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Original Article

Use of large osteochondral allografts in reconstruction of traumatic uncontained distal femoral defects

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ABSTRACT

Large osteoarticular injuries with subchondral bone loss involving the knee in young active patients often result in significant morbidity and loss of normal joint function. A review of the current literature reveals that multiple surgical management options are currently employed, however there is no consensus on standard of care. Osteochondral allografting provides an attractive alternative treatment option for the repair of large articular defects of the knee.

Methods: In this article we present the case of a young male who suffered traumatic intraarticular bone loss secondary to a grade IIIA distal femoral fracture and subsequently underwent reconstruction of his medial femoral condyle using a fresh-frozen osteochondral allograft.

Results: We present the radiographic and functional outcome of this patient at two years post-operative. The range of motion of the knee was 0–130° and the patient's post-operative functional outcome was evaluated using the Knee injury and Osteoarthritis Outcome Score (KOOS), which was 76%.

Conclusions: While further research is required, the results of our case study concur with the current body of literature supporting the use of fresh-frozen osteochondral allograft as a reconstructive option for treating large traumatic intraarticular lesions involving the distal femur.

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1. Introduction

Large osteoarticular injuries with subchondral bone loss involving the knee in young active patients often result in

significant morbidity and loss of normal joint function. Due to the young age and high activity level of this patient demographic, these injuries pose a major treatment challenge to orthopedic surgeons. A review of the current literature reveals that multiple surgical management options are currently

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employed, however there is no consensus on standard of care.¹ Procedures used in the past such as arthrodesis, arthroplasty and unloading osteotomy are generally not considered appropriate options for these individuals.² Knee arthrodesis results in significant joint dysfunction and therefore is not a reasonable treatment option in these patients. Arthroplasty is a suitable option in older patients, however in young highly active patients, prosthetic loosening and failure requiring revision is inevitable. Unloading osteotomy, while potentially providing some symptomatic relief, does not address the repair of the osteoarticular defect. Furthermore, unloading osteotomy in the knee may result in ligamentous redundancy with excess loading of the contralateral joint compartment contributing to early degenerative changes.^{3,4} The poor outcomes associated with the above treatment options has led to the development of biological treatment options used for reconstruction and repair of osteochondral defects in young active individuals.

Biological options aim to restore articular surface congruity as well as reestablish normal joint kinematics. Abrasion arthroplasty and autologous chondrocyte implantation are effective options for the treatment of chondral and small osteochondral defects in the knee. These techniques do not address the repair of underlying bone defects and therefore are not suitable treatment options for lesions with concomitant bone loss.^{1,5} Mosaicplasty has shown promising results as a reconstructive option for the treatment of small focal osteochondral defects, however this technique is restricted to defects less than 3 cm in diameter and one cm in depth. This is due to the limited amount of non-articulating cartilage available for graft harvesting. Concerns regarding donor site morbidity associated with this procedure must also be considered when using this surgical approach.^{6,7}

Osteochondral allografting provides an attractive alternative treatment option for the repair of large articular defects of the knee. Advantages of this method include the ability to resurface large areas of damaged articular cartilage with mature hyaline cartilage. Furthermore, allografting allows for the reconstruction of any associated subchondral bone loss in the same operation.^{2,8,9} Osteochondral allografting has also been shown to be effective for use in the reconstruction of large uncontained lesions. Currently, three types of allografts are available including fresh allografts, cryopreserved allografts and fresh frozen allografts.

Fresh osteochondral allografts are harvested from donors and stored at 4 °C or 37 °C and are typically used within 14–21 days after procurement.¹⁰ Fresh allografts have been shown to have better chondrocyte viability compared to cryopreserved and fresh frozen grafts.^{11–15} Multiple studies have shown promising long-term outcomes using these allografts in post-traumatic osteochondral reconstruction of the knee.^{2,9,16–20} Despite these encouraging results limitations and concerns regarding the use of fresh allografts exist. Major limitations include availability of grafts, increased immunogenicity of fresh grafts as well as increased risk of disease transmission from the donor.¹⁶

Cryopreserved osteochondral allografts utilize DMSO or glycerol in an attempt to enhance chondrocyte viability while still allowing the graft to be stored at –80 °C. Studies investigating chondrocyte viability have shown chondrocyte survival

to vary from 20% to 70%.¹⁰ These grafts have been used to a limited extent for the repair of post-traumatic osteochondral injuries; however, they have showed inferior result when compared to fresh osteochondral grafts.^{21,22}

Fresh-frozen osteochondral allografts are harvested from donors and stored at –80 °C. Although these grafts have the lowest chondrocyte viability of the available grafts, fresh-frozen grafts are the least immunogenic and therefore have been proposed to be more appropriate for major osseous reconstructions.^{10,23} Fresh-frozen grafts have been successfully used for reconstruction following tumor resection, however only 6 cases exist in the literature describing its use for post-traumatic osteoarticular reconstruction.^{24–27}

In this article we present the case of a young male who suffered traumatic intraarticular bone loss secondary to a grade IIIA distal femoral fracture and subsequently underwent reconstruction of his medial femoral condyle using a fresh-frozen osteochondral allograft.

2. Case report

An otherwise healthy 19-year-old male was involved in a motor vehicle accident in which the patient, a pedestrian, was struck by a motor vehicle and dragged a significant distance resulting in a grade IIIa open femoral fracture with concurrent

Fig. 1 – Anteroposterior radiograph showing a large medial femoral condylar defect after initial trauma.

Fig. 2 – a) Pre-operative sagittal CT scan of the knee showing a significant osteochondral defect of the medial femoral condyle. b) Preoperative coronal CT scans of the knee showing a significant osteochondral defect of the medial femoral condyle. c) CT three-dimensional reconstruction showing large osteochondral defect of the patient's medial femoral condyle.

bone loss. Radiological investigation demonstrated that a large fragment of bone was missing from his left medial femoral condyle (Figs. 1 and 2.). Significant soft tissue damage was also noted. Initial treatment included irrigation and debridement of his bony injury with primary closure of the soft tissues. He was then transferred to our center for delayed primary reconstruction (Fig. 3).

Reconstruction of the left medial femoral condylar defect was performed using fresh-frozen osteochondral allograft. The fresh-frozen distal femoral allograft was obtained from the Halifax bone bank after being appropriately size matched using computed tomography scans of the patient's contralateral knee as a reference.

A curvilinear skin incision was made followed by an anteromedial parapatellar arthrotomy to expose the

osteoarticular defect. A proximal tibial defect was identified and following irrigation and debridement, was repaired. Next, the MCL was identified and elevated directly from the femoral condylar defect. The defect was then cut down to bleeding, healthy cancellous bone. The osteochondral allograft was then cut from the donor femur to the appropriate size based on intra-operative measurements. The graft was then secured to the defect using three 3.5 mm cortical lag screws. A contoured 4.5 T buttress plate was used to complete fixation of the allograft to the fracture site. The MCL was then repaired by suturing it directly to the osteochondral allograft through the plate.

The post-operative period was uncomplicated. The patient was initially non-weightbearing in a locked knee brace. Passive flexion and extension exercises were initiated 2 weeks

Fig. 3 – a) Anteroposterior and b) lateral radiographs taken at 2 years post-op. Radiographs show the osteochondral allograft is in good position. Bridging callous is noted across the fracture site. No degenerative changes are noted.

after the operation. Partial weight bearing was initiated at 5 months followed by gradual progression to full weight bearing.

At the most recent follow-up, 2 years after the operation, the patient had progressed to full weight bearing. Clinical evaluation revealed normal joint alignment and showed the range of motion through the knee to be 130° of flexion and full active extension. Clinically the patient's knee was stable to both varus and valgus forces. The patient denied any pain with ambulation. The patient's post-operative functional outcome was evaluated using the Knee injury and Osteoarthritis Outcome Score (KOOS), which is a validated joint-specific functional outcome measure used to determine pain, symptoms, activities of daily living, sport and recreation function, and knee-related quality of life after knee injury.²⁸ The patient's KOOS score was 76%. Radiographs taken 2 years post-operatively revealed the osteochondral allograft to be in good position with adequate alignment. The allograft appeared to be well integrated with the patient's femur. Joint space was maintained and there was no evidence of early degenerative changes.

3. Discussion

Traumatic osteochondral defects of the knee are often severely debilitating injuries that require surgical management. Multiple surgical options, including abrasion arthroplasty, autologous chondrocyte implantation and mosaicplasty, have been shown to effectively treat smaller lesions. However, the reconstruction of large uncontained intraarticular lesions is controversial. In this case report we present an excellent early outcome when using fresh-frozen osteochondral allograft in the reconstruction of a large uncontained defect involving the distal articular surface of the femur.

While little has been published regarding the results of using fresh-frozen allograft in the treatment of large traumatic intraarticular lesions of the distal femur, survivorship and functional outcomes have been reported in the setting of knee reconstruction following tumor excision. Muscolo et al demonstrated an 85% graft survival rate at 5 and 10 years and of the 33 patients receiving unicondylar femoral allografts, 30 patients rated their results as excellent while 3 rated their satisfaction as good. Burdygin et al investigated the functional outcome of 76 patients who underwent distal femoral reconstruction following tumor resection and reported that 37 patients had good results and could walk without aids while 22 had fair outcomes and required a walking aid for ambulation. Other studies have reported similar results.

A detailed review of the literature revealed 6 cases in which a fresh frozen osteochondral allograft was used for the repair of a large post-traumatic osteochondral defect. Muscolo et al presented two cases in which pediatric patients underwent distal femoral reconstruction following grade III open fractures. The first case presented a 12-year-old girl who underwent reconstruction of her lateral femoral condyle following a motor vehicle accident. At ten years follow-up, clinical exam showed normal alignment of the joint, equal leg length, 90° of flexion and full extension. The patients

Musculoskeletal Tumor Society score (MSTS), used to evaluate functional outcome after limb salvage procedures, was 93%. Her radiographs were evaluated using the radiographic scoring system proposed by the MSTS. The radiographic score was 94% and rated as excellent. The second case in this series was that of an 8-year-old male who underwent reconstruction of his medial femoral condyle following a high-energy ballistic injury. At two years follow-up, clinical exam showed normal joint alignment, with a range of motion of 100° of flexion and 30° of active extension. This patient's functional MSTS score was 86% with an MSTS radiographic score of 94%.

In a separate study, Muscolo et al reported the results of osteoarticular reconstructions of the knee with fresh-frozen allografts. In this series, 38 patients underwent reconstruction after tumor excision while 2 patients were treated for post-traumatic defects. The two patients treated for post-traumatic defects both underwent medial femoral condyle reconstruction. The functional outcome score in these patients were 27/30 and 28/30 respectively. Both patients scored 94% on the MSTS radiographic score and had minimal or no joint changes detected on clinical examination. Bianchi et al also reported results of using fresh-frozen osteochondral allografts for reconstructions around the knee. In this study, 9 patients underwent reconstruction of the distal femur. Of these patients, only a single case was for the reconstruction of a post-traumatic osteochondral defect. In this case, at 10-year follow-up, the patient demonstrated good clinical functional outcome in accordance with MSTS functional analysis. Radiographic analysis demonstrated a varus alignment of the affected knee and showed severe joint degenerative changes.

J.H. Lee et al also presented a case in which fresh-frozen osteochondral allograft was used to reconstruct the distal femur after traumatic injury. They reported the clinical and radiographic outcome at 5 years. In their case, clinical examination demonstrated normal joint alignment, equal leg length and a full range of motion through the knee. Functional outcome was determined using the KOOS, which was 89.4/100. Radiographs showed good union of the graft with progressive degenerative changes seen in the graft compartment.

In our present case study, a 19-year-old male underwent reconstruction of his medial femoral condyle following an injury sustained during a motor vehicle accident. At 2 years follow-up the patient demonstrated an excellent clinical result including a normal joint alignment with 130° of flexion and full active extension in the knee. His KOOS score was rated as 76%. Radiographs taken 2 years post-operatively demonstrated that the allograft was well incorporated into the patient's native femur and was in a good anatomical position with adequate alignment.

Although not commonly described, the use of fresh-frozen osteochondral allograft in the reconstruction of large uncontained lesions of the distal femur has been reported a total of 6 times in the literature. Our case report presents a seventh case. At this time there is no commonly accepted treatment for large uncontained defects of the distal femur. While further research is required, the results of our case study concur with the current body of literature supporting the use of fresh-frozen osteochondral allograft as a reconstructive option for treating large traumatic intraarticular lesions involving the distal femur.

Conflicts of interest

All authors have none to declare.

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