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# Simultaneous arthroscopic implantation of autologous chondrocytes and high tibial osteotomy for tibial chondral defects in the varus knee

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**Abstract**

There is no consensus on the ideal management of patients with chondral defects of the medial tibial plateau and varus malalignment of the knee. We performed a cohort study to evaluate the outcome of patients affected by these conditions, who underwent arthroscopic implantation of autologous chondrocytes and a medial opening wedge high tibial osteotomy. Eight patients (four men and four women; mean age, 50 years, range: 42 to 58) with chondral defects of the medial tibial plateau in a varus knee underwent arthroscopic implantations of autologous chondrocytes in conjunction with a medial opening wedge osteotomy. At final post-operative follow up of 28 months following the index procedure, the post-operative scores were improved for the IKDC score (four patients abnormal and four patients severely abnormal to four patients normal, three patients nearly normal and one patient abnormal), Lysholm score (65.7 range 49–88 to 94.6 range89–100), Tegner score (3.7 range3–5 to 7 range 5–8) and VAS score (7.2 to 2.0). In conclusion, the association of arthroscopic implantation of autologous chondrocytes with a medial opening wedge osteotomy of the proximal tibia is a viable option for the management of chondral defects in varus knees.


*Keywords:* High tibial osteotomy; Arthroscopic autologous chondrocyte implantation; Varus knee; Chondral defects; Knee; Arthroscopy

## 1. Introduction

If adequate correction is achieved by high tibial osteotomy (HTO) in a varus knee with a chondral defect, the hyaline cartilage lesion can be partially repaired by fibrocartilage [1,2]. Articular cartilage defects can be managed by marrow stimulation (i.e. subchondral drilling, abrasion arthroplasty, microfracture), autologous cultured chondrocyte implantation [3,4], osteochondral autograft transplantation [5] (i.e. mosaicplasty), or autogenous periosteal grafts [6]. Autologous chondrocyte implantation is a management option for chondral defects, but it is contraindicated in the presence of tibio-femoral malalignment, which would impose mechanical overload to the repair tissue [7,8].

For this reason, in patients with chondral defects plus a varus knee malalignment, we perform an opening wedge high tibial osteotomy and arthroscopic autologous chondrocyte implantation.

We report the outcome of patients with chondral defects of the medial tibial plateau and varus malalignment of the knee who underwent arthroscopic implantation of autologous chondrocytes and a medial opening wedge high tibial osteotomy.

## 2. Patients and methods

All procedures described in this investigation were approved by our Institutional Ethics Review Board. In the period January 2002 to December 2003, we performed arthroscopic implantations of autologous chondrocytes in conjunction with a medial opening wedge osteotomy in eight patients (four men and four women; mean age, 49.6 years, range: 42 to 58; Table 1) with chondral defects of the medial tibial plateau in idiopathic varus knee. The aetiology of the cartilage defect was unknown. All patients practised recreational sport. The exclusion criteria were age >60 years, associated meniscal lesions and diffuse

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Table 1
Characteristics of the patients

| Patient | Age | Gender | Defect size (cm2) | Weight bearing axis pre-op (varus) (°) | Weight bearing axis post-op (valgus) (°) | IKDC pre-op | IKDC post-op | Lysholm pre-op | Lysholm post-op | Tegner pre-op | Tegner post-op | VAS pre-op | VAS post-op | Follow up (months) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 55 | M | 2.8 | 8 | 3 | C | A | 88 | 100 | 3 | 8 | 7 | 0 | 30 |
| 2 | 44 | M | 2.1 | 10 | 3 | C | A | 66 | 95 | 4 | 7 | 8 | 1 | 28 |
| 3 | 58 | M | 3.2 | 6 | 4 | D | B | 68 | 90 | 4 | 6 | 6 | 3 | 29 |
| 4 | 42 | F | 2.4 | 12 | 2 | C | A | 67 | 98 | 5 | 8 | 9 | 0 | 27 |
| 5 | 47 | F | 4.1 | 14 | 1 | D | C | 68 | 89 | 3 | 5 | 8 | 5 | 26 |
| 6 | 42 | M | 3.6 | 5 | 3 | D | B | 49 | 95 | 3 | 8 | 7 | 2 | 9 |
| 7 | 51 | F | 2.6 | 6 | 3 | D | A | 57 | 96 | 5 | 8 | 6 | 2 | 31 |
| 8 | 58 | F | 3.7 | 4 | 4 | C | B | 63 | 94 | 3 | 6 | 7 | 3 | 25 |

arthritis, chondral defects of the medial femoral condyle or kissing lesions. All lesions were Outerbridge [9] grade III–IV, and the mean size of the chondral defect was 3 $cm^2$ (range 2.1–4.1 $cm^2$).

The weightbearing axis of the knee was determined from standard long-leg radiographs as the angle subtended by a line from the centre of the hip to the centre of the knee and continued to the center of the ankle. The average pre-operative varus deformity was 8.1° (range 4°–14°). No patient had undergone prior surgery to the affected knee.

The correction angle was calculated as the angle between the line from the center of the femoral head to 50% of the width of the tibia and the line from the center of the talus to the 50% coordinate [10].

We performed all pre-operative evaluations the day before surgery, and all post-operative evaluations at the final follow up. Patients were evaluated 5 weeks after the scaffold implantation with high resolution MRI. Final follow up took place at 28 months (range 25–31) from the index procedure.

Each patient was evaluated using clinical history, clinical examination, conventional radiographs, MRI, arthroscopy, pre- and post-operative objective IKCD (International Knee Documentation Committee) [11] score, pre- and post-operative Lysholm score [12], pre- and post-operative Tegner score [13], and pre- and post-operative VAS. The IKCD score was divided into normal (A), nearly normal (B), abnormal (C) and severy abnormal (D). A simple satisfaction question was also administered. The simple satisfaction question asked whether the patient felt worse, the same, better, or much better than before the operation (0–3 range).

Descriptive statistics were calculated. Statistical analyses were performed with Wilcoxon Sign Rank test. Significance was set at $P<0.05$.

## 3. Surgical technique

### 3.1. Arthroscopic autologous chondrocyte implantation

The autologous chondrocyte implantation was performed as a 2-step surgical procedure.

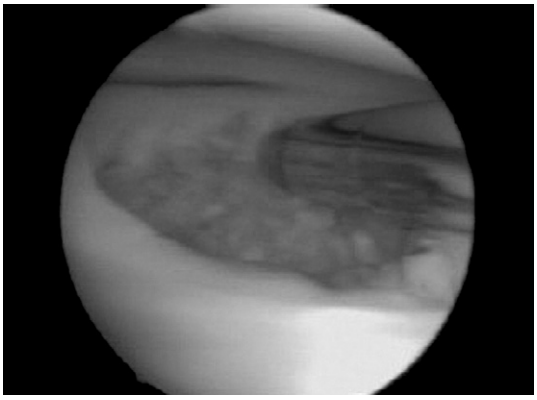

Fig. 1. Pre-debridement chondral lesion.

#### 3.1.1. Step 1

Arthroscopic surgery was performed initially with the patient under general or spinal anaesthesia in a bloodless field furnished by a thigh tourniquet inflated to 250 mm Hg. The defect was examined, accurately measured, and slivers of cartilage (300–500 mg) were obtained from the lateral margin of the trochlea of the affected knee for culture and later implantation. The biopsy was placed in transport medium, and sent to the laboratory where it was enzymatically digested releasing the chondrocytes. After culturing the cells for 3 to 5 weeks in each patient's autologous serum, they were seeded onto Hyalograft C scaffolds (HYAFF ®, Fidia Advanced Biopolymers Laboratories, Padova, Italy) [14]. The patients were then readmitted for the second stage procedure.

#### 3.1.2. Step 2

At the time of chondrocyte implantation, prophylactic antibiotics were given for 24 h, beginning at the initiation of the procedure. With the patient under general or spinal anesthesia and a bloodless field furnished by a thigh tourniquet inflated to 250 mm Hg, a 30° arthroscope was inserted through the standard antero-lateral portal. Surgical instruments were inserted through the antero-medial portal, through which a 10.0 mm arthroscopic cannula was placed. Under arthroscopic control, the injured cartilage on the medial tibial plateau was debrided using a curette and an abrader (Fig. 1) until normal healthy cartilage bordered the debrided defect. The chondral defect was sized with a measuring rod, and the dimensions were transferred onto the seeded collagen scaffold, which was subsequently cut in circular patches, reproducing the shape of the lesion [15]. Irrigation was stopped, and residual fluid in the joint was drained.

The circular patches were inserted into the joint using atraumatic arthroscopic forceps (Fig. 2). A probe was used to place the membranes in the correct position over the defect. Minimal pressure on the membranes was applied using the arthroscopy probe to not break the scaffold and to achieve optimal contact with the underlying bone (Fig. 3) [14,15].

After this step, the high tibial osteotomy was carried out [16,17] (Fig. 4).

### 3.2. Osteotomy

A radiolucent table was used to allow fluoroscopic visualization of the hip, knee and ankle joints for intra-operative

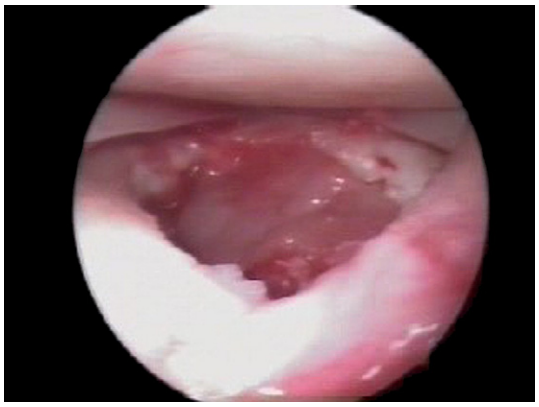

Fig. 2. Insertion of the circular membrane into the joint.

assessment of alignment. The knee was extended and free from the leg holder. The anterior border of the medial collateral ligament was exposed, and the pes anserinus raised with a periosteal elevator. The medial edge of the patellar tendon was identified. The medial insertion of the tendon was released to clear the antero-superior corner of the tibial tubercle. A guide wire was inserted along the planned direction of the osteotomy starting from the medial cortex approximately 3 to 4 cm distal to the medial joint line and directed toward the upper end of the head of the fibula. The Arthrex instruction manual provides a goniometric formula table, which gives the extent of the opening wedge for a specific correction [18]. The osteotomy was performed distal to the guide pin using a low speed oscillating saw and osteotomes under fluoroscopic control to ensure appropriate depth and direction of the cut. A tapered osteotome was then advanced slowly into the osteotomy, and the planned alignment was reached and checked with the alignment rod. Once the desired re-alignment was achieved, the osteotomy defect was filled with hydroxyapatite wedges of the appropriate size, and a plate was applied and fixed with screws [16,17]. The hydroxyapatite wedges are bone substitutes made of an osteoinductive material which promotes the filling of osteotomy bone defect. They are used instead of bone graft, and provide good clinical results [19].

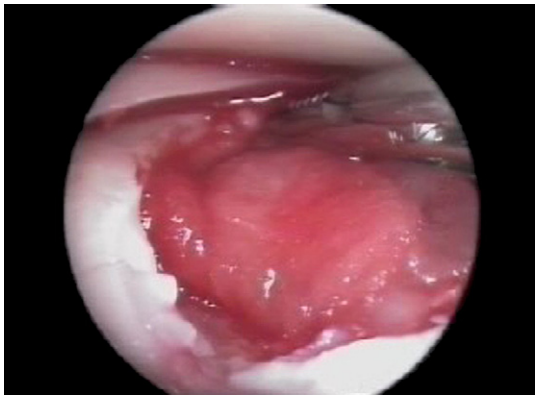

Fig. 3. Minimal pressure is applied on the membranes to achieve optimal contact with the underlying bone.

Fig. 4.

### 3.3. Post-operative rehabilitation protocol

Continuous passive motion was started the day after surgery 4 h daily with 1 cycle per minute until 90° of flexion is reached. In the following 3 weeks, passive range of motion was increased as tolerated. Foot touch weight bearing was permitted. Weight bearing was increased starting from 7 to 8 weeks, after obtaining plain radiographs of the osteotomy site confirming maintenance of the correction [15]. Rehabilitation was performed under the guidance of a physiotherapist from the end of the second post-operative week. Return to strenuous weight bearing activities was permitted 4 to 5 months after the procedure.

## 4. Results

The Lysholm score, Tegner score and the VAS score showed significant improvements from pre-operative to post-operative values (Table 2) ($P<0.05$). All patients showed improved IKDC scores: all had abnormal and severely abnormal pre-operative values. At post-operative follow up, seven patients had normal and nearly normal values, and one had abnormal value. The mean post-operative weight-bearing axis for all knees at final follow up was 2.8° (range 1°–4°) of valgus alignment.

All patients rated their surgery as successful and returned to their recreational sport activities (three patients returned to soccer, two to ski,

Table 2
Lysholm score, Tegner score and the VAS score before and after the index procedure

| | Pre-operative | Post-operative |
|---|---|---|
| Lysholm score | 65.7 (49–88) | 94.6 (89–100) |
| Tegner score | 3.7 (3–5) | 7 (5–8) |
| VAS | 7.2 (6–9) | 2 (0–5) |

and three to recreational running). No infective, neurological or vascular complications were detected. All osteotomies united uneventfully.

## 5. Discussion

We performed arthroscopic implantation of autologous chondrocytes combined with an opening wedge osteotomy on the medial side of the proximal tibia for the management of varus malalignment and chondral surface lesions of the medial tibial plateau. In our hands, this technique produced good results for the management of chondral defects, with statistically significant clinical improvements.

Cartilage repair procedures aim to obtain a mechanically durable graft that can resist high impact loading and wear and tear. Consequently, uncorrected mechanical malalignment is a contraindication to articular cartilage restoration.

HTO transfers mechanical loads to the unaffected compartment of the knee. The most common indications for HTO in a varus knee are medial compartment osteoarthritis, painful medial knee compartment with associated medial meniscus deficiency, articular cartilage defects, or osteochondritis dissecans lesions in adults [1,20].

HTO alone and conventional treatments that abrade or penetrate the subchondral bone (drilling or microfracture) produce fibrocartilaginous repair [21,22]. On the weightbearing surfaces of the knee, large areas of fibrocartilage are mechanically inferior and eventually deteriorate, necessitating additional intervention. Autologous chondrocyte implantation and transplantation of osteochondral grafts can provide adequate hyaline-like articular cartilage, which is better able to restore the durability and natural function of the knee joint [23]. Autologous chondrocyte implantation is used in cartilage injuries, and is classically undertaken using an arthrotomy. The major indications are symptomatic large full-thickness chondral lesions located on the femoral condyles and trochlear groove, with good clinical long-term results [3,4].

Autologous chondrocyte implantation and osteochondral grafting are contraindicated alone in the presence of tibiofemoral malalignment, which produces overload on the affected compartment of the knee, and subjects the repair tissue to mechanical overload [23].

Opening wedge HTO involves a relatively long period of restricted weight bearing post-operatively, which should allow better integration of the autologous chondrocyte implant. Furthermore, opening wedge HTO achieves precise correction, and allows accurate intra-operative ‘dialling in’ of the correction desired. Also, an opening wedge HTO involves one single bone cut, can easily be combined with other surgical procedures, and it is not necessary to mobilize the proximal tibiofibular joint [1]. Finally, peroneal nerve palsies and other neurological complications are rare, and it is easier to convert to a total knee replacement than a lateral closing wedge osteotomy [24,25].

The association of chondral resurfacing of chondral defects of femoral condyles with HTO can produce a good outcome [26–28]. However, no level I randomized controlled trails have been performed on this topic. The treatment of tibial chondral defects is not well described in literature because of the rarity of isolated full-thickness chondral defects of tibial plateau [29–34]. For this reason, in patients with simultaneous chondral defects of the medial tibial plateau and varus knee malalignment, we perform an opening wedge high tibial osteotomy plus arthroscopic autologous chondrocyte implantation.

We acknowledge that we did not consider a control group where only the HTO was performed. Also, we acknowledge that our study lacks second look surgery to verify the restoring of hyaline-like articular cartilage after autologous chondrocyte implantation on tibial plateau defect.

The relatively small sample size of our cohort and the lack of a control group preclude definitive conclusions. Nevertheless, in our hands the association of arthroscopic implantation of autologous chondrocytes with an opening wedge osteotomy on the medial side of the proximal tibia is a viable option for the management of medial tibial chondral defects in varus knees.

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