paper 08: Baseline Characteristics of the Median Nerve on Ultrasound Examination

Evaluation/Diagnosis, Anatomy, Hand and Wrist, Nerve, Diseases and Disorders
Level 2 Evidence

Tiffany Pan, MD
RJ White, BS
Caiyan Zhang, MS
William C. Hagberg, MD
Joseph Imbriglia, MD
John Fowler, MD

Hypothesis
Previous studies using musculoskeletal ultrasound for the diagnosis of carpal tunnel syndrome have reported on relatively small series of patients and in Asian or European populations. It is possible that U.S. populations have different baseline median nerve characteristics, thus affecting the sensitivity and specificity of ultrasound as a diagnostic test. The purpose of this study is to define baseline characteristics of the median nerve in a U.S. population.

Methods
Consecutive patients without history of carpal tunnel release were recruited from an upper extremity practice. Demographic information including age, gender, ethnicity, and hand dominance as well as clinical information including height, weight, and presence of diabetes were recorded. All study subjects were evaluated using the CTS-6 diagnostic questionnaire as a standard diagnostic tool. A score of =12 was considered a positive diagnosis of carpal tunnel syndrome. Ultrasound examination was performed on both wrists of all subjects using a 13-6 MHz linear array transducer. Statistical analysis was then performed using correlations, independent T-tests, and logistic regression to determine the relationship between median nerve size and CTS-6 score.

Results
A total of 349 wrists underwent examination. The mean median nerve CSA was significantly larger ($p<0.001$) for patients with a positive CTS-6 (mean = 11.16, SD 2.51) compared to patients with a negative CTS-6 (mean 6.91, SD 2.06). There was a significant correlation (0.527, $p<0.001$, $n=349$) between CSA and CTS-6 score (Table 1). This remained true when hands were separated by dominant or non-dominant status. Logistic regression was performed to determine the most appropriate cutoff CSA size with respect to a CTS-6 score =12 as the clinical standard for

diagnosis. Sensitivity and specificity at a CSA cutoff of 10mm2 was 80% and 88%, respectively. Accuracy of ultrasound in this study was 87.9% (Table 2).

Summary Points

- There is a significant difference in mean median nerve CSA between patients with and without carpal tunnel syndrome as diagnosed by a CTS-6
- Median nerve CSA shows a statistically significant positive correlation with CTS-6
- A cross-sectional area of 10mm2 was confirmed as the optimal cutoff with the highest sensitivity and specificity
- US is a sensitive, specific, and accurate test for confirmation of a clinical diagnosis of CTS in a large series of patients

Median Nerve CSA in the Presence or Absence of CTS

CSA	Presence of CTS[1]	Absence of CTS[2]	Presence vs Absence of CTS	Association
	Mean (SD)	Mean (SD)	t-test	Corr
Combined	11.16 (2.51) (n = 35)	6.91 (2.06) (n = 314)	11.60** (df = 347, p<0.001)	0.527** (n = 349, p<0.001)
Dominant Hand	11.09 (2.98) (n = 22)	7.14 (2.11) (n = 153)	7.77** (df=174, p<0.01)	0.575** (n = 175, p<0.01)
Non-Dominant Hand	11.31 (1.80) (n = 13)	6.75 (2.03) (n = 161)	7.84** (df=173, p<0.01)	0.599** (n = 174, p<0.01)
	[1]CTS-6 score ≥12, [2]CTS-6 score <12, *p<0.05, **p<0.01			

Sensitivity, specificity, and accuracy of ultrasound

Parameter	Combined	Dominant Hand	Non-Dominant Hand
AUC	89.88%	86.22%	94.90%
Youden Index	68.29%	64.29%	74.12%
Sensitivity	80.00%	77.27%	84.62%
Specificity	88.29%	87.01%	89.51%
Accuracy	87.85%	85.96%	89.66%

Paper 09: Mini-Flouroscopy Radiation Exposure: Does Flouroscope Position Make a Difference?

Treatment, Surgical Technique, Basic Science, General Principles
N/A - Not a clinical study

Hassan Shah, MD
C. Edward Hoffler, II, PhD MD
Nayoung Kim, BS
Asif Ilyas, MD

Hypothesis

Previous studies have examined the potential risk of radiation exposure to the surgeons' various anatomic regions. However, little is known about how the position of the fluoroscope itself relative to the operative field effects potential radiation exposure to the surgeon. We examined which mini-flouroscopy position puts the surgeon at the highest risk for radiation exposure during a distal radius surgery using 3 different positions: standard vertical, inverted vertical, and horizontal.

Methods

An anthropomorphic model was fit with unprotected thermoluminescent dosimeters placed on its eyes, thyroid, chest, groin and hand. The model was positioned in a standardized fashion at a hand table with its hands flanking a volar plated distal radius sawbone. Mini-flouroscopy positions and settings were standardized. The mAs settings were fixed based on kVp selection. The model was scanned for 15 continuous minutes at each of the three positions. Five dosimeter exposures were recorded from each three positions and analyzed.

Results

The horizontal position yielded the highest average dose of radiation (51.3mrem) ($p<0.05$), followed by the inverted (38.4mrem) and the standard vertical (39.1mrem) positions. Among anatomic positions, the hands received the highest average dose (106.5mrem) ($p<0.05$), followed by all the other anatomic sites including the eyes (21.7mrem), groin (20.0mrem), thyroid (19.7mrem), and chest (19.3mrem) on average, irrespective of flouroscopy position.

Summary Points

- Placing the fluoroscope in the horizontal position had the statistically highest radiation exposure to the surgeon model.

- The model's hands statistically received the greatest radiation exposure compared to the model's other anatomic locations.
- We recommend surgeons taking this information into account when positioning the fluoroscope and to consider minimizing horizontal positioning and taking precautions against hand radiation exposure.

Paper 10: Complications and Comorbidities in Syndactyly Reconstruction: National Trends from 2012 and 2013

Prognosis/Outcomes, Congenital and Pediatric Problems
N/A – Not a clinical study

Rajiv Parikh, MD
Ketan Sharma, MD, MPH
Grant M. Kleiber, MD

Hypothesis

Current literature regarding syndactyly reconstruction utilizes only single-institution retrospective data. We hypothesize the assessment of a large, prospective national database will improve our understanding of risk factors for 30-day complications after syndactyly reconstruction and provide novel information regarding comorbid conditions in this population.

Methods

The American College of Surgeons National Surgical Quality Improvement Program Pediatric (NSQIP Peds) is a quality improvement database that collects demographic data, perioperative risk factors, and 30-day postoperative morbidity outcomes across 56 institutions. Patients undergoing syndactyly reconstruction were extracted from the NSQIP Peds 2012 and 2013 databases using CPT codes 26560, 26561, or 26562. Patient characteristics, intra-operative variables and potential risk factors were analyzed for any association with adverse 30-day postoperative outcomes. Univariate and multivariate logistical regression analyses were performed.

Results

528 patients were included. There were 59 (11%) reconstructions with skin flaps, 359 (68%) with skin flaps and grafts, and 110 (21%) complex reconstructions. The average age was 2.61 years, 64% were male, and 90% were outpatient procedures. Neurological, gastrointestinal, pulmonary, cardiac, nutritional, and hematological comorbidities were present in 14%, 8.0%, 7.4%, 6.8%, 3.4%, and 0.9%, of patients, respectively. 59 patients (11%) had multiple comorbidities (=2). Additional congenital limb anomalies were present in 13%; 73 patients (14%) had concomitant non-limb congenital malformations, most commonly craniofacial (9.3%), genitourinary (1.5%), and spinal (0.5%) anomalies. Average operative time was 134 minutes. The overall 30-day complication rate was 2.8%; there were 10 superficial and 1 deep infection, and 4 unplanned readmissions. Neurological comorbidities (p=0.03), hematological disorder (p=0.05), and inpatient status (p=0.05) were risk factors for complications. On multivariate analysis,

neurological comorbidities (p=0.03) was an independent predictor of complications. Complex syndactyly (p<0.01), operative time (p<0.01), inpatient status (p<0.01), gastrointestinal (p<0.01) and neurological (p<0.01) comorbidities, multiple comorbidities (p=0.02), associated non-limb congenital anomalies (p<0.01), associated craniofacial malformations (p<0.01) and ASA class (p<0.01) were associated with increased hospital stay.

Summary

- The overall complication rate in syndactyly reconstruction is low (2.8%), with wound complications most prevalent; however, the risk for complications is significantly elevated in patients with hematological comorbidities, neurological comorbidities, and inpatient status.
- Patients with syndactyly had a high percentage of associated congenital limb anomalies (13%), craniofacial malformations (14%), and neurological comorbidities (14%).
- Large, prospective national databases (NSQIP-Peds) provide an unparalleled opportunity in congenital hand surgery to identify comorbidities and risk factors associated with morbidity for targeted improvement through preoperative risk stratification and evidence-based interventions.

Paper 11: Regional Ulnar Nerve Kinematics: Simple Decompression versus Anterior Subcutaneous Transposition in Cubital Tunnel Syndrome

Treatment, Surgical Technique, Therapy/Rehabilitation, Anatomy, Elbow and Forearm, Nerve, Diseases and Disorders
Level 4 Evidence

Ian Foran, MD
Kenneth Vaz, MD
Eric Hetnzen, MD, PhD
Sameer B. Shah, PhD

Hypothesis

In patients with cubital tunnel syndrome (CTS), we hypothesized that simple decompression would result in nerve strains that are greatest with elbow flexion and at the elbow articular region. In contrast, we hypothesized that anterior subcutaneous transposition would result in comparatively lower nerve strains with elbow flexion, higher strains with elbow extension, and strains distributed evenly throughout the exposed nerve.

Methods

Approval by our institutional review board was obtained for the study. Five male patients, aged 36-61, were diagnosed with CTS by clinical and electrodiagnostic exams. 10-15cm of the ulnar nerve was exposed and a standard simple decompression was performed. Twelve 6-0 black sutures were placed in the exposed epineurium, centered at the medial epicondyle. Photographs were taken with a digital camera with the elbow and wrist in 4 configurations (Figure 1). Scale was set with a surgical ruler. Subcutaneous transposition was subsequently performed and images acquired as above. Distances between sutures were quantified using ImageJ (NIH, MD, USA). Strain was calculated using a baseline of suture distances found in the ulnar nerve in joint configuration 1 following simple decompression. Average overall strain and regional strain were calculated proximal to, at, and distal to the elbow articular region. Two two-way repeated-measure ANOVAs were used to compare strains using factors of surgical intervention and joint configuration, and surgical intervention and regional strain, respectively. Post-hoc comparisons were made using Tukey's HSD with $a = 0.05$.

Results

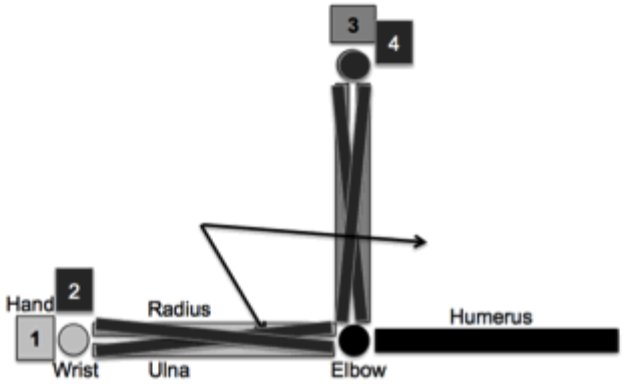
Results are summarized in Figure 2. Simple decompression increased articular strain compared to proximal strain with elbow flexion (Figure 2C,D). Anterior transposition reduced average strain during elbow flexion compared to elbow extension (Figure 2A). Anterior transposition also led to relatively increased proximal region strain compared with articular and distal strain with the

elbow extended (Figure 2B), but shifted strain distally with elbow flexion (Figure 2C,D). Compared with simple decompression, anterior transposition resulted in reduced articular strain (Figure 2C) as well as reduced average strain with elbow flexion with or without wrist extension/pronation (Figure 2C,2D). These findings were statistically significant.

Summary

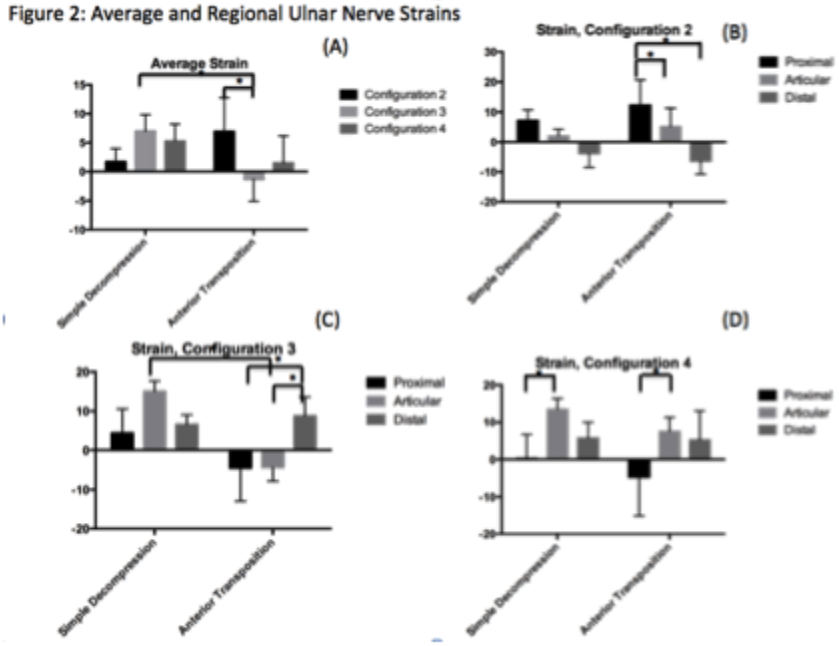
In patients with CTS, anterior subcutaneous transposition decreases average and articular region strain with elbow flexion more than simple decompression. In contrast, anterior transposition increases average strain with elbow extension. These findings corroborate prior cadaveric data in normal elbows and highlight specific anatomic regions and joint configurations of increased nerve traction post-surgery. These results may inform post-operative immobilization and physical therapy protocols.

Figure 1



Position	Elbow	Wrist
1	Extended (0-10°)	Neutral
2	Extended (0-10°)	Extended (80°) + Pronation
3	Flexed (90°)	Neutral
4	Flexed (90°)	Extended (80°) + Pronation

Figure 2: Average and Regional Ulnar Nerve Strains



Reference 1: Zlowodzki M, et al. JBJS 2007, 89: 2591-8.
Reference 2: Ochi K, et al. J Hand Surg Eur Vol. 2013, 38:474-480.
Reference 3: Hicks D, Toby EB. J Hand Surg Am. 2002, 27: 1026-31.
Reference 4: Toby EB, Hanesworth D. J Hand Surg AM. 1998, 23: 992-7.
Reference 5: Wright TW, et al. J Hand Surg Am. 2001, 26: 655-62.
Reference 6: Gelberman RH, et al. JBJS Am. 1998, 80: 492-501.

Paper 12: A Critical Appraisal of Vascularized Bone Grafting for Scaphoid Nonunion: A Systematic Review of Surgical and Functional Outcomes

Treatment, Surgical Technique, Prognosis/Outcomes, Hand and Wrist
Level 3 Evidence

Ram Alluri, MD
Hyuma Leland, MD
Matthew L. Iorio, MD
Alidad Ghiassi, MD
Joseph Carey, MD
Ketan M. Patel, MD

Hypothesis

Scaphoid nonunion may occur up to 15% of the time following scaphoid fixation and/or occult fracture.(1-5) Vascularized bone grafting (VBG) has been the mainstay treatment for these complex scenarios. We performed a systematic review to critically evaluate outcomes following VBG for patients with scaphoid nonunion.

Methods

The MEDLINE and PubMed databases were queried for the use of VBG in the treatment of scaphoid nonunion; 393 articles were identified. Studies were excluded based on predefined criteria. Analysis included operative techniques and postoperative outcomes. A subgroup analysis comparing location of the vascularized graft, pedicled versus free technique, K-wire versus screw fixation and primary versus revision procedures was performed. A Student's t-test and analysis of variance weighted by sample size with control for age and gender were used for comparative analysis with $p = 0.05$ considered statistically significant.

Results

Forty-six studies involving 863 patients met inclusion/exclusion criteria. The mean study size was 18.7 patients (range 2 to 111 patients) with an average follow-up of 32.7 months (range 4 to 89 months). The average patient age was 28.2 years old. The mean duration of nonunion before vascularized bone grafting was 32.7 months (range 7 to 103 months). On average 88.9% of all VBG resulted in union at 14.5 weeks and 90% of patients returned to work/sport by 16 weeks. Post-operatively, significant improvements were seen in clinical and radiographic outcomes (Table 1). Subgroup analysis demonstrated VBG to the proximal scaphoid resulted in poorer Mayo scores and lower percent return to function compared to VBG for all regions of the

scaphoid (Table 2). Pedicled VBG resulted in improved ROM compared to free VBG while all other clinical and radiographic outcomes remained similar between these two techniques (Table 2). K-wire fixation resulted in an earlier and higher percentage of scaphoid union compared to screw fixation (Table 2). There were no significant differences in clinical or radiographic outcomes when VBG was done as a primary or revision procedure for scaphoid nonunion (Table 2). Fifty-two percent of studies reported complication rates affecting 87 of 521 eligible patients. Eleven patients (2%) experienced major complications and 76 patients (15%) experienced minor complications.

Summary

VBG is a valuable tool to re-establish hand functionality following scaphoid nonunion.
The technique, type of fixation and location of grafting can affect postoperative outcomes.
Similar outcomes can be expected in both primary and revision cases.
Significant improvements in patient-centered outcome metrics can be appreciated following scaphoid reconstruction.

Table 1. Clinical Results of all Vascularized Bone Grafting for Scaphoid Nonunion

	Number of Studies Reporting Outcome (%)	Number of Patients	Postoperative Measurement	Percentage Improvement†	P-value
DASH Score	5 (11%)	99	12.4 (5-21)	91.2% (78-112%)	0.013
Mayo Wrist Score	12 (26%)	257	84.3 (74-92)	60.2% (33-100%)	0.001
Flexion *(degrees)*	28 (61%)	527	52.4 (35-72)	19.5% (-22%- 100%)	0.023
Extension *(degrees)*	28 (61%)	527	53.7 (34-86)	23.0% (-19%-89%)	0.004
Radial Deviation *(degrees)*	21 (46%)	400	14.2 (5-20)	41.9% (-20-122%)	0.007
Ulnar Deviation *(degrees)*	19 (41%)	378	27.8 (20-38)	46.0% (-14-200%)	0.068
Grip Strength *(% Contralateral)*	29 (63%)	504	83.4% (60-99)	29.7% (4-80%)	0.001
Grip Strength (kg)	12 (26%)	191	38.3 (28-50)	42.4% (-3-94%)	0.004

†Relative to preoperative values

Table 2. Clinical and Radiographic Outcomes of Vascularized Bone Grafting. Subgroup Analysis.

	Proximal	All Regions	P-value	Pedicled	Free	P-value	K-wire	Screw	P-value	Primary	Revision	P-value
Dash	-------	----	n/a	-----	-----		----	----	----	----	----	----
% Improvement	-------	----	n/a	-----	-----		----	----	----	----	----	----
MAYO	78.79 (2.56)	88.20 (1.20)	0.016*	86.30 (1.41)	82.93 (5.01)	0.17	82.56 (2.36)	83.56 (8.90)	0.92	90.06 (1.90)	80.64 (4.38)	0.16
% Improvement	23.19 (77.98)	80.17 (37.36)	0.70	----	-----		----	----	----	----	----	----
Flexion	49.53 (3.18)	52.91 (2.41)	0.41	54.80 (2.06)	45.58 (2.96)	0.023*	48.63 (2.88)	40.60 (10.78)	0.48	58.11 (2.73)	45.23 (6.16)	0.095
% Improvement	16.69 (11.41)	17.47 (6.93)	0.96	27.02 (5.29)	-18.46 (12.76)	0.0074*	17.94 (10.62)	17.44 (72.11)	0.99	23.25 (7.64)	7.58 (16.18)	0.42
Extension	50.92 (4.58)	53.85 (3.46)	0.62	58.82 (2.81)	42.37 (4.03)	0.004*	45.28 (3.26)	47.71 (12.23)	0.85	59.51 (4.23)	51.47 (9.55)	0.47
% Improvement	23.44 (11.68)	20.00 (7.09)	0.81	28.02 (5.08)	-2.60 (12.24)	0.043	20.48 (7.82)	-31.53 (53.13)	0.42	24.56 (7.95)	29.81 (16.83)	0.79
Grip Strength (kg)	38.29 (4.74)	39.94 (1.48)	0.74	41.06 (1.48)	35.68 (3.74)	0.23	39.76 (1.41)	35.28 (6.18)	0.53	39.96 (2.67)	39.74 (5.54)	0.97
% Improvement	35.88 (25.92)	46.29 (8.76)	0.72	75.36 (24.86)	-22.61 (92.91)	0.34	36.31 (13.17)	31.64 (34.33)	0.92	35.41 (9.84)	62.06 (20.56)	0.33
% Contralateral	89.83 (5.59)	83.18 (2.49)	0.29	86.05 (2.48)	81.14 (5.78)	0.46	82.55 (1.89)	88.39 (4.90)	0.33	86.36 (3.63)	83.98 (8.22)	0.80
Time To Union (weeks)	15.16 (2.38)	13.51 (1.09)	0.54	13.50 (1.08)	13.67 (3.10)	0.96	12.54 (0.99)	22.97 (3.41)	0.021*	12.00 (1.42)	17.15 (3.28)	0.19
% Union	90.00 (5.74)	85.36 (3.22)	0.49	85.42 (2.97)	91.60 (6.15)	0.38	94.28 (1.61)	82.38 (5.04)	0.049*	92.86 (3.75)	82.04 (7.75)	0.24
% Return to Function	71.47 (6.91)	93.24 (1.93)	0.009*	90.40 (2.66)	97.22 (8.06)	0.44	96.86 (2.88)	81.23 (9.41)	0.18	91.76 (3.80)	81.98 (7.30)	0.26

Numbers in table are adjusted mean, adjusted (SEM)

Reference 1: Herbet TJ, Fisher WE. Management of the fractured scaphoid using a new bone screw. J Bone Joint Surg. 1984; 66B: 114-123.

Reference 2: Merrell GA, Wolfe SW, Slade JF III. Treatment of scaphoid non-unions: quantitative meta-analysis of the literature. J Hand Surg. 2002; 27A: 685-691.

Reference 3: Pao VS, Chang J. Scaphoid nonunion: diagnosis and treatment. Plast Reconstr Surg. 2003; 112: 1666-1679.

Reference 4: Steinmann SP, Adams JE. Scaphoid fractures and nonunions: diagnosis and treatment. J Orthop Sci. 2006; 11: 424-431.

Reference 5: Trumble TE, Salas P, Barthel T, Robert KQ III. Management of scaphoid nonunions. J Am Acad Orthop Surg. 2003; 11: 380-391.

Paper 13: Do Children with C5-C6 Birth Brachial Plexus Palsy Have Normal Hand Function?

Evaluation/Diagnosis, Prognosis/Outcomes, Hand and Wrist, Congenital and Pediatric Problems
Level 4 Evidence

Derek Bernstein, MD
Gloria R. Gogola, MD

Hypothesis

Children with an isolated C5-C6 birth brachial plexus palsy (BBPP) are presumed to have normal ipsilateral hand function; however, clinical observation suggests atypical bimanual hand use. We hypothesize that when specifically testing dexterity, the ipsilateral hand would show deficits while the contralateral hand would resemble that of typically-developing children.

Methods

Data from thirty-two pediatric patients with isolated C5-C6 BBPP were reviewed, including age, gender, prior shoulder surgery, modified Mallet score, and FDT (Functional Dexterity Test) score. Patients with primary nerve surgeries were excluded. The FDT is a timed 16-hole pegboard test with pediatric norms that assesses tripod pinch and in-hand manipulation. Patients rated their affected hands as good, medium, or poor helpers. The FDT speeds of each hand were evaluated against age-matched norms. Kendall's tau b was employed to correlate FDT performance with self-assessment of ipsilateral hand function and the modified Mallet score. Student's T-test was employed to determine if FDT speed was affected by gender or prior shoulder surgery.

Results

The average patient age was 8.5 years (range: 3-17) with an equal gender ratio. BBPP affected the left side in nine patients (all right-hand-dominant), and the right side in twenty-three patients (nineteen were left-hand-dominant). Twelve patients had no prior surgeries. Twenty patients had undergone secondary procedures about the shoulder. The average modified Mallet aggregate was 20.7 (range: 15-24). Two-thirds of subjects rated the affected hand as a medium helper. Patients with C5-C6 BBPP performed worse than age and hand dominance-matched norms with the affected ($p=0.0003$) and unaffected hands ($p=0.0001$). This discrepancy worsened bilaterally with age. There was no significant difference between affected and unaffected hands ($p=0.456$); typically-developing children demonstrate a consistent difference between dominant and non-dominant hands throughout growth. FDT speed was not influenced by gender ($p=0.631$) or prior surgical intervention ($p=0.563$). There was no correlation with self-assessment of the affected hand ($p=0.861$) or modified Mallet aggregate score ($p=0.416$).

Summary Points

- Children with upper plexus lesions demonstrate diminished dexterity with both the ipsilateral and contralateral hands.
- These deficits increase with age, suggesting that these children progress slower than typically-developing peers.
- The severity of shoulder impairment (modified Mallet score, shoulder surgery) did not correlate with hand dexterity.
- Self-perception did not correlate with objective clinical measures.
- This study highlights the need to address bilateral hand function in the treatment of children with C5-C6 BBPP.

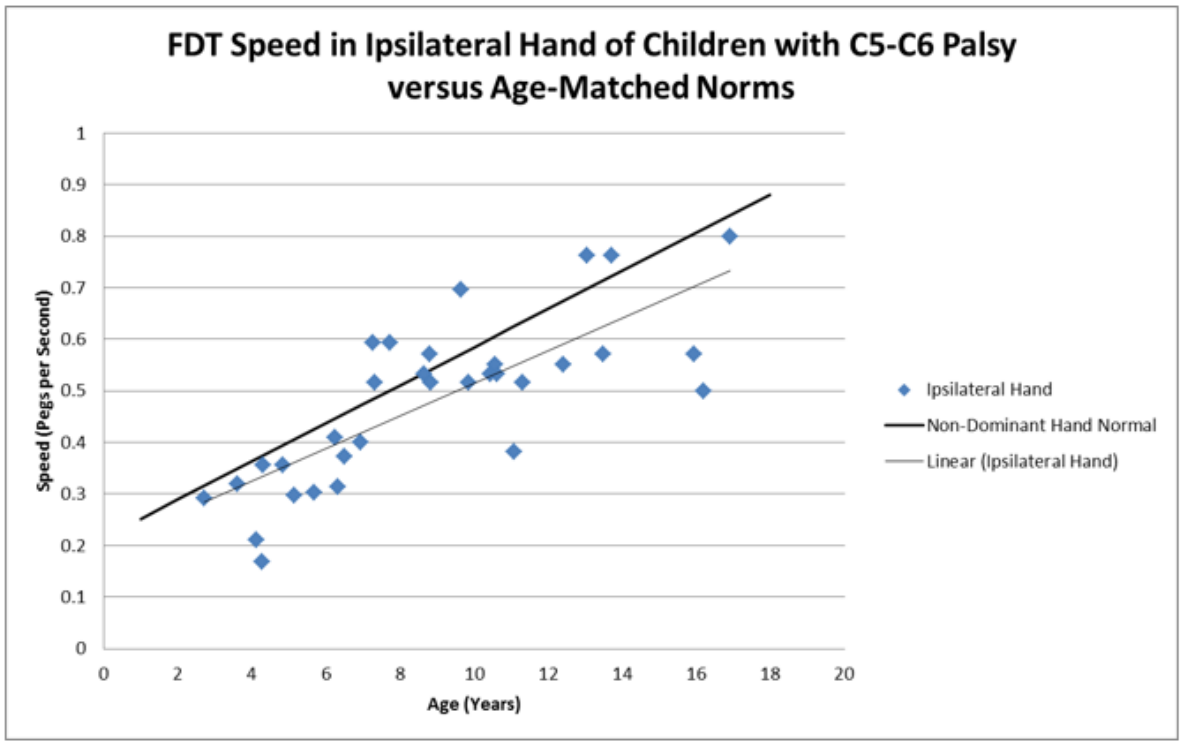


Figure 1. Comparison of FDT performance in the ipsilateral hands of children with C5-C6 birth brachial plexus palsy compared to age-matched norms

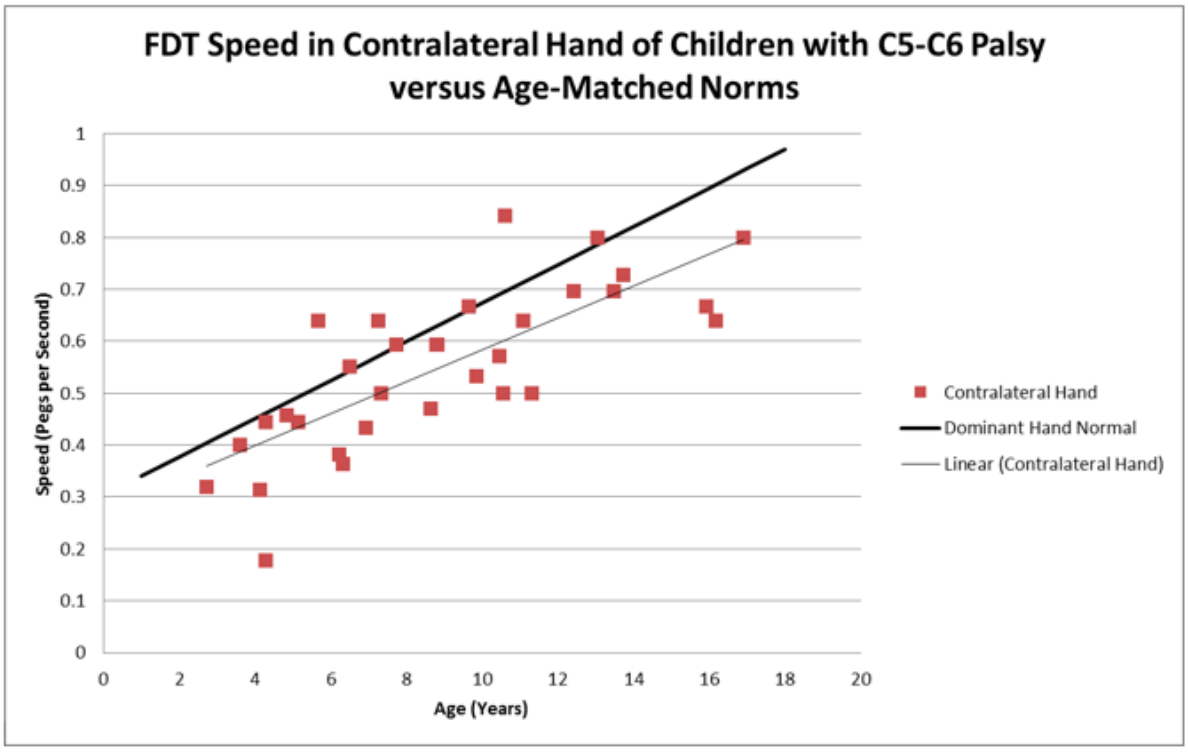


Figure 2. Comparison of FDT performance in the contralateral hands of children with C5-C6 birth brachial plexus palsy compared to age-matched norms.

Paper 14: A Custom iOS Application Provides Improved Efficiency and Similar Precision to Mechanical Goniometer for Finger Motion Measurement

Evaluation/Diagnosis, Basic Science, Hand and Wrist
N/A – Not a clinical study

Jeremy Smalley, MD
Eric William Angermeier, MD
William R. Barfield, PhD
Kyle Pentti Kokko, MD, PhD

Hypothesis
A custom iOS application provides equivalent precision and superior efficiency compared to a mechanical goniometer with paper recording for measurement of finger range-of-motion.

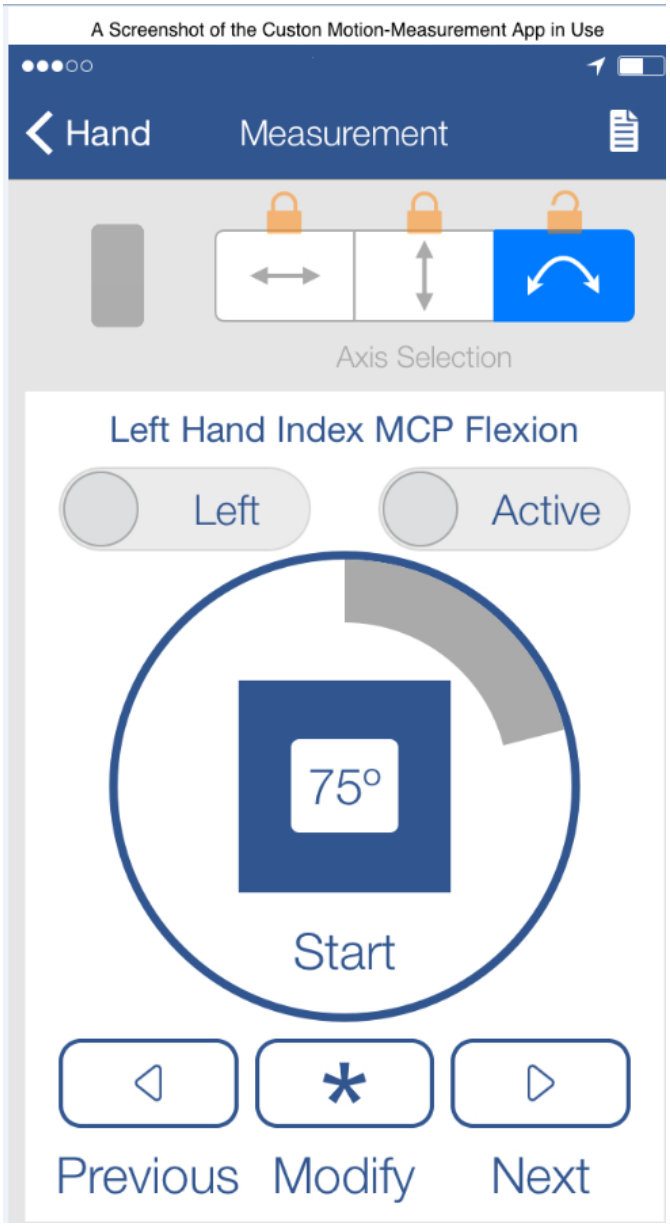
Methods
Examinations of finger range of motion were conducted by a volunteer group of clinicians using the iOS application (app) and an off-the-shelf plastic mechanical goniometer routinely used in hand clinics. The measurements were performed on off-the-shelf plastic anatomic models of the hand, the articulating fingers of which were glued in flexion for standardization. These models have limited range of motion representing a symptomatic hand arthritis patient. The examiners were two specialty-trained orthopaedic hand surgeons and five orthopaedic residents. The examiners were given a printed protocol for their examinations, a brief verbal explanation of the app interface, and familiarized themselves with the devices before starting. Each hand examination consisted of 14 measurements: the flexion angles of the thumb MP and IP joints and the finger MCP, PIP, and DIP joints. The measured angle was immediately recorded at the time of capture, in the app as programmed or on paper in a pre-printed grid. Examiners measured each hand twice with each device, for a total of 8 exams and 112 data points per examiner and 784 overall measurements. Each hand examination was timed. Statistical analysis was performed with IBM-SPSS Statistics Version 20.

Results
The app and the goniometer both demonstrated high reliability for repeated and comparative measurements. Reliability of repeated measures was tested with Intraclass Correlation Coefficient; the Cronbach's alpha score for the goniometer was 0.929 and for the app 0.938.

Correlation between measurements with the goniometer and app was also high with Pearson Correlation score of 0.845. All correlation measures were significant at the 0.01 level.
The app provided significantly more rapid data acquisition. Dependent t-testing showed significant ($p<0.001$) mean time differences. App hand exam time was 2:13 and goniometer time was 2:52.

Summary Points

- The app is a similarly reliable measurement instrument to the goniometer.
- The app allows significantly faster capture of the range of motion of all finger joints than a mechanical goniometer and paper recording.
- For a clinic using electronic patient records, the time advantage of digital data capture with the app is likely underestimated vs. the need for transcription or scanning of measurements documented on paper.



Reference 1: Werner B, Holzgrefe R, Griffin J, Lyons M, Cosgrove C, Hart J, Brockmeier S. Validation of an innovative method of shoulder range-of-motion measurement using a smartphone clinometer application. J Shoulder Elbow Surg (2014), 1-8.
Reference 2: Jenny J.-Y. Measurement of the Knee Flexion Angle With a Smartphone-Application is Precise and Accurate. The Journal of Arthroplasty 28 (2013) 784–787.
Reference 3: Bland J, Altman D. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986;1:307e10.

Paper 15: Long-term Knee Morbidity after Harvest of Medial Femoral Condyle Flaps for Carpal Reconstruction

Treatment, Surgical Technique, Therapy/Rehabilitation, Prognosis/Outcomes
Level 4 Evidence

Victor Wong, MD
Heinz K. Burger, MD
Christian Windhofer, MD
James P. Higgins, MD

Hypothesis

Osseous and osteocartilaginous flaps from the medial femoral condyle (MFC) are an increasingly recognized option for upper extremity reconstruction. However, the long-term donor site morbidity has not been studied. We hypothesize that long-term knee morbidity would be minimal following harvest of MFC flaps.

Methods

A retrospective, multi-center study was conducted to evaluate long-term knee function following MFC harvest for carpal reconstruction. Eligible patients were identified upon review of prospectively maintained databases. Patient demographics, operative reports, and post-operative regimens were recorded. Visual analog pain scores, WOMAC, and IKDC scores were calculated. Means were calculated using Student's t-test and multivariate analysis performed using ANOVA. P values less than 0.05 were considered significant.

Results

Forty-two patients were identified as eligible for this study. The mean time since operation was 31 months. There were no cases of knee instability or patellar subluxation. The range of motion between the harvest site and the contralateral normal knee was similar. The majority of subjective complaints including pain, numbness, and loss of strength resolved after five months. The presence of complaints was associated with the lack of post-operative lower extremity physical therapy. IKDC and WOMAC scores (greater than 90% and less than 5%, respectively) demonstrated excellent functional knee outcomes. There was a high degree of satisfaction (4.7 out of 5) and over 95% of patients would have the procedure again if needed.

Summary Points

- Knee stability is not adversely affected by harvest of osseous and osteocartilaginous tissues from the MFC.

- Most functional complaints resolved within five months and were associated with a lack of post-operative knee physical therapy.
- Harvest of MFC flaps does not impair knee function long-term and is well-tolerated by most patients.

Paper 16: Unilateral Digital Artery Based Extended Lateral V-Y Advancement Flap for Covering Fingertip Wounds

Treatment, Surgical Technique, Anatomy, Basic Science, Hand and Wrist
N/A - Not a clinical study

Kevin Himschoot, MD
Matthew Williams, BS

Hypothesis

A unilateral digital artery based extended lateral V-Y advancement flap can be designed to repair fingertip wounds that are too large to be covered by conventional V-Y advancement flaps.

Methods

An extended lateral V-Y advancement flap was designed based on utilizing a unilateral digital artery dissection. The lateral side of the V-Y flap is based on a mid-axial incision (Figure 1). The flap is then elevated above the tendon sheath. This allows the digital a. to be easily identified and protected compared to the conventional volar V-Y advancement flaps (1). The incision is extended proximally to release the restrictions on the neurovascular bundle (e.g. Cleland ligament and Grayson ligaments). We extended the lateral V-Y flap to 3 cm in length, compared to 1 cm incision length of traditional volar or lateral V-Y advancement flaps (1, 2). Anatomy studies were performed on cadavers. We compared the extended unilateral V-Y flap to conventional volar and lateral V-Y flaps based on the advancement length achieved using student's t-tests.

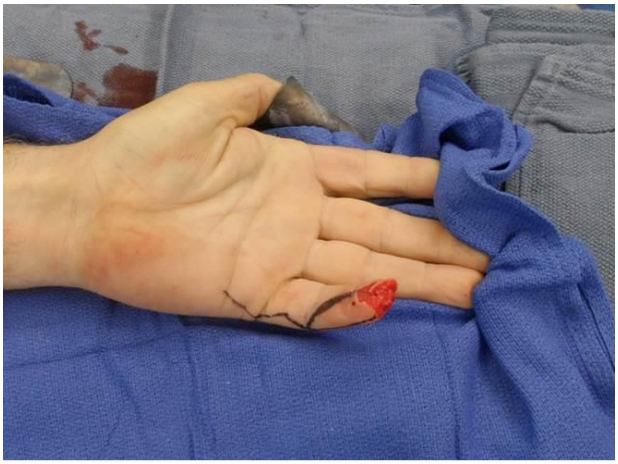
Results

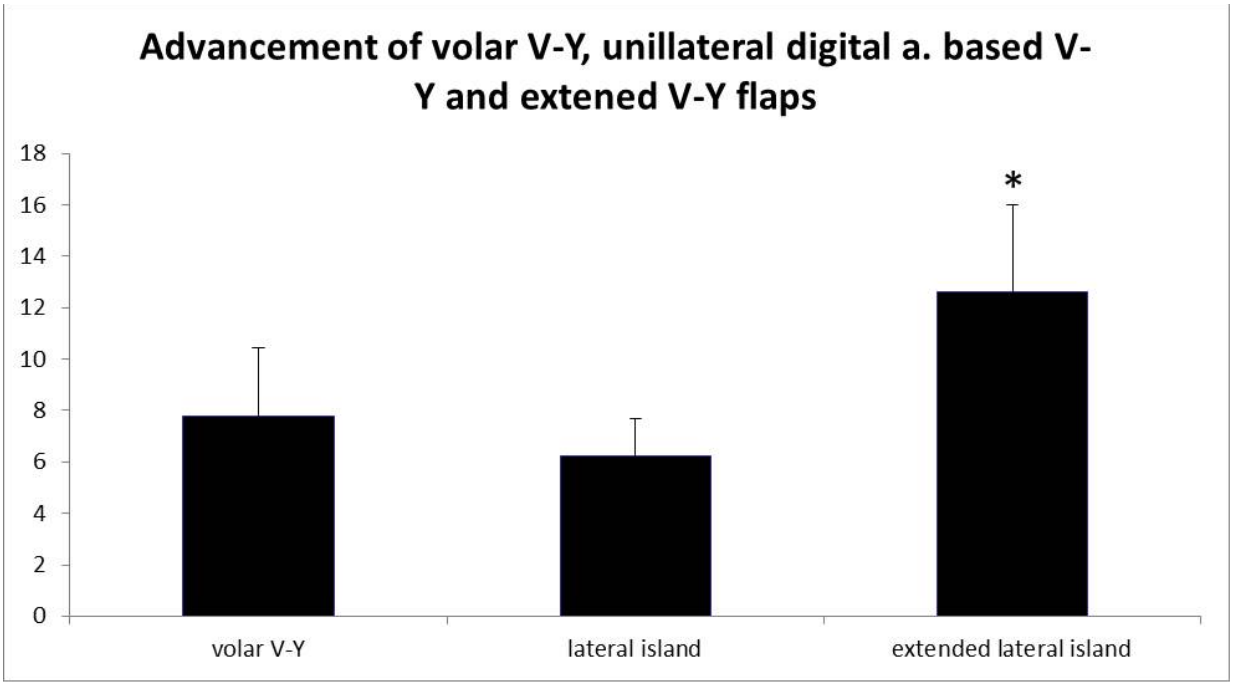
The anatomy study showed that the extended lateral V-Y flaps had significant more advancement than the conventional V-Y flaps and lateral V-Y flaps (figure 2, $p<0.01$). We also used this technique in 2 clinical cases. The flap could be easily advanced greater than 2 cm to cover a fingertip injury by releasing the unilateral neurovascular bundle more proximally as shown in figure2. Postoperatively, all patients had good sensation and excellent ROM of the repaired fingers.

Summary Points

- The extended lateral V-Y advancement flap based on unilateral digital artery allows for further advancement to provide better coverage of fingertip wounds than conventional V-Y advancement flap

- By using a mid-axial incision on one side of the V-Y flap, the dissection is much easier than conventional V-Y advancement flaps
- Only one side of the neurovascular bundle is used, which preserves the blood supply to the finger
- Less tension is placed on the flap, decreasing the risk of tissue death and is thus more reliable than the volar flap
- Compared to the conventional V-Y advancement flap, the secondary wound created by the extended lateral V-Y advancement flap is much easier to be closed without any tension.
- Postoperatively, patients had good sensation excellent ROM of the repaired fingers





Reference 1: Atasoy E, Ioakimidis E, Kasdan ML, Kutz JE, Kleinert HE. Reconstruction of the amputated finger tip with a triangular volar flap. A new surgical procedure. The Journal of Bone and Joint Surgery (American volume). 1970;52(5):921-6.
Reference 2: Roberts AH. Kutler repair for amputated fingertip. Annals of the Royal College of Surgeons of England. 1980;62(1):75-6.

Paper 17: Use of WALANT in Carpal Tunnel Release Decreases Operating Room Time

Treatment, Surgical Technique, Hand and Wrist, General Principles
Level 3 Evidence

Chase Maloy, MD
Toni Lin, MD
Jimmy Beasley, Jr.

Hypothesis

There are pressures to increase operating room (OR) and surgeon efficiency. We hypothesize carpal tunnel release (CTR) performed wide awake under local anesthestic and no tourniquet (WALANT) increases OR efficiency in both academic and private practices.

Methods

We retrospectively reviewed 123 consecutive (75 private practice, 48 with residents at teaching hospital) CTR surgeries for one surgeon practicing in the United States. Thirty-seven cases were performed using monitored anesthesia; WALANT was used for the remaining 88 CTRs. OR entry and exit and surgery start and stop times were analyzed for significant differences using unpaired t tests.

Results

For each setting, the total OR time was significantly less for CTR performed using WALANT (private: 37.43 versus 28.87 min, $p < 0.0001$; teaching: 49.6 versus 41.97 min, $p = 0.0097$). The combined OR time was 8.02 minutes less using WALANT (95% CI from 4.29-22.74 min). There was no significant difference in surgical times for either setting using WALANT (p=0.0812 teaching; p=0.2193 private; p=0.8901 combined).

Summary

Using WALANT, total operating room time was significantly less in both private and academic settings for one surgeon, while surgery time was unaffected. This may translate to increased time and economic efficiency for both hospital systems and surgeons.

Reference 1: Farhangkhoee H, Lalonde J, Lalonde DH. Teaching medical students and residents how to inject local anesthesia almost painlessly. Can J Plas Surg;2012;20(3):169.

Reference 2: Leblanc MR, Lalonde J, Lalonde DH. A detailed cost and efficiency analysis of performing carpal tunnel surgery in the main operating room versus the ambulatory setting in Canada. HAND 2007;2(4):173
Reference 3: Lalonde DH, Martin A. Epinephrine in local anesthesia in finger and hand surgery: The case for wide-awake anesthesia. J Am Acad Orthop Surg; 2013;21(8):443
Reference 4: Lalonde DH. Reconstruction of the hand with wide awake surgery. Clin Plas Surg 2011;38(4):761-9.
Reference 5: Strazar AR, Leynes PG, Lalonde DH, Minimizing the pain of local anesthesia injection. Plast Reconstr Surg; 2013:132(3):675.
Reference 6: Lalonde DH. How the wide awake approach is changing hand surgery and hand therapy: J Hand Therapy; 2013:26(3):175.
Reference 7: McKee DE, Lalonde DH, Thoma A, Glennie DL, Hayward JE. Optimal time delay between epinephrine injection and incision to minimize bleeding. Plast Reconstr Surg; 2013;131(4):811.

Paper 18: Tourniquet Pressure: Does it need to be at 250 mmHg?

Surgical Technique, Hand and Wrist
Level 3 Evidence

Shumaila Sarfani, B.A.

Hypothesis
Traditional teaching dictates that during hand surgery, the tourniquet should be set at 250 mmHg. We set out to challenge this dogma and hypothesized that there will be no significant difference in intra-operative variables between lower tourniquet pressures compared to the current practice of 250 mm Hg during carpal tunnel surgery.

Methods
An IRB retrospective review was conducted of patients undergoing open carpal tunnel release from June 2009 to June 2012. Those undergoing surgery with a tourniquet pressure of 250 mmHg were compared to those with lower tourniquet pressures regarding their demographics, operative and anesthesia time and whether the tourniquet pressure needed to be increased to 250 mmHg during surgery.

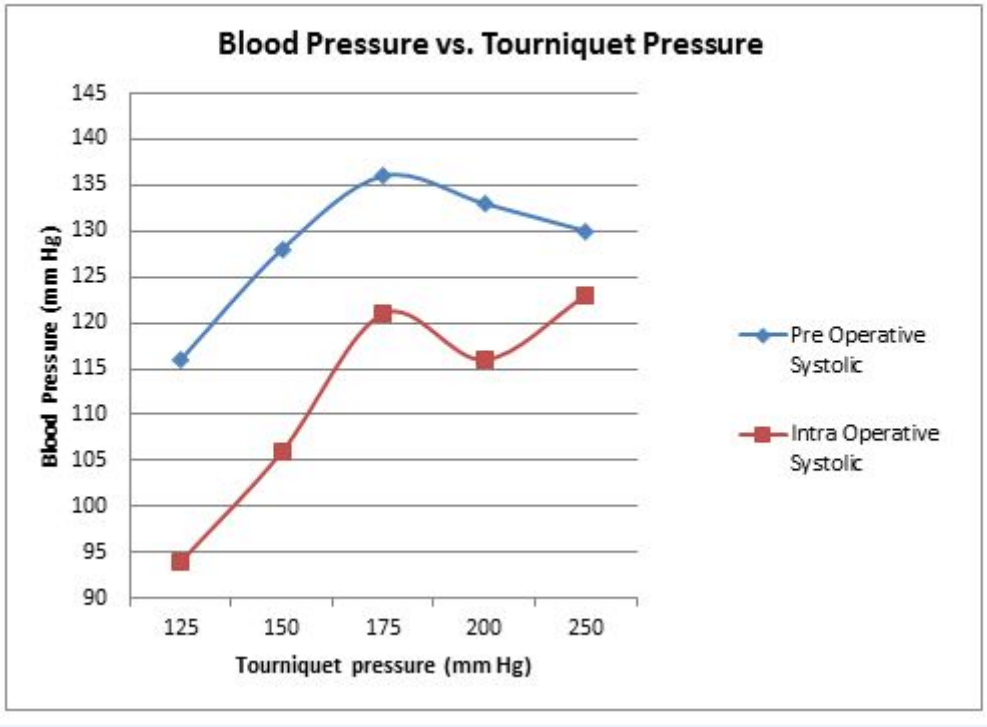
Results
A total of 474 patients underwent carpal tunnel release over the three year period. There were no differences with respect to patient demographics. There was no significant difference between operative or anesthesia time between different tourniquet pressure groups. There were no reported problems with break through bleeding, or difficulty with visualization of structures in any of the lower pressure groups. None of the patients with lower tourniquet pressures needed tourniquet pressure to be adjusted during surgery.

Summary Points

- Lower tourniquet pressures have no effect on the operation for open carpal tunnel release including effect on operative or anesthesia time, breakthrough bleeding, or development of complications.
- Orthopedic surgeons may consider reducing tourniquet pressures during carpal tunnel release to avoid reported complications and patient discomfort related to use of standard tourniquet pressure of 250 mm Hg.

Table: Blood pressure readings by tourniquet pressure						
	125 mm Hg	150 mm Hg	175 mm Hg	200 mm Hg	250 mm Hg	p value
Pre-operative systolic (range)	116 +/- 15	128 +/- 16	136 +/- 21	133 +/- 22	130 +/- 22	**p<0.03***
Pre-operative diastolic (range)	65 +/- 8	76 +/- 11	77 +/- 11	76 +/- 16	75 +/- 12	p=0.06
Intra-operative systolic range	95 +/- 6	106 +/- 12	121 +/- 16	116 +/- 20	124 +/- 21	**p<0.01***
Intra-operative diastolic range	55 +/- 12	59 +/- 11	64 +/- 11	62 +/- 13	65 +/- 15	**p<.002***
Post-operative systolic (range)	112 +/- 9	121 +/- 19	133 +/- 22	129 +/- 21	126 +/- 22	**p<0.03***
Pre-operative diastolic (range)	65 +/- 9	71 +/- 11	73 +/- 11	74 +/- 12	72 +/- 13	p=0.13

Figure: Comparison of pre-operative systolic and intra-operative systolic blood pressures by tourniquet pressure groups.



Paper 19: Smartphone Photography as a Tool to Measure Elbow Range of Motion

Evaluation/Diagnosis, Therapy/Rehabilitation, Patient Education, Prognosis/Outcomes, Elbow and Forearm, General Principles
N/A - Not a clinical study

Eric Wagner, MD
Alexander Y. Shin, MD

Salary: Mayo Clinic (Shin)
Royalty: Trimed (Shin)

Hypothesis
In the evolving digital world, the ability to utilize digital photography via smartphones could provide a very important tool to evaluate elbow range of motion postoperatively. The purpose of this study was to determine if smartphone photography is as reliable as clinical goniometry in measuring elbow range of motion.

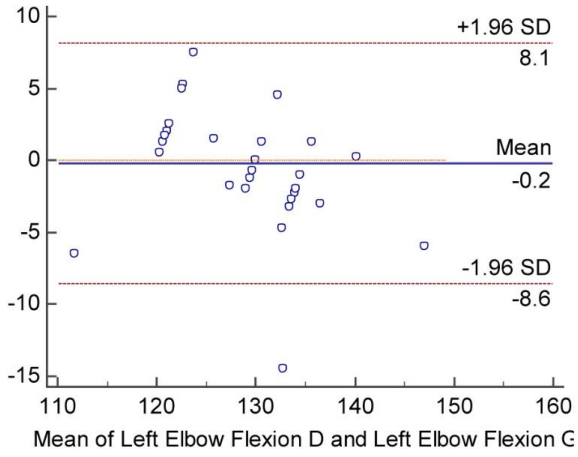
Methods
The validity and reliability of smartphone photography was examined using bilateral elbows of 32 normal participants (64 elbows). Smartphone photos were taken utilizing smartphones, measuring the angles at the extremes of flexion and extension with commercially available goniometry software (Adobe). The photographs were taken by a volunteer (simulating a patients perspective) and by a researcher for comparison. Clinical goniometry measurements were taken prior to obtaining the photographs. Comparisons were performed in a blinded fashion, utilizing a Bland Altman analysis and interclass analysis of variance.

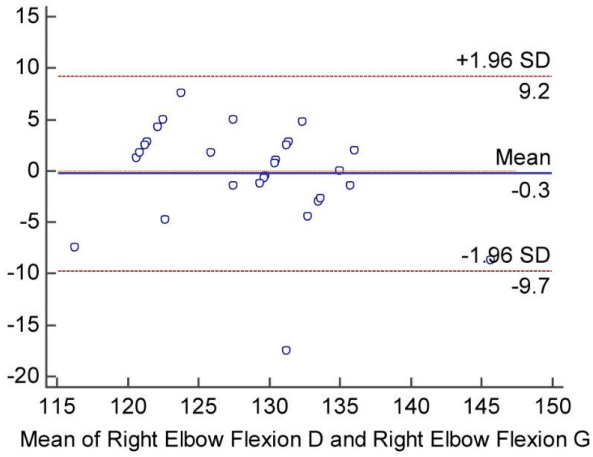
Results
In the measurement of the bilateral elbows of 32 patients, there was minimal difference in the overall mean in total arc of motion (<1o). Examining the interclass correlation, the concordance coefficient for the left was 0.828 and 0.740 on the right. The Pearson coefficient was 0.845 on the left and 0.757 on the right. The Bland-Altman plots demonstrated 30 of 32 digital measurements were within the 95% confidence interval of the clinical measurements on the left, and 31 of 32 measurements were within the 95% confidence interval on the right. The measurements from the photography taken by the volunteer compared to the researcher were statistically highly similar, with a mean difference in the measurements of the total arc of motion of 1.5o on the left and 1.8o on the right. The left concordance and Pearson coefficients of 0.955

and 0.962, respectively, and were 0.941 and 0.957 on the right. When estimating interobserver reliability, the difference between researchers was negligible (<1o), with concordance coefficients of 0.793 (left) and 0.767 (right) and Pearson coefficients of 0.811 (left) and 0.780 (right).

Summary Points:

- The use of smartphone digital photography to measure elbow range of motion proved to be a reliable and accurate tool to measure range of motion.
- There was no significant difference as to whether the patient or a medical expert took the photograph.
- These findings validate the concept of having patients send in digital photography on their smartphones of their elbow range of motion in clinical and research follow-up.





Paper 20: Effect of high-glucose condition on rat tenocytes

Basic Science, Diseases and Disorders
N/A - Not a clinical study

Yasuhiro Ueda, MD
Atsuyuki Inui, MD
Takeshi Kokubu, MD
Mifune Yutaka, MD
Ryosuke Sakata, MD
Fumiaki Takase, MD

Hypothesis
Hyperglycemia caused by diabetes mellitus is associated with many musculoskeletal disorders such as tendinopathy. The molecular mechanism of tendinopathy under hyperglycemia is not fully understood yet. We hypothesize that Reactive oxygem species (ROS) produced under the high glucose concentration which lead to degeneration and inflammation of tenocytes.

Methods
Cell Culture
The tenocytes of Achilles tendons from Sprague–Dawley rats were cultured in DMEM medium. These cells were cultured in DMEM of two different glucose concentration, 12 mM glucose as regular glucose group and 33 mM as high glucose group.
Cell Viability Assays
Cell viability was measured by a water-soluble tetrazolium salt (WST) assay at 48 or 72 hours after treated with regular glucose group and high glucose group.
Real-time PCR
Total RNA was extracted from the cell cultures and then reverse transcribed into single-strand cDNA. Real-time PCR was performed in duplicate on the cDNA. Results were normalized to housekeeping gene expression levels. We analyzed the mRNA expression of type I and type III collagen, MMP-2, TIMP-1 and TIMP-2.
ROS analysis
The induction of ROS was assessed by Carboxy-H2-DCFDA staining method at 48 and 72 hour. The nucleus was stained with diamidino-2-phenylindole (DAPI).

Results
Cell Viability Assays

Cell viability in high glucose group was lower than that in regular glucose group at 48 and 72 hours (Fig.1).

Real-time PCR

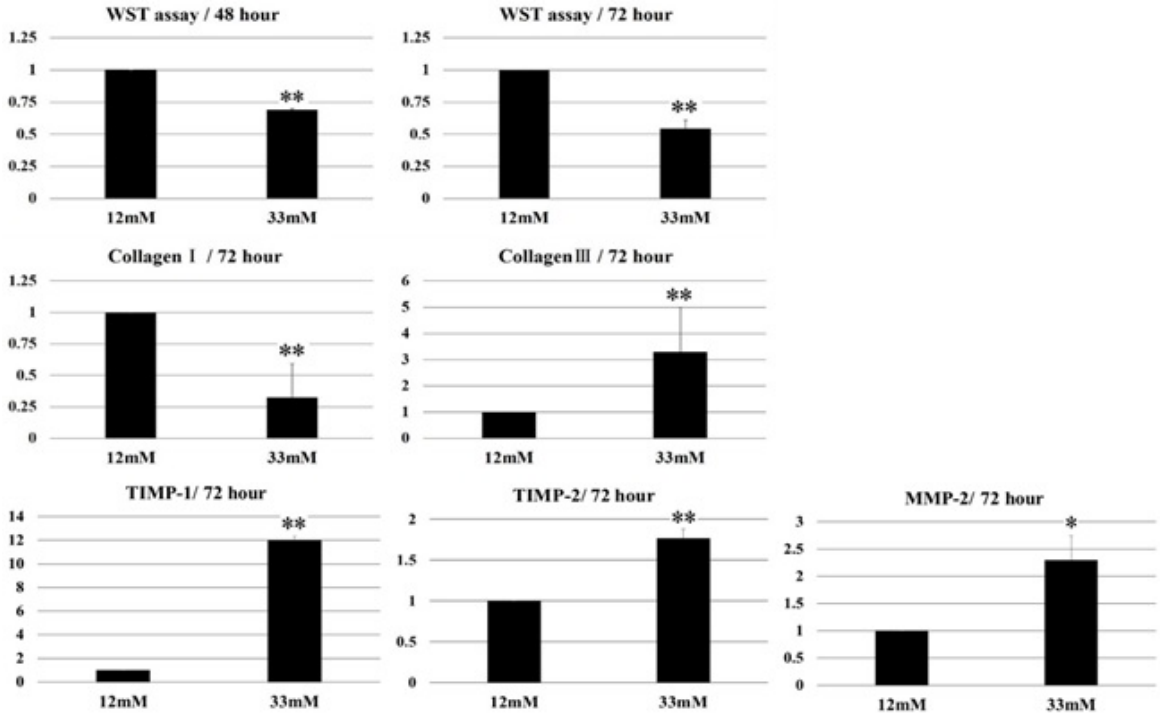
The mRNA expression of type I collagen in high glucose group was lower than that in regular glucose group while the expression of type III collagen in high glucose group was higher than that in regular glucose group .The expression of TIMP-1 in high glucose group was higher than that in regular glucose group .TIMP-2 and MMP-2 in high glucose group was higher than that in regular glucose group (Fig.1).

ROS analysis

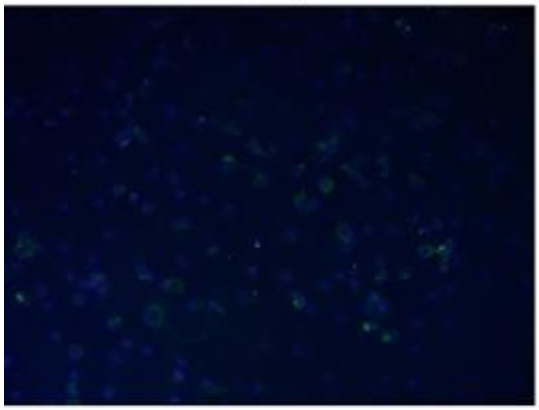
Carboxy-H2-DCFDA staining method showed the expression of ROS in each group as green. The expression was higher at 48 hours, and then the expression decreased at 72 hours (Fig.2).

Summary

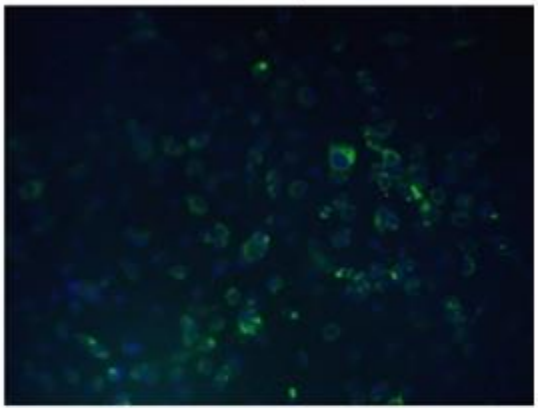
Our study showed that high glucose concentration leads to lower cell viability and has an influence on the normal tendon composition of collagen or molecules which related to tendon degeneration. In addition, the production of ROS increased in high glucose concentration group. These results suggest that ROS production induced by high glucose concentration causes inflammation and degeneration on tenocytes.



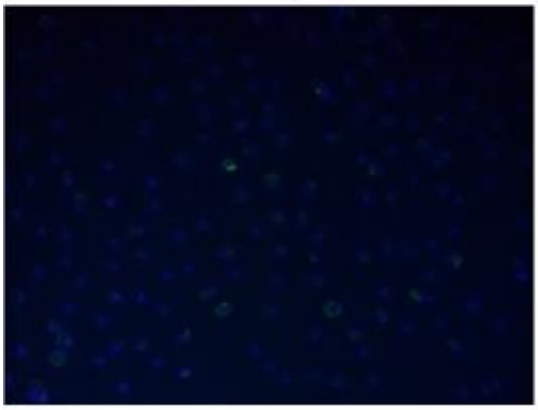
Ros / 48 hour, 12mM



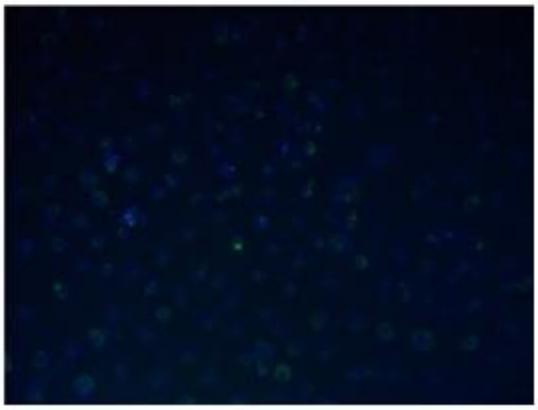
Ros / 48 hour, 33mM



Ros / 72 hour, 12mM



Ros / 72 hour, 33mM



Paper 21: Comparisons of Bone Graft Harvesting from the Olecranon Process and the Distal Radius

Treatment, Surgical Technique, Prognosis/Outcomes, Hand and Wrist, Elbow and Forearm, General Principles
Level 3 Evidence

Alan Micev, MD
William Slikker, III, MD

Hypothesis
Bone graft harvested from either the olecranon process or the distal radius will have comparable effectiveness and there will be no difference in terms of graft harvest-site healing, recipient-site healing, post-operative pain, range of motion, or rate of complications.

Methods
We evaluated 44 patients who underwent bone graft harvesting from either the olecranon process (OP, 25 cases) or the distal radius (DR, 19 cases) for various procedures in the same extremity. Follow-up averaged 14 months in the OP group and 19 months in the DR group. Outcome measures included a Visual Analog Scale (VAS) for graft harvest-site pain; a VAS for satisfaction with the appearance of the harvest-site scar; joint motion; and x-rays of the graft harvest and recipient sites. The VAS scores ranged from 0 to 10 with a low score reflecting no pain and excellent satisfaction, and a high VAS score reflecting severe pain and poor satisfaction.

Results
The VAS scores for pain averaged 0.4 (range, 0 - 4) in the OP group and 0.5 (range, 0 - 5) in the DR group, and the VAS scores for satisfaction with scar appearance averaged 0.3 (range, 0 - 2) in the OP group and 0.7 (range, 0 - 4) in the DR group. No differences were noted between groups ($p > 05$). Within each group, there were no observed differences between the operative and nonoperative limbs for elbow (OP group) or wrist (DR group) motion ($p > 0.05$). A radiographic defect at the graft harvest site was detected in 84% of OP cases and 67% of DR cases, and bone healing at the graft recipient sites was documented in 88 and 95%, respectively ($p> 0.05$). Wound complications at the graft harvest site involved one superficial wound infection (OP) and one wound dehiscence (DR).

Summary Points
- Harvesting bone graft from either the olecranon process or the distal radius leads to comparable patient outcomes

- There was no difference in post-operative pain, range of motion, graft harvest-site healing, or recipient-site healing with bone graft harvested from either the olecranon or the distal radius.
- Harvesting bone graft from the olecranon or the distal radius had an equally low risk of complications.

Paper 22: Retrospective Analysis of Distal Ulna Fractures Associated with Distal Radius Fractures in Women 50 years and Older: Clinical, Radiographic, and Patient Related Outcomes

Prognosis/Outcomes, Hand and Wrist
Level 2 Evidence

Laura Sims, BSc., MD
Samuel A. Stewart, PhD
Geoffrey H.F. Johnston, MD

Hypothesis
The effect of distal ulna fracture (DUF) on outcomes of distal radius fracture (DRF) is not known. Previous studies noted trends in outcomes but did not reach statistical significance. The purpose of this analysis was to determine the incidence of DUF associated with DRF in a discrete group (women 50 years and older); to classify and describe the incidence of DUF by location; and to determine whether the presence, location, or union of DUF influences the radiographic, clinical, and patients' self-reported outcome measures in DRF treatment.

Methods
Data for 781 women 50 years and older who had sustained a displaced, isolated DRF were collected prospectively. Clinical outcomes of grip strength and range of motion (ROM) (dorsiflexion, palmar flexion, supination, and pronation), and Patient Related Wrist Evaluation (PRWE) scores were measured at nine, 12, 26 and 52 weeks post fracture. Radial inclination (RI), ulnar variance (UV), radial tilt (RT) were measured up to 12 weeks post-fracture from serial radiographs which were also retrospectively reviewed to determine the frequency, type, and union of associated DUFs.

Results
The rate of DUF associated with DRF was 74%. DUFs were classified by location: 19% were Type 1A (styloid apex), 39% Type 1B (styloid body), 33% Type 2T (transverse - proximal to fovea), 11% Type 2O (oblique - proximal to fovea), 0.3% Type 3 (head) and 10% Type 4 (periphyseal and distal shaft). DUF rates did not vary with age, although the type of fracture did. The DUF union rate was 35%, influenced by fracture type and age. Significant associations included: Type 1A with younger age (50-60 y), lower union rates and a higher final RI; Type 1B with lower union rates; Type 2T with lower RI; Type 2O with older age group (81+), higher union rates, and lower RI;

Type 4 with older age groups (81+), higher union rates, and higher RI; united DUFs with significantly higher RI.
PRWE scores were higher at 9 and 12 weeks post-fracture in those with DUFs (NS), higher in un-united DUFs (NS), but not at 6 and 12 months post-fracture. DUFs had no effect on grip strength or ROM.

Summary Points

- 74% of DRF women 50 years and older had an associated DUF.
- 35% of DUFs healed, rates being type and age specific.
- There are distinct DUF types, knowledge of which helps predict behavior of not only the DUF, but also the radiographic outcome of the associated DRF.

Paper 23: Description and Validation of a Non-invasive Ultrasound Technique to Measure Motor Nerve Recovery in Rabbits

Evaluation/Diagnosis, Basic Science, Nerve
N/A - Not a clinical study

Liselotte Bulstra, MD
Caroline A. Hundepool, MD
Patricia F. Friedrich, AAS
Steven E.R. Hovius, MD,PhD
Allen T. Bishop, MD
Alexander Y. Shin, MD

Hypothesis
Currently established outcome measurements to evaluate functional recovery after peripheral nerve reconstruction in animal models are invasive and require the animals to be sacrificed. The aim of this study was to develop and validate a novel non-invasive ultrasound technique for the longitudinal analysis of the functional recovery after peripheral nerve reconstruction in the rabbit model.

Methods
Twelve male New Zealand White rabbits underwent a 1cm peroneal nerve autograft reconstruction. Ultrasound measurements were performed prior to surgery and 1, 2, 4, 8, 12 and 16 weeks post operatively. All rabbits were able to undergo manual restraint instead of anesthesia for the ultrasound procedure, avoiding the risks of anesthetics. At 12 and 16 weeks, functional recovery was tested using established measurements for motor nerve recovery including Compound Muscle Action Potential (CMAP), isometric tetanic force measurements, wet muscle mass and nerve histomorphometry. All data were compared to the ultrasound measurements by calculation the Pearson correlation coefficient and intra- and inter-rater reliability of ultrasound were determined.

Results
The standardized protocol that was developed, required approximately 15 minutes per animal for the preparation and ultrasonic measurements of the tibial muscle. Ultrasound showed very good correlations with isometric tetanic force (r=0.83) and muscle mass (r=0.98) and a good correlation with the CMAP measurements (r=0.59) and nerve histomorphometry (r=0.69). Both

the intra- and inter-rater reliability were excellent, r=0.994 and 0.989 respectively. All correlations were statistically significant.

Summary Points

- Ultrasound provides a reliable and valid method for analysis of functional recovery in the rabbit nerve reconstruction model.
- The non-invasive nature allows for longitudinal follow-up within the same animal and measurement of early recovery without the use of anesthesia.
- Application of this technique could reduce the variability and required sample size in peripheral nerve reconstruction studies and will provide an ideal tool for comparative studies in larger animal models.

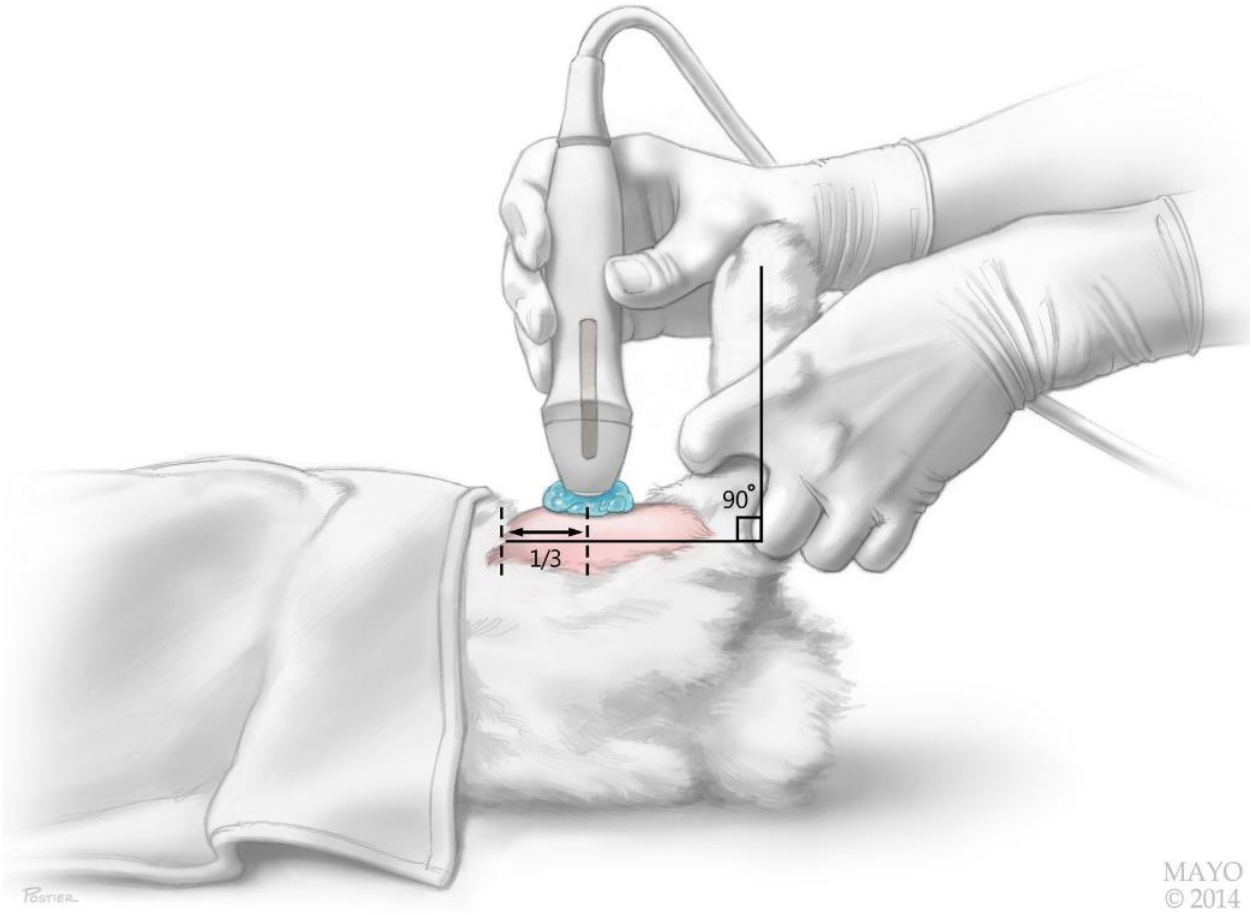


Figure 1. Experimental set-up. The experimental set-up of the ultrasound recording. The position of the probe and lower leg of the rabbit are depicted.

Paper 24: Full versus Partial Fixation in Osteoporotic Distal Radius Fractures

Treatment, Surgical Technique, Basic Science, Hand and Wrist
N/A - Not a clinical study

Peter Mansuripur, MD
Dale Cassidy, MD
Patrick M. Kane, MD
Joseph J. Crisco, PhD
Augusta Whitney, MD
Edward Akelman, MD

Hypothesis
In osteoporotic bone, distal radius fractures fixed with a volar locking plate and a submaximal complement of distal locking screws will fail at a significantly lower load than fractures fixed with a construct using the maximum number of distal locking screws.

Methods
10 matched pairs of cadaveric forearms (all females over 85) were obtained and their bone mineral density determined by q-CT. They were then randomized within each pair to Group F (full fixation) or Group P (partial fixation). Each specimen was skeletonized and instrumented according to group (volar plate and all 7 distal locking screws for Group F; volar plate with 4 distal locking screws for Group P). Instrumentation was performed using current best practices: unicortical screws going to but not through the dorsal cortex, distal screws within 4 mm of the joint surface, and utilization of both distal rows. An AO C-2 type fracture was then simulated by resecting 1 cm of bone at the metadiaphyseal junction and by making an osteotomy between the fossae. All specimens were then tested cyclically, with an axial load of 60 N, at 3 hz for 1000 cycles to simulate early postoperative motion. All specimens were then tested to mechanical failure. Data collected were stiffness, load to yield, peak load, and load at 2mm displacement (clinical failure). Data were analyzed using a paired t-test.

Results
There were no failures in either group during cyclical testing. There was no statistically significant difference between groups for mean stiffness (Group F, 245.9; Group P, 252.4; p=0.9), load to yield (Group F, 160.3 N; Group P, 132.3 N; p=0.06), peak load (Group F, 996.2 N; Group P, 891.7 N; p=0.54), or load to 2mm displacement (Group F, 339.4 N; Group P, 351.4 N; p=0.85).

Summary Points

We were unable to demonstrate a significant difference in any clinical relevant parameter between the two groups. In our model of a highly unstable fracture pattern in osteoporotic bone, fixed using currently acknowledged best surgical practices, two screws per fragment appear to be sufficient to maintain fixation against loads seen in early range of motion.

Results

	Full	Partial	P
vBMD(mg/cm3)	332.8	350.1	0.7
Stiffness	245.9	252.4	0.9
Yield	160.3	132.3	0.06
Peak	996.2	891.7	0.54
Load at 2mm disp	339.4	351.4	0.85

Table 1. No statistically significant differences were demonstrated between the two treatment groups in any tested parameters.

Figure 1. Specimen from Group F showing a simulated AO C-3 fracture and volar plate fixation with 7 distal screws.

Reference 1: Mehling, Isabella, Lars P Müller, Katharina Delinsky, Dorothea Mehler, Klaus J Burkhart, and Pol M Rommens. 2010. “Number and Locations of Screw Fixation for Volar Fixed-angle Plating of Distal Radius Fractures: Biomechanical Study.” The Journal of Hand Surgery 35 (6) (June): 885–891. doi:10.1016/j.jhsa.2010.03.027.
Reference 2: Moss, David P, Kenneth R Means Jr, Brent G Parks, and Christopher L Forthman. 2011. “A Biomechanical Comparison of Volar Locked Plating of Intra-articular Distal Radius Fractures: Use of 4 Versus 7 Screws for Distal Fixation.” The Journal of Hand Surgery 36 (12) (December): 1907–1911. doi:10.1016/j.jhsa.2011.08.039.
Reference 3: Putnam, M D, N J Meyer, E W Nelson, D Gesensway, and J L Lewis. 2000. “Distal Radial Metaphyseal Forces in an Extrinsic Grip Model: Implications for Postfracture Rehabilitation.” The Journal of Hand Surgery 25 (3) (May): 469–475. doi:10.1053/jhsu.2000.6915.
Reference 4: Rikli, Daniel A, Philipp Honigmann, Reto Babst, Alessandra Cristalli, Michael M Morlock, and Thomas Mittlmeier. 2007. “Intra-articular Pressure Measurement in the Radioulnocarpal Joint Using a Novel Sensor: In Vitro and in Vivo Results.” The Journal of Hand Surgery 32 (1) (January): 67–75. doi:10.1016/j.jhsa.2006.10.007.
Reference 5: Rozental, Tamara D, Laura N Deschamps, Alexander Taylor, Brandon Earp, David Zurakowski, Charles S Day, and Mary L Bouxsein. 2013. “Premenopausal Women with a Distal Radial Fracture Have Deteriorated Trabecular Bone Density and Morphology Compared with

Controls Without a Fracture.” The Journal of Bone and Joint Surgery. American Volume 95 (7) (April 3): 633–642. doi:10.2106/JBJS.L.00588.

Paper 25: The Modern Role of Botulinum Toxin During Treatment of Children with Brachial Plexus Birth Palsy

Treatment, Prognosis/Outcomes, Shoulder and Arm, Congenital and Pediatric Problems, Nerve
Level 4 Evidence

Dustin Greenhill, MD
Scott H. Kozin, MD
Dan A. Zlotolow, MD

Royalty: arthrex, elsevier (Zlotolow)
Receipt of Intellectual Property Rights/Patent Holder: osteomed (Zlotolow)
Consulting Fee: osteomed (Zlotolow)

Hypothesis

Few recent studies have investigated the use of Botulinum toxin A (botox) injections directed at the shoulder internal rotator muscles in children with brachial plexus birth palsy and results are contradictory. We hypothesize that botox is an effective management strategy during early shoulder subluxation or dislocation. However, we believe positive outcomes depend on the researchers definition of success and the likelihood of avoiding further shoulder surgery in this patient population is underestimated. Furthermore, we sought to determine which patients are most likely to maintain glenohumeral joint reduction after treatment.

Methods

Fifty-seven children with brachial plexus palsy who received botox injections during closed glenohumeral joint reduction were included in this study. Patients were followed for more than one year after treatment. Included patients did not receive any concomitant shoulder surgery nor undergo microsurgery within 8 months of treatment. Records were reviewed for severity of palsy, age at time of treatment, and subsequent orthopaedic procedures (including repeat injections, arthroscopic or open reduction, shoulder tendon transfers, and humeral osteotomy). Treatment success was defined as a patient who did not require subsequent reduction of the glenohumeral joint. Success was then redefined to include only patients who maintained functional external rotation (Mallet>3 or AMS>5) and all data were reanalyzed.

Results

The average age during treatment was 13.3 months old. Average follow up was 35 months (range 1-9 years). After treatment, 68.33% did not require subsequent reduction procedures. However, 59.65% underwent later surgical intervention. Furthermore, only 20% of patients

initially defined as a treatment success maintained functional external rotation at final follow-up. Age, preoperative Mallet scores, or preoperative AMS scores did not predict maintenance of glenohumeral joint reduction. Preoperative composite Toronto score (OR=1.19, p=0.03) was predictive of a successful outcome. A mean preoperative passive external rotation of +20.6 degrees was associated with success whereby an average of -6.9 degrees was associated with treatment failure, and this difference was significant (p=0.006).

Summary

This is the largest series reported regarding the use of botox as an adjunct treatment in children with shoulder dislocation related to brachial plexus birth palsy.

Botox injections during shoulder reduction may avoid subsequent reduction procedures and, in theory, optimize glenohumeral joint development.

However, a large proportion of these patients will still have functional deficits warranting subsequent shoulder surgery.

Limited preoperative passive external rotation and low composite Toronto scores can help physicians identify which patients are least likely to maintain reduction after isolated adjunct botox injections and closed reduction.

Reference 1: Ezaki M, Malungpaishrope K, Harrison RJ, Mills JK, Oishi SN, Delgado M, Bush PA, Browne RH. Onabotulinum toxinA injection as an adjunct in the treatment of posterior shoulder subluxation in neonatal brachial plexus palsy. J Bone Joint Surg Am. 2010 Sep 15;92(12):2171-7.

Reference 2: Arad E, Stephens D, Curtis CG, Clarke HM. Botulinum toxin for the treatment of motor imbalance in obstetrical brachial plexus palsy. Plast Reconstr Surg. 2013 Jun;131(6):1307-15.