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Letter to the editor

Combined autologous chondrocyte implantation and meniscus reconstruction for large chondral defect in the lateral compartment due to discoid lateral meniscus tear: A case report

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A B S T R A C T

Discoid lateral meniscus tear leads to large chondral defect in the lateral compartment of the knee joint. There are few effective treatments for large chondral defect in both the tibial and femoral sides with severe degenerative lateral meniscus. We have developed a combined autologous chondrocyte implantation and meniscus reconstruction technique using hamstring tendon. This technique allows biological reconstruction and avoids knee arthroplasty.

1. Introduction

The lateral meniscus can have some anomalies, such as discoid shape, ring shape, or double-layers [1,2]. A discoid lateral meniscus has been reported to be more common in the Asian population [1]. Discoid lateral meniscus has a role in the maintenance of knee articular cartilage; however, an untreated or partially resected torn lateral discoid meniscus can lead to articular cartilage degeneration and large chondral defect in the lateral compartment of the knee joint [3,4].

Distal femoral osteotomy has been reported to be effective for lateral osteoarthritis of the knee with valgus knee deformity [5]. However, most Asians have varus knee alignment [6]; therefore, few patients have valgus knee deformity, even with the presence of large chondral lesion in the lateral compartment of the knee joint. We have developed a novel technique of biological reconstruction in the lateral compartment of the knee joint.

For large chondral defect, autologous chondrocyte implantation (ACI) is considered. Since April 2013, the J-TEC Autologous Chondrocyte Cultured Cartilage (JACC®; Japan Tissue Engineering Co., Ltd., Aichi, Japan) has been covered by the Japanese health insurance. Currently, it remains the only autologous cartilage implantation method used in Japan.

We have three cases (one female and two male patients, aged 57, 50, and 39 years, respectively) with large chondral defects due to discoid lateral meniscus tear, which were treated by combined ACI and meniscus reconstruction. However, only the female patient has been followed for more than 1 year postoperatively. Although all the cases showed good postoperative course, we present a case that had a second-look arthroscopy 1 year postoperatively. This report aimed to describe the combined meniscus reconstruction and ACI technique for both tibial and femoral sides.

2. Case presentation

A 57-year-old female presented with 10 years of left knee joint pain and limited range of motion. The range of motion of the left knee was 140 degrees of flexion, with extension lag of 15°. The initial examination revealed mild patellar floating after a patellar tap test. Anterior drawer test, posterior drawer test, Lachman test, pivot-shift test, posterior drawer test, and valgus and varus stress tests were negative. McMurray test was positive with pain and click on the lateral joint line. The knee injury and osteoarthritis outcome score (KOOS) was 62.5 points, while the 5 sub-scores (symptoms, pain, activities of daily living, sports and recreational activities, and quality of life) were 64.3, 50.0, 75.0, 60.0, and 37.5 points, respectively. The Lysholm knee score was 68 points.

Preoperative images of the left knee joint were taken. Plain radiograph (frontal view) showed lateral joint space narrowing (Fig. 1a). Computed tomography (coronal cross-section) showed irregularity of the subchondral bone surface of the lateral compartment (Fig. 1b). Magnetic resonance imaging (coronal view) showed severe chondral defects of the articular cartilage on the femoral and tibial sides of the lateral compartment (Fig. 1c).

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Abbreviations: ACI, autologous chondrocyte implantation; ICRS, International Cartilage Repair Society; JACC®, J-TEC Autologous Chondrocyte Cultured Cartilage; KOOS, Knee injury and Osteoarthritis Outcome Score.

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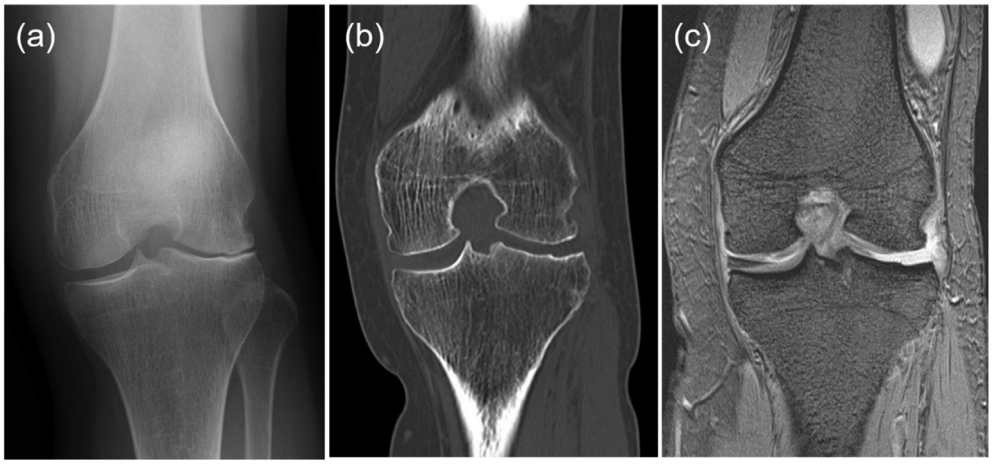

Fig. 1. Preoperative images. (a) Plain radiograph (frontal view) showing lateral joint space narrowing. (b) Computed tomography (coronal cross-section) showing irregularity of the subchondral bone surface of the lateral compartment. (c) Magnetic resonance imaging (coronal cross-section) showing severe chondral defect of the articular cartilage on the femoral and tibial sides of the lateral compartment. The middle segment of lateral meniscus cannot be seen.

Arthroscopic assessment and harvesting of normal cartilage were performed 4 weeks before the surgery, including ACI, during which arthroscopic synovectomy, meniscectomy, and excision of intra-articular free bodies were performed. A posterior part of discoid lateral meniscus with complex tear remained (Fig. 2a). Subchondral bone was exposed at both the tibial and femoral sides (Fig. 2b). More than 0.4 g of chondral fragments was harvested and brought to the J-TEC laboratory plant using an exclusive culture kit (Fig. 2c).

Four weeks after the first surgery, the next operation was performed. The patient was placed in a supine position on the operating table. An air tourniquet was placed on the thigh joint. A side support unit was placed at the lateral side of the knee, which should be kept at a 90° position during the arthroscopic surgery.

A midline skin incision was made, and a parapatellar approach was performed.

For tibial autologous chondrocyte implantation, the intra-articular space was opened and the remaining, irreparable lateral meniscus was excised (most were subtotally excised during initial arthroscopy). A surgical burr was used to smoothen and level the subchondral bone under the extensive chondral defect of the lateral tibial plateau. On the tibial side, 1.4-mm-diameter curved JuggerKnot® soft anchors (ZimmerBiomet, Biomet Sports Medicine, Warsaw, IN, USA) were inserted around the lateral tibial plateau every few centimeters (Fig. 3a). Three-dimensionally cultured autologous chondrocyte sheets were implanted (Fig. 3b) onto the lateral tibial articular facet and covered with periosteum. The surgical thread from the JuggerKnot® soft anchor was used for suturing (Fig. 3c).

For meniscus reconstruction, the semitendinous tendon was harvested as a graft. Both ends were sutured using baseball glove suture technique. The periosteum was wrapped around the inner portion of the semitendinous tendon and fixed by attraction. From the anterior surface of the tibia, a foramen was created on the anterior and posterior horns of the lateral meniscus with a 4.5- to 5.0-mm-diameter cannulated drill on the lateral tibial joint. The graft was passed through the foramen and fixed to the lateral tibial joint on top of the tibial periosteum using the surgical sutures from the JuggerKnot®, which uses periosteal sutures. The inside-out method was used to suture the graft to the articular capsule at various sites. Sutures from both stumps protruding from the anterior part of the tibia were fixed at optimal tension using the Arthrex Attachable Button System® (Arthrex Inc., Naples, FL, USA) (Fig. 3d).

For the femoral ACI, a surgical burr was used to smoothen and level the subchondral bone under the lateral femoral condyle chondral defect. Three-dimensionally cultured autologous chondrocyte sheets were implanted (Fig. 3e) and covered with periosteum (Fig. 3f). The periosteum was fixed using a 1.0-mm-diameter ZimmerBiomet JuggerKnot® soft anchor (ZimmerBiomet, Biomet Sports Medicine, Indiana, USA). The border along the normal cartilage was tightly fixed with 6-0 nylon sutures at 2-mm intervals. Localized chondral lesion on the medial femoral condyle (ICRS grade 3) was treated with osteochondral transfer. Two osteochondral plugs (8-mm diameter) were transplanted to the chondral lesion of the medial femoral condyle (Fig. 3f).

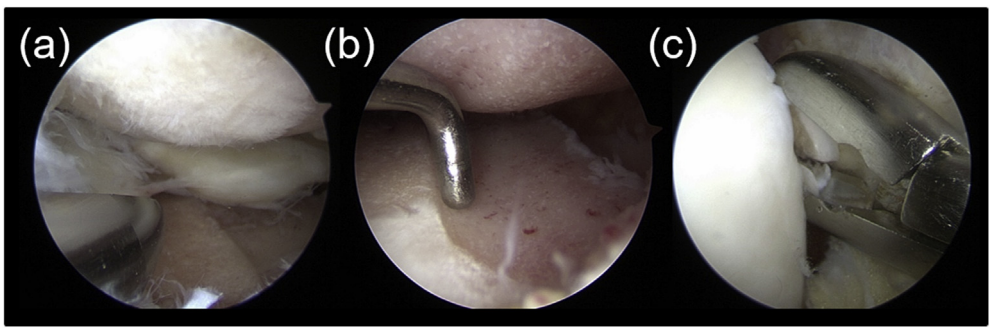

Fig. 2. Preoperative arthroscopic findings. (a) The remaining, irreparable, unstable discoid lateral meniscus is resected. (b) Severe chondral deficit and irregularity in the subchondral bone were observed in the lateral femoral condyle and lateral tibial plateau of the lateral compartment. (c) Normal chondral fragments were harvested from the non-weightbearing areas for autologous chondrocyte implantation.

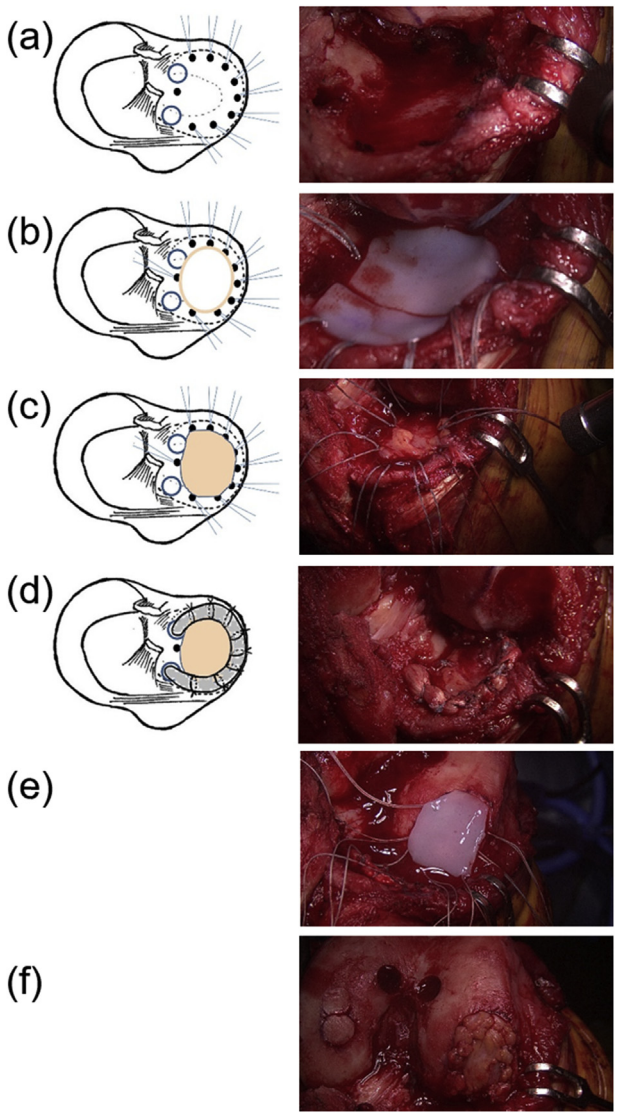

Fig. 3. Autologous chondrocyte implantation on the lateral compartment and lateral meniscus reconstruction. (a) After leveling the lateral tibial plateau, a foramen for lateral meniscus reconstruction is created and anchored on the rim of the lateral tibial plateau. (b) An autologous chondrocyte sheet is implanted onto the leveled lateral tibial plateau surface. (c) The implanted chondrocyte sheet is covered with periosteum and fixed with sutures from the anchors. (d) The semitendinous tendon was inserted as a graft and the anchor sutures were fixed. After the site of the chondral defect in the lateral femoral condyle is leveled, the autologous chondrocyte sheet is implanted. (e) The autologous chondrocyte sheet implanted into the lateral femoral condyle is covered with periosteum.

Postoperative rehabilitation included mild range of motion exercises 2 weeks postoperatively, aiming for full range of motion after 3 months, and partial weightbearing at 6 weeks postoperatively. This progressed to full weightbearing after 8 weeks. Jogging was permitted 9 months postoperatively.

Postoperative images of the left knee joint were taken one year after the surgery. Plain radiograph showed lateral joint space opening (Fig. 4a). Computed tomography showed that the subchondral bone irregularity of the lateral tibial plateau had improved (Fig. 4b). Magnetic resonance imaging showed the transplanted cultured cartilage sheets during the maturation process in the lateral compartment (Fig. 4c).

A second-look arthroscopy was conducted 1 year postoperatively to evaluate the condition of the autologous chondrocyte implant and meniscus reconstruction sites (Fig. 5).

One year postoperatively, each of the KOOS and Lysholm knee scores was 100 points and demonstrated great improvement. Seventeen months after the surgery, the range of motion of the left knee was 150 degrees of flexion, with no extension lag, and the patient was able to walk without pain.

3. Discussion

Neglect of a discoid lateral meniscus tear and malreduction of a tibial plateau fracture can cause lateral compartment osteoarthritis [3,4]. Meniscal damage is often present in plateau fractures [7]. Unstable lateral meniscus damage can cause progression of lateral compartment osteoarthritis, in addition to the malreduction of a lateral tibial plateau fracture [8]. The lateral meniscus is instrumental in the preservation of the joint cartilage in all cases. Therapy outcomes for discoid lateral meniscus vary, and sometimes might result in an even worse condition [3,4]. Progression of cartilage degeneration occurs in more than 30% of cases, even after meniscoplasty [4]. Discoid lateral meniscus is related to lateral compartment osteoarthritis. It is difficult to ameliorate a patient's symptoms (such as range of motion limitations, pain, hydrarthrosis) solely through arthroscopic partial meniscectomy to address the progression of cartilage degeneration in the lateral compartment after damage or through resection of a discoid lateral meniscus.

Generally, surgical management of lateral compartment osteoarthritis includes osteotomy and unicompartmental and total knee arthroplasties [9,10]. Although unicompartmental and total knee arthroplasties are effective, they may not necessarily be satisfactory for active or young patients [11]. Osteotomy is considered for young patients who are very active. Distal femoral osteotomies are considered for isolated lateral compartment arthritis accompanied by valgus deformation [5]. Discoid lateral meniscus is more common in Asia than in the West [1]. Varus knee alignment is frequent among Asians. There are also cases of progressive cartilage degeneration in the lateral compartment in which valgus is not present. The present treatment method was performed in patients with mechanical axis <55%, severe cartilage lesion in the lateral compartment (International Cartilage Repair Society classification grade 3 or 4), and severely degenerative lateral meniscus (irreparable torn discoid lateral meniscus or loss). We believe that this technique is useful for severe cartilage degeneration of the lateral compartment not accompanied by evident valgus deformity. It is suggested that midterm clinical results are improved by distal femoral osteotomy in combination with cartilage restoration [12]. This technique can also be used together with distal femoral osteotomy if valgus deformity is evident.

In July 2012, ACI, which was developed by Ochi et al. [13], was approved by the Japanese Ministry of Health, Labour and Welfare as the first orthopedic cell therapy in Japan. Since April 2013, J-TEC Autologous Chondrocyte Cultured Cartilage (JACC®) has been covered by the Japanese health insurance. The only ACI currently covered by insurance in Japan in 2018 is JACC® (J-TEC). JACC® is an ACI that requires periosteal coverage; however, the autologous chondrocyte sheet has been cultured three-dimensionally and has the characteristics of a third-generation ACI [14]. It is the only effective treatment method that enables chondral restoration via ACI for severe chondral defects. One advantage is that restoration is feasible with the hyaline cartilage-like tissue, which is similar to articular cartilage. Engraftment and maturation of the implanted chondrocyte sheet are time-intensive processes; thus, failure of the implant due to premature weightbearing or lower extremity muscle weakness is a cause for concern [15]. Tight suturing upon periosteal coverage is required to prevent premature leaking of the cultured cartilage before engraftment can take place. However,

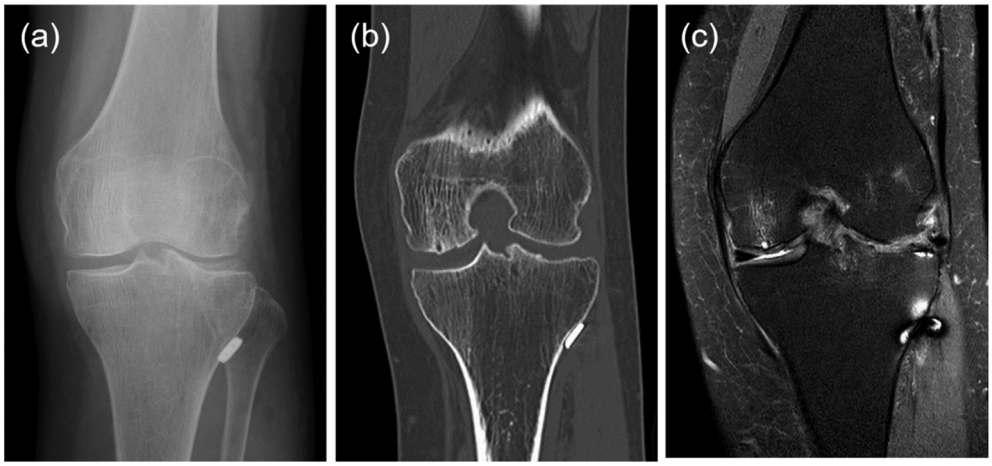

Fig. 4. One-year postoperative images. (a) Plain radiograph showing the lateral joint space opening, compared with the preoperative condition. (b) Computed tomography (coronal cross-section) showing that the subchondral bone irregularity of the lateral tibial plateau has improved. (c) Magnetic resonance imaging (coronal cross-section) confirming that the transplanted chondral sheet is undergoing maturation process in the lateral compartment.

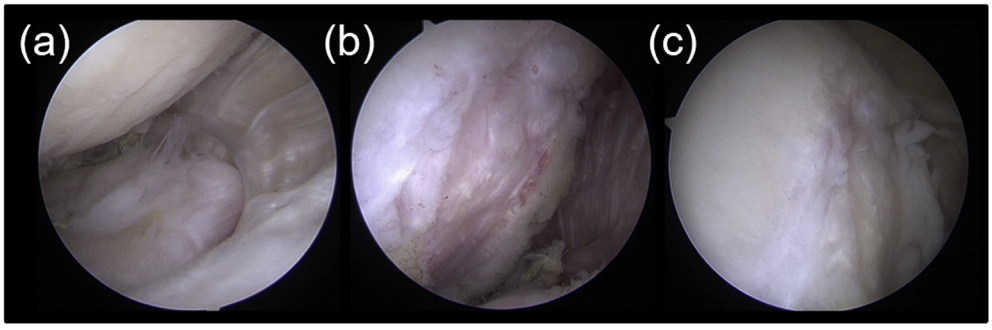

Fig. 5. Second-look arthroscopic findings. (a) The lateral meniscus reconstructed with the semitendinous tendon is integrated with the joint. The periosteum remains at the site of the tibial autologous chondrocyte implantation (ACI), and there are no signs of detachment, hypertrophy, or delamination. (b) Although there was mild fibrillation around the ACI on the femoral side, the ACI engraftment is satisfactory, and there are no signs of detachment, hypertrophy, or delamination. (c) The border between normal articular cartilage and ACI on the lateral femoral condyle.

accomplishing the task is extremely difficult due to the confined working space at the tibial side. This method reduces the burden on and the leakage of the implant with the use of hamstring tendons around the rim of the implant for meniscus reconstruction.

The use of a meniscal allograft implant for irreparable lateral meniscus has been reported [16]. Allografts are not widely used in Japan because institutional problems make implementation difficult. Transplantation of autologous tissue using tendon has been reported [17–19]. However, satisfactory results were seldom obtained due to compromised mechanical properties, poor angiogenesis, and difference in the shape [20]. Therefore, previously reported autologous tissues have not been considered good substitutes for meniscus in clinical cases [21]. The meniscus reconstruction method in this technique, which uses autologous tissue, such as semitendinosus and gracilis tendons, can be performed in Japan. Restoring similar functionality akin to normal menisci remains difficult, but our second-look arthroscopic findings revealed restoration of structures analogous to menisci. In our technique, autologous grafts are transplanted on the periosteum used for ACI. This is significantly different from previous reports. The autologous graft implanted as a meniscal substitute may be engrafted with the periosteum on the tibia and joint capsule together.

In this report, a novel technique is introduced as a pilot study. While our cases indicated excellent short-term results, mid- or long-term results are still unclear. It is of concern that progression of osteoarthritis occurs with time. Long-term follow-up is necessary.

This type of regenerative medicine is ever-expanding, but the field is heavily influenced by practitioner acumen, surgical techniques, and development of operative procedures. The researchers hope that this technique will contribute to further development of ACI.

4. Conclusion

A novel method of lateral meniscus reconstruction using hamstring tendon was introduced. We have only three cases and have presented one case with second-look arthroscopic findings. This has been suggested as a possibly effective method for advanced chondral degeneration in the lateral compartment in the knee; however, long-term results are needed.

Ethical statement

All procedures done were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and in accordance with the Helsinki Declaration of 1964 and its later versions.

Informed consent

Informed consent was obtained from all patients included in the study.

Conflict of interest

The authors declare no conflict of interest.

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