



# Simultaneous Medial Patellofemoral Ligament and Medial Quadriceps Tendon–Femoral Ligament Reconstructions Using an Artificial Ligament for Lateral Patella Instability

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**Abstract:** Recent studies on the detailed anatomy of the medial patellar stabilizer have revealed that the medial patellofemoral ligament (MPFL) not only attaches to the patella but also has fibers that attach to the quadriceps muscle, known as the medial quadriceps tendon femoral ligament (MQTFL). Reconstruction of the medial stabilizer for patellar dislocation that includes both the MPFL and MQTFL may achieve better anatomical and physiological correction. In this Technical Note, we will describe a simultaneous reconstruction technique of the MPFL and MQTFL for patellar dislocation using an artificial ligament.

In recent years, medial patellofemoral ligament (MPFL) reconstruction has become the most common surgical treatment for patellar dislocation.<sup>1,2</sup> Although there are variations in surgical methods such as graft selection, fixation position, and fixation methods, generally good outcomes have been reported. However, a recent systematic review reported that 8.3% of patients had postoperative dislocation instability,<sup>3</sup> suggesting that patellar instability remains relatively common after reconstruction. There are various factors that could cause this instability, but one potential cause may be that the reconstructive ligament

is not able to exert its inherent physiological resistance to dislocation as a medial patellar stabilizer.

Detailed anatomical studies on the medial patellar stabilizer have been reported in recent literature.<sup>4,5</sup> Mochizuki et al.<sup>6</sup> reported in their cadaver study that the MPFL has a fan-like morphology and is attached not only to the patella but also to the medial margin of the vastus medialis. Fulkerson et al.<sup>7</sup> named this the medial quadriceps tendon femoral ligament (MQTFL) and stated that reconstruction of this ligament provides stability for the patellofemoral joint. These findings suggest that the MQTFL, along with the MPFL, pulls directly on the quadriceps and patella, increasing the resistance to dislocation from the lateralizing force of the knee extension mechanism. Therefore, reconstruction of the medial patellar stabilizer for patellar dislocation that includes both the MPFL and MQTFL may achieve better anatomical and physiological correction. For the reconstruction of these 2 ligaments, the use of autologous tendons is limited in volume and may result in failure of the harvest site. The use of artificial ligaments may be a viable solution. In this Technical Note, we describe a simultaneous reconstruction method for the MPFL and MQTFL using artificial ligaments.

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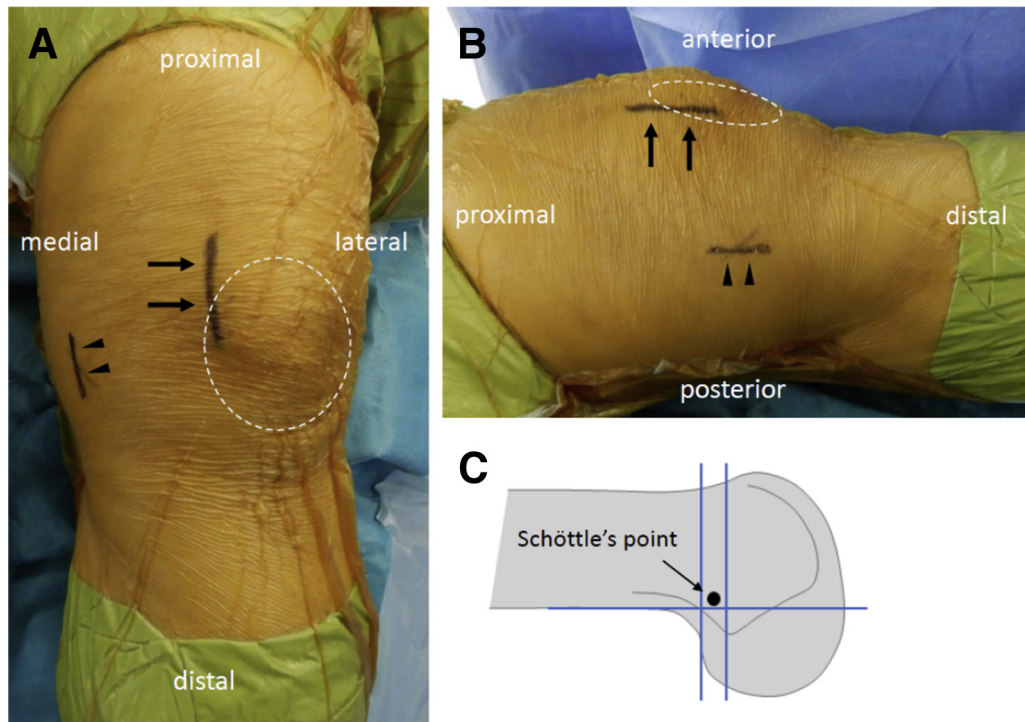
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## Surgical Technique (With Video Illustration)

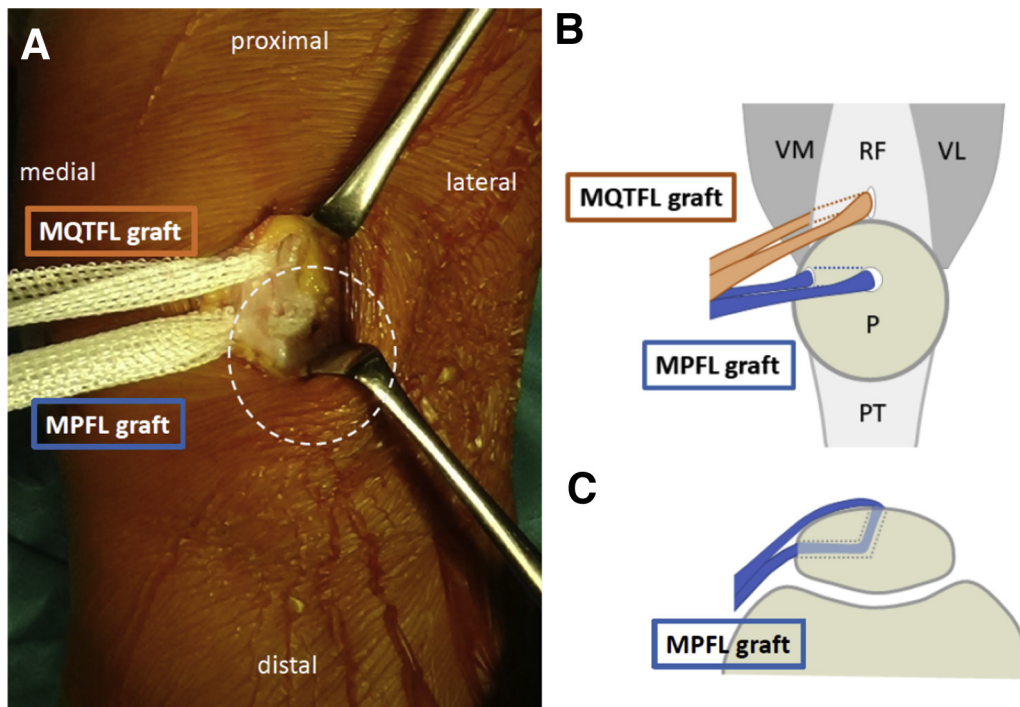
The patient is placed in the supine position, and a tourniquet is placed on the thigh. We usually use a limb



**Fig 1.** Location of the skin incision in the left knee. The first skin incision (arrows) is approximately 3 cm in length along the medial edge of the patella from a point 1 cm proximal to the superior edge of the patella to the center of the patella. The second skin incision (arrowheads) is approximately 2 cm in length just above the position of the femoral attachment of the MPFL, which corresponds to Schöttle's point<sup>8</sup> in the fluoroscopic image of the lateral knee. (A) Anterior view of the left knee. (B) Medial view of the left knee. (C) Schema for Schöttle's point in the fluoroscopic image of the lateral knee. White dotted circle, edge of patella.

positioner (AssistArm; CONMED, Largo, FL) attached to the foot to facilitate limb positioning. The first skin incision is a longitudinal incision of approximately 3 cm along the medial edge of the patella, extending from a point 1 cm proximal to the superior edge of the patella to the center of the patella (Fig 1). The soft tissue adhering to the medial aspect of the patella is partially detached, and a guide pin is inserted in a lateral direction from the medial aspect of the proximal third of the patella, with the tip coming out of the lateral aspect. After confirming its optimal placement, a bone tunnel reaching the center of the patella is created with a 4.0-mm cannulated drill. The guide pin is removed, and a pair of Kocher forceps is inserted into the tunnel. Using the Kocher forceps as a landmark, a next guide pin is inserted from the anterior aspect of the patella to meet at the tip of the tunnel. After confirming that the guide pin contacts the Kocher forceps within the tunnel, another entry to the bone tunnel is created from the anterior side with a 4.0-mm cannulated drill to connect the first bone tunnel from the medial and anterior side at the center of the patella. In this way, an L-shaped bone tunnel is created. An artificial ligament (Leeds-Keio 20; Xiros Ltd., Leeds UK) is passed through this bone tunnel using a guiding suture into and then folded back into a loop shape (MPFL graft). Subsequently, the

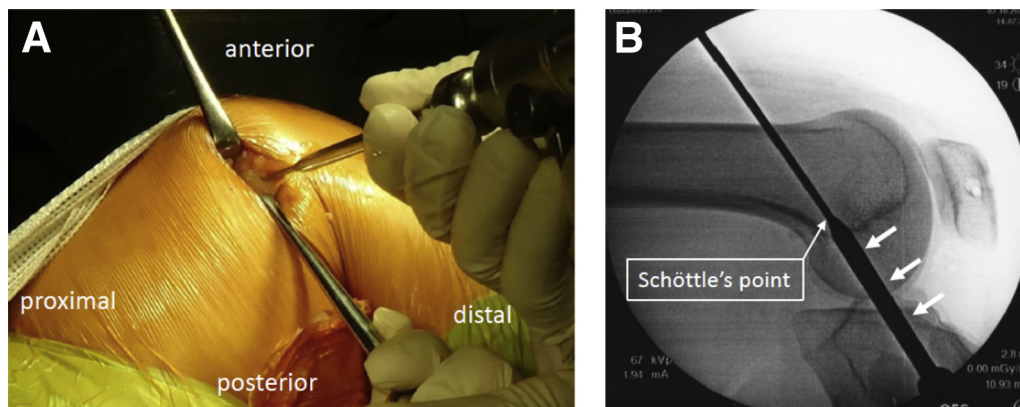
distal rectus femoris tendon is split approximately 1 cm from its center with a sharp pointed scalpel along the longitudinal fiber. A curved mosquito forceps is inserted and passed between the rectus femoris and the vastus intermedius tendon, and the tip of the mosquito forceps is brought out to the medial edge of the rectus femoris tendon. The artificial ligament (Leeds-Keio 15) is clamped at the tip of the mosquito forceps and folded back through the split tendon to form a loop (MQTFL graft). The 2 looped artificial ligaments are pulled medially and confirmed whether the patella shifts to the medial side (Fig 2). Next, a bone tunnel is created to pass the artificial ligaments through the femur. The hip of the affected limb is flexed, abducted, and internally rotated in position, and a C-arm is used to obtain an accurate lateral view of the knee joint. The position of the femoral attachment of the MPFL in the lateral view of the knee joint is 1 mm anterior to the posterior cortex extension line, 2.5 mm distal to the posterior origin of the medial femoral condyle, and proximal to the level of the posterior point of the Blumensaat line as described by Schöttle et al.,<sup>8</sup> and a skin incision of about 2 cm is made just above this position. The medial epicondyle and adductor tubercle are identified and marked with electrocoagulation at a point proximal and posterior to the medial epicondyle and distal to the



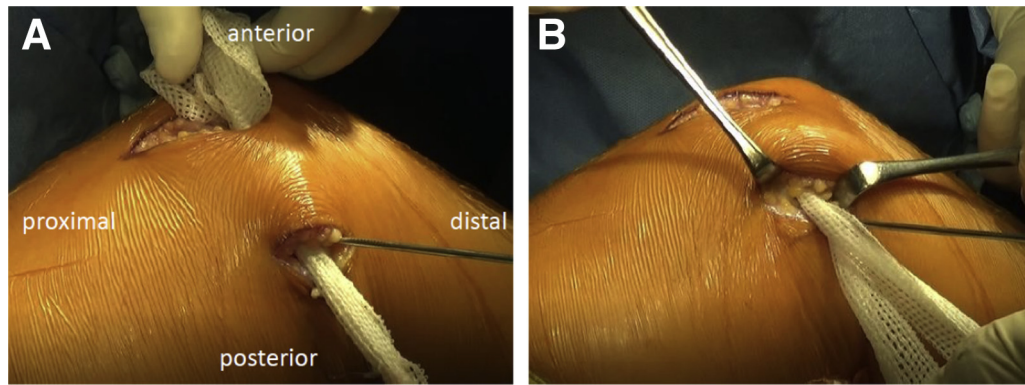
**Fig 2.** Anterior aspect of the left knee. (A) Two artificial ligaments are passed through the bone tunnel created at the proximal third of the patella and the slot created distal to the quadriceps tendon, respectively. After each is passed through, a loop is made. (B) Schematic illustration of Figure 2A. (C) Schema for patellar bone tunnel. Patellar bone tunnel is L-shaped. White dotted circle, edge of patella. (MPFL, medial patellofemoral ligament; MQTFL, medial quadriceps tendon femoral ligament; P, patella; PT, patella tendon; RF, rectus femoris; VM, vastus medialis; VL, vastus lateralis.)

adductor tubercle. This point is the femoral attachment point of the anatomical MPFL.<sup>9</sup> After confirming that the marked position is consistent with that of Schöttle et al. by fluoroscopy, a guide pin is inserted from the marked position in the lateral direction of the proximal femur and penetrated through the contralateral bone cortex (Fig 3). The artificial ligament that was passed through the patella and quadriceps tendon is

subsequently passed between the deep fascia and the capsule of the knee joint using Kocher forceps to exit through the second skin incision (Fig 4). With each artificial ligament under equal tension, the artificial ligament is folded over the guide pins, and the artificial ligament is temporarily fixed between the folded portions of the ligaments with a pair of Kocher forceps (Fig 5 A). Tensioning of the artificial ligament should be



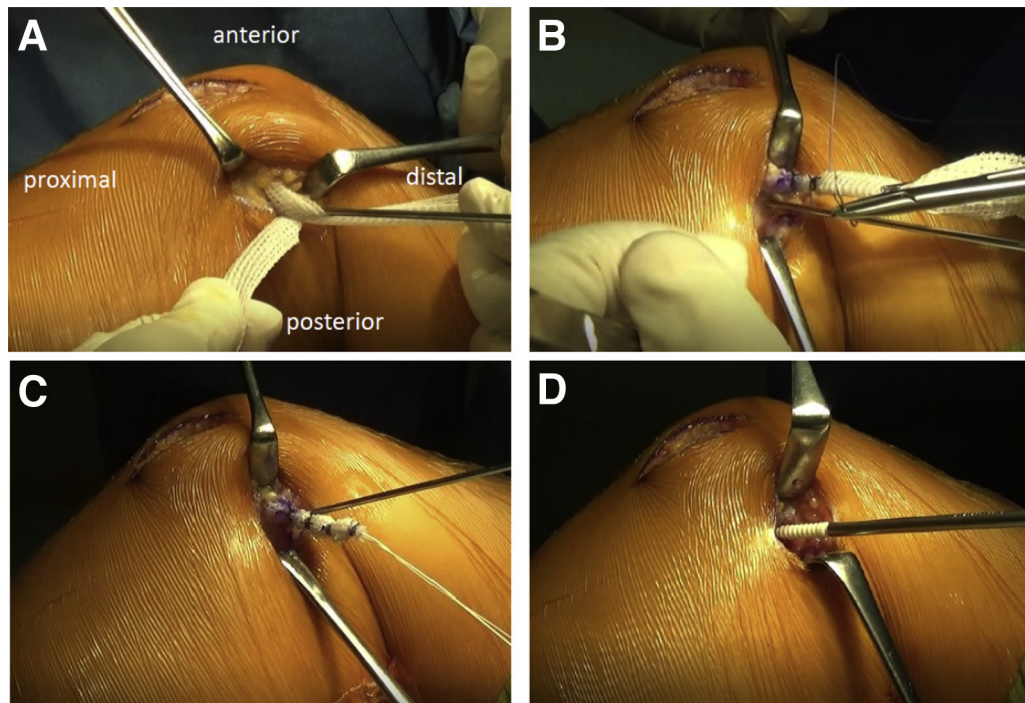
**Fig 3.** Bone tunnel creation at the femoral side. (A) Medial aspect of left knee. With the affected limb in frog leg position and an accurate lateral image of the knee on fluoroscopy, a guide pin is inserted proximally and posterior to the medial epicondyle of the femur and distal to the adductor tuberosity, which corresponds to the Schöttle's point. (B) After inserting the guide pin, press the tip of the drill guide (white arrows) against the femoral insertion point of the guide pin and confirm that the tip of the drill guide is aligned with the Schöttle's point on fluoroscopy.



**Fig 4.** Medial aspect of left knee. (A) The artificial ligaments that are passed through the patella (MPFL graft) and quadriceps tendon (MQTFL graft) are subsequently passed between the deep fascia and the knee joint capsule, that is, the second layer. (B) The artificial ligaments are passed out through the second skin incision. (MPFL, medial patellofemoral ligament; MQTFL, medial quadriceps tendon femoral ligament.)

moderately taut at full knee extension and lax at more than  $60^\circ$  of knee flexion. The length of the artificial ligament is adjusted to meet this condition, and the position where the artificial ligament enters the femoral tunnel is marked after determining the suitable length. The section entering the bone tunnel from the marked area (approximately 30 mm) is cylindrically bound

together with absorbable sutures, the ligament extending beyond the mark is cut off, and the tip of the remaining section is attached to a guide suture (Fig 5 B and C). After creating a 40-mm deep femoral tunnel with a 5-mm cannulated drill, an artificial ligament is placed using a guide suture into the bone tunnel until reaching the marked area. Again, the artificial ligament



**Fig 5.** Medial aspect of left knee. (A) With each artificial ligament (MPFL and MQTFL graft) under equal tension, the artificial ligament is folded over the guide pins, and the artificial ligament is temporarily fixed between the folded portions of the ligaments with a pair of Kocher forceps. (B) The stability of the patella and the tension of the artificial ligaments are checked, and an absorbable suture then binds together the artificial ligaments from the marked point to the area where the ligaments enter the tunnel (30 mm). (C) The ligament extending beyond the mark is cut off, with and the tip of the remaining section is attached to a guide suture. (D) After the femoral tunnel is created by the drill, the bound artificial ligaments are inserted into the tunnel and subsequently fixed with the interference screw with the knee flexed to  $60^\circ$ . (MPFL, medial patellofemoral ligament; MQTFL, medial quadriceps tendon femoral ligament.)

**Table 1.** Surgical Pearls and Pitfalls

Pearls
<ul style="list-style-type: none"> <li>• Carefully plan whether to perform a lateral release and/or tibial tubercle medialization in addition to reconstructing the medial patellar stabilizer based on physical examination and radiographic/CT imaging findings.</li> <li>• To accurately create the patellar tunnel, the morphology and size of the patella should be confirmed using preoperative 3D-CT images to determine the position of the tunnel in the patella.</li> <li>• Palpate and position the distal quadriceps tendon well before splitting it. Also split the tendon long enough to allow the artificial ligament to pass easily.</li> <li>• The MQTFL graft exits the medial skin incision of the femur through the bottom of the vastus medialis rather than above.</li> <li>• Fix with equal tension so that the MQTFL and MPFL graft tension is not biased in knee flexion.</li> </ul>
Pitfalls
<ul style="list-style-type: none"> <li>• Inadequate splits in the distal quadriceps tendon leads to tendon damage when passing through the artificial ligament.</li> <li>• Overstrained MQTFL graft leads to damage to the quadriceps tendon in the split area.</li> <li>• Excessive lateral release, tibial tubercle medialization, and overstraining of the graft lead to patellar subluxation in the medial direction.</li> </ul>

3D, 3-dimensional; CT, computed tomography; MPFL, medial patellofemoral ligament; MQTFL, medial quadriceps tendon femoral ligament.

is checked for tension, and the artificial ligament is fixed with a 5 mm × 23 mm Milagro interference screw (DePuy Mitek, Inc., Raynham, MA) at 60° of knee flexion (Fig 5D). After fixation, knee flexion and extension movements are repeated to ensure that the patella is stable and the wound is closed.

A knee brace is applied postoperatively, and quadriceps training is started in the knee extension position. Range of motion training and partial loading of the knee is started at 1-week postoperatively and full loading at 3 weeks' postoperatively. Patients are allowed to jog at 2 months' postoperatively and return to sports at 3 months' postoperatively. The surgical pearls and pitfalls in addition to the advantages, risks, and limitations of the technique are summarized in Tables 1 and 2, and the detailed technique is described in Video 1. This study was approved by our ethics committee.

## Discussion

In this Technical Note, we described a simultaneous reconstruction technique of the MPFL and MQTFL using artificial ligaments. This technique provides a more anatomical reconstruction of the medial patellar stabilizer based on recent research findings. In addition, this technique adds a simple technique to the commonly performed MPFL reconstruction in which a graft is passed through the distal quadriceps tendon, making the technique more familiar to surgeons who perform MPFL reconstruction.

Biomechanical studies on MQTFL remain scarce in the literature.<sup>10</sup> Spang et al.<sup>11</sup> reported that in mechanical

tests on the dissected knee, MQTFL reconstruction was as resistant to lateral patellar movement as the knee without ligament damage, and Sanchis-Alfonso et al.<sup>12</sup> used a 3-dimensional parametric finite element to show that the MQTFL graft, like the MPFL graft, exhibited tension at 0° to 30° of knee flexion, with graft tension increasing in the MPFL at 0° of knee flexion and in the MQTFL at 30° of knee flexion. Kang et al.<sup>13</sup> also suggested that as the quadriceps muscle contracts with knee flexion, the fibers of the medial patellar stabilizer attached to the quadriceps muscle are pulled proximally, exhibiting dynamic soft tissue bracing and pulling the patella medially. These findings suggest that the MPFL functions as a static stabilizer, especially in knee extension, and the MQTFL functions as a dynamic stabilizer during knee flexion. We believe that reconstruction of both the MPFL and MQTFL leads to a more physiological patellar stabilization.

Although autogenous tendons such as semitendinosus and gracilis are commonly used in MPFL reconstruction,<sup>1,2</sup> Tanaka<sup>4</sup> reported that the average length of the MPFL and MQTFL is 62.6 mm and 69.7 mm, respectively, and that there is a limit to considering the use of autogenous tendons when reconstructing the 2 ligaments in a loop. We used the Leeds-Keio artificial ligament, which has excellent biocompatibility and early adhesion to the bone, as well as excellent tissue inducibility. Nomura et al.<sup>14</sup> performed an evaluation of excised tissue after MPFL reconstruction using artificial ligaments and reported that longitudinal collagen fibers were formed around the artificial ligament, resulting in a mature ligament. This ligament has been used as a graft for anterior cruciate ligament (ACL) reconstruction in the past with poor clinical results; however, unlike the ACL, the MPFL is an extra-articular ligament, and good clinical outcomes have been reported.<sup>15,16</sup> Considering the aforementioned, we believe that the Leeds-Keio artificial ligament in MPFL reconstruction is a very useful grafting material that does not cause problems found in ACL reconstruction.

**Table 2.** Advantages, Risks, and Limitations of MPFL and MQTFL Reconstructions Using an Artificial Ligament

Advantages
<ul style="list-style-type: none"> <li>• Simple and familiar technique to surgeons who perform MPFL reconstruction.</li> <li>• Easy to adjust the length and size of the graft.</li> <li>• No harvest-site pain.</li> <li>• High biocompatibility of the Leeds-Keio ligament prosthesis.</li> </ul>
Risks and limitations
<ul style="list-style-type: none"> <li>• Possible foreign body reaction to the artificial ligament.</li> <li>• Proper tension of MQTFL graft with artificial ligament is not fully understood.</li> <li>• Anterior knee pain and quadriceps muscle weakness due to the interference of the artificial ligament with the quadriceps tendon.</li> </ul>

MPFL, medial patellofemoral ligament; MQTFL, medial quadriceps tendon femoral ligament.

However, several issues remain with this technique, such as what to do with the initial tension of the MQTFL graft and whether the fixed limb position should be identical to that used in MPFL. Furthermore, some biomechanical characteristics are not yet fully understood, including the length pattern of MQTFL and the interaction between MPFL and MQTFL. Further biomechanical studies are warranted to clarify these problems.

In conclusion, we described a simultaneous reconstruction technique of MQTFL and MPFL using artificial ligaments. Careful follow-up is needed to determine whether this technique provides stable clinical outcomes in the medium and long term.

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