Lesser Metatarsal Metallic Hemiarthroplasty

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Abstract: The literature on treatment of advanced arthritic changes in the lesser metatarsophalangeal joints is sparse. Options include fusion, resection or interpositional arthroplasty, biological resurfacing, as well as silastic or metallic joint replacement. Little data surround the use of a metallic hemiarthroplasty of the lesser metatarsal heads, and clinical outcomes data for the mid-term to long-term results is currently nonexistent.

Level of Evidence: Diagnostic Level 5. See Instructions for Authors for a complete description of levels of evidence.

Key Words: lesser metatarsophalangeal joint (MPJ), arthritis, joint replacement, foot pain, Freiberg infraction

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HISTORICAL PERSPECTIVE

Treatment of advanced degenerative disease of the lesser metatarsophalangeal joint (MPJ) has received fairly little attention in the literature. The majority of reports (levels IV and V) center around Freiberg infraction, with even less attention given to primary, posttraumatic, or iatrogenic cases of lesser MPJ arthrosis. Certainly this is a reflection of the rarity of these lesions.

Freiberg first described osteonecrosis of the lesser metatarsal head in 1914 in a series of 6 patients. He used the term "infraction" because patients presented with a history of minor trauma.[1] Many subsequent terms have been used to describe the same process seen in an adolescent nearing skeletal maturity when the blood supply to the epiphysis is tenuous. The process occurs most frequently in the second metatarsal head likely due to its length and fixed position. Damage to the epiphyseal blood supply results in subchondral avascularity and later resorption with deformation. The adolescent typically presents with pain and swelling at the joint. This can progress to loss of motion and chronic pain. Acute trauma, repetitive microtrauma, poor vascularity, and systemic disorders may each be involved in the initiation of the disease. As long as significant collapse has not occurred, with reduction of activity and passage of time for creeping substitution to occur, revascularization and remodeling can occur with resolution of symptoms. With continued symptoms, surgery is recommended. Smillie[2] in 1957 classified the progression of Freiberg infraction. This staging system is still in use and assists with determining the appropriate procedure based upon radiographic findings (Table 1).

Treatment is stage dependent, although conservative management has been recommended initially for every stage with surgery reserved for failure of conservative management. For early stages interventions include debridement, removal of osteophytes, synovectomy, and drilling via open or arthroscopic methods.[3–10] For late-stage Freiberg, excision of the metatarsal head and or base of the proximal phalanx,[4,11–13] dorsiflexion osteotomy of the metatarsal head via intra-articular or extra-articular site,[5,8,9,14–16] interpositional arthroplasty,[17–19] osteochondral plug transplantation,[6,20] silicone prosthetic joint replacement,[4] and titanium resurfacing of the proximal phalanx with contouring of the metatarsal head[21] have all been reported. These studies are all case reports or small case series with the exception of Kilic and colleagues who evaluated 14 patients treated for stages IV or V Freiberg infraction: 8 patients were treated with cheilectomy and dorsiflexion osteotomy and 6 patients were treated with cheilectomy and microfracture. At a mean follow-up of 22 months, both groups had improved significantly.[8] To our knowledge, no randomized controlled trials exist to guide treatment of late-stage Freiberg infraction.

Freiberg infraction certainly is not the only cause of lesser MPJ arthrosis. Additional causes include inflammatory arthropathy, posttraumatic arthropathy, and avascular necrosis in the adult, as well as iatrogenic causes. While Davies and Saxby[22] reported no cases of avascular necrosis after 50 metatarsal neck osteotomies (Weil osteotomy) for metatarsal phalageal joint (MTP) instability and Trnka et al[23] reported a series of 25 Weil osteotomies without any cases of avascular necrosis, cases of avascular necrosis have been reported although they are uncommon. In addition, Scheck[24] reported on 3 cases of lesser metatarsal head avascular necrosis after correction of severe hammer-toe deformity without metatarsal neck osteotomy. Primary osteoarthritis of the second MPJ has been termed "second toe rigidus."[25]

HISTORY OF LESSER MPJ IMPLANTS

Most implants for the lesser MPJs have been adaptations of implants designed for use in the hand. Similar to other lesser MPJ literature, the reports are primarily case reports or small series with only short follow-up. Implant arthroplasty for the lesser MPJs began in the early 1960s. The Seeburger prosthesis was a cap and intramedullary stem used at Doctors Hospital in Tucker, Georgia in 32 lesser MPJs between 1963 and 1969. Problems with the implant included floating toe, excessive motion, and loosening of the implant resulting in displacement of the implant as well as transfer lesions under adjacent metatarsal heads.[26] The Silastic Ulnar-Head "Overgrowth implant" had similar complications as the Seeburger prosthesis.[26] The double-prong Swanson Silastic implant was adapted from use in the hand for use in the MPJs. This implant had good reported short-term results, but shear forces not encountered in the hand cause loosening at stem-bone interface and often, bony overgrowth and poor longer-term results. Cracchiolo and colleagues reported 31 arthroplasties for degenerative arthritis, and 6 for Freiberg. At 3-year follow-up, 60% of patients had good results with transfer metatarsalgia as the most common complication.[27] The sizing of these implants was not ideal for the anatomy of the metatarsal and proximal phalanx.[26] McGlamry and Ruch[26] described how the stems from the Swanson-designed finger implants did not fit the proximal phalanx shape. In 1982, Swanson[28] reported a double-stemmed MPJ implant after modification of the dimensions of the Silastic first MPJ implant. The Calnan-Nicolle is another double-pronged finger joint prosthesis with a

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TABLE 1. Smillie Classification of Freiberg Infraction[2]

Stage I: Subchondral fracture through epiphysis visualized only on MRI or bone scan, although subtle widening of the joint space may be seen on x-ray
Stage II: Early collapse of the dorsal metatarsal head seen on radiographs
Stage III: Continued collapse flattening and development of lateral projections, plantar metatarsal head remains intact
Stage IV: Entire metatarsal head is involved, loose body develops after plantar cartilage fractures, arthrosis
Stage V: Severe arthritic changes, joint space obliteration

polypropylene hinge and silicone capsule over the hinge described by Kaplan and Cohen in 1976.[29] Similar problems with loosening and bone overgrowth were noted. Transfer lesions were noted in 4 of 4 cases with loosening of the prosthesis in 2 of the 4 at 1-year follow-up.[26] The Niebauer-Cutter is a double-pronged finger joint prosthesis modified with a Dacron weave around the stems.[26] Addante et al[30] in 1977 described a silicone spacer with no stems for use at the fifth MPJ. Weil (in 1977) and Swanson (in 1979) developed a single-stem condylar implant for partial metatarsal head replacement.[26]

In general, silicone (silastic) implants allow restoration of toe length and axial alignment. However, loosening, breakage, and silicone synovitis noted at short-term to mid-term follow-up, has complicated silicone implant use. In addition, weight-bearing through the affected toe does not return to normal, resulting in transfer lesions.

The Moje unconstrained total ceramic arthroplasty was performed in 9 patients for Freiberg or posttraumatic arthrosis. At mean follow-up of 23 months, 8 of the 9 reported good or excellent outcomes with American Orthopaedic Foot and Ankle Society lesser MPJ-IPJ score mean of 75 (range, 42 to 92). There was no evidence of loosening of the implants at final follow-up, although mean follow-up was only 23 months. These implants were originally screw fit with a titanium screw, but metallosis was noted and these were withdrawn from the market, and replaced by a press-fit design coated with "Bioverite," a bioactive glass, to promote osteointegration in 1999.[31]

The HemiCAP implant (Arthrosurface, Franklin, MA) has been used for both hallux rigidus as well as lesser MPJ pathology. Although short-term results have been good for the hallux, no data are available specifically for the lesser metatarsal heads.[32]

Currently, the Encompass implant (Osteomed Addison, TX) has been designed with specific sizing for resurfacing of the lesser MTP joints on the metatarsal side. There is no current outcomes data on the implant in the lesser MTP.

INDICATIONS/CONTRAINDICATIONS

In 1976, McGlamry and Ruch considered the indications for lesser MPJ implant arthroplasty to include: osteochondritis with severe joint destruction, dislocation of the MPJ with articular destruction or adaptation to deformed position, bony destruction of one or both articular surfaces in rheumatoid, gouty or postosteomyelitis arthrosis, iatrogenic flail toes with dislocation due to resection of the base of the proximal phalanx, head of metatarsal or both, or severe angular deviation.[26] Additional indications include iatrogenic arthrosis due to malunion or avascular necrosis after metatarsal neck osteotomy, and transfer lesions after previous resection arthroplasty.

Absolute contraindications to implant arthroplasty include active or latent infection, vascular insufficiency that would preclude healing, nickel sensitivity for any implants that contain nickel, and history of foot ulcers.

Relative contraindications include inflammatory arthropathy, chronic steroid use, and osteoporosis as poor bone stock may lead to early failure of the implant. Wear rate of the prosthesis may be hastened by a medial column that is ineffective in weight-bearing because of severe hallux valgus or instability at the medial cuneiform—navicular or first tarsometatarsal joint, as well as unaddressed equinus contracture.

PREOPERATIVE PLANNING

The underlying etiology should be considered during the preoperative planning process. In a young active patient, an implant is likely to fail over time, and other techniques such as osteotomy[5,8,9,14–16] or biological interpositional arthroplasty[17–19] are generally favored over implant arthroplasty. Weight-bearing radiographs should be obtained to evaluate the joint, alignment of the digit, bone stock, and relative length of the affected metatarsal. If there was prior resection of the proximal phalanx with loss of the plantar plate and Flexor Digitorum Brevis, consideration for use of a double-stemmed implant, or secondary reconstruction of the plantar plate and/or flexor tendon transfer should be performed. Sagittal alignment should be ensured at the time of procedure with collateral ligament imbrication, or extensor digitorum brevis tendon transfer if needed.

FIGURE 1. Preoperative radiograph showing a second MTP joint with chronic dislocation.

FIGURE 2. Intraoperative image that demonstrates what appears to be soft-tissue reaction and granulation tissue at the second MTP joint.

SURGICAL TECHNIQUE

After appropriate preoperative consultation and informed consent the patient is taken for the elective surgery. A peripheral nerve block and appropriate sedation to make the patient comfortable is the preferred anesthesia. The patient is then placed on a well-padded radiolucent surgical table with a bump under the ipsilateral hip. A thigh tourniquet is applied and the operative leg is prepped and draped in the usual manner (Fig. 1).

After confirmation of the surgical procedure, an incision is made over the dorsal aspect of the affected MTP joint. After sharp dissection through the skin, blunt dissection is carried through the deep layers. The extensor tendon unit is identified and mobilized to allow access to the MTP capsule. Sharp dissection is made through the MTP capsule and a complete capsulotomy and synovectomy is completed of the MTP joint (Fig. 2).

Thorough inspection of the MTP joint is then undertaken. Loose bodies and nonviable tissue should be removed. After identification of the area of pathology, a decision to proceed with the resurfacing arthroplasty is made. Both the metatarsal and phalangeal portions of the joint require inspection. The plantar plate is also evaluated at this time to determine if repair is needed.

Once the MTP joint has been completely evaluated, attention is turned to the interphalangeal joint (IPJ). If secondary pathology exists at the level of the IPJ, this may also need to be addressed with osseous or soft-tissue procedures at the surgeon's discretion.

If the decision has been made to proceed with resurfacing arthroplasty, then the MTP must be exposed adequately and

FIGURE 3. Guide pin placement in the second metatarsal head in preparation for reaming.

FIGURE 4. Reaming of the second metatarsal head.

FIGURE 5. Implant trail is placed to confirm size and position.

FIGURE 6. Broaching of the canal is completed in preparation for implant placement.

FIGURE 7. Broaching of the canal is completed in preparation for implant placement.

the soft tissues protected. Near-complete plantar flexion of the joint is required. The collateral ligaments are released from the metatarsal head, although as these are usually revision/salvage cases the anatomy is usually distorted. A guide pin is then placed in the head of the MTP slightly above the equatorial line to account for the cam shape of the MTP head (Fig. 3).

Image intensification is then utilized to confirm appropriate placement of the guide pin for the reamer. If satisfied with the guide pin position, MTP head reaming may be completed. The reamer selected should match the size of the MTP appropriately (Fig. 4).

If significant deformity exists or osseous overgrowth is present, sequential reaming may be required. Once reaming has been completed, the guide pin is removed.

A trial may be used if desired to confirm the implant dimensions (Fig. 5).

A broach for the stem is then impacted gently to prepare the canal for the implant stem (Figs. 6, 7).

Orientation is essential to allow for appropriate placement of the implant. At this time the correctly sized implant is press-fit into position (Figs. 8, 9).

Adjunct procedure may now be completed based on identified associated pathology. The plantar plate, tendon, or IPJ issues should now be rectified to complete the procedure

FIGURE 8. Impaction of the implant to seat against the second MTP head.

FIGURE 9. Impaction of the implant to seat against the second MTP head.

and balance the forefoot mechanics. Intraoperative radiographs assist in assuring maintenance of the normal parabola (Fig. 10).

A layered closure is then completed, and the patient is placed in a sterile well-padded forefoot dressing. The tourniquet is released, and the patient is recovered appropriately. They are given a stiff postoperative shoe and directed to do heel weight-bearing to the tolerance once sensation has returned to the foot (Fig. 11).

FIGURE 10. Intraoperative imaging.

FIGURE 11. Final postoperative weight-bearing x-rays.

POSTOPERATIVE MANAGEMENT

The patient is maintained in the postoperative dressing for 10 to 14 days. The patient is then seen in the out patient clinic for follow-up. The author's preference is to use absorbable intradermal sutures that do not require removal. If satisfactory healing has occurred, the patient is allowed to begin weight-bearing as tolerated in the postoperative shoe and is instructed on gentle mobilization techniques. During ambulation in the postoperative shoe, they are taught plantar flexion cross-taping technique to protect the healing area.

The patient is seen back in 3 weeks for evaluation. If radiographic studies show satisfactory position of the MTP implant, and healing of the soft tissue is complete, the patient is encouraged to transition to accommodative shoe wear. Further mobilization of the MTP joint is encouraged.

The patient is seen at 8 weeks for a final clinical and radiographic evaluation. If satisfactory healing is noted, the patient is encouraged to return to nonimpact activities to their tolerance. They may then progress activity as their comfort allows.

COMPLICATIONS

Complications of resurfacing arthroplasty of the lesser MTP joints can be broken down into intraoperative/immediate postoperative and medium-term complications. As long-term follow-up on these implants is significantly limited, we will not comment directly on long-term outcomes.

Intraoperative complications fall into 2 major issues. Failure of the anatomy and failure related to the implant. Preoperative evaluation may fail to clearly disclose the extent of the pathology at the lesser MTP level. Bone stock may be significantly absent, or of such poor quality as to not allow for proper fixation of the implant. In addition, the soft-tissue envelope, especially the plantar plate may be non-reconstructable leading to instability that may not allow for proper balancing of the lesser MTP joint.

In the event that bone stock is absent, limited bone grafting may be attempted as long as the implant can be seated with good stability. If bone stock does not allow for adequate fixation then soft-tissue interpostional arthroplasty may be more appropriate using graft material of preference.

TABLE 2. Treatment Options for Late-Stage Lesser Metatarsophalangeal Joint Arthrosis

Excision of metatarsal head, base of proximal phalanx, or both with or without syndactylization[11]
Intra-articular closing dorsiflexion osteotomy of the metatarsal head[8,14–16,22]
Osteochondral Autologous Transfer System (OATS)[20]
Biological interpositional arthroplasty[17,18]
Hemiarthroplasty (metatarsal or proximal phalanx)[21,26,32]
Total joint replacement[4,26,27,31]

When capsular deficits occur, every attempt should be made to stabilize the joint if the implant can be solidly fixated. This may involve direct repair of the plantar plate, augmented repair of the plantar plate, or flexor to extensor tendon transfer. Stability should be confirmed intraoperatively if an implant will be placed.

RESULTS

Early results have been encouraging to date. In our experience pain has been decreased and patients receiving these implants have returned to most activities. Current mid-term or long-term follow-up is not available on these lesser MTP implants to date. The authors are closely following the implants that have been placed to continue to collect information on outcomes.

The implants to date have been used in only limited applications where other options seemed to offer less benefits. These are often revision or salvage cases, so results may be skewed due to patient selection. Continued monitoring of the patients is currently underway to look at the survivorship of these implants.

CONCLUSIONS

Lesser MTP resurfacing implants appear to offer an option for patients with significant forefoot pathology related to destruction of the lesser MTP joint. With the continued development of improved implants and close follow-up to review outcomes, these implants will likely continue to find applications in lesser MTP pathology.

As limited information is available at this time on outcomes, judicious use of these implants is warranted. Hopefully, short-term outcome studies will be available soon to help direct the use of metallic resurfacing implants in lesser MTP arthritis. Early promising results have thus far been encouraging and will hopefully lead to better understanding of when to best apply this technology for patients.

POSSIBLE CONCERNS, FUTURE OF THE TECHNIQUE

The primary concern with lesser MPJ arthroplasty at this time remains lack of long-term data to guide treatment. With young active individuals, the implant is likely to loosen and fail with time because of repetitive shearing forces if the implant does not obtain true osteointegration. Future implants are likely to address this through improved design considerations at the bone-implant interface.

Also, as we continue to gain understanding of the complex mechanics of the lesser MTP joint, we may be able to improve the implant design to better manage the forces across the joint to improve survivorship (Table 2).

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