

Case Report

Simultaneous medial opening wedge high tibial osteotomy and revision anterior cruciate ligament reconstruction using a bone-patella tendon-bone graft: A case report

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It is said that the clinical results of cases with anterior cruciate ligament reconstruction (ACLR) who have knee osteoarthritis (OA) are not very good. A case of simultaneous medial opening wedge high tibial osteotomy (MOWHTO) and revision ACLR using a bone-patella tendon-bone (BPTB) graft for medial knee OA after re-tear of a reconstructed ACL graft is reported.

The patient was a 49-year-old man who underwent surgery for a right knee ACL injury by ACLR using an ipsilateral hamstring tendon graft 7 years earlier. He sprained his right knee while he was skiing and injured his reconstructed ACL graft. He had knee instability and pain at the medial side of his knee. X-ray showed a tibia vara deformity and medial knee OA of Kellgren-Lawrence grade II. It was thought that the medial knee pain would remain if he were treated by revision ACLR alone. Therefore, simultaneous MOWHTO and revision ACLR using an ipsilateral BPTB graft were performed. The excellent clinical results and radiological findings 3 years after the operation indicate the usefulness of this approach.

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Introduction

Injuries of the anterior cruciate ligament (ACL) usually occur in sports activity. Because of their low natural healing rate^{1,2}, most cases are treated operatively. Cases of ACL injury seldom develop knee osteoarthritis (OA) because they mostly occur in teenagers. However, we sometimes encounter a case of ACL injury with knee OA in patients whose knees give way frequently. Patients who have tibia vara also sometimes develop knee OA. ACL reconstruction (ACLR) improves knee instability even in the presence of knee OA, but it does not improve the knee pain from knee OA completely^{3,4}. It, therefore, has been considered that ACLR is not a good

option for patients with concomitant knee OA.

For medial knee OA of young or middle-aged patients, high tibial osteotomy (HTO) achieves stable pain relief with activities of daily living⁵⁻⁷. The combination of simultaneous HTO and ACLR for ACL injury with knee OA has been reported from the 1990s⁸⁻¹². Development of rigid fixation by a medial locking plate system accelerated postoperative rehabilitation. As a result, good return to sports activity was reported following simultaneous HTO and ACLR¹³.

A case of a torn ACL graft of hamstring tendons followed by medial knee OA after 3 years is reported. This patient underwent simultaneous medial opening wedge HTO (MOWHTO) and revision ACLR using a bone-patella tendon-

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bone (BPTB) graft. The good short-term outcomes at 3 years in this case are reported.

Case

The patient was a 49-year-old man who injured the ACL of his right knee when he fell from a truck platform 7 years earlier. He was treated surgically by the anatomical two-route ACLR using ipsilateral hamstring tendons. He returned to sports activity and was making steady progress. He sprained his right knee when he was skiing 3 years earlier and re-injured the right reconstructed ACL graft. His knee started to repeatedly give way, and his medial knee pain increased. He was treated conservatively by his doctor for 3 years. He returned to our hospital for surgery because his knee instability and pain were getting worse.

He had no particular family history or past history except for the primary ACLR of the right knee. His general condition and blood tests were all good.

Ballottement of the patella was negative in both knees. The range of motion of both knee joints was normal, with zero degrees of extension and 145 degrees of flexion. The McMurray test was negative in both knees. The Lachman test and pivot shift test were positive in the right knee, indicating ACL insufficiency. Anterior translation of the tibia measured by the KT-2000 knee arthrometer (MED metric Corporation, San Diego, CA) was 13 mm in the right knee and 9 mm in the left knee (Table 1). There was a 4-mm side-to-side difference between the knees.

According to the radiological assessment, the P-A X-ray of Rosenberg's view showed that the medial joint space of the right knee was narrower than that of the left knee by 1.3 mm. There were osteophyte formations at the medial side of the tibia and the intercondylar space of the femur. The medial knee OA was Kellgren-Lawrence¹⁴ grade II (Figure 1). The long leg standing A-P X-ray showed that the femoro-tibial angle (FTA) was 186 degrees in the right knee and 179 degrees in the left knee. The hip knee angle (HKA, valgus is positive and varus is negative) was minus 10.4 degrees in the right knee and minus 5.8 degrees in the left knee. The percentage of the mechanical axis (%MA) was 10% in the right knee and 28% in the left knee, indicating severe varus deformity in the right knee. The mechanical lateral distal femoral angle (mLDFA) was 86 degrees, the medial proximal tibial angle (MPTA) was 79 degrees, and the joint line convergence angle was 2.7 degrees, indicating that the reason for the varus knee was primarily the medial inclination of the tibial plateau. The lateral X-ray view showed that the posterior tibial slope (PTS), the complementary angle between the center shaft of the tibia and the tangential line of the medial tibial plateau, was 17 degrees (Table 2). The MRI of the right knee showed no primary reconstructed ACL graft intensity on T2-weighted imaging. Cartilage wear of the medial femoro-tibial (FT) joint and a horizontal tear of the medial meniscus were also seen (Figure 2).

This case was diagnosed as a tear of the primary reconstructed ACL graft with medial knee OA, and simultaneous HTO and revision ACLR were planned.

Table 1. Clinical findings of knee joints

	Pre operation		Three years after operation
	Right	Left	Right
Ballottement of patella	(-)	(-)	(-)
extension [degrees]	0	0	0
flexion [degrees]	145	145	145
McMurray test	(-)	(-)	(-)
Lachman test	(+)	(-)	(-)
Pivot shift test	(+)	(-)	(-)
Anterior translation of tibia (KT-2000 manual max) [mm]	13	9	10

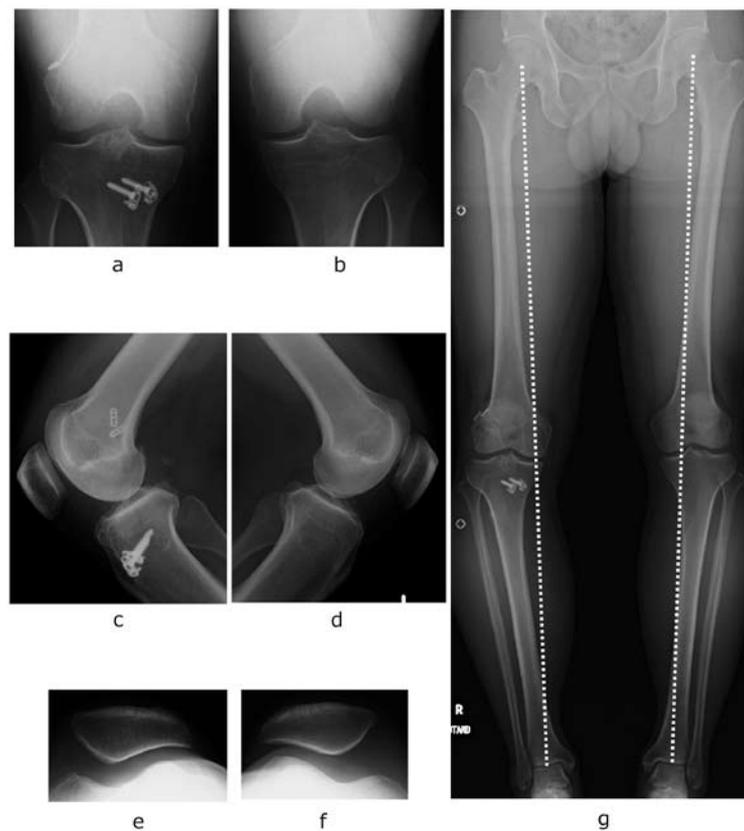


Figure 1 Preoperative X-ray

- Rosenberg's view of the right knee: slight narrowing of medial joint space / osteophytes of the medial proximal tibia and intercondylar space
- Rosenberg's view of the left knee
- Lateral view of the right knee: primary ACL graft fixation device
- Lateral view of the left knee
- Skyline view of the right knee
- Skyline view of the left knee
- Bilateral long leg standing A-P X-ray: dotted line is the weight-bearing line

Table 2. X ray deformity analysis of lower legs

	Pre operation		Three years after operation
	Right	Left	Right
Femoro-Tibial Angle [degrees]	186	179	168
Hip Knee Angle [degrees]	-10.4	-5.8	6.2
% Mechanical Axis [%]	10	28	73
mechanical Lateral Distal Femoral Angle [degrees]	86	85	87
Medial Proximal Tibial Angle [degrees]	79	80	96
Joint Line Convergence Angle [degrees]	2.7	1.6	2.8
Posterior Tibial Slope [degrees]	17	17	15

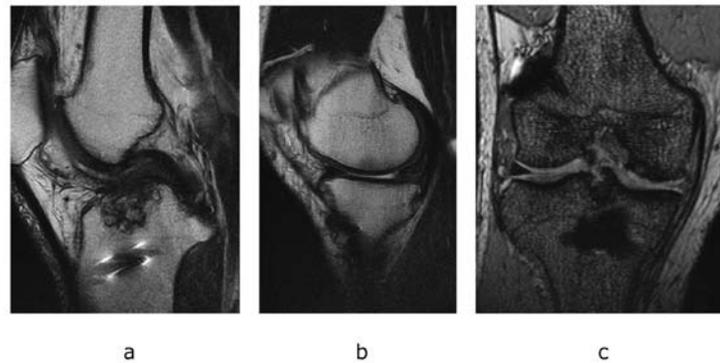


Figure 2 Preoperative MRI of the right knee
 a. T2WI sagittal: reconstructed ACL graft tear
 b. T2WI sagittal: cartilage wearing of the medial FT joint
 c. T2*WI coronal: medial meniscus tear/cartilage wearing of the medial FT joint

Preoperative planning

An ipsilateral BPTB graft for revision ACLR was planned because the ipsilateral hamstring tendons had already been used for primary ACLR. The rectangular bone tunnel technique for revision ACLR developed by Shino et al¹⁵ was used. It creates a narrow tunnel that is just sufficient to achieve stabilization, which allows its flexible positioning and anatomical fiber recruitment. The Double Spike Plates (DSP; Smith-Nephew Endoscopy, Andover, MA) were used for femoral and tibial side graft fixation.

MOWHTO was planned for correction of varus alignment. The target postoperative %MA was 62%¹⁶. The correction angle and opening height were determined by Miniaci's methods¹⁷. It was planned to insert the wedge shaped β -TCP (OSferion 60; OLYMPUS Corporation, Tokyo, Japan) into the opening site, with fixation of the opening site by the TomoFix™ Medial High Tibial Standard plate (TomoFix plate; DePuy Synthes trauma, West Chester, PA).

Operation

On arthroscopy, the reconstructed ACL graft at primary ACLR was torn, thin, and slack (Figure 3a). The cartilage injury at the medial femoral condyle and medial tibial plateau was International Cartilage Repair Society (ICRS)¹⁸ grade II (Figure 3b). The medial meniscus was partially resected due to the horizontal tear at the middle and posterior segments. The lateral meniscus was intact. There was no cartilage injury at the lateral FT joint or the patello-femoral joint.

The torn ACL graft was debrided, and the soft tissue around the previous femoral bone tunnels was dissected. The

previous tunnels were positioned within the anatomical ACL insertion. A skin incision was made at the lateral distal thigh, and the femoral bone surface was exposed. Two pieces of Endobutton-CL (Smith & Nephew plc, Andover, MA) that were used at primary ACLR were removed. A Kirschner wire (K-wire) was inserted into the previous femoral tunnel of the antero-medial (AM) bundle. Another K-wire was inserted 5 mm distal from the K-wire of the AM tunnel. These K-wires were overdrilled by a 5-mm-diameter endoscopic drill. Two drill holes were dilated to create a rectangular bone tunnel by a 5 x 11-mm cannulated dilator (Smith & Nephew plc) using outside-in technique.

An 8-cm-long oblique skin incision was made at the proximal medial part of the lower leg and exposed pes anserinus. Two DSPs used at primary ACLR were removed. A K-wire was inserted into the previous tibial tunnel of the posterolateral (PL) bundle, which should be avoided when placing a TomoFix plate and inserting screws.

HTO was then performed following the technique of MOWHTO¹⁹ using a TomoFix plate. Biplane osteotomy was performed from the medial to the lateral side of the tibia (Figure 4a). The osteotomy site of the medial proximal tibia was spread 13 mm to achieve a postoperative %MA of 62%. A wedge-shaped β -TCP was inserted into the osteotomy site. The osteotomy site was fixed by a TomoFix plate without interfering with the inserted K-wire in the tibial drill hole (Figure 4b).

Finally, the revision ACLR was completed. Another K-wire was inserted 5 mm anterior from the temporary K-wire of the tibia. These K-wires were overdrilled by a 5-mm-diameter endoscopic drill. The two drill holes were dilated to create a rectangular bone tunnel by a 5 x 11-mm cannulated dilator using outside-in technique. The BPTB graft, a rectan-

gular bone plug, was inserted into the knee joint. First, the femoral bone plug was fixed by DSP. Then, the tibial bone plug was fixed by DSP under 30-N pretension for five minutes using a tensioning boot (Meira Corporation, Aichi, Japan) (Figure 3c, Figure 4c, d).

Postoperative protocol

Range of motion exercise was started from one week after operation, partial weight-bearing gait exercise was started from two weeks after operation, and full weight-bearing gait exercise was permitted from five weeks after operation. The patient started sports activities such as jogging from four months after operation.

The DSPs, TomoFix plate, and screws were removed 18 months after operation. At second-look arthroscopy, there was good synovial covering of the reconstructed ACL graft.

It still remained at proper tension at proving and had no tears (Figure 3d). The cartilage surface of the medial FT joint had no progression from wear (Figure 3e).

The patient had no knee pain and no giving way when followed-up three years after operation. Range of motion was unlimited. The Lachman test and the pivot shift test were negative. Anterior translation of the tibia measured by the KT-2000 knee arthrometer improved from 13 mm to 10 mm (Table 1). The Japanese Orthopaedic Association score for osteoarthritic knees (JOA score, 100 points maximum)²⁰ improved from 85 points to 100 points postoperatively. The β -TCP inserted into the osteotomy site was almost replaced by cancellous bone structure. There was no progression of knee OA (Figure 5). Postoperative FTA was 168 degrees, HKA was 6.2 degrees, and %MA was 73% (Table 2). The patient was satisfied with his knee condition because he could return to mountain climbing.

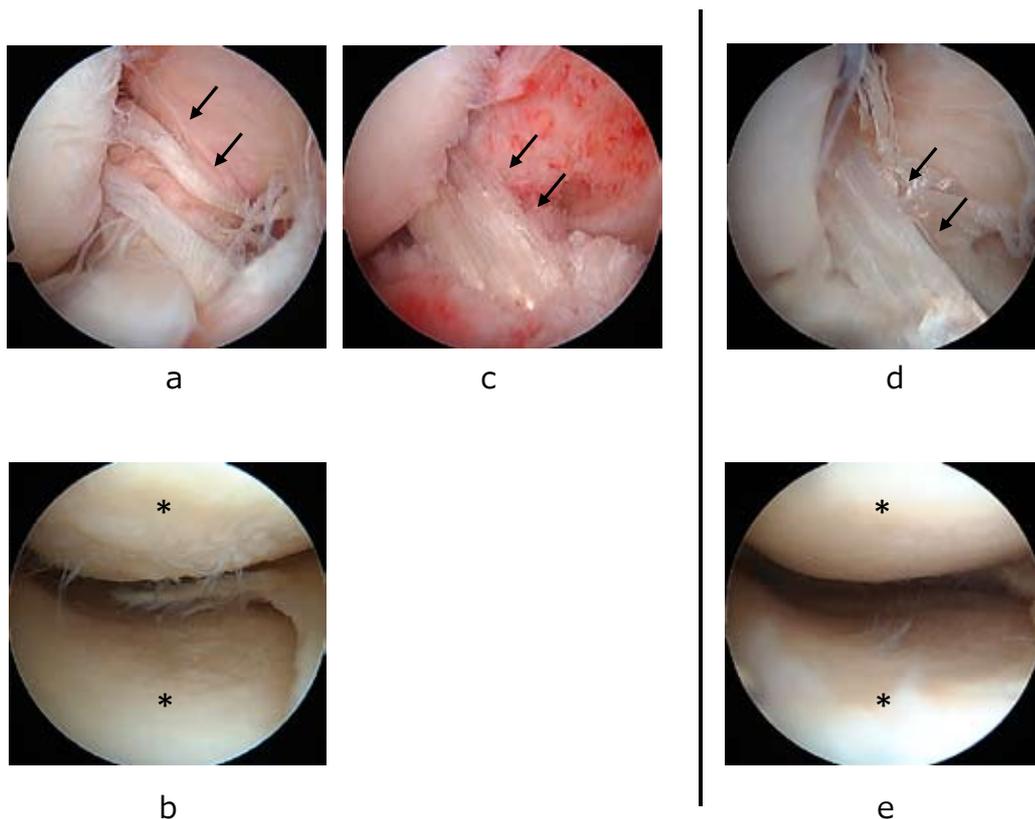


Figure 3 Arthroscopic findings of the right knee: a, b, c, at simultaneous HTO and revision ACLR; d, e, at hardware removal surgery
 a. The ACL graft by hamstring tendons at primary ACLR (arrow) is torn.
 b. Cartilage wearing of the medial FT joint (*) / medial meniscus tear
 c. ACL graft by BPTB at revision ACLR (arrow)
 d. Second look of c after 1 year 6 months (arrow)
 e. Second look of b after 1 year 6 months (arrow) / no progression of cartilage wearing



Figure 4

a. X-ray image intensifier at operation; arrow: K-wire inserted temporarily into the tibial tunnel of primary ACLR, AR: alignment rod, BS: bone spreader b. TomoFix plate fixation avoiding interference with the K-wire
 c. A-P view X-ray 1 week after operation d. Lateral view X-ray 1 week after operation

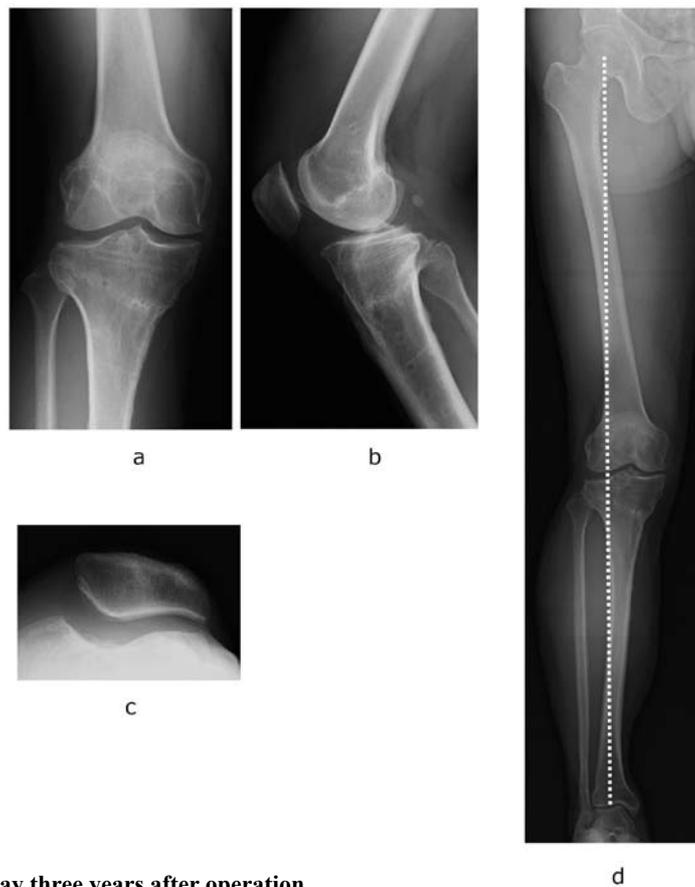


Figure 5 X-ray three years after operation

a. A-P view of the right knee b. Lateral view of the right knee
 c. Skyline view of the right knee d. Right long leg standing A-P X-ray: dotted line is the weight-bearing line.

Discussion

This is the first report of simultaneous HTO and revision ACLR using a BPTB graft as far as we are aware. There have been a few reports of simultaneous HTO and revision ACLR using hamstring tendons¹² or the quadriceps tendon²¹. On the other hand, there are quite a few reports of simultaneous HTO and primary ACLR from the 1990s⁸⁻¹¹. The combination of closed wedge HTO and ACLR using BPTB^{8,9,11} or artificial ligaments¹⁰ was performed in earlier periods. Akamatsu et al reported 4 cases of simultaneous MOWHTO fixed by a TomoFix plate and primary ACLR using a single-strand quadruped hamstring tendon¹³. They reported not only improvement of the clinical score for knee OA and knee instability, but also of the Tegner Activity Scale, which evaluates sports activity. Their operation method is thought to be a gold standard for simultaneous HTO and primary ACLR, because it allows early weight-bearing gait and is less invasive. Similar results were reported after their report²². A BPTB graft was used in the present case because the hamstring tendons had already been extracted in the primary ACLR. The MOWHTO using a TomoFix plate allowed early postoperative rehabilitation and led to good results.

The lower limb alignment of medial knee OA is usually varus. The cadaveric study by van de Pol et al showed that the more varus the limb alignment, the larger was the tension of the ACL graft when axial compression force was added²³. They concluded that HTO should be performed simultaneously to prevent an ACL graft tear in a severe varus knee that has lateral thrust. The retrospective clinical study by Won et al showed that varus limb alignment was a risk factor of re-tear of a reconstructed ACL graft²⁴. They showed that the limb alignment of the revision ACLR group (n=58) was more varus than that of the primary ACLR group (n=116). These reports support the rationale of simultaneous HTO and ACLR.

On the other hand, some reports questioned the necessity of ACLR. Mehl et al reported a sufficient result by HTO without ACLR, because there were no significant differences in the IKDC score²⁵ and the KT-2000 value compared with simultaneous HTO and ACLR²⁶. Meanwhile, Williams et al reported satisfactory results by both operative methods, but simultaneous HTO and ACLR had more cases with good or excellent results²⁷. Lattermann et al analyzed the age, pain, and instability of operated patients²⁸. They recommended simultaneous HTO and ACLR for patients from 20 to 35 years old with severe knee instability. They recommended HTO without ACLR for patients above 40 years old who had knee pain mainly with severe knee OA, such as exposure of

subchondral bone of the medial FT joint on arthroscopy. Although the present patient was 49 years old, he had high activity with his job and sports and did not have severe knee OA. Thus, he was considered a good candidate for simultaneous HTO and revision ACLR.

The controversy over simultaneous versus separate operations of HTO and ACLR has been discussed in the literature. Noyes et al reported 41 closed-wedge HTO cases of medial knee OA with ACL injury. They performed additional ACLR in 34 cases. The remaining 7 cases did not require ACLR because of their low sports activity²⁹. Lattermann et al reported postoperative complications such as flexion contracture, valgus overcorrection of lower leg alignment, and intra-articular fracture in 13% of the simultaneous HTO and ACLR cases. Thus, they recommended two-staged ACLR from 9 to 12 months after HTO for patients ranging in age from 25 to 40 years who initially had knee instability as well as knee pain if they still had knee instability²⁸. Giffin et al reported in their cadaveric study that the increase of PTS significantly increases anterior translation of the tibia during axial loading³⁰. This result indicates that decreasing PTS after HTO would reduce the symptoms of ACL insufficiency. We should evaluate postoperative complications, sports activity, and change of PTS in each patient. We should consider isolated HTO or isolated ACLR especially for cases of revision ACLR. In the present case, simultaneous surgery was performed because of the patient's high level of sports activity. Attention was also paid to the PTS change, as a decrease of the PTS by two degrees might provide a protective effect for the reconstructed ACL graft.

The appropriate alignment of the lower leg in simultaneous HTO and ACLR has not been clarified. Yasuda et al reported good clinical results in isolated HTO patients whose postoperative FTA was from 164 to 168 degrees³¹. Kilger et al investigated the tensile strength of the ACL graft of simultaneous HTO and anatomic two-route ACLR in their cadaveric study. They reported doubled tensile strength, especially in the posterolateral graft³², and average postoperative FTA of 166.6 degrees. This indicates that valgus alignment may increase tensile strength of the ACL graft. Kawamura Demange et al reported postoperative HKA of 1.2 degrees with a small standard deviation (1.04 degrees) in simultaneous HTO and ACLR with computer-navigated surgery³³. They highlighted the importance of the accuracy of postoperative HKA. An FTA around 166 degrees may be ideal if the main purpose is to decrease pain from medial knee OA, but a larger FTA might be ideal for simultaneous HTO and ACLR. Further investigation is needed in the present case because postoperative lower leg alignment was slightly valgus: %MA

was 73%, FTA was 168 degrees, and HKA was 6.2 degrees.

The first limitation of this study is that it is a case report. However, currently, the hamstring tendons are used for ACL grafts in 90% of primary ACLR cases³⁴. Thus, the number of cases who need simultaneous HTO and revision ACLR by ipsilateral BPTB graft will increase. Verification of our operation method is expected. The second limitation is the short follow-up period. The arthritis from knee OA would adversely affect the ACL graft, and the valgus lower leg alignment would increase the tensile strength of the ACL graft. A long duration of follow-up will be needed in the present case.

The operation methods and clinical result of simultaneous MOWHTO and revision ACLR using ipsilateral BPTB were reported. The short-term clinical result 3 years after operation was satisfactory. This procedure appears useful. However, there are some pitfalls, such as interference between the tibial bone tunnel of ACLR and the locking screws of the TomoFix plate. There are also matters to be resolved, such as the indications for simultaneous surgery and the appropriate postoperative alignment of the lower leg.

Conclusion

Simultaneous MOWHTO and revision ACLR using an ipsilateral BPTB were performed, and the good clinical result at 3 years indicates the usefulness of this procedure.

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