Technical Note

Dry arthroscopy with a simple retraction technique for knee joint cartilage repair using allogenic human umbilical cord blood-derived mesenchymal stem cells

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Abstract: Mesenchymal stem cell treatment has become more widely available and has shown promising potential for the repair of knee articular cartilage defects. More recently, open arthrotomy has been performed via a para-patellar incision for cartilage repair using allogenic human umbilical cord blood-derived mesenchymal stem cells (hUCB-MSCs). However, arthroscopy allows better visualization and leads to earlier gain of the range of motion and less scar formation than open arthrotomy, especially in the knee joint. In this study, we present an easy and effective technique for arthroscopic hUCB-MSCs implantation without any special equipment.

Introduction

Cartilage repair of the knee joint is challenging, and there are various cartilage repair methods according to defect size.[1,2] Mesenchymal stem cell (MSC) implantation is a promising and evolving treatment for large cartilage defects and osteoarthritis of the knee joint.[3-6] Umbilical cord blood is one of the sources of MSCs that has been proven to be safe and effective.[7] Recently, several studies have reported successful implantation of allogenic human umbilical cord blood-derived MSCs for the repair of cartilage defects of the knee joint through a 3-5-cm arthrotomy incision.[8-13] Dry arthroscopic allogenic human umbilical cord blood-derived MSCs (hUCB-MSCs) implantation is not easy because soft tissue collapse and bleeding reduce the working space, especially in case of large cartilage defects. However, arthroscopy leads to earlier recovery and less scar formation than open arthrotomy. To create working space for dry arthroscopy, a simple suture or probe is used for soft tissue retraction.[14] In addition, special equipment such as a retraction plate[15] and CO_2 gas as a substitute for saline solution is used.[16,17] In this study, we introduce an easy and effective technique for dry arthroscopic hUCB-MSC implantation using a conventional arthroscopic device.

Surgical Technique (with Video Illustration)

Preparation of hUCB-MSCs

In this study, we used a mixture of hUCB-MSCs and hyaluronic acid (HA) (Cartistem; Medipost, Seongnam, Gyeonggi-do, South Korea) for the cartilage repair. The Korea Food and Drug Administration approved Cartistem as a therapeutic material for cartilage defect in January 2012. One vial (1.5 mL) of Cartistem contains 7.5×10^6 hUCB-MSCs. After confirming the size of a cartilage defect using MRI, the therapeutic dosage of Cartistem was decided. During the surgery, hUCB-MSCs were mixed with 4% HA, according to the manufacturer's instructions.

Patient Positioning and Arthroscopic Examination

The patient was placed in the supine position, and conventional arthroscopy was performed under spinal anesthesia. Cartilage repair using a mixture of hUCB-MSCs and HA was conducted by inserting a 30° arthroscope into the anterolateral (AL) portal. The Kwon's technique, a simple retraction technique, was then used for dry arthroscopic implantation (Video 1). Arthroscopic examination was performed through the anteromedial (AM) and AL portals. The cartilage defect

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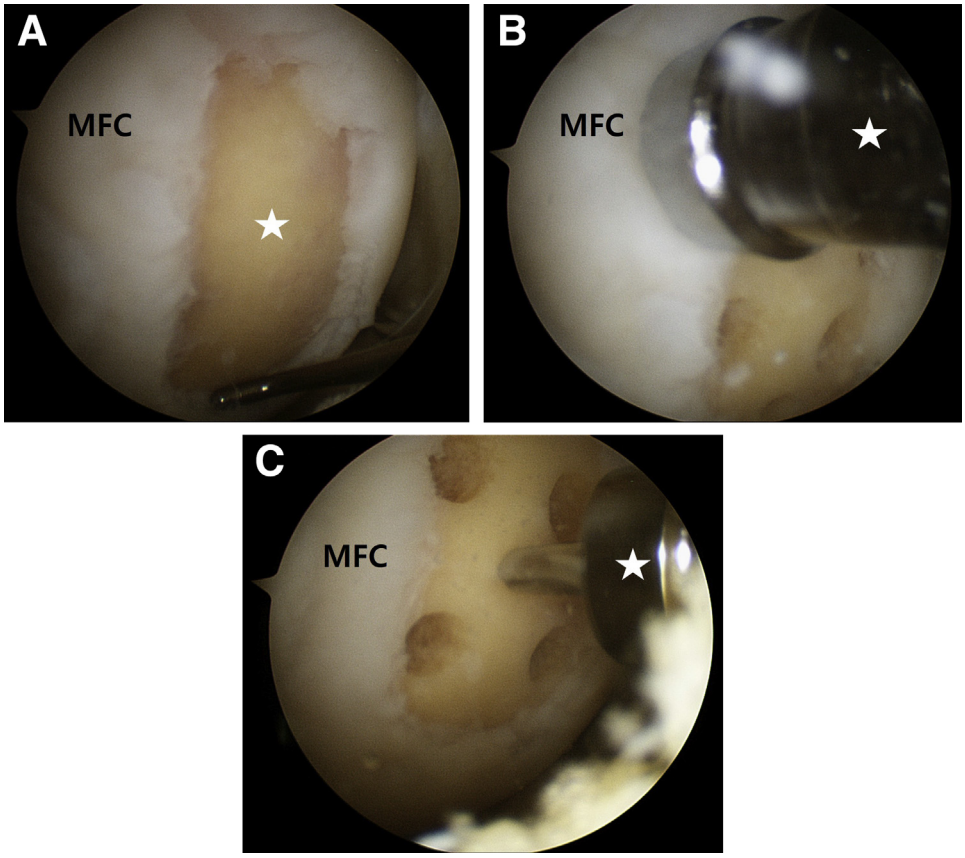

Fig 1. Arthroscopic view of the right knee through AL portal, while using the AM portal as the working portal. (A) The margin of a full-thickness chondral defect (star) in the MFC was debrided. (B) Multiple drill holes with a diameter of 4 mm drill bit (star) were created at the lesion site. (C) Multiple drilling with a 2-mm drill bit (star) was performed to create additional holes between the 4-mm holes. AL, anterolateral; AM, anteromedial; MFC, medial femoral condyle.

of the femoral condyle was debrided down to the bed of the underlying bone with a curette. After debridement with the clear margin of cartilage defect, multiple main holes with a circumference of 4 mm were created from the margin of the cartilage defect using a drill bit at 2-mm intervals. Then, additional holes with a diameter of 2 mm were created between the main holes (Fig 1, A-C). Then, irrigation was performed to wash out bone and cartilage debris.

Dry Arthroscopy with a Retraction Technique and the Implantation of a Mixture of hUCB-MSCs and HA

After multiple drilling and irrigation, under AL arthroscopic visualization, a spinal needle was inserted from the superomedial aspect of the medial femoral condyle (MFC) cartilage lesion to the anteroinferior aspect of the intercondylar notch. An additional spinal needle was inserted from the inferomedial aspect of the cartilage lesion to the anterosuperior aspect of the

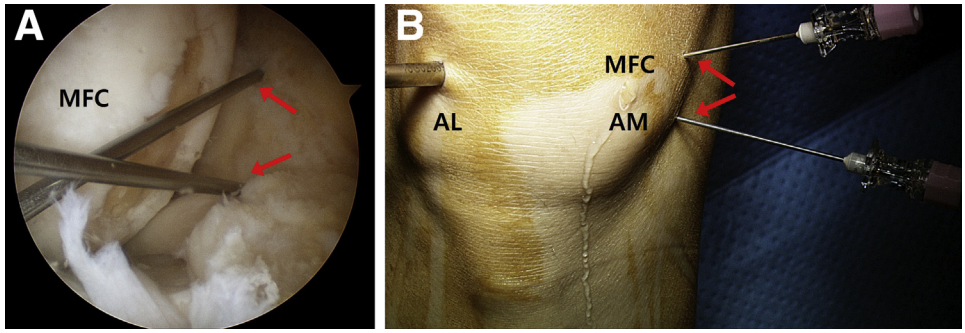

Fig 2. Arthroscopic view of the right knee through the AL portal. (A) Spinal needles (arrows) were inserted from the superomedial and inferomedial aspect of the MFC. The needles crossed over the anterior aspect of the MFC. (B) Extra-articular view of the spinal needles (arrows) inserted from the medial aspect of the knee joint. AL, anterolateral; AM, anteromedial; MFC, medial femoral condyle.

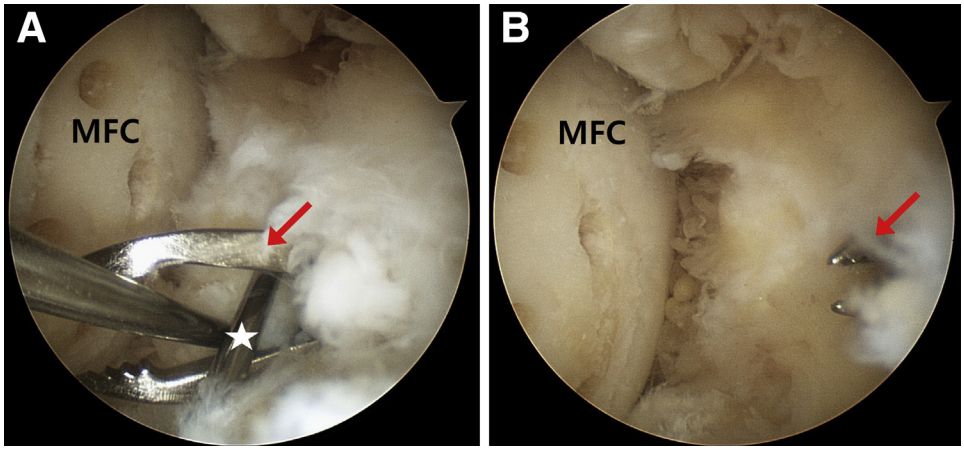

Fig 3. Arthroscopic view of the right knee through the AL portal. (A) Through the AM portal, a suture receiver (arrow) was inserted to grab the crossing point of two spinal needles (star). (B) The suture receiver (arrow) was retracted to enlarge the working space. AL, anterolateral; AM, anteromedial; MFC, medial femoral condyle.

intercondylar notch. Two spinal needles crossed over the cartilage defect (Fig 2, A and B). Through the AM portal, a suture receiver (KingFisher; Arthrex, Sheffield, United Kingdom) was introduced to grab the crossing point of the spinal needles and to retract it anteriorly for creating sufficient working space anterior to the cartilage defect (Fig 3, A and B). Another spinal needle was inserted aiming at the center of the cartilage defect for creating a working portal (Fig 4A). After confirming the location of the spinal needle, a far medial working portal was created (Fig 4B). Through the far medial working portal, fluid was drained from the joint space using a suction device such as a motorized shaver (Fig 4C). The valve on the arthroscopic sheath was opened to equalize pressure for better visualization.

After that, hUCB-MSCs and HA were mixed and implanted into the 4-mm drill holes. After filling the holes from the base to the surface by slowly injecting the mixture through the far medial working portal, the remnant mixture of hUCB-MSCs and HA was implanted into the 2-mm drill holes and onto the debrided subchondral bone surface (Fig 5, A and B). After the implantation, the knee was carefully extended. The wound was closed, and a cylinder splint was applied. The pearls and pitfalls of dry arthroscopic cartilage

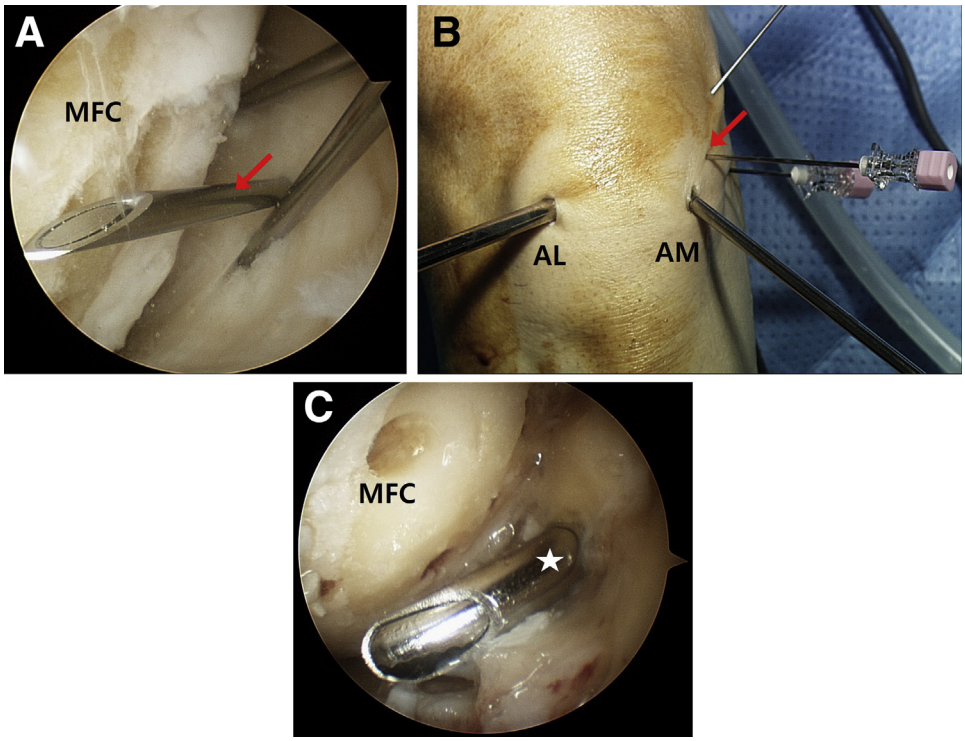

Fig 4. Arthroscopic view of the right knee through the AL portal, while retracting spinal needles using a suture receiver through the AM portal. (A) A spinal needle (arrow) was inserted targeting the center of the cartilage defect to create a far medial working portal. (B) Extra-articular view of the spinal needle though the far medial portal (arrow). (C) Fluid was drained out of the knee joint using a suction device through the far medial portal (star). AL, anterolateral; AM, anteromedial; MFC, medial femoral condyle.

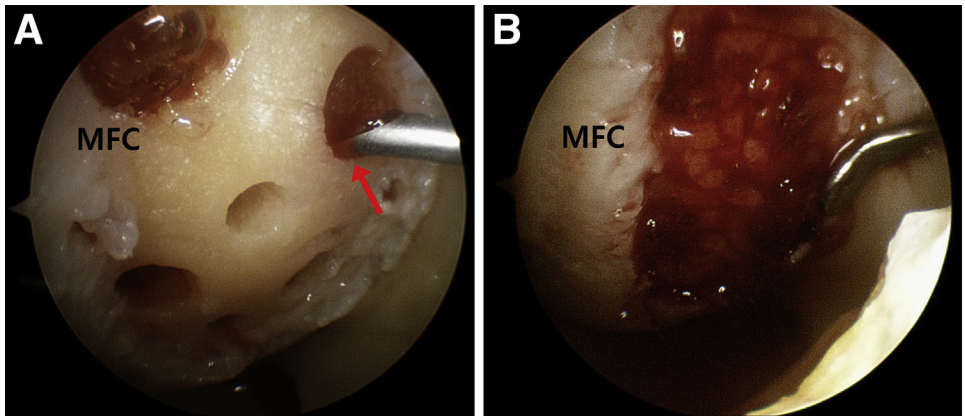

Fig 5. Arthroscopic view of the right knee through the AL portal, while retracting spinal needles using a suture receiver though the AM portal and using the far medial portal as the working portal. (A) After drying the chondral defect, the hUCB-MSCs and HA hydrogel composite was implanted into the 4-mm drill holes (arrow). (B) The hUCB-MSCs and HA hydrogel composite was implanted into the 2-mm drill holes and onto the surface of the lesion. AL, anterolateral; AM, anteromedial; HA, hyaluronic acid; hUCB-MSCs, human umbilical cord blood derived mesenchymal stem cells; MFC, medial femoral condyle.

repair using hUCB-MSCs are described in Table 1, while the tips are described in Table 2.

Rehabilitation

The cylinder splint was replaced with a knee brace on postoperative day 1. The patient started quadriceps setting and straight leg raise exercises while wearing the knee brace. Range-of-motion exercises using a continuous passive motion machine were started on postoperative day 3. Non-weight-bearing ambulation using a crutch was recommended for 3 months after the surgery. Gradual and tolerable increase in weight bearing was allowed thereafter.

Discussion

MSCs have been applied for cartilage regeneration and are becoming more widely available.[3,18] There are many sources of MSCs, including bone marrow, adipose tissue, and cord blood.[19] hUCB-MSCs are not invasively isolated and, they differentiate into chondrocytes with a high expansion capacity.[7] HA is a good scaffold for ameliorating MSCs function.[20] More recently, the mixture of hUCB-MSCs with HA has been used to repair large cartilage defects of the knee under arthrotomy.[8-13,21]

Arthroscopy allows better visualization due to magnification, provides easier access to the cartilage defect approaching from several different angles, and leads to earlier gain of the range of motion and less scar formation compared with arthrotomy. However, arthroscopic hUCB-MSCs implantation is not easy because the collapse of anterior soft tissue might make the working space smaller and remnant saline solution might dilute hUCB-MSCs. Simple evacuation of the fluid in the knee joint and opening of the inflow and outflow ports of a trocar sleeve were used, but these measures were not sufficient for the repair of large cartilage defects. Therefore, open arthrotomy using a 3-5-cm incision often has been used for hUCB-MSCs implantation.[8-13,21]

To achieve successful dry arthroscopy and safe implantation, several techniques have been applied to

Table 1. Pearls and Pitfalls of Dry Arthroscopic Cartilage Repair Using hUCB-MSCs

Pearls	Pitfalls
Access to the entire drilling hole is necessary for proper cartilage preparation and hUCB-MSCs implantation.	Before dry arthroscopy, retraction needle positioning and far medial working portal creation should be completed in conventional arthroscopy with saline solution.
The holes should be created as close as possible for better coverage of the cartilage defect, but drilling should be performed carefully to avoid connecting neighboring holes, which might cause subchondral fracture.	During the implantation of hUCB-MSCs, the surgeon should try to avoid the use of a suction device to prevent the loss of hUCB-MSCs.
hUCB-MSCs were implanted into the large main holes to fill them from the bottom to the surface, and the remaining hUCB-MSCs were sequentially implanted into the small additional holes and onto the surface of lesion.	

hUCB-MSCs, human umbilical cord blood-derived mesenchymal stem cells.

Table 2. Tips for Dry Arthroscopic Cartilage Repair Using hUCB-MSCs

Keep an arthroscopic trocar tap open to the air to prevent joint collapse.
Use a spinal needle as a suction device to drain saline solution from the main holes.
Use neuropatties to dry the surface of cartilage defects.

hUCB-MSCs, umbilical cord blood-derived mesenchymal stem cells.

other cartilage defect repair methods.[14-17,22] Heng et al. recommended the use of a switching stick or probe as a soft tissue retractor and the application of traction sutures to keep wet soft tissue away from the lesion.[14] Shetty et al. and DeFroda et al. used CO_2 gas instead of saline solution to keep the knee joint fluid-free.[16,17] Sadlik et al. applied a special plate for soft tissue retraction.[15,22] However, the use of switching stick and probe can only retract a small amount of tissue. Traction suture technique might be inconvenient because it cannot be modulated after suturing. Dry arthroscopy using CO_2 gas is expensive and may cause a gas-induced vascular embolism. The traction plate technique cannot be performed without this special device. Therefore, a safe and effective technique that can be performed without any special equipment is needed.

In this study, we described dry arthroscopic knee cartilage repair using crossed spinal needles, and a suture receiver. Our technique has several advantages over the others. First, it is simple and easy to perform. It only requires usual arthroscopic equipment, including two spinal needles and a suture retriever. Second, the working space can be modulated according to the retraction power. Third, depending on the position of the spinal needles, the technique can be applied in any compartment of the knee joint, including the patellofemoral joint. However, this technique has a limitation. It requires an additional far medial working portal. Nevertheless, it is much better than making a 3-5-cm incision line for open arthrotomy. To date, no case series has been reported using this technique. Our early experience suggests that the rates of cartilage recovery achieved by this technique are similar to the results of open arthrotomy.

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