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A Metallic Hemiarthroplasty Resurfacing Prosthesis for the Hallux Metatarsophalangeal Joint

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ABSTRACT

Two-hundred seventy-nine arthritic hallux metatarsophalangeal joints treated surgically with a metallic resurfacing hemiarthroplasty over a 40-year period were reviewed. The implant, which is made available in three evenly graded sizes, is designed to replace only the articular surface of the proximal phalanx, with minimal resection of bone stock. The pathologic indications for surgery included classical hallux rigidus, rheumatoid arthritis, and degenerative changes associated with hallux valgus and bunion deformity. Follow-up at 8 months to 33 years after surgery revealed good or excellent clinical results in 95%. The time to follow-up was in excess of 5 years in 101 (36%) of the procedures, beyond 10 years in 62 (22%), and longer than 20 years in 23 (8%). Unlike other available surgical options for this debilitating condition, biomechanics of the hallux metatarsophalangeal joint remained unaffected and problems associated with prosthetic wear or mechanical failure were not encountered.

INTRODUCTION

A stable, pain-free, and mobile great toe is essential for normal foot function and gait. The pain and limited motion associated with arthrosis of the hallux metatarsophalangeal (HMP) joint produces a syndrome of functional disability that may include progressive loss of the propulsion function of the foot, transfer lesser metatarsalgia, and gait alteration. For optimal restoration of function, the ideal surgical procedure must not only eliminate pain, restore motion, and maintain the strength and stability of the great toe, but must also reconstitute the normal distribution of weightbearing stresses sustained by the transverse metatarsophalangeal arch of the forefoot. Furthermore, since in our experience disabling arthritic conditions of the HMP joint occur predominantly in relatively young patients, commonly before the fifth and sixth decades, the procedure must also possess a reasonable degree of durability and functional longevity. A comprehensive review of the literature underscores the general fallibility of other currently available surgical options in accommodating all of these basic criteria.

The most commonly advocated surgical procedures have included cheilectomy,[28] Keller resection arthroplasty,[21] arthrodesis[8,30] and silastic joint replacement.[36,39] Although satisfactory results can be achieved with all of these procedures, each has its own unique disadvantages and the long-term results have been variable and inconsistent.

While cheilectomy may provide satisfactory relief of symptoms early on by improving motion, particularly in patients with limited joint destruction, this procedure fails to address the basic underlying arthritic problem. Consequently, the degree of postoperative pain relief is unpredictable and the longevity of the procedure is limited by the recurrence and natural progression of the degenerative joint pathology. Cheilectomy is now commonly viewed as a conservative delaying measure with the expectation that a more radical procedure may eventually be required.

Aside from the uncertain cosmetic results, the Keller procedure[27,35,44] is frequently associated with complications stemming from disturbances in the anatomy and biomechanics of the first ray. Complications that have been reported include excessive shortening,[3,7,16,23,42] transfer metatarsalgia,[7,18,23,26,30,35,37,44,45] clawtoe or cock-up deformity,[7,9,18,35,44,45] valgus drift,[26,44] weakening with impaired control and function of the great toe,[15,16,23,42] and recurrent pain at the reformed HMP pseudarthrosis.

A properly performed and successful arthrodesis can be expected to relieve pain and produce reasonably acceptable cosmetic results. However, imprecise positioning may sacrifice the range of hallux dorsiflex-

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ion necessary to allow normal push-off function of the forefoot. Consequently, the surgically fixed position of the HMP joint may then restrict the ability to wear shoes with heels of varying heights.[7,11,25,29,43] Achieving optimal multiplaned alignment is technically difficult[35] and, at best, imprecise. The distal transference of abnormal stress and motion induced by the immobile HMP joint proximally may also result in the development of painful degenerative changes in the interphalangeal joint of the great toe.[6,7,11,12,26,34,43]

The gratifying results that were reported early on with the use of Silastic implants led to the widespread use of this material as a resurfacing arthroplasty or hinged replacement. However, there have been increasing reports of late failure due to wear,[4,40,48] osteolysis,[18,33,47,48] foreign body reaction,[1,5,10,13,18,41,46] and fracture or dislodgment of the components.[1,4,14,18,20,22,31,38,46–48] The potential hazards associated with inguinal granulomatous adenopathy resulting from dissemination of silicone wear debris[24,41] have yet to be determined. It has become increasingly apparent that this material possesses neither the biological surface characteristics nor the structural durability to withstand the severe shear and tension stresses generated by the repetitive motion that is associated with normal ambulatory activities.

This report is informed by the senior author's long-term experience with the use of a nonconstrained, metallic, resurfacing implant for arthroplasty of the hallux metatarsophalangeal joint. The primary objective was to provide a durable arthroplasty procedure that would relieve pain and restore motion while leaving undisturbed the normal biomechanical arrangement of the great toe and the forefoot.

MATERIALS AND METHODS

Over a span of 40 years, between February 1952 and February 1992, 312 arthritic HMP joints were treated surgically with a metallic hemiarthroplasty. All arthroplasties were consecutively performed and none was excluded from this study. The design of the prosthesis, which is machined from surgical cobalt-chrome alloy,[2] remained unchanged throughout the 40 years of use reviewed in this study. (All of the implants used in this study had been manufactured by Zimmer, Inc., Warsaw, IN. They are currently manufactured by Biopro, Port Huron, MI, and are now porous coated.) The implant was conceived to replace only the articular surface of the proximal phalanx with minimal resection of bone stock (Fig. 1). The thin articular resurfacing plate is secured to a short diamond-shaped stem to provide intramedullary fixation. The contoured articulating surface of the prosthesis simulates the normal concave articulation of the proximal phalanx. The implants were designed by the lead author in three evenly graded sizes to assure an accurate, individualized fit.

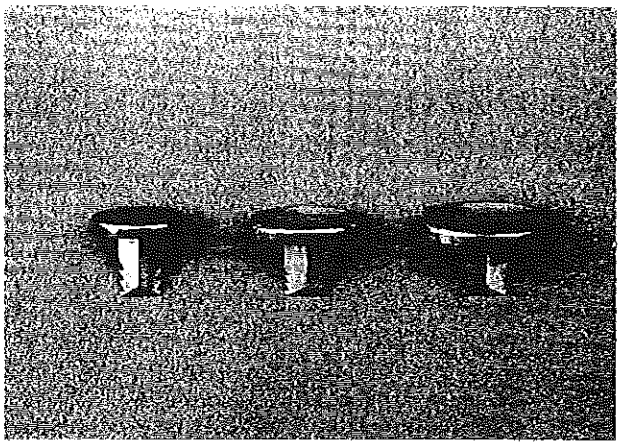

Fig. 1. The prosthesis is made available in three sizes and is designed to replace only the articulating surface of the proximal phalanx.

Thirty-three of the 312 procedures were lost to follow-up. The results of the remaining 279 procedures were evaluated by personal examination and by x-ray evaluation at a postoperative follow-up time ranging from 8 months to 33 years. The senior author performed 171 of these procedures. The remaining 108 procedures were performed by five associated orthopaedists.

For the purposes of this article, the patients were divided into short term (last postoperative visit less than 5 years) and long term (range 5–33 years). In the short-term group, postoperative assessment was 8 months to 1 year in 113 and 1 to 5 years in 65. The long-term assessment in the remaining 101 patients was between 5 and 10 years in 39, 10 to 20 years in 39, 20 to 30 years in 22, and in excess of 30 years (33 years) in 1. The pathological indications for surgery included osteoarthritis with the classical hallux rigidus syndrome in 171, rheumatoid arthritis in 29, and varying degrees of degenerative changes of the HMP joint associated with hallux valgus and bunion deformity in 79. All of the patients in the latter group were treated simultaneously with either a simple "bumpectomy" procedure or a radical bunionectomy with osteotomy. The type of bunion procedure was determined by preoperative assessment of the severity of hallux valgus and metatarsus varus. Fifty-seven (20%) of the hemiarthroplasties were in men and 222 (80%) were in women. Patient age at surgery averaged 52 years in men and 55 years in women, ranging from 22 years in a woman with rheumatoid arthritis to a healthy 91-

year-old woman with degenerative arthritis associated with severe hallux valgus and bunion deformity.

Surgical Procedure

The HMP joint is exposed through a medial incision, slightly curved dorsally to reduce the potential for postoperative shoe pressure and the development of a painful scar. The capsule is incised with a straight medial incision and is released subperiosteally by sharp dissection from the basal portion of the proximal phalanx. Meticulous care must be taken to avoid the inadvertent release of the insertions of the flexor hallucis brevis and the abductor and adductor tendons of the great toe to minimize the potential for postoperative hallux contractural deformities. The tendons are left attached to the periosteal sleeve to ensure that they are not released in the dissection. The articular surface of the phalanx is resected in a common flat plane with an oscillating saw, removing only sufficient bone to accommodate the thickness of the articulating plate of the implant and avoid prosthetic overspacing and excessive joint tension. The plane of the resection is positioned parallel to the plane of the phalangeal articular concavity. The medullary canal of the phalanx is opened in the transverse plane with a narrow osteotome, reciprocating saw, or small burr. Marginal osteophytes are resected completely from the lateral, dorsal, and medial aspects of the metatarsal head sufficiently to allow normal unimpinged motion of the "new" joint (Fig. 2). Lateral osteophytes may be removed through the same incision using a curved osteotome or a small rongeur. The implant to be used is selected on the basis of the size that will most nearly approximate the dimension of the osteotomized phalanx without extending beyond the margins of the cut surface. With the properly sized implant inserted and completely seated, the joint is reduced and is examined for tension and motion. If the reduced and neutrally positioned articulation cannot be separated with the application of modest manual traction on the great toe, the implant is removed and an appropriate amount of additional bone is resected from the proximal phalanx. An overly tight joint may result in limited motion and contractural hallux deformity after surgery. A normal range of concentric, unimpinged motion, particularly in dorsiflexion, should be demonstrated. This may require additional marginal resection and remodeling of the metatarsal head. Unresected, impinging marginal overgrowths of bone that extend beyond the containment provided by the concavity of the prosthetic articulation may compromise the result early on by limiting motion and, in later years, by osteophyte reproliferation. A secure and stable press fit was achieved in all cases without the use of cement fixation.

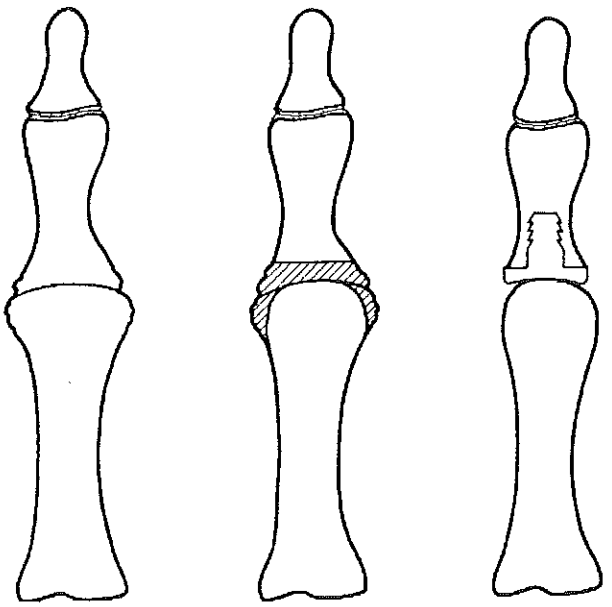

Fig. 2. Sequential line drawings demonstrate the phalangeal resurfacing hemiarthroplasty procedure for hallux rigidus. Sufficient bone is resected from the base of the proximal phalanx to accommodate the thickness of the articular portion of the implant and avoid excessive postoperative joint tension. The metatarsal head is remodeled by generous resection of marginal osteophytic overgrowths medially, laterally, and dorsally (see text for details).

Postoperative Management

The patients were allowed to ambulate with weightbearing to tolerance on the operated foot within limits imposed by postoperative discomfort, utilizing modified foot gear (a soft bedroom slipper, a postoperative wooden shoe, or a cut-out in a standard shoe). The progression to normal ambulation and the use of standard foot gear was limited only by the persistence of postoperative swelling and discomfort.

RESULTS

Patients were questioned regarding pain with activity (none, minimal, moderate, or severe), stiffness (+/−), functional disability (+/−) and overall satisfaction (+/−). They were examined for range of motion and hallux alignment. Subjective dissatisfaction, pain limiting any activity, loss of motion limiting activity, or hallux malalignment was considered a failure. Satisfied patients with nondisabling pain during excessive activities but no functional motion deficits or alignment abnormalities were categorized as having good results. Excellent results required the patient to be entirely pain free in all activities, with no functional

limitation of motion and no meaningful alignment abnormalities. The results were excellent in 259 (93.1%), with no pain or limitation of activity, good in 7 (2.2), with occasional discomfort with excessive activities, and unsatisfactory in 13 (4.7%), 12 of which were revised. Of the 13 unsatisfactory results, two had failed before 1 year, six between 1 and 5 years, four between 5 and 10 years, one in the time span of 10 to 20 years, and none in the group of 23 procedures that were available for review in excess of 20 years after surgery. The short-term group was included to illustrate that most failures were generally related to technique and were not time related. When those patients whose last follow-up visit was less than 5 years were excluded, the results were 89 (88.1%) excellent, 7 (6.9%) good, and 4 (4%) unsatisfactory. The results were not influenced by the preoperative degree of arthrosis. There were no cases of postoperative hallux malalignment, except in failed patients who had undergone bunionectomy realignment procedures. Eight of the 13 unsatisfactory results were in the patients who had been treated with a combined arthroplasty and bunionectomy procedure, and all failed due to either inadequate index correction or recurrence of the hallux valgus deformity. There were three failures in the rheumatoid arthritic group of patients, all due to the recurrence of preoperative contractural deformities resulting from the severely advanced degeneration of the HMP joint and the associated compromise of the stabilizing soft tissue structures. The final two failures occurred in the group of patients with the classical osteoarthritis-hallux rigidus syndrome, one due to the only incidence of postoperative infection in the series of 279 procedures and one resulting from the use of an oversized implant and the subsequent development of a painful weightbearing pressure area at the base of the replaced proximal phalanx. In one of the rheumatoid patients who had failed primarily due to the recurrence of contractural deformities, the implant had changed position as a result of the structural inadequacies of the phalangeal bone. There were no other cases in which clinical or radiographic evidence of loosening occurred, i.e., periprosthetic lucent lines, bone reaction, or change of implant position. Twelve of the 13 failures were revised. One of the patients in the bunionectomy group who sustained a poor result declined further surgery at the time of her last recorded follow-up at 4 years after surgery. The 12 revision procedures included seven Keller resection arthroplasties, four fusions, and one amputation 20 years after surgery in one of the more severe rheumatoid patients who developed unmanageable hallux contractural deformity, shortening, and vascular complications.

DISCUSSION

The relatively simple anatomy and biomechanical arrangement of the HMP joint make it particularly suitable for phalangeal low friction hemiarthroplasty replacement. It is not a weightbearing joint, except as associated with muscular action. Much of the shear force acting on the joint is dissipated by the normal dorsal gliding of the hallux on the MP articulation. This favorable mechanical arrangement is maintained in metallic hemiarthroplasty procedures that replace only the proximal phalangeal articular surface, allowing the toe and the smooth surfaced implant to dorsiflex normally on the remodeled articular surface of the metatarsal head. Consequently, hemi- or total arthroplasty procedures that replace the metatarsal head[17,49] are vulnerable to these dorsally directed weightbearing stresses, which lead to loosening and dorsal migration[32] of the metatarsal component.

In 1971, Joplin[19] published two documented case studies using a similar phalangeal resurfacing implant. A 40-year-old woman was asymptomatic 5 years after surgery, and a 67-year-old woman was symptom free at 2-year follow-up, walking 2 miles daily in any type of shoe regardless of heel height. He also recounted undocumented but "outstandingly good results" following implantation of an additional 55 Vitallium proximal phalangeal hemiarthroplasties. In contrast to these, he reported inferior results following 24 hemiarthroplasties in which he utilized a metal implant to replace the metatarsal head.

In our series, there was only one incident of mechanical implant failure. This occurred in one of the rheumatoid patients in whom the implant changed position due to the inordinately severe osteoporotic bone deficiency. Most failures were due to recurrence of preoperative deformities in both bunion and rheumatoid patients. Care must be taken to avoid lengthening the phalanx, which will contribute to muscle imbalance and recurrent deformities.

It should be noted that only one failure occurred in the 10- to 20-year follow-up group and none in any of the patients followed over 20 years. Some of the longer term patients have developed radiographically demonstrated recurrent marginal osteophytes (Figs. 3 and 4), occasionally associated with mild loss of dorsiflexion to objective examination. However, this did not result in any meaningful subjective discomfort or ambulatory dysfunction. There was only one case with radiographic evidence of loosening or change in the position of the implant. Otherwise, there was no symptomatic or radiographic evidence of implant loosening or deleterious bone changes, such as structural bone dissolution, periprosthetic interface lucency, etc. In

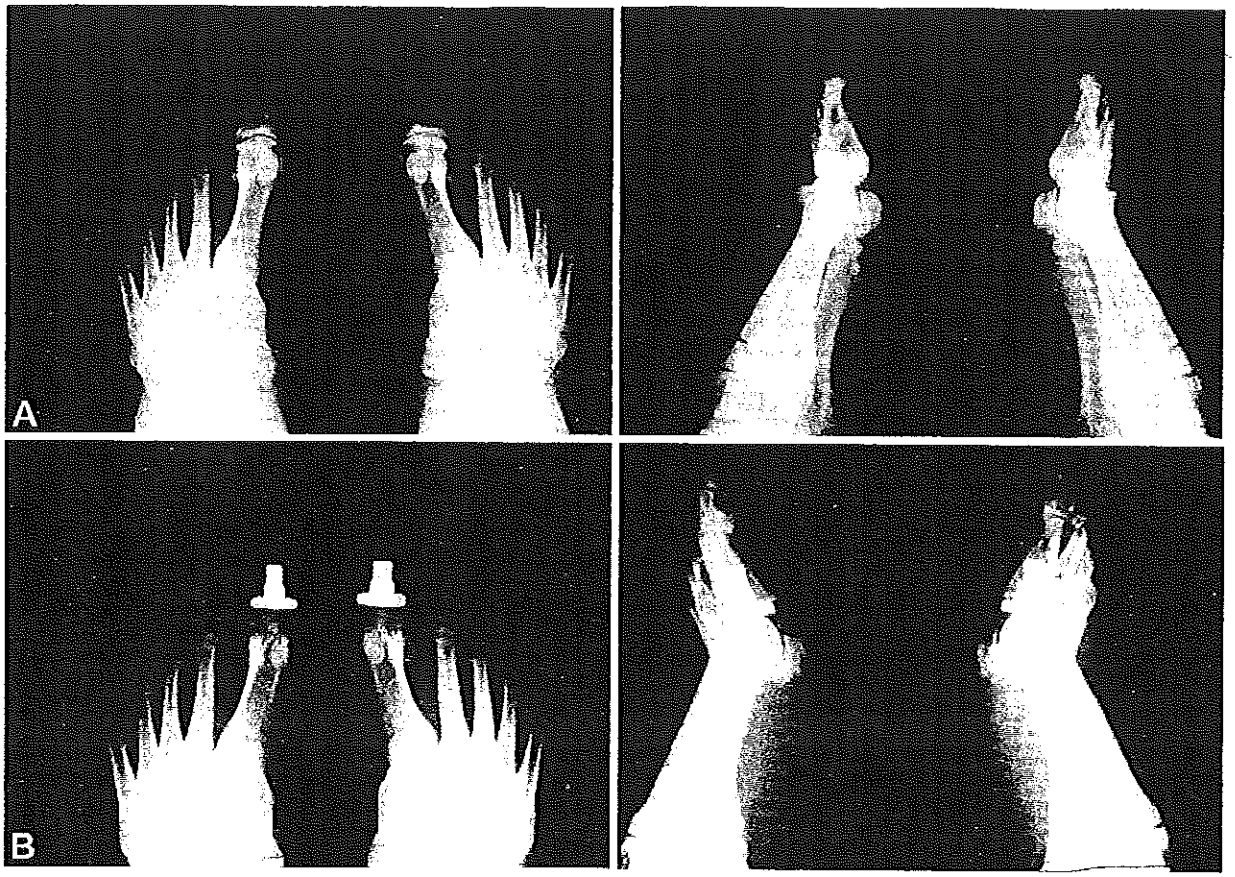

Fig. 3. Preoperative (A) and postoperative x-rays (B) 3 years after bilateral arthroplasty for moderately advanced degenerative arthritis in a 36-year-old woman (MB) with severe pain and ambulatory dysfunction. Note the normal position of the sesamoids confirming preservation of the flexor brevis insertions.

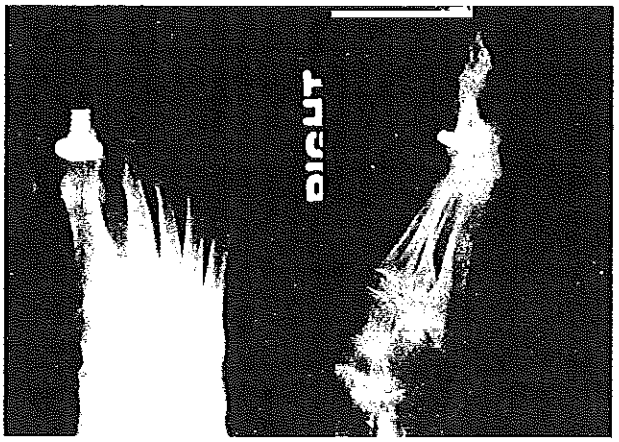

Fig. 4. Twenty-six years after surgery for severely advanced degenerative arthritis with hallux rigidus in a 42-year-old woman (BA). Although there is a mild degree of osteophytic reformation along the lateral margin of the surgically remodeled metatarsal head, the patient has experienced no recurrence of pain or loss of motion. Preoperative films were unavailable.

contrast to when silicone implants are used, clinical evidence of reactive synovitis was not observed.

This long-term retrospective study provides radiographic and clinical evidence to support the use of a low friction phalangeal hemiarthroplasty as an alternative to existing surgical techniques available for the treatment of severe arthrosis of the hallux metatarsophalangeal joint. The procedure is technically uncomplicated and successful results are predictable and enduring.

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