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Revision of Failed Hemiarthroplasty of 1st MTP Joint with Salvage Arthrodesis and Calcaneal Bone Autograft

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Abstract: For decades, the gold standard surgical treatment for end-stage hallux rigidus has been first metatarsophalangeal (MTP) arthrodesis. With approval for use by the United States Food and Drug Administration (FDA) in 2016, Synthetic Cartilage Implants (SCI) showed promise for an alternative treatment to hallux rigidus while preserving motion as well as anatomical and mechanical alignment of the first MTP joint. Early studies concluded that SCI was equivalent to MTP fusion with the additional benefit of preserving joint motion and ease of application, however recent publications have suggested less satisfactory results. The purpose of this article is to present a case study of a 48-year-old male who underwent a salvage first metatarsophalangeal arthrodesis after failed synthetic cartilage implant one-year prior.

Key words: hallux rigidus, arthroplasty revision, arthrodesis, synthetic cartilage implant

Hallux rigidus is a degenerative disease of the first metatarsophalangeal (MTP) joint which presents with pain, decreased range of motion, and impairment of ambulation.[7] This condition can be debilitating with a significant impact on a patient's quality of life. First MTP joint arthrodesis is widely accepted as the gold standard for end-stage hallux rigidus treatment as it is the most predictable surgical intervention for eliminating pain.[4] Joint arthrodesis is not, however, without complications or potential long-term functional deficits. Along with sacrificing motion, joint arthrodesis may produce transfer metatarsalgia and interphalangeal joint arthritis. [7, 6, 11]

The 2016 advent of the Cartiva Synthetic Cartilage Implant (SCI) by Wright Medical Group showed promise as an alternative motion-sparing treatment to the historical first MTP joint arthrodesis.[12] It gained popularity for its ease of utilization as well as its potential to improve ROM while eliminating pain and maintaining anatomical and mechanical alignment of the joint.[5]

The synthetic cartilage implant is a cylindrical polymer hydrogel composed of polyvinyl alcohol with similar water content, tensile strength, and biomechanical properties of human articular cartilage.[13] It was designed for use as a hemiarthroplasty within the metatarsal head to provide a new cartilage-like articulating surface for the first MTP joint.

While arthroplasty of the first MTP joint through use of these SCI may appear to be an appealing option, many recent studies have called into question longevity of the procedure.[8] Common findings of a failed MTP implant on physical examination include gross instability of the joint, pain and crepitus with range of motion, and valgus deformity. Likewise, common radiographic findings of a failed MTP

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implant include bony erosions, cystic changes, implant subsidence, or often dislocation.[10]

When these implants fail, often the only surgical treatment option is a salvage arthrodesis of the first MTP joint.

Case Study

A 48-year-old male with no significant past medical history presented to clinic with complaint of left great toe pain. He underwent a partial 1st MTP joint arthroplasty with Cartiva implant one year prior. Patient reported numbness and swelling to the medial and lateral aspect of his left hallux for the entire year following the procedure. He also admitted to increased pain to the 1st MTP joint with ambulation and exercise.

Physical exam was notable for mild pain on palpation of the left great toe at the MTP joint level with crepitation and obvious dorsal-medial and medial exostosis formation. There was a positive grind test to the left 1st MTP joint with mild synovitis and effusion present. Upon ROM, there was 20-25 degrees of dorsiflexion as well as plantarflexion. There was no fixed erythema or increase in warmth noted to the 1st MTP joint, however there was evidence of mild edema within the first webspace dorsally and plantarly, as well as a mild sensory deficit noted to the left lateral hallux.

Weightbearing radiographs were obtained of the left foot revealing hallux rigidus deformity with asymmetrical joint space narrowing, dorsomedial and medial exostosis formation of proximal phalanx, and mild cystic changes (Figure 1).

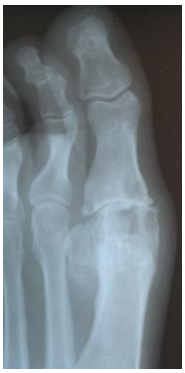


Figure 1. Medial-oblique radiograph of left great toe revealing hallux rigidus deformity.

An MRI of the left foot was obtained which revealed moderate to marked narrowing of the 1st MTP joint with moderate osteophytosis. Also noted was subchondral cyst formation at the base of the proximal phalanx measuring up to 8mm as well as multiple cysts at the head of the metatarsal adjacent to the prosthesis (Figure 2). Per radiologist report, "Cysts may be secondary to osteoarthritis but may in part be due to reactive and secondary to particle disease given the prosthesis."

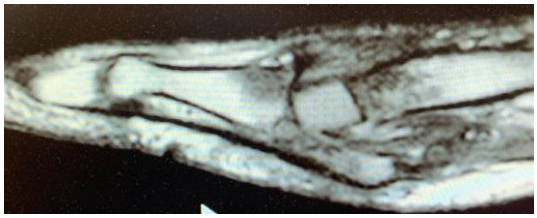


Figure 2. MRI. T1 sagittal view of left great toe demonstrating implant within metatarsal head, as well as subchondral cyst formation within metatarsal head and base of proximal phalanx.

The patient chose to undergo revisional surgery to the left great toe including removal of 1st MTP joint implant, calcaneal bone autograft, and 1st MTP joint fusion. He was given MAC anesthesia and a preoperative popliteal block.

A calcaneal autograft was first obtained in standard technique under fluoroscopy using the Paragon 28 Bone Graft Harvest System. The 1st MTP joint was then carefully dissected to reveal a thickened and fibrotic joint capsule with scar tissue and synovitis formation. Further dissection down to bone revealed significant degenerative changes including osteophyte formation and erosion of cartilage circumferentially around the previously placed 1st MTP joint implant. The remaining cartilage of the metatarsal head and base of the proximal phalanx was noted to have brownish-yellowish discoloration (Figure 3).

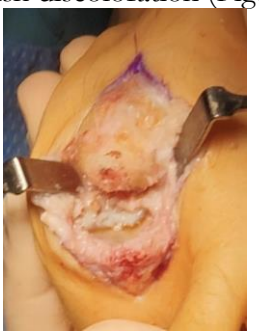


Figure 3: Intra-operative image of cartilage surrounding metatarsal head and base of proximal phalanx.

The implant was removed from the metatarsal head and the void was debrided by curette. An 11-mm Paragon 28 Avitrac reamer was used to expose bleeding subchondral bone, the site was flushed with saline, and an-11 mm Paragon 28 Avitrac graft was placed in the void.

Fibrotic soft tissue was removed from the 1st MTP joint space and joint surfaces were debrided of all remaining cartilage using Paragon 28 male and female reamers in standard fashion. Two subchondral bone cysts were revealed at the base of the proximal phalanx: dorsally measuring 0.8 x 1.0 cm and plantarly measuring 0.4 x 0.7 cm. Both cysts were debrided (Figure 4).

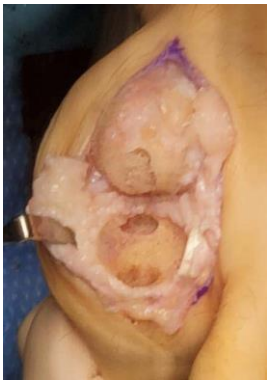
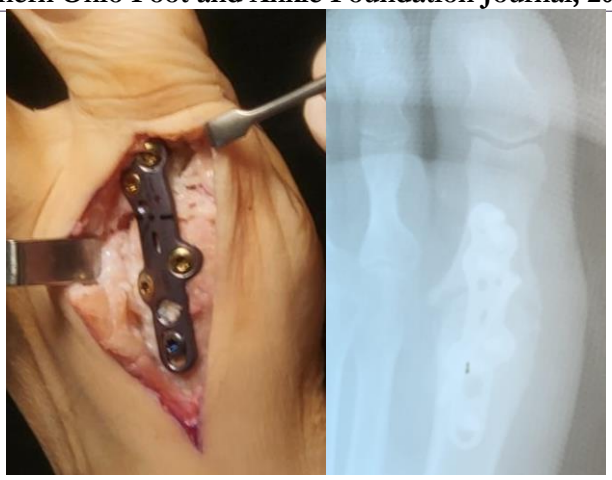


Figure 4. Intra-operative image of 1st MTP joint demonstrating subchondral cysts.

The 1st MTP joint surfaces were prepped by subchondral drilling and the freshly harvested calcaneal autograft was inserted into the fusion site. The hallux was positioned parallel to the second toe with the distal tuft of the hallux just off the weight-bearing surface and the toenail pointing directly upward. This position was secured under fluoroscopy with a 0.062 k-wire. A Paragon 28 0-degree MTP plate was then placed under fluoroscopy and secured using both locking and non-locking screw fixation (Figures 5 and 6). Demineralized bone matrix was back-filled into both the fusion site and calcaneal harvest site.



Figures 5 and 6: Intra-operative image of plate fixation over 1st metatarsal head, graft, and proximal phalanx; AP radiograph left great toe immediately post-operative, foot in posterior splint.

Surgical sites were closed, and dry sterile dressing was applied. The patient was placed into a Jones compression dressing and then a posterior splint.

At two and a half weeks follow-up, osteotomy sites were without crepitation or instability under stressed range of motion exam. The patient was able to return to work in a CAM boot under non-weightbearing restrictions to the operative foot and with the assistance of a walker.

Two weeks later, the patient reported complete resolution of pain and numbness to the great toe which had been present since the original arthroplasty. Radiographs taken at this time demonstrated appropriate alignment with hardware intact and progressive healing across the fusion site.

Also noted however was a 2 mm area of lucency on the AP radiograph at the lateral articulation. A bone stimulator was recommended for delayed healing on the lateral articular surface however the patient declined. He was instructed to begin protected partial weightbearing to his heel in a CAM boot.

Radiographs of the left foot at eight and a half weeks demonstrated continued healing across the fusion site (Figure 7). The patient was transitioned to protected full-weightbearing in a CAM boot.

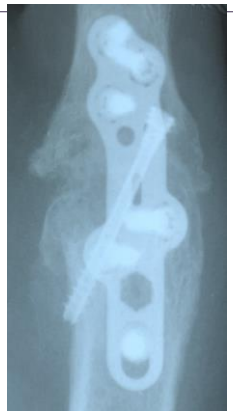


Figure 7: AP radiograph of left great toe demonstrating continued healing across fusion site at 8.5 weeks.

At ten and a half weeks, the patient was fully weightbearing in an athletic shoe. He remains pain free at rest, during ambulation as well as during exercise.

Discussion

Initial approval from the United States FDA for SCI was based on a multicenter randomized controlled study from Baumhauer, et al. The authors considered a composite of pain, function, and safety outcomes and reported improved visual analog scale (VAS) pain scores of >30% at 1 year, with a 9.2% rate of conversion to arthrodesis at 2 years. Baumhauer, et al then concluded that SCI was equivalent to MTP fusion with the additional benefit of preserving joint motion. Recent publications however have suggested less satisfactory patient- reported outcomes.[3]

A 2019 retrospective chart review by Cassinelli, et al. investigated 64 SCI implants in 60 patients over an average follow-up of 18.5 months. Contrary to the original randomized prospective trial, these authors found that in this study population, SCI yielded neutral patient satisfaction, mild pain, and physical dysfunction at early follow-up. Fifty-two percent of SCI patients had at least 1 injection of corticosteroid postoperatively for pain; 30% of patients underwent advanced imaging postoperatively due to pain; and 14% required the postoperative use of dynamic splinting devices for functional range of motion

limitations. In addition, 20% underwent further surgical procedures, and 8% of SCIs were converted to arthrodesis.[5]

Radiographic analysis was not an outcome measure of the original Baumhauer, et al. study, and no advanced imaging studies were examined. A 2019 retrospective review by An, et al. studied eighteen cases of symptomatic SCI in an attempt to characterize the radiologic findings of SCI and surrounding tissues. Radiographic loss of MTP joint space and progression of arthritis was evident in all cases studied. MRI revealed an 11% loss of implant volume and subsidence of the implant below the level of surrounding subchondral bone. All 18 cases also had evidence of bone and soft tissue edema, as well as peri-implant fluid suggesting instability at the implant-bone interface. Ultimately, 37.5% underwent revisional surgery at an average of 20.9 months follow-up.1

A prospective, randomized, noninferiority clinical trial by Glazebrook, et al. in 2018 assessed safety and efficacy outcomes for SCI implant hemiarthroplasty at 2 years and 5 years. Radiographs of participants of this study revealed the presence of bony reactions in 45.9% and 49.5% at the 2-year and 5-year follow-up, respectively. The bony reactions included erosions, cystic changes, loss of cortical margins, and osteolysis.[9]

The surgical retrieval of a SCI has shown evidence of implant shrinkage, bony erosions, and even histologic evidence of foreign body reaction[1]. Furthermore, poor bone quality, extensive bone defects with metatarsal shortening, and multiplanar deformity present a challenge for salvage of a failed first MTP joint arthroplasty.[2] When compared to studies of outcomes following primary arthrodesis, salvage arthrodesis has been shown to have longer time to fusion, lower rates of fusion, higher reoperation rates, and increased wound healing complications.[10]

Gross, et al. retrospectively investigated patients who underwent a first MTP joint fusion after failure of an implant arthroplasty to determine the average time to radiographic and clinical union. Participants of this study took an average of 6.9 months to fusion. The authors highlighted the difference in fusion between salvage arthrodesis and primary arthrodesis, which takes an average of 2.5 months. This also emphasizes that salvage arthrodesis after failed first MTP arthroplasty is not without its own obstacles.

Conclusion:
While treatment of hallux rigidus with SCI may seem like an attractive option for hemiarthroplasty, it is important to consider that when these implants fail, often times the only surgical option that remains is a salvage arthrodesis of the first MTP joint.

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