ORTHOPAEDIC & OUTCOMES RESEARCH

Hand & Wrist

VOLUME 2

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SERVICES

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- Microvascular surgery
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- Treatment of Dupuytren's disease
- Treatment of traumatic injuries

Dear Colleagues,

I am happy to share this Jefferson Health update on some exciting clinical care and research developments in the area of hand and wrist care.

The past year has been challenging for all of us. But we remain committed to advancing research that helps improve patient outcomes and contributes to a better understanding of a long list of hand and wrist conditions that can be debilitating and even life altering if not properly treated.

Our Department of Orthopaedic Surgery is fortunate to have the combined expertise of hand and wrist specialists from the Rothman Orthopaedic Institute at Jefferson Health and the Philadelphia Hand to Shoulder Center at Jefferson Health.

As a major referral center, Jefferson Health treats patients with the most complex injuries and disorders of the hand and wrist, as well as patients with more common conditions who benefit from a highly experienced care team. Considering that the hand and wrist are involved in nearly every task of daily living, even a small amount of dysfunction can diminish people's ability to work, exercise, play sports and take care of themselves and their families.

Our clinical care is strengthened by findings from our research agenda. This past year the hand and wrist team at Jefferson Health published studies on a variety of topics ranging from the risk of infection in trigger release surgery when the procedure is done soon after a corticosteroid injection, to a case report on a ground-breaking heterotopic thumb-to-thumb replantation following a mangled hand injury.

Hand and wrist care is continually being refined as Jefferson Health researchers identify optimal non-operative and operative techniques and embrace promising new technologies such as 3-D printing. On most days it seems as though the future of orthopaedic care is already here.

Take a look at some of the key research by Jefferson Health's hand and wrist team. I also invite you to learn more about our research and clinical services by going to our website, **JeffersonHealth.org/Ortho**. To refer a patient, please call, **215-503-8888** or have your patient call **1-800-JEFF-NOW**.

Thank you for your interest. I wish you all the best in 2021.

Sincerely,

Alexander R. Vaccaro, MD, PhD, MBA

Richard H. Rothman Professor and Chair
Department of Orthopaedic Surgery, Jefferson Health
Sidney Kimmel Medical College, Thomas Jefferson University

Rothman Orthopaedic Institute Studies

Splinting after Distal Radius Fracture Fixation: A Prospective Cohort Analysis of Postoperative Plaster Splint versus Soft Dressing

Distal radius fractures (DRFs) are among the most common fractures. Incidence is increasing across all age groups worldwide for the past several years, with DRFs being increasingly treated through open reduction internal fixation (ORIF) with locking volar plates.

The effect of postoperative dressing and splinting after DRF ORIF is not well understood.

Jefferson Health researchers led by Spencer Poiset, MD, conducted a prospective cohort analysis to assess differences in functional and radiographic outcomes with the use of plaster splinting or soft dressing following DRF ORIF.

All patients undergoing DRF ORIF with locking volar plates were consecutively enrolled. Preoperative demographic and postoperative radiographic and function outcome data were collected at two weeks and three months postoperatively. Functional data included range of motion (ROM), pain on visual analog scale (VAS), Patient-Rated Wrist Evaluation (PRWE), and quick Disabilities of the Arm, Shoulder and Hand (DASH) scores. Radiographic data included loss of fracture reduction.

A total of 139 patients (79 who had plaster splinting and 60 who had soft dressing) were included in the analysis, which was published in the *Journal of Wrist Surgery*.

The study found that by the first postoperative visit, there was one case of loss of reduction with plaster splinting and one case with soft dressing. Neither group had hardware failure or revision

An example of a postoperative distal radius fracture repair immobilized with a (A) plaster splint and (B) soft dressing.
Source: Jack Abboudi, MD

surgery. There were also no differences in DASH, PRWE or VAS pain scores.

By the final postoperative visit, however, some differences emerged between the two groups. The soft dressing group showed greater ROM in extension by 9.6°, flexion by 10.9° and supination by 4.8° over plaster splinting. The soft dressing group also demonstrated statistically significant improvement in PRWE and DASH scores as well as VAS pain scores as compared with plaster splinting.

"This study finds no benefit in applying a plaster splint over a soft dressing following DRF ORIF with volar locking plate," the researchers concluded. "The less restrictive soft dressing may also grant modest increases in the range of motion at 3 months postoperatively, with no relative increased risk of loss of reduction, increased pain or compromised function."

The researchers said they hoped the findings will help guide postoperative care in the future.

Intramedullary Headless Screw Fixation of Metacarpal Fractures: A Radiographic Analysis for Optimal Screw Choice

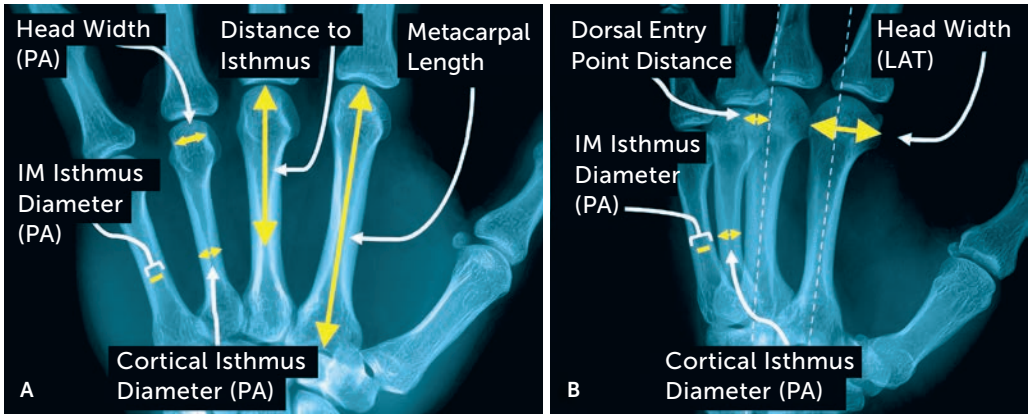
Metacarpal fractures are responsible for 10% of all fractures and account for 18% to 41% of hand injuries presenting to the emergency department or urgent care. Most hand fractures result from a fall, crush injury or direct impact with the hand and can occur in the base, shaft, head or neck. Due to variation in fracture type and pattern, different treatment options should be tailored for each injury presentation. Options for fixation of metacarpal neck and shaft fractures include lag screws, plate fixation, K-wire pinning and intramedullary headless cannulated screw fixation.

Jefferson Health researchers led by Michael Okoli, MD, conducted a study to investigate variations in radiographic anatomy as it relates to intramedullary (IM) fixation of metacarpal fractures and to compare this anatomy with available headless screw dimensions.

Researchers radiographically analyzed posteroanterior and lateral (LAT) radiographs of 120 metacarpals across 30 patients with structural abnormalities. Primary outcomes included IM isthmus diameter, isthmus location, metacarpal cascade, and head entry point collinear with the IM canal. Measurements were compared with a list of commercially available headless screws used for IM fixation.

Findings, published in *Hand*, included:

- The average largest isthmus diameter was in the small metacarpal (3.4 mm), followed by the index (2.8 mm), long (2.7 mm), and ring (2.7 mm) metacarpals.
- The average cascade angle between long and index, long and ring, and long and small was 0°, 24°, and 27°, respectively.
- The appropriate head entry point ranged between 25% and 35% from the dorsal surface of the metacarpal head on a LAT view.
- The retrograde isthmus location of the index and long finger was 39.2 mm and 38.1 mm, respectively.
- Twenty-five screws from seven manufacturers were analyzed, with sizes ranging from 1.7 mm to 4.5 mm.



Depiction of radiographic measurements. *Source: Asif Ilyas, MD*

Only eight of 17 screws between 2.3 mm and 3.5 mm in diameter had a length range above 35 mm.

The researchers noted that while the study found differences between men and women and between metacarpals within the same individual, there are several radiographic landmarks that are relatively consistent, such as distal entry point and cascade angle, which can be used to approximate screw placement and fracture reduction.

"Metacarpal head entry point and cascade angle can help identify the appropriate reduction with the guide pin starting point in the dorsal 25% to 35% of the metacarpal head," the researchers noted. "Surgeons should be mindful to choose the appropriate fixation system in light of the variations between metacarpal isthmus size, isthmus location and available screw lengths."

Risk of Infection in Trigger Finger Release Surgery Following Corticosteroid Injection

Trigger finger or stenosing flexor tenosynovitis of the A1 pulley is a fairly common condition in adults, with an estimated lifetime prevalence of 2%. Corticosteroid injections are the mainstay of nonsurgical treatment and have a reported success rate between 40% and 90%.

Theoretical risks of injection include flare reaction, tendon rupture, local infection, blood glucose elevation and fat atrophy, but limited data exist on these complications.

Jefferson Health researchers led by Jonas Matzon, MD, set out to quantify the risk for infection in trigger finger release surgery after preoperative corticosteroid injection. They retrospectively evaluated all patients undergoing the procedure by 16 surgeons over a two-year period.

The data collected included demographic information, medical comorbidities, trigger finger(s) operated on, presence of a prior corticosteroid injection, date of most recent injection, postoperative signs of infection, and need for surgery due to deep infection. Superficial infection was defined according to Centers for Disease Control and Prevention (CDC) criteria. Deep infection was defined as the need for surgery because of a surgical site infection.

Deep Infections per Injection Interval

Injection Interval, d	Total	DI	% DI	% DI/3 mo
0–30	69	0	0.0	
31–60	190	5	2.6	2.0
61–90	136	3	2.2	
91–120	100	1	1.0	
121–150	98	1	1.0	1.1
151–180	76	1	1.3	
181–210	87	0	0.0	
211–240	95	0	0.0	0.0
241–270	74	0	0.0	
271–300	79	0	0.0	
301–330	79	0	0.0	0.0
331–360	66	0	0.0	
>360	216	0	0.8	
Total	1,342	11	0.8	

Source: Asif Ilyas, MD

A total of 2,480 fingers in 1,857 patients undergoing trigger release surgery were included in the analysis, which was published in *Journal of Hand Surgery*.

Among the findings:

- Of the total number of fingers, 53 (2.1%) developed an infection. There were 41 superficial infections (1.7%) and 12 deep infections (0.5%).
- Before surgery, 1,137 fingers had no corticosteroid injection. Of those, one finger (0.1%) developed a deep infection and 17 (1.5%) developed a superficial infection.
- In comparison, 1,343 fingers had a corticosteroid injection before surgery. Of those, 11 (0.8%) developed deep infection and 24 had superficial infection (1.8%).
- Median time from corticosteroid injection to trigger release surgery was shorter for fingers that developed a deep infection (63 days) compared with those that developed no infection (183 days).
- The risk for developing a deep infection in patients who were operated on within 90 days of an injection (8 infections in 395 fingers) was higher compared with patients who were operated on greater than 90 days after an injection (3 infections in 948 fingers).

"Preoperative corticosteroid injections are associated with a small but statistically significant increased rate of deep infections after trigger release surgery," the researchers concluded, noting that the risk seems greater when the injection is given within 90 days of surgery and especially within 31 to 90 days.

"We counsel patients that risk for infection decreases the longer the time from the injection. This may be a consideration in particular when discussing surgery with patients who had a short duration of success with previous corticosteroid injection," the researchers said.

Three-Dimensional Printing in Orthopaedic Surgery

Three-dimension (3D) printing is being incorporated into all kinds of industries and businesses, including health care. While 3D printing was first developed in the 1980s, the technique has more recently been adopted for medical applications.

In an article in *Journal of Bone Joint Surgery*, Jefferson Health researchers led by Kevin Lutsky, MD, explored the history and growing potential of 3D printing in orthopaedic surgery.

"The ability to precisely engineer, complex 3D structures allows for improved preoperative planning for difficult orthopaedic reconstruction cases, such as joint revision surgery and reconstruction in patients with massive bone loss secondary to trauma or malignancy," the article said. Also, "the advent of 3D printing has ushered in the era of 'patient-specific orthopaedics,' with custom-designed, patient-specific implants, instrumentation, models, and bioscaffolds for tissue-engineering applications."

The article outlined various ways of creating files that can be modeled and printed, including computer-assisted design software, a 3D scanner, Digital Imaging and Communications in Medicine files, and online libraries. It also detailed the types of printers used for 3D medical applications, including fused deposition modeling, stereolithography, selective laser sintering and bioprinters.

The article said that orthopaedic applications of 3D printing include the generation of prosthetics and orthotics, intraoperative guides, patient-specific implants and anatomic models for preoperative planning and education.

"The availability of 3D-printed anatomic models may enhance surgeons' preoperative planning and improve orthopaedic education with the generation of anatomic models," the article said.

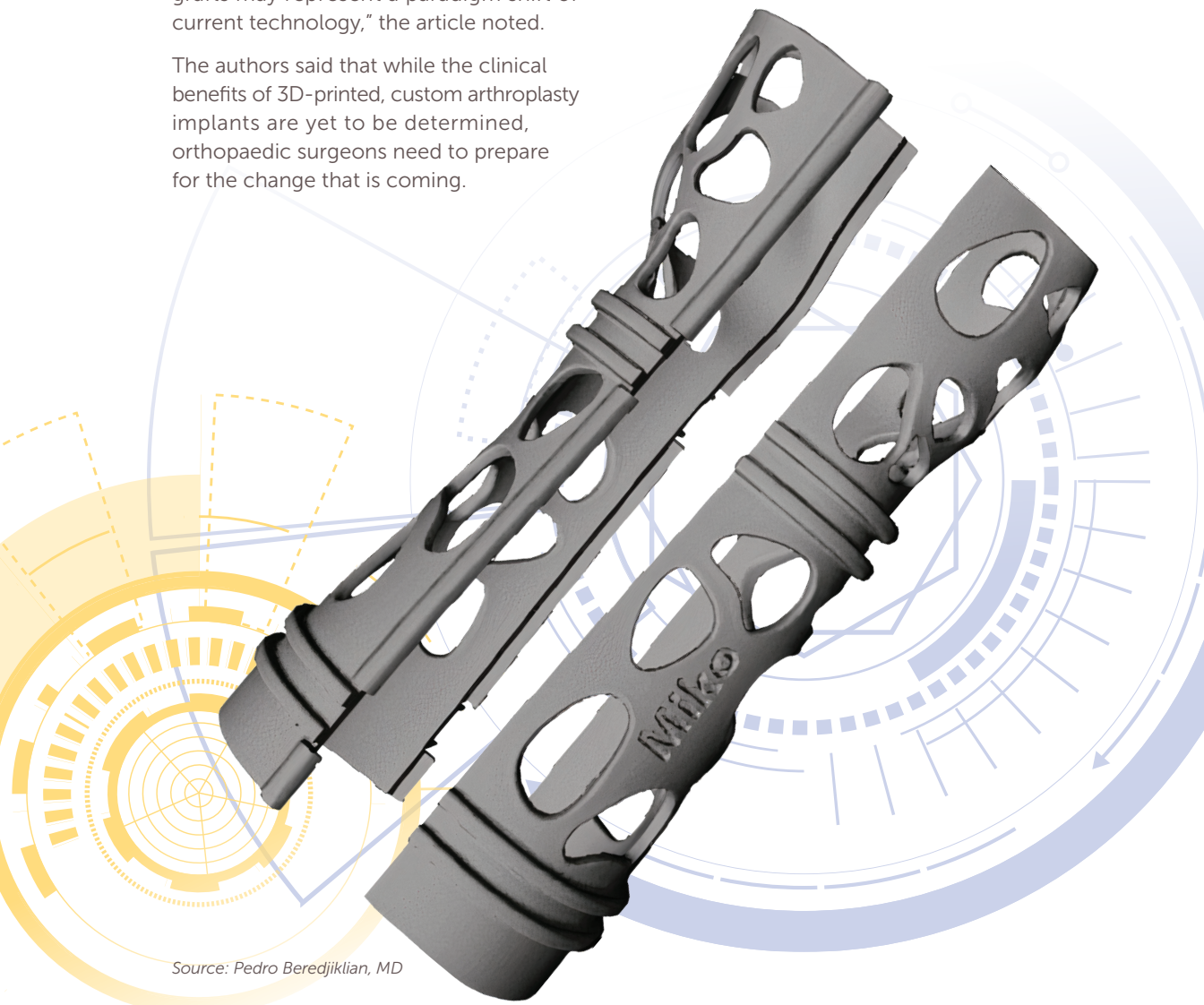
A printed clamshell cast made using a plastic polymer on a desktop fused deposition modeling 3D printer.
Source: Pedro Beredjiklian, MD

Another potential is that children with an amputation or congenital limb difference can benefit from increased access and diminished cost of 3D-printed prostheses, especially if they live in communities with limited resources.

"Similarly, the biologic augmentation of bone and soft-tissue healing processed with bioactive, tissue size and shape-specific grafts may represent a paradigm shift of current technology," the article noted.

The authors said that while the clinical benefits of 3D-printed, custom arthroplasty implants are yet to be determined, orthopaedic surgeons need to prepare for the change that is coming.

"Orthopaedic surgeons will greatly benefit from familiarizing themselves with the potential of this technology and evaluating the efficacy of currently available technology and devising future applications in clinical practice," the authors recommended. An ongoing research project at Jefferson involves studying outcomes of treatment of upper extremity fractures using 3D-printed orthoses.



Source: Pedro Beredjiklian, MD

Philadelphia Hand to Shoulder Center Studies

Osteochondral Autograft Transplantation for Hand and Wrist Articular Problems

Management of hand and wrist avascular necrosis (AVN) with osteochondral fragmentation (OCF) or focal arthritis can be a challenging problem. A variety of procedures have been described for its treatment.

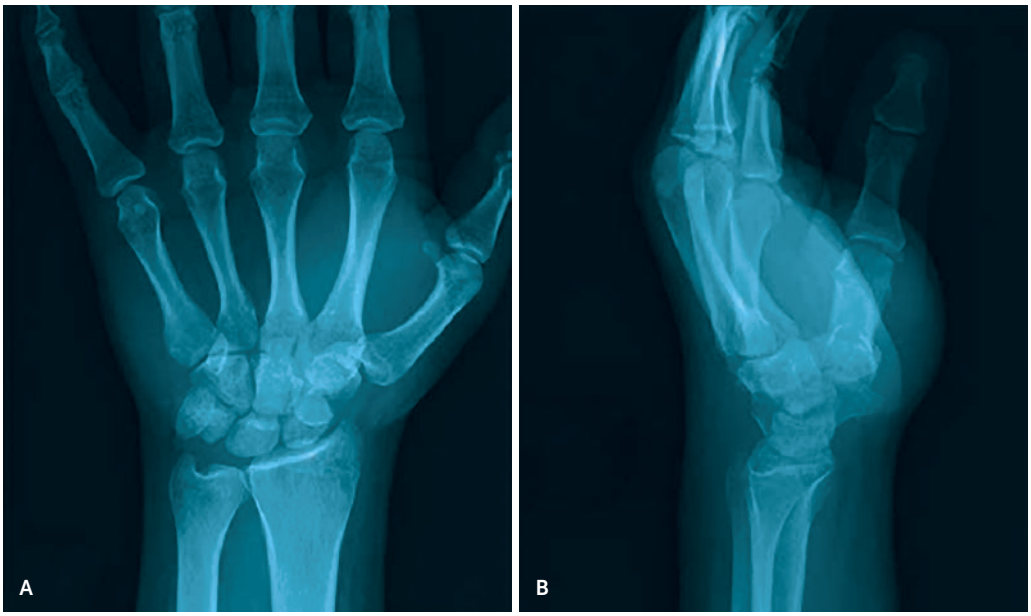
One treatment possibility is osteochondral autograft transplantation systems (OATS), which have been utilized on various focal defects of the knee, ankle, elbow and wrist. In an article in *Techniques in Hand & Wrist Upper Extremity Surgery*, Jefferson Health hand surgeons led by Andrew J. Miller, MD, describe the potential benefits in using the approach in hand and wrist cases, particularly in the treatment of small joint AVN or nonunion OCF of the hand and wrist.

"The application of OATS for problems of the hand and wrist presents a unique opportunity to restore focally damaged cartilage," Dr. Miller said.

The article focused on two case studies in which the authors detailed their use of OATS. The first involved a 13-year-old female who was active in gymnastics and softball for several years. She had an insidious onset of dorsal central right wrist pain that resulted in casting and modification of her activities. Subsequently, CT and MRI scans showed proximal fragmentation and fracture of the capitate consistent with AVN.

The other case involved a 14-year-old male, with a history of Ehlers-Danlos syndrome, who was injured with a direct blow to the right hand. Following initial casting for a diagnosis of a third metacarpal fracture, he developed pain in an adjacent joint. He was subsequently diagnosed with fourth metacarpal AVN.

Both patients underwent an OATS procedure and had favorable results, the researchers reported.



AP and lateral x-rays of a left wrist demonstrating squaring of the proximal capitate. *Source: Andrew Miller, MD*

Contralateral Heterotopic Thumb-to-Thumb Replantation With Free Ulnar Forearm Fasciocutaneous Flap and Targeted Muscle Reinnervation

A mangled hand often presents a difficult clinical scenario for the upper-extremity surgeon, especially when limb salvage may not be possible and amputation results. Few mangled extremity injuries are identical and the literature offers little guidance for managing devastating bilateral injuries.

An awareness of the array of microsurgical reconstructive options may enable the hand surgeon to restore some function even in the direst of circumstances.

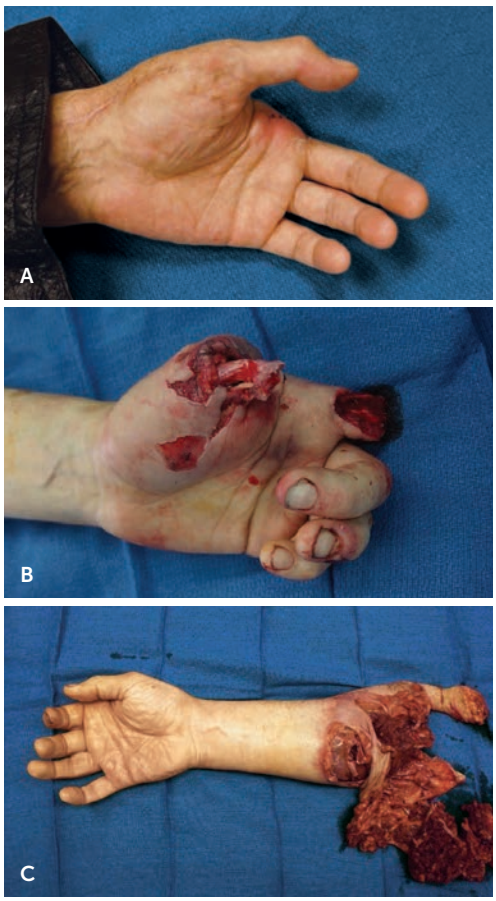
Jefferson Health surgeon Rick Tosti, MD, published a case report of an unusual "spare parts reconstruction" of a bilateral upper-extremity mangling injury treated with a heterotopic thumb-to-thumb replantation, an acute forearm fasciocutaneous free flap, and targeted muscle reinnervation. According to Dr. Tosti, an acute thumb-to-thumb transfer has never been previously reported.

The spare parts surgery involved a 55-year-old man who had been struck by a train. At presentation to the hospital, his right upper extremity was amputated at the distal humerus with degloving of skin to the axilla. The amputated extremity distal to the elbow was in good condition. The man's left upper extremity had an amputated thumb and amputated index finger with exposed bone. The amputated digits were not available to the surgeons.

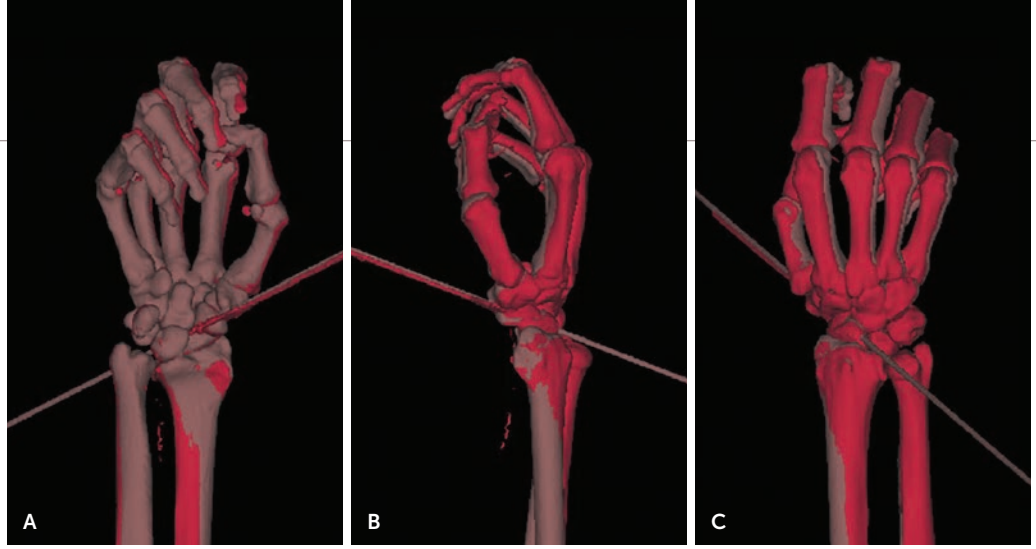
The surgeons describe in detail their technical approach to the complex case in an article in *Journal of Hand Surgery*. They said their overall goal in the multi-step process, including the thumb-to-thumb replantation, was to improve the patient's ability to carry out basic personal needs such as eating, hygiene and toileting. In the absence of the right arm and left thumb, he would have to depend on others.

The surgeons reported that at one year, the patient remained independent and was using his left hand for daily household and self-care activities.

The targeted muscle reinnervation was performed to the stump of the right arm. By transferring nerves to specific regions of the pectoralis muscles, the surgeons said that the risk of pain from a neuroma is reduced and the chance of functioning with an intuitive myoelectric prosthetic is optimized for the future.



Source: Rick Tosti, MD



Preprocedure scaphoid with simulated guidewire surface model and postprocedure scaphoid surface model were overlapped in different views to evaluate the accuracy of the guidewire placement. (A) Palmar view. (B) Lateral view. (C) Dorsal view. *Source: Rick Tosti, MD*

A Cadaveric Study on the Accuracy of an Individualized Guiding Template to Assist Scaphoid Fixation Using Computed Tomography and 3-Dimensional Printing

Screw fixation of an acute scaphoid fracture has become a popular technique due to its well-known mechanical advantages. It has been shown in biomechanical and clinical studies that the central placement of a scaphoid screw improves the healing rate and reduces the immobilization period of a scaphoid fracture. However, precise central placement of the screw in the scaphoid remains a challenging task for surgeons.

Jefferson Health researcher Dan Zlotolow, MD, in collaboration with a group from Beijing, China designed a study using cadaver wrists to evaluate the feasibility and accuracy of scaphoid screw guidewire placement using a computer-assisted-designed 3-dimension-printed surgical guiding template.

Computed tomography (CT) scans of 12 fresh-frozen cadaver wrists were performed and the data were imported into a surgical planning system. A 3D skin surface template block with a guiding hole was generated from the CT data to allow a screw guidewire to be placed in the central third of the scaphoid. The 3D model was printed and then put back into the wrist.

A screw guidewire was inserted through the palmar guide hole into the intact scaphoid and then a post-procedural CT scan was done. The post-procedure data were introduced into the surgical planning system. Angular and linear deviation between the preprocedural simulation and the image of the guidewire was measured in the system to assess accuracy.

The results of using the innovative technique were favorable. The mean angular deviation was 3.85° $\pm$ 1.32° and linear deviations of the 12 specimens were less than 1.1 mm. In addition, no specimen required a repeat drilling to the scaphoid. All of the screw guidewires were considered to be centrally placed in the scaphoid based on study criteria of central placement of the scaphoid screw.

"The use of a computer-assisted 3-dimensional-printed surgical guide template to assist screw guidewire placement into an intact scaphoid, mimicking a nondisplaced scaphoid fracture, showed acceptable accuracy in cadaver wrists," the researchers reported in *Journal of Hand Surgery*.

While the study was conducted using cadaver wrists, the technique shows clinical promise. The researchers noted that "our technique may provide a simple and effective method for the guidance of screw guidance insertion in a nondisplaced scaphoid fracture surgery."

Early Results of Nerve Transfers for Restoring Function in Severe Cases of Acute Flaccid Myelitis

The Centers for Disease Control and Prevention (CDC) confirmed 558 cases of acute flaccid myelitis (AFM) in the U.S. from December 2012 to March 2019. This rare polio-like disease has been recognized in a number of states, with cases peaking in incidence every two years and most cases involving children younger than 15. Cases of AFM have also been confirmed in other countries.

AFM has been defined as an acute onset of flaccid limb weakness affecting one or more limbs. Paralysis occurs five to seven days after initial influenza-like symptoms and may progress quickly in the next 48 to 72 hours to affect the neck, trunk muscles, and cranial nerves. Many patients also have respiratory dysfunction.

More than 75% of AFM patients have incomplete recovery with persistent motor deficits. Studies report recovery plateauing during the first six to nine months, with proximal muscles less likely to recover. For now, the treatment for AFM is mainly supportive because immunomodulating agents have failed to alter its course.

For AFM patients with motor deficits persisting beyond six to nine months, nerve transfer surgery is sometimes performed. The benefits of the surgery, however, have not been clearly established in the medical literature.

Jefferson Health researcher Dan Zlotolow, MD, led a team at Shriners Hospital for Children in conducting a retrospective case analysis of patients with AFM at their center who underwent nerve transfer surgery by a study author between 2007 and 2018. Surgical criteria were persistent motor deficits after six months from onset and available donor nerves.

Thirty-two patients with AFM were evaluated, of whom 16 underwent nerve transfer surgery. Motor function was evaluated by a licensed occupational therapist using the Active Movement Scale preoperatively and during follow-up examinations. Patients with six months or more of follow-up were included in the analysis. Patients who had procedures other than nerve transfers were excluded.

Of the 16 patients who had nerve transfers, 75% were males and the median age was 2.5 years (with ages ranging from four months to 12 years). Forty-five nerve transfers were performed in the 16 patients. Thirteen patients had nerve transfers for shoulder reanimation, eight for elbow flexion and six for elbow extension. One patient had a nerve transfer for finger and thumb extension.

Of the 16 patients, 11 had six months of follow-up and were included in the final analysis, which was published in *Annals of Neurology*. Results included:

- Of nerve transfers done to restore elbow function, 87% of patients had an excellent recovery for elbow flexion.

(A–B) Preoperative examination. (A) Maximum elbow flexion, through Steindler effect. Shoulder pseudosubluxation is evident. (B) Maximum shoulder abduction. (C) Intraoperative picture of shoulder nerve transfer for shoulder external rotation. (D–F) Twelve-month follow-up showing shoulder. (D) Elbow flexion, (E) External rotation, (F) Abduction. *Source: Dan Zlotolow, MD*

- Of nerve transfers to restore elbow extension, 67% of patients had recovery of 50% or more of motion against gravity.
- Of the cases of nerve transfer done for shoulder reanimation, 50% of patients achieved excellent shoulder external rotation, while 20% achieved excellent shoulder abduction.
- Nine of 10 patients (90%) had resolution of shoulder pseudosubluxation following nerve transfer to the suprascapular nerve.

"Restoration of elbow function was more reliable than restoration of shoulder function," the study reported, though it was not clear why that was the case.

Overall, "Patients with AFM with persistent motor deficits 6 to 9 months after onset benefit from nerve transfer surgery," the study concluded.

The researchers added a caveat – that previous research has demonstrated that delayed assessment and intervention in children with nerve injuries can lead to worse outcomes after nerve transfers.

"We recommend early referral of (AFM) patients with incomplete recovery to a center experienced in nerve transfers for timely evaluation and treatment," they said.

Funded Clinical Trials

A Multicenter, Prospective, Randomized, Subject and Evaluator Blinded Comparative Study of Nerve Cuffs and Avance® Nerve Graft Evaluating Recovery Outcomes for the Repair of Nerve Discontinuities (RECON); Axogen, Inc: 2017–Current; (Asif Ilyas, MD)

Prospective, Non-Randomized, Multi-Center Clinical Evaluation of Metacarpal Neck Fracture Outcomes Study (aka, MetaNeck Study); Exsomed: 2019–Current; (Asif Ilyas, MD)

The Effects of Surgical Timing on Infection and Union in Open Distal Radius Fractures; 2018–Current (Rick Tosti, MD and Andrew Baron, MD)

Long Thoracic Nerve Transfers for Children with Brachial Plexus Injuries; 2019–Current (Dan Zlotolow, MD and Chase Kluemper, MD)

Restoration of Elbow Flexion in Acute Flaccid Myelitis; 2019–Current (Dan Zlotolow, MD; Scott Kozin, MD; Remy Rabinovich, MD)

Complications of Proximal Phalanx Fractures Treated with Intramedually Screws; 2018–Current (Rick Tosti, MD and Ryan Tarr, MD)

Grants

Prospective Randomized Controlled Double-Blinded Trial Comparing Oxycodone, Ibuprofen and Acetaminophen after Wide Awake Hand Surgery; American Foundation for Surgery of the Hand Clinical: 2017–Current; (Asif Ilyas, MD)

ASSH: 2015–Current; (Michael Rivlin, MD); 2019–Current; (Asif Ilyas, MD)

Sharpe Strumia: 2017–Current (Jack Abboudi, MD); 2017–Current (Christopher Jones, MD)

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