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ORIGINAL ARTICLES

Anatomic Restoration of the Femoral Tunnel in Medial Patellofemoral Ligament Reconstruction. A Clinical Data Study

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Abstract

Introduction: Medial Patellofemoral Ligament (MPFL) reconstruction is the standard of care for recurrent patellar dislocation. However, clinical success depends heavily on precise femoral tunnel placement. Malpositioning can compromise ligament isometry and lead to poor postoperative outcomes. This study evaluates the correlation between anatomical tunnel accuracy and clinical recovery, underscoring the importance of meticulous surgical technique.

Materials and Methods: We retrospectively analyzed 124 patients (124 knees) treated for recurrent patellar dislocation from January 2021 to December 2024. The cohort comprised 31 males and 93 females (mean age, 15.4 years). Inclusion criteria included a positive apprehension test, a J-sign, and lateral patellar tilt. Postoperative outcomes were assessed using the Lysholm Knee Score.

CT and MRI were used to measure the distance from the center of the femoral tunnel to the anatomical isometric point, thereby classifying the positions as isometric or non-isometric.

Results: At a mean follow-up of 18 months, no recurrent dislocations were observed. The mean Lysholm score was 93.8. The mean deviation from the isometric point was 4.51 mm; 86 cases (69.4%) were classified as isometric, and 38 (30.6%) were non-isometric.

A strong negative correlation was observed between tunnel deviation and Lysholm scores ($r = -0.851$, $P < 0.001$). The isometric group had significantly higher functional scores (95.4 ± 2.2) than the non-isometric group (88.4 ± 3.3; $P < 0.001$). Furthermore, 58% of the non-isometric group had persistent retropatellar pain, and two patients required revision arthroscopy.

Conclusion: Anatomical and isometric restoration of the femoral tunnel is critical for optimal recovery of knee function in MPFL reconstruction. Meticulous surgical technique is vital to minimize complications. such as residual pain, and ensure favorable long-term outcomes.

Keywords: MPFL reconstruction; isometric femoral tunnel; patellar luxation; surgical anatomy.

Introduction

Reconstruction of the medial patellofemoral ligament has recently become popular for restoring patellofemoral stability. The femoral insertion site anatomy of the medial patellofemoral ligament has been described [1].

Since biomechanical studies have shown that the medial patellofemoral ligament (MPFL) is the primary restraint against lateral patellar displacement, MPFL reconstruction has become an accepted surgical technique to restore patellofemoral stability [2].

The Schöttle point remains the mainstream method for locating the femoral attachment; the single-bundle patellar

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attachment is situated at the junction of the proximal one-third and distal two-thirds of the longitudinal axis of the patella. For double-bundles, one is located in the proximal one-third of the medial patellar edge, and another is in the center of the patellar edge. [3]

The procedure is often performed alongside bony procedures, such as distalization of the tibial tuberosity or trochleoplasty, for patella alta or high-grade trochlear dysplasia, respectively. To date, few studies have evaluated the clinical effectiveness of MPFL reconstruction as an isolated intervention. [4]

Medial patellofemoral ligament reconstruction has a high success rate for patients with patellofemoral instability; however, the complication rate of 26.1% associated with this procedure is substantial. This study quantified complications and documented the variety of complications reported in outcomes-based literature. [5]

Despite numerous techniques reported for reconstructing the MPFL, there is no consensus on the optimal procedure, and debate continues. Isolated MPFL reconstruction for recurrent patellofemoral instability yields reliable surgical outcomes. Patients with pathoanatomical predisposing factors have reported worse surgical outcomes. [6]

Materials and Methods:

Data collection:

We conducted a retrospective study at our Level I Trauma Center of 124 cases (124 knees) treated for recurrent patellar dislocations from January 2021 to December 2024, who underwent MPFL reconstruction. There were 31 males and 93 females, with an average age of 15.4 years (range, 9-25 years).

All patients had a history of trauma and at least one dislocation without hemarthrosis (possible retropatellar or trochlear fractures could alter the final result and the comparison between the cases). Recent literature has aimed to determine the optimal surgical management for patients with and without concurrent osseous anatomical risk factors, such as patella alta, abnormal tibial tubercle–trochlear groove (TT-TG) distance, trochlear dysplasia, and patellar tilt [7-8].

Furthermore, several recent studies have examined the optimal tunnel location, graft fixation angle, and graft tension to improve outcomes and prevent graft failure [9].

The primary study outcome was to assess any correlation between the correct anatomical reconstruction of the MPFL and patients' clinical outcomes. The use of an image intensifier during the operation to set the Schöttle point is mandatory. (Picture 1).

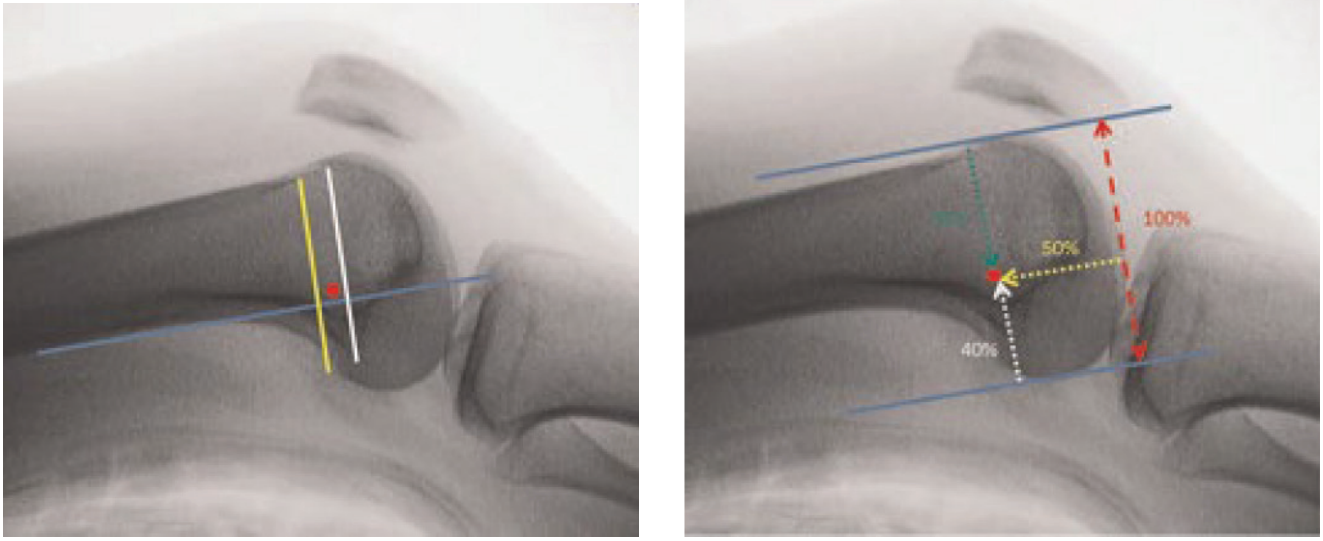
Clinical and Radiological Assessment:

Patellar instability was established through clinical examination, evaluating an apprehension test, patellar tilt, and abnormality in patellar tracking (positive ''J-sign''), as well as radiographic features (picture 2), including the Lysholm score, patellar tilt (picture 3), and TT-TG distance.

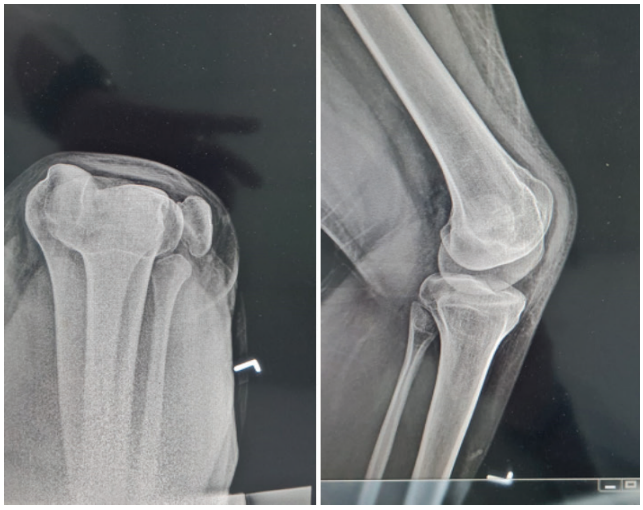
All patients had preoperative magnetic resonance imaging or computed tomography scans, but the TT-TG distance was not systematically measured and could not be measured in all patients. Patients were followed for 14-24 months (mean: 18 months). Clinical evaluation included the apprehension test and the patella-tracking test. A functional assessment was performed using the Lysholm score.

Surgical technique

All surgical procedures were performed by a single senior



Picture 1. Schöttle point;
Horizontal line variability (as determined by perceived location of the posterior aspect of the condyle) in placement can result in anterior-posterior variability in tunnel placement. Vertical line variability (determined by perceived location of the posterior cortex) in placement can result in proximal-distal variability in tunnel placement.



Picture 2. Positive "J-sign"

Picture 3. Patellar tilt

surgeon using the same technique. With the patient supine and a thigh tourniquet in place, a diagnostic arthroscopy was performed to evaluate intra-articular abnormalities of the knee.

An autologous ipsilateral hamstring tendon graft was then harvested and prepared. The fixation technique used was first described by Siebold et al. The gracilis tendon was the preferred choice. The patella was approached through a 4-cm midline incision. A superficial bony sulcus was created at the anatomic MPFL insertion site on the medial patellar rim using a bur or "gouge scissors."

A looped hamstring tendon graft was secured to this superficial sulcus with a pair of non-resorbable transosseous sutures passed through the patella. The retinaculum was sutured over the hamstring tendon graft at the level of the patella to provide additional graft stability.

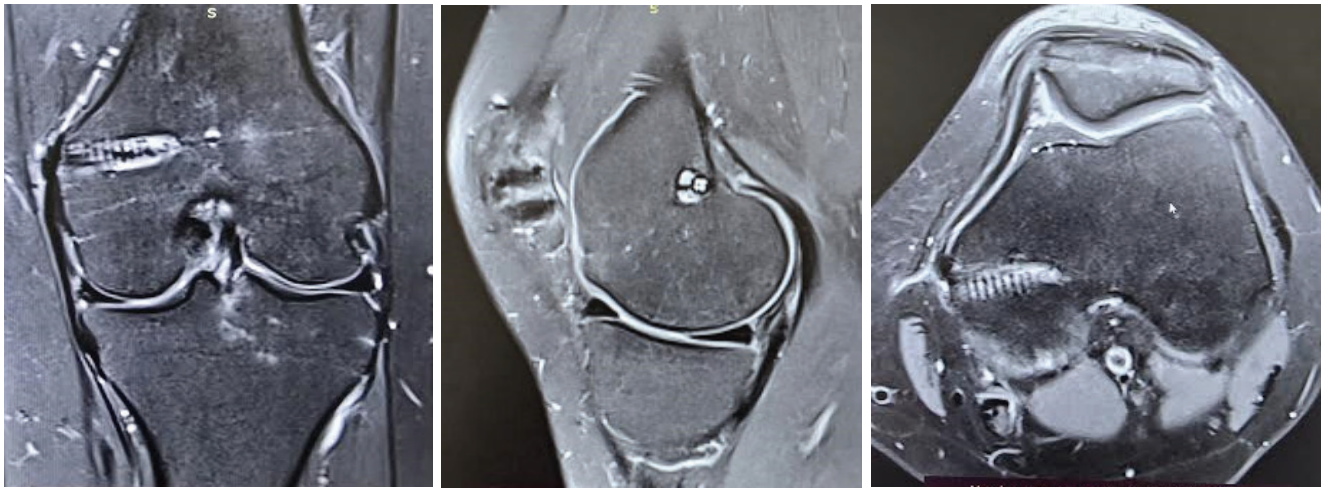
The graft was passed between the deep fascia and the knee joint capsule and out through a 2-cm longitudinal incision over the medial epicondyle. The 2 ends of the graft were secured into a 6-mm tunnel, approximately 3 cm long, located between the adductor tubercle and the proximal part of the superficial medial collateral ligament, and guided by a transfemoral pin.

The position of the femoral tunnel was verified under fluoroscopy. Appropriate graft tension was achieved by cycling the knee from full extension to full flexion. The graft was then secured within the tunnel with a 30-mm (length) 6-8 mm (diameter) interference screw and fixed at 30 of knee flexion.

***Aim of the study**:* referring to the literature, the whole procedure is well described and performed in the literature. The only weak point appears to be the correct positioning of the femoral tunnel, for which Schöttle et al. first prescribe landmarks. [1, 2]

Results

Although the operative technique protocols were followed in the entire series of 124 patients, misplacement of the femoral canal was again identified. We studied clinical outcomes in patients with a well-defined canal and those with an inaccurately defined canal, grouping outcomes by Lysholm score. We were interested in whether the



Picture 4. Femoral channel placement evaluation

performance of the operated knees or the patients' clinical complaints were related to the inaccurate definition of the femoral canal. MRIs were performed in all the cases complaining of pain and muscle hypotrophy for more than 6 months after the surgery *(Picture 4)*.

All clinical data were sorted by Lysholm score and compared. The patients were followed up 14-24 months (mean, 18 months). In all patients, primary wound healing was achieved. No patellar dislocation or subluxation occurred. The result of the apprehensive test was negative.

At the last follow-up, the mean Lysholm score was 93.8 (range, 83-100). The mean distance from the center of the femoral tunnel to the femoral isometric point was 4.51 mm (range, 2-14 mm). The femoral tunnel position was isometric in 86 cases (69.4%) and non-isometric in 38 cases (30.2%).

The distance from the center of the femoral tunnel to the femoral isometric point was negatively correlated with the postoperative Lysholm score ($r = -0.851$, $P = 0.000$). The postoperative Lysholm score was 95.4 ± 2.2 in patients with an isometric tunnel and 88.4 ± 3.3 in those with a non-isometric tunnel, showing a significant difference ($t = 6.911$, $P = 0.001$).

In more than 22 (58% of the 38 cases) patients from the non-isometric group, retropatellar pain occurred and was difficult to treat. Two of these cases underwent a second-look arthroscopy. The aim of this second-look arthroscopy was lateral release and chondroplasty using radiofrequency.

Discussion

Despite several recent studies focused on optimal MPFL reconstruction techniques, there is currently no consensus on the optimal graft type (most commonly hamstring autografts, allografts, and, more recently, synthetic grafts) or on femoral fixation strategies, with similar results reported for each technique [10].

The importance of anatomical graft placement has been reported in several studies, as non-anatomic placement on the femoral side can cause recurrent instability or increase medial patellofemoral contact pressures, overloading the medial cartilage and leading to premature degenerative changes [11, 12]. The number of patellar dislocations remains unclear, with no consensus [16, 17, 19].

Based on our experience, we decided to proceed with patellar dislocation surgery even after the first episode. Malpositioning of the femoral tunnel has been reported as the most common cause of MPFL reconstruction failure requiring revision surgery, occurring in up to 40% of cases [13].

In particular, a femoral tunnel that is malpositioned too anteriorly has been shown to lead to overloading of the medial patellofemoral cartilage [12]. The variables considered included age, gender, and weight. Tunnel malpositioning is a well-discussed topic in the literature [1, 14, 15, 20, 21].

Some authors tolerate a wide range of errors in aiming the entry point, from 0 to 8 millimeters [21]. In our study, we allowed no deviation from the exact point in evaluating aiming errors. This is why the percentage of errors at this point differs.

Although it was not the aim of our study, we would like to emphasize our view on graft fixation within the tunnel. The majority of authors follow the original technique by fixing the graft with an interference screw (as we also did). There are also other alternatives, such as the endo/ultra button [18]. In our experience, the interference screw provides the graft a greater likelihood of undergoing metaplasia within the tunnel.

Conclusion:

One of the most common causes of MPFL failure, in order of decreasing frequency, is malposition of the femoral tunnel. MPFL reconstruction with a gracilis tendon autograft consistently normalized patellar stability and improved knee function. Moderate medial pain was observed.

Schöttle's point was approximately 8 mm distal to the apex of the adductor tubercle and 8 mm from the posterior edge. Schöttle's point-localization method using fluoroscopy demonstrated high accuracy. We concluded that placing the graft at the correct location in the femur yields the best clinical outcome in an MPFL reconstruction.

COI Statement: This paper has yet to be submitted in parallel, presented fully or partially at a meeting, podium, or congress, published, or submitted for consideration beforehand.

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