The Journal of Foot & Ankle Surgery 49 (2010) 331–339

Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Original Research

A Retrospective Cohort Study of the BioPro® Hemiarthroplasty Prosthesis

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ARTICLE INFO

Level of Clinical Evidence: 2
Keywords:
arthroplasty
endoprosthesis
hallux limitus
hallux rigidus
implant

ABSTRACT

We reviewed the outcomes of 79 procedures in 76 patients who underwent first metatarsophalangeal joint hemiarthroplasty. The cohort included 23 men (2 bilateral cases) and 53 women (1 bilateral case), with a mean age of 59.6 ± 11.05 years and a mean follow-up of 2.91 years (range, 1.6-4.5 years). Hemiarthroplasty with the BioPro Hemi Implant (BioPro, Inc., Port Huron, MI) was undertaken in all cases, and 34 (43.04%) of the procedures involved long flexor transfer to the proximal phalanx. Mean first metatarsophalangeal joint dorsiflexion increased from 36.13° ± 17.89° to 56.92° ± 9.82° ($P < .0001$), plantarflexion increased from 2.71° ± 8.43° to 9.05° ± 4.52° ($P < .0001$), the first intermetatarsal angle decreased from 8.65° ± 1.17° to 8.41° ± 0.90° ($P = .0009$), and the prevalence of first-ray elevatus went from 52 (65.82%) to 44 (55.70%) ($P = .0047$). Postoperative prevalences included: antalgic gait, 11 (13.92%); normal hallux purchase, 74 (93.67%); satisfaction with the appearance of the great toe, 49 (62.03%); ability to wear conventional shoes, 42 (53.16%); freedom from pain, 45 (56.96%); and satisfaction or high level of satisfaction with the outcome, 68 (86.08%). The mean postoperative American College of Foot and Ankle Surgeons Universal Evaluation score was 94.00 (range, 44-100). Eight (10.13%) cases experienced complications: 2 severe pain (1 required implant removal), 1 sesamoiditis, 1 extensor hallucis longus contracture, 1 hallux subluxation and 1 dislocation, and 2 misaligned implants. Based on these results, use of the BioPro hemi-implant is a useful option for the treatment of first metatarsophalangeal joint degeneration.

Hallux valgus, hallux limitus, and hallux rigidus are common deformities of the adult forefoot, and patients with first metatarsophalangeal joint (MTPJ) osteoarthritis typically experience pain and functional limitations. Conservative treatment of these conditions includes the judicious use of soluble steroid injections, oral antiinflammatory medications, physical therapy, and biomechanical control with either functional or accommodative foot orthoses. When conservative treatment options are exhausted or fail, surgical intervention is indicated. Surgical options for these degenerative conditions of the first MTPJ include synovectomy, cheilectomy, phalangeal and/or metatarsal osteotomy, partial joint resection, joint replacement, and arthrodesis (1). Although combined synovectomy and cheilectomy provide a less aggressive surgical approach, osteotomy may be required to correct joint orientation, metatarsal position, and metatarsal length. Joint reorientation options such as a shortening decompression osteotomy, or an angular osteotomy, can be used to correct osseous deformities of the damaged first MTPJ. In fact, a decompression osteotomy can, in certain instances, be used to reduce the first intermetatarsal angle (IMA) and realign the proximal articular set angle (2), and this may result in increased first MTPJ range of motion. If desired, the surgeon can modify a decompression osteotomy to shorten and plantarflex the first metatarsal. Furthermore, joint destruction procedures such as resection arthroplasty, arthrodesis, or partial or total joint replacement are generally considered surgical options for severely damaged joints. Overall, the procedure of choice for the treatment of first MTPJ degeneration that has not responded satisfactorily to nonsurgical interventions should be based on the functional needs of the patient, the structural characteristics of the joint, and the skills of the surgeon (3). Drago et al. (4) described 4 categories of first MTPJ degeneration (Table 1) and noted that grades 2, 3, and 4 typically warrant surgical repair. Criteria for

Financial Disclosure: None reported.
Conflict of Interest: David C. Novicki, DPM, periodically gives lectures for Biopro about first MTPJ implants.

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doi:10.1053/j.jfas.2009.12.003

Table 1
Drago, Oloff, and Jacobs scale of hallux limitus (4)

Grade	Description of the joint
1	Functional hallux limitus with minimal adaptive changes
2	Joint adaptation, development of proliferative, destructive joint changes
3	Joint deterioration, arthritis, established arthrosis
4	Ankylosis

joint replacement include severe degenerative joint disease and decreased, painful range of motion. This type of advanced joint disease in patients who have not sustained acute articular injury is more prevalent in patients 50 years of age and older. Contraindications to joint replacement include a history of joint or adjacent bone infection, poor bone stock, inadequate soft tissue coverage, and a joint that can be preserved by means of osteotomy or other reconstructive options. In addition, many surgeons consider implant surgery in a young patient as relatively contraindicated (5). In general, joint replacement or resurfacing procedures should be avoided in young patients, as well as in those who are required to participate in significant weight bearing activities. However, if conservative measures have failed and joint preservation reconstructive surgery is not an option for a symptomatic young patient, we believe that implantation of an endoprosthesis, resection arthroplasty, or fusion should be considered (5).

The BioPro metallic hemiarthroplasty resurfacing prosthesis for the hallux MTPJ (BioPro, Inc.) (Figure 1) was designed by Charles O. Townley, MD. The implant, which has been in continuous use for more than 52 years, replaces the articular surface of the proximal phalanx of the great toe (3). In 1994, Townley reviewed 279 cases that ranged over a 40-year period, and follow-up revealed good to excellent clinical results in 95% of the cases (3). The joint resurfacing prosthesis is designed to simulate the articular surface of the proximal phalanx and thereby restore unconstrained triplanar joint function. Currently, the implant is available in 4 sizes and is made of either cobalt chrome or titanium in both nonporous and porous-coated models. A porous coat on the stem and nonarticular surface of the implant allows cancellous bone in-growth up to the surface of the implant, thereby increasing stability in the phalanx. Although Townley recommended the use of an approximately 2-mm resection of the base of the proximal phalanx (3), we typically resect 4 to 5 mm to shorten the skeletal segment, decompress the joint, and increase range of motion. Moreover, by means of careful dissection of the transected base of the proximal phalanx, the intrinsic musculature attachments and vascularity are preserved (3). In particular, flexor hallucis brevis is preserved intact to maintain the sagittal plane stability and position of the first MTPJ. Furthermore, abductor and adductor hallucis attachments are preserved attached to the periosteum of the proximal phalanx in an effort to further preserve the transverse plane stability of the hallux.

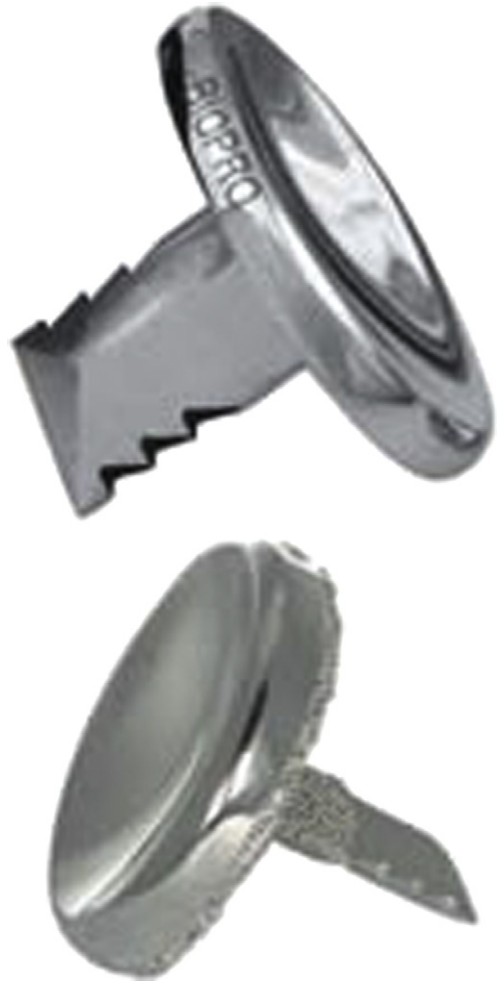

Fig. 1. The BioPro first MTPJ (BioPro, Inc., Port Huron, MI) implant.

Patients and Methods

Patient Population

A retrospective analysis of the records of 76 consecutive patients who underwent implantation of the BioPro first MTPJ (BioPro, Inc.) implant between January 2002 and December 2004, was undertaken by all of the authors. In order to be included in the cohort, the patient had to have undergone reconstructive first-ray surgery with implantation of the BioPro proximal phalangeal resurfacing hemiprosthesis.

Intervention

All of the operations were performed by two of the coauthors (DCN and MMP) and entailed an incision made over the first MTPJ just dorsal and medial to the extensor hallucis longus tendon (Figure 2). The dissection was then carried down to the capsule of the first MTPJ, where a linear capsulotomy was made over the joint just medial to the extensor hallucis longus tendon. After careful dissection of the first MTPJ, with preservation of the attachments of the flexor hallucis brevis tendons, the joint was evaluated (Figure 3). The base of the proximal phalanx was then resected, taking care to make the thickness of the removed portion of the bone 3 to 4 mm greater than the thickness of the articulating flange of the implant (Figure 4). This was done to accommodate the thickness of the articulating flange of the implant, which was placed in the joint and oriented parallel to the articulating surface of the metatarsal head (Figure 5). Care was taken to avoid release of the attachments of the flexor hallucis brevis tendons to the base of the proximal phalanx when the base was excised. Identification of the flexor hallucis longus (FHL) tendon after resection of the phalangeal base suggested that the attachments of the short flexor had been detached (Figure 6). In such cases, the FHL tendon was attached to the plantar-central aspect of the proximal cortical margin of the proximal phalanx with a 2-0 suture as an adjunct procedure to increase the sagittal plane stability of the great toe.

After resection of the proximal phalangeal base, osteophytic spurs on the metatarsal head were removed dorsally, medially, and laterally, and the metatarsal head contoured to allow for smooth, triplanar translation of the implant over the residual articular cartilage. If indicated, repositioning the distal aspect of the first metatarsal by means of a joint decompression or angulational osteotomy was undertaken, and the position of the first metatarsal evaluated intraoperatively to avoid excessive lengthening, shortening, and elevatus.

After resection of the phalangeal base and preparation of the first metatarsal segment, the medullary canal broach was used to create an intramedullary canal in the proximal phalanx for reception of the stem of the implant. The canal was oriented parallel to the long axis of the phalanx, and it is important to understand that an improperly oriented canal could allow the stem to infringe on and penetrate the adjacent cortical margin, thereby destabilizing the implant and joint. For this reason, checking the orientation and fit of the implant with trial sizers was an important element of the operation (Figures 7, 8, and 9). Because the implant is a press-fit design, the medullary canal broach is actually smaller than the stem of the implant, and the implant has to be steadily tapped into place in the medullary canal to create a tight fit (Figures 10 and 11). Proper fitting required that the articulating base flange of the implant matched the contour of the cortical rim of the remaining portion of the