# Foot and Ankle

# Polyvinyl alcohol hemiarthroplasty for first metatarsophalangeal joint arthritis

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## ABSTRACT

End stage arthritis of the first metatarsophalangeal joint has been treated surgically in the past by fusion and replacement. Fusion has remained the most commonly performed procedure and gives excellent pain relief but may interfere with activities in some patients. Joint replacement previously has had limited success. Problems include loosening, osteolysis, subsidence, and failure to regain motion. Osteolysis associated with wear debris has limited the success of silastic replacements. Polyvinyl alcohol (PVA) has shown promise as a material for hemiarthroplasty in the great toe. The material has better wear patterns than silastic and does not fragment. The hemiarthroplasty is inserted through a dorsal incision into a reamed bed in the first metatarsal head. The implant is available in two sizes, 8 mm and 10 mm. The PVA hemiarthroplasty has been the subject of a randomized controlled trial compared with fusion, with the results as yet to be published. Limited results to date have shown promise for this arthroplasty as an alternative to fusion for patients wishing to maintain joint motion and may avoid the fragmentation and loosening seen in prior replacements.



**Key Words**
arthritis, first metatarsophalangeal joint, hallux rigidus, degenerative arthritis, posttraumatic arthritis, first ray, great toe joint, joint replacement



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*Financial Disclosure: Dr. Younger has received institutional support from Cartiva Inc. He is a consultant for Biomimetic and Acumed and has received grants from Smith and Nephew, Acumed, Biomimetic, and Bioset. He holds a patent for an ankle joint replacement design. Dr. Baumhauer is the past president of AOFAS and ABOS and is a board member of ABMS, and OREF. She is a consultant for BMTI research and owns stock in American Medical Center. Dr. Glazebrook reports an unspecified consultancy and has received funds for travel committee participation, development of educational presentations, lectures, meeting expenses, and expert testimony. All three authors have received institutional support from Carticept Medical Inc. to assist in the conduct of a randomized controlled study. No sources of support were received for this study.*


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## INTRODUCTION

First metatarsophalangeal joint (MTP) joint arthritis usually occurs without preceding trauma. The arthritis often is associated with loss of motion and dorsal osteophyte formation; in this case the arthritis also can be termed hallux rigidus.[1••]

While arthrodesis has been used as the surgical alternative to resolve symptoms, and can be successful in creating a pain-free foot, a successful fusion restricts motion. Arthrodesis also has to be performed in the correct position because a malunion may cause problems.[2] Varus and dorsal alignment can irritate the great toe, valgus alignment can impinge on the second toe, and extension can cause pain at the interphalangeal (IP) joint level. As a result, replacement has been sought as an alternative to arthrodesis. However, replacements have been compromised by loosening, fragmentation, and osteolysis as complications and as a result have not been widely used in the recent past.

## BACKGROUND

While arthrodesis remains the mainstay of surgical treatment of end-stage arthritis of the first MTP joint, patient demand and expectations have resulted in the development of joint replacements. Joint implants have either been complete joint replacements or hemiarthroplasties.

Silastic implants were developed for the foot and first MTP joint in the 1970s.[3] These implants enjoyed initial success, although a large resection was required to implant the prosthesis. In the late 1980s, osteolysis was observed to occur in silicone implant joint replacements and on revision fragmentation of the implants.[4–6] The implants were modified by the placement of grommets around the stems,[7] but this failed to prevent fragmentation. Microscopy demonstrated birefringent particles arising from the implant, and these were thought to induce a foreign body reaction causing the osteolysis.[8] These particles may migrate to regional nodes.[9]

Large bone defects may result causing a complex revision challenge.[10,11] As a result, silastic implants for first MTP joint arthritis largely have been abandoned since the mid 1990s.

Other complete joint replacements include those more along the lines of total hip and total knee replacements, with either an ingrowth surface or a cemented surface to

bond the components to bone. The articulation has included polyethylene or ceramic.[12]

Total joint replacements have been limited by their ability to bond to bone and their ability to restore normal kinematics. These designs were used less often in North America compared with the silastic implants and have not been adopted in any consistent manner, largely because of concern over loosening.

Hemiarthroplasties made from metal also are available. These also may result in failure to bond to bone and ongoing pain.[13,14•,15]

The polyvinyl alcohol implant (PVA; Cartiva TM, Alpharetta, GA) is made of a material that is softer than titanium and cobalt chrome used in metal hemiarthroplasties. The material has a water content similar to healthy cartilage[16•] and mechanical properties similar to cartilage.[17•] The PVA implant has been studied in animals and has been shown to have promising biocompatibility and biomechanical properties in these studies. The implant has been used for osteochondral defects of the knee with good success.[16•] It also has been used for the talus and first MTP joint. In one study of the knee at 4-8 years follow-up in 20 patients, 19 were pain free and had no synovitis, osteolysis, or wear.[18]

Limited studies are available to date for the first MTP joint. A paper presented at the British Orthopaedic Foot and Ankle Society Meeting showed that of 175 implants, American Orthopaedic Foot Ankle Society (AOFAS) scores improved from 28.4 to 87.3 points. The follow-up was short (2–64 months) but only two were converted to fusion within the study period.[19] The hydrogel implant may cause less inflammation than other biomaterials.[20]

The MOTION randomized controlled study was performed in Canada and the United Kingdom, enrolling 236 patients. The results will be available after 2014, when all patients have been followed for 2 years.

## CLINICAL PRESENTATION AND EXAMINATION

Patients with MTP joint arthritis complain of pain localized in the first MTP joint region. Trauma rarely is a preceding event. Usually, discomfort is localized to the first MTP joint and is aggravated by activity. Swelling of the first MTP joint often is present. Osteophytes can form around the joint causing problems with footwear. The osteophytes also can restrict dorsiflexion range and can result in overload of the IP joint of the great toe.

On examination, the joint will be inflamed and the osteophytes can be palpated on the dorsal side. Range of motion in both dorsiflexion and plantarflexion is restricted. Hallux valgus or varus deformity rarely is present in end-stage arthritis and hallux rigidus.

Lesser toe deformities and metatarsalgia also can co-exist. The sesamoids also should be palpated and examined because arthritis of the sesamoid to metatarsal head articulation may result in restricted motion after a joint replacement.[21,22]

Arthritis of the midfoot at the tarsometatarsal joint level, and elevation of the metatarsal shaft through the tarsometatarsal joint should be ruled out at the time of assessment because both of these conditions may cause a poor result after a replacement.

## DIAGNOSIS

Standing anteroposterior and lateral views of the foot should be obtained to assess the first MTP joint. The lateral view will show the dorsal osteophyte, and may show plantar subluxation of the proximal phalanx on the metatarsal head. Sesamoid-first metatarsal head arthritis also may be visible on the lateral view. Arthritis and subluxation of the first or second tarsometatarsal (TMT) joints may be visible on the lateral view. The anteroposterior view may show differences in length of the first and second rays. The alignment of the MTP joint also is assessed.

On occasion CT may be required to assess the anatomy of the osteophytes and the sesamoid-to-metatarsal head articulation. As the extent of cartilage damage is the basis of management of the condition, an MRI may be of benefit in borderline cases to assess the degree of cartilage damage. In general, arthritis that affects the joint plantar to the mid point of the joint results in poor outcome for joint preservation, and instead a fusion or hemiarthroplasty should be considered.

## CLASSIFICATION

First MTP joint arthritis is classified using the Coughlin grading system for hallux rigidus.[1••] There is no other relevant classification system. In grade 0, dorsiflexion range is 40-60° and/or 10-20% loss compared with the other side. Radiographs are normal. Clinically, there is no pain and only loss of motion on examination.

In grade 1, dorsiflexion range is 30-40° and/or 20-50% loss compared with the opposite side. Radiographs show a dorsal osteophyte, with minimal joint space narrowing, or other signs of arthritis. Clinically, mild or occasional pain and stiffness may be present as well as pain at extremes of dorsiflexion or plantarflexion.

In grade 2, dorsiflexion range is 10-30° of dorsiflexion and/or 50-75% loss of motion compared with the normal side. On radiographic examination, dorsal, lateral, and medial osteophytes are present, giving a flattened appearance to the metatarsal head. No more than one-fourth of the dorsal joint space is involved on the lateral radiograph, with mild to moderate joint space narrowing and sclerosis, and no involvement of the sesamoids. Clinically, there is moderate to severe pain and stiffness that may be constant. Pain occurs just before maximal dorsiflexion and maximal plantarflexion on examination.

In grade 3, less than 10° dorsiflexion is present and 75-100% loss compared with the normal side. Notable loss of metatarsophalangeal plantarflexion occurs as well (often less than 10°). Radiographic findings are the same as grade 2 but with substantial joint space narrowing, possible cystic changes, more than one-fourth of the dorsal joint space involved, and the sesamoids are enlarged or cystic and irregular. At extremes of range of motion, constant pain and stiffness are noted but no pain in the mid range.

For grade 4, the clinical and radiographic findings are the same as grade 3 but with pain in the mid range of passive motion (Figures 1–5).[1••]

## TREATMENT

End-stage arthritis of the first MTP joint is treated by footwear modification and counseling. In early stages, the degenerative change may be treated by debridement or steroid injection. Footwear modifications include the use of a rigid sole to the shoe. During gait a soft sole shoe will allow dorsiflexion of the first MTP joint causing motion and pain. A rigid sole shoe will prevent this.[23] However, once the sole is rigid the patient will not be able to roll off the forefoot unless a forefoot rocker is built into the shoe.[23] If the surgeon decides that end-stage arthritis is present and the joint is not salvageable, an arthrodesis or hemiarthroplasty may be considered.

Joints that have Coughlin grade 2, 3 or 4 arthritis may be considered unsalvageable with a joint preservation procedure. Patients with grades 1 and 2 arthritis may be best treated with dorsal cheilectomy.

For a joint replacement to be considered, the skin envelope needs to be mobile and no infection present. The first ray should be well aligned. Enough bone must be present to allow the prosthesis to be inserted. The flexor and extensor tendons should be intact. Diabetes should be well controlled.

Arthrodesis techniques are well described elsewhere. The remainder of this article will describe the technique for hemiarthroplasty of the great toe using the Cartiva implant.

## SURGICAL TECHNIQUE OF FIRST MTP JOINT REPLACEMENT

Before the procedure, the surgeon should practice delivery of the implant using the delivery tube and plunger. The delivery tube that is slightly tapered compresses the implant. As the implant is pushed out of the bottom end of the delivery tube, it expands into the bed. If the delivery is not done in a smooth efficient motion, then the implant will not bottom out in the prepared bone bed. A Perspex practice bone bed is used until the delivery can be done effectively.

The patient is placed on the operating table in a neutral position with the foot to the edge of the operating table. Antibiotic prophylaxis is used before inflation of the tourniquet. A calf or thigh tourniquet can be used depending upon surgeon choice and the method of anesthesia.

After skin preparation and draping, the first MTP joint is approached from the dorsal side (Figure 1). An incision is made medial to the extensor tendon and the extensor tendon is retracted to the lateral side. Care is taken not to damage the dorsomedial or dorsolateral cutaneous nerves.

The dorsal capsule is incised in line with the incision. The joint is exposed, and the joint flexed so that the osteophytes can be inspected. The joint surface is inspected and the

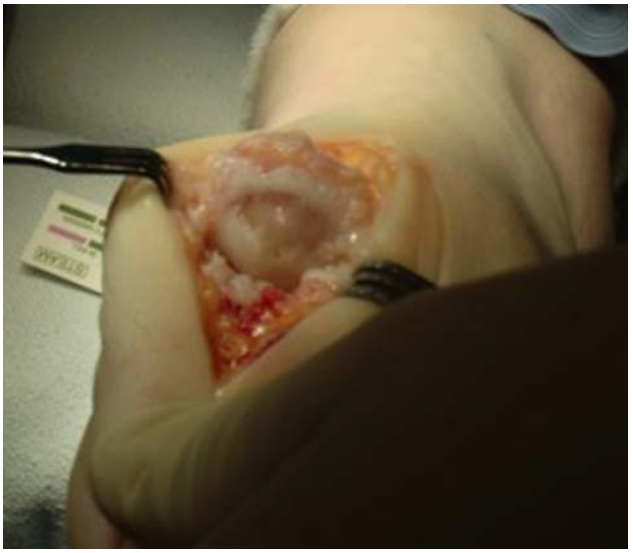

**FIGURE 1.** The first metatarsophalangeal joint exposed showing the arthritis and osteophytes present.

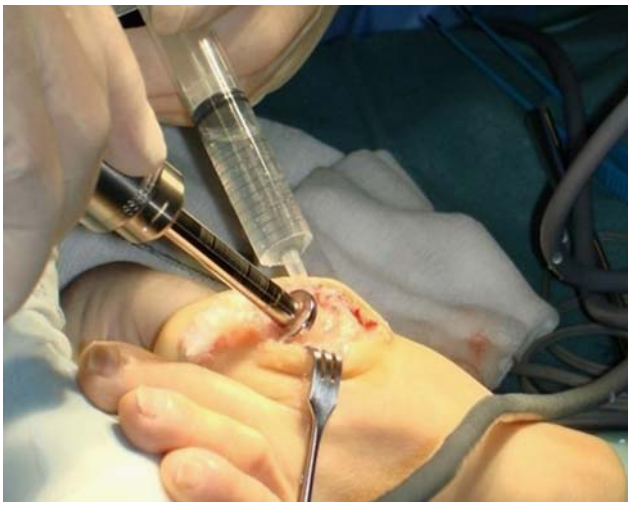

**FIGURE 2.** Drilling the recipient site in the first metatarsophalangeal joint.

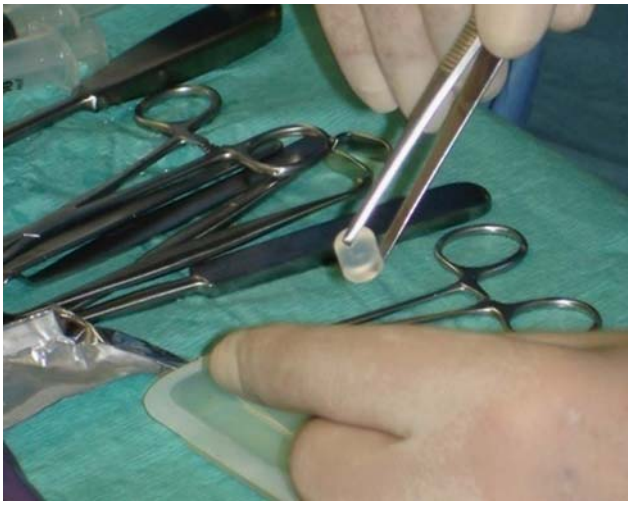

**FIGURE 3.** The polyvinyl alcohol implant just before insertion.

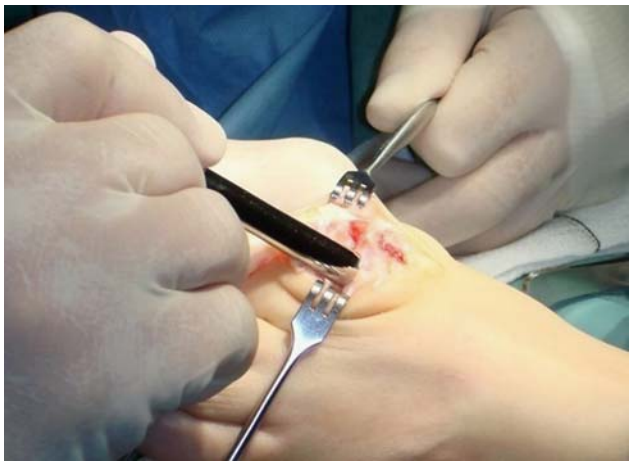

**FIGURE 4.** Inserting the implant using the delivery tube.

extent of arthritis is confirmed. If minimal, the surgeon may consider converting to a dorsal cheilectomy.

Using an osteotome the medial and lateral osteophytes as well as the dorsal osteophyte are carefully removed from the metatarsal head. If the resection is excessive, then the implant cannot be seated. The osteophyte on the dorsal side of the proximal phalanx also may need to be removed.

The medial and lateral gutters are released until the joint can be plantarflexed to the point that the proximal phalanx can be brought down allowing the reamer into the metatarsal head in a vertical orientation.

Using the appropriate sizer, the size of the implant is determined. Either an 8-mm or 10-mm implant is used. An appropriate rim is required (1.5–2 mm on all sides) to ensure containment of the prosthesis. The sizer is then held on the selected bone bed and moved slightly until the surgeon is sure that it is perpendicular to the metatarsal head. Retractors will need to be held steadily to ensure that the phalanx is held out of the way. Retractor ends should not penetrate the metatarsal head because these may catch the reamer and cause a fracture.

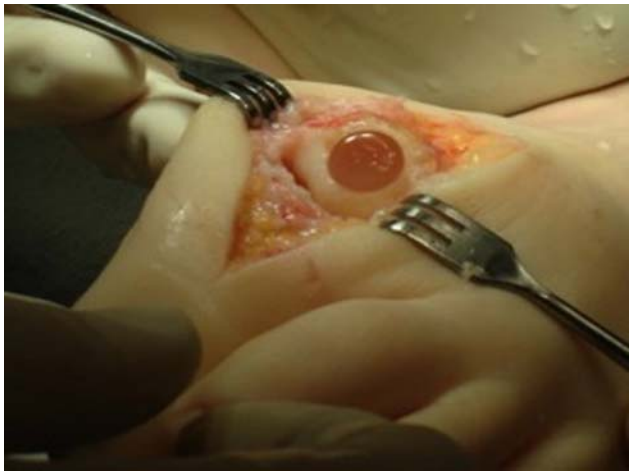

**FIGURE 5.** The appearance of the implant once inserted.

A Kirschner wire is then placed down the central core of the sizer into the metatarsal head by a depth of 15–20 mm. The sizer is removed from the Kirschner wire, and the appropriate reamer placed over the Kirschner wire. A final check is made to ensure that the retractors are correctly positioned and that the reamer can be seated without being off centered by the proximal phalanx (Figure 2). The reamer is then slowly advanced down into the bone to the depth of the rim, at which point it will not advance any further.

The Kirschner wire and reamer are removed and the base inspected. Any defect of the base can be bone grafted using the reamings. In osteoporotic patients, an area of deficiency can exist. Reversing the sizer and marking the depth can check the depth. The depth should be 1.5 mm less than the implant height (i.e. 8.5 in a 10-mm implant and 6.5 in an 8-mm implant).

The correct implant is opened (Figure 3). The delivery tube is lubricated with the storage saline. The implant is placed in the delivery tube with the beveled side up. The implant is then advanced until it is flush with the bottom of the delivery tube. The delivery tube is held vertically on the bone bed with the left hand, the plunger in the palm of the right hand, and the top end of the delivery tube with the right hand fingertips. Once held perpendicular and in the bone bed the implant is delivered in a single smooth motion into the bed (Figure 4).

The implant is inspected to ensure that it is neither too superficial nor too deep (Figure 5). If it has been misplaced, then it is removed with a Kirschner wire and discarded. A new implant is selected. If the implant has advanced too far, then bone graft should be placed into the bed. If it was too prominent more reaming needs to be done. If the implant is held at the right depth, then range of motion is checked and recorded. If needed the sesamoid complex is released off the plantar side of the metatarsal head.

After irrigation the wound is closed using absorbable suture to the dorsal capsule, subcutaneous suture, and an interrupted nylon skin closure.

The patient is placed in a postoperative shoe and encouraged to walk after 1 week. Sutures are removed at 2 weeks and physiotherapy initiated.

## CONCLUSION

PVA implants are a new alternative for arthritis of the first MTP joint. There are few outcome reports as yet for the great toe, but initial biomechanical tests and studies in the knee suggest a better outcome than has been obtained for silastic implants. The PVA implant is of potential value in patients wishing to maintain first MTP motion in whom there is no infection, additional pathology, or deformity in the first ray or at the sesamoid articulation.

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