Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology 20 (2020) 1–5

Contents lists available at ScienceDirect

Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology

journal homepage: www.ap-smart.com

Original Article

Early chondral damage following meniscus repairs with anterior cruciate ligament reconstruction

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ARTICLE INFO

Article history:
Received 30 October 2019
Received in revised form
10 January 2020
Accepted 16 January 2020

Keywords:
Anterior cruciate ligament reconstruction
Chondral damage
Meniscal repair

ABSTRACT

Background: Meniscal tears are commonly observed in patients with anterior cruciate ligament (ACL) injuries. Meniscal repair has become a common procedure for the injured meniscus, and good clinical outcomes have been reported in such cases when used concurrently with ACL reconstruction. However, it is unclear whether early chondral damage progression can be prevented following meniscal repair with ACL reconstruction, as meniscal damage is a potential risk factor for the development of osteoarthritis. The purpose of this study was to evaluate the zone-specific chondral damage that occurs after arthroscopic meniscal repair with concomitant ACL reconstruction. Our hypothesis was that meniscal repair with ACL reconstruction would not decrease the rate of progression of chondral damage compared to that observed in isolated ACL reconstruction with intact menisci.

Methods: This study included 40 patients who underwent anatomic double-bundle ACL reconstruction. We divided the patients into the following two groups: Group A with an intact meniscus (20 knees) and Group M requiring meniscal repair (20 knees). Chondral damage was evaluated arthroscopically in six compartments and 40 sub-compartments, and these features were graded using the International Cartilage Repair Society lesion classification. The cartilage damage in each sub-compartment and compartment was compared between the two groups both at reconstruction and at second-look arthroscopy (average 16 months postoperatively). At the latest follow-up examination (average 37 months postoperatively), the International Knee Documentation Committee (IKDC) score was compared between the two groups.

Results: Group M had a significantly worse cartilage status than Group A in five sub-compartments (mainly in the medial compartment) at reconstruction and in nine sub-compartments (mainly in the bilateral compartments) at second-look arthroscopy. The mean IKDC score was better in Group A than in Group M (Group A; 90 vs. Group M; 86). The overall success rate of meniscal repairs was 92% (23 of 25 menisci) at second-look arthroscopy.

Conclusion: The progression of post-traumatic chondral damage may occur at a faster rate in patients who require ACL reconstruction and meniscal repair than in patients with intact menisci.

Introduction

The absence of a functioning anterior cruciate ligament (ACL) is now accepted as a risk factor for progression to post-traumatic knee osteoarthritis (OA), as it induces abnormal kinematics of the knee.[1] In addition, the menisci themselves are also known to contribute to knee stability as secondary restraints. They are considered to carry 40%–70% of the load across the knee and they play a role in shock

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https://doi.org/10.1016/j.asmart.2020.01.001

Table 1
Patient demographics.

	Group A	Group M	P value
Cases (knees)	20	20	
Gender (male: female)	9 : 11	7 : 13	0.519
Age (years)	22.3 ± 6.3	27.5 ± 9.7	0.059
Height (m)	1.67 ± 0.07	1.63 ± 0.07	0.107
Weight (kg)	67.8 ± 13.9	65.8 ± 14.1	0.711
Body mass index (kg/m^2)	24.1 ± 3.4	24.6 ± 4.2	0.363
Duration (months)			
from injury to reconstruction	3.5 ± 3.4	6.2 ± 7.9	0.314
from reconstruction to second-look	16.0 ± 6.5	16.4 ± 4.3	0.421

Data of age, height, weight, body mass index, and durations are presented as a mean ± standard deviation.

absorption, proprioception, and enhancement of stability.[2] Knees without a functioning meniscus may have a worse outcome due to increased local contact pressure and decreased contact area on the articular cartilage.[3] Meniscal tears are commonly observed in patients with ACL injuries, with a reported prevalence of approximately 60%.[4]

The main options for meniscal tear management are either partial meniscectomy or meniscal repair.[5] Partial meniscectomy is the most commonly used treatment option for the majority of meniscal tears; however, meniscal resection, in addition to ACL reconstruction (ACLR), is considered to be a significant risk factor for post-traumatic OA.[6] However, in recent years, meniscal repair has become a common procedure for the injured meniscus.[1] It is also considered a successful procedure in conjunction with ACLR and is increasingly preferred over meniscectomy.[7] Current recommendations include aggressive repair of meniscal tears in association with ACLR because of the existing evidence suggesting that tears that extend into the avascular zone can heal and are potentially functional.[8]

However, there are few reports of radiographic outcomes after meniscal repair with ACLR. Furthermore, the occurrence of early chondral change in such cases is unclear. To date, no studies have used second-look arthroscopy to compare the changes in cartilage status after meniscal repair with ACLR. Some reports have demonstrated that meniscal damage is a potent risk factor for the development of chondral damage.[9,10] We hypothesized that more chondral damage would be observed in meniscal repair with ACLR than in isolated ACLR with intact menisci at reconstruction and second-look arthroscopy. The purpose of this study was to compare the zone-specific cartilaginous damage after meniscal repair with ACLR and that after isolated ACLR.

Material and methods

Patients

This study was approved by our Institutional Review Board, and written informed consent was obtained from all included patients. We retrospectively reviewed and examined 64 knees in 64 patients who underwent double-bundle ACLR between 2014 and 2017. We excluded 18 knees that did not undergo second-look arthroscopy or where there was a lack of data, three knees that underwent partial meniscectomy for degenerative or complex tears, two knees that underwent bone marrow stimulation for severe cartilage damage and 1 knee that had a graft re-rupture. The remaining 40 knees (40 patients) were enrolled in the study and divided into the following two groups: Group A with an intact meniscus (20 knees) and Group M requiring meniscal repair (20 knees). Mean follow-up period was 37.4 months (range: 24–74 months). There were no cases of multiple ligament injury. Patient demographics are shown in Table 1. The location-specific cartilage damage was compared between the two groups at reconstruction and during second-look arthroscopy. The location and types of meniscal tears were evaluated at reconstruction, and the healing status of repaired menisci was evaluated during second-look arthroscopy (average 16 months postoperatively).

Methods

Surgical technique

Double-bundle arthroscopic ACLRs were performed using hamstring-tendon autografts in all patients. The femoral and tibial bone tunnels were created using an outside-in technique within the ACL footprints as previously described.[11] Femoral fixation was achieved using either a Tight Rope RT (Arthrex, Naples, FL) or an Endobutton system (Smith & Nephew, Andover, MA).[12] Tibial fixation was performed with the knee flexed at 20° using double-spike plates (Meira, Aichi, Japan), with an initial tension of 20 N for the posterolateral (PL) bundle and 30 N for the anteromedial (AM) bundle.

Different surgical options were used depending on the degree of cartilage damage; either debridement or no treatment was selected for relatively mild cartilage damage, as in cases with International Cartilage Repair Society (ICRS) grades 1 to 3. Bone marrow stimulation, such as microfracture or drilling, was used for severe cartilage damage as in the case of ICRS grade 4.

Meniscal injuries were treated by meniscal repair. Both the medial meniscus (MM) and lateral meniscus (LM) were repaired using an inside-out technique for middle third and bucket-handle tears, an all-inside repair technique for posterior horn tear or ramp lesions, and a pullout repair technique for the posterior root tears.

Postoperative rehabilitation protocols

In Group A, all patients wore a knee brace for 1 week to promote initial healing of the graft. Weight-bearing was initiated at week 2 postoperatively. Full weight-bearing was permitted at 4 weeks postoperatively, running at 5 months, and a return to sports at 8 months. In Group M, all patients wore a knee brace for 2 weeks, and knee range-of-motion exercises and partial weight-bearing were initiated at week 2 postoperatively. Full weight-bearing was permitted at 5 weeks postoperatively, and the rest of the protocol was the same as in Group A.

Methods of assessment

Evaluation of clinical and radiological outcomes

At the latest follow-up examinations, the International Knee Documentation Committee (IKDC) knee examination form, side-to-side difference of KT-2000, and a pivot shift test were used to collect the clinical outcomes. The Kellgren-Lawrence (KL) grade was evaluated independently as the radiological outcome by two orthopaedic surgeons blinded to the procedures. All measurements were compared between reconstruction and the latest follow-up in both groups.

Evaluation of meniscal healing

During second-look arthroscopy, meniscal healing was classified as complete healing (no defect in the repaired meniscus), partial healing (a partial-thickness defect was visible), or failure (there remained a large defect at the torn area) as reported previously.[13] Complete and partial healing were defined as success of meniscal healing.

Evaluation of cartilage injury

Cartilage injury was independently evaluated via arthroscopy in

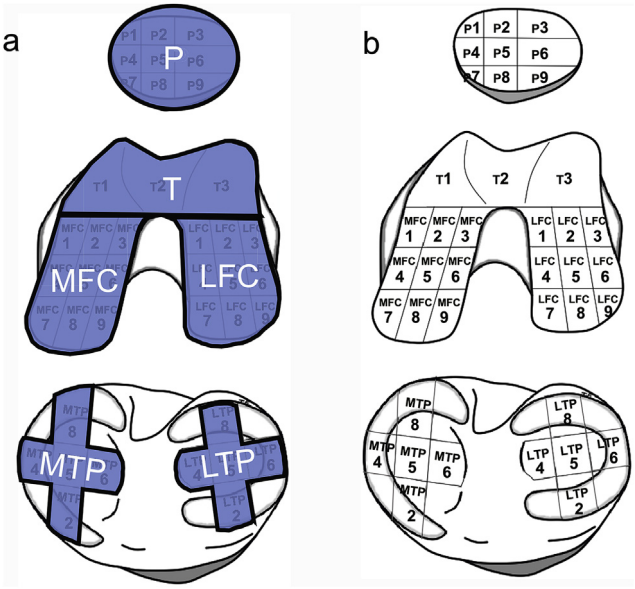

Fig. 1. Evaluation of cartilage lesions.
a. Six compartments (P, patella; T, trochlea; MFC, medial femoral condyle; MTP, medial tibial plateau; LFC, lateral femoral condyle; LTP, lateral tibial plateau). b. Forty sub-compartments. Each compartment was divided into sub-compartments.

the six compartments and in 40 sub-compartments as shown in Fig. 1. Each sub-compartment was evaluated according to the modified ICRS articular cartilage injury classification, which combined the subclassifications in each grade and was used as a point-addition scoring system as reported previously.[14] The same score, as evaluated in the ICRS grade, was given to the sub-compartment. The average sub-compartment score was described in each sub-compartment as shown in Figs. 2 and 3. Each compartment score was calculated as the sum of all scores for the sub-compartments belonging to that compartment, for semi-quantitative evaluation. Two orthopaedic surgeons independently evaluated the cartilage status at reconstruction and after second-look arthroscopy. Each observer performed each evaluation twice, at least 2 weeks apart. Both sub-compartment and compartment scores were compared between the two groups at reconstruction and at second-look arthroscopy.

Statistical analysis

Statistical analyses were performed using EZR (Saitama Medical Centre Jichi Medical University, Saitama, Japan). The Mann–Whitney U test was used to compare the values of clinical data or sub-compartment scores and compartment scores between Group A and Group M. Statistical significance was set as $p < 0.05$. The inter-observer reproducibility and intra-observer repeatability were assessed, with an intraclass correlation coefficient (ICC) > 0.83 considered as a reliable measurement.

Results

Clinical and radiographic outcomes

Preoperatively, there was no significant difference between the two groups for the average IKDC score, side-to-side difference of KT-2000, and the positive pivot shift test (Table 2).

At the latest follow-up (37 months postoperatively), IKDC score was lower in Group M than in Group A, but no significant difference was seen between the two groups. For the average side-to-side

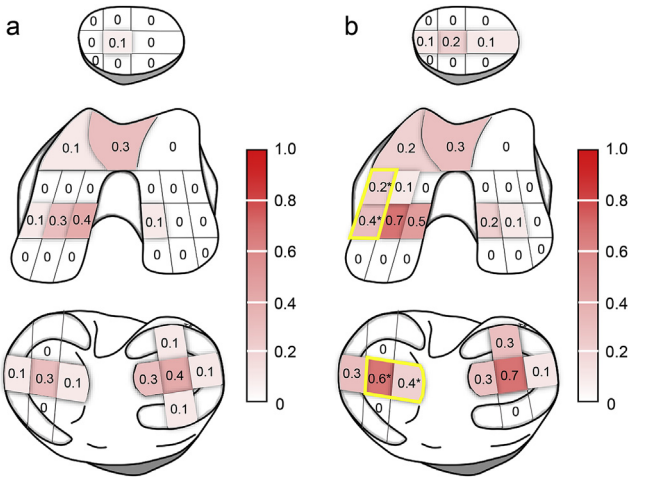

Fig. 2. Sub-compartment scores at reconstruction. The value described in this figure shows the average sub-compartment score.
a. Group A.
b. Group M. * shows the sub-compartments where significant worsening was found.

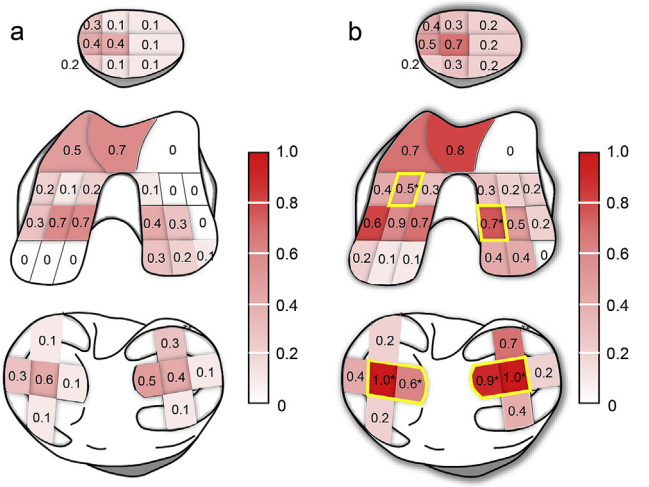

Fig. 3. Sub-compartment scores at second-look arthroscopy. The value described in this figure shows the average subcompartment score.
a. Group A.
b. Group M. * shows the sub-compartments where significant worsening was found.

difference of KT-2000 and positive pivot shift test, no significant difference in the values at reconstruction and at the latest follow-up (37 months postoperatively) was found between the two groups. The KL grade at reconstruction and the latest follow-up remained the same (Table 2).

The evaluation of meniscal tears

For the overall population, MM tears were seen in six knees, LM tears in nine knees, and both MM and LM tears in five knees. The tear site of the MM was the body in one knee, posterior in nine knees, and body to posterior in one knee. The type of MM tear was longitudinal in eight knees, radial in two knees, and a bucket-handle tear was seen in one knee. The tear site of the LM was body to posterior in two knees, posterior in eight knees, and posterior root in four knees. The type of LM tear was longitudinal in six knees, radial in six knees, horizontal in one knee, and complex in one knee. The overall success rate of meniscal repairs was 92% (23

Table 2
Clinical and radiographic outcomes at preoperative and latest follow-up.

	Preoperative			Latest follow-up		
	Group A	Group M	P value	Group A	Group M	P value
IKDC score	63.0 ± 15.8	59.8 ± 20.5	0.458	89.7 ± 8.8	86.1 ± 11.4	0.454
Side-to-side difference of KT-2000 (mm)	3.6 ± 1.5	5.1 ± 3.1	0.096	0.5 ± 0.9	−0.1 ± 1.6	0.064
Pivot shift test (positive)	20	20		0	0	
Kellgren-Lawrence grade (0/1/2/3/4)	18/ 2/ 0/ 0/ 0	10/ 7/ 3/ 0/ 0		18/ 2/ 0/ 0/ 0	10/ 7/ 3/ 0/ 0	

Data of International Knee Documentation Committee (IKDC), side-to-side difference of KT-2000 are presented as a mean ± standard deviation.

Table 3
Arthroscopic evaluation of the cartilage compartments at reconstruction.

	Group A	Group M	P value
Patella	0.1 ± 0.3	0.3 ± 0.7	0.310
Trochlea	0.4 ± 1.1	0.4 ± 0.9	0.469
MFC	0.8 ± 1.0	1.9 ± 2.5	0.047*
MTP	0.4 ± 0.8	1.3 ± 1.0	0.004*
LFC	0.1 ± 0.3	0.4 ± 0.7	0.091
LTP	0.9 ± 1.6	1.3 ± 1.6	0.119

Medial femoral condyle, MFC. Medial tibial plateau, MTP. Lateral femoral condyle, LFC. Lateral tibial plateau, LTP. The condition of the articular cartilage was graded according to the International Cartilage Repair Society (ICRS)-articular cartilage injury classification. Data are displayed as a mean ± standard deviation. *P < 0.05.

Table 4
Arthroscopic evaluation of the cartilage compartments at second-look arthroscopy.

	Group A	Group M	P value
Patella	1.5 ± 1.9	2.9 ± 3.4	0.103
Trochlea	1.2 ± 1.4	1.5 ± 1.2	0.137
MFC	2.1 ± 1.6	3.8 ± 3.0	0.048*
MTP	1.1 ± 1.4	2.4 ± 1.5	0.002*
LFC	1.2 ± 2.2	2.9 ± 2.7	0.001*
LTP	1.2 ± 1.5	3.0 ± 1.8	0.001*

Medial femoral condyle, MFC. Medial tibial plateau, MTP. Lateral femoral condyle, LFC. Lateral tibial plateau, LTP. The condition of the articular cartilage was graded according to the International Cartilage Repair Society (ICRS)-articular cartilage injury classification. Data are displayed as a mean ± standard deviation. *P < 0.05.

of 25 menisci) during second-look arthroscopy.

Cartilage grade of each sub-compartment

The inter-observer reproducibility and intra-observer repeatability were considered high, with mean ICC values of 0.85 and 0.87, respectively. The average sub-compartment score at reconstruction is shown in Fig. 2. In Group M, significant worsening was seen in four sub-compartments, including the medial femoral condyle (MFC) 1/4 and medial tibial plateau (MTP) 5/6, compared with that in Group A at reconstruction ($p < 0.05$). The average sub-compartment score during second-look arthroscopy is shown in Fig. 3. In Group M, significant worsening was seen in six sub-compartments, including MFC 2, MTP 5/6, LFC 4, and lateral tibial plateau (LTP) 4/5 compared to that in Group A during second-look arthroscopy ($p < 0.05$).

Cartilage grade of each compartment

The compartment scores of each group at reconstruction and at second-look arthroscopy are shown in Tables 3 and 4, respectively. Significant worsening was noted in Group M at the MFC and MTP compartments ($p < 0.05$) at reconstruction (Table 3) and in Group M at the MFC, MTP, LFC, and LTP during second-look arthroscopy ($p < 0.05$) (Table 4).

Discussion

The most important finding of this study is that more cartilage loss was observed in Group M than in Group A at reconstruction and second-look arthroscopy and the cartilage loss was similarly different at these two points. This finding indicates that the repaired meniscus might have functions similar to the intact meniscus.

Given the advances in arthroscopic surgery, the recommended treatment for pathologic conditions of the meniscus has changed from total meniscectomy to partial excision, and currently to repair.[15] There are some reports of meniscal repair concurrent with ACLR. Melton et al. reported that long-term IKDC scores in patients undergoing ACLR and meniscal repair remain better than those in patients undergoing ACLR and partial meniscectomy.[15] There are further reports demonstrating good clinical outcomes or meniscal healing after meniscal repair concurrent with ACLR.[7,16] In this study, favourable clinical scores and meniscal healing rates were obtained, and they were comparable with these reports. However, Group M had worse clinical outcomes than Group A, which may correlate with a faster progression of chondral damage. Surgeons should pay careful attention to the progression of chondral damage and appearance of knee symptoms in patients undergoing meniscal repair with ACLR.

Several reasons were considered for OA progression after ACLR and meniscal repair. A substantial alteration in tibiofemoral motion has been reported in patients who have undergone ACLR, resulting in the altered loading on the knee cartilage and the progression of early OA.[17] A biomechanical study showed that double-bundle ACLR was better able to restore knee function[18]; in this study, double-bundle ACLRs were performed in both groups. However, early chondral changes progressed faster in Group M than in Group A in the early postoperative stage. This result suggests that, although the torn menisci were repaired at reconstruction and most of these had healed successfully at second-look arthroscopy, they might not possess the secondary restraining characteristics of the native meniscus. Further biomechanical investigation after meniscal repair with concomitant ACLR is required. In the current study, age and body mass index were higher in Group M than in Group A. These variables have been reported as contributing factors to meniscal injury or cartilage damage.[19] Furthermore, duration from ACL injury to reconstruction was longer in Group M, which is also a risk factor for OA due to the absence of structures contributing to knee stability. Past literature has shown an increasing frequency of meniscal injuries with increasing time between injury and surgical intervention.[20,21] There is also a report of increased OA among patients with longer times between injury and reconstruction.[22] Early intervention for ACL injury may be recommended because of a perceived high risk of additional injuries in patients who continue to participate in daily activities.

There are some limitations to this study. It has a small sample size and is a retrospective study with a short follow-up period. More importantly, the cartilage status and clinical outcomes were not evaluated according to the type or location of the meniscal tear.

Finally, the cartilage status in patients with partial meniscectomy and ACLR was not addressed in this study. As mentioned, meniscal resection was a strong risk factor for OA, and we therefore compared meniscal repair with intact menisci. Further examination with a larger sample size, and the evaluation of OA changes according to the meniscal tear location will be required.

Conclusion

Progression of OA could not be prevented by meniscal repair with double-bundle ACLR to the same degree as isolated ACLR with an intact meniscus. However, the cartilage loss was similarly different at two different points, which indicated that the repaired meniscus might have functions similar to the intact meniscus.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors, and no material support of any kind was received.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgements

We thank Editage (http://www.editage.jp) for English language editing.

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