SCIENTIFIC ARTICLE

Assessment of Cartilaginous and Tendinous Lesions Following Intramedullary Compression Screw Fixation of Middle Phalangeal Fractures: A Cadaveric Study

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Purpose Phalangeal fractures are undergoing surgical intervention more frequently and can be stabilized via a range of modalities. Intramedullary screw (IMS) fixation has become popular in the management of metacarpal and phalangeal fractures, with promising short- to medium-term results. Violation of articular cartilage and the terminal extensor tendon is a concern when IMS fixation is used in the middle phalanx. The aim of this study was to assess the cartilaginous and soft tissue footprint resulting from retrograde IMS insertion in the middle phalanx.

Methods Ten cadaveric hands underwent radiographic guided insertion of 1.7 and 2.2 mm diameter headless compression screws. The width of the extensor tendon lesion and the surface area of the surface defect within the articular cartilage were both measured using digital processing software.

Results Using the 1.7 mm screw, the mean lesion involved 12.1% of the width of the extensor tendon and 1.8% of the total articular surface. Using the 2.2 mm screw, the mean lesion involved 20.4% of the width of the extensor tendon and 3.5% of the total articular surface.

Conclusions The use of retrograde intramedullary screw fixation in the middle phalanx results in minimal violation of the articular cartilage and terminal extensor tendon.

Clinical relevance This study finds minimal disruption of the articular cartilage and terminal extensor tendon when intramedullary screws are inserted into middle phalanges in a retrograde fashion. When combined with promising early- to mid-term clinical outcomes, these findings render intramedullary screw fixation a suitable therapeutic option in this cohort. *(J Hand Surg Am. 2025;■(■):1.e1-e5.*

Key words Intramedullary fixation, phalangeal fractures.

Online Exclusive

PHALANGEAL FRACTURES are undergoing surgical intervention more frequently and can be stabilized via a range of modalities.[1] Intramedullary screw (IMS) fixation has become popular in the management of metacarpal and phalangeal fractures, with promising short- to medium-term results.[2–5] It may also be particularly useful for middle phalanx fractures, where dorsal plating in the context of the

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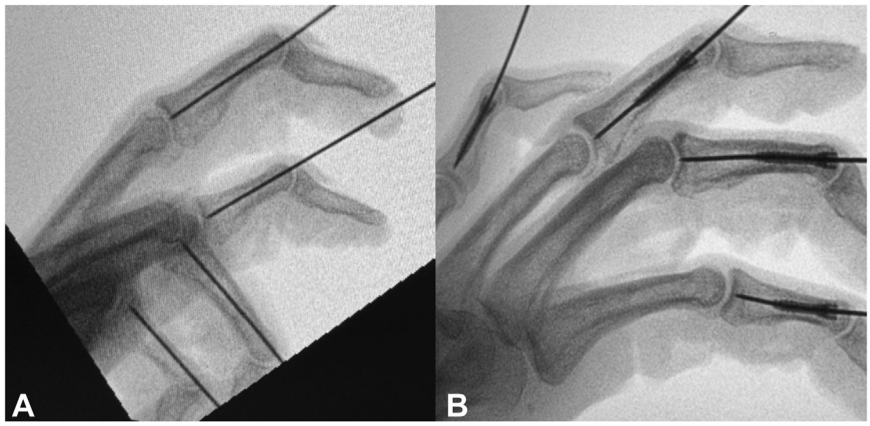

FIGURE 1: Wire **A** and screw **B** insertion under fluoroscopy guidance.

intimately related extensor apparatus and bone can result in postoperative stiffness. The obvious concern, however, is of violation of articular cartilage and the terminal extensor tendon.

Although there have been multiple prior assessments of the cartilaginous and tendinous lesions following IMS fixation of proximal phalangeal and metacarpal fractures, there is a paucity of literature studying the footprint imparted by the use of this modality in the middle phalanx. Thus, the aim of this study was to quantify the proportion of the articular cartilage and terminal extensor tendon affected following retrograde insertion of intramedullary screws for stabilization of middle phalangeal fractures. We hypothesized that the use of IMS fixation in this setting would result in a negligible soft tissue footprint.

MATERIALS AND METHODS

Following approval by the Northern Sydney Local Health District Human Research Ethics Committee, a sample of convenience of 10 unmatched fresh frozen cadaveric hands was procured. The middle phalanges of all digits, except the thumb, were used, resulting in a total sample of 40 phalanges. The hands were alternately allocated to receive either 1.7 or 2.2 mm diameter headless compression screws (Speedtip CCS, Medartis), yielding two groups of 20 phalanges each.

Radiographs were performed prior to instrumentation to exclude the presence of pre-existing hardware, malunion, or fracture. Digits with osteoarthritis in the distal interphalangeal joints were included in the study.

Under radiographic guidance, appropriate guide wires—0.6 mm for the 1.7 mm diameter headless compression screw and 0.8 mm for the 2.2 mm diameter screw—were inserted percutaneously through maximally flexed distal interphalangeal joints to facilitate retrograde intra-articular insertion. The wires were inserted in the center of the intramedullary canal on both coronal and sagittal radiographs. A small skin incision was created adjacent to the wire, and the cannulated screw was inserted over the wire without predrilling. Adequate subchondral seating of the screw was checked on fluoroscopy (Fig. 1).

Each digit then underwent removal of the skin and subcutaneous tissues, leaving the extensor apparatus intact. A ruler was used to measure the width of the extensor tendon lesion because of screw insertion, the total width of the extensor tendon at the level of the lesion, and the distance of the lesion from the terminal insertion.

The middle phalanges were then extracted, denuded of all soft tissue attachments, and mounted securely in a standardized position using a vice-clamp. Digital photographs were taken perpendicular to the articular surface of the middle phalangeal head using a stationary digital camera at a distance of 140 mm. The photographs were then assessed via two investigators using Image J processing software (National Institute of Health) to calculate both the total surface of the articular cartilage, as well as the surface area of the articular defect caused by the insertion of the screw (Fig. 2).

Each measurement was performed twice by the two investigators, with the mean of the four measurements used for final analysis. A descriptive statistical analysis was performed where appropriate.[6]

RESULTS

The cohort consisted of six females and four males, with a mean age of 78.4 ± 5.2 years (71−85). There was an equal distribution of right and left hands.

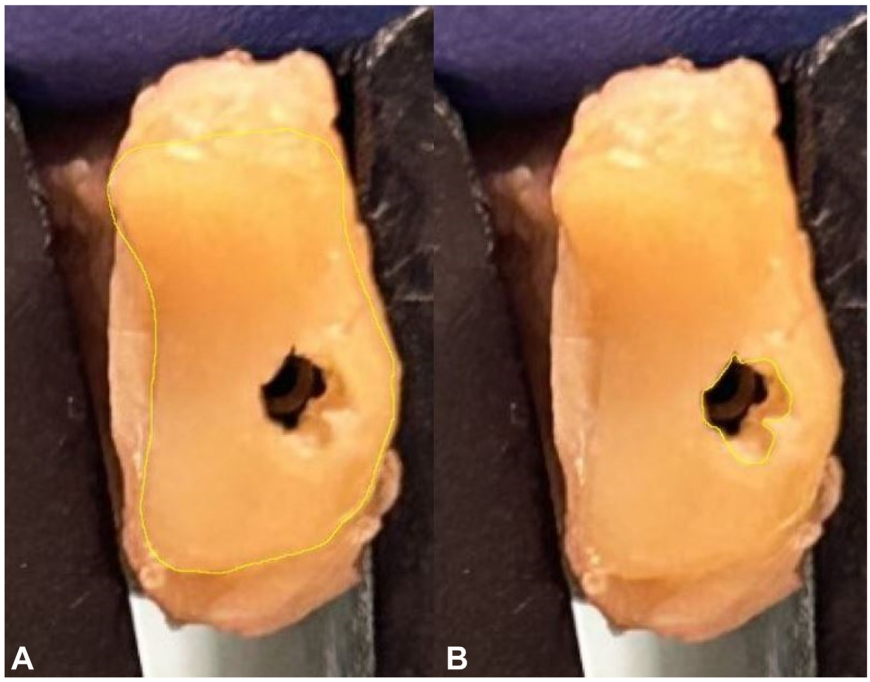

FIGURE 2: Surface area measurement of **A** total articular cartilage and **B** articular surface defect.

The extensor tendon defect because of the passage of a 1.7 mm screw was a mean of 1.1 ± 0.4 mm (0.5−2.0) in width and occurred 3.9 ± 0.6 mm (2.5−5.0) from the terminal extensor insertion. The total width of the extensor apparatus at the level of the lesion was a mean of 9.3 ± 1.5 mm (7.0−13.0). Thus, the lesion affected approximately 12.1% of the width of the extensor tendon.

Similarly, the mean width of the extensor tendon lesion resulting from the insertion of a 2.2 mm screw was 1.7 ± 0.9 mm (1.0−4.0). This defect occurred at a mean of 3.5 ± 0.8 mm (2.0−5.0) from the terminal insertion on the distal phalanx. The total width of the tendon at the level of the lesion was 8.1 ± 1.7 mm (6.0−11.0), accounting for 20.4% of the total width.

The articular cartilage defect in the head of the middle phalanx following the insertion of 1.7 mm screws was a mean of 1.8% ± 1% (0.3−3.6) of the total articular surface, whereas that resulting from the implantation of 2.2 mm screws was a mean of 3.5% ± 1% (1.7−5.2) (Table 1).

TABLE 1. Articular Cartilage Defect as a Proportion of Total Articular Surface Per Digit

Finger	1.7 mm Screw (%)	2.2 mm Screw (%)
Index finger	1.7 ± 0.9 (0.6−2.9)	3.1 ± 0.6 (2.4−3.8)
Middle finger	1.1 ± 0.8 (0.3−2.5)	3.2 ± 1 (1.7−5.0)
Ring finger	2.1 ± 0.6 (1.4−3.0)	4.2 ± 0.8 (2.7−5.2)
Little finger	2.1 ± 1.3 (0.4−3.6)	3.5 ± 0.8 (2.6−4.6)

DISCUSSION

Phalangeal fractures are common, occurring at an incidence of 12.5 per 10,000 person-years.[5] These fractures may require fixation based on the mechanism of injury, fracture pattern, and patient characteristics. Data from Australia over the last two decades reveal an increasing trend toward internal fixation when surgical intervention is carried out, with a corresponding decrease in closed or percutaneous methods.[1]

Surgical intervention in these fractures must balance the need for stable fixation to permit early movement against extensive soft tissue dissection resulting in adhesions. Dorsal plating via a tendon-splitting approach has been traditionally used but may result in stiffness because of both its inherent invasiveness and the limited space available for the implant. This is particularly relevant in the middle phalanx, where the extensor apparatus and bone are intimately related. Dorsal plating may also result in screw penetration into the volar groove, which is present along the length of the proximal and middle phalangeal shaft and prominent screw tips can lead to pain, flexor tendon irritation, or rupture, as well as contribute to diminished tendon glide and stiffness.[7,8]

Alternate and minimally invasive approaches to phalangeal fracture fixation have been explored with promising results. Lateral plating with tendon sparing has been shown to result in greater after-surgery total active motion than tendon-splitting approaches.[9] More recently, intramedullary fixation of metacarpal and phalangeal fractures has attracted great interest and uptake, with novel methods of instrumentation and implementation broadening the range of fractures in which they can be used.[2–4,10] George et al[4] published the largest series of middle phalangeal fractures stabilized via retrograde intramedullary screws when assessing 23 digits in 20 patients, noting a mean total active motion of 246°; *Quick*DASH (Disabilities of the Arm, Shoulder, and Hand) of 4.9; verbal numerical rating scale for the pain of 1.1; return to work at 62.5 days; and a single intraoperative complication of a broken screw head. This mirrors the excellent results reported in the proximal phalanx and metacarpal.[2,3,5,11] Intramedullary screw fixation has also been found to result in shorter surgical durations, less extensive follow-up requirements, fewer hardware costs, and a quicker return to work and function than plate fixation.[12]

Choice of fixation method is affected by many factors, including underlying surgical specialty training, clinician experience, and procedural volume, which inform biases and opinions toward various modalities.[13] One concern often raised about intramedullary screw fixation is that of articular cartilage violation. This has been studied in some detail in the proximal phalanx.[14,15] Vegas et al[14] used cadaveric hands to assess osteochondral and extensor apparatus damage resulting from retrograde insertion of screws, noting that utilization of a 2.8 mm screw affected 6.2% of the articular surface, whereas a 4.1 mm screw affected 13.5%. The central slip attachment was not affected, with the tendinous lesion on average 2.7 mm in width and 4.9 mm proximal to the attachment on the middle phalanx. Borbas et al[15] quantified cartilage lesions on cadaveric proximal phalangeal articular surfaces via an antegrade technique, finding that only 4.5% was disrupted using a 2.2 mm screw and 8.5% with a 3.0 mm screw. Techniques involving transarticular screw insertion in other locations in the hand have not resulted in an increased short- to medium-term incidence of arthritis.[16]

This study assessed the damage imparted to the articular surface and terminal extensor tendon resulting from retrograde intramedullary screw stabilization of middle phalangeal fractures. It found minimal disruption of the terminal extensor apparatus, with a 1.7 mm screw resulting in disruption of approximately 12.1% of the width of the tendon, and a 2.2 mm screw affecting 20.4%. The resultant tendon lesions were located at least 3.5 mm proximal to the terminal tendon insertion on the distal phalanx on average. Notably, the use of a 2.2-mm screw on a slender little finger resulted in a lesion that was 57% of the width of the tendon at that level—we recommend the use of smaller screws at this location, particularly in woman or smaller patients. The articular cartilage lesion in the head of the middle phalanx was 1.8% of the total surface following the insertion of a 1.7 mm screw, and 3.5% when using a 2.2 mm screw. We hypothesize that the flutes of the screw raise chondral flaps as they turn—these then settle once the prosthesis has been buried to result in lesions that are smaller than the area of the screw head itself.

The only other assessment of damage to the middle phalanx resulting from intramedullary screw insertion used computed tomography scans on cadaveric specimens. Urbanschitz et al[17] reported that the median osseous defect in the distal articular surface possessed a diameter of 4 mm, which corresponded to $> 6\%$ of the total surface when a 2.2 mm screw was used. The larger articular defect reported is likely because computed tomography analysis does not allow visualization of cartilaginous surfaces—thus, chondral flaps and the total articular surface cannot be accurately estimated. Urbanschitz et al[17] also noted that retrograde screw insertion yielded extensor tendon lesions that comprised less than 50% of the total tendon width in all specimens.

The current study has several limitations. A small sample size may limit generalization to a broader clinical population. Generalizability may also be restricted as all hardware was sourced from a single manufacturer. The older age of cadaveric donors is not representative of the patients who undergo surgical intervention for these fractures who are usually younger. Specimens with osteoarthritis were included in the study—although this may have a biased measurement of the cartilaginous surface area, it is envisioned that the use of nonarthritic specimens alone would have yielded proportionally smaller cartilage lesions. A two-dimensional image of the head of the middle phalanx does not accurately portray the curved distal articular surface and likely underestimates the total surface area, although measurements of the articular lesion (which is located in the flat distal aspect perpendicular to the camera) are expected to be unaffected. Use of unfractured specimens renders screw insertion simpler—repeated attempts at wire or prosthesis insertion would result in greater soft tissue damage.

This study found that the use of retrograde intramedullary screw fixation in the middle phalanx results in minimal violation of the articular cartilage and terminal extensor tendon. In combination with promising early- to mid-term clinical outcomes, it renders intramedullary screw fixation an attractive therapeutic option in this cohort.[4] Further clinical studies with long-term follow-ups are required.

CONFLICTS OF INTEREST

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

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