A Novel Technique utilizing Fresh Cryopreserved Chondral Allograft for the Repair of First Metatarsal Head Osteochondral Defects: A Cadaveric Study and Review of Literature

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Introduction & Literature review

Osteoarthritis of the first metatarsophalangeal joint, or hallux rigidus, may lead to osteochondral defects at the articular surfaces, subsequent stiffness and loss of range of motion. OCDs of the 1st MPJ are often associated with repetitive micro-trauma secondary to abnormal forces, and systemic degenerative diseases. Jastifer et.al. evaluated 56 feet undergoing hallux abductovalgus correction intraoperatively and found that 91% had associated osteochondral lesions.[1] Uncertainty exists on the clinical outcomes associated with lesions after HAV correction; yet, it is important to recognize these lesions as potential nidus for recurrent pain and stiffness.

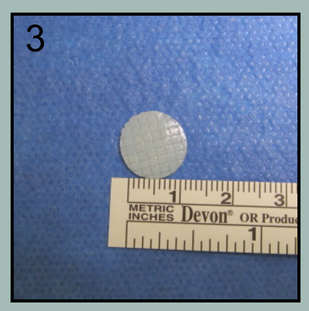
Hallux rigidus can be treated with joint arthrodesis or joint sparing arthroplasties. Currently, 1st MTPJ arthrodesis remains to be the gold standard of hallux rigidus. Often times, however, patients decline fusion due to post-operative shoe gear and activity limitations. In a retrospective study by Baumhauer et.al, a polyvinyl hydrogel synthetic cartilage implant was compared to arthrodesis in grade 2-4 hallux limitus. Outcomes for pain, function and safety between the two groups were equivocal; however, nearly 10% of the implant group did go on to arthrodesis within the study period.[2] Nonetheless, the study demonstrated that alternatives to fusion are available with similar pain and functional outcomes.

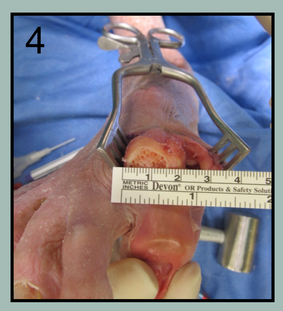
Interpositional arthroplasty serves as an alternative to arthrodesis. Aynardi et.al retrospectively evaluated 133 patients who had undergone 1st MTPJ interpositional arthroplasty via dermal matrix allograft or joint capsule-extensor hallucis brevis autograft with a mean follow up of 62.2 months. They found good to excellent results in 89.5% with an overall failure rate of 3.8%[3]. Berlet and colleagues also evaluated the use of acellular dermal regenerative tissue matrix for interposition in 9 patients at a mean follow up of 12.7 months and reported significant improvements in AOFAS scores.[4] Sanhudo et.al and Harshadkumar et.al found similar results and determined that interpositional arthroplasty provides good results while addressing hallux limitus.[5,6] Despite having multiple studies demonstrate efficacious results with interpositional arthroplasty in advanced hallux limitus, questions still remain on the need for joint resection with a modified Keller for an isolated osteochondral lesion.

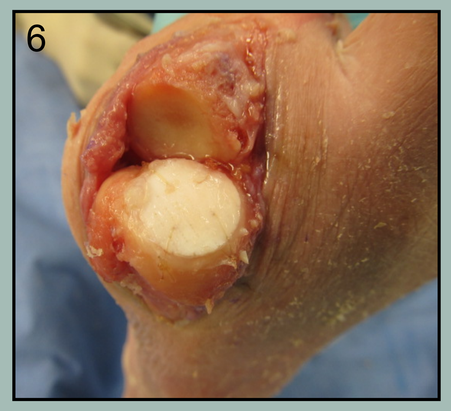
This study aims to describe an alternative treatment for 1st MTPJ osteoarthritis with the use of fresh cryopreserved chondral allograft for osteochondral lesions in preserving joint range of motion. We present a unique allograft implantation technique for the repair of first metatarsal head osteochondral defects utilizing a fresh cryopreserved chondral allograft on a cadaveric specimen.

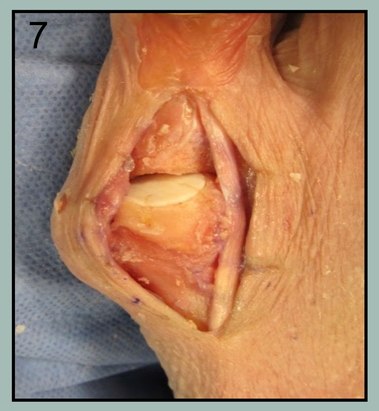
Methods

A standard open dorsal incisional approach to the first metatarsophalangeal joint was performed on a fresh cadaver limb (Fig 1); the articular surfaces were exposed and osteochondral lesions were artificially created on the first metatarsal head (Fig 2). Simulated microfracture drill holes were made with k-wire into the osteochondral lesions (Fig 2). Then, multiple 1mm-thick fresh cryopreserved osteochondral allografts were tested and individually fashioned according to the diameters of the OCD (0.5cm, 1.5cm respectively (Figs 2, 3, 4). We assessed two fixation techniques including fibrin glue sealant application alone, and fibrin glue with several tack down absorbable sutures to the allograft (Figs 5-7). Pliability of the allograft to contour to the metatarsal head was subsequently inspected via multiple trials of simulated passive range of motion.









Results

The graft withstood multiple cyclical loads and passive joint range of motion. The allograft maintained its integrity and allowed for smooth, uninterrupted range of motion of the proximal phalanx on the first metatarsal head, demonstrating preservation of inherent joint stability.

This method has been applied in vivo, and results are pending for more conclusive evidence of the success and durability of the allograft. Patient outcome factors including SF-36 and FAOS (foot and ankle outcome score) will be collected during the ongoing in vivo study.

Discussion

There is an emerging interest in alternative treatment options for 1st MPJ osteoarthritis. Literature regarding various arthroplasty techniques to treat the early stages of hallux rigidus have been well described, however, arthrodesis remains the gold standard. Despite the reliability of pain relief associated with 1st MPJ arthrodesis, patients with small osteochondral defects who wish to remain active should not be predicated to fusion when alternative treatment options to preserve 1st MPJ motion exist. There is limited research evaluating the use of chondral allograft to repair osteochondral defects in the 1st metatarsal. However, Van Dyke et.al retrospectively evaluated 9 patients with focal OCDs of the 1st metatarsal head utilizing particulated juvenile cartilage. With an average follow up of 3.3 years, 7 out of 9 patients were pain free and very satisfied.[7] Albeit a limited sample size, Van Dyke and colleagues demonstrated that treating isolated lesions of the 1st MPJ can provide excellent pain relief while preserving motion and activity levels.

We present a unique allograft implantation technique for the repair of first metatarsal head osteochondral defects utilizing a fresh cryopreserved chondral allograft on a cadaveric specimen. After implantation, the graft demonstrated the durability to withstand multiple cyclical loads through passive range of motion of the 1st MPJ. The allograft maintained its integrity and position throughout every trial, provided a consistently, smooth articular interface between the base of the proximal phalanx and first metatarsal head, demonstrating the preservation of inherent joint stability.

Conclusion

There are limitations to this cadaveric study, which question the allograft's integrity to withstand the high loads and forces in the foot during ambulation. Additionally, the morphology of the osteochondral lesion within the first metatarsal head can pose an arduous task when contouring and implanting the graft. Further research is needed to assess the performance of chondral allografts utilizing our proposed surgical technique to treat patients with symptomatic first metatarsal articular cartilage lesions. Pain associated with degenerative changes to the 1st MPJ has been a well archived dilemma for foot and ankle surgeons, however this study promotes efforts to procure an alternative treatment option to offer patients whom were previously relegated to 1st MPJ arthrodesis.

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