

## Medial Capsular Interpositional Arthroplasty for Severe Hallux Rigidus

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### ABSTRACT

**Background:** Multiple surgical options have been described for severe hallux rigidus. One option is capsular interpositional arthroplasty. We report our initial results with a technique using the thicker medial capsule as our interpositional material instead of the dorsal capsule and extensor hallucis brevis (EHB). **Materials and Methods:** Twenty-two patients with grade IV hallux rigidus underwent minimal proximal phalanx resection (modified Keller) with preservation of the flexor hallucis brevis (FHB) insertion and medial capsular interpositional arthroplasty. **Results:** Postoperative AOFAS hallux MTP-IP scores (mean 77.8), and SF-36 scores (mean 68.7 on physical function, 79.5 role limitations) demonstrated clinical improvement compared to historical controls. Alignment and stability were well maintained (mean preoperative HV angle of 11.8 degrees, mean postoperative HV angle of 13.0 degrees). Dorsiflexion/plantarflexion arc of motion showed sustained improvement (mean 38.4 degrees preoperative, mean 62.3 degrees postoperative). **Conclusion:** These results are comparable to other forms of interpositional arthroplasty and arthrodesis for end stage arthritis of the hallux MTPJ.

**Level of Evidence: IV, Retrospective Case Series**

**Key Words: Hallux Rigidus; Interpositional Arthroplasty**

### INTRODUCTION

Hallux rigidus is a clinical condition which is characterized by pain, limited motion, and proliferative peri-articular bone formation of the first metatarsophalangeal joint (MTPJ).

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This condition was originally described in 1887 by Davies-Colley.<sup>12</sup> Other common terms include hallux limitus, dorsal bunion, hallux flexus, and hallux malleus. Other than hallux valgus, it is the most common pathology of the hallux MTPJ.<sup>32</sup> More than 80% of patients with long-term followup had bilateral involvement.<sup>9</sup>

Clinical symptoms include pain, swelling, MTP synovitis, and most characteristically a loss in dorsiflexion. Numerous clinical and radiographic classifications have been developed. Currently, the classification as defined by Coughlin is most commonly used.<sup>10</sup> Grade 1 is defined as having only 50% loss of motion and only having a dorsal osteophyte on radiographic exam. Grade 2 has moderate radiographic joint narrowing. Grades 3 & 4 hallux rigidus are defined as having 75% to 100% loss of MTPJ range of motion and substantial joint space narrowing on radiographic exams. Clinically, a grade 4 is differentiated from grade 3 by having pain at the mid range of motion. Non-surgical methods of treatment include activity modification, anti-inflammatory medication, corticosteroid injections, and shoe-wear modification.

Surgical methods of treatment are numerous and include cheilectomy, interpositional arthroplasty, resectional arthroplasty, implant arthroplasty, and arthrodesis. Cheilectomy is the favored surgical intervention for symptomatic grades 1 & 2 hallux rigidus since it is a joint preserving procedure which is successful in improving MTPJ range of motion and reducing pain.<sup>3,16,18,21,23</sup> Interpositional, resection, and implant arthroplasty are generally used for grades 3 & 4 hallux rigidus due to the arthritic nature of the MTPJ. Interpositional arthroplasty involves the placement of a biologic tissue in the MTPJ while resecting less bone from the joint than resection or implant arthroplasty.<sup>1-3,5,8,17,21,29,34,37</sup> In theory, this procedure allows for more joint motion than a fusion and avoids an implant which would generally fail with time. Resection arthroplasty (Keller arthroplasty) typically involves a generous resection of the proximal phalanx (up to one third, which likely includes the flexor hallucis brevis insertion) which can lead to toe shortening with transfer metatarsalgia and weakness in toe push-off.<sup>4,27,41</sup> Implant arthroplasty has had some success but has the disadvantage

of implant loosening, synovitis, and difficult salvage for failures due to a large bone defect.<sup>11,20,22,26,33,35,39</sup> Arthrodesis, while also successful for treating high grade hallux rigidus, has the disadvantage of eliminating MTPJ range of motion thus increasing stress on the IP joint and limiting shoe-wear options.<sup>6,7,13,25,30,31</sup>

Various modifications of soft tissue interpositional arthroplasty have been reported in the literature including allograft tendons, autografts (gastroc-soleus, extensor hallucis longus, extensor hallucis brevis, and extensor digitorum longus) and acellular regenerative tissue matrix.<sup>1-3,5,8,17,21,29,34,37</sup> In this study, we report our data on a consecutive series of patients who underwent medial capsular interpositional arthroplasty. We hypothesized that medial capsular interpositional arthroplasty would produce equal clinical results to other forms of interpositional arthroplasty but have a more predictable flap of tissue to interpose.

## MATERIALS AND METHODS

Twenty-two consecutive patients were identified who had undergone a medial capsular interpositional arthroplasty by a single surgeon (DBT). All patients had radiographic Coughlin grade 3 & 4 arthritis of the hallux MTPJ.<sup>10</sup> Average age at surgery was 58 (range, 38 to 76 years old). Seventeen patients were women and five were men. Twelve were left feet; ten were right feet. Ten of the 22 patients had undergone prior cheilectomy. Two patients had undergone a prior interphalangeal joint fusion. Charts were reviewed to collect the following preoperative data: age, prior hallux metatarsophalangeal joint surgery, complications, pain (none, mild/occasional, moderate/daily, or severe/almost always), activity limitations (no limits, limited recreation, limited daily & recreational, or severe daily & recreational), footwear (fashionable, comfort footwear/shoe insert, or modified shoe-wear/brace), MTPJ dorsiflexion, MTPJ plantarflexion, interphalangeal joint motion (no restriction or severe restriction), MTPJ stability (stable or unstable), callus (no callus/asymptomatic or painful callus), and alignment (good, mild malalignment/no symptoms, or poor symptomatic malalignment).

Survey forms were mailed to and completed by patients. These surveys included an AOFAS hallux metatarsophalangeal-interphalangeal (AOFAS hallux MTP-IP) score, and a SF-36 questionnaire (Table 1).<sup>28</sup> Postoperative AOFAS hallux MTP-IP scores were obtained from survey data and chart review. The average length of followup was 24 months (range, 12 to 47). Average length of radiographic followup was 9.4 months. Eleven of 22 patients participated in the clinical survey (AOFAS score and SF-36).

Radiographs were reviewed to assess for arthritis grade (3,4), peripheral sclerosis (preoperative only), hallux valgus angle, intermetatarsal angle (IM2 angle), joint space on AP view (average of three different points in joint), joint space

**Table 1:** AOFAS Hallux Metatarsophalangeal-Interphalangeal Scale (100 Points Total)

<b>Pain (40 points)</b>	
None	40
Mild, occasional	30
Moderate, daily	20
Severe, almost always present	0
<b>Function (45 points)</b>	
<b>Activity limitations</b>	
No limitations	10
No limitations on ADL's, limits on recreation	7
Limited daily and recreational activities	4
Severe limitation of daily and recreational activities	0
<b>Footwear requirements</b>	
Fashionable, conventional shoes, no insert	10
Comfort footwear, shoe insert	5
Modified shoes or brace	0
<b>MTP joint arc of motion</b>	
Normal or mild restriction ( $\geq 75^\circ$ )	10
Moderate restriction ( $30^\circ-74^\circ$ )	5
Severe restriction ( $<30^\circ$ )	0
<b>IP joint motion (plantarflexion)</b>	
No restriction	5
Severe restriction ( $<10^\circ$ )	0
<b>MPT-IP stability (all directions)</b>	
Stable	5
Definitely unstable or able to dislocate	0
<b>Callus related to hallux MTP-IP</b>	
No callus or asymptomatic callus	5
Callus, symptomatic	0
<b>Alignment (15 points)</b>	
Good, well aligned	15
Fair, some degree of malalignment, no symptoms	8
Poor, obvious symptomatic malalignment	0

on the lateral view (average of three different points in joint), and interphalangeal joint space on AP view (Figure 1).<sup>10</sup>

Statistical calculation of confidence intervals and *p* value was performed using a Student's *t*-test.

### Surgical technique

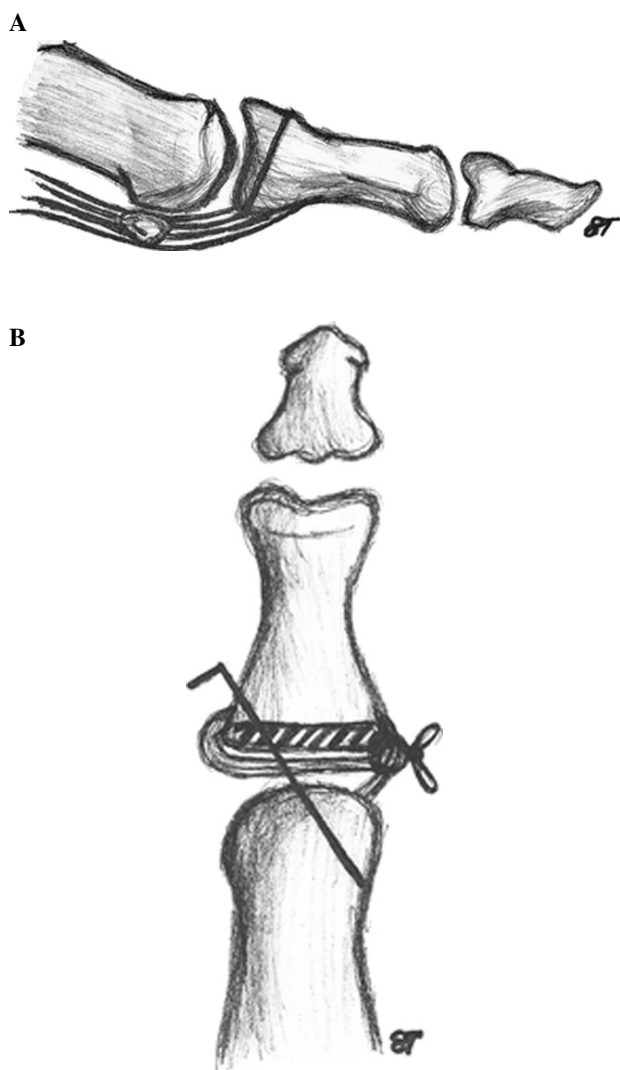
After administration of ankle block anesthetic and intravenous antibiotics, a sterile ankle tourniquet was inflated. A dorsomedial skin and capsular incision over the hallux metatarsophalangeal joint was made, taking care to protect the dorsal cutaneous nerve. A cheilectomy was performed if the osteophyte had not been resected previously. The dorsal base of the proximal phalanx was resected in a slightly oblique fashion with an oscillating saw in order to preserve



**Fig. 1:** A, AP standing radiograph of left foot with Grade 4 arthritis of hallux metatarsophalangeal joint. Solid white arrow demonstrating Intermetatarsal 1–2 (IM1-2) angle measurement. Open white arrow demonstrating hallux valgus angle measurement. B, Lateral radiograph of same patient demonstrating advanced arthritis with large dorsal osteophyte. C, Magnified view of AP radiograph of same foot. Solid white arrow points to the three interphalangeal joint measurements. Open white arrow points to the three metatarsophalangeal joint measurements. D, Magnified lateral radiograph of same foot. White arrow points to the hallux MTP joint and subsequent joint space measurements. E, Postoperative AP view with joint space measurements. F, Postoperative lateral view with joint space measurements.

the flexor hallucis brevis attachments to the plantar base of the proximal phalanx (Figure 2A). The hallux metatarsophalangeal joint capsule was then elevated off the medial eminence while preserving its distal attachment to the proximal phalanx forming a tongue shaped flap. This capsular flap was then transversely interposed into the joint and sutured to the lateral capsule with an absorbable suture. The joint was then pinned with a 0.062-mm Kirschner wire from (Figure 2B) in five degrees of valgus and 10 to 15 degrees of extension.

The patient was allowed to bear partial weight on their heel in a postop shoe. The Kirschner wire was removed at 3 weeks, at which time the patient was allowed to bear full weight in a hard-soled shoe and begin range of motion. Regular shoes and activities were gradually advanced at that time.



**Fig. 2:** A, Diagram of hallux MTPJ demonstrating minimal resection of the proximal phalanx. B, Dorsal view of hallux MTPJ with medial capsular interposition sutured to lateral capsule and stabilizing Kirschner wire.

## RESULTS

Twenty-two consecutive patients (from 2003 to 2007) who underwent medial capsular interpositional arthroplasty for hallux rigidus were evaluated.

The mean overall total AOFAS MTP-IP score was 77.8 (100 points total possible). The mean sub-scores were as follows: pain 28.2 (40 points possible), activity 7.5 (10 points possible), footwear requirements 7.3 (10 points possible), MTPJ motion 5.6 (10 points possible), IP joint motion 4.5 (5 points possible), callus 5.0 (5 points possible), MTP stability 5.0 (5 points possible), and alignment 14.2 (15 points possible).

The postoperative SF-36 overall mean was 72.9 for the 11 patients where it was calculated (maximum possible score of 100 overall). Mean sub-scores for each category were: physical functioning 68.7, role limitations due to physical health 79.5, role limitations due to emotional problems 75.8, energy/fatigue 68.2, emotional well being 79.7, social functioning 85.2, pain 62.5, and general health 75.5.

MTPJ dorsiflexion improved from 34.2 degrees preoperatively to 42.9 degrees postoperatively ( $p$  value 0.13). MTPJ plantarflexion improved from 14.2 degrees preoperatively to 19.4 degrees postoperatively ( $p$  value 0.19). Overall MTPJ arc of motion improved 13.9 degrees ( $p$  value 0.11).

Mean hallux valgus angles were 11.8 degrees (preop) and 13.0 degrees (postop) which was not statistically, nor clinically significant. Mean intermetatarsal 1–2 angles were 10.6 degrees (preop) and 10.9 degrees (postop) which was not statistically different. Preoperative mean joint space on the AP and lateral views were 0.9 mm (0.7 to 1.6 with 95% confidence intervals) and 1.5 mm (1.0 to 2.0 with 95% confidence intervals) respectively. Postoperative mean joint space on the AP and lateral views were 2.1 mm (1.7 to 2.6 with 95% confidence intervals) and 2.3 mm (1.8 to 2.8 with 95% confidence intervals) respectively ( $p < 0.002$  (AP view joint space) and less than 0.003 (lateral view joint space)). Interphalangeal joint (IPJ) space on the AP view was 1.6 mm (preop) and 1.8 mm (postop), which was not significantly different.

Two patients developed stress fractures of a lesser metatarsal postoperatively. No other postoperative complications were identified.

## DISCUSSION

Hallux rigidus is a common clinical condition which is often unresponsive to conservative treatment, thus necessitating surgery for pain relief and functional improvement. Cases with mild arthritic changes and a predominantly symptomatic dorsal exostosis respond well to surgical treatment with cheilectomy alone.<sup>16,18,23,35</sup> Cases with more advanced arthritic changes that correspond to Coughlin grade 3 & 4 hallux rigidus can require more aggressive surgical options

including resection arthroplasty, interpositional arthroplasty, implant arthroplasty, or arthrodesis.

Arthrodesis has been long considered the gold standard treatment for advanced hallux rigidus.<sup>1,6,7,25,30,31</sup> However, patients desiring to maintain motion and not limit shoe-wear options often prefer to have a “joint sparing” procedure. Implant arthroplasty is often complicated by loosening, synovitis, and difficult salvage for failures due to excessive bone loss.<sup>11,20,22,26,33,35,39</sup> Freed et al. showed a 74.5% radiographic failure rate of silicone arthroplasty at average radiographic followup of 8 years.<sup>35</sup> Resection arthroplasty (Keller arthroplasty) is currently used only for low demand elderly patients due to loss of toe flexion power, cock-up deformity, and transfer metatarsalgia secondary to metatarsal shortening.<sup>18,19</sup> Various interpositional arthroplasty techniques have been developed as “joint sparing” procedures for advanced hallux rigidus.<sup>1–3,5,8,17,21,29,34,37</sup> These procedures involve the placement of a biologic substrate into the joint in an attempt to prevent arthritic bone on bone contact, allow joint motion, maintain toe push-off strength due to preservation of the FHB insertion, and maintain length of the first ray.

The goals of interpositional arthroplasty for hallux rigidus include pain relief, maintenance of first ray length, and preservation of motion.<sup>31</sup> Only three published studies have used the standardized AOFAS hallux metatarsophalangeal-interphalangeal score as a clinical assessment tool (Table 2).<sup>2,8,29</sup> Coughlin and Shurnas reported on a retrospective series of seven cases of interpositional arthroplasty using an autogenous gracilis tendon bundle.<sup>8</sup> Their mean preop and postop AOFAS scores were 46 and 86, respectively. Lau and Daniels reported on a retrospective series of eleven patients who underwent capsular interpositional arthroplasty with an EHB tendon graft with a postop AOFAS score of 71.6.<sup>29</sup> Berlet et al. reported on nine patients who underwent interpositional arthroplasty with regenerative tissue matrix.<sup>2</sup> They reported preoperative and postoperative AOFAS scores of 63.9 and 87.9, respectively. The results in these studies are similar to our study which reports an AOFAS MTP-IP score total of 77.8.

Overall, our postoperative patients had SF-36 scores which were comparable to normative data for women age 55 to

64,<sup>40</sup> scoring only noticeably lower in the pain sub-score. Mean sub-scores for each category were (study vs. normative): physical functioning (68.7 vs. 74.8), role limitations due to physical health (79.5 vs. 82.8), role limitations due to emotional problems (75.8 vs. 79.7), energy/fatigue (68.2 vs. 58.7), emotional well being (79.7 vs. 70.8), social functioning (85.2 vs. 85.7), pain (62.5 vs. 78.6), and general health (75.5 vs. 70.3).

Our postoperative AOFAS score total of 77.8 compares favorably to results for arthrodesis. Reported postoperative AOFAS scores include: Coughlin et al. with 34 feet—89, Lombardi with 21 feet—75.6, Raikin et al. with 27 feet—83.8, Goucher et al. with 54 feet—82, and Flavin et al. with 12 feet—80.6.<sup>10,14,19,30,36</sup> However, each of these studies automatically lost 10 points on the score as the MTPJ had no motion which would indicate that fusion patients do have better pain relief overall than any of the interpositional procedures. This was evident on the pain subscore of the SF-36 in which patients only scored a 62.5 on average. However, we feel the benefit of preserving motion and potentially decreasing stress on adjacent joints may be a potential reason for using this technique. The senior author has noted that many women report they can comfortably wear a two-inch heel for an hour or longer while most patients with a fusion do not wear more than a one-inch heel.

The strengths of this study include the use of standardized protocols for radiographic and clinical assessment for data collection. This will hopefully allow comparison and evaluation of these results with future studies. The limitations of this study are due to its retrospective nature and relatively short followup. Preoperative subjective data was limited by information available via chart review which can be inaccurate but the senior author does specifically record this data to be able to generate an AOFAS score.<sup>38</sup> Thus, it was not possible to directly compare the preoperative and postoperative AOFAS scores, and SF-36 scores.

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**Table 2:** Comparison of mean pre- and postoperative AOFAS MTP-IP scores for published interpositional arthroplasty series

Study AOFAS Score Component	Berlet et al.		Lau/Daniels		Coughlin/Shurnas		Present	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Total Score (100 max)	63.9	87.9	N/A	71.6	46	86	N/A	77.8
Pain (40 max)	17.8	34.4	N/A	22.7	N/A	N/A	N/A	28.2
Alignment (15 max)	15	15	N/A	15	N/A	N/A	N/A	14.2
Function (45 max)	31.1	38.4	N/A	33.9	N/A	N/A	N/A	34.9

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