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Original Article

Treatment of hallux rigidus: allograft interpositional arthroplasty vs arthrodesis

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Abstract

Objective: Surgery for severe hallux rigidus includes interpositional arthroplasty and arthrodesis. Interpositional arthroplasty maintains joint mobility, while arthrodesis limits motion. The aim of this study was to compare changes in Visual Analog Scale and American Orthopedic Foot and Ankle Society scores between interpositional arthroplasty and arthrodesis patients.

Methods: A retrospective cohort study of 48 patients was performed. There were 24 patients in the interpositional arthroplasty group and 24 patients in the arthrodesis group. A follow-up phone survey was administered from which updated Visual Analog Scale and American Orthopedic Foot and Ankle Society scores were obtained.

Results: Visual Analog Scale scores improved by 4.08 (SD, 2.02) points after interpositional arthroplasty and 4.54 (SD, 3.64) points after arthrodesis. American Orthopedic Foot and Ankle Society scores improved by 28 (SD, 16) points after interpositional arthroplasty and 29 (SD, 26) points after arthrodesis.

Conclusion: In hallux rigidus patients, pain improvement results were similar for both interpositional arthroplasty and arthrodesis. Interpositional arthroplasty has been reported in the literature as maintaining mobility, which is an important goal of many patients.

Level of Evidence III; Therapeutic Studies; Case-Control Study.

Keywords: Hallux rigidus; Arthroplasty; Arthrodesis.

Introduction

Hallux rigidus, a degenerative condition of the first metatarsophalangeal (MTP) joint, is characterized by common symptoms of arthritis, including a painful range of motion and functional limitations. Patients commonly present with pain at the extreme ranges of motion, or during mid-motion in advanced disease. Hallux rigidus also demonstrates classic radiographic findings of decreased joint space, subchondral sclerosis, and osteophyte formation. Jacob et al.[1] reported that the first MTP joint carries 119% of an individual's body weight with each step. This leads to significant MTP joint reactive forces, which become exacerbated with arthritis, causing severe pain and loss of motion and function. Hallux rigidus is second only to bunions in great toe pain. The etiology can be degenerative, post-traumatic, inflammatory, or idiopathic. It is associated with female sex, hallux valgus interphalangeus, and positive family history in bilateral cases[2].

Conservative management of hallux rigidus includes rigid shoe inserts, steroid injections, oral anti-inflammatory medications, and activity modification. When conservative management fails, a variety of surgical treatment options are available. These include cheilectomy, osteotomy, arthrodesis, synthetic cartilage, resurfacing[3,4], hemiarthroplasty[5], implant-based interpositional arthroplasty, and resection arthroplasty. Joint-preserving procedures like cheilectomy are recommended for early stages of the disease[6]. When pain is present with MTP dorsiflexion and there is evidence of dorsal osteophyte formation, the osseous dorsal block to motion can be removed through cheilectomy. An additional procedure is the Moberg osteotomy, which consists of a dorsal closing-wedge osteotomy of the proximal phalanx. This technique decreases joint forces by creating a rocker in the foot and shifting the point of maximal pressure plantarly[7]. Arthrodesis or interpositional arthroplasty are generally recommended for severe

Study performed at the Spectrum Health/Michigan State University, Michigan, United States.

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grades of the disease (Coughlin and Shurnas 3 or 4). There are numerous classification systems for hallux rigidus, and they are used inconsistently in the literature[8].

Arthrodesis of the first MTP joint is the standard of care for end-stage hallux rigidus, with reported fusion rates between 77% and 100%[9]. The procedure has been shown to predictably reduce pain, restore stability to the MTP joint, and improve weight-bearing in the foot among patients with severe hallux rigidus[10]. However, motion preservation is the goal of both patient and surgeon whenever possible, and motion limitation is a common reason for patient reluctance toward this treatment option. Patients are also often disappointed with the residual stiffness and limited activities and footwear after surgery. Moreover, the literature reports a 13% nonunion rate for first MTP arthrodesis[11].

A number of new techniques and implants have recently been developed to meet the goals of both pain relief and motion preservation. Implant-based joint arthroplasty, both total and hemiarthroplasty, is associated with complications such as instability, aseptic loosening, pathological wear, failure, limited soft tissue coverage, and infection[12,13]. The high complication rate of implant-based arthroplasty has led surgeons to use this option less frequently[14]. Bone loss with implant failure creates a challenging salvage scenario. Arthrodesis can also be considered as a salvage procedure for failed interpositional arthroplasty and end-stage hallux rigidus. Polyvinyl alcohol hydrogel is used in hemiarthroplasty implants to minimize bone loss while preserving motion. Assessing this implant type in 27 patients over a mean follow-up of 5.4 years, Daniels et al.[15] reported a mean maximum dorsiflexion of 29.7° (range 10-45°). Patient-reported outcome scores also improved. This study demonstrated good survivorship with no implant failure or bone loss.

Methods

A retrospective cohort study was performed on patient data collected from 2002 to 2015 at a single institution after approval by the Institutional Review Board. The inclusion criteria were age ≥18 years, painful end-stage hallux rigidus, decreased first MTP motion, and decreased joint space with evidence of osteophytes. The exclusion criteria were ipsilateral peripheral neuropathy, inflammatory arthritis, non-English speakers, interphalangeal arthritis, and simultaneous ankle/hindfoot fusion procedures. A total of 48 patients met the inclusion criteria and were included in the retrospective chart review, with 24 patients in each group. Basic demographic data was obtained, as well as symptom duration (Table 1 and Figure 1), pre-operative Visual Analog Scale (VAS) and American Orthopedic Foot and Ankle Society (AOFAS) scores, and post-operative VAS and AOFAS scores. The VAS is a universal pain assessment tool in which patients rate pain on a scale of 0-10. AOFAS scores are derived from several variables, including pain, functional limitation, footwear, walking distance, walking surfaces, gait abnormality, and alignment. Range of motion was not quantitatively documented in the electronic health records. The three surgeons in the study performed either procedure. The initial decision to pursue arthroplasty vs arthrodesis was based on patient preference and shared decision-making, since either operation was performed after failed conservative management or cheilectomy. A regenerative acellular allograft dermal matrix (GraftJacket Regenerative Tissue Matrix, Wright Medical, Memphis, TN, USA) was used for patients undergoing interpositional arthroplasty. The specific operative technique is described below.

A modification to the study, approved by the Institutional Review Board, allowed the patients to be contacted via phone for a follow-up survey. This was done to increase the follow-up time after surgery and determine how well patients were functioning years after their procedures. A total of 15 patients in the interpositional arthroplasty group and 11 patients in the arthrodesis group could be contacted and agreed to participate in the telephone survey. The rest of the patients could not be reached by telephone. Updated VAS and AOFAS scores were obtained through these calls. The mean total follow-up time after surgery was 44 months in the interpositional arthroplasty group and 39 months in the arthrodesis group. Statisticians in the Grand Rapids Medical Education Partners department assisted with data analysis, including mean, standard deviation, and analysis of variance tests to determine significance of changes in subjective pain scores.

Table 1. Duration of Symptoms for Each Treatment Group

Duration of Symptoms	Arthroplasty	Fusion		Total
Duration of Symptoms	≤1 year	5	4	9
	1 to 5 years	8	14	22
	6 to 10 years	4	0	4
	>10 years	4	3	7
Total		21	21	42

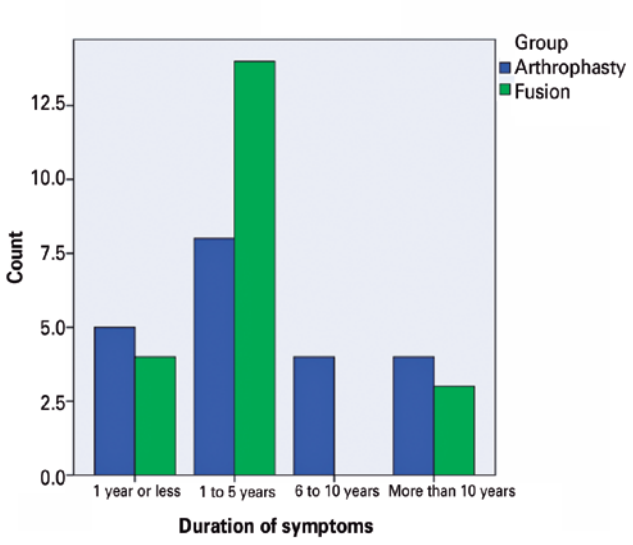

Figure 1. Duration of Symptoms for Each Treatment Group.

Surgical Techniques

MTP interpositional arthroplasty: An approximately 3cm dorsal incision was made over the extensor hallucis longus (EHL) tendon and MTP joint. Sharp dissection was carried down to the EHL tendon sheath. The tendon sheath was opened sharply and the tendon was retracted medially. The joint capsule was then opened in line with the skin incision and elevated medially and laterally around the joint for visualization. The medial and lateral release was needed to allow adequate plantar flexion of the proximal phalanx to view the entire metatarsal head. The metatarsal head typically showed signs of degeneration, more prominent dorsally. Osteophytes from the base of the proximal phalanx and the metatarsal head were resected with a rongeur. Any loose bodies were removed as well. Once adequate debridement had taken place, a small microsagittal saw was used to resect the dorsal third of the metatarsal head, exiting dorsally and in plane with the dorsal diaphysis of the metatarsal. Dorsiflexion of the joint was assessed to ensure that adequate cheilectomy had been performed to increase postoperative range of motion in the joint.

After the cheilectomy was completed, a 2.5-mm drill bit was used to create two tunnels in the head of the metatarsal from proximal-dorsal to distal-plantar. Care was taken to ensure that the tunnels ended plantarly at the base of the articular surface of the metatarsal head. On the back table, the acellular allogenic dermal matrix graft (GraftJacket) was opened. The graft was prepared with two 0 Ethibond sutures on a free needle, which were placed in the corner in horizontal mattress fashion, with a similar spread to the metatarsal drill holes. Once both sutures had been passed and secured, a suture passer was used to pass them plantar-to-dorsal out of the tunnels. We ensured that the graft was adequately positioned over the metatarsal head prior to continuing. At this point, with the graft in the correct position, the free needle was used to pass the sutures through the graft over the drill holes dorsally. Once all four strands had been passed, the pairs were tied down over the graft and the corresponding drill hole, securing the graft in place. Redundant graft was removed with scissors. The wound was irrigated and closed in a layered fashion. See Figure 2 for a postoperative radiograph.

MTP arthrodesis: A dorsal incision of approximately 3 cm was made over the EHL tendon and MTP joint. Sharp dissection was carried down to the EHL tendon sheath. The EHL tendon sheath was opened sharply and the tendon retracted medially. The joint capsule was then opened in line with the skin incision and elevated medially and laterally around the joint for visualization. The first MTP joint was prepared for arthrodesis by removing all cartilage with a combination of curved Lambotte osteotomes and curettes. Cup and cone reamers were also used to clear all cartilage. A 2.0 mm drill bit or 0.45 K-wire was then used to perforate the articular surface to increase postoperative bleeding. The MTP joint was then placed in the appropriate position. A non-cannulated screw was placed in a lag fashion across the MTP joint, and dorsal plating was used according to the surgeon's preference. Intra-operative X-rays were obtained to show appropriate implant position and MTP joint alignment. The wound was irrigated and closed in a layered fashion. See Figure 2 for a postoperative radiograph.

Results

The mean patient age and smoking status were similar between groups, but BMI and sex were not (Table 2). No patients had a history of diabetes. Mean VAS scores decreased by 4.08 (SD, 2.02) points after surgery in the interpositional arthroplasty group and 4.54 (SD, 3.64) points in the arthrodesis group. According to an analysis of variance test, VAS score improvement did not differ significantly between the groups (p=0.592). Mean AOFAS scores increased by 28 (SD, 16) points in the interpositional arthroplasty group and 29 (SD, 26) points in the arthrodesis group. According to an analysis of variance test, the AOFAS score improvement also did not differ significantly between the groups (p=0.969) (see Tables 3 and 4 below).

Figure 2. Postoperative radiograph of MTP arthrodesis (left) and postoperative radiograph of MTP interpositional arthroplasty (right).

Table 2. Demographic Data for Each Treatment Group

	Interpositional Arthroplasty	Arthrodesis
Male	2	8
Female	22	16
Mean Age	55.5	57.7
Mean BMI	26.2	29.0
BMI Range	19.6-33.4	23.0-36.0
Current Smoker	1	2
Former Smoker	4	5
Never Smoker	19	16
Unknown smoking history	0	1

Discussion

Few high-quality studies have compared interpositional arthroplasty to arthrodesis for hallux rigidus: the majority being level III, IV, or V[16]. In this study, we found no significant difference between interpositional arthroplasty and arthrodesis for mean improvement in VAS or AOFAS scores. The degree of improvement in AOFAS scores is markedly similar to previous studies on interpositional arthroplasty. Berlet et al. performed a retrospective study on 9 patients with hallux rigidus, following them for a mean of 12.7 months after interpositional arthroplasty. The mean total AOFAS scores at the most recent follow-up (87.9) were significantly higher than preoperatively (63.9)[17]. These results were reproduced in their same cohort at 5 years of follow-up, with mean AOFAS scores improving from 38 preoperatively to 65.8 postoperatively[18]. The 24-point difference at 12.7 months and 27.8-point difference at five years were almost identical to the 28-point difference found in our study at 3.5 years. However, their results are limited by the small sample size of 6 patients.

Long-term outcomes published by Vulcano et al.[19] had a mean follow-up of 11.3 years for 42 patients treated with capsular interposition arthroplasty. This retrospective case series evaluated patients using the VAS, Foot Function Index, and Short Form 12 scores. All categories showed statistically significant improvement, with 92.9% of patients stating they would have the surgery again. Four patients required conversion to fusion an average of 6.1 years after the index procedure. A recent retrospective case series of 133 patients by Aynardi et al.[20] showed an overall failure rate of 3.8% for interpositional arthroplasty in a mean follow-up of 62.2 months. Complications included infection (1.5%), cock-up deformity of the first MTP joint (4.5%), and metatarsalgia (17.3%). Of 133 patients, 101 were able to return to normal or fashionable footwear. This high rate of metatarsalgia after interpositional arthroplasty has also been reported in other studies. In a study by Lau and Daniels[21], pedobarographic analysis showed that cheilectomy patients had more normal plantar pressure distribution than interpositional arthroplasty patients. In our study, we did not obtain quantitative complication rates. However, stiffness, malalignment, and difficulty with footwear or certain activities were common concerns in both patient groups (Table 5). Patients in both groups also wished the recovery process was faster.

The advantage of MTP interpositional arthroplasty, as described in previous reports, is preserved joint mobility. This is especially relevant in active individuals and middle-aged patients with severe hallux rigidus[22]. Studies have shown that cheilectomy alone improves first MTP motion by an mean of 16.7°[23]. Roukis[24] performed a systematic review of patients undergoing soft tissue interpositional arthroplasty, finding that MTP joint dorsiflexion improved from a mean of 16.7° pre-operatively to 51.1° post-operatively. Coughlin and Shurnas[25] reported results of soft-tissue interposition arthroplasty in 7 patients with a 42-month follow-up. AOFAS scores improved substantially (from 46 to 86 points), as did mean

Table 3. Pre-and Postoperative VAS and AOFAS Scores

Group	VAS Pre	VAS Post	AOFAS Pre	AOFAS Post
Interpositional Arthroplasty	5.58	1.50	47	75
Arthrodesis (Fusion)	5.33	0.79	48	77

AOFAS: American Orthopedic Foot and Ankle Society; VAS: Visual Analog Scale

Table 4. Mean VAS and AOFAS Score Improvement After Surgery

Group	VAS Improvement	AOFAS Improvement
Interpositional Arthroplasty	4.08 (SD, 2.02)	28 (SD, 16)
Arthrodesis (Fusion)	4.54 (SD, 3.64)	29 (SD, 26)

p=0.592 (VAS); p=0.969 (AOFAS). AOFAS: American Orthopedic Foot and Ankle Society; VAS: Visual Analog Scale

Table 5. Patient Complaints via Follow-Up Telephone Survey

Interpositional Arthroplasty	Arthrodesis
• Persistent pain	• Residual surgical site numbness, unable to pick up stones with feet
• Transfer metatarsalgia	• Lesser toe malalignment and instability
• Toe malalignment	• Stiffness
• Stiffness	• Cannot wear heels or shoes that bend at the toe
• Cannot wear heels or ballerina shoes	• Difficulty with yoga or push-ups, cannot bend toes
• Difficult time with yoga and running, especially on sand	• Foot cramps
• Feels “lump on foot” or “bone chip”	• Long recovery
• Long recovery, only achieved 75-80% function	

MTP dorsiflexion (9° to 34°). DelaCruz et al.[26] found first MTP dorsiflexion improvement from 15.77° to 47.77° for 12 patients who underwent cadaver meniscus allograft interposition arthroplasty. Quantitative measurements of MTP dorsiflexion were not performed in our study, but it would be useful to objectively assess and compare mobility and its effect on patient outcomes in future studies. Since both operations lead to a comparable reduction in pain, MTP interpositional arthroplasty remains an alternative treatment for preserving motion and reducing pain in hallux rigidus in select patient populations.

Our study does have limitations. Due to its retrospective design, this study inherently involves selection bias, given the lack of randomized matched patient cohorts. Although the mean age and smoking status of our patient cohorts were similar, BMI and sex differed between the groups (Table 2). This might have been due to selection bias toward enrolling more active patients who had a greater desire to preserve motion and undergo interpositional arthroplasty. Further studies with matched cohorts are needed in the future to minimize selection bias and increase the external validity of our results. While this study does have limitations, it does provide insight. These data can be used as a guide to counsel patients about treatment outcomes and expected pain improvement after hallux rigidus surgery. Few other studies involve long-term follow-up of at least 3 years. Furthermore, previously published studies have not included as many patients. While arthrodesis has been established as the gold standard, interpositional arthroplasty may be an alternative in select patient populations. However, further studies are needed to establish the ideal candidates for interpositional arthroplasty.

Conclusions

Although it is difficult to draw extensive conclusions from a retrospective study of this sample size, our data has shown that pain improvement is similar for patients who undergo MTP interpositional arthroplasty or MTP arthrodesis for hallux rigidus at 3 years. Interpositional arthroplasty maintains greater joint mobility, which is an important goal of many patients.

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