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Accuracy of Schottle's point location by palpation and its role in clinical outcome after medial patellofemoral ligament reconstruction

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ABSTRACT

Introduction: Medial patellofemoral ligament (MPFL) reconstruction is performed for the recurrent patellar dislocation (RPD). The crux of sound clinical results depends upon accurate placement of the graft at or within the 7-mm circle of Schottle point (acceptable position) over the femur. Most studies recommend the location of Schottle's point using intraoperative fluoroscopy or seldom by clinical palpation. We conducted a clinical study to understand the accuracy of locating Schottle's point by clinical palpation and its effect on outcome after MPFL reconstruction.

Method: 30 patients with RPD were included in this retrospective study after MPFL reconstruction. Post-operative CTscan was performed to locate the position of the femoral tunnel using Servien grid criteria and Schottle's point location. The clinical outcome was assessed using Lysholm and Kujala Scores at the end of a minimum of two years.

Results: 30 patients (11 male, 19 female) with a mean age of 24.8 years (range, 16–45 years) were followed for a mean of 42 months (range, 24–96 months). Mean Kujala score improved from 53.8 to 91.5 ($p = 0.0001$), and Lysholm score improved from 59.0 to 93.3 ($p = 0.0001$) in all 30 patients. Post-operative CT assessment revealed 19 patients (63.3%) had a tunnel in an acceptable position and 11 patients (36.7%) in an unacceptable position. Eight of the eleven unacceptable tunnels were placed in the anteroposterior direction, and three in superior-inferior direction. However, there was no significant difference between the Lysholm and Kujala scores of patients with acceptable versus unacceptable tunnels.

Conclusion: Placement of the femoral tunnel over the medial femoral condyle by the palpatory method is accurate in close to 2/3rd of the cases only whereas rest 1/3rd may fall outside the acceptable position. Hence, it is recommended to confirm the placement of femoral tunnel with intraoperative fluoroscopy at the acceptable position to avoid error.

Level of study: Retrospective case series, level IV.

1. Introduction

Since Ellera Gomes stressed the importance of MPFL reconstruction in 1992 for recurrent patella dislocation,[1] it is increasingly performed to prevent such recurrences and improve the clinical outcome.[2–6] The clinical outcome after MPFL reconstruction depends upon many factors such as the location of femoral and patella tunnels,[7] trochlear dysplasia,[8,9] static versus dynamic reconstruction,[10] graft tension,[11] flexion angle of graft fixation[12] and associated cartilage lesions. A major factor which affects the patellofemoral kinematics is the location of the femoral tunnel over medial femoral condyle (MFC). A malpositioned femoral tunnel can lead to altered patellofemoral mechanics,

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increased medial facet compressive forces and medial patella arthrosis.[13,14] Hence, one of the key factor to a successful MPFL reconstruction lies with the restoration of the isometric property of MPFL, and this goal is achieved by the anatomic placement of the graft over the MFC.[15–17]

The optimal position of the femoral tunnel at the MFC is still debatable as various studies suggest different landmark for attachment of MPFL for isometry restoration such as over the medial epicondyle,[18,19] adductor tubercle[20–22] or anterior to the medial epicondyle.[23,24] However, most authors conclude that it lies over a dimple between the adductor tubercle and medial epicondyle more specifically proximal and posterior to ME and distal and anterior to AT which is also known as 'Nomura point'[25–30] and it possesses the isometric properties.[16,31,32] However, Blatter et al. suggested that the landmark for MPFL origin over MFC could be patient specific.[33]

The identification of such landmarks over the MFC during the surgery could be done by fluoroscopy or clinical palpation. The most common fluoroscopic method used to locate 'anatomic, native' MPFL attachment over MFC is the one described by Schottle et al. who concluded that the "MPFL insertion over MFC could be reproducibly identified using intra-operative fluoroscopy at a point 1.3 mm anterior to the posterior cortical line extension, 2.5 mm distal to a perpendicular line intersecting the origin of the posterior medial femoral condyle, and 3 mm proximal to a perpendicular line intersecting the posterior point of the Blumensaat line", and all these points were within a circle of 5 mm diameter.[34] Servian et al. expanded the '5-mm circle' to '7-mm circle' as "acceptable tunnel position" over MFC because most tunnel diameters at MFC are of 7 mm.[35]

In comparison to radiographic landmarks, the clinical palpation of designated anatomical landmarks for the placement of MPFL over MFC depends upon the experience of the surgeon and how well the palpation of Adductor tubercle (AT) and medial epicondyle (ME) could be executed. Further, the bony landmarks are covered with soft tissues making it difficult to palpate. This may lead to inaccurate graft placement over the MFC.[36] Whichever method, fluoroscopy or palpatory, is used to locate the area over MFC to attach graft for MPFL reconstruction; the good outcome is dependent upon how close it is to the anatomical insertion of MPFL restoring isometry.[37]

We hypothesize that the accuracy of clinical palpation by an experienced surgeon is similar to that of the fluoroscopic method and it will lie within the acceptable limits described by Servian et al.[35] Secondly, the placement of the tunnel outside the acceptable zone will affect the clinical outcome as compared to accurately placed ones.

2. Material and method

This study was approved by institutional review board which constituted the retrospective evaluation of patients with recurrent patellar dislocation (RPD) who underwent MPFL reconstruction by Christiansen patella dual tunnel technique.[38] From 2010 to 2013, a total of 38 patients were operated for MPFL reconstruction and were included in the study. A total 30 patients were finally included in the study with a minimum follow-up of two years. Eight patients were excluded either due to lack of acceptable postoperative imaging, or they did not turn up for minimum follow-up period required. Inclusion criteria were patients with recurrent patellar dislocation who had magnetic resonance imaging (MRI) proven MPFL tear and tibial tubercle-tibial tuberosity (TT-TG) distance less than 20 mm. Patients with TT-TG interval greater than 20 mm, those who underwent distalisation or medialization procedure of tibial tuberosity, Dejour type 3 and 4 trochlear dysplasia, patellofemoral arthritis, patients with open physis, patients with multi-ligament injury and periarticular fractures were excluded from the study.

Each patient had undergone a standard preoperative detailed clinical evaluation to confirm the diagnosis of the RPD. MRI was performed to confirm the tear in MPFL, type of trochlear dysplasia and TT-TG interval assessment. Postoperatively, each patient underwent plain radiograph (anteroposterior and true lateral) and computed tomography (CT) scan with 3-dimensional reconstruction accurately locate the tunnel over the MFC.

Surgical technique: All the surgeries were performed by a single senior surgeon who had experience in patella reconstructive surgery for more than seven years. After appropriate anesthesia, standard part preparation and draping, the diagnostic arthroscopy was performed. The status of patellar cartilage was documented, and the loose body was removed, if any. The meniscal and cartilage lesions were treated as per standard protocol. After diagnostic arthroscopy, the ipsilateral semitendinosus graft was harvested with standard technique. The two ends of graft were prepared by running baseball sutures using no.5 Ethibond sutures (Johnson and Johnson, USA). The MPFL reconstruction was performed by the technique described by Christiansen et al. using two transverse patella tunnel.[38] Then, a 2 cm long incision was made over the skin of superior two-third of the lateral border of the patella. Subcutaneous tissue and deeper lateral retinaculum were incised linearly to expose the lateral border of the patella. Then, two 4.5 mm parallel transverse patellar tunnels were drilled from lateral to the medial border of the patella. Then, another incision was made over the medial border of the patella to expose the medial ends of the tunnels. Next, a one-inch long incision was made over the MFC between ME and AT. Subcutaneous tissue and deep fascia were sharply incised along the lines of skin incision. The ME and AT were palpated, and its center point was felt and visually confirmed. A 2.0 mm guide wire was placed over the center point and was drilled towards the superolateral direction to exit from the superolateral cortex of the femur. Then, 7.0 mm cannulated femoral reamer was used to drill the near cortex only.

Then; the ST graft was looped around the two patellar tunnel, and two free limbs of ST graft were passed between the second and third layer of the knee on the medial aspect. Further, the two limbs were passed via the femoral tunnel keeping the knee in 30^0 flexion, and the graft was fixed in the femoral tunnel with a 7×25 mm bioabsorbable interference screw. The knee was extended back to check the adequacy of graft tension. An adequately tensioned MPFL graft allows one to two quadrants of lateral patellar movement possible. Then, the knee was moved passively to full range of flexion to confirm that the graft fixation is not tight to prevent full flexion. The wounds were closed in layers. Three patients underwent lateral release too.

Rehabilitation: All patients underwent standard rehabilitation in the form of gradual knee mobilization in hinge brace, quadriceps strengthening exercises, and progressive weight bearing. Return to sports was allowed after 5–6 months when patient achieved full range of motion (ROM) and strength.

Postoperative radiographic assessment of femoral tunnel: Each patient underwent postoperative plain radiograph (anteroposterior and lateral) and a CT scan to assess the placement of tunnel on the standard Schottles' point. Though Schottle stated that all the points of MPFL attachment were within the circle of 5 mm diameter, we considered circle diameter as 7 mm as a reference because the standard femoral tunnel diameter was 7 mm as described by Servian et al. method.[35] All the tunnels lying within this range were considered to be adequate (SPA). A mal-positioned tunnel was considered anywhere outside this circle (SPU) of 7 mm diameter. Fig. 1 depicts the relationship of three landmarks (AT, ME, and MPFL

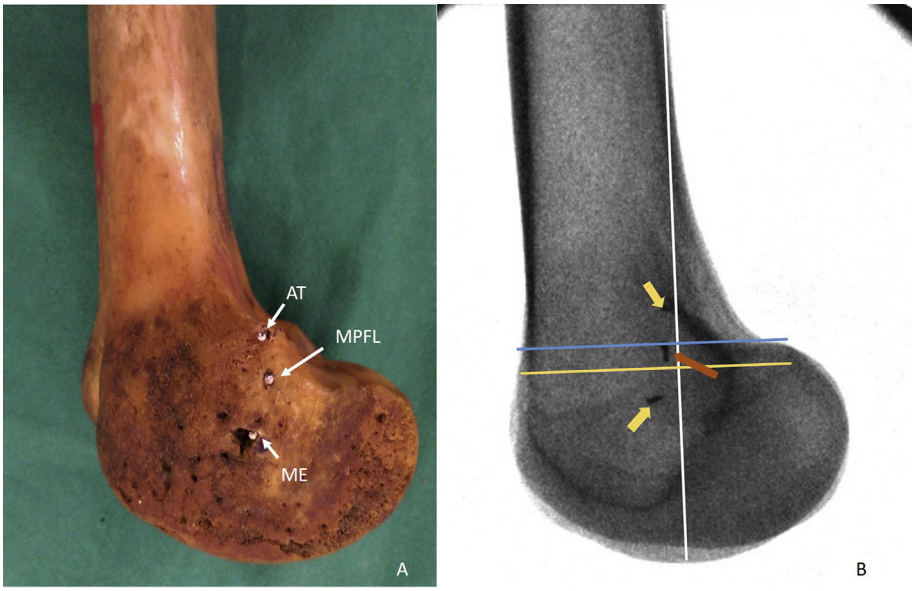

Fig. 1. (A,B): Figure 1A shows the landmarks on the medial femoral condyle of right cadaveric femur specimen where the centre of MPFL is attached in the middle of the AT and ME. Figure 1B shows the lateral radiographic image of the same cadaveric femur with lines drawn to indicate Schottle's point. The Schottle point is indicated by deep orange arrow while AT and ME by yellow arrows. AT, Adductor tubercle; ME, Medial epicondyle; MPFL, Medial patellofemoral ligament.

center) over the cadaveric femur specimen and adjoining radiograph. All images were displayed on imaging software provided by InstaRISPACS for assessment of various parameters. All the outliers (SPU) were plotted on the standard X-ray and CT scan concerning their distance from Schottle's point (Fig. 2). Further, the Servian grid was 1 × 1 cm square was superimposed over the image with outlier points (SPU) to assess how many were in an anteroposterior

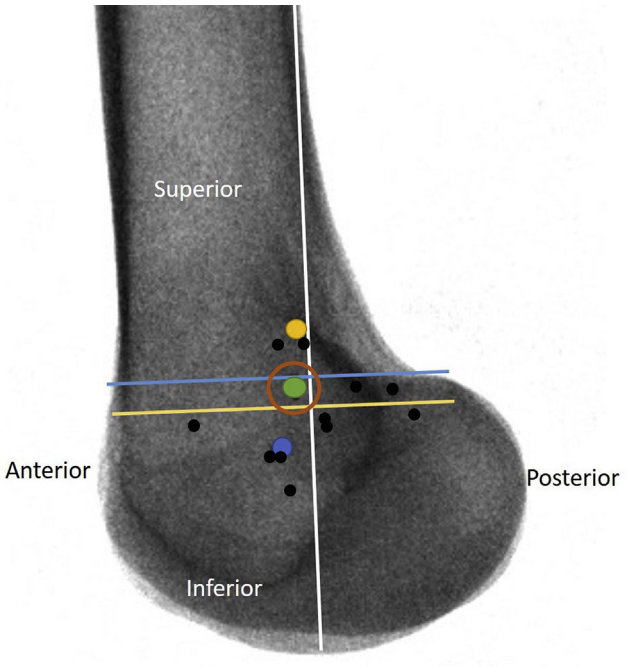

Fig. 2. Lateral radiographic image of the femur plotted with the all eleven outliers (black circles). Yellow circle indicates AT, Blue circle indicates ME and green circle shows Schottle's point. The 7 mm wide brown circle indicates maximum permissible acceptable position for a tunnel. Three lines (white, blue and yellow) used to draw Schottle point. AT, adductor tubercle; ME, medial epicondyle.

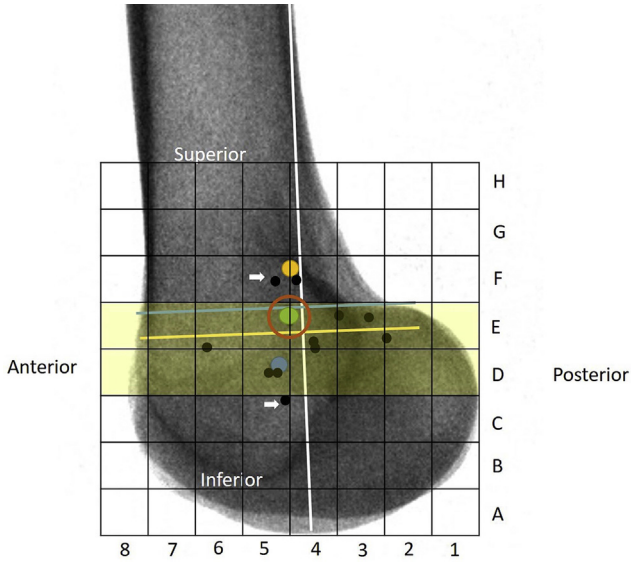

Fig. 3. Lateral radiographic image of the femur plotted with the all eleven outliers (black circles) and a grid of 1×1 cm squares described by Servian et al. The squares shaded in light yellow indicate anteroposterior plane. Yellow circle indicates AT, Blue circle indicates ME and green circle shows Schottle point. The 7 mm wide brown circle indicates maximum permissible acceptable position for a tunnel. AT, Adductor tubercle; ME, Medial epicondyle.

direction or superior-inferior direction (Fig. 3). The horizontal square row of D and E was considered to be anteroposterior in direction, and any square lying elsewhere was superior or inferior.

The preoperative and postoperative data were analyzed using chi-square and paired *t*-test.

3. Results

The final follow-up included 30 patients (11 males and 19 females) with a mean age of 24.8 years (range, 16–45 years). The

mean follow-up was 42 months (range, 24–96 months). Eight had right knee involvement, and 22 had left knee involvement.

At the final follow-up, the mean preoperative Kujala score improved from 53.83 to 91.57 postoperatively ($p = 0.0001$). The mean Lysholm score improved from 59.0 to 93.37 ($p = 0.0001$) [Table 1]. No patient had any recurrence of dislocation or subluxation.

The postoperative radiographic assessment revealed that 19 (63.3%) out of 30 patients had tunnels in the acceptable position (SPA) whereas 11 (36.7%) patients had their tunnels located outside the acceptable limit of Schottle's point (SPU). Fig. 2 demonstrates the location of 11 tunnels which were outside the acceptable limit (SPU). The mean distance of these 11 tunnels from Schottle's point was 11.9 mm (range, 8–24 mm) or approximately 4 mm outside the acceptable circle of 7 mm with Schottle point at center. On superimposing the Servian grid over the tunnels located over the MFC, eight tunnels were mal-positioned in the anteroposterior direction (in the block of D and E) whereas two were in superior and one in an inferior direction (Fig. 3). Fig. 4 illustrates three cases of the malpositioned tunnel on a 3-D CT scan.

However, the Kujala and Lysholm score of patients "within, SPA" and "outside, SPU" did not show any significant difference (Table 2).

4. Discussion

The significant finding from our study states that even in the experienced surgeon's hand, palpatory localization of Schottle's point or anatomical insertion of MPFL is accurate only in two-third cases and a third of tunnels are located outside the acceptable limits. Derived from this study, fluoroscopic guidance is now mandatorily used in our unit by default. However, the tunnels outside the 'currently defined' acceptable limits do not affect the clinical outcomes significantly.[11]

The palpatory method in our series could place only 63.3% tunnels over acceptable area whereas 36.7% cases were in outlier group (SPU). By the palpatory method, Servian et al. reported 70% accuracy in tunnel placement whereas McCarthy et al. reported only 36% of tunnels placed in the acceptable position.[35,39] In a cadaveric study wherein surgeons of varying experience located accurate position by palpatory method; Hershel et al. reported that 29% of all the tunnels were in correct zone, another 47% in less than 5 mm of correct zone and another 23% were complete outliers.[36] Further, Hershel et al. did not find any difference in the tunnel localization by surgeons with different level of expertise. So, in most cases, a third of tunnel placement might remain out of the acceptable zone using palpatory method.

Our series shows that most malpositioned tunnels are in the anteroposterior direction (8 out of 11, 77%) where as only three in the superior-inferior direction. Serivan et al. reported more outliers in proximal (5 out of 10, 50%) in the proximal direction and less in anterior direction (3 out of 10, 30%) on MRI assessment.[35] The mean distance erred in our series using palpatory method was 11.9 mm (approximately 5 mm outside the acceptable circle of 7 mm diameter) whereas McCarthy et al.[39] reported an error of 13.25 mm from Schottle point (approximately 6 mm outside the acceptable circle of 7 mm diameter). This data suggests that the palpatory method remains an inaccurate method to locate the exact tunnel position for MPFL attachment and should be avoided.

Although the fluoroscopic methods described in the literature[34,40] result in the reproducible and acceptable placement of the femoral tunnel for MPFL reconstruction, but fluoroscopy is often routinely not used due to practical reasons, and surgeons often feel confident about their skills of the palpatory method. Further, the accuracy of the palpatory method also depends upon that how well these landmarks (AT or ME) can be palpated with ease. The Adductor tubercle is often well palpated in comparison to medial epicondyle as latter is often flat or like a groove.[29] Also, the area between the ME and AT is often covered with scar tissue due to ruptured MPFL from femoral origin further blunting the palpatory feeling of these landmarks especially ME.

The major factor deciding the outcome after MPFL reconstruction is accurate tunnel placement over the medial femoral condyle[27] and deviation as little as 5 mm from the designated point of MPFL anatomic insertion leads to altered isometric behavior of the graft affecting the outcome.[16,24] Hence, it is our strong recommendation that the positioning of the tunnel should always be confirmed with the intraoperative fluoroscopic method to avoid mal-positioning of tunnels and one should not rely on one's palpatory skills to locate the landmarks for tunnel placement.

The second observation arising out of our study is that although there were 36% "anisometric outliers" but they did not influence the outcome as compared to the 64% of "acceptable isometric position" ones. Similar observations were reported by McCarthy et al. and Servian et al. who did not find any difference between the patients who had mal-positioned tunnel compared to the anatomic tunnel.[35,39] Stephen et al. also suggested that tunnel placement in proximal or distal direction results in a larger effect on isometry as compared to anterior to posterior direction on anatomic MPFL attachment point.[16]

Further, this anomaly may be explained by the fact that still there lies an ambiguity about the precise origin of MPFL and an exact landmark for MPFL attachment on MFC which may contribute to the isometric behavior of the graft.

Apart from the debate over the accurate anatomic location of MPFL, there continues to have disagreement by various authors over the isometric point for the MPFL attachment. Zhang et al. suggested that the most isometric point is located in a triangular area formed by joining the point forming the dome of the Blumensaat line, the point 10 mm inferior to the AT and a midpoint between the AT and ME.[41] Gobbi et al. suggested that placement of MPFL graft directly posterior or distal to ME is 'risky' and should be avoided whereas Smirk and Morris have shown that worst isometric position lies at the Adductor tubercle.[24,31] Blatter et al. suggested that most isometric point showed a non-uniform distribution in subjects.[33] Blatter further suggested that radiographic points lead to worst isometric scores as compared to the surgeon defined ones. Therefore, he suggested that careful intraoperative assessment of isometric behavior of MPFL is important for each patient rather than considering it as a fixed point in the entire population.

Limitations: Although the mid-term results of our study conclude that the clinical outcome is not affected if tunnels are malpositioned in anterior or posterior direction but we do not know the effect of the malpositioned tunnel over the increased patellofemoral pressures in the long term. A longer follow-up may reveal an increased incidence of patellofemoral arthritis.

5. Conclusion

Irrespective of their experience, the surgeons should avoid

Table 1
Mean pre- and post-operative Lysholm and Kujala scores of patients. CI, confidence interval.

	Mean Score	95% CI	P value
Preoperative Lysholm score	59.0	54.11–63.9	0.0001
Postoperative Lysholm score	93.3	91.25–95.5	
Preoperative Kujala score	53.83	41.8–59.86	0.0001
Postoperative Kujala score	91.5	89.96–93.18	

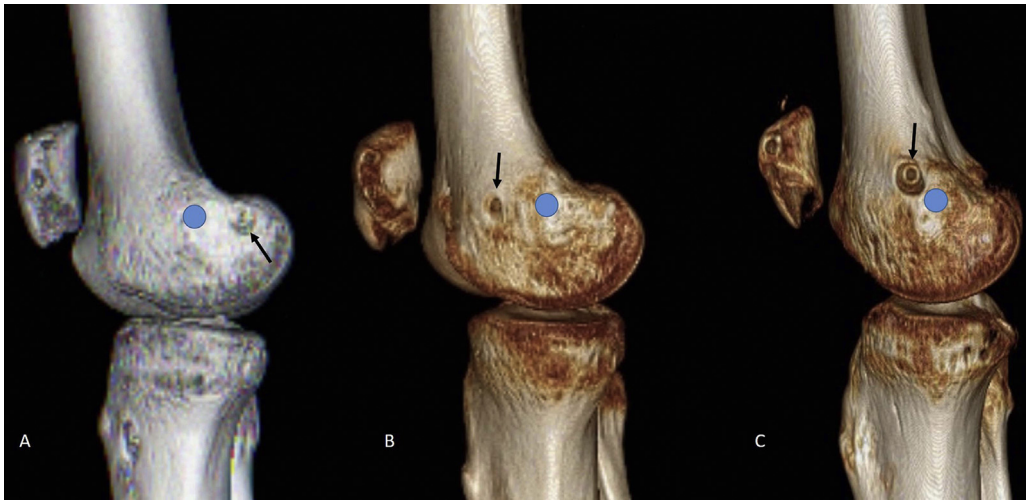

Fig. 4. (A,B and C): 3-D reconstruction of CT scan showing three images with mal-positioned tunnel (black arrow) in posterior (4A), anterior (4B) and superior (4C) direction. Blue circle indicates position of Schottle point.

Table 2
Comparison between postoperative Lysholm and Kujala scores of two groups (SPA and SPU) using Independent sample test. SPA, Schottle's position acceptable; SPU, Schottle's position unacceptable.

	Position of tunnel	Number of patients (N)	Mean Score	± Standard deviation	P value
Postoperative Lysholm score	SPA	19	92.84	6.23	0.51
	SPU	11	94.27	4.67	
Postoperative Kujala score	SPA	19	91.58	3.58	0.98
	SPU	11	91.55	5.55	

palpatory skills alone for the placement of femoral tunnel during MPFL reconstruction as the chances of error in tunnel placement can happen in one-third of all the cases. However, an error in anteroposterior direction could be more forgiving and may not affect the clinical outcome.

Patient declaration statement

"The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed."

Conflicts of interest

None.

References

1. Ellera Gomes JL. Medial patellofemoral ligament reconstruction for recurrent dislocation of the patella: a preliminary report. *Arthroscopy*. 1992;8:335–340.
2. Ambrozic B, Novak S. The influence of medial patellofemoral ligament reconstruction on clinical results and sports activity level. *Phys Sportsmed*. 2016;44:133–140.
[3]. Mulliez A, Lambrecht D, Verbruggen D, Van Der Straeten C, Verdonk P, Victor J. Clinical outcome in MPFL reconstruction with and without tuberositas transposition. *Knee Surg Sports Traumatol Arthrosc*. 2017 Sep;25(9):2708–2714.
4. Neri T, Philippot R, Carnesecchi O, Boyer B, Farizon F. Medial patellofemoral ligament reconstruction: clinical and radiographic results in a series of 90 cases. *Orthop Traumatol Surg Res*. 2015;101:65–69.
5. Stupay KL, Swart E, Shubin Stein BE. Widespread implementation of medial patellofemoral ligament reconstruction for recurrent patellar instability maintains functional outcomes at midterm to long-term follow-up while decreasing complication rates: a systematic review. *Arthroscopy*. 2015;31:1372–1380.
6. Valkering KP, Rajeev A, Caplan N, Tuinebreijer WE, Kader DF. An evaluation of the effectiveness of medial patellofemoral ligament reconstruction using an anatomical tunnel site. *Knee Surg Sports Traumatol Arthrosc*. 2017;25:3206–3212.
7. Bicos J, Fulkerson JP, Amis A. Current concepts review: the medial patellofemoral ligament. *Am J Sports Med*. 2007;35:484–492.
8. Hiemstra LA, Kerslake S, Loewen M, Lafave M. Effect of trochlear dysplasia on outcomes after isolated soft tissue stabilization for patellar instability. *Am J Sports Med*. 2016;44:1515–1523.
9. Hopper GP, Leach WJ, Rooney BP, Walker CR, Blyth MJ. Does degree of trochlear dysplasia and position of femoral tunnel influence outcome after medial patellofemoral ligament reconstruction? *Am J Sports Med*. 2014;42:716–722.
10. Rood A, Hannink G, Lenting A, et al. Patellofemoral pressure changes after static and dynamic medial patellofemoral ligament reconstructions. *Am J Sports Med*. 2015;43:2538–2544.
11. Beck P, Brown NA, Greis PE, Burks RT. Patellofemoral contact pressures and lateral patellar translation after medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2007;35:1557–1563.
12. Burrus MT, Werner BC, Conte EJ, Diduch DR. Troubleshooting the femoral attachment during medial patellofemoral ligament reconstruction: location, location, location. *Orthop J Sports Med*. 2015;3, 2325967115569198.
13. Stephen JM, Kittl C, Williams A, et al. Effect of medial patellofemoral ligament reconstruction method on patellofemoral contact pressures and kinematics. *Am J Sports Med*. 2016;44:1186–1194.
14. Elias JJ, Kelly MJ, Smith KE, Gall KA, Farr J. Dynamic simulation of the effects of graft fixation errors during medial patellofemoral ligament reconstruction. *Orthop J Sports Med*. 2016;4, 2325967116665080.
[15]. Sanchis-Alfonso V, Ramirez-Fuentes C, Montesinos-Berry E, Domenech J, Marti-Bonmati L. Femoral insertion site of the graft used to replace the medial patellofemoral ligament influences the ligament dynamic changes during knee flexion and the clinical outcome. *Knee Surg Sports Traumatol Arthrosc*; 2015. https://doi.org/10.1007/s00167-015-3905-0.
16. Stephen JM, Lumpaopong P, Deehan DJ, Kader D, Amis AA. The medial patellofemoral ligament: location of femoral attachment and length change patterns resulting from anatomic and nonanatomic attachments. *Am J Sports Med*. 2012;40:1871–1879.
17. Stephen JM, Kaider D, Lumpaopong P, Deehan DJ, Amis AA. The effect of femoral tunnel position and graft tension on patellar contact mechanics and kinematics after medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2014;42:364–372.

18. Hautamaa PV, Fithian DC, Kaufman KR, Daniel DM, Pohlmeyer AM. Medial soft tissue restraints in lateral patellar instability and repair. *Clin Orthop Relat Res*. 1998:174–182.
19. Reider B, Marshall JL, Koslin B, Ring B, Girgis FG. The anterior aspect of the knee joint. *J Bone Joint Surg Am*. 1981;63:351–356.
20. Conlan T, Garth Jr WP, Lemons JE. Evaluation of the medial soft-tissue restraints of the extensor mechanism of the knee. *J Bone Joint Surg Am*. 1993;75:682–693.
21. Desio SM, Burks RT, Bachus KN. Soft tissue restraints to lateral patellar translation in the human knee. *Am J Sports Med*. 1998;26:59–65.
22. Tuxoe JI, Teir M, Winge S, Nielsen PL. The medial patellofemoral ligament: a dissection study. *Knee Surg Sports Traumatol Arthrosc*. 2002;10:138–140.
23. Feller JA, Feagin Jr JA, Garrett Jr WE. The medial patellofemoral ligament revisited: an anatomical study. *Knee Surg Sports Traumatol Arthrosc*. 1993;1:184–186.
24. Smirk C, Morris H. The anatomy and reconstruction of the medial patellofemoral ligament. *Knee*. 2003;10:221–227.
25. Nomura E, Inoue M, Osada N. Anatomical analysis of the medial patellofemoral ligament of the knee, especially the femoral attachment. *Knee Surg Sports Traumatol Arthrosc*. 2005;13:510–515.
26. Philippot R, Chouteau J, Wegrzyn J, Testa R, Fessy MH, Moyen B. Medial patellofemoral ligament anatomy: implications for its surgical reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2009;17:475–479.
27. Baldwin JL. The anatomy of the medial patellofemoral ligament. *Am J Sports Med*. 2009;37:2355–2361.
28. LaPrade RF, Engebretsen AH, Ly TV, Johansen S, Wentorf FA, Engebretsen L. The anatomy of the medial part of the knee. *J Bone Joint Surg Am*. 2007;89:2000–2010.
29. Fujino K, Tajima G, Yan J, et al. Morphology of the femoral insertion site of the medial patellofemoral ligament. *Knee Surg Sports Traumatol Arthrosc*. 2015;23:998–1003.
30. Placella G, Tei M, Sebastiani E, et al. Anatomy of the Medial Patello-Femoral Ligament: a systematic review of the last 20 years literature. *Musculoskelet Surg*. 2015;99:93–103.
31. Gobbi RG, Pereira CA, Sadigursky D, et al. Evaluation of the isometry of different points of the patella and femur for medial patellofemoral ligament reconstruction. *Clin Biomech*. 2016;38:8–12.
32. Steensen RN, Dopirak RM, McDonald 3rd WG. The anatomy and isometry of the medial patellofemoral ligament: implications for reconstruction. *Am J Sports Med*. 2004;32:1509–1513.
33. Blatter SC, Furnstahl P, Hirschmann A, Graf M, Fucentese SF. Femoral insertion site in medial patellofemoral ligament reconstruction. *Knee*. 2016;23:456–459.
34. Schottle PB, Schmeling A, Rosenstiel N, Weiler A. Radiographic landmarks for femoral tunnel placement in medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2007;35:801–804.
35. Servien E, Fritsch B, Lustig S, et al. In vivo positioning analysis of medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2011;39:134–139.
36. Herschel R, Hasler A, Tscholl PM, Fucentese SF. Visual-palpatory versus fluoroscopic intraoperative determination of the femoral entry point in medial patellofemoral ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2017;25:2545–2549.
37. Tateishi T, Tsuchiya M, Motosugi N, et al. Graft length change and radiographic assessment of femoral drill hole position for medial patellofemoral ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2011;19:400–407.
38. Christiansen SE, Jacobsen BW, Lund B, Lind M. Reconstruction of the medial patellofemoral ligament with gracilis tendon autograft in transverse patellar drill holes. *Arthroscopy*. 2008;24:82–87.
39. McCarthy M, Ridley TJ, Bollier M, Wolf B, Albright J, Amendola A. Femoral tunnel placement in medial patellofemoral ligament reconstruction. *Iowa Orthop J*. 2013;33:58–63.
40. Redfern J, Kamath G, Burks R. Anatomical confirmation of the use of radiographic landmarks in medial patellofemoral ligament reconstruction. *Am J Sports Med*. 2010;38:293–297.
41. Zhang N, Jiang Z, Wen X, Sugamoto K, Yang C. The triangle zone as a femoral attachment location in medial patellofemoral ligament reconstruction: an in vivo three-dimensional analysis using an open MRI scanner. *Knee*. 2015;22:585–590.