Article

Outcome of Lesser Metatarsophalangeal Joint Interpositional Arthroplasty With Tendon Allograft

Eugene F. Stautberg III, MD, Sandra E. Klein, MD, Jeremy J. McCormick, MD, Amber Salter, PhD, and Jeffrey E. Johnson, MD

Abstract

Background: Lesser toe metatarsal head degeneration and collapse can cause significant pain and disability. In the setting of global metatarsal head collapse, there are limited operative options. The purpose of our study was to evaluate clinical and radiographic outcomes after lesser toe metatarsophalangeal (MTP) joint interpositional arthroplasty with a tendon allograft and to describe the operative technique.

Methods: We retrospectively reviewed a consecutive series of patients treated by 3 fellowship-trained foot and ankle surgeons at one institution. We created a phone survey to evaluate satisfaction, pain, and likelihood to repeat the surgery. Foot and Ankle Ability Measure (FAAM) scores were reviewed before and after surgery. Preoperative and postoperative radiographs were evaluated for preservation of metatarsal length. The procedure was performed through a dorsal midline approach. The metatarsal head was reamed to a concave shape. A tendon allograft was fashioned into a ball and secured to the metatarsal with an anchor. Fifteen feet in 14 patients underwent lesser MTP joint interposition arthroplasty, with the average age of 49 years (range, 24-69), and an average follow-up of 4.2 years.

Results: Eighty percent (12/15) reported they would have the procedure again. Visual analog scale pain scores showed a decrease in pain from 7 to 1. FAAM sports subscale improved from 56% to 85%. Radiographically, the ratio of the affected metatarsal length to the adjacent metatarsal remained constant before and after surgery, suggesting preservation of the metatarsal cascade.

Conclusion: Interpositional arthroplasty of the lesser MTP joints with a rolled tendon allograft provided a unique solution, as it allows the surgeon to fill a large void without harvesting an autograft. This study showed improved patient-reported outcomes, high patient satisfaction, and good radiographic outcomes. Lesser metatarsophalangeal joint allograft interposition arthroplasty was a viable solution as a salvage procedure in the setting of global metatarsal head collapse.

Level of Evidence: Level IV, retrospective case series.

Keywords: lesser MTP joint, interposition arthroplasty, anchovy technique, Freiberg infraction, allograft tendon

Introduction

Metatarsophalangeal (MTP) joint degeneration of the lesser toes can occur for a variety of reasons. Common causes of MTP joint pain and deformity include prior trauma, Freiberg infraction, failure of previous surgery, primary osteoarthritis, or inflammatory arthritis.16 Radiographically, disease can range from minimal joint space narrowing or focal area of subchondral bone necrosis to global metatarsal head collapse. Conservative treatment includes metatarsal pads, full-length orthotics, change in activity, and shoe modification.

If conservative measures fail, numerous operative treatments have been described for focal cartilage injury. For partial metatarsal head involvement of the dorsal half to one-third of the head, a dorsal cheilectomy and joint

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debridement or a rotational distal metatarsal osteotomy has been used. This closing wedge osteotomy excises the dorsal damaged cartilage and rotates the intact plantar cartilage into contact with the proximal phalanx. Other authors have described, in small series or case reports, procedures using a variety of soft tissues and synthetic materials for interpositional arthroplasties including dorsal capsule, extensor digitorum brevis, extensor digitorum longus, palmaris longus autograft, and silicone. Recently, Abdul et al described the use of a local pedicle graft as an interposition arthroplasty for severe Freiberg disease. Coughlin and Shurnas described the use of a rolled allograft tendon as an interposition soft tissue arthroplasty for the treatment of advanced hallux rigidus with preparation of both sides of the first MTP joint to accept the spherical graft.

The purpose of our study was to evaluate clinical and radiographic outcomes after lesser MTP joint interpositional arthroplasty with a rolled tendon allograft and to describe the “anchovy” technique as a salvage option in a series of patients with global lesser metatarsal head articular degeneration and collapse.

Methods

Following institutional review board approval, we retrospectively reviewed a consecutive series of patients treated from 2007 to 2017 by 3 foot and ankle fellowship–trained surgeons at one institution. Seventeen patients with 18 feet underwent allograft interpositional arthroplasty for severe degeneration of the second or third MTP joint. A retrospective chart review was performed to obtain demographics, diagnosis, and concomitant procedures. Patients were contacted via phone, and consent was obtained to participate in the study.

We identified 18 feet in 17 patients who underwent the interposition arthroplasty procedure to the second or third metatarsal. One pediatric patient (younger than 18 years) was excluded. We contacted the remaining 16 patients, and 14 patients with 15 feet consented to participate in the study, all of whom completed the phone survey. Visual analog scale (VAS) pain scores were available for 13 feet preoperatively and 13 feet postoperatively. Of the 15 feet, 14 completed preoperative FAAMs, and 13 completed postoperative FAAMs. Thirteen feet underwent second MTP joint interposition, and 2 feet underwent third MTP joint interposition arthroplasty. In this series of 15 feet in 14 patients, the average age at time of surgery was 49 (range 24-69) years. Average follow-up was 4.2 years. There was a variety of different diagnoses of the lesser MTP joint pathology, including 6 Freiberg infraction, 5 primary osteoarthritis, 2 post-traumatic, and 2 postsurgical arthrofibrosis with bone loss. Seven of 15 feet (46.7%) had at least 1 procedure on the same foot at the time of the interposition arthroplasty. These included 3 cases with metatarsal shortening osteotomies (Weil) to another lesser toe, 2 first MTP joint arthrodesis, 1 Lapidus bunionectomy, and 1 first MTP joint dorsal cheilectomy.

Preoperative VAS and Foot and Ankle Ability Measure (FAAM) scores were reviewed, which were obtained at the patient’s initial clinic visit. A phone survey was performed to evaluate satisfaction, pain, and likelihood to repeat the surgery. After completion of the phone survey, the VAS and FAAM questionnaire were mailed to the patient and returned. Preoperative and postoperative VAS and FAAM scores were compared.

Radiographic Review

Preoperative and postoperative weightbearing radiographs were reviewed. In each radiograph, the length of the affected digit and the next lesser digit (if second metatarsal affected, then second and third metatarsal were measured) were recorded to evaluate for preservation of the metatarsal length and the parabolic arc or cascade created by the varying length of the lesser metatarsals. This technique is similar to the method described by Coughlin and Shurnas for measuring metatarsal length in his interpositional arthroplasty study for hallux rigidus. We first drew a horizontal line connecting the medial aspect of the talonavicular joint to the lateral aspect of the calcaneocuboid joint. Then, a point was established at the distal most aspect of the metatarsal, and a line was drawn down the metatarsal shaft. This defined the metatarsal length. Then, the joint space was evaluated by measuring the distance from the distal-most aspect of the metatarsal to a point in the middle of the proximal phalanx articular surface. These 2 measurements were added together to define the ray length (metatarsal plus joint space) (Figure 1). This process was repeated on postoperative imaging. The postoperative joint space was defined as the distance from the distal metatarsal to the base of the proximal phalanx, including the allograft tendon. The preoperative and postoperative lengths and joint space were compared. Further, in order to evaluate the cascade, the ratio of the length of the affected ray to the adjacent ray was evaluated (affected ray–adjacent ray).

Operative Technique

Preoperative regional block was performed along with general anesthesia. A dorsal skin incision was made over the metatarsophalangeal joint and the extensor tendons were elevated off of the dorsal capsule in a defined layer for later closure and retracted laterally. A longitudinal capsulotomy was made and the joint debrided (Figure 2). A guide pin was placed into the metatarsal shaft in a retrograde fashion, centered in the remaining metatarsal head. A 10- or 12-mm hemispherical reamer was used to create a concave surface of the distal metatarsal head (Figure 3). A frozen
semitendinosus tendon allograft was then rolled into a ball and sutured with 2-0 braided absorbable suture (Figure 4). The allograft was sized to fill the void and restore the length of the metatarsal. Overfilling of the joint was avoided. Proper fit was judged by tension on adjacent soft tissues, restoration of toe length, and adequate MTP joint range of motion. The interposition allograft was typically between 10 and 15 mm in diameter. A 2.7-mm corkscrew suture anchor with nonabsorbable suture was placed into the medullary canal of the metatarsal (Figure 5). The sutures in the anchor were passed through the allograft tendon in a parallel fashion and tied to secure the “anchovy” in place (Figure 6). Fluoroscopy confirmed the proper placement of the suture anchor and interposition allograft. The dorsal capsule was closed with interrupted absorbable sutures, further stabilizing the MTP joint. The extensor hood was reapproximated as a separate layer of closure to centralize the extension digitorum longus tendon, if possible. After skin closure, a compressive forefoot dressing was applied, and the patient was made touch-down weightbearing on their heel in a postoperative sandal or boot for 2 weeks. At 2 weeks after surgery, sutures were removed, and the patient was instructed to advance weight bearing as tolerated with gentle active and passive range of motion of the digit.

Figure 1. Weightbearing radiograph with demarcated lengths of metatarsal and joint space of affected second metatarsal and adjacent metatarsal.

Figure 2. Through a dorsal midline approach, loose body and collapse of the second metatarsal head can be seen.

Figure 3. Reaming of the metatarsal head to create a concave surface.

Figure 4. Fashioning semitendinosus allograft with suture.
Statistical Analysis

Descriptive statistics were used to summarize patient characteristics. Continuous data were summarized using median (range), and categorical variables were summarized using frequencies (percentages). $\chi^2$ or Fisher exact tests were performed to evaluate any associations with categorical variables. Wilcoxon sign rank sum tests were performed to evaluate preoperative and postoperative differences within the FAAM patient-reported outcomes. All tests were 2-sided. SAS, version 9.4, was used to conduct data analyses (SAS Institute, Cary, NC).

Results

Phone surveys were completed in all 14 patients with 15 feet who enrolled in the study. During the survey, the patients were asked to attempt to distinguish their lesser toe results from other pain or foot deformity. The average satisfaction was 8, with 10 being most satisfied and 0 being unsatisfied. The average current pain level was 2.5, with 10 being the most painful and 1 being no pain. No one used an ambulatory assist device. At the time of the phone survey, 5 of 15 patients either used a custom or over-the-counter orthotic for the affected foot (Table 1).

Overall, there were no acute postoperative complications. There were no superficial or deep infections. There was one case where the suture anchor migrated proximally up the metatarsal shaft after the index procedure; however, the graft did not become unstable. Regarding further surgery, 12 patients (12/15) have not had any further surgery on the foot. In the 3 patients who had subsequent surgery, 1 had removal of the allograft implant, 1 patient had hallux valgus correction, and 1 patient had a bone spur removed from the operated MTP joint. The patient who had the allograft removed had continued discomfort and swelling approximately 18 months after the index surgery, and an outside provider removed the implant and did not fill the defect. This was the only patient who reported a final level of function as “abnormal.” Twelve patients (12/15) report they would have the surgery again.

VAS pain scores decreased from a median 7 to 1 ($P = .008$). Overall, FAAM Activities of Daily Living (ADL) scores improved from 75% to 90%, but this did not reach significance ($P = .11$). In the FAAM ADL subscale, individual questions were analyzed. Patients’ ability to “walk initially” significantly improved from 2.5 to 3.8 ($P = .031$). The patients’ reported “level of function” increased from a median of 75% to 96% ($P = .023$) (Table 2).

![Figure 5](image1.png)

**Figure 5.** Placement of suture anchor in distal metatarsal after reaming.

![Figure 6](image2.png)

**Figure 6.** (A) Placement of graft with sutures from anchor passing through the graft. (B) Securing the semitendinosus allograft in joint space. (C) Completed interpositional allograft of the second metatarsal.
The sports subscale outcomes significantly increased from 56% to 86% \((P = .02)\). On the FAAM sports subscale, patients reported their ability to perform “low-impact activities” significantly increased from median of 2 to 3.6 \((P = .01)\) (Table 3). When asked to rate their function as “normal” or “nearly normal,” 10 patients had preoperative and postoperative responses. Preoperatively, 4/10 patients reported their function as normal or nearly normal. Postoperatively, 9/10 patients reported their function as normal or nearly normal. Three patients omitted this question. There was a statistically significant change in the level of current function from preoperative to postoperative \((P = .025)\). Clinically, no patients reported transfer metatarsalgia to an adjacent metatarsal head.

Radiographic results are summarized in Table 4. The average length of the affected ray (metatarsal plus joint space) was 123 mm preoperatively and 120 mm postoperatively, showing an average of 3 mm of shortening. The metatarsal cascade was evaluated using ray lengths analyzed as a ratio (affected ray–adjacent ray). If the ratio was greater than 1, the cascade was preserved, which was the case for 13 of 15 feet. The mean preoperative ratio was not different from the postoperative ratio \((P = 1.0)\). The average preoperative joint space of the 2 feet that did not have preservation of the cascade was 13.2 mm, compared to 2.2 mm in the 13 feet that had preservation of the cascade. One patient had a loss of cascade preoperatively. Of the remaining 14 patients, 13 had preservation of their cascade.

### Table 1. Phone Survey Responses.

<table>
<thead>
<tr>
<th>Question</th>
<th>Average (SD) or % Responses (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction (1-10)</td>
<td>8.0 (2.8) 15</td>
</tr>
<tr>
<td>Pain (1-10)</td>
<td>2.5 (2.5) 15</td>
</tr>
<tr>
<td>Subsequent surgery, %</td>
<td>20 3/15</td>
</tr>
<tr>
<td>Have procedure again (yes), %</td>
<td>80 12/15</td>
</tr>
<tr>
<td>Ambulatory assist device (none), %</td>
<td>60 9/15</td>
</tr>
</tbody>
</table>

### Table 2. FAAM Scores.

<table>
<thead>
<tr>
<th>FAAM</th>
<th>Preoperative Score, Median (n = 14)</th>
<th>Postoperative Score, Median (n = 13)</th>
<th>(P^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS</td>
<td>7</td>
<td>1</td>
<td><strong>.008</strong></td>
</tr>
<tr>
<td>Walking initially</td>
<td>2.5</td>
<td>4</td>
<td><strong>.031</strong></td>
</tr>
<tr>
<td>ADLs, %</td>
<td>75</td>
<td>96</td>
<td>.106</td>
</tr>
<tr>
<td>Reported level of function, %</td>
<td>75</td>
<td>96</td>
<td><strong>.023</strong></td>
</tr>
</tbody>
</table>

Abbreviations: ADLs, activities of daily living; FAAM, Foot and Ankle Ability Measure; VAS, visual analog scale.

*aBoldface text represents \(P < .05\).

### Table 3. FAAM Sports Subscale.

<table>
<thead>
<tr>
<th>FAAM-Sports</th>
<th>Preoperative Score, Median (n = 14)</th>
<th>Postoperative Score, Median (n = 13)</th>
<th>(P^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports subscale, %</td>
<td>56</td>
<td>86</td>
<td><strong>.022</strong></td>
</tr>
<tr>
<td>Low-impact activities</td>
<td>2</td>
<td>4</td>
<td><strong>.010</strong></td>
</tr>
<tr>
<td>Function during sports</td>
<td>55</td>
<td>86</td>
<td>.084</td>
</tr>
<tr>
<td>Current level of function</td>
<td>4/10(^a,b)</td>
<td>9/10(^a,b)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: FAAM, Foot and Ankle Ability Measure.

\(^a\)Nearly normal/normal.

\(^b\)Five feet were excluded as preoperative or postoperative responses were omitted.

\(^c\)Boldface text represents \(P < .05\).

### Discussion

This study described a technique for treatment of lesser MTP joint degeneration. High rates of pain relief and overall patient satisfaction are reported in this study of a small number of patients undergoing an allograft tendon interposition arthroplasty procedure. At an average of 4.2 years of follow-up, most patients continued to have satisfactory pain relief.

Operative solutions that have been described for second MTP joint arthritis include joint debridement with dorsal cheilectomy, microfracture, and metatarsal rotational or shortening osteotomies for focal areas of cartilage loss. Additionally, soft tissue interposition and implant arthroplasty for global metatarsal head involvement have been described, as summarized by Seybold and Zide. Previous studies have evaluated joint preserving osteotomies with good results. A series of patients with end-stage Freiberg’s disease were treated with either cheilectomy and microfracture or cheilectomy with dorsal crescentic osteotomy. Both groups improved significantly after surgery, with excellent results in 11/14 (78%) of patients. Lee et al treated a series of 12 patients with symptomatic Freiberg disease with intrarticular dorsal wedge osteotomy with significantly decreased pain. Further, a case report described successfully using microfracture with micronized cartilage allograft matrix. The use of arthroscopic debridement has also been described, but it does require specialized equipment and technique. However, none of these treatments address global metatarsal head collapse.

Historically, authors have described in small series or case reports various interpositional procedures, typically using autograft tissue. Lavery described interposition with the dorsal capsule in a series of 9 patients with degenerative joint disease and reported good or excellent results in 8 of the patients. Other authors have described a variety of other interpositional grafts including the extensor digitorum brevis used in 10 patients with Freiberg disease. They
showed decreased pain with joint motion in 90% of patients. Another series of 13 patients with Freiberg disease used the extensor digitorum longus tendon as an interposition graft. Although range of motion was not improved, painless motion was seen in 85% of patients. A case report also suggested using palmaris longus autograft as an interpositional allograft with a satisfactory outcome. Recently, Abdul et al described the use of a local pedicle graft as an interposition, called a “Rollmop,” for severe Freiberg disease. They studied 25 patients and found a significant decrease in VAS pain scores and an increase in American Orthopaedic Foot & Ankle Society ankle-hindfoot scale scores. All of these studies evaluated a novel technique for a challenging clinical problem, but they all relied on the native tissue being robust enough for harvest and interposition. With the chronic nature of these pathologies, the health of surrounding tissues is often a concern.

Coughlin and Shurnas described a salvage technique with the use of a rolled allograft tendon for the treatment of advanced hallux rigidus. In their series of 7 patients, all had excellent or good satisfaction with an average dorsiflexion of 34 degrees after interposition arthroplasty. They concluded that interposition arthroplasty is a good salvage technique when arthrodesis is not indicated. Recently, Thomas and Thordarson used an allograft interposition for first MTP joint collapse in a series of 19 patients, and the authors stopped using the procedure because of unsatisfactory outcomes, as 26% required revision surgery. Perhaps the differences are related to the different mechanics and forces through the lesser MTP joints compared with the MTP joint, or possibly anatomical differences with the existence of the sesamoid articulation in the great toe MTP joint.

The advantage of using allograft is consistency of the frozen graft tissue and no donor site morbidity. To our knowledge, this is the first technique described using this type of soft tissue interpositional allograft for global metatarsal head degeneration of the lesser MTP joints (Figure 7). Patients in this study had pain and functional limitations before surgery. In this salvage setting, most patients reported a decrease in pain and 12 patients (12/15) reported they would have the surgery again. At final follow-up, no patient used an ambulatory assist device such as a walker or cane, and 5/15 used an over-the-counter or custom orthotic. Although 3 patients had further surgery on the foot, only 1 had removal of the allograft, 1 had a bone spur removed, and 1 had an unrelated hallux valgus surgery. Additionally, none of our patients reported transfer metatarsalgia.

The VAS scores showed a significant decrease in pain, and the FAAM showed an increasing trend in the ADL subscale but did not reach significance. When individual questions within the ADL subscale were evaluated, only the patient’s ability to walk initially was noted to be significantly improved. Further, the sports subscale showed a significant improvement. Ten patients completed the subjective rating of their function on preoperative and postoperative FAAMs, and 9/10 patients reported themselves as “normal” or “nearly normal” at final follow-up. Almost half of the patients had concomitant procedures, suggesting that this clinical entity often presents with additional forefoot pathology.

On radiographic review, the length of the affected ray was maintained. This was shown with both the direct

<table>
<thead>
<tr>
<th>Table 4. Radiographic Results.</th>
<th>Preoperative</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affected Ray</td>
<td>Adjacent Ray</td>
<td>Ratio</td>
</tr>
<tr>
<td>Length</td>
<td>Joint Space</td>
<td>Affected/Adjacent</td>
</tr>
<tr>
<td>Average length (mm)</td>
<td>123</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Figure 7. Postoperative weightbearing radiograph of a second metatarsal interpositional allograft.
measurement of ray length and a ray length ratio comparing the ray length to the adjacent metatarsal. This shows that even large preoperative defects can be addressed with this technique. In the 2 patients who did not have preservation of their metatarsal cascade, both had much larger preoperative defects than the patients who had their cascade preserved.

There are limitations of this study. We have a small sample size over a wide time span, with less than 2 cases being performed per year. This could lead to inconsistency between procedures. There was a heterogeneous patient population, with some patients having a narrow joint space and others having complete metatarsal head collapse and large joint spaces. Further, there was a variety of diagnoses and concomitant procedures, indicating that the patients did not have pain isolated solely to the affected MTP joint. For the patient-reported outcomes obtained postoperatively, we asked the patients to focus their responses on the pain and function of the affected lesser toe, but it can be difficult for patients to distinguish between pain at a lesser MTP joint and pain at other locations in the foot.

**Conclusion**

Lesser metatarsophalangeal joint tendon interposition arthroplasty was a viable solution as a salvage procedure in the setting of lesser metatarsal head collapse. This procedure did not rely on the patient’s own tissue to provide the graft. Overall, there were good clinical outcomes, the majority of patients would have the procedure again, and there was preservation of metatarsal length and cascade on weightbearing radiographs.

**Declaration of Conflicting Interests**

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