Case Report With Video Illustration

Arthroscopic Implantation of a Matrix to Cover Large Chondral Defect During Microfracture

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Abstract: Microfracturing techniques have been reported to be successful cartilage-restoring treatment options in defects of smaller sizes. The success may be limited by the size of the defect and the shoulder of the intact surrounding cartilage. We report a new technique using a 3-dimensional matrix to cover large cartilage defects during microfracture healing. In contrast to autologous chondrocyte implantation techniques, this technique is a 1-stage procedure. The defect cover consists of a resorbable polymer felt and sodium hyaluronan to induce hemostasis and to protect the underlying tissue. After conventional microfracture, the defect size is determined with an intra-articular measuring device, and the matrix is sized and introduced with an arthroscopic grasp. Depending on the size of the defect, the 3-dimensional matrix is fixed with 1 or 2 biodegradable pins perpendicular to the surface. The combination of the common microfracture technique with the implantation of the matrix leads to complete defect filling with cartilaginous repair tissue and therefore improves cartilage regeneration in the defect. We conclude that the introduced technique may be helpful in large cartilage defects combining the benefit of microfracturing and avoidance of the increased morbidity of matrix-associated autologous chondrocyte implantation. **Key Words:** Arthroscopic microfracture technique—Femoral condyle defect—Cell-free chondroinductive implant—Defect cover—Biodegradable pin—Cartilage regeneration.

Articular cartilage lesions are diagnosed with increasing frequency and are often associated with functional limitation and substantial morbidity. Murrell et al.[1] reported a high incidence of cartilage defects in patients after anterior cruciate ligament rupture with a mean size of 6 cm^2. Because of the poor spontaneous repair potential of the articular cartilage, several techniques for clinical treatment were developed.[2] Microfracture is one of the frequently used bone marrow–stimulating arthroscopic techniques to repair smaller symptomatic articular cartilage defects (<2 cm^2).[3] It is a first-line treatment option whose advantages are minimal invasiveness, technical simplicity, low morbidity, and cost-effectiveness. The method includes the penetration of the subchondral bone plate, which results in a clot forming in the defect.[4] Steadman et al.[5] reported a series of 72 patients with a mean 11-year follow-up who showed significant subjective improvement in Tegner, Western Ontario and McMaster Universities Osteoarthritis Index, Lysholm, and Short Form 36 scores. Recently, it has been hypothesized that a perpendicular shoulder of the cartilage defect as in traumatic cartilage lesions may be associated with better restoration of the cartilage defect.[2] A well-shouldered defect may show reduced shear and compression on the lesion, thereby allowing the formation of fibrocartilage.[2]

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Larger defects may be treated by use of matrix-associated autologous chondrocyte implantation (ACI). A downside of this procedure is that a staged procedure has to be used. After arthroscopic harvesting of chondrocytes and in vitro cultivation, the matrix is implanted in a second surgery.

Theoretically, a matrix to cover the microfractured area may offer several potential benefits for the marrow-stimulated regeneration. First, the blood clot will be held in place, and the matrix may support the adhesion to the shoulder in cases where the shoulder is not perpendicular to the defect. Second, by use of microfracture in combination with a 3-dimensional matrix (Chondrotissue; BioTissue Tech, Freiburg, Germany) and a new cell-free chondroinductive cover, which consists of a resorbable polymer felt and sodium hyaluronan, a defect cover to induce hemostasis and protect the underlying tissue is created.[6] This may be important in defects that are larger than 2 cm^2. Moreover, this approach, in contrast to ACI techniques, is a 1-step procedure. The combination of the common microfracture technique with the implantation of the cell-free implant can be performed arthroscopically and improves cartilage regeneration in the defect as shown previously in an ovine model.[7]

The aim of this report is to describe our surgical technique for arthroscopic matrix-covered microfracturing by use of a Chondrotissue matrix. We hypothesize that this technique is a safe and effective technique to address cartilage defects of larger sizes and may be able to produce a good clinical outcome.

CASE PRESENTATION

A 35-year-old male patient with a clearly defined cartilage defect of approximately 4 cm^2 at the lateral

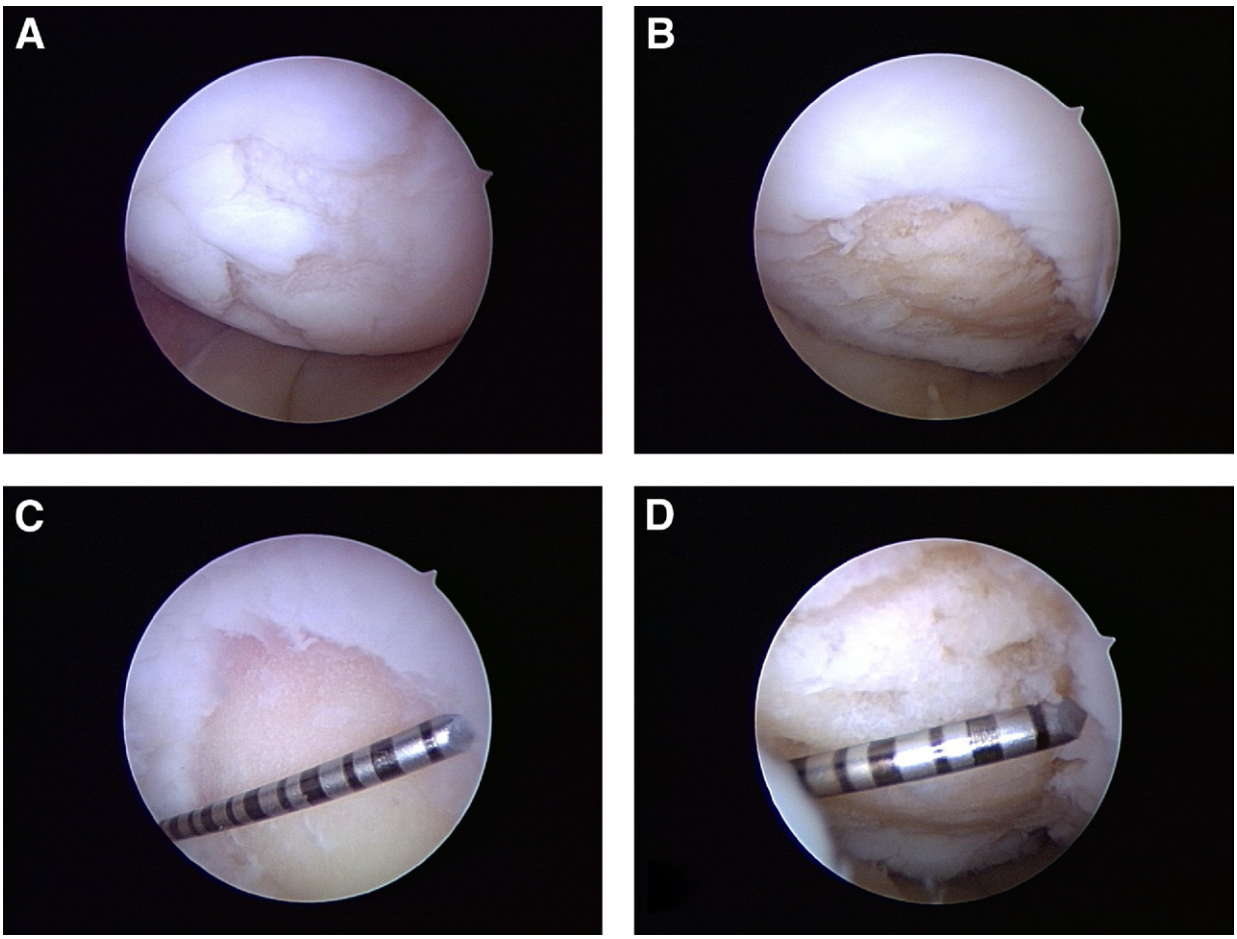

FIGURE 1. Arthroscopic view before debridement of (A) traumatic defect and (B) degenerative defect, and assessment of defect size with scaled needle after debridement of (C) traumatic defect and (D) degenerative defect.

femoral condyle (case 1) and a 54-year-old woman with a degenerative cartilage defect of approximately 3 cm^2 at the medial femoral condyle (case 2) were treated with microfracture in combination with Chondrotissue matrix. This matrix is a cell-free chondroinductive cover consisting of a resorbable polymer felt and hyaluronan.[7] The arthroscopic surgery is a 1-step procedure, using a standard high anterolateral portal, and standard arthroscopy is performed in the supine position.

In both patients clinical examination by use of the Lachman, pivot-shift, and Losee tests and magnetic resonance imaging (MRI) diagnostics showed no injury to the anterior cruciate ligament, posterior cruciate ligament, or the collateral complex of the medial collateral ligament and lateral collateral ligament. Measurements on weight-bearing standing radiographs showed no signs of varus or valgus malalignment.

SURGICAL TECHNIQUE

In both cases the same technical approach was used (Video 1, available at www.arthroscopyjournal.org). After complete inspection of the joints (Figs 1A and B) and assessment of the defects, the chondral lesions were carefully debrided down to the subchondral bone with a curette, spoon, and shaver until a stable shoulder surrounded the defect. The size of each defect was assessed by a specific scaled needle (Figs 1C and D).

Subsequently. microfracturing was performed with a 45° microfracturing awl (Karl Storz, Tuttlingen, Germany) (Fig 2A). After the microfracturing procedure, the polymer cover (Chondrotissue; BioTissue Tech) for each patient was immersed in 3 mL of autologous serum for 10 minutes and cut with a scalpel to the size of the defect. It was coiled up and introduced into the joint through a cannula (Karl Storz) and placed into the defect with an arthroscopic grasp instrument (Karl Storz) (Fig 2B). A special drill guide was inserted through an additional anteromedial portal at a perpendicular angle to the surface of the matrix. A 1.5-mm K-wire with a round tip was drilled into the subchondral bone through the implant in oscillating mode (Fig 3). Next, a bioresorbable pin (length, 16 mm) (Smart Nail; ConMed Linvatec, Largo, FL) was placed in the guide and carefully tapped into the subchondral bone (Fig 4). Care was taken to avoid any change of angle or position of the aiming device after the drill was retrieved and before the pin was inserted. The joint was flexed so that the drill guide could be placed on the posterior end of the scaffold. At that location, another hole was drilled with the K-wire and a second pin was inserted.[6,8]

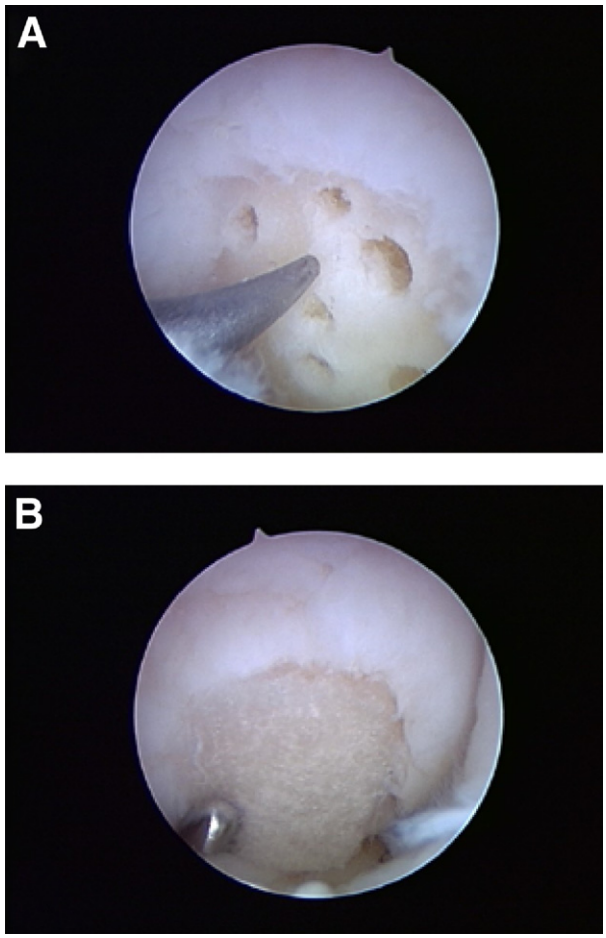

FIGURE 2. Microfracture procedure of (A) traumatic defect and (B) insertion of Chondrotissue matrix into defect.

CLINICAL RESULTS

The patients started continuous passive motion exercises directly on day 1 postoperatively and were mobilized with partial weight bearing on crutches for 6 weeks.[5]

At 12 months postoperatively, both patients were free of pain and discomfort. MRI was performed to assess the quality of cartilage regeneration 12 months after surgery. Volume filling of the defect by repair cartilage was measured by use of coronal and sagittal images and was graded as excellent based on the percentage of the defect that was filled.

MRI follow-up data showed that the traumatic defect (case 1) as well as the degenerative defect (case 2) was filled with cartilaginous repair tissue. The scans showed good filling of the defect with hyperintense repair tissue signal and smooth peripheral integration (Fig 5). The fixation of the Chondrotissue with

FIGURE 3. Fixation of matrix. (A) The matrix is cut to size in vitro. (B) The aiming device is placed perpendicular to the articular cartilage surface, and a drill hole is made with a 1.5-mm drill. (C) The drill is retrieved and care is taken to avoid any change in direction or angulation of the aiming device. (D, E) The implant is inserted into the cannulated aiming device and advanced gently by pushing the rod. (F) Subsequently, the implant is tapped through the matrix into the predrilled hole.

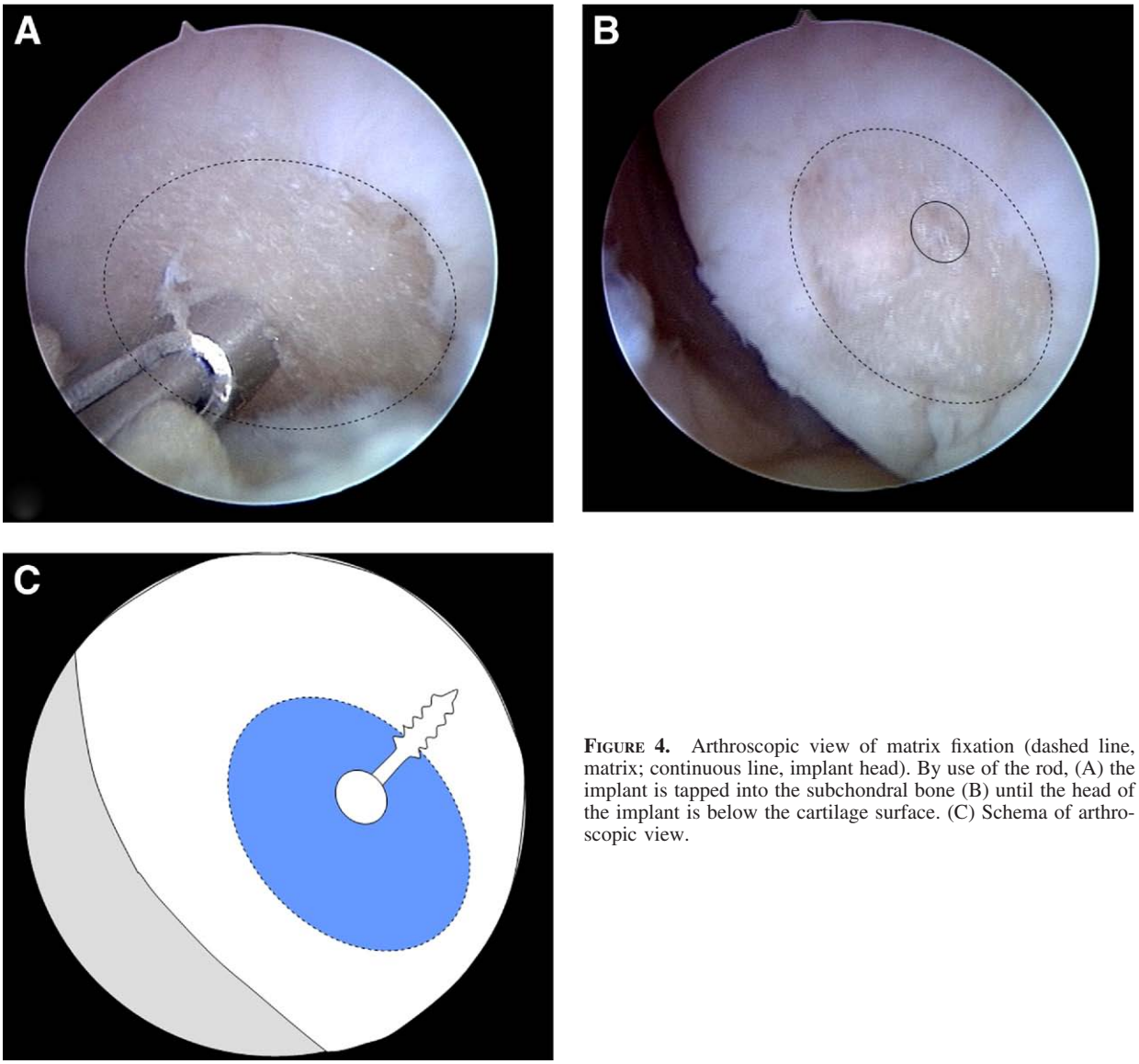

Figure 4. Arthroscopic view of matrix fixation (dashed line, matrix; continuous line, implant head). By use of the rod, (A) the implant is tapped into the subchondral bone (B) until the head of the implant is below the cartilage surface. (C) Schema of arthroscopic view.

Smart Nails was successful and stable. On MRI, a signal from the fixation was still visible after 12 months postoperatively (Fig 5B). No osseous overgrowth of the subchondral bone with resultant relative thinning of the overlaying repair cartilage could be detected.

DISCUSSION

The aim of this report was to present an arthroscopic technique using a 3-dimensional matrix to cover large cartilage defects. We used a new implant that covers and therefore protects the subchondral bone after microfracture. The clinical results after 12 months seem to support our initial hypothesis that this arthroscopic technique is safe and effective in addressing cartilage defects of larger sizes (Table 1).

Recent clinical studies[9] have indicated good clinical outcomes after microfracture in cartilage defects measuring less than 2 cm^2; however, Steadman et al.[10] reported an increased incidence of second surgery in patients after microfracture with degenerative cartilage damage. It has been recommended in the literature to use ACI techniques in larger cartilage defects to improve the clinical outcome.[2,11] The downsides of microfracture techniques could be solved by use of a

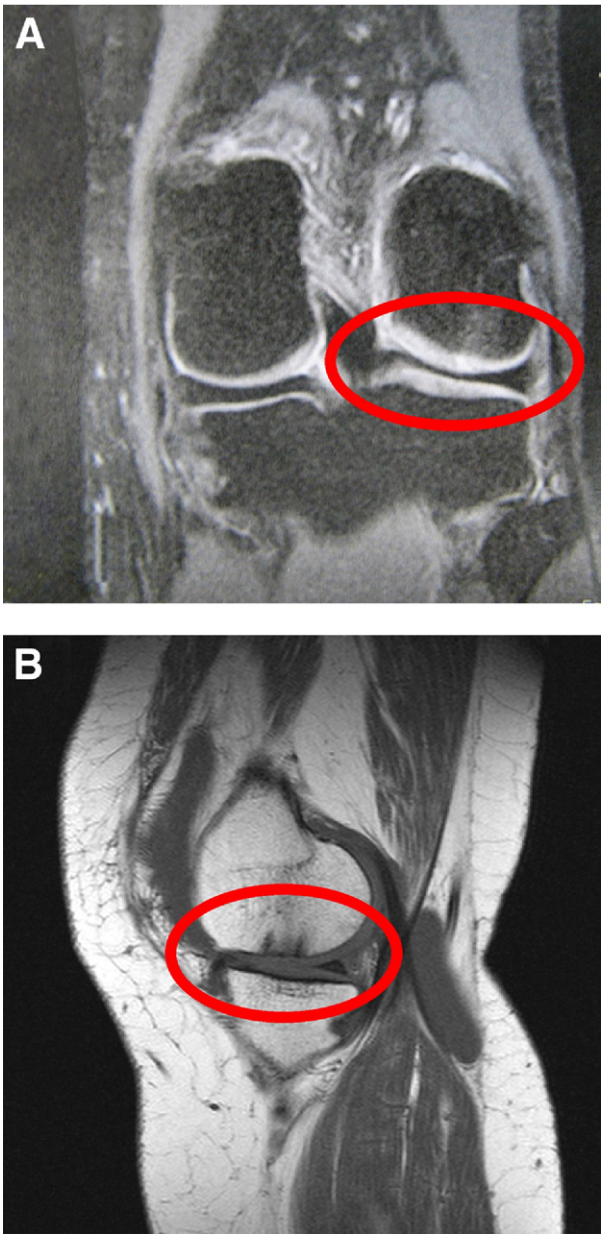

Figure 5. Cartilage regeneration of joints at 12 months postoperatively (circles): (A) treated traumatic defect and (B) treated degenerative defect.

matrix to cover the defect after microfracture. There is some evidence that this advanced microfracture technique might improve cartilage tissue regeneration. Complete defect filling was achieved with cartilaginous tissue as described recently in an animal study in sheep.[7] In our 2 cases we found no wound infections or other complications (e.g., intra-articular inflammation). A matrix consisting of type I/III collagen was used to treat local cartilage defects in the knee joint after microfracture.[12] In contrast to this cell-free technique, we used an implant with hyaluronan in combination with autologous serum for the recruitment of mesenchymal stem cells (MSCs) from the subchondral bone, which were allowed to enter the defect by microfracture. The recruitment of mesenchymal progenitor cells by blood serum was also shown previously.[7] Hegewald et al.[13] described the positive effect of hyaluronan on the re-differentiation of MSCs in 3-dimensional culture in vitro.

The combination of a bioresorbable matrix and recruitment and differentiation factors will help to keep the MSCs directly in the defect and prevent bleeding into the joint space. In addition, the differentiation of MSCs within the defect will be supported to build up regenerative tissue. The technique can be performed arthroscopically and is, in contrast to ACI techniques, a 1-step procedure. It is known that arthroscopic techniques are minimally invasive and therefore decrease the postoperative duration of rehabilitation and prevent muscular deficits and pain. In addition, the minimally invasive technique minimizes side effects such as scar formation, adhesions, and arthrofibrosis.[14]

The implant was fixed with bioresorbable nails, which ensure that the implant remains in the defect when the knee is flexed. The advantage of the fixation technique by bioresorbable nails consists of the initial more stable fixation of the implant compared with other techniques such as sutures or gluing.[8] When one is using this kind of fixation, it is extremely important that the pins are inserted perpendicular to the surface of the matrix. The use of a matrix to cover the microfractured area offers potential several benefits for marrow-stimulated regeneration. The matrix may be able to hold the blood clot in place, and the matrix may support the adhesion to the shoulder in cases where the shoulder is not perpendicular to the defect. Second, the Chondrotissue matrix may induce hemostasis

Table 1. *Advantages of Arthroscopic Matrix Implantation to Cover Chondral Defects During Microfracture (Chondrotissue)*

Safe and easy application
Application through 1-step approach
No second surgery necessary
Minimally invasive arthroscopic approach
Secure fixation using biodegradable pin solution
"Off-the-shelf" approach for larger cartilage defects
Matrix with high mechanical properties ensures good sizing and firm fixation
Matrix acts as construction for blood cells

and protect the underlying tissue that is created.[6] This may be important in defects that are larger than 2 cm^2. The combination of the common microfracture technique with the implantation of the cell-free implant can be performed arthroscopically and improves cartilage regeneration in the defect as shown in an ovine model previously.[7]

We conclude that the technique introduced in this report may be successful in addressing larger cartilage defects. It may be performed through a single-step arthroscopic approach and may be able to eliminate the morbidity that is associated with an arthrotomy when performing an open matrix-associated ACI.

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