REVIEW ARTICLES

Articular cartilage transplantation for post-traumatic defects in the athletes knee: A Review[1]

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"Ulcerated cartilage is a troublesome thing, once destroyed is not repaired" Hunter, 1743

ABSTRACT

OSTEOCHONDRAL DEFECTS are common sequelae of traumatic injuries to lower limb weight-bearing joints. The knee joint is the most commonly affected joint in the athletic population. When these defects persist, the incongruity of the joint surface can lead to mechanical joint dysfunction. Disintegration of the surrounding articular cartilage may lead to osteoarthritis of the affected compartment, causing pain and disability in this relatively young athletic population. The treatment of these injuries is controversial, with a number of options available.

The ideal option for the treatment of the osteochondral injury in the knee is one that aims to treat the defect early and aggressively before the onset of osteoarthritis in the affected joint. Articular cartilage transplantation is described in the literature as an effective method to achieve this outcome in the athletic population. Osteochondral allografts and autografts are two techniques that are currently being utilised to restore joint congruity. This article reviews the current literature and results of articular cartilage transplantation for the treatment of post-traumatic defects in the knee.

INTRODUCTION

OSTEOCHONDRAL INJURIES present serious diagnostic and treatment difficulties in the athletic population. There are few long-term studies and no general consensus in the current literature as to the best way to manage these lesions. In the treatment of focal defects, the optimal management is for the replacement with a like substance. This article is a review of the current literature on two methods of cartilage transplantation currently being employed to treat these defects, with the emphasis on treatment in the young, active population.

BACKGROUND

When a segment of articular cartilage is separated from its surrounds, along with its underlying subchondral bone, an osteochondral lesion is produced. Trauma, osteonecrosis, osteochondritis dissecans and some hereditary abnormalities can cause these defects to occur, with trauma being the major contributor in the adult population[2]. Breakdown of articular cartilage can result in severe pain and disability, and may progress to premature osteoarthritis.

The knee is the most commonly involved joint, with 75% of all osteochondral injuries occurring in this joint. They occur two to three times more commonly in males, but this ratio is on the decline due to the increased participation of females in sporting activities[3]. Osteochondral injuries frequently occur in the second to fourth decade.

AETIOLOGY

Articular cartilage injuries are very common in the athletic population. One study found chondral lesions in 63% of >31,000 knee arthroscopies[4]. These injuries occur when repetitive and prolonged joint overload, or a sudden impact, provides high compressive forces to the tissues and high shear stress also at the subchondral bone interface. A subchondral fracture occurs as a result of these forces acting tangentially to the joint surface. In contact sports, or those involving torsional stresses on the lower extremity, focal articular defects commonly occur[5].

The most common injuries that can lead to an osteochondral injury in the knee are patella disloca-

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tions and anterior cruciate ligament (ACL) ruptures. The momentary dislocation-relocation of the patella may cause an osteochondral fracture of the lateral femoral condyle. A pivoting injury on a fixed weight-bearing knee may result in the anterior tibial spine abutting the medial femoral condyle while the ACL is injured. Bobic[6] noted that of the 250 patients treated at his clinic for an ACL injury, as many as 70% had some form of chondral lesion.

DIAGNOSIS

Pain is the most common symptom of a chondral injury, and may be associated with an effusion or locking. A haemarthrosis may herald an intra-articular injury, including an osteochondral fracture. Radiographs are often normal. Cartilage defects that extend to subchondral bone frequently mimic other intra-articular knee pathology. Differential diagnoses of the injury may include meniscal pathology, loose body and ligamentous injury. Diagnosis is also challenged by attempting to differentiate between osteochondral lesions and early gonarthrosis. The distinction is important, as treatment options differ between the two diagnoses.

Magnetic resonance imaging (MRI) is a non-invasive method of imaging the chondral defect, but its role in the diagnosis of these defects is still disputed. O'Shea *et al*[7] demonstrated that in 83% of cases, the primary diagnosis of a knee injury could be accurately obtained with history, clinical examination and plain radiographs. They concluded that MRI was not a necessary tool for the evaluation of traumatic knee injuries.

Arthroscopy is the diagnostic tool of choice for osteochondral lesions in the knee, with the accuracy of arthroscopy being reported to be between 69% and 98% for the evaluation of traumatic knee injuries[8]. It has been shown by Boden *et al*[9] that arthroscopy was more cost effective than MRI in the evaluation of acute traumatic knee injuries.

There are a variety of classifications for articular injuries in the knee. The most commonly used system is the Outerbridge classification[10], which is based on the qualitative appearance of the cartilage surface, as seen at arthroscopy:

- Grade 1 softening with swelling
- Grade 2 fragmentation and fissuring
- Grade 3 fragmentation and fissuring > _ inch in diameter
- Grade 4 subchondral bone exposed

Classification is important for prognosis, and to identify those lesions best suited for repair techniques.

EVALUATION OF CURRENT TREATMENT MODALITIES

There is a lack of knowledge in the current literature about the natural history of acute osteochondral injuries in the knee. This leads to problems when evaluating current treatment options, as there is nothing to compare the outcome to. Linden[11] reviewed seventy-six knee joints, which had a diagnosis of osteochondritis dissecans, over a period of thirty-three years. He concluded that symptomatic osteoarthritis in the knee joint of patients with osteochondral lesions of their femoral condyle tended to begin approximately ten years earlier in life than symptoms of primary osteoarthritis. At least twenty years appears to be the time between onset of symptoms related to the osteochondral defect and evidence of osteoarthritis. Most studies on new interventions in the current literature have a more limited follow-up period, so the long-term efficacy of these treatment options is still unknown.

Osteochondral grafting

Various advances in the understanding of the physiology and biomechanical properties of articular cartilage have led researchers to explore different treatment options, depending on the size of the defect. In the treatment of focal cartilage defects, replacement with like tissue is recommended[12].

Articular cartilage injuries in the knee can be treated with osteochondral allografts and autografts. Each method has the common goal of filling the defect with a stable hyaline cartilage graft. The aim is to retard the onset of post-traumatic osteoarthritis in this young population of athletes, and the resulting pain and disability associated with it.

The choice of allografts and autografts both have positive and negative aspects. Allografts have limited availability and can only be harvested in areas with appropriate tissue banking facilities. They, however, do not cause any problems with donor site morbidity. Autografts are readily available but harvesting can cause problems locally for the patient.

Osteochondral allografts

As a technique for the treatment of localised defects in the knee, fresh osteochondral allografts, from young

cadaveric donors, is the one with the longest clinical experience[13]. This experience extends over several decades, with at least three centres in North America routinely performing this procedure since the 1970's.

The perfect candidate for the osteochondral allograft is the young individual with a single, focal defect in an otherwise healthy knee that has not yet progressed to post-traumatic osteoarthritis[14]. Articular grafts are best transplanted fresh, to maintain the viability of the chondrocytes. The chondrocytes are immunogenic, but humoral antigens cannot penetrate the intact articular cartilage matrix. Tissue typing is not required, and rejection appears to be insignificant in this transplantation process[2]. The possibility of disease transmission is inherent in any allograft transplant, but there have been no documented cases of transmission of disease in the current studies to date.

The mature cartilage surface is transplanted along with a shell of subchondral bone ranging from 3mm to 10mm thick. The benefit of this transplant is the mature cartilage does not need to "heal" to provide the biomechanical properties required of a weight bearing joint. All that is necessary is for the underlying subchondral bone to be incorporated into recipient bone stock by the process of "creeping substitution" (allograft bone incorporation).

Allografting relies on the availability of fresh donor material and experienced staff to harvest and handle this material. Donor and recipient are matched solely on size, using the mediolateral dimensions of the tibia. The transplantation process involves two surgical teams, one for the preparation of the donor graft and the second team for the recipient surgery. The graft is bedded via an arthrotomy, and internal fixation or press fit is required for graft localisation.

The first series of patients to undergo fresh osteochondral allograft transplantation began in 1972 and McDermott *et al*[15] reviewed the first 100 patients. The average age of the patients was 48 (range: 11 to 78), with an average follow-up of six years (range: 0.5 to 13). Conclusions drawn from this review reveal a high success rate of 75% in patients with traumatic defects in the knee. Single pole grafts performed better than bipolar grafts and post-traumatic defects healed better than those caused by degenerative arthritis or spontaneous osteonecrosis.

The authors then went on to review 91 cases of post-traumatic knee defects, which also underwent fresh allograft transplantation with an average follow up of 68 months (range: four to 174 months). 75% of grafts were clinically successful at five years, 64% at ten years and 63% at 15 years[16]. This same group in 1997 reviewed 123 patients with an average age of 35 years (range: 15 to 64) and showed a 93% graft survival at five years, 71% at ten years and 61% at 20 years[17].

Chu *et al*[18] replicated this outcome with a review of 55 knees with an average follow up of 75 months (range: 11 to 147 months). 84% of unipolar allografts and 50% of bipolar grafts had regained virtually normal use of their resurfaced knees. They showed that fresh osteochondral shell allograft resurfacing of massive full thickness articular cartilage defects consistently returned near normal function and comfort to 42 of 55 patients (76%), with 73% of knees receiving allografts > ten years ago have continued to have good ratings at follow up.

The final large study reviewed was by Aubin *et al*[13] who examined their results in 72 patients, average age 27 (range: 15-47 years), with a minimum follow up of five years. Excellent long-term survival was demonstrated with 85% surviving without additional surgery as long as ten years post transplantation and a projected survivorship of 74% at 15 years.

Results of osteochondral allografts are encouraging when appropriate patient selection occurs. This method appears to be most successful in young, active candidates with defects >3cm in diameter. The success of osteochondral allografts appears to be more reliant on biomechanical properties of graft placement than on graft rejection[5]. Patient selection and technical proficiency are the most significant factors in clinical success rates.

Osteochondral autografts (Mosaicplasty)

Dr Hangody and Dr Kárpáti developed Mosaicplasty in Budapest in the early 1990's and, by the end of 1998, had performed this procedure on 463 patients. For the athletic population within this patient group, the major concern was not only the hyaline cartilage survival but also the involved joint's performance under extreme weight bearing loads.

Mosaicplasty is a one-stage arthroscopic procedure that harvests multiple osteochondral grafts from non-weight bearing areas of the ipsilateral patello-femoral joint. Approximately 60-80% of the defect is filled with the transplanted grafts, with the

rest of the area reconstituting with fibrocartilage "grouting"[19]. By using multiple cylindrical grafts of small sizes, the congruity of the defect in relation to the surrounding recipient cartilage was maintained.

The results show a hyaline-like congruous surface at the site of focal defects[20]. At the eight-year follow-up, Hangody *et al*[21] showed a 92% good to excellent result in patients receiving grafts to the femoral condyle, and 88% for tibial resurfacing, with a low complication rate. The concern with this procedure is donor site morbidity but patients to date rarely have symptoms secondary to the donor site, which heal with fibrocartilage.

Smaller studies by Outerbridge *et al*[22] followed ten patients with an average age 29 years (range: 18-40) for an average period of six and a half years (range: four to nine years) who underwent grafting from the lateral facet of the patella into a defect in the weight bearing portion of femoral condyle. Their results showed that all ten patients were satisfied with the results of the surgery and had returned to their recreational sporting activities. The authors have suggested that it is the reconstruction of the articular integrity, which allows the patient to resume all activities. All the patients reviewed reported an improvement in terms of pain, swelling, giving way and over-all function.

A study by Maracci *et al*[23] reviewed 13 patients treated with autologous osteochondral grafting to their knee, with 12 out of 13 patients being satisfied with their outcomes. Menke *et al*[24] used a lateral facet patella graft in a 37-year-old patient with a large medial femoral condyle defect. Ten years post-surgery, the patient mobilised without pain and had a full range of motion. No radiographic signs of degenerative arthritis were found.

Interest in this procedure has expanded over the past few years. There are two definitive advantages over other techniques of transplantation; it is a one step procedure that can be performed arthroscopically and it is a low cost procedure. The limitation is the size of the lesion to be grafted, with the upper limit reportedly being 6-8 cm[19].

CONCLUSION

There is a serious lack of studies in the area of healing joint cartilage damage. None of the procedures reviewed here have their outcomes compared to a non-operative group, and neither procedure has been trialled against the other.

Osteochondral allografts have an excellent outcome in the young, compliant individual, but the availability of cadaveric donors and specialised centres for the harvesting of the graft severely limit this option.

Mosaicplasty is a one step arthroscopic technique, which harvest grafts from the non weight bearing portion of the patients knee, alleviating the potential risks associated with autologous transplants. It does appear to be a favourable option, but results have only been studied since 1992, so medium term results only exist to date.

As stated by Tyyni[19] and confirmed by this review of the literature, randomised, well-controlled studies comparing available methods to treat cartilage injuries are altogether lacking.

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