

Novel Use of Human Pericardium Allograft Interpositional Arthroplasty in the Surgical Management of Trauma Induced Hallux Rigidus A Case Report

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Abstract

Hallux rigidus is a form of degenerative arthritis affecting the first metatarsophalangeal joint characterized by pain, stiffness, and loss of motion, particularly dorsiflexion. Interpositional arthroplasty and arthrodesis are two common surgical interventions used to manage painful and dysfunctional joints. Arthrodesis involves the fusion of the joint, eliminating motion to provide stability and relief. Arthrodesis has been demonstrated to be reliable and provide long lasting pain-relief and has a low revision rate. However, arthrodesis eliminates joint motion which impairs function, can lead to adjacent joint degeneration due to transferred biomechanical stress, and carries a nonunion risk depending on bone quality and comorbidities. Interpositional arthroplasty preserves joint motion which maintains gait biomechanics, produces less stress on adjacent joints, and may be preferred in young, active patients. Interpositional arthroplasty can be performed with autografts, allografts, and spacers. Autografts are the most used, however they carry donor site morbidity. Spacers can be synthetic or biologic but are less popular due to long-term complications like implant failure or synovitis. Allografts are widely available, avoid donor site morbidity, and do not carry the same risks as spacers. Human pericardium allograft consists of a loose arrangement of collagen, elastic fibers (elastin and fibrillin), is primarily composed of Collagen Type I and has been shown to allograft has also been shown to have the biochemical and biomechanical properties of tendinous structures in the body. The aim of this case study was to highlight the novel use of human pericardium allograft interpositional arthroplasty in the surgical management of hallux rigidus.

Introduction

Hallux rigidus is a degenerative arthritis affecting the first metatarsophalangeal joint that results in pain, stiffness, and limited dorsiflexion. It is the most common arthritic condition of the foot and can significantly impair gait and quality of life [1]. Patients often complain of difficulty with activities such as squatting or walking uphill [2]. Pain is most notable during toe-off in gait and there is often dorsal osteophyte formation on the first metatarsal head which may cause shoe irritation [2]. The etiology of hallux rigidus is multifactorial and includes genetic predisposition, trauma, and anatomic abnormalities such as long or elevated first metatarsal [2,3]. It is commonly seen in adults aged 30-60 and has no strong gender predilection [2]. Radiographically, the is usually joint space narrowing, dorsal osteophyte formation, subchondral sclerosis, and flattening of the metatarsal head [4]. Grading systems such as Coughlin and Shurnas classification help to determine the severity and can guide treatment [5]. Conservative treatment options include shoe modification, orthotics (Morton's Extension), corticosteroid injection, and physical therapy [6]. Surgical options depend on severity and include cheilectomy, Moberg osteotomy, interpositional arthroplasty, Keller resection, and 1st MPJ arthrodesis [7,8].

The pericardium is a membrane that forms a protective, sac-like enclosure around the heart and the origins of the great vessels, serving both mechanical and protective roles [9,10]. It is composed of two layers: an outer fibrous layer known as the parietal pericardium, and an inner serous layer that lies in direct contact with the heart muscle, also referred to as the epicardium [10]. The parietal pericardium is rich in collagen and contains glycoproteins and glycosaminoglycans—such as hyaluronic acid—suspended in a loose, gel-like matrix. This matrix functions as a storage site for various signaling molecules, including growth factors and cytokines [10,11]. Structurally, the tissue is primarily made up of Type I collagen interwoven with elastic fibers like fibrillin and elastin [10]. When used as an allograft, pericardial tissue retains its original structural integrity and biochemical characteristics even after decellularization [9]. BioShell Pericardium (BSP) is one such lyophilized allograft, derived from human pericardial tissue. It is processed using a proprietary decellularization method called GraftCleanse® and sterilized through gamma irradiation to ensure safety and suitability for surgical applications.

PalinGen® XPlus Hydromembrane (Amnio Technology, Phoenix, Arizona) is chemically cross-linked with extracellular matrix fibers to give it strength, shape, and slower resorption in vivo [12]. These amniotic allografts contain collagen types I, III, IV, V, and VII, cytokines, hyaluronic acid, fibronectin, laminin, fibrinogen, amino acids, proteoglycans, tissue inhibitors of metalloproteinases (TIMPs), extracellular matrix proteins, and mesenchymal stem cells [13]. Amniotic allografts also include key growth factors such as fibroblast growth factor (FGF), epidermal growth factor (EGF), platelet-derived growth factor (PDGF), vascular endothelial growth fac tor (VEGF), and transforming growth factor beta (TGF-β).[13]

Interpositional arthroplasty of the first metatarsophalangeal joint is a surgical procedure designed to alleviate pain and preserve joint motions in patients with moderate to severe hallux rigidus. This technique involves resecting the damaged joint surface and placing a synthetic or biologic interlay to maintain the joint space and mobility[14]. Interpositional arthroplasty is especially considered in cases where there is significant joint degeneration but some range of motion remains and the patient desires to preserve joint mobility for functional or lifestyle reasons[15]. Various materials have been utilized for interpositional spaces including autogenous tissues such as the patient's joint capsule or tendons (either via graft or transfer), allogenic grafts using decellularized matrices, and synthetic materials like polyvinyl alcohol hydrogels[14,15]. A systematic review by Emmons et al reported that most patients experienced improvement with this procedure and in a retrospective study by Aynardi et al the 89.5% of patients rated their outcomes as excellent or good [16,17].

Case Report

Initial visit occurred March 18, 2025 with a 63 year-old female with past medical history of pes planus and bilateral trauma induced hallux rigidus secondary to a violent assault which occurred April 2021 which also left the patient with a traumatic brain injury. Patient had known allergies to beta-lactam antimicrobials, Baclofen, Darvon, and Gabapentin. No pertinent surgical or social history other than a history of former tobacco use and being employed in a physically demanding profession. Physical examination demonstrated intact neurovascular status, no gross deformity of the foot was identified besides pes planus and hallux rigidus bilaterally and the patient ambulated without ambulatory aids.

The patient complained of pain in the first metatarsophalangeal joints of both feet that was worsened with activity, especially during the toe-off phase of gait. Patient described the pain as deep, aching and occasionally sharp pain. Patient demonstrated limited dorsiflexion of the metatarsophalangeal joint, <10 degrees on the right foot and <20 degrees on the left foot, with crepitus throughout range of motion. There was a palpable osteophyte dorsally on the right first metatarsal head and pain was elicited with forced dorsiflexion on the right. Radiographs of both feet demonstrated joint space narrowing at the first metatarsophalangeal joint, dorsal osteophyte formation bilaterally with the right being more prominent than the left, subchondral sclerosis and cysts, flattening of the metatarsal head and loss bodies in the right first metatarsophalangeal joint. The right first metatarsophalangeal joint was graded 3 and the left first metatarsophalangeal joint was graded 2 based on the Coughlin and Shurnas Classification.

The patient had tried and failed conservative therapies including footwear modifications with stiff-soled and rocker bottoms, custom orthotic inserts, activity modifications, physical therapy, pharmacologic treatments including oral and topicals, and corticosteroid injections. After discussing the treatment options available, including continued conservative care and surgical intervention, the patient elected to pursue surgical management. The risks and benefits of surgical intervention were explained in detail and we discussed the various surgical treatments available including cheilectomy, Moberg osteotomy, interpositional arthroplasty, Keller resection arthroplasty, implant arthroplasty, and arthrodesis. The decision was reached to proceed with an interpositional arthroplasty to preserve motion in the joint. The patient underwent interpositional arthroplasty using pericardium allograft on both first metatarsophalangeal joints three weeks apart, starting with the right foot. For both surgeries the patient was taken to the operating room and placed on the operating room table in the supine position. Local anesthesia was attained, and a pneumatic tourniquet was used on the ankle. A linear longitudinal incision was then made dorsally over the first metatarsophalangeal joint

which extended midway on the first metatarsal to the hallux interphalangeal joint. Using blunt and sharp dissection, the incision was carried down to bone. A McGlamry elevator was then used to free up and expose the head of the first metatarsal completely. A Kirshner wire was driven centrally into the first metatarsal to be used as a guide for the reamer. The head of the first metatarsal was then rounded and smoothed using a series of reamer sizes, larger to smaller. A Kirschner wire was then driven centrally into the proximal phalanx to be used as a guide for the reamer. The base of the hallux proximal phalanx was then rounded and smoothed using a series of reamer sizes, smaller to larger. Any bony irregularities of the first metatarsal head or of the base of the hallux proximal phalanx were then removed with a rongeur and smoothed with a rasp. Using a 2.5 mm drill, a hole was made dorsal to plantar through the neck of the first metatarsal.

The pericardium allograft was removed from the saline it was soaked in and using Vicryl 1 suture, each corner of the pericardium allograft was tied with a surgeon's knot leaving a 6 cm tail on each corner. The pericardium allograft was then placed interpositionally into the first MTPJ so that it covered the head of the first metatarsal completely. Using a suture passer, the tails from the plantar two corners of the graft were passed through the hole that had been drilled into the neck of the first metatarsal and were brought dorsally. The plantar corner sutures were then tied with a dorsal corner suture in a crisscross fashion, securing the pericardium allograft in place. The deep tissues were then reapproximated with suture using 3-0 Vicryl. PalinGen® XPlus Hydromembrane Amnio Technology, Phoenix, Arizona) was implanted overtop the deep tissues. The subcutaneous tissue and skin were then coapted and suture closed with 3-0 Vicryl and 3-0 Nylon. The surgical incision was dressed with Xeroform, sterile gauze, castpadding, and ACE wrap. Patient was discharged home same day with full weight bearing status in a protective postoperative shoe.

Following both surgeries, the patient was able to manage pain using only over the counter acetaminophen. The patient had rapid and successful recoveries without complication and has been able to enjoy activities again that she previously was unable to due to loss of function and pain.



Conclusion

The outcome of this case report supports the use of interpositional arthroplasty in the surgical management of hallux rigidus and highlights the novel use of pericardium allograft in this surgical procedure. The patient made an excellent recovery from both surgical procedures and has since returned to all of the activities she previously enjoyed but had been limited from due to her condition.

It is important to note that this case was performed at the Southern Arizona Veteran Affairs Health Care System, therefore cost and reimbursement were not factors in determining treatment. All products used are all reimbursable through Medicare and private insurance and have their own designated HCPCS codes. The cost to benefit ratio would need to be assessed on an individual provider and patient basis. All pricing of the wound care products used in this case are available to the public through the Department of Veteran Affairs Federal Supply Schedule.

Hallux rigidus, a degenerative arthropathy of the first metatarsophalangeal joint, remains a challenging condition to manage, particularly in patients for whom joint preservation is a priority. Traditional surgical approaches such as arthrodesis have long been considered the gold standard for end-stage disease due to their consistent pain relief and durability. However, the resulting loss of motion can negatively impact biomechanics, adjacent joint health, and quality of life, particularly for active individuals or patients who require functional push-off for work or daily activities. In this context, interpositional arthroplasty emerges as an appealing alternative by preserving joint motion while alleviating pain.

This case report is notable for its innovative application of a human pericardium allograft as the interpositional material in a bilateral first metatarsophalangeal joint arthroplasty. The authors report successful outcomes, with the patient experiencing resolution of pain and restoration of function, returning to activities she had previously been unable to enjoy. The report underscores not only the feasibility of using pericardium in this context but also its potential biomechanical and biological advantages.

The decision to utilize a pericardium allograft was multifactorial. Compared to autografts, which require tissue harvesting and pose donor site morbidity, allografts eliminate additional surgical trauma. Moreover, while synthetic spacers have historically been used, they carry long-term risks such as synovitis, implant failure, or wear-related complications. In contrast, the human pericardium, particularly when decellularized and processed, retains native extracellular matrix components, primarily Type I collagen, along with elastic fibers, glycoproteins, and glycosaminoglycans. These features provide a scaffold that is not only structurally sound but also bioactive, supporting tissue integration and modulating inflammation.

Although the use of human pericardium in joint reconstruction is better established in other specialties such as cardiac and maxillofacial surgery, this report is among the first to document its successful application in forefoot surgery. Our technique is relatively straightforward and reproducible, with the graft securely anchored through a transosseous tunnel and reinforced with suture fixation. We attribute some of the success of the surgery, including the minimal postoperative pain and fast recovery to the amniotic allograft that was implanted overtop the deep tissues which we believe reduced inflammation and facilitate faster healing.

Despite the promising results, this report represents a single case, and broader conclusions about the efficacy of pericardium allograft in interpositional arthroplasty should be approached with caution. Long-term outcomes, graft durability, and comparative studies with traditional autografts or other biologics are necessary to validate its role.

In conclusion, this case highlights the successful use of human pericardium allograft in preserving motion and alleviating pain in a patient with trauma-induced hallux rigidus. Its application offers a novel, biologically favorable option for interpositional arthroplasty, warranting further exploration in larger studies to evaluate its long-term outcomes and position within the surgical armamentarium for hallux rigidus.

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Conflict of Interest Statement

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