EDITOR'S CHOICE

Anatomic Considerations of Retrograde Intramedullary Nail Placement in Distal Ulna Fractures

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Purpose To characterize the anatomic relationship between retrograde intramedullary nail placement in distal ulna fractures and important surrounding structures, with particular focus on the triangular fibrocartilage complex (TFCC).

Methods Eight fresh-frozen cadaveric upper extremity specimens underwent simulated distal ulnar neck fracture fixation using a 4.5 mm retrograde intramedullary threaded nail. Pre- and postinsertion arthroscopy was performed to assess TFCC integrity. Dissection was used to evaluate proximity to surrounding structures, including the extensor retinaculum, extensor carpi ulnaris, extensor digiti minimi, and dorsal cutaneous branch of the ulnar nerve. TFCC involvement was classified by location and quantified using surface area analysis.

Results The nail path disrupted the distal extensor retinaculum in all specimens, with no direct injury to the extensor carpi ulnaris, extensor digiti minimi, or dorsal cutaneous branch of the ulnar nerve, although these structures were in close proximity. The superficial TFCC and the deep radioulnar ligament footprint were involved in the majority of specimens, with the dorsal peripheral region most commonly penetrated. However, the overall surface area of the TFCC impacted was minimal.

Conclusions Retrograde intramedullary nail placement for distal ulna fractures frequently involves both the superficial TFCC and deep radioulnar ligament footprint, with perforations most common in the dorsal peripheral region rather than the central disc of the TFCC. Despite this, the overall surface area of involvement is limited.

Clinical relevance Surgeons should be aware of the proximity of important surrounding structures and the likelihood of TFCC involvement when using a retrograde intramedullary approach for distal ulna fractures. *(J Hand Surg Am. 2026;■(■):■−■. Copyright © 2026 by the American Society for Surgery of the Hand. All rights are reserved, including those for text and data mining, AI training, and similar technologies.)*

Key words Intramedullary nail placement, radioulnar ligament, triangular fibrocartilage complex, ulna fractures.

DISTAL ULNAR NECK FRACTURES are a concomitant injury seen in distal radius fractures, accompanying displaced distal radius fractures in roughly 6% of cases.[1] Fixation of distal ulnar fractures after anatomic fixation of the distal radius remains controversial, but proponents advocate that persistent fracture displacement, instability with passive range of motion, and articular displacement after rigid distal radius fracture fixation are indications for intervention. It has been suggested that distal ulnar neck fracture fixation could also allow for early range of motion when compared to immobilization required for nonsurgical management.[2]

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There have been many proposed constructs for distal ulnar neck fixation including percutaneous Kirschner wires (K-wires) and plate osteosynthesis. However, plate osteosynthesis is often complicated by minimal soft tissue coverage and symptomatic hardware prominence requiring hardware removal.[3] Alternatively, use of intramedullary nail fixation has been implemented in the fixation of distal ulna fractures because of its relative stability, allowing for early range of motion, and minimally invasive technique.[4–6] Previous studies have suggested a percutaneous retrograde approach through the ulnar head while avoiding the fovea. Authors suggest that this would theoretically focus the start point through the central disc of the triangular fibrocartilage complex (TFCC), which is less likely to have sensory innervation and would not cause postoperative instability.[4–7] However, there is a lack of evidence confirming whether this starting point selectively disrupts only the central fibrocartilaginous disc, nor the extent of such involvement. Furthermore, the proximity of critical surrounding structures to this approach has not been systematically characterized.

We hypothesized that retrograde intramedullary nail placement through the distal ulna would result in minimal disruption of the TFCC, primarily involving the central disc, and avoiding injury to adjacent structures.

MATERIALS AND METHODS

An anatomic cadaveric study was performed using eight fresh-frozen left-sided midhumerus to fingertip cadaveric specimens. There were four female and four male specimens with an average age of 76 years (range, 64−81 years). Prior to experimentation, each specimen was inspected radiographically to confirm no existing upper extremity deformities. Each specimen underwent a single freeze-thaw cycle before experimentation, with thawing occurring at room temperature for approximately 24 hours before testing. The specimens were first potted at the midhumerus and then a dry arthroscopy was performed using the standard 3,4 viewing portal with a probe in the 6R portal to assess any pre-existing pathology present.

A transverse osteotomy was made through a subcutaneous approach approximately 2.5 cm proximal to the ulnar head to simulate an ulnar neck fracture. We followed previously described techniques which recommended orthogonal fluoroscopic guidance to assess our guidewire entry point after making a 1 cm incision over the skin for guidewire entry.[4,5] Each specimen was placed in pronation. The wrist was flexed and radially deviated with carpal supination to expose the ulnar head to obtain the ideal starting point. Once the starting point was obtained, the wire was advanced proximally across the fracture site into the ulnar shaft while manual manipulation was applied to reduce the fracture and the fracture was supported. The wire position was confirmed on orthogonal fluoroscopy, as we tried to align centrally within the intramedullary canal and on the ulnar head, while attempting to stay out of the fovea (Fig. 1A, B). The arm was kept in the same position used for guidewire placement, and we reamed proximal and distal to the osteotomy using a 4.0 mm cannulated drill (Fig. 1C) followed by placement of a 4.5 mm noncompressive intramedullary threaded nail (INnate Nail, Acumed LLC) to gain fixation of the distal ulnar neck fracture (Fig. 1D). Care was taken to avoid inadvertent wire advancement and loss of wire position to ensure the implant was seated deep to the ulnar head (Fig. 1E). We selected the 4.5 mm nail as it has been consistently used in previous clinical studies with this technique based on reported mean diameters of the ulnar head and neck.[4–6] Postinsertion arthroscopy was then performed to assess visualization of the guidewire and surrounding structures. The skin entry site was then marked on the wire. Localized skin was removed to measure the proximity to extrinsic structures including the extensor retinaculum, extensor carpi ulnaris (ECU), extensor digiti minimi (EDM), and the dorsal cutaneous branch of the ulnar nerve (DCBUN). The measurement was taken along the guidewire path nearest to each structure (Fig. 2). Next, we dissected the carpus off the wrist in the direction of radial to ulnar, taking care to preserve the triangular fibrocartilage. The location of the nail path was documented as either outside of the triangular fibrocartilage, contained within the central disc, or at the periphery, involving the superficial radioulnar fibers and capsule (Fig. 3). The remaining surface area of the components of the TFCC involved were marked with an indelible marker and photographed. The superficial components of the TFCC were removed to evaluate the deep radioulnar ligament (RUL) insertions at the fovea and the process of marking and photography was repeated.

The percentage of surface area removed by the nail was calculated using SketchAndCalc, a scaled irregular surface area image processor (Fig. 4). Location of disruption, average distance to critical structures, and percentages of TFCC components

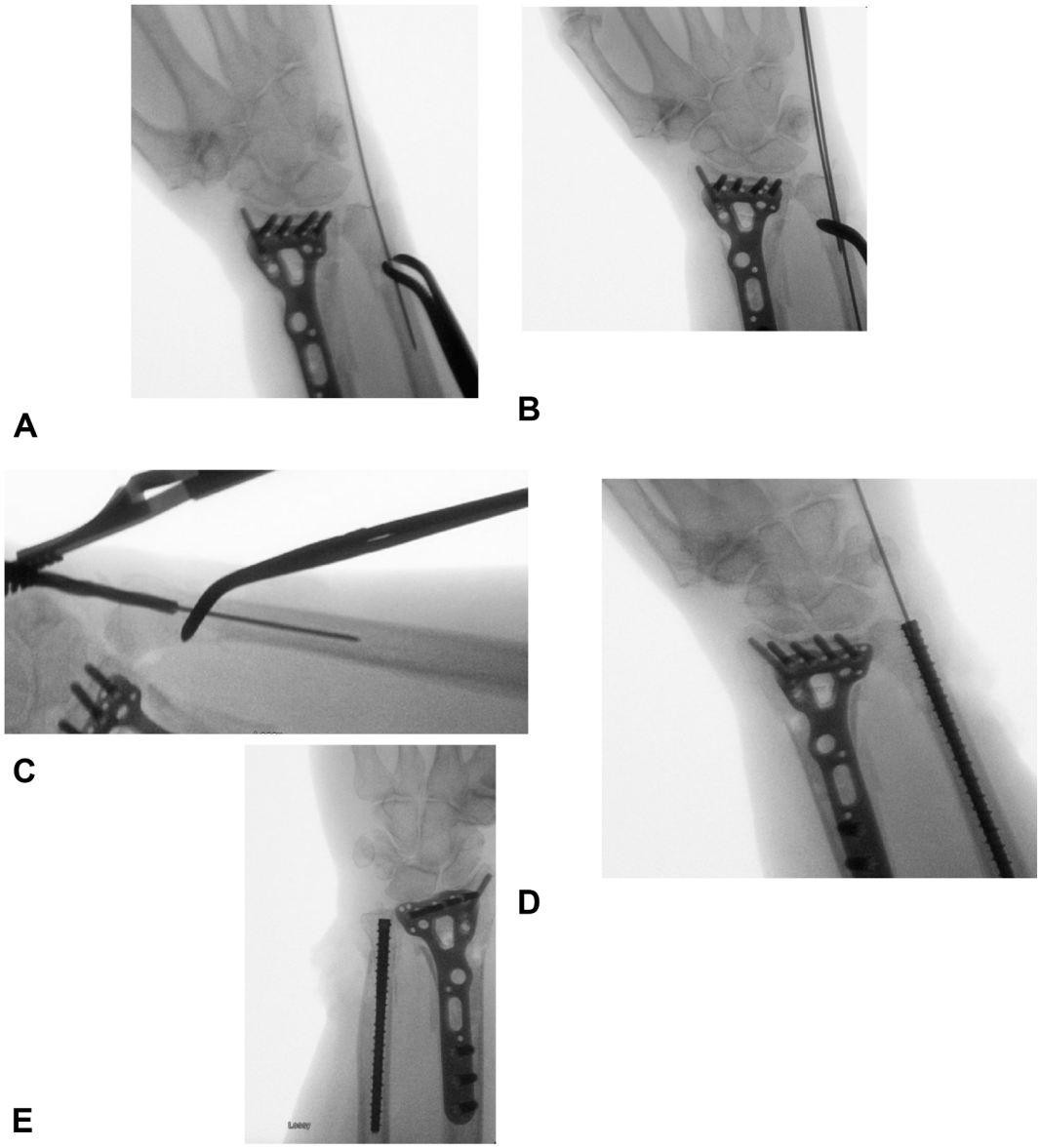

FIGURE 1: Images taken during ulnar retrograde intramedullary nail placement. **A** Guidewire placed attempting to be located centrally within the intramedullary canal. **B** Placement of a secondary guidewire directed further radially, as anatomical access permitted. **C** Reaming within the intramedullary canal in preparation for nail placement. **D** Final image of intramedullary nail with guidewire still in place. **E** Final image of intramedullary nail postoperatively.

were calculated and reported, alongside observed range of measurements.

RESULTS

On average, the distal 10% of the extensor retinaculum was disrupted by the nail path (range, 0% to 30%). There were no disruptions of the ECU, the EDM, or the DCBUN. The DCBUN was 7 mm distal to the path (range, 1−12 mm), the EDM was 2 mm (range, 1−6 mm) radial to the path, and the ECU was 3 mm ulnar to the path (range, 1−6 mm; Table 1).

In total, 75% of the cadavers (6/8) had preexisting TFCC pathology. Four had central perforations, one had a volar peripheral tear, and one specimen had both a dorsal peripheral and central perforation. After placement of the guidewire and nail, the guidewire could only be visualized arthroscopically in 38% (3/8) of specimens. Two were dorsal peripheral, and one was peripheral at the styloid (Fig. 5).

The superficial TFCC was involved in 63% (5/8) of specimens. The remainder were in the pericapsular tissue dorsal to the complex and did not involve any portion of the superficial TFCC. Of those that violated the complex, three were in the dorsal peripheral fibers, and two reached the edge of

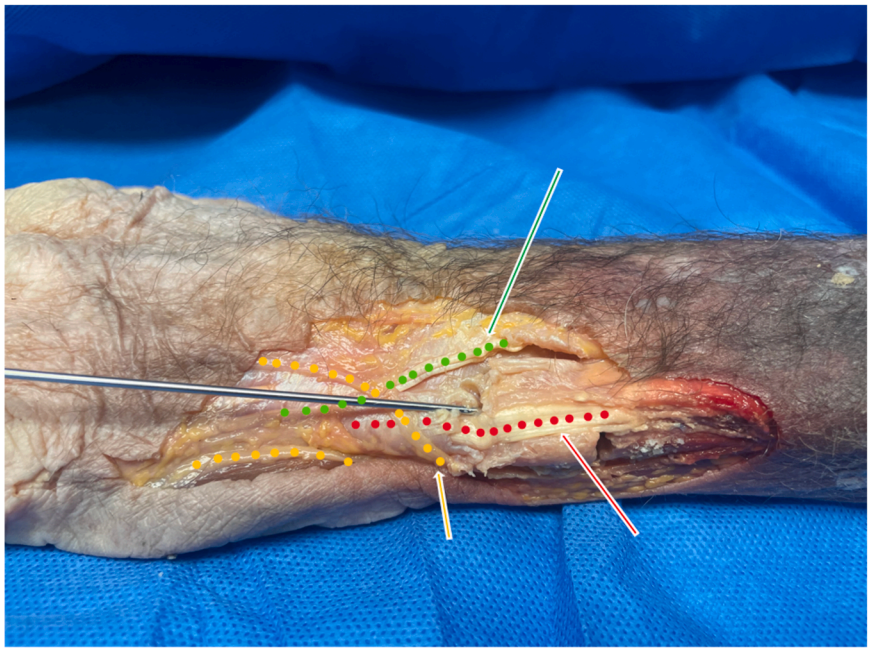

FIGURE 2: Cadaveric dissection demonstrating the intramedullary nail path relative to the EDM (green), ECU (red), and dorsal cutaneous branch of the ulnar nerve (orange).

the central disc. The average total superficial TFCC surface area when involved was 5% (Table 1). We found 88% (7/8) of specimens involved the deep RUL footprint during nail insertion. When the nail went through the deep RUL footprint, it occupied an average of 20% of the structure (Table 1; Fig. 6). The entire surface area of the deep RUL footprint measured 28 mm^2 on average.

DISCUSSION

The present study evaluated the anatomical margins associated with retrograde intramedullary nail fixation for distal ulnar neck fractures. Our results demonstrate that although this technique perforates the distal extensor retinaculum and avoids adjacent tendinous and neural structures, it causes quantifiable disruption to the TFCC, with perforations predominantly in the dorsal peripheral region rather than the central disc, contrary to our original hypothesis.

When observing the distal extensor retinaculum, an average of 10% (range, 0% to 30%) of its total surface area was perforated. Although bowstringing is a theoretical concern with retinacular disruption, prior studies have shown that complete release of the sixth dorsal compartment and segmental resections of up to two-thirds of the fourth dorsal compartment do not cause bowstringing, values considerably greater than our findings.[8,9] Tendinous or neural structures in our study were also not penetrated.

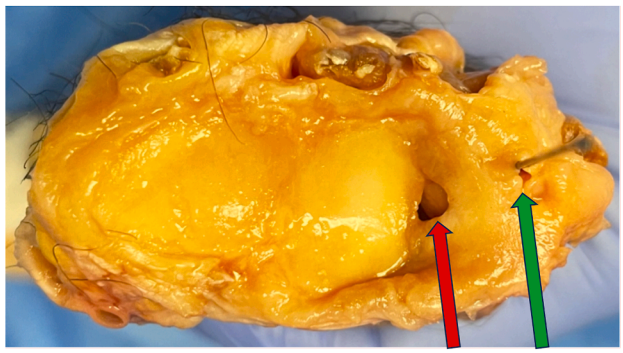

FIGURE 3: Dissection of the TFCC illustrating a pre-existing tear (red) and intramedullary nail path damage (green).

However, the DCBUN approached within 1 mm of the nail trajectory in one specimen. Care should be taken to protect the DCBUN. We recommend a limited open incision during drilling and nail insertion to carefully visualize and protect the nerve, such as is done when tying down sutures for arthroscopic TFCC repair.

The technical description for retrograde intramedullary nails in the distal ulna has proposed that the nail traverses the central disc of the TFCC.[4,5] When TFCC involvement occurred in our study, the dorsal peripheral region was most commonly penetrated and the central disc was largely spared. This finding may be important given that the peripheral TFCC is richly innervated compared to the central

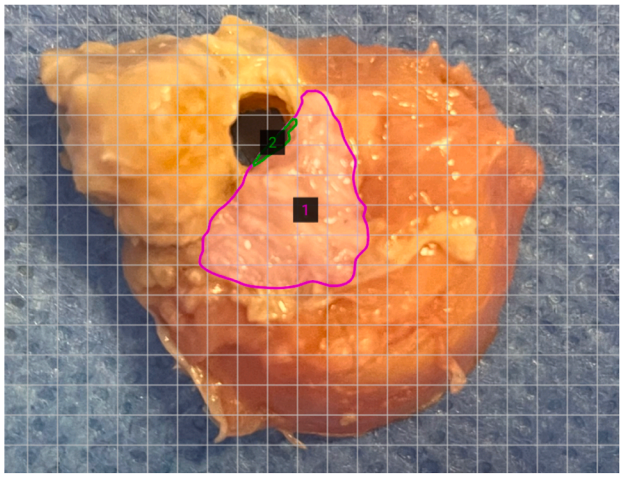

FIGURE 4: Surface area processor outlining the components of the deep TFCC and nail perforation. The pink outline is the deep TFCC. The green outline is the perforation from the nail and guidewire.

disc and disruption of the peripheral fibers could theoretically produce pain or contribute to instability.[10] Despite this concern, low postoperative pain and early return of wrist mobility has been reported in clinical series. However, the outcomes are limited by small sample sizes.[4–6]

Furthermore, forearm positioning during guidewire and nail placement may also influence the observed anatomical relationship. Since the TFCC is fixed to the radius, pronation causes the ulnar head to rotate and translate dorsally relative to the TFCC. Although forearm positioning has not been consistently specified across prior clinical reports, Jeffs et al[6] performed nail insertion in neutral rotation. This is in contrast to the pronated position employed in the present study, which likely shifted the wire trajectory toward the dorsal peripheral TFCC fibers. Forearm positioning represents a technical consideration worth emphasizing for reproducibility and safety.

Retrograde intramedullary nail insertion also involved the deep RUL footprint in seven of eight specimens (88%), disrupting a mean of 20% of the total footprint area. Prior anatomic studies have shown that the deep RUL spans the radial wall and foveal bottom of the ulna, with fibers oriented at an acute angle relative to the distal TFCC and a mean footprint area of approximately 26 mm^2, concordant with our own measurement of 28 mm^2.[11] Given the location of the deep RUL footprint, consistent nail involvement of this structure implies that passage through the foveal region is largely obligate when the nail is centered within the intramedullary canal. The single specimen without RUL footprint involvement had the nail passed through the base of the styloid, suggesting that shifting the entry point even slightly ulnar on the longitudinal axis of the ulna may redirect the nail. We propose that the originally described technique of avoiding the fovea may not be consistently achievable in practice when attempting to align centrally within the intramedullary canal.[4,5]

Retrograde intramedullary nails for distal ulna fractures have shown high success rates across transverse, oblique, and comminuted fracture patterns in small case series. However, indications remain undefined, and comminuted morphology may carry risk of implant back-out.[4–6] K-wire fixation is a common alternative approach, aiming for coronal plane stability of the ulnar head and reduction of shaft convergence. However, this carries recognized drawbacks including poor canal fill, pin migration, pin tract infection, and soft tissue irritation.[12] Plate fixation may also be effective, but the soft tissue envelope of the distal ulna can contribute to hardware prominence, with secondary removal rates of 29%.[3,13] Intramedullary nail fixation may offer advantages as elimination of exposed hardware removes pin site infection risks and secondary removal rates have been reported at lower than 6% at 1 year.[6] Biomechanical data have also demonstrated that intramedullary nail fixation provides construct stability in flexion and extension with reduced interfragmentary motion. However, it does exhibit significantly lower fatigue resistance during pronation-supination when compared to volar locking plate fixation.[7] Although small clinical case series show promising results, retrograde intramedullary nail fixation remains an uncommonly employed technique.[4–6] The hardware-related morbidity associated with K-wire and plate fixation must be weighed against the iatrogenic TFCC disruption demonstrated in the present study. In addition, until larger prospective functional outcome data is available, broad adoption of this technique should be approached cautiously.

Limitations of this study include a small sample size of eight specimens, making generalizability of the findings uncertain. Arthroscopic assessment was only performed above the TFCC. Therefore, pre-existing deep TFCC fiber pathology cannot be formally excluded. However, given the semicircular disruption seen at the level of the nail insertion, we postulate that this consistent disruption would only be from the nail. Additionally, our study did not assess distal radioulnar joint stability

TABLE 1. Summary Table for Each Specimen Undergoing Retrograde Intramedullary Nail Implantation*

Specimen	Superficial Tear Location	Superficial TFCC Surface Area Disrupted (%)	Deep RUL Footprint Surface Area Disrupted (%)	DCBUN (mm)	EDM (mm)	ECU (mm)
1	Dorsal peripheral fibers	5	22	1	1	6
2	Edge of central disc	5	20	4	1	5
3	Edge of central disc	5	24	4	1	4
4	Dorsal pericapsular tissue	0	21	10	6	1
5	Dorsal peripheral fibers	5	4	4	2	1
6	Dorsal pericapsular tissue	0	22	10	1	2
7	Dorsal pericapsular tissue	0	0	8	2	1
8	Dorsal peripheral fibers	3	26	12	3	1

*Individual values for each specimen after analysis of retrograde intramedullary nail placement into the ulna.

before and after nail insertion, which would provide valuable information about the functional impact of TFCC disruption. The high prevalence of pre-existing TFCC pathology in our elderly specimens may limit generalizability to younger patient populations. This study also did not assess fracture stability or evaluate the biomechanical appropriateness of retrograde intramedullary nail fixation for the fracture pattern reproduced in our model. The use of fresh-frozen specimens may also demonstrate different tissue characteristics and limits our collection of patient pain data. Furthermore, this study used a single nail diameter of 4.5 mm. Commercially available intramedullary nails offer a range of diameters, and the degree of TFCC and surrounding structure involvement may vary with implant size.

CONFLICTS OF INTEREST

No benefits in any form have been received or will be received related directly to this article.

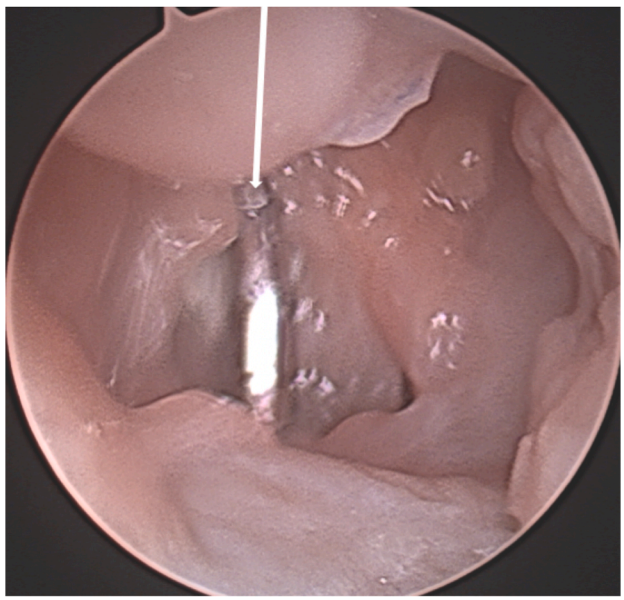

FIGURE 5: Arthroscopic visualization of the guidewire for intramedullary nail placement. The arrow denotes the guidewire in the image showing a postinsertion peripheral tear.

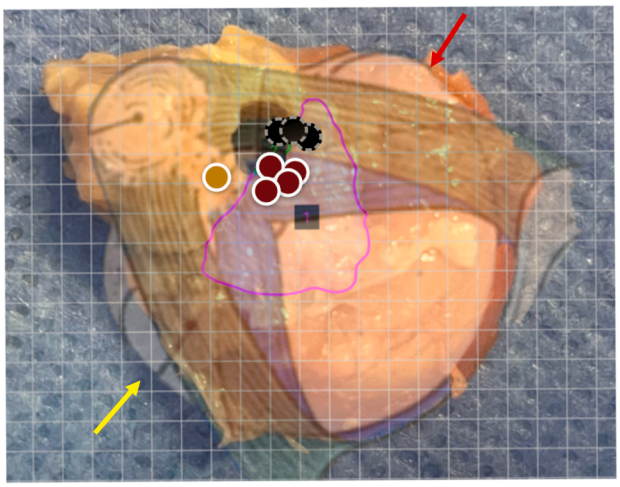

FIGURE 6: Pictorial representation of nail entry points relative to the ulnar head, overlaid on a cadaveric specimen photograph with the forearm in neutral. Note that this neutral-position image does not reflect the position of the superficial TFCC fibers at the time of nail insertion. The forearm was pronated during insertion allowing the ulnar head to rotate and translate dorsally, displacing the superficial TFCC. The deep RUL, which inserts at the fovea, does not displace appreciably with pronation and therefore remains vulnerable at this location regardless of forearm position. The pink outline denotes the measured surface area of the deep RUL footprint in this specimen. Dot color indicates nail trajectory and foveal involvement: yellow, nail passed through the ulnar styloid; red, nail passed centrally through the fovea; black, nail passed through the dorsal fovea. The red arrow indicates the dorsal side; the yellow arrow indicates the palmar side.

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