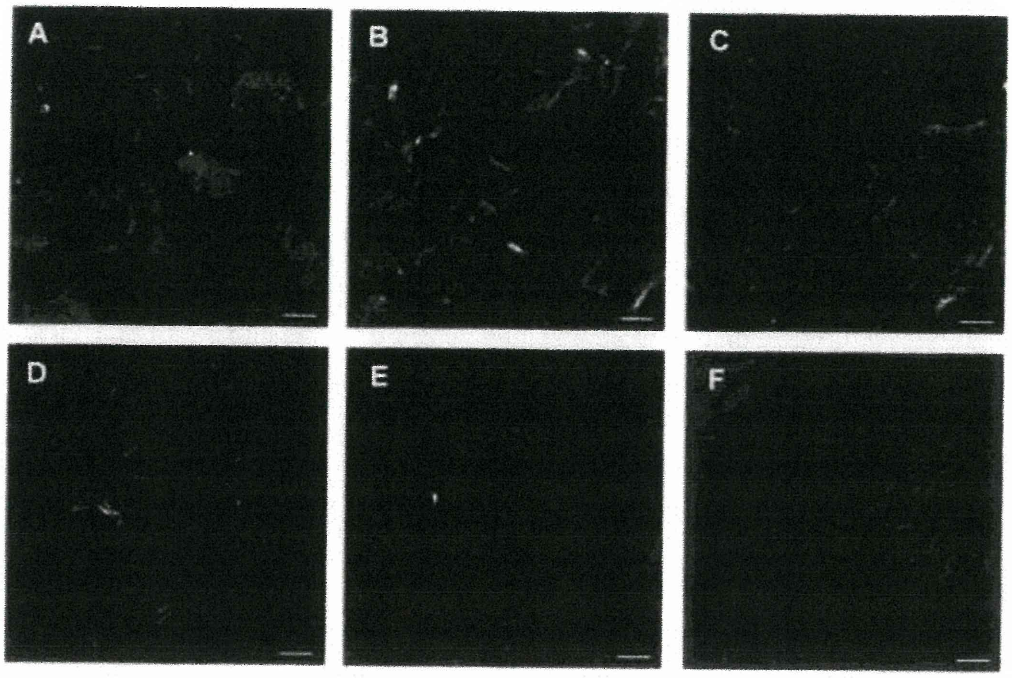

Figure 7

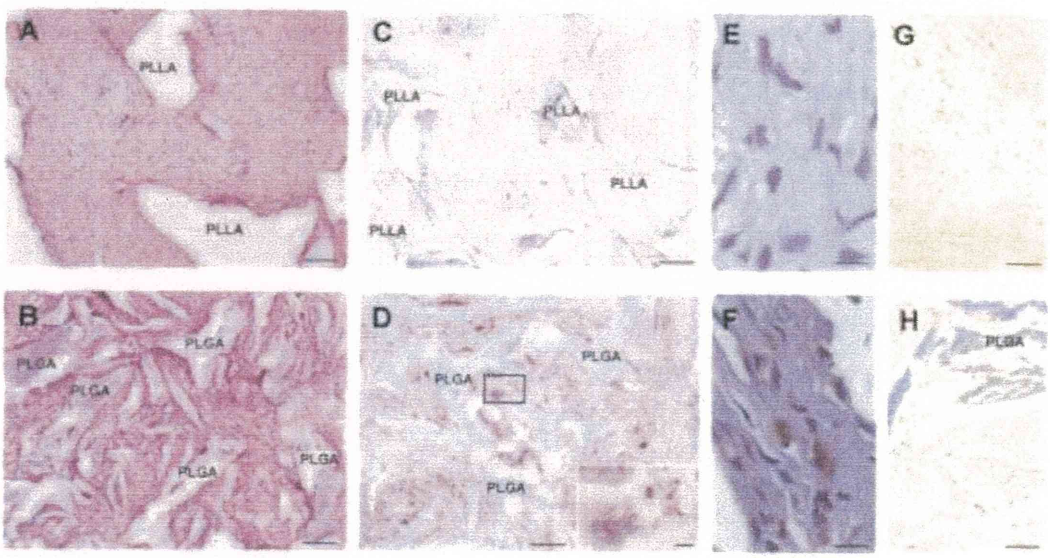

Figure 8

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Cross-cultural adaptation and validation of the Japanese Knee Injury and Osteoarthritis Outcome Score (KOOS)

Norimasa Nakamura • Ryohei Takeuchi • Takeshi Sawaguchi • Hiroyuki Ishikawa • Tomoyuki Saito • Sabine Goldhahn

Abstract

Background In Japan, only few cross-culturally adapted, internationally used orthopaedic patient self-assessed outcome scores are available. In addition, the high incidence of knee osteoarthritis (OA) suggests the need for validated outcome measures such as the widely used Knee Injury and Osteoarthritis Outcome Score (KOOS) for Japanese populations. The purpose of this study was to provide a crossculturally adapted and validated KOOS questionnaire for further use in national and international clinical projects involving Japanese patients.

Methods The Japanese KOOS was developed according to the standard cross-cultural adaptation guidelines. For validation, the KOOS was tested on 58 patients diagnosed with OA. Reliability was tested using the intraclass correlation coefficient (ICC). Internal consistency or homogeneity was assessed using Cronbach's alpha. Construct validity was evaluated by quantifying the correlation between the KOOS and the Japanese OKS and SF-36 questionnaires with Spearmann's correlation coefficients.

Results No major difficulties were encountered during the translation and pre-testing stages. All five KOOS subscales showed adequate reproducibility with ICC values greater than 0.85, high internal consistency with Cronbach's alpha values around 0.90, and high Spearmann's coefficients over 0.50 signifying good correlation between the KOOS subscales and the OKS as well as the majority of the established subscales of the SF-36. No floor and ceiling effects were observed for the five subscales.

Conclusions Our validated Japanese KOOS is a reliable and stable outcomes measure that provides a valuable basis for national and international clinical projects focusing on patient-based assessments in knee OA.

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AO Foundation

膝外傷と変形性関節症評価点数 - KOOS

記入日:_____/______/______　　　　生年月日:_____/______/______

苗字 : ____________________　　　　名: ____________________

説明:
この調査では、あなたの膝の状態についてお尋ねします。この情報は、あなたが膝の状態をどのように感じるか、そしてどの
程度日常生活をおこなえるかについて、経過を見るのに役立ちます。
全ての質問に答えて四角のマス(□)にチェックを入れてください。どの質問についても、最も当てはまる項目を1つだけ選び、チェッ
クを入れてください。答えに迷う場合は、最も近いと思うものをお選びいただくよう、お願いします
。

症状:
これらの質問では、ここ1週間の膝の症状についてお答えください。

S1. 膝に腫れ(はれ)がありますか?

まったくない	まれにある	ときどきある	ひんぱんにある	いつもある
□	□	□	□	□

S2. 膝を動かしたとき、軋み(きしみ)を感じたり、ひっかかる音が聞こえたり、その他の雑音が聞こえたりしますか?

まったくない	まれにある	ときどきある	ひんぱんにある	いつもある
□	□	□	□	□

S3. 動いている最中に膝が引っかかったり、動かなくなったりしますか?

まったくない	まれにある	ときどきある	ひんぱんにある	いつもある
□	□	□	□	□

S4. 膝を完全に伸ばすことができますか?

いつもできる	たいていできる	ときどきできる	ほとんどできない	まったくできない
□	□	□	□	□

S5. 膝を完全に曲げることができますか?

いつもできる	たいていできる	ときどきできる	ほとんどできない	まったくできない
□	□	□	□	□

こわばり:
以下の質問はここ1週間のあなたの膝のこわばりについての質問です。こわばりとは膝を動かした時に制限を感じたり、
ゆっくりとしか動かせない状態です。

S6. 朝起きた時にどの程度の膝のこわばりがありますか?

まったくない	すこしある	あるていどある	かなりある	ひどい
□	□	□	□	□

S7. 午後や夕方、座ったり、横になったり、休んだ後にどの程度の膝のこわばりがありますか?

まったくない	すこしある	あるていどある	かなりある	ひどい
□	□	□	□	□

痛み:

P1. 膝の痛みの頻度はどのくらいですか？

まったくない	月に1，2回	週に1，2回	매日に1，2回	いつも
☐	☐	☐	☐	☐

ここ1週間に、以下の動作をした時にどの程度の膝の痛みがありましたか？

P2. 膝をひねったり回したりする時

まったくいたくない	すこしいたい	あるていどいたい	すごくいたい	ものすごくいたい
☐	☐	☐	☐	☐

P3. 膝を完全に伸ばす時

まったくいたくない	すこしいたい	あるていどいたい	すごくいたい	ものすごくいたい
☐	☐	☐	☐	☐

P4. 膝を完全に曲げる時

まったくいたくない	すこしいたい	あるていどいたい	すごくいたい	ものすごくいたい
☐	☐	☐	☐	☐

P5. 平らな場所を歩く時

まったくいたくない	すこしいたい	あるていどいたい	すごくいたい	ものすごくいたい
☐	☐	☐	☐	☐

P6. 階段を上り下りする時

まったくいたくない	すこしいたい	あるていどいたい	すごくいたい	ものすごくいたい
☐	☐	☐	☐	☐

P7. 夜、寝ている時

まったくいたくない	すこしいたい	あるていどいたい	すごくいたい	ものすごくいたい
☐	☐	☐	☐	☐

P8. 座っている時や、横になっている時

まったくいたくない	すこしいたい	あるていどいたい	すごくいたい	ものすごくいたい
☐	☐	☐	☐	☐

P9. まっすぐ立っている時

まったくいたくない	すこしいたい	あるていどいたい	すごくいたい	ものすごくいたい
☐	☐	☐	☐	☐

機能

日常生活:
以下の質問では、あなたの身体機能 についてお尋ねします。これは、あなたの動作や身の回りのことを行う能力のことを指します。
以下のそれぞれの活動について、ここ1週間、あなたの膝が原因で感じた困難の程度をお答えください。

A1. 階段を下りる時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A2. 階段を上る時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A3. 座った状態から立ち上がる時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A4. 立っている時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A5. 身をかがめて、床に落ちたものを拾う時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A6. 平らな場所を歩く時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A7. 車の乗り降り

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A8. 買い物に行く時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A9. 靴下やストッキングをはく時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A10. ベッドから起き上がる時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A11. 靴下やストッキングを脱ぐ時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A12. ベッドに横たわっている時（寝返りをうつなど）

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A13. 浴槽に入る/浴槽から出る時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A14. イスに座っている時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A15. 洋式トイレを使う時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A16. 大変な家事を行う時（重い箱を動かす、床を拭くなど）

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

A17. 簡単な家事を行う時（料理、ちりやほこりを払うなど）

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

機能

スポーツおよびレクリエーション活動:
以下の質問では、より高いレベルでの活動を行った際のあなたの身体機能についてお尋ねします。
以下のそれぞれの活動について、ここ1週間、あなたの膝が原因で感じた困難の程度をお答えください。

SP1. しゃがむ時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

SP2. 走る時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

SP3. ジャンプする時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

SP4. 悪い方の膝をひねったり、回したりする時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

SP5. ひざまずく時

まったく不自由を感じない	すこし困難である	ある程度困難である	とても困難である	ほとんどできない
☐	☐	☐	☐	☐

生活の質

Q1. どのくらいの頻度で自分の膝の問題を自覚しますか？

まったくない	月に１，２回	週に１，２回	日に１，２回	いつも
☐	☐	☐	☐	☐

Q2. 膝によくない行動を避けるために、生活様式を変えましたか？

まったく変えていない	すこし変えた	ある程度変えた	かなり変えた	完全に変えた
☐	☐	☐	☐	☐

Q3. 膝に自信を持てないことで、どの程度困っていますか？

まったく困っていない	すこし困っている	ある程度困っている	かなり困っている	非常に困っている
☐	☐	☐	☐	☐

Q4. 全体的に、どのくらい膝について困難を感じますか？

まったくない	すこし困難である	ある程度困難である	かなり困難である	非常に困難である
☐	☐	☐	☐	☐

質問にお答えいただきありがとうございました。

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KNEE

Effects of medial patellofemoral ligament reconstruction on patellar tracking

Keisuke Kita · Shuji Horibe · Yukiyoshi Toritsuka · Norimasa Nakamura · Yoshinari Tanaka · Yasukazu Yonetani · Tatsuo Mae · Ken Nakata · Hideki Yoshikawa · Konsei Shino

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Abstract
Purpose Medial patellofemoral ligament (MPFL) reconstruction has been performed to treat recurrent patellar dislocation. However, the effects on patellar tracking have not been well documented, particularly in patients. The purpose of this study is to compare patellar tracking pattern and chondral status at MPFL reconstruction with those at second-look arthroscopy.
Methods Between 1999 and 2008, 71 patients with recurrent patellar dislocation underwent MPFL reconstruction using a double-looped semitendinosus tendon. Of these, 25 knees in 24 patients underwent second-look arthroscopy (at 6–26 months after initial surgery), forming the subject for the present study. No other surgical procedures such as tibial tuberosity transfer, lateral release, or osteotomy were performed in any patients. To assess the patellar tracking pattern, the position of the patella on femoral groove was evaluated arthroscopically during passive knee motion through lateral suprapatellar portal.
Results Before MPFL reconstruction, the patella in all patients was shifted laterally throughout the entire range of knee motion. Immediately after MPFL reconstruction, patellar malalignment was corrected in all cases. On second-look arthroscopy, two different patellar tracking patterns were observed. In 9 knees, the patella was located on the center of the femoral groove throughout the range of motion. Meanwhile, in the remaining 16 knees, the patella was shifted laterally at knee extension and migrated to the center of femoral groove with increased knee flexion. No significant deteriorations in chondral status were seen on second-look arthroscopy.
Conclusion The present study revealed that not all improved patellar trackings after MPFL reconstruction remained intact at follow-up. Chondral status in patellofemoral joint was not aggravated by MPFL reconstruction.
Level of evidence Therapeutic studies, Level IV.

Keywords Lateral patellar dislocation · Medial patellofemoral ligament reconstruction · Second-look arthroscopy · Patellar tracking pattern · Chondral status

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Introduction

Recurrent lateral patellar dislocation, subluxation and functional instability commonly occur in patients with various combinations of predisposing factors, such as general joint laxity, abnormal Q angle, abnormal patellar morphology, femoral trochlear aplasia, and patella alta [3, 16, 30]. Movement of the patella thus varies between individuals [40]. The importance of the medial patellofemoral ligament (MPFL) as the primary soft-tissue restraint to lateral displacement of the patella has recently been corroborated by several studies [5, 7, 9, 17], and the MPFL is always injured to some extent during traumatic lateral patellar dislocations [20, 29]. Many operative techniques to reconstruct the MPFL have been described [2, 8, 23, 25, 35, 37]. Good midterm clinical results with up to 97% patient satisfaction and up to 10 years follow-up have been reported [31, 38], and MPFL reconstruction has become the first choice for treating recurrent patellar dislocation. Several reports have described the good effects of MPFL reconstruction on patellofemoral kinematics and contact pressure [4, 14, 26, 33, 34]. However, all these studies used normal cadaveric knees and examined only just after MPFL reconstruction. In many knee ligament reconstruction surgeries such as anterior cruciate ligament reconstruction, posterior cruciate ligament reconstruction, and medial collateral ligament reconstruction, biomechanical properties of implanted grafts are known to change with the effects of stress relaxation and graft remodeling [1, 42]. Although such physiological factors may also be relevant to MPFL reconstruction, it is unknown whether the restored patellar maltrackings remain intact for a long while, particularly in practical patients with a variety of predisposing factors. Furthermore, no previous reports showed clearly whether MPFL reconstruction improved or damaged the patellofemoral articular surface. The purpose of the present study was to investigate whether the patellar tracking restored by MPFL reconstruction is maintained for a long time, comparing the patellar kinematics of patients at MPFL reconstruction with that at second-look arthroscopy. To evaluate the effect of MPFL reconstruction on patellofemoral joint surfaces, chondral status at second-look arthroscopy was also compared with that at initial surgery. The hypothesis of the present study was that the patellar tracking pattern at second-look arthroscopy might differ from that immediately after MPFL reconstruction, and MPFL reconstruction did not aggravate the articular surfaces.

Materials and Methods

Between 1999 and 2008, 71 patients underwent MPFL reconstruction using a double-looped semitendinosus tendon at our hospital. All patients were diagnosed with recurrent or habitual patellar dislocation by physical examinations, with positive apprehension sign in all cases. Four patients with a history of prior knee surgery (medial tubercle transfer in two, lateral retinaculum release in two) were excluded from the present investigation. In the present study, 24 patients (25 knees; 18 women, 6 men) underwent second-look arthroscopy at median of 13.2 months postoperatively (range, 6–26 months). Median age at the time of MPFL reconstruction was 22.7 years (range, 13–43 years). Prior to MPFL reconstruction, informed consent was obtained from all patients for hardware removal with simultaneous second-look arthroscopy 1 year after the initial surgery. The surgery was performed only when the patient was willing to undergo the procedure at postoperative follow-up.

Surgical Technique

All reconstructions were performed using a modified "dual tunnel medial patellofemoral ligament reconstruction" technique reported by Toritsuka et al. [39]. First, chondral status and patellar tracking were carefully evaluated by arthroscopy. A semitendinosus autograft was then harvested through a 3-cm incision over the pes anserius. The semitendinosus tendon was exposed and released from muscle using a tendon stripper. The distal end (17 cm) of the tendon was used and was doubled over. Both free ends of the graft were connected with a No. 3 braided polyester suture using Krackow suture technique.

A small 1-cm incision was made on the lateral side of the patella, and a skin incision of approximately 5 cm in length was made from the medial patellar edge to the medial femoral epicondyle. With the patella reduced in the femoral groove, the distance between the two anatomical insertions of MPFL was measured, and the exact length of the tendon was determined. Two guidewires were transversely inserted, one from proximal one-third of the medial edge of the patella and another from the center of the patella. Patellar guidewires were overdrilled using a 4.5-mm cannulated reamer to create sockets 15 mm in depth (Fig. 1). Care was taken not to violate the chondral surface or the anterior cortex of the patella. Until 2003, patellar bone tunnels were created from the medial to the lateral

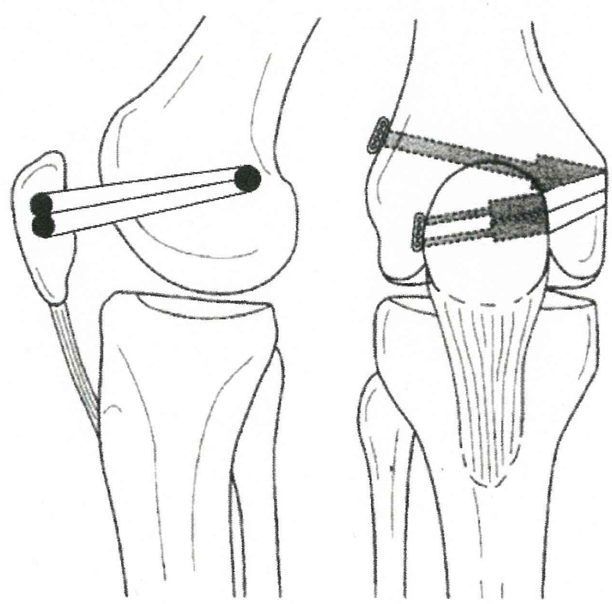

Fig. 1 Schematic view of MPFL reconstruction

side of the patella using a 4.5-mm cannulated reamer. However, the bone tunnel technique was changed to a bone socket technique in 2003 after one patient suffered patellar fracture in relation to bone tunnel procedure 2 months after MPFL reconstruction. Another guidewire was inserted from superoposterior portion of the medial femoral epicondyle toward the proximal cortex of the lateral femoral condyle. The guidewire was overdrilled with an EndoButton® drill (Smith & Nephew Endoscopy, Andover, MA), and 5- to 6-mm socket was drilled to a depth of 20 mm at the anatomical femoral insertion of the MPFL (Fig. 1).

The center of the graft was pulled into the femoral socket to a depth of pre-determined length and was fixed using an EndoButton® on the proximal cortex of the lateral femoral condyle. The two free ends of the graft were pulled into the bone sockets of the patella, and the two No. 3 braided polyester sutures connected to the graft were fixed by an EndoButton® on the lateral side of the patella at 45° of knee flexion. At this time, care was taken not to overtense the graft. After fixation of both sites, negative manual lateral dislocation of the patella was confirmed and patellar tracking was then evaluated arthroscopically (Fig. 1).

Postoperative Management

For 2 weeks after MPFL reconstruction, the knee was immobilized with a brace at 45° of knee flexion. After the brace was removed, passive- and active-assisted range of knee motion was started. Weight bearing was gradually increased to full at 4 weeks postoperatively. Running was allowed at 3 months, followed by a return to previous sporting activity at 6 months.

Evaluation

All patients were evaluated preoperatively, postoperatively, and by second-look arthroscopy. Clinical data included the incidence of recurrent subluxation and dislocation, lateral patellar hypermobility [21], lateral patellar apprehension, and Kujala score [22]. Radiographs of the knee, including a conventional anteroposterior view, lateral view, 30° skyline view, and Merchant's view, were taken at each of the three time points. The skyline view was used for measuring lateral tilt [12], and Merchant's view was used for measuring congruence angle [27] (Fig. 2). Insall-Salvati ratio at the three time points was measured on the lateral view [19]. Arthroscopically, patellar tracking was evaluated at 0° through 60° of knee flexion through a lateral suprapatellar portal. A median ridge of the patella located above the middle third of the femoral groove was defined as "centrally located", while a ridge located lateral to the middle third of femoral groove was defined as "laterally shifted". Evaluation of patellar movement was repeated three times, and it was confirmed that patellar tracking pattern was same in each time. Patellar trackings were recorded on video disc and verified by two skilled orthopedic surgeons postoperatively. Chondral status of patellofemoral joint according to the Outerbridge classification was also evaluated at initial surgery and second-look arthroscopy. The view during arthroscopic operations was kept clear by means of irrigation and tourniquet. The pressure of irrigation fluid was set to 40 mmHg, and the pressure of air tourniquet was set to 300 mmHg.

Statistical analysis

Statistical analysis was performed using the paired *t*-test, one factor analysis of variance, Mann–Whitney U test, and the Wilcoxon rank-sum test. Values of $P < 0.05$ were defined as significant.

Results

No patient reported re-dislocation of the patella in the follow-up period. All patients showed full range of motion at the time of second-look arthroscopy. One patient, who had not been allowed to return to sports activity, had

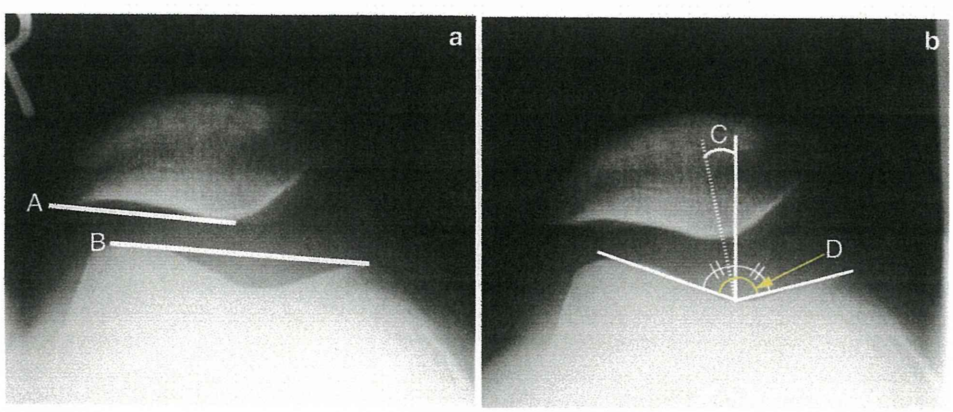

Fig. 2 Measuring methods on radiograph. **a** 30° skyline view. Lateral tilt angle was defined as an angle with *line A* to *B*. **b** Merchant view. *C* congruence angle, *D* sulcus angle

suffered patellar fracture during badminton 2 months after MPFL reconstruction and underwent open reduction and internal fixation. In terms of passive patellar hypermobility, abnormal lateral patellar movement was found in all cases preoperatively. At final follow-up, all patellae were firmly fixed on the femoral groove and no abnormal hypermobility was found in any case. While 22 knees showed clear improvements in apprehension sign, positive results were still evident in 3 cases. Median Kujala score improved from 73 (66–82) preoperatively to 95 (85–100) at second-look arthroscopy.

Radiographic Findings

Median sulcus angle was 147.7° (130–170°). Preoperatively, median lateral tilt angle, median congruence angle, and Insall-Salvati ratio were −8.0° (−44 to 20°), 20.8° (−25 to 80°), and 1.1 (0.8–1.4), respectively (Table 1). Immediately after MPFL reconstruction, these three indices had improved. However, at final follow-up, these indices had returned toward preoperative values to some extent (Table 1). Although patellar maltracking was reduced in all cases immediately after surgery, the position had shifted laterally to some extent at follow-up (Fig. 3a–c).

Patellar tracking

At arthroscopic evaluation prior to MPFL reconstruction, patellae in all cases had shifted laterally for all knee flexion angles (Fig. 4a–d). Immediately after MPFL reconstruction, all preoperative patellar maltracking was reduced, and patellae were congruent with femoral groove in 0–60° of range of motion (Fig. 4e–h). At second-look arthroscopy, tensed reconstructed grafts were recognized arthroscopically from the inside of the joint in all cases (Fig. 5). In 9 knees, the patella was always located above the center of the femoral groove within 0–60° of range of motion and thus classified as "centrally located type". In 16 knees, the patella was located in a "laterally shifted" position at knee extension, moving on the center of the femur and becoming congruent with the femoral groove as the angle of knee flexion increased. This pattern was classified as "laterally shifted type".

No demographic data affected the difference in patellar tracking between the two groups (Table 2). However, 3 patients who complained of positive apprehension sign at follow-up were classified as "laterally shifted type". Kujala scores, sulcus angles, and preoperative lateral tilt angles were not different between the two groups (Table 3). Only median preoperative congruence angle, which was 9.2° (−25 to 52°) in "centrally located type" and 26.5° (−2 to 85°) in "laterally shifted type", differed significantly according to various preoperative factors ($P = 0.03$; Table 3).

Chondral Status

At MPFL reconstruction, cartilage lesions on the patellofemoral joint were observed in 96% of patients. At second-look arthroscopy, no obvious deterioration in chondral status was seen. The patella cartilage in "centrally located type" patients showed little change, compared with that at MPFL reconstruction (Fig. 6a). In the "laterally shifted type", 2 patients displayed slight deteriorations in the patella surface and 6 patients showed improvement in lesions (4 lesions, grade 4; 2 lesions, grade 2; Fig. 6b). The femur showed no deterioration in the chondral status in "laterally shifted type" patients, while 4 of 9 patients with "centrally located type" exhibited slight deterioration in the chondral surfaces (Fig. 6c, d).

Table 1 Radiographic measurement

Median (range)	Before MPFL reconstruction	After MPFL reconstruction	Second-look arthroscopy	Significance (P value)
Lateral tilt angle (°)	−8.0 (−44 to 20)	5.5 (−16 to 20)	−3.8 (−48 to 18)	<0.05
Congruence angle (°)	20.8 (−25 to 80)	−11.8 (−64 to 45)	9.3 (−27 to 92)	<0.05
Insall-Salvati ratio	1.1 (0.8 to 1.4)	1.0 (0.8 to 1.3)	1.1 (0.8 to 1.4)	<0.05

One-factor ANOVA

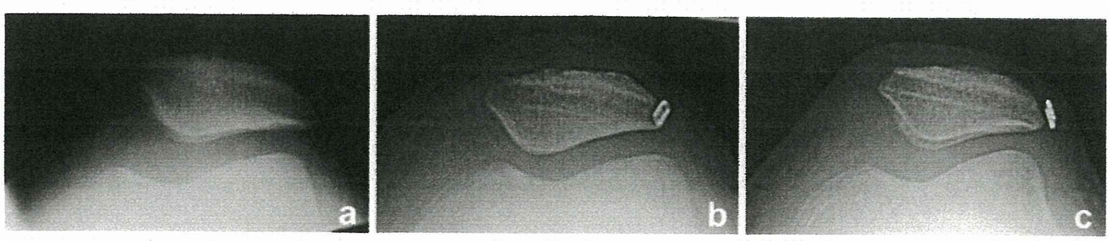

Fig. 3 Radiographs of Merchant's view at the three time points. **a** Before surgery, **b** Immediately after surgery, **c** Second-look arthroscopy

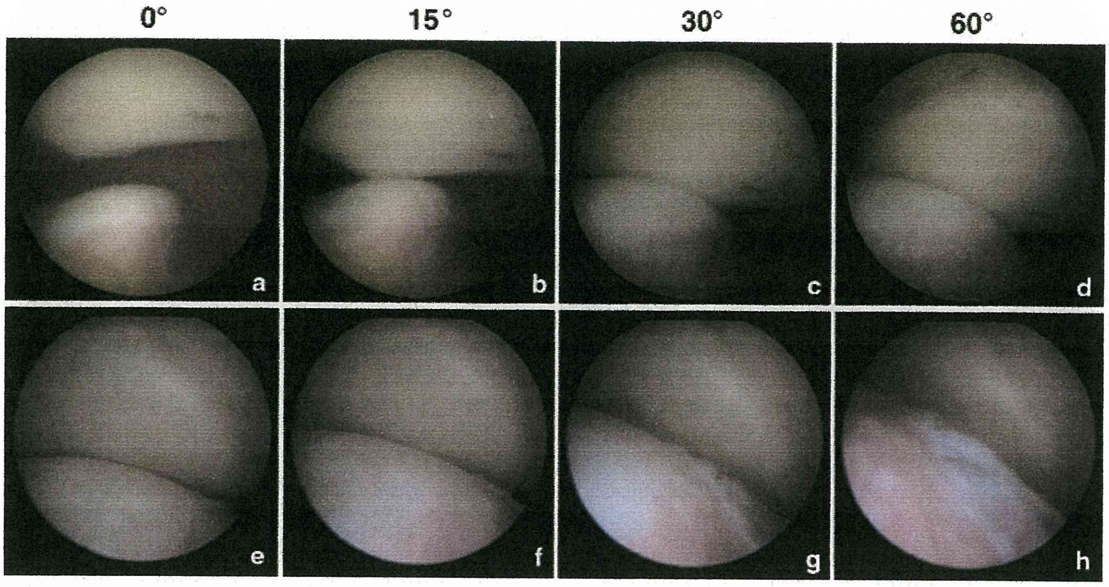

Fig. 4 Arthroscopic view of the patellofemoral joint at MPFL reconstruction. Arthroscopic view of the patellofemoral joint at 0° (**a**), 15° (**b**), 30° (**c**), 60° (**d**) before surgery and 0° (**e**), 15° (**f**), 30° (**g**), 60° (**h**) immediately after surgery

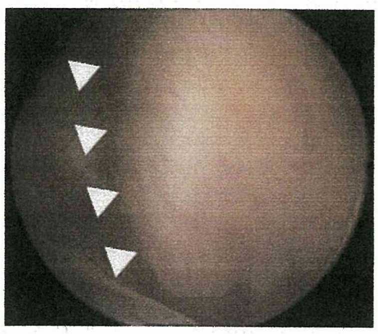

Fig. 5 Arthroscopic view of reconstructed MPFL at second-look arthroscopy. *Arrowheads* indicate a reconstructed MPFL

Discussion

The most important finding in the present study was that not all instances of reduced patellar tracking remained intact despite good clinical outcomes, even if patellar maltracking had been completely restored just after MPFL reconstruction. Arthroscopically evaluated patellar tracking patterns at follow-up were divided into two types: with 36% of patellar trackings classified as "centrally located type", and 64% classified as "laterally shifted type". All patellar tracking patterns of the three cases complaining of positive patellar apprehension were "laterally shifted type". Preoperative radiographic measurements revealed a significant difference only in the congruence angle between the two groups. No significant deteriorations in chondral status were seen on second-look arthroscopy. However, grade 1 cartilage damages that had not been recognized in initial surgery was observed in the femoral groove for 44% of the "centrally located type" patients and in the central ridge of the patella for 13% of "laterally shifted type" patients,

Although MPFL reconstruction has become the first choice for treating recurrent patellar dislocation and good midterm clinical results with up to 97% patient satisfaction and up to 10 years of follow-up have been reported [31], patellar tracking after MPFL reconstruction, particularly in

Table 2 Demographic data of "centrally located type" and "laterally shifted type"

Median (range)	Centrally located type	Laterally shifted type	Significance (*P* value)
Patient age (years old)	25.6 (15–39)	22.1 (13–43)	n.s.
Duration from injury to MPFL reconstruction (years)	10.2 (1.6–23.3)	6.7 (0.2–22.7)	n.s.
Duration from initial surgery to second-look arthroscopy (months)	10.5 (6.7–26.0)	14.2 (5.9–31.1)	n.s.
Kujala score at second-look arthroscopy	95 (85–100)	94 (81–100)	n.s.
Apprehension sign at second-look arthroscopy (−/+)*	(9/0)	(13/3)	–

Paired *t*-test

* (−/+) represents that apprehension sign is negative/positive

Table 3 Preoperative radiographic findings in "centrally located type" and "laterally shifted type"

Median (range)	Centrally located type	Laterally shifted type	Significance (P value)
Sulcus angle (°)	147.6 (138 to 156)	147.7 (130 to 170)	n.s.
Lateral tilt angle (°)	−0.5 (−13 to 8)	−11.7 (−44 to 20)	n.s.
Congruence angle (°)	9.2 (−25 to 52)	26.5 (−2 to 85)	0.03
Insall-Salvati ratio	1.2 (1.0 to 1.4)	1.1 (0.8 to 1.4)	n.s.

Mann–Whitney U test

patients, has not been described. Radiologic findings showed that all patellar maltracking was reduced immediately after MPFL reconstruction. However, tracking position had shifted somewhat laterally by second-look arthroscopy. Deie et al. reported clinical and radiologic results of MPFL reconstruction using transferred semitendinosus tendon 5 years after surgery [11]. They concluded that congruence angle, tilting angle, and lateral shift ratio were within normal ranges at 5 years postoperatively. However, detailed examination of their data showed that the three indices were improved at 6 months after reconstruction, but tended to return toward preoperative values to some extent. This fact is consistent with the present results, which found a lateral shift in the patella at follow-up. As a tensed graft was recognized from inside the joint in all cases and relatively good results were obtained in this series, the transplanted graft might undergo remodeling or stress relaxation without breaking [18], and the graft might function as a seatbelt to reinforce lateral displacement of the patella. Yamada et al. reported 3-dimensional morphological differences in the articular surface of the femoral trochlea in patients with recurrent dislocation of the patella using 3-dimensional computational models [41]. They concluded that the lateral border of articular cartilage of the trochlea in patients was located more laterally than in the control group. The two patellar tracking patterns observed in this study might have been caused by the unique patellofemoral congruency in recurrent patellar dislocation patients, as cases with subdislocation of the patella at knee extension showed significantly higher congruence angles. Furthermore, patients with patellar subluxation exhibit a tight lateral retinaculum [15]. With larger

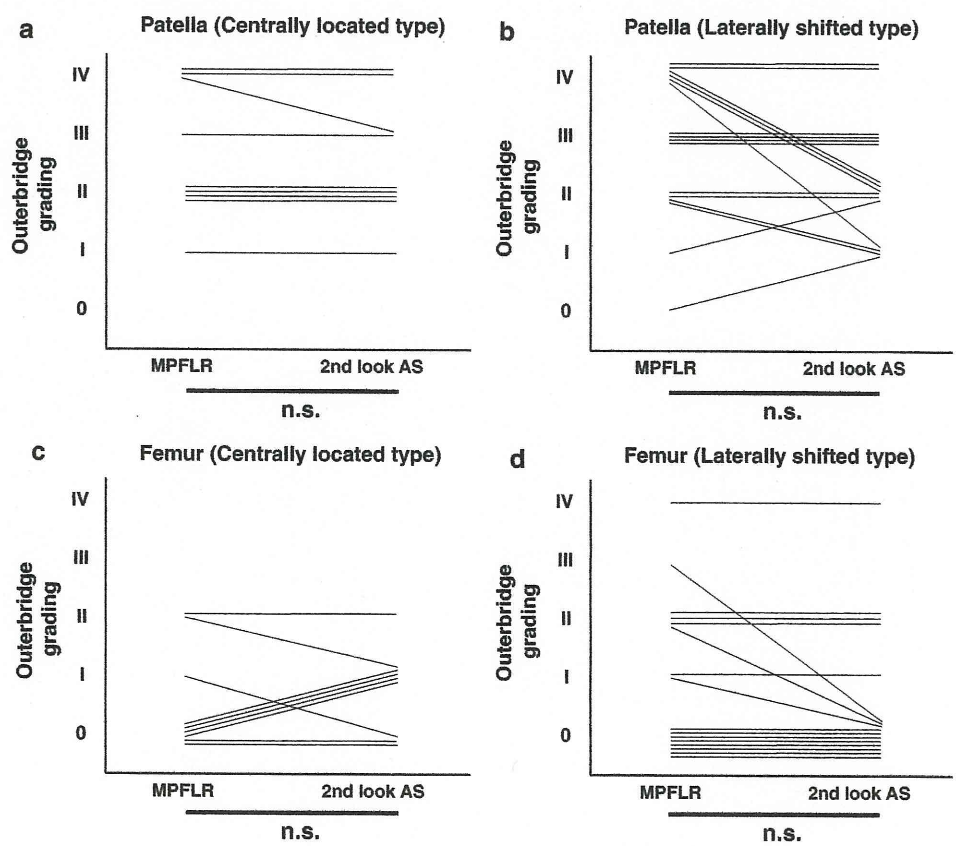

Fig. 6 Chondral status at MPFL reconstruction and at second-look arthroscopy. **a** Chondral status of the patella in "centrally located type". **b** Chondral status of the patella in "laterally shifted type". **c** Chondral status of the femur in "centrally located type". **d** Chondral status of the femur in "laterally shifted type"

congruence angle, the tighter and shorter the lateral retinaculum is considered to be. The reconstructed MPFL may be matched to the proper length by remodeling depending on individual patello-femoral congruence and tightness of the lateral retinaculum. However, all three cases with positive apprehension sign remaining at follow-up were classified into "laterally shifted type". For such cases, other surgical procedure such as lateral retinaculum release or tibial tuberosity transfer may be necessary, although further examination of this issue is needed before such recommendations can be made.

Patellar tracking of normal and abnormal subjects has been investigated using radiograph, computed tomography, magnetic resonance imaging, and arthroscopy by many authors [6, 12, 36]. Arthroscopically, quantitative evaluation of the patellar position is impossible. Brossmann et al. reported that the arthroscopic patellar tracking pattern correlated with motion-triggered cine magnetic resonance imaging [6]. By simplifying the classification of arthroscopic patellofemoral alignment, they minimized the influence of subjective impressions by operators. Arthroscopic evaluation of patellar tracking in the present study might have been subjective, but arthroscopy remains an important technique for evaluating patellofemoral problems. In the present study, although the subluxing patella was not centered on the femoral groove with increased knee flexion before surgery and patellar maltracking had been reduced immediately after surgery, arthroscopic patellar tracking patterns observed at second-look arthroscopy could be simply classified into two types, retrospectively. The influence of operator subjectivity was thus considered minimal. The pressure of irrigation fluid is another important factor affecting arthroscopic patellar tracking. Delaunay and Kapandji reported that serum inflow affected patella-trochlear centralization [13]. In the present study, to avoid differing effects of irrigation pressure on patellar tracking, the pressure was set to 40 mmHg in each case. The tracking pattern in the present study might not reflect the true pathology, but the present findings could provide useful information regarding alternations in patellar tracking after MPFL reconstruction.

Although movement of the patella varies among patients with recurrent patellar dislocation [40], the two patellar tracking patterns were observed only with reconstruction of the MPFL anatomically without any procedure for various predisposing factors. Sandmeier et al. compared patellar tracking in cadaveric knees with medial restraints intact, either sectioned or reconstructed [34]. They concluded that, with a lateral force applied to the patella, patellar tracking changed significantly with loss of the medial restraints and improved after MPFL reconstruction using a gracilis tendon. They also noted that patellar tracking was not completely restored, and the reconstructed MPFL tended to overconstrain the specimens, particularly under knee extension. Ostermeier et al. compared the effects of two different techniques of MPFL reconstruction using cadaveric knees and concluded that both reconstruction techniques created sufficient stabilization of the patella, but that patellar position was slightly overmedialized following MPFL reconstruction with a semitendinosus autograft, which could lead to overload on the medial retropatellar cartilage [32]. The present results are partially in accordance with their results, with the patella medialized and overconstrained immediately after reconstruction. However, both studies used cadaveric knees, and patellar tracking immediately after MPFL reconstruction was evaluated in vitro. Cadaveric studies do not always throw light on the true pathology of lateral patellar dislocation and MPFL reconstruction, as lateral patellar dislocation caused by various predisposing factors and physiological effects such as graft remodeling cannot be evaluated. Therefore, patellar tracking patterns in actual patients approximately 1 year after surgery were investigated.

In "centrally located type" knees, the patella was always centered in the femoral groove from 0° to 60° of knee flexion. This type of patellar tracking might differ from normal patellar tracking, as the median ridge of the patella lies lateral to the center of the trochlea in the normal knee from 0 to 30° of flexion, then moves medially to become centered in the femoral groove at between 30° and 60° of flexion [10]. In fact, 44% of the chondral status of the femoral groove in the "centrally located type" cases was deteriorated to grade 1 at second-look arthroscopy. This suggested that, in some cases, MPFL reconstruction was overtensioned immediately after surgery. Meanwhile, in the "laterally shifted type", the patella was located lateral to the center of the femoral groove and become centered with an increase in knee flexion angle. Two of 16 "laterally shifted type" patients showed deterioration at the central ridge of the patella. This fact suggests that the return of incongruence caused that excessive lateral pressure would also return. Even though the same MPFL reconstruction in all cases was performed, different patterns of patellar tracking were observed. In some cases, the reconstructed MPFL might be overtensed immediately after surgery. In other cases, the reconstructed graft might undergo graft remodeling or stress relaxation, and excessive lateral pressure might return. Long-term follow-up is needed to assess the progression of osteoarthritis. Any important factors contributing to the two types of patellar tracking could not be identified in this study. Several specific imaging protocols designed for patellofemoral disorders have been reported, including axial view with lateral rotation of the leg, measurement of patellar height, and crossing sign [12]. The crossing sign could not be investigated for systematically due to the difficulty in obtaining lateral views with perfect superposition of the femoral condyles. The Insall-Salvati ratio was measured on lateral radiographs, but no significant differences between groups were noted. A significant difference was only identified in preoperative congruence angle between groups. Proper tension and graft length applied at MPFL reconstruction may be necessary to prevent further dislocation after surgery. Conversely, re-dislocation and return of excessive lateral pressure may occur with reductions in tension. Recurrent patellar dislocation is caused by the combination of various predisposing factors, and nobody knows the exact length of MPFL in each patient. To solve the double-edged sword problems, further research is needed.

Several limitations in this study must be considered. First, not all patients who underwent MPFL reconstruction were examined in this series. Some potential for bias in patient selection may thus exist, and the 24 patients investigated in the present study might not have been representative of the entire 71 patients. However, the cohort of 25 knees that underwent MPFL reconstruction and second-look arthroscopy represents a bigger group of patients compared with previous studies, and the information provided by this investigation is meaningful. Second, one patient suffered patellar fracture related to a drill hole in this series. Until 2003, a 4.5-mm transverse bone tunnel had been created in the patella. To decrease the potential risk of patellar fracture, the bone tunnel technique has been changed to bone socket technique using a 2.4-mm Kirschner wire. This procedure still carries some risk of patellar fracture, but a stronger initial fixation is expected by both pull-out fixation and bone-tendon healing compared with suturing to the periosteum or VMO tendon [28]. Finally, the duration between initial surgery and second-look arthroscopy might have been too short to evaluate the patellar movement after MPFL reconstruction, as the mean duration tended to be shorter for "centrally located type" than for "laterally shifted type", although the difference was not significant. No correlation was evident between the interval to MPFL reconstruction and duration of follow-up and patella tilt and congruence angle (data not shown). In anterior cruciate ligament reconstruction, the implanted graft reportedly underwent graft remodeling or stress relaxation for 6 months postoperatively [24]. This finding is relevant to MPFL reconstruction, and ≥6 months between initial and second-look arthroscopy is sufficient to examine patellar tracking.

Conclusion

Not all improved patellar tracking seen just after MPFL reconstruction surgery remained intact at follow-up. Two patterns of patellar tracking were observed arthroscopically following MPFL reconstruction: "centrally located type" and "laterally shifted type". No obvious chondral damage in the patellofemoral joint was seen at second-look arthroscopy, but locations showing cartilage deterioration differed between types.

Conflict of interest The authors report no conflict of interest.

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