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Contemporary Approaches to Stage II and III Hallux Rigidus: The Role of Metallic Hemiarthroplasty of the Proximal Phalanx

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The pain and diminished motion that are associated with arthrosis of the hallux metatarsophalangeal joint produce a syndrome of disability that is termed hallux rigidus. Additional symptoms may include diminished propulsion, transfer metatarsalgia, habitual forefoot supination, and other gait alteration. Hallux rigidus often occurs in a younger age group, typically in the fourth and fifth decades.

Common surgical procedures for the treatment of hallux rigidus include cheilectomy, resection arthroplasty, soft tissue interposition arthroplasty, arthrodesis, and silastic joint replacement. Although reasonably satisfactory results can be achieved with all of these procedures, each has its unique disadvantages.

Cheilectomy [1–9] addresses the offending marginal exostoses and restores a reasonable degree of dorsiflexion. The procedure typically is used in patients who have limited joint involvement. Outcomes are less satisfactory in higher grade lesions [10–12]. The longevity of the procedure may be compromised by recurrence and the natural progression of the degenerative joint pathology.

The Keller resection arthroplasty procedure [13], usually reserved for patients who have low forefoot functional demands, attempts to unload the arthritic joint. The amount of resection that is required at the base of the proximal phalanx can

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result in the release of stabilizing soft tissue attachments, and frequently leads to deformity [9,12–17] and instability [18]. Other potential problems include transfer metatarsalgia [9,13–15,17,19–21], shortening [9,16,18,22,23], and collapse impingement [13].

Soft tissue interposition arthroplasty procedures [1,6,24–27] have been developed to address the problems that are associated with resection arthroplasty. Improved outcomes have been described, but transfer metatarsalgia [6,24,25], diminished flexion [6], and weakness [6] can result.

Although arthrodesis can be expected to relieve pain and produce acceptable cosmetic results in most patients who have severe hallux rigidus, the procedure results in altered gait biomechanics [28]. The convalescence period typically is prolonged [1,9,16,25,29] and can be complicated by delayed or nonunion. Achieving optimal alignment in three planes can be technically difficult [1,15,21]. Furthermore, sacrificing hallux motion restricts the ability to wear shoes with heels of varying heights [16,21,25,30–33]. The hallux metatarsophalangeal (HMP) fusion limits a person's ability to kneel [25], and activities (eg, racquet sports and jogging) may be difficult [14]. The distal transference of ambulatory stresses can induce degenerative changes in the interphalangeal joint [1,9,14,30,33,34].

Silicone does not possess the structural durability or the surface characteristics to withstand the severe shear and tension stresses that are generated by the repetitive motion of normal ambulation. Failure that is due to wear [35–38], osteolysis [13,21,36–41], subchondral cystic degeneration [13,41,42], foreign body reaction [13,38,42,43], and fracture or dislodgment of the components [13,35,37–39,41,44,45] has been reported widely. The clinical implications of systemic dissemination of silicone that results in granulomatous adenopathy following HMP arthroplasty are unclear [36,37,46].

Results of total and hemi-arthroplasty procedures that involve replacement of the metatarsal head with a variety of prosthetic materials have been disappointing. The dorsally directed forces that pass through the metatarsal prosthesis during ambulatory push-off commonly result in osteolysis or loosening [47–49] and dorsal migration, regardless of the material used.

A metallic proximal phalangeal hemiarthroplasty [50–52] avoids the structural faults that are inherent in silicone arthroplasty, as well as the mechanical failures that are associated with shear forces in arthroplasty procedures of the metatarsal head. A reported long-term experience with the use of a nonconstrained metallic resurfacing implant for hemiarthroplasty of the HMP joint demonstrated excellent pain relief, restoration of motion, and durability. In a retrospective study of 279 HMP joints that were implanted with this prosthesis, Townley and Taranow [52] reported 95.3% good or excellent results with a follow-up time that ranged from 10 months to 33 years. Joplin [53] reported two case studies using a similar metallic proximal phalangeal hemiarthroplasty which resulted in stable, pain-free, functional joints. He also recounted undocumented, but similar "outstanding," results in 55 additional cases that were treated with this procedure.

The purpose of this article is to determine the subjective and objective outcomes of patients who have severe hallux rigidus that is treated with metallic proximal phalangeal hemiarthroplasties. One surgeon performed the surgeries over a 9-year period. Less severe cases were treated with other methods.

Material and methods

Thirty-seven patients (15 men and 22 women; 42 HMP joints) were treated by the senior author (WST) with metallic proximal phalangeal hemiarthroplasty for symptomatic hallux rigidus between September 1995 and October 2004. The average age was 52.9 years, with a range of 38 to 71 years. The indications were severe symptoms with grade III radiographic changes, or grade II changes with an intraoperative finding of absence of articular cartilage on greater than 50% of the metatarsal head.

Twenty-three patients (25 joints) returned for a final evaluation. An additional 5 patients (7 joints) answered telephone questionnaires and allowed determination of Foot Function Index (FFI) [54–72] in 28 patients (32 joints).

Surgical technique

The HMP joint was exposed through a dorsal skin incision. The dorsal approach allows easy access to medial, dorsal, and lateral osteophytes and easier implant insertion. Care is taken to avoid injury to the dorsomedial cutaneous nerve. The capsule is incised longitudinally in line with the skin incision 2 mm to 3 mm medial to the extensor hallucis tendon. Careful subperiosteal sharp dissection is performed medially, dorsally, and laterally on the metatarsal head and base of the proximal phalanx (Fig. 1). This technique spares the capsular

Fig. 1. Dorsal approach demonstrating subperiosteal dissection and absence of articular cartilage.

Fig. 2. The proximal phalangeal articular resection is slightly thicker than the implant.

tissue and allows later watertight closure. Meticulous care must be given to avoid inadvertent release of the insertions of the flexor hallucis brevis and the abductor and adductor, and thus, avoid the propensity for postoperative contractural deformities.

The exposure is augmented by the preliminary resection of osteophytes that involve the metatarsal head and base of the phalanx. The articular surface of the phalanx is osteotomized in a common flat plane with an oscillating saw, and sufficient bone is resected to accommodate the thickness of the articulating plate of the implant. The resected fragment is removed; any remaining plantar capsular attachments are released carefully by subperiosteal dissection. The resected bone can be assessed to help determine the size of the prosthesis and to assure that the bone removed is slightly thicker than the implant (Fig. 2).

Any remaining marginal osteophytes are resected completely from the medial, dorsal, and lateral metatarsal head to allow normal, unimpinged motion of the joint. The metatarsal head can be drilled to stimulate fibrocartilage growth (Fig. 3).

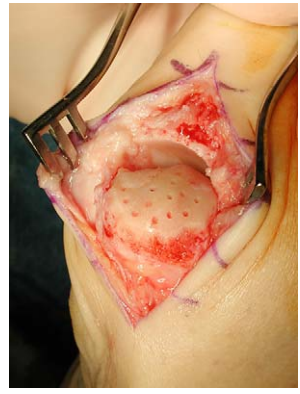

Fig. 3. Marginal osteophytes removed, exposed bone drilled.

Fig. 4. Normal, concentric range of motion.

A slotted surface sizing template, which approximates the dimensions of the osteotomized phalanx without extending beyond the margins of the cut surface, is positioned accurately to localize the intramedullary ingress for the implant stem. With the template slot maintained precisely in the transverse plane, a delineating mark is made on the bone surface with an osteotome. The template is removed and the bone aperture is enlarged and deepened sufficiently to accommodate the geometry of the stem and to allow flush seating of the trial implant. Although this usually can be accomplished with an osteotome, it is may be necessary to use a small burr in patients who have dense bone or a narrow medullary canal. Insertion sometimes is difficult, and may be facilitated by an assistant applying manual traction with flexion.

The trial implant is ‘‘pushed’’ into position manually or with the aid of an impactor. After the trial is flush with the bone, the joint is observed for proper fit. A normal range of smooth, concentric, unimpinged motion, particularly in dorsiflexion, should be demonstrated (Fig. 4). Modest traction is applied to the

Fig. 5. Implant press-fit.

toe. If the articulation cannot be separated by at least 3 mm, the implant is removed and more bone is resected. An overly tight joint can result in limited motion and pain. The trial may then be removed and the final prosthesis is press fit in the canal (Fig. 5).

Postoperative management

Immediate weight bearing to tolerance is permitted in a postoperative shoe. Patients are encouraged to progress rapidly to a soft slipper or dorsally cutout athletic shoe. The progression to normal ambulation and the use of standard foot gear is limited only by the persistence of swelling and discomfort. Following complete convalescence, no restrictions are placed on reasonable activities.

The FFI is used to measure the impact of foot pathology on function in terms of pain, disability, and activity restriction. The FFI is a self-administered index which consists of 23 items that are divided into three subscales. Total and sub-scale scores are produced. The first subscale measures pain when walking and standing at startup and at the end of the day, barefoot, in shoes, and with orthotics. The second subset measures disability in terms of difficulties walking indoors and out, walking four blocks, ascending and descending stairs, standing on toes, rising from a chair, climbing curbs, and walking fast. The third subset measures activity restriction. The incidence of staying inside all day, staying in bed, and limiting activities because of foot pain are measured. The use of assistive devices in and out of doors is documented.

A simple patient satisfaction questionnaire was administered. Patients were asked if they were satisfied completely with their surgical outcome, satisfied with reservations, or dissatisfied. They were queried if they would recommend the procedure to a friend or a relative, and whether they would undergo the procedure again under identical circumstances.

Physical examinations documented degrees of dorsiflexion, gross deformities, and pain or crepitus. Two-view weight-bearing foot radiographs were reviewed for immediate postoperative implant alignments, as well as later evidence of loosening, progressive malalignment, implant migration, or formation of osteophytes.

Results

Clinical outcome

Twenty-eight patients with 32 hemiarthroplasties completed pre- and postoperative modified FFI and patient satisfaction questionnaires (Fig. 6). Twenty-three patients with 25 implants returned for a final clinical evaluation. Preoperative and postoperative radiographs in all patients were reviewed to

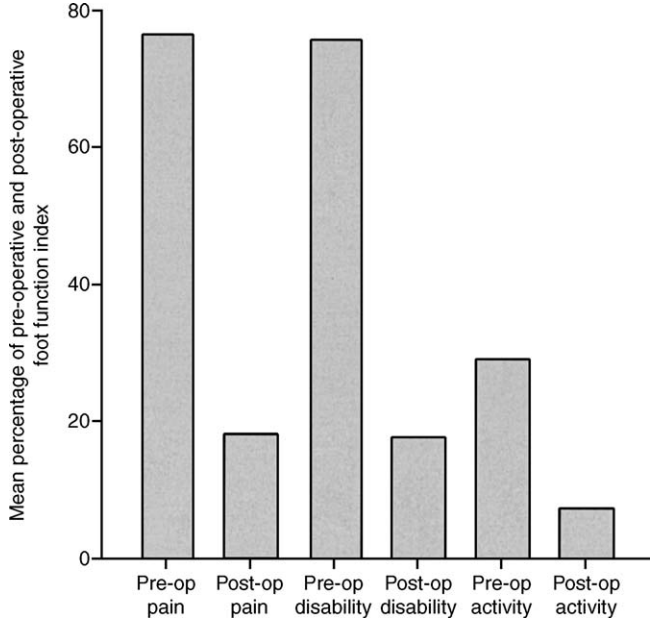

Fig. 6. Pre- and postoperative modified Foot Function Index patient satisfaction questionnaires.

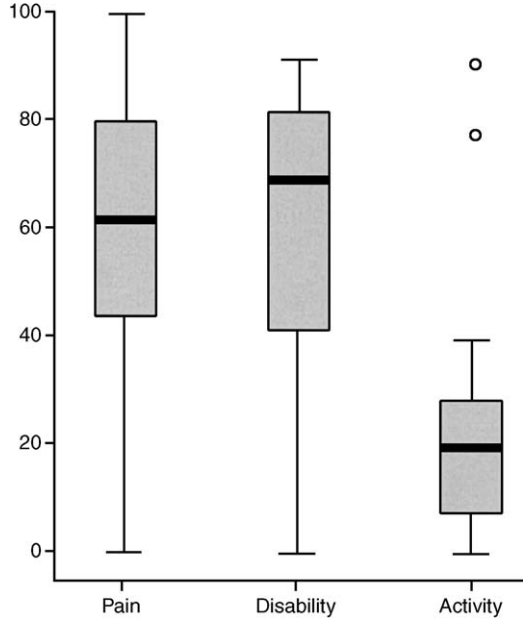

Fig. 7. Percent improvement in Foot Function Index Scores ($P = .001$) Black bar indicates median. Box represents 25% of cases below and above the median. Whiskers capture the remaining 25% of the observed values. Circles represent outliers.

Table 1
Pre- and postoperative Foot Function Index scores

Patient number	Sex	Age	Site	FFI Pain Score	FFI Disability Score	FFI Activity Score	Months follow-up	Radiographic findings	Complications
101	M	58	R	58.7	90.1	31.1	5	Satisfactory	None
Post				1.6	8.6	0			
102	F	71	L	90.1	98.8	44.4	6	Satisfactory	None
Post				23.5	14.8	6.7			
103	F	49	R	90.5	55.5	22.2	23	Satisfactory	None
Post				9.5	14.8	2.2			
104	M	62	R	100	92.6	2.2	97	Satisfactory	None
Post				0	1.2	0			
105	M	53	R	84.1	84.0	53.6	8	Satisfactory	None
Post				69.8	70.4	28.9			
106	F	67	R	100	88.9	0	17	Satisfactory	None
Post				0	0	0			
107 B/L	F	51	R	69.8	80.2	28.9	5	Satisfactory	None
Post				23.8	19.8	0			
107 B/L			L	69.8	80.2	28.9	4	Satisfactory	None
Post				18.5	19.8	0			
108	F	47	R	85.7	60.5	11.1	6	Satisfactory	None
Post				44.4	40.7	0			
109	F	50	R	85.7	88.9	20	74	Implanted in varus	None
Post				4.8	16.0	8.9		Migrated medial/plantar	
110	M	57	L	86.4	85.2	24.4	57	Osteophyte formation	None
Post				0	0	0			
111	F	51	R	2.5	71.6	0	46	Implanted dorsiflexed	None
Post				0	0	0			
112	F	61	R	88.9	88.9	11.1	57	Implanted dorsiflexed	None
Post				2.5	1.2	0			

113	M	44	R	48.4	21.0	20.0	49	Osteophyte formation	None
Post				0	0	0			
114	F	54	R	72.8	11.1	11.1	48	Satisfactory	None
Post				11.1	11.1	11.1			
115 B/L	F	49	R	49.9	56.8	35.6	78	Satisfactory	None
Post				18.5	14.8	11.1			
115 B/L			L	49.9	56.8	35.6	78	Implanted dorsiflexed	None
Post				12.2	12.3	11.1			
116	M	70	R	88.9	88.9	88.9	64	Satisfactory	None
Post				11.1	11.1	11.1			
117 B/L	M	52	R	77.8	79.0	42.2	8	Satisfactory	None
Post				77.8	79.0	42.2			
117 B/L			L	77.8	79.0	42.2	8	Satisfactory	None
Post				77.8	79.0	42.2			
118	M	38	R	93.7	96.3	95.6	112	Satisfactory	None
Post				22.2	21.0	4.4			
126 B/L	F	56	R	100	92.6	31.1	48	Satisfactory	None
Post				31.7	19.8	2.2			
126 B/L			L	100	92.6	31.1	67	Satisfactory	None
Post				25.4	19.8	2.2			
128	F	56	R	81.5	81.5	11.1	72	Satisfactory	None
Post				4.9	0	6.7			
130	M	45	L	79.4	86.4	17.8	15	Satisfactory	None
Post				25.4	12.3	6.7			
131	M	50	R	66.7	71.6	28.9	16	Satisfactory	None
Post				20.6	23.5	24.4			
132	F	47	L	45.7	37.0	31.1	28	Satisfactory	None
Post				4.8	4.9	11.1			

(continued on next page)

Table 1 (*continued*)

Patient number	Sex	Age	Site	FFI Pain Score	FFI Disability Score	FFI Activity Score	Months follow-up	Radiographic findings	Complications
133	F	68	L	54.0	55.5	17.8	27	Satisfactory	None
Post				1.6	1.4	4.4			
134	F	50	R	90.5	91.4	17.8	11	Inserted in varus	None
Post				22.2	24.7	0			
136	M	52	L	92.1	87.7	35.6	2	Satisfactory	None
Post				0	0	11.1			
137	F	50	L	79	87.7	37.8	6	Satisfactory	None
Post				17.2	28.4	2.2			
FFI	Preoperative			76.14	75.43	29.33			
Averages	Postoperative			18.80	18.40	8.09			

identify malalignment, loosening, or implant migration. Recurrent marginal osteophytes also were assessed.

No major postoperative complications occurred that were related to the procedure. One patient developed postoperative superficial cellulitis, which resolved with oral antibiotics. One patient developed septicemia and multiple organ failure 2 weeks postoperatively secondary to cholelithiasis. She survived and her implant remains unaffected clinically and radiographically. There were no other instances of acute or late infections.

Mean FFI pain scores improved from 76.14 (range, 28.4–100) preoperatively to 18.80 (range, 1.6–77.8) postoperatively. Mean FFI disability scores improved from 75.43 (range, 11.1–98.8) preoperatively to 18.40 (range, 0–79.0) postoperatively. Mean FFI activity restriction scores improved from 29.33 (range, 11.1–95.6) preoperatively to 8.09 (range, 0–42.2) postoperatively. Student *t* test that compared paired samples (pre- and postoperative FFI scores) demonstrated $P < .001$. (Fig. 7; Table 1).

Fig. 8. Patient #104. (*A*) Preoperative lateral radiograph. (*B*) Preoperative anteroposterior radiograph. (*C*) 8-year postoperative lateral radiograph. (*D*) 8-year postoperative anteroposterior radiograph.

Twenty-three of 28 patients were completely satisfied, 3 were satisfied with reservations, and 2 were dissatisfied. Twenty-five of 28 (89.3%) patients said that they would repeat the procedure under identical preoperative conditions. Twenty-six of 28 (92.9%) patients said that they would recommend the procedure to a friend or relative. The average follow-up was 33.14 months (range, 3–112 months).

Radiographic outcome

Pre- and postoperative radiographs were reviewed in 35 of 37 patients (40 implants). Average radiographic follow-up was 33.14 months (range, 3–112 months). Thirty-one patients' radiographs demonstrated acceptable alignment of the implant and the metatarsophalangeal joint (Fig. 8). Four patients had implants inserted in a dorsiflexed position (ie, the stem in contact or protruding through the plantar cortex of the proximal phalanx), as demonstrated on the immediate postoperative radiographs. Three joints in two of these patients showed radiographic evidence of subsidence and loosening. There were no other incidences of progressive deformities (valgus, varus) or loosening. One patient demonstrated mild recurrence of dorsal, medial, and lateral osteophytes at 57 months follow-up. One showed mild medial and lateral osteophytes at 49 months. Patient satisfaction did not correlate with the radiographic findings.

Two patients never followed up postoperatively. Nine other patients (10 implants) were not available for final evaluation. Their charts were reviewed.

Clinical and radiographic follow-up in these patients ranged from 0.5 to 24 months (mean, 5 months). All were doing well clinically and radiographically at latest follow-up, and the techniques and demographics of these patients were identical to those who were available for final examination.

Discussion

This case review demonstrates acceptable outcomes following a metallic proximal phalangeal hemiarthroplasty. FFI scores were improved significantly, and high rates of patient satisfaction were noted.

Technical errors likely contributed to radiographic loosening that was noted in two patients (three implants). At one point it was presumed that inserting the implant in a plantarflexed position (ie, dorsiflexing the toe on the implant) would improve postoperative dorsiflexion. This was not demonstrated, and a higher rate of loosening was seen in these patients.

Several factors influence the decision to proceed with an implant versus a cheilectomy or fusion. Patients with radiographically mild to moderate arthrosis are treated with a cheilectomy, unless intraoperative findings demonstrate loss of articular cartilage on greater than 50% of the metatarsal head. The cases with severe cartilage loss are treated with a hemiarthroplasty.

Patients who have severe arthritis who already have lost HMP motion are offered a fusion or an implant. Those who have severe arthritis but maintained motion typically are treated with a hemiarthroplasty after discussion of risks, alternatives, and benefits.

Several design and surgical features exist that explain the high success rate in this series compared with other great toe arthroplasty procedures. The simplicity of the design and use of durable material eliminates the risk of mechanical failure of the implant. Shear stresses are avoided by replacing only the proximal phalanx, and leaving an intact metatarsal head for push off. The prosthesis is manufactured to mimic the radius of curvature of the articular metatarsal base. The highly polished surface diminishes friction. Its thin base allows minimal bone resection, and reduces the risk of progressive deformities by maintaining normal soft tissue attachments. Resection of marginal osteophytes and removal of bone that is slightly thicker than the implant decompresses the joint and decreases joint contact pressures.

This clinical series demonstrates similar patient satisfaction outcomes compared with other clinical series that studied arthrodesis, with the advantage of retained motion, shorter convalescence, and less restrictions of shoe wear. Superior results were noted in our clinical series when compared with published reports that studied cheilectomy for advanced hallux rigidus.

Our results offer further support to the use of a low friction proximal phalangeal hemiarthroplasty as an acceptable alternative to existing surgical techniques that are available for the treatment of moderate to severe arthrosis of the HMP joint. The procedure is technically uncomplicated, and rapid recovery and acceptable patient satisfaction were demonstrated.

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