Trapeziometacarpal Fusion With and Without Distal Scaphoid Excision: A Cadaveric Model Comparing Thumb Range of Motion

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Abstract

Purpose: To describe the biomechanical changes seen after thumb carpometacarpal (CMC) fusion with distal scaphoid excision (DSE), a surgical technique used for pantrapezial disease in high-demand individuals. **Methods:** A cadaveric study with 13 fresh-frozen cadaveric specimens was conducted. Fluoroscopic measurements in posteroanterior (PA) and lateral planes were performed. Thumb CMC fusion was then simulated. The same images were taken after fusion. The distal scaphoid was excised, and the measurements were obtained again. The angle between the index finger and thumb metacarpals was recorded. Statistical analysis was performed using Wilcoxon signed rank test. **Results:** The mean arcs of motion in the PA plane pre-fusion, post-fusion, and post-fusion with DSE were 48.5°, 25.1°, and 34.6°, respectively. An increase in arc of 9.5° was obtained after DSE compared with thumb CMC fusion alone. The mean arcs of motion in the lateral plane pre-fusion, post-fusion, and post-fusion with DSE were 53.4°, 22.4°, and 33.6°, respectively. A statistically significant increase in arc of motion of 11.2° in the lateral plane was obtained after DSE compared with thumb CMC fusion alone. This was a 20% and 21% increase in pre-fusion range of motion in the PA and lateral planes, respectively, from fusion alone compared with fusion and DSE. **Conclusions:** Thumb CMC fusion combined with DSE maintains motion lost in simple CMC arthrodesis.

Keywords: pantrapezial arthritis, high-demand individual

Introduction

The thumb carpometacarpal (CMC) joint is the second most common location of osteoarthritis (OA) in the hand after distal interphalangeal joints and the most common site requiring surgical reconstruction.^{1,2} Two distinct populations are most commonly affected: middle-aged women and younger patients with posttraumatic OA. Treatment ranges from nonoperative management with anti-inflammatory medication, activity modification, splinting, and steroid injections to operative intervention. Multiple procedures have been described for the treatment of thumb CMC arthritis, including ligament reconstruction, trapeziectomy, trapeziectomy with ligament reconstruction and tendon interposition (LRTI), trapeziometacarpal (TM) fusion, suspensionplasty, metacarpal osteotomy, arthroplasty, and arthroscopic debridement. Trapeziectomy with and without LRTI has proven to be an effective treatment; however, subsidence remains a concern as a cause of failure with this procedure.³⁻⁵ The TM fusion is another viable option to

improve pain and does not carry the risk of subsidence. The TM fusion complications include nonunion and decreased range of motion (ROM) compared with trapeziectomy procedures. It is also felt to be contraindicated in pantrapezial disease, as the arthritic scaphotrapezial joint becomes symptomatic after fusion. We propose a novel procedure, thumb CMC fusion combined with distal scaphoid excision (DSE) (Figure 1). This procedure addresses the concern of subsidence with trapeziectomy while improving the ROM compared with traditional TM fusion techniques. It is especially useful in younger, high-demand patients, given that it preserves thumb length and motion compared with trapeziectomy and fusion, respectively. We present the results of a

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Figure 1. Four postoperative radiographs demonstrating wire fusion of the carpometacarpal joint with distal scaphoid excision.

cadaveric study to demonstrate the improved ROM from traditional TM fusion to the ROM achieved with TM fusion combined with DSE. A preliminary summary of our data was reported in 2013; this article represents the complete findings of our study.⁶

Materials and Methods

Thirteen fresh-frozen cadaveric upper extremity specimens were used in this study. None of the specimens had evidence of prior surgery or trauma. A 2.0-mm Kirschner wire (K-wire) was passed from the radius to the proximal scaphoid and from the radius to the lunate to eliminate radiocarpal motion while taking measurements. A 2.0-mm K-wire was placed in a retrograde manner down the shaft of both the thumb metacarpal and index finger metacarpal. These K-wires were used as radiographic reference lines for all measurements. A standard dorsoradial approach to the thumb CMC joint and distal scaphoid was performed, allowing exposure of the distal scaphoid. This initial dissection was performed prior to initial radiographs in an attempt to limit any effect of changes in soft tissue attachments on ROM measurements before and after the procedure. Initial fluoroscopic images were obtained using a mini C-arm in the posteroanterior (PA) plane, with the thumb in radial abduction and adduction, and the lateral plane, with the thumb in palmar abduction and adduction. All PA images were taken with the elbow flexed at 90°, with the wrist in neutral posi-

tion and the palm flat on the table. True lateral images were obtained with the palmar cortex of the pisiform in the central third of the distance between the palmar cortex of the capitate and the palmar cortex of the distal pole of the scaphoid. A thumb TM fusion was then simulated by passing two 1.6-mm K-wires across the TM joint. The same 4 fluoroscopic images were taken after the simulated fusion. The distal 25% of scaphoid was then excised using an osteotome, and the 4 images were obtained again. The angle between the index finger metacarpal and thumb metacarpal K-wires was measured using Adobe Photoshop. Statistical analysis was performed using Wilcoxon signed rank test.

Results

The cadaveric study mean arcs of motion in the PA plane pre-fusion, post-fusion, and post-fusion with DSE were 48.5°, 25.1°, and 34.6°, respectively (Table 1). An increase in arc of motion of 9.5° ($P = .0002$) was obtained after DSE compared with thumb CMC fusion alone. The mean arcs of motion in the lateral plane pre-fusion, post-fusion, and post-fusion with DSE were 53.4°, 22.4°, and 33.6°, respectively (Table 2). A statistically significant increase in arc of motion of 11.2° ($P = .0005$) in the lateral plane was obtained after DSE compared with thumb CMC fusion alone. This was a 20% ($P = .0002$) and 21% ($P = .0005$) increase in pre-fusion ROM in the PA and lateral planes, respectively, from fusion alone compared with fusion with DSE (Table 3).

Table 1. Cadaveric Study Results: Degrees of Motion.

Assessment of Range of Motion	Pre-fusion of thumb CMC, deg	Post-fusion of thumb CMC, deg	Post-fusion of thumb CMC with DSE, deg
Lateral			
Palmar abduction	42.36	29.95	34.01
Palmar adduction	-11.05	7.56	0.39
Posteroanterior			
Radial abduction	39.09	32.58	35.42
Radial adduction	-9.38	7.52	0.87

Note. CMC = carpometacarpal; DSE = distal scaphoid excision.

Table 2. Average Arc of Motion.

Assessment of Range of Motion	Pre-fusion of thumb CMC, deg	Post-fusion of thumb CMC, deg	Post-fusion of thumb CMC with DSE, deg
Lateral	53.42	22.39	33.62
Posteroanterior	48.47	25.05	34.55

Note. CMC = carpometacarpal; DSE = distal scaphoid excision.

Table 3. Percentage of Pre-fusion Arc of Motion.

Assessment of Range of Motion	Post-fusion of thumb CMC, %	Post-fusion of thumb CMC with DSE, %
Lateral	51.69	71.29
Posteroanterior	41.92	62.93

Note. CMC = carpometacarpal; DSE = distal scaphoid excision.

Discussion

Thumb CMC arthritis is a common cause of pain, causing dysfunction in the hand. Current treatment for Eaton stage IV (pantrapezial) arthritis is varied with options that include trapeziectomy alone, LRTI, and joint replacement with a number of different implants, including silicone, titanium, pyrocarbon, synthetic resurfacing agents, or allograft. All procedures have their proponents, and all include trapeziectomy as part of the procedure. Trapeziectomy with or without LRTI has had excellent results in the literature; however, complications exist, including missed metacarpophalangeal hyperextension, missed scaphotrapezoid arthritis, neurogenic pain, secondary injury to the dorsal radial sensory nerve or lateral antebrachial cutaneous nerve, mechanical pain, instability, impingement, and subsidence of the thumb metacarpal on the scaphoid. Although this subsidence has not been shown to correlate with clinical outcomes as shown by Lins et al⁷ in 1996 and Yang and Weiland⁸ in 1998, others have documented instability and impingement as a cause of failure. Conolly et al described 4 patients in their series with failed trapeziectomy who "had pain, weakness and instability with proximal migration of the first metacarpal and metacarposcapoid arthritis."⁴ Cooney

et al. found that "instability after resection arthroplasty can be symptomatic and not necessarily related to bone-on-bone contact mechanical pain."⁵ In addition, when approaching revision surgery for failed thumb CMC arthroplasty, Braun et al³ stated that metacarpal subsidence must be addressed in revision surgery. Subsidence may be particularly relevant in the younger, high-demand population undergoing surgical intervention for thumb CMC arthritis, compared with the typical low-demand patients who do well with standard thumb CMC procedures.

Performing a thumb CMC fusion in high-demand patients would address the issue of subsidence and possibly increase strength; however, this procedure is not typically used in pantrapezial arthritis because it does not address the arthritic scaphotrapeziotrapezoid (STT) joint. In addition, thumb CMC fusion decreases ROM of the thumb compared with arthroplasty procedures, with subjective complaints of the inability to place the palm flat on a table.⁹⁻¹¹ The DSE combined with thumb CMC fusion addresses the problems seen with thumb CMC fusion alone. The STT joint is removed and, as shown by this cadaveric biomechanical study, ROM is improved compared with fusion alone. The DSE is well described with good results for both scaphoid nonunion and STT arthritis.¹²⁻¹⁴ Double interposition arthroplasty combined with ligamentous reconstruction has been shown to prevent subsidence while resecting arthritic surfaces in pantrapezial disease.¹⁵ The DSE has been shown to improve motion in limited fusions of the wrist, such as radioscapulunate fusion, improving not only the flexion-extension arc but also the radial and ulnar deviation loss after fusion.¹⁶⁻¹⁹ This study confirms that thumb CMC fusion combined with DSE increases motion compared with fusion alone.

Limitations of this study include that it is only a cadaver study; we have future studies showing patient outcomes in the works. The effect of DSE on midcarpal stability and progression of degeneration in adjacent joints should also be further examined.

In summary, this cadaveric biomechanical study demonstrates an increase in ROM in both the PA and lateral planes after DSE compared with thumb CMC fusion alone. Although thumb CMC fusion provides adequate pain relief from thumb CMC arthritis, the ROM of the thumb is significantly limited. Patients are often unable to place their palm flat on a table after fusion. The DSE improves ROM and addresses the STT joint in patients with pantrapezial arthritis while maintaining the potential benefits of improved strength and decreased risk of subsidence in the younger, high-demand patients.

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Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

Informed consent is not applicable to this study as it was cadaveric with no identifiers included.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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