Comparison of Arthrodesis and Metallic Hemiarthroplasty of the Hallux Metatarsophalangeal Joint

By Steven M. Raikin, MD, Jamal Ahmad, MD, Aidin Eslam Pour, MD, and Nicholas Abidi, MD

Investigation performed at the Department of Orthopaedic Surgery, Rothman Institute and Thomas Jefferson University Hospital, Philadelphia, Pennsylvania

Background: Currently, arthrodesis is the most commonly performed surgical procedure for the treatment of severe arthritis of the first metatarsophalangeal joint. The objective of this study was to compare the long-term clinical and radiographic outcomes of a metallic hemiarthroplasty with those of arthrodesis for the treatment of this condition.

Methods: A series of patients with osteoarthritis of the first metatarsophalangeal joint were treated with either a metallic hemiarthroplasty or an arthrodesis between 1999 and 2005. Postoperative satisfaction and function were graded with use of the American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal (AOFAS-HMI) scoring system, and pain was scored with use of a visual analogue scale.

Results: Twenty-one hemiarthroplasties and twenty-seven arthrodeses were performed in forty-six patients. Five (24%) of the hemiarthroplasties failed; one of them was revised, and four were converted to an arthrodesis. Eight of the feet in which the hemiprosthesis had survived had evidence of plantar cutout of the prosthetic stem on the final follow-up radiographs. At the time of final follow-up (at a mean of 79.4 months), the satisfaction ratings in the hemiarthroplasty group were good or excellent for twelve feet, fair for two, and poor or a failure for seven. The mean pain score was 2.4 of 10. All twenty-seven of the arthrodeses achieved fusion, and no revisions were required. At the time of final follow-up (at a mean of thirty months), the satisfaction ratings in this group were good or excellent for twenty-two feet, fair for four, and poor for one. The mean pain score was 0.7 of 10. Two patients required hardware removal, which was performed as an office procedure with the use of local anesthesia. The AOFAS-HMI and visual analogue pain scores and satisfaction were significantly better in the arthrodesis group.

Conclusions: Arthrodesis is more predictable than a metallic hemiarthroplasty for alleviating symptoms and restoring function in patients with severe osteoarthritis of the first metatarsophalangeal joint.

Level of Evidence: Therapeutic Level III. See Instructions to Authors for a complete description of levels of evidence.

Severe arthritis of the first metatarsophalangeal joint can be challenging to treat. Currently, the most commonly performed surgical procedure to address this condition is arthrodesis. Since it was first described by Broca in 1852, numerous methods for achieving joint fusion have been detailed. Reported union rates have ranged from 77% to 100%, with a mean rate of approximately 90%. However, stiffness as a result of the fusion can lead to patient dissatisfaction. In addition, gait patterns can be altered, with a decreased step length and some loss of ankle plantar flexion at toe-off on the fused side.

An alternative, motion-sparing approach is a joint arthroplasty. Use of single-stem, and later double-stem, silicone implants had encouraging early results, but they were followed by late complications due to the propensity of silicone to fragment under axial loading. Subsequent arthroplasties have predominantly been done with metallic components, with or without polyethylene articulations. However, many of...
these procedures were followed by high loosening rates, periprosthetic bone loss, and poor patient satisfaction.\textsuperscript{12,13,16}

Metallic hemiarthroplasty was developed in an effort to address these shortfalls. In this procedure, a small portion of the base of the proximal phalanx, including the articular surface, is resected and is replaced with an implant of an appropriate size. The metatarsal head then articulates with the metallic implant. First-generation metallic hemiarthroplasties were abandoned because of problems with loosening of the implant and bone loss at the joint.\textsuperscript{12,17} Currently, there are four newer metallic devices approved by the United States Food and Drug Administration for use in hemiarthroplasty at the first metatarsophalangeal joint. The BioPro implant (BioPro, Port Huron, Michigan) is a porous-coated, noncemented prosthesis made of cobalt-chromium alloy. Townley designed this implant, and he and Tananow presented their results in a retrospective case series of 279 patients.\textsuperscript{18} They reported good or excellent clinical results in 95% of their patients, who were followed for eight months to thirty-three years postoperatively. They concluded that, compared with earlier prostheses, this device is less likely to loosen and results in less bone loss. However, we are not aware of any independent studies with long-term follow-up of Biopro or other metallic hemiarthroplasties.

The purpose of this study was to evaluate and compare the perioperative complications and medium-term clinical and radiographic outcomes of arthrodesis with those of a BioPro metallic hemiarthroplasty of the first metatarsophalangeal joint. Our hypothesis was that there is no significant difference in the long-term clinical and radiographic outcomes between these two procedures for the treatment of severe degenerative arthritis of the first metatarsophalangeal joint.

**Materials and Methods**

This study was performed after we obtained appropriate approval from our institutional review board and patient consent. The study, which was conducted in a retrospective manner, involved two sequential series of patients. Inclusion criteria were painful arthritis of the first metatarsophalangeal joint (grade-I\textsuperscript{18,19} and grade-II hallux rigidus were excluded) without instability of a lesser metatarsophalangeal joint. Patients with pre-existing instability of a lesser metatarsophalangeal joint (including joint subluxation and dislocation), inflammatory arthritis (including rheumatoid arthritis), post-infectious arthritis, or Charcot neuroarthropathy were excluded from the study. The study population was not limited to a single sex or ethnic background.

The treatment period was from January 1999 through April 2005. All hemiarthroplasties were performed by one surgeon (N.A.) between April 1999 and August 2000, and all arthrodeses were performed by another surgeon (S.M.R.) between September 2000 and April 2005. The first metatarsophalangeal joint was exposed through a dorsal capsulotomy medial to the extensor hallucis longus tendon for both surgical procedures. All hemiarthroplasties involved a cholecotomy of the metatarsal head, removal of a small portion from the base of the proximal phalanx including the articular cartilage, and implantation of an appropriately sized BioPro implant. All fusions entailed resection of the articular cartilage from both sides of the joint to achieve flat surfaces of exposed cancellous bone, and then rigid internal fixation was achieved by placing two 4.0-mm screws obliquely from medial to lateral across the joint. The postoperative protocol was identical for both populations.

Patients were assessed clinically, radiographically, and with a questionnaire by an independent observer who was not involved in the care of the patients. Postoperative satisfaction and function were scored according to the unvalidated American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal (AOFAS-HMI) scoring system.\textsuperscript{21} Pain was assessed with use of a visual analogue scale ranging from 0 to 10, with 0 indicating the absence of pain and 10 describing the worst pain imaginable. Preoperative scores were obtained with a retrospective chart review by the independent observer. The range of motion of the first metatarsophalangeal joint was measured with a goniometer. In the arthrodesis group, the maximum AOFAS-HMI score obtainable was 90 points, as up to 10 points are allowed for metatarsophalangeal joint motion. This score of 90 points was then adjusted to a percentage for comparative purposes.\textsuperscript{22} Postoperative complications, including the need for revision surgery, were identified by chart review.

Preoperative and final follow-up weight-bearing radiographs of the foot were assessed for both groups of patients. Patients who were unable to return for a clinical and radiographic evaluation were interviewed by telephone, and radiographs from their final clinical evaluation were reviewed. The quality of osseous fusion and the alignment of the first metatarsophalangeal joint were assessed in the arthrodesis group. The initial position of the implant was evaluated in the hemiarthroplasty group. At the final evaluation, the position and alignment of the hemiprosthesis were assessed radiographically, and bone loss and any evidence of loosening were identified. Patients were examined for tenderness, range of motion, and alignment of the hallux metatarsophalangeal joint.

Patients were asked to rate the outcome of the procedure as poor, fair, good, or excellent. They were also asked if they would have the procedure again under similar circumstances or would recommend it to a friend.

A paired Student t test and a Pearson chi-square test were performed to evaluate the significance of differences in outcomes between the arthrodesis and hemiarthroplasty groups. Kaplan-Meier survivorship analysis was performed for both patient populations. A p value of <0.05 was defined as significant.

**Results**

Forty-six patients were included in the study. Twenty-one feet in twenty patients received a hemiarthroplasty, and twenty-seven feet in twenty-six patients underwent an arthrodesis. Each of the bilateral procedures was done in a staged manner. The two groups were similar in terms of age, sex distribution, side of the surgery, comorbidities, and estimated
Comparison of Arthrodesis and Metallic Hemiartroplasty of the Hallux Metatarsophalangeal Joint

Of the twenty patients who had had a hemiarthroplasty, seventeen (eighteen feet) were seen for follow-up at a mean of 79.2 months (range, sixty-eight to 85.7 months). Three patients had moved out of state and were unable to return for evaluation. However, they were assessed by telephone, with a questionnaire. Five (24%) of the twenty-one joints required subsequent surgical treatment, at an average of thirteen months (range, nine to eighteen months) after the index surgery, because of failure of the hemiarthroplasty. All of these revisions were performed to address pain and aseptic loosening of the implant. In four patients, the hemiarthroplasty was converted to an arthrodesis through the original incision. Double-cross-screw fixation was supplemented with bone graft that had been harvested from the lateral part of the calcaneus. No arthrodeses required block interposition grafts to treat bone loss or osteolysis. All four conversions achieved fusion, at an average of 15.5 weeks. The remaining patient underwent revision hemiarthroplasty at fourteen months to treat pain and aseptic implant loosening. These five cases were considered to be failures of the initial hemiarthroplasty and poor results.

The mean AOFAS-HMI scores for the sixteen feet of the fifteen patients with a surviving hemiprosthesis increased from 35.6 of 100 points preoperatively to 71.8 of 100 points at a mean of 79.4 months (range, sixty-eight to 85.7 months) postoperatively. The mean postoperative score on the visual analogue scale for pain for these sixteen feet was 2.4. Thirteen feet in the hemiarthroplasty group were available for radiographic assessment, and eight of them displayed cutout of the distal portion of the implant through the plantar cortex of the proximal phalanx (Fig. 1). In addition, all thirteen implants showed evidence of dorsal subsidence at the final evaluation (Figs. 2-A and 2-B). The range of motion of the first metatarsophalangeal joint averaged 10°, ranging from 0° to 30°. None of the joints displayed instability. Five of the sixteen feet had a symptomatic plantar callus under the second metatarsal head. The one patient who had had bilateral staged hemiarthroplasty had bilateral plantar callosities and instability of the second and third metatarsophalangeal joints.

When the twenty patients were asked if they were satisfied with the postoperative outcome, twelve (60%) stated that they would undergo the same procedure again under similar circumstances. The results of five (24%) of the twenty-one hemiarthroplasties were rated as excellent by the patients; those of seven (33%), as good; those of two (10%), as fair; and those of seven (including the five failures), as poor.

### TABLE I Preoperative Demographic Data on the Patients in the Two Treatment Groups*

<table>
<thead>
<tr>
<th></th>
<th>Arthrodesis (N = 27)</th>
<th>Hemiarthroplasty (N = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male:female</td>
<td>10:16</td>
<td>6:14</td>
</tr>
<tr>
<td>Mean age (yr)</td>
<td>54.1 (32-73)</td>
<td>59.7 (39-70)</td>
</tr>
<tr>
<td>Right:left</td>
<td>13:14</td>
<td>11:10</td>
</tr>
<tr>
<td>Mean preop. AOFAS-HMI score (points)</td>
<td>36.1 (19-62)</td>
<td>35.6 (10-59)</td>
</tr>
</tbody>
</table>

*There was no difference between the two groups with regard to any parameter. †AOFAS-HMI = American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal. The maximum possible score is 100 points.
Kaplan-Meier survivorship analysis of the hemiarthroplasty population (Fig. 3) revealed rates of implant failure, defined as the need for fusion or revision hemiarthroplasty, of 4.8%, 14.3%, and 23.8% at nine, twelve, and eighteen months postoperatively. These rates suggest that most failures occur within the first two years after surgery. At the time of the latest follow-up, the patient with bilateral hemiarthroplasty in whom bilateral plantar callosities and instability of the second and third lesser metatarsophalangeal joints developed requested revision surgery.

All twenty-six patients (twenty-seven feet) treated with an arthrodesis returned for follow-up examination, at a mean of 30.0 months (range, thirteen to sixty-seven months). All fusions were healed, as seen clinically and radiographically, by twelve weeks after the surgery. No revision procedures were performed in this group. Two patients who were troubled by a prominent screw head over the medial aspect of the proximal phalanx underwent screw removal as an office-based procedure with the use of local anesthesia at one year postoperatively. The mean AOFAS-HMI score increased from 36.1 of 100 points preoperatively to 83.8 (93.1%) of 90 points at the time of final follow-up. This postoperative AOFAS-HMI score was significantly higher than the mean score of 71.8% for the hemiarthroplasty group (p = 0.006). Twenty-six (96%) of the twenty-seven feet with an arthrodesis demonstrated a well-healed fusion in appropriate alignment on final follow-up radiographs. A painful plantar callosity under the second metatarsal head and instability of the second metatarsophalangeal joint developed in one patient at
twelve months after the surgery. In this patient, the fusion was aligned in 35° of dorsiflexion (20° relative to the floor) and 20° of valgus. The patient was dissatisfied with the result, which she rated as poor. When asked if they were satisfied with the postoperative outcome, twenty-two (85%) of the twenty-six patients stated they would undergo the procedure again under similar circumstances. Twenty-one feet (78%) were rated as excellent; one (4%), as good; four (15%), as fair; and one, as poor.

The mean postoperative score on the visual analogue scale for pain was 0.7, which was significantly lower than that in the hemiarthroplasty group (p = 0.021). Two (7%) of the twenty-seven feet had symptomatic plantar calluses. This rate was significantly lower than the rate of 31% seen in the hemiarthroplasty group (p = 0.041).

A summary of the final results with statistical correlations can be found in Table II.

**TABLE II Final Postoperative Results That Differed Significantly Between Groups (P < 0.05)**

<table>
<thead>
<tr>
<th></th>
<th>Arthrodesis (N = 27)</th>
<th>Hemiarthroplasty (N = 21)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean duration of follow-up</td>
<td>30.0</td>
<td>79.4</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Mean postop. AOFAS-HMI* score</td>
<td>93% (83.8/90 points)</td>
<td>71.8%</td>
<td>0.006</td>
</tr>
<tr>
<td>Satisfaction (no. of patients)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>1 (4%)</td>
<td>7 (33%)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Fair</td>
<td>4 (15%)</td>
<td>2 (10%)</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>1 (4%)</td>
<td>7 (33%)</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>21 (78%)</td>
<td>5 (24%)</td>
<td></td>
</tr>
<tr>
<td>Mean score on visual analogue scale (out of 10)</td>
<td>0.7</td>
<td>2.4</td>
<td>0.021</td>
</tr>
<tr>
<td>Plantar callosities</td>
<td>2/27</td>
<td>5/16</td>
<td>0.041</td>
</tr>
</tbody>
</table>

* AOFAS-HMI = American Orthopaedic Foot and Ankle Society Hallux Metatarsophalangeal Interphalangeal.
Discussion

Treatment of severe arthritis of the first metatarsophalangeal joint remains a challenge. The debate continues regarding the choice between arthrodesis, which achieves predictable and reliable satisfaction but eliminates metatarsophalangeal joint motion and affects normal gait mechanics, and arthroplasty, the aim of which is to preserve motion and gait mechanics. Few comparative studies can be found in the literature. Gibson and Thomson recently reported on a randomized controlled trial comparing arthrodesis with a two-component arthroplasty of the metatarsophalangeal joint. Six (15%) of thirty-nine prostheses had to be removed because of component loosening, and the remainder demonstrated a poor range of motion associated with altered gait mechanics. Pain relief (p = 0.021) and patient satisfaction (p < 0.01) were significantly better in the arthrodesis group.

In another recent, noncomparative study, of the Bio-Action great toe implant (OsteoMed, Addison, Texas), Pulavarti et al. reported a 77% satisfaction rate while 33% of the radiographs showed evidence of loosening and subsidence. Brodsky et al. performed arthrodesis on sixty feet in fifty-three patients and reported a 94% satisfaction rate, a 100% union rate, and effective pain relief.

Our study had some shortcomings. Patients were assessed retrospectively rather than prospectively, which may have affected preoperative scoring as it was based on chart review. Surgical treatment was not randomized, as one surgeon performed the hemiarthroplasties and another did the arthrodeses. As the hemiarthroplasties were performed before the arthrodeses, the patients treated with hemiarthroplasty were followed for a longer period. These factors could result in some inequalities between the two patient populations. It can also be argued that, in order to fully assess the final clinical and radiographic outcomes, both patient groups require longer than the medium-term follow-up performed in our study. The rate of implant failure may increase in the hemiarthroplasty group, and adjacent arthritis at the first interphalangeal and tarsometatarsal joints, which can affect the AOFAS-HMI score, may develop in the patients treated with the arthrodesis. In addition, plantar callousities and instability of the lesser metatarsophalangeal joints may develop in more patients in both populations with longer follow-up.

While there may have been some disparities between our study populations and they may require longer follow-up, they were well matched in terms of age and preoperative AOFAS-HMI scores. We demonstrated that, in patients with severe arthritis, arthrodesis of the first metatarsophalangeal joint is more predictable than metallic hemiarthroplasty for alleviating symptoms and restoring function. Patients who underwent arthrodesis had lower pain scores, higher function scores, and greater satisfaction than those who received a hemiarthroplasty. The patients who had the hemiarthroplasty also had a higher rate of long-term failure, often necessitating conversion to a fusion.

We found one advantage of the BioPro prosthesis over any of the older, first-generation metatarsophalangeal joint prostheses. It requires less bone resection for implantation. However, all of these implants showed dorsal subsidence at the final evaluation. Eight of thirteen implants displayed cutout of the distal portion through the plantar cortex of the proximal phalanx. However, none were associated with osteolysis, as has been well documented with earlier prostheses. These features made revision or conversion to a fusion technically easier and more reliable in the five patients in whom the implant failed as a result of loosening.

In conclusion, while the newer-generation metallic hemiarthroplasty system offers some advantages over earlier generations of silicone or metallic two-component arthroplasty systems, the clinical and functional results were found to be significantly inferior to those obtained with arthrodesis of the first metatarsophalangeal joint when the two procedures were evaluated in similar patient populations.

References