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Original Research

Operative Treatment for Osteoarthritis of the First Metatarsophalangeal Joint: Arthrodesis Versus Hemiarthroplasty

Timothy Voskuijl, MD [1], Ron Onstenk, MD [2]

[1] *Resident, Orthopaedic Surgery, Groene Hart Ziekenhuis, Gouda, The Netherlands*
[2] *Orthopaedic Surgeon, Groene Hart Ziekenhuis, Gouda, The Netherlands*

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ABSTRACT

Controversy remains whether hemiarthroplasty or arthrodesis results in better postoperative outcomes for patients who request surgery for advanced osteoarthritis of the first metatarsophalangeal joint. Therefore, we tested the primary null hypothesis that the 2 treatment groups would not differ in the postoperative American Orthopaedic Foot and Ankle Society hallux metatarsophalangeal interphalangeal scale scores after a follow-up period of ≥1 year. Secondary analyses addressed the satisfaction rates, percentage of patients who would recommend the procedure, and unplanned repeat operation rates. A total of 58 primary arthrodeses and 36 hemiarthroplasties performed from January 2005 to December 2010 were evaluated at ≥1 year postoperatively. At a mean average of 4 (range 1 to 7) years after surgery, the mean American Orthopaedic Foot and Ankle Society hallux metatarsophalangeal interphalangeal scale score was 77.5 ± 18.5 in the arthrodesis group and 77.8 ± 12.0 in the arthroplasty group ($p = .93$). The number of repeat operations did not differ between these 2 groups, and patients treated with hemiarthroplasty reported greater mean satisfaction ($p = .04$). These results showed that the symptom intensity and magnitude of disability were similar at ≥1 year after arthrodesis or hemiarthroplasty for osteoarthritis of the first metatarsophalangeal joint, although the patients were subjectively more pleased with the results after hemiarthroplasty.

Osteoarthritis of the first metatarsophalangeal (MTP-1) joint can influence the performance of daily activities, because it is a painful condition that can physically limit the joint's range of motion and, therefore, limit gait. Nonoperative treatment includes anti-inflammatory drugs, intra-articular corticosteroid injections, physical therapy, and shoe modifications, such as the use of a stiff sole, enlarged toe box, and/or rocker bottom shoe (1,2). Depending on the severity of the limitation and the patient's desired activity level, surgical treatment can be recommended for severe stages of osteoarthritis when patients are not satisfied with nonsurgical treatment. Arthrodesis is the most commonly used treatment for late stage hallux rigidus (1). Maintenance of joint mobility with hemi- or total joint replacement can, however, have less effect on a patient's gait.

A recent evidence-based review of published studies showed fair evidence (grade B) in support of arthrodesis and poor evidence (grade C) in support of total joint arthroplasty for the treatment of hallux rigidus (3). Previous comparative studies supporting arthrodesis as the preferred approach have reported better postoperative scores, lower complication rates, better outcomes after gait analysis, and greater patient satisfaction compared with arthroplasty (1,4–7). However, 1 multicenter review found no differences in the subjective outcomes after arthrodesis, hemiarthroplasty, and resection arthroplasty (8). A few comparative studies have favored implant arthroplasty because of greater satisfaction and the absence of severe postoperative pain (9–11). Greater satisfaction after arthroplasty has also been found by ≥1 meta-analysis (12).

Because disagreement exists regarding which procedure provides the best outcomes, both arthrodesis and hemiarthroplasty have been offered at our hospital to patients when surgery has been recommended for late-stage MTP-1 joint arthritis. The aim of the present study was to determine whether patients treated with hemiarthroplasty have better postoperative outcome scores than those treated with arthrodesis after a minimum follow-up period of 1 year. Secondary analyses addressed the incidence of satisfaction, percentage of patients who would recommend the procedure, and the incidence of unplanned repeat operations.

Patients and Methods

From January 2005 to December 2010, 102 arthrodeses and 51 hemiarthroplasties with the BioPro® First MPJ (BioPro Inc., Port Huron, MI) were performed in 136 patients

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Address correspondence to: Ron Onstenk, MD, Groene Hart Ziekenhuis, Bluelandweg 10, Gouda 2803 HH, The Netherlands.
E-mail address: ron.onstenk@ghz.nl (R. Onstenk).

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by 5 orthopedic surgeons at our hospital. The fixation techniques used for arthrodesis included Kirschner wires, staples, plates, and lag screws. The procedure (fusion or hemiarthroplasty) performed was determined by surgeon preference in all cases, with both procedures performed for all stages of MTP-1 osteoarthritis. The after-treatment protocol included 6 to 8 weeks of cast immobilization after arthrodesis and a stiff-soled shoe for 2 weeks with passive range of motion exercises of the MTP-1 joint as soon as possible after hemiarthroplasty.

All patients treated with either arthrodesis or hemiarthroplasty from January 2005 to December 2010 were interviewed in early 2012 (ie, a minimum of 1 year after surgery) and asked to visit our outpatient clinic to participate in our study. They were informed in writing that the foot would be examined clinically and radiographically, and questionnaires would be administered. A total of 91 patients (66.9%) responded to our request: 67 (65.69%) had undergone arthrodesis and 37 (72.55%) hemiarthroplasty. Nine patients (entailing 9 arthrodeses and 1 hemiarthroplasty) were excluded from the analyses because of other lower limb issues, including ankle fracture and hindfoot arthrodesis, which we believed could have influenced the measures we used to quantify pain and function.

The modified hallux metatarsophalangeal-interphalangeal scale of the American Orthopaedic Foot and Ankle Society (AOFAS-HMI) (13,14) measures the postoperative scores for pain, function, and alignment. Because 10 points are available for MTP-1 joint motion, the maximum obtainable points for function after arthrodesis are 90 points and 100 points after arthroplasty. In the present study, the AOFAS-HMI scores were analyzed as a percentage of the maximum obtainable score to be comparative. Joint motion and stability were measured clinically, and alignment was measured radiographically. For research purposes, good alignment of the MTP-1 joint was defined as dorsiflexion of $\leq 30^{\circ}$ and valgus of $\leq 15^{\circ}$.

Other measures administered during the follow-up visit intended for the present study were patient satisfaction on a 5-point Likert-scale (1, totally satisfied and 5, totally unsatisfied), patient recommendation for the procedure on a 3-point Likert scale (1, would recommend and 3, would not recommend), and patient complaints and existing complications present at the follow-up examination.

Retrospectively, the number of unplanned repeat operations was measured. Removal of hardware after arthrodesis was excluded as an unplanned repeat operation in our analyses, because we considered it a part of the standard treatment plan. All other repeat operations were considered unplanned. Preoperative data were not available for all patients and, therefore, were not analyzed.

Statistical Analysis

A post hoc power analysis for the primary null hypothesis that the postoperative AOFAS-HMI scores would not differ in the 2 treatment groups revealed 96% power to detect a statistically significant difference using a 2-tailed analysis, with an effect size of 0.8 and α of 0.05. The scores for the AOFAS-HMI questionnaire and patient satisfaction and recommendation were analyzed as continuous variables, and an independent sample Student *t* test was used to evaluate the differences between the 2 groups. The chi-square test was used to compare the number of unplanned repeat operations. Differences with $p \leq .05$ were considered statistically significant.

Results

A total of 58 arthrodeses in 50 patients and 36 hemiarthroplasties in 33 patients were evaluated. Initially, 67 arthrodeses and 37 hemiarthroplasties in 57 and 34 potentially eligible patients were identified, respectively. However, 9 patients (9 arthrodeses [13.4%] and 1 hemiarthroplasty [2.7%]) were excluded from the analyses because of other lower limb issues, including ankle fracture and hindfoot arthrodesis. We believed these issues would have influenced the measures we used to quantify pain and function. The 2 groups were similarly distributed in terms of age, sex, and side of surgery (Table 1). The mean follow-up duration was 4.4 (range 1.3 to 7.0) years in the arthrodesis group and 3.5 (range 1.4 to 6.7) years in the arthroplasty group ($p = .02$). The AOFAS-HMI scores for function and, consequently, the total AOFAS-HMI scores were adjusted to percentages and thus made comparable for both treatment groups. The mean postoperative AOFAS score was 77.5 ± 18.5 in the arthrodesis group and 77.8 ± 12.0 in the arthroplasty group ($p = .93$). Better function was found in the arthrodesis group ($p = .015$) and better alignment in the hemiarthroplasty group ($p < .001$). The postoperative satisfaction score was 2.50 ± 1.2 in the arthrodesis group and 2.03 ± 0.8 in the hemiarthroplasty group, and this difference was statistically significant ($p = .04$). Both procedures received equal subjective patient recommendations ($p = .23$; Table 2).

Table 1
Patient characteristics

Demographic Variable	Arthrodesis (n = 58 procedures)	Hemiarthroplasty (n = 36 procedures)
Patients (n)	50	33
Male sex (n)	8 (16)	8 (24)
Age (yr)		
Mean	63 ± 7.1	60 ± 6.6
Range	47 to 78	42 to 74
Operated side (n)		
Right	24 (48)	18 (55)
Left	18 (36)	12 (36)
Bilateral	8 (16)	3 (9.1)

Data in parentheses are percentages.

Table 2
Postoperative results

Outcome Variable	Arthrodesis (n = 58 procedures; 50 patients)	Hemiarthroplasty (n = 36 procedures; 33 patients)	*p* Value
Follow-up (y)			
Median	4.4	3.5	.019
Range	1.3 to 7.0	1.4 to 6.7	
AOFAS-HMI score			
Total	77 ± 18	78 ± 12	.927
Pain	30 (±11)	30 (±7.3)	>.05
Function	37 ± 6.7	34 ± 5.3	.015
Alignment	11 ± 5.4	15 ± 1.8	<.001
Satisfaction*	2.5 ± 1.2	2.0 ± 0.9	.036
Recommendation†	1.5 ± 0.68	1.3 ± 0.59	.228

Abbreviation: AOFAS-HMI, American Orthopaedic Foot and Ankle Society hallux metatarsophalangeal-interphalangeal scale.

* Score: 1, very satisfied; 2, satisfied; 3, equal; 4, unsatisfied; and 5, very unsatisfied.

† Score: 1, yes; 2, maybe; and 3, never.

An initial repeat operation incidence of 8 patients (13.8%) after arthrodesis and 5 patients (13.9%) after hemiarthroplasty was observed. Two or more repeat operations were performed in 1 patient (1.7%) in the arthrodesis group and 1 patient (2.8%) in the hemiarthroplasty group. These numbers included nonunion repair after arthrodesis in 7 feet (12%) and conversion of an implant to arthrodesis in 3 feet (8.3%). The difference in unplanned repeat operations was not statistically significant between the 2 treatment groups ($p = .99$; Table 3).

At the final follow-up visit intended for the present study, after a mean of 4 (range 1.3 to 7) years postoperatively, the patients' complaints included metatarsalgia in 5 feet (8.6%) in the arthrodesis group and 3 feet (8.3%) in the hemiarthroplasty group. In the hemiarthroplasty group, other complaints included restriction of motion in 3 feet (8.3%) and persisting pain in the MTP-1 joint in 2 feet (5.6%). In 1 foot (1.7%), clinical nonunion was found at 54 months after arthrodesis; however, no reoperation was planned, because the patient had no complaints. One other foot (1.7%) was treated for complex regional pain syndrome type I after arthrodesis (Table 4).

Discussion

Many studies have indicated arthrodesis as the current standard of care for grade 3 or 4 hallux rigidus according to the Coughlin and Shurnas classification (15), mainly because of the consistently high satisfaction rates and high AOFAS scores and low pain scores postoperatively. The different fixation techniques include Kirschner wires, staples, plates, and screws (1). Implant arthroplasty is performed in patients with advanced stages of hallux rigidus, in whom stiffness of the MTP-1 joint is not wanted. For this procedure, a variety of implants are available (16). Silastic implants are no longer commonly used because of their high rates of complications (1,9,10). A meta-analysis of 47 peer-reviewed publications showed a satisfaction rate

Table 3
Unplanned repeat operation

Variable	Value
Arthrodesis procedures (n)	58
Repeat operation (n)	8 (14)
Type* (n)	
Nonunion repair	7
Position correction	1
Interval after primary surgery (mo)	
Nonunion	
Mean	4.7
Range	2 to 8
Position correction	
Mean	4
Range	NA
>1 Repeat operation† (n)	1 (1.7)
Type	Position correction
Mean interval after first repeat operation (mo)	8
Hemiarthroplasty procedures (n)	36
Repeat operation (n)	5 (14)
Type* (n)	
Capsular release	3
Arthrodesis	2
Interval after primary surgery (mo)	
Capsular release	
Mean	9.3
Range	7 to 14
Arthrodesis	
Mean	19
Range	15 to 17
>1 Repeat operation† (n)	1 (2.7)
Type	Arthrodesis
Mean interval after first repeat operation (mo)	6

Abbreviation: NA, not applicable.
Data in parentheses are percentages.
* $p = .99$ between arthrodesis and hemiarthroplasty groups for reoperation type.
† $p = .731$ between arthrodesis and hemiarthroplasty groups for >1 reoperation.

with implant arthroplasty ranging from 85.7% to 94.5% (12). A retrospective study of the BioPro® hemiarthroplasty found satisfaction or high satisfaction without severe pain in 54.4% of the patients in the cohort (10). In a case series of 23 hemiarthroplasties, only 2 patients were disappointed with the postoperative results because of limited range of motion (11).

Comparative studies have diverged on the differences in postoperative outcomes between arthrodesis and implant arthroplasty. One study found significantly better AOFAS-HMI scores and greater satisfaction after arthrodesis compared with hemiarthroplasty after mean follow-up period of 79.4 months (6). However, a multicenter retrospective review found no differences in subjective outcomes after arthrodesis, hemiarthroplasty, or resection arthroplasty (8). A few comparative studies have favored implant arthroplasty for greater satisfaction and an absence of severe postoperative pain (9–11). Greater satisfaction after arthroplasty has also been found by ≥1 meta-analysis (12). Our study showed comparable postoperative AOFAS-HMI scores for patients treated with arthrodesis and those treated with hemiarthroplasty after a mean follow-up period of 4 (range 1.3 to 7) years. A multicenter retrospective review indicated no significant improvement in the AOFAS scale scores at 12 months postoperatively compared with 6 months postoperatively (8). Therefore, we consider our follow-up term (mean 48.4 months) to be long enough to detect significant differences in the AOFAS scale scores after both procedures.

Table 4
Complaints and complications reported at follow-up visit*

Complaints and Complications	n (%)
After arthrodesis (n = 58 procedures; 50 patients)	
Metatarsalgia	5 (8.6)
Posture of MTP-1 joint	3 (5.2)
Posture of second digit	6 (10)
Interphalangeal joint pain	2 (3.4)
Joint pain in MTP-1	1 (1.7)
Clinical nonunion	1 (1.7)
CRPS I	1 (1.7)
After hemiarthroplasty (n = 36 procedures; 33 patients)	
Metatarsalgia	3 (8.3)
Limited range of motion	3 (8.3)
Persisting pain in MTP-1 joint	2 (5.6)

Abbreviations: CRPS, complex regional pain syndrome; MTP-1, first metatarsophalangeal.
* After a mean follow-up period of 4 (range 1 to 7) years.

Although previous studies have differed regarding patient satisfaction after different procedures for MTP-1 joint osteoarthritis, we found greater satisfaction after hemiarthroplasty. Because joint mobility is maintained after arthroplasty, gait is less affected; thus, patients might be more pleased with this procedure. The choice of procedure in our study was by surgeon preference, and both procedures were performed for all stages of MTP-1 osteoarthritis. One can imagine younger, more active patients or those with a lower stage of osteoarthritis to possibly be less satisfied with arthrodesis.

Previous studies have differed in the incidence of repeat operations for both procedures. One comparative study reported a 0% repeat operation rate after arthrodesis but found that 5 of 21 hemiarthroplasties (23.8%) required revision (6). Although Gibson and Thomson (5) showed that 0 of the 38 patients in their study required repeat operation after arthrodesis, 10 of them were prescribed insoles or a rocker bar. In the study by Salonga et al (10), 1 patient (1.27%) required implant removal after hemiarthroplasty because of persistent joint pain. Carpenter et al (2) found no revisions were needed after metatarsal hemiarthroplasty at a mean follow-up period of 27.3 months. In our study, the number of unplanned repeat operations did not differ statistically between patients treated with arthrodesis and those treated with arthroplasty ($p = .99$). A previous study found that almost all revisions after arthroplasty occurred within the first 2 years (5); thus, we believe that our follow-up term for measuring unplanned repeat operations was satisfactory.

Nonunion and metatarsalgia are commonly reported after arthrodesis (1). A multicenter review found an incidence of metatarsalgia of 9.8% and 7.7% after arthrodesis and arthroplasty respectively, somewhat comparable to our outcomes (8). However, in contrast to our findings, no complaint regarding the second digit after arthrodesis or stiffness after arthroplasty was reported in that study (8). Another study, however, did report stiffness as the most common problem after arthroplasty (14%) (9). Because we found stiffness of the MTP-1 joint after arthroplasty was a common complaint and the main reason for revision surgery, we strongly recommend a rehabilitation program that includes passive range of motion promptly after the initial surgery.

Our results should be interpreted with some reservations. Baseline or preoperative data were not present for all patients; therefore, a more accurate estimate of improvement could not be assessed. This could have played a role in the magnitude of the satisfaction scores postoperatively, with a greater improvement from the preoperative situation leading to greater satisfaction. Also, treatment and surgeon were not randomized; thus, surgeon preference and experience could have biased the outcomes. Moreover, different techniques were used for fixation of the MTP-1 joint. The present study did not correct for confounders such as smoking or diabetes, which could have influenced failure risk. Deep infections, which could eventually result in worse outcomes, were not documented; thus, we could not determine whether our results were affected by infection. Therefore, the results of the present study need to be verified by prospective, multicenter, randomized controlled trials. We also appreciate that it would not be very meaningful, in most cases, to compare our results with those of previous case series.

In conclusion, we found symptom intensity and magnitude of disability were similar after arthrodesis and hemiarthroplasty for osteoarthritis of the MTP-1 joint. However patients treated with hemiarthroplasty reported greater satisfaction; therefore, we recommend this procedure. Moreover, although the numbers of repeat operations were comparable for both groups, salvage arthrodesis after failed arthroplasty remains a more straightforward procedure than intervention for failed fusion.

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References

1. Deland JT, Williams BR. Surgical management of hallux rigidus. J Am Acad Orthop Surg 20:347–358, 2012.
2. Carpenter B, Smith J, Motley T, Garrett A. Surgical treatment of hallux rigidus using a metatarsal head resurfacing implant: mid-term follow-up. J Foot Ankle Surg 49:321–325, 2010.
3. McNeil DS, Baumhauer JF, Glazebrook MA. Evidence-based analysis of the efficacy for operative treatment of hallux rigidus. Foot Ankle Int 34:15–32, 2013.
4. Brewster M. Does total joint replacement or arthrodesis of the first metatarsophalangeal joint yield better functional results? A systematic review of the literature. J Foot Ankle Surg 49:546–552, 2010.
5. Gibson JN, Thomson CE. Arthrodesis or total replacement arthroplasty for hallux rigidus: a randomized controlled trial. Foot Ankle Int 26:680–690, 2005.
6. Raikin SM, Ahmad J, Pour AE, Abidi N. Comparison of arthrodesis and metallic hemiarthroplasty of the hallux metatarsophalangeal joint. J Bone Joint Surg Am 89:1979–1985, 2007.
7. Brodsky JW, Baum BS, Pollo FE, Mehta H. Prospective gait analysis in patients with first metatarsophalangeal joint arthrodesis for hallux rigidus. Foot Ankle Int 28:162–165, 2007.
8. Kim PJ, Hatch D, DiDomenico LA, Lee MS, Kaczander B, Count G, Kravette M. A multicenter retrospective review of outcomes for arthrodesis, hemi-metallic joint implant, and resectional arthroplasty in the surgical treatment of end-stage hallux rigidus. J Foot Ankle Surg 51:50–56, 2012.
9. Giza E, Sullivan M, Ocel D, Lundeen G, Mitchell M, Frizzell L. First metatarsophalangeal hemiarthroplasty for hallux rigidus. Int Orthop 34:1193–1198, 2010.
10. Salonga CC, Novicki DC, Pressman MM, Malay DS. A retrospective cohort study of the BioPro hemiarthroplasty prosthesis. J Foot Ankle Surg 49:331–339, 2010.
11. Sorbie C, Saunders GA. Hemiarthroplasty in the treatment of hallux rigidus. Foot Ankle Int 29:273–281, 2008.
12. Cook E, Cook J, Rosenblum B, Landsman A, Basile P. Meta-analysis of first metatarsophalangeal joint implant arthroplasty. J Foot Ankle Surg 48:180–190, 2009.
13. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 15:349–353, 1994.
14. Ibrahim T, Beiri A, Azzabi M, Best AJ, Taylor GJ, Menon DK. Reliability and validity of the subjective component of the American Orthopaedic Foot and Ankle Society clinical rating scales. J Foot Ankle Surg 46:65–74, 2007.
15. Coughlin MJ, Shurnas PS. Hallux rigidus: grading and long-term results of operative treatment. J Bone Joint Surg Am 85-A:2072–2088, 2003.
16. Sullivan MR. Hallux rigidus: MTP implant arthroplasty. Foot Ankle Clin 14:33–42, 2009.