THIEME OPEN ACCESS

Distalization and Medialization of Tibial Tuberosity for the Treatment of Potential Patellar Instability with Patella Alta

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Joints 2018;6:80–84.

Abstract

Purpose The aim of the study was to test the distalization and medialization of the tibial tuberosity (DMTT) for the treatment of patellar instability associated with patella alta, focusing on residual instability and pain.

Methods Twenty-four consecutive patients (26 knees) suffering from patellofemoral instability and patella alta were treated by DMTT. Two groups were identified, which differed for documented history of frank patella dislocation. The groups were named objective patellar instability (OPI) (history of dislocation) and potential patella instability (PPI) (no dislocation). Outcome was measured with visual analogue scale (VAS), Kujala score, and Tegner score. Comparison between groups was performed using Student's *t*-test, Wilcoxon rank score, and Fisher's exact test (significance at $p < 0.05$).

Results At 50 ± 18 and 41 ± 18 months of follow-up, respectively, both PPI and OPI groups obtained a significant pain reduction and functional improvement. The PPI group showed a significant decrease of the subjective instability. No procedure-related complications were reported.

Conclusion This study suggests that DMTT is a viable option for PPI patients with patella alta. The outcome was comparable between PPI and OPI cases; however, decrease in subjective instability was significantly greater in PPI patients.

Level of Evidence Level III, retrospective comparative study.

Keywords
- patellar instability
- distalization
- medialization
- patella alta
- tibial tuberosity

Introduction

Anterior knee pain and patellofemoral tracking disorders are major orthopaedic problems, which require an accurate diagnosis to achieve good treatment results. The "Lyon's School" categorized those disorders as: (1) objective patellar instability (OPI), when a dislocation occurs and anatomical abnormalities are present; (2) potential patellar instability (PPI), when anatomical abnormalities does not lead to a dislocation; and (3) patellofemoral pain syndrome, when cases of anterior knee pain are not related to anatomical abnormalities and/or dislocations.[1] Patella alta, trochlear dysplasia, and increased tibial tuberosity-trochlear grove (TT-TG) distance are major contributors of patella instability, alongside with other minor factors, such as medial patellofemoral ligament (MPFL) injury or dysplasia that impair the restrain forces acting on the joint.[2] In particular, patella alta, defined by a Caton–Deschamp index (CDI) > 1.2,[3] was found to be present in 24% of patients who suffered patellar dislocation and in 3% of normal controls.[1]

Distalization of the tibial tubercle represents a consolidated treatment for the management of patella alta associated with OPI.[4] Many studies consider patellar distalization in association with different procedures such as tibial

published online
June 22, 2018

DOI https://doi.org/10.1055/s-0038-1661340.
ISSN 2282-4324.

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tubercle medialization, patellar tendon tenodesis, vastus medialis advancement, or MPFL reconstruction.[5–9] A three-dimensional transfer of the tibial tuberosity (distalization, medialization, and anteriorization) has also been proposed.[10]

When performing a tibial tubercle transfer, the amount of distalization and/or medialization should be based on the preoperative assessment of the patellar height and TT-TG distance.[8] It has also been reported that distalization and medialization of the tibial tuberosity (DMTT) is effective in restoring patellar stability in patients with OPI who presented concomitant patella alta, increased TT-TG distance, and mild trochlea dysplasia.[11] Specifically in such setting, the two procedures can be combined so that the distalization provides correction for abnormal CDI, allowing the patella to engage earlier in its trochlea and increasing restraints and stability. Medialization, instead, diminishes the lateralizing forces acting during flexion–extension movements, caused by the increased TT-TG distance.

Due to the kinematic changes caused by this kind of transfer, some authors advocated not to perform it in the absence of a frank patellar dislocation or an abnormal TT-TG distance.[12,13] Very few studies focused on DMTT treatment for PPI,[14] and there was no focus on the use of DMTT in patients suffering from PPI and patella alta.

The aim of this study was to determine if DMTT could be effective in patients with PPI and patella alta complaining for instability and pain. The hypothesis of the study was that DMTT is an effective procedure in addressing symptoms of instability and pain in patients suffering from PPI with patella alta.

Methods

Study Design

The study was designed as a retrospective comparative cohort study. A consecutive cohort of 24 patients (26 knees), 21 females and 5 males, was enrolled between 2008 and 2011. All patients suffered from anterior knee pain and patellofemoral instability during daily activities associated with patella alta. Patients were divided into two groups according to the type of patella instability: the PPI group, which complained about instability without history of frank patella dislocation; and the OPI group, which instead had at least one episode of patella dislocation.

All patients followed a minimum of a 6-month rehabilitation program involving quadriceps and vastus medialis obliquus strengthening (closed kinetic chain eccentric exercises, open kinetic chain isotonic/isometric exercises), along with the application of a patellar medializing brace and proprioception enhancement. Nonsteroidal anti-inflammatory drugs and painkillers were prescribed as needed by patient's general practitioner.

Inclusion criteria were: history of pain and patellofemoral instability, CDI > 1.2,[3] and failed conservative treatment. Exclusion criteria were: previous knee realignment surgical procedures (i.e., previous tibial tubercle transfer procedure, tibial or femoral osteotomy, MPFL reconstruction, and lateral release), trochlear dysplasia grade B and D,[1] grade 4 patellar and/or trochlear chondral lesions according to Outerbridge's classification,[15] patellar tendinopathy, and any other previous surgery on the same knee.

Standard knee radiograms (anterior-posterior, lateral, and axial views), and magnetic resonance imaging (MRI) of the knee were gathered for each patient. TT-TG distance and lateral patellar displacement were assessed on MRI to define the eventual need and amount of tibial tubercle medialization; however, their values were not recorded as medialization was lastly defined by intraoperative tracking assessment. Lateral patellar displacement was defined as the medial/lateral distance between the most posterior point on the patella in the mid-patellar axial image and the deepest point in the sulcus at the axial level of the femoral epicondylar width.[16]

All subjects provided their informed consent to participate in this study. The local ethics committee approved the study.

Intervention

Surgical procedure begun with knee arthroscopy to evaluate and grade eventually associated patellofemoral chondral lesions. Arthroscopic lateral release was routinely performed. Tibial tubercle osteotomy was then performed parallel to the coronal plane, so that no anteriorization of the tubercle occurred during medialization. A distal bone fragment of approximately 10 mm was removed from the tubercle to allow for distal transfer. Tibial tubercle transfer was then performed, starting from its medialization in a range comprised between 3 and 10 mm; it was then temporarily fixed in place with Kirschner wires to assess the new tracking. After medialization, distalization was performed, and final fixation was achieved with two 4.5-mm cancellous lag screws without washers.

Patients were discharged in the second postoperative day. Continuous passive motion was initiated on postoperative day 7, gradually increasing flexion as tolerated by the patient. A knee brace was adopted as well, with the following range of motion limitations: 0 to 15° for 2 weeks, 0 to 60° up to the 25th day, 0 to 90° up to the 35th day, and limitless up to the second month. Weight bearing was allowed after 35 days. Active and progressive muscle strengthening were started from the 45th day.

Outcome Measurements

Visual analogue scale for pain (pain VAS), Kujala score, and Tegner's activity level score, recorded at the day of hospital admission and at the follow-up, assessed clinical outcomes.

Data Analysis

Dependent *t*-test and Student's *t*-test were used to analyze differences within and between groups, respectively, for the Kujala score and pain VAS. Data were expressed as means and standard deviations. The nonparametric Wilcoxon-signed rank test and Mann–Whitney *U*-test were used to analyze differences within and between groups, respectively, for the Tegner activity scale. Data were expressed as medians and interquartile ranges. Fischer's exact test was used for discrete

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dichotomic variables. For all tests, a p-value of < 0.05 was considered significant. All analyses were performed with IBM SPSS v 17.0 (IBM, Armonk, New York, United States) statistical software.

Results

The PPI group had 18 patients (19 knees), 14 females and 4 males. The OPI group had 6 patients (7 knees), 5 females and 1 male. Baseline characteristics of the two groups are reported in ►**Table 1**. Populations were homogeneous for each examined parameter, except for participation in sports activities. One patient in the PPI group had a major associated procedure (femoral osteotomy for a severe valgus knee), and was excluded from the final computation. No other knee pathologies, or chondral defects, were either identified or treated at the time of surgery.

The patient-reported outcome data are reported in ►**Table 2**.

The PPI group had a significant increase of the Kujala score and a significant decrease of the referred pain (according to VAS) and subjective symptoms of instability. The Tegner activity scale did not vary significantly from preoperative to postoperative evaluations.

The OPI group had the same improvement in all reported outcome measures except the subjective instability. Even though no patient experienced patellar subluxation or dislocation after the procedure, five patients still complained about subjective symptoms of knee instability. This significantly differed from the PPI group.

Table 1 Baseline characteristics of patients' knees according to group

Variables	Patella alta PPI ($n = 19$)	Patella alta OPI ($n = 7$)	p-Value
Age at surgical intervention [y], mean (± SD)	28 (±11)	27 (±8)	n.s.[a]
Gender [Male], *n* (%)	4 (21)	1 (14)	n.s.[b]
Sport participation [Yes], *n* (%)	11(58)	6(86)	< 0.05[b]
Associated pathology [Yes], *n* (%)	1 (5)	0 (0)	n.s.[b]
Correction [Yes], *n* (%)	1 (5)	0 (0)	n.s.[b]
Subjective Instability feeling [Yes], *n* (%)	15 (79)	7 (100)	< 0.05[a]
Follow-up [mo], mean (± SD)	50 (±18)	41 (±18)	n.s.[a]

Abbreviations: n.s., nonsignificant; OPI, objective patellar instability; PPI, potential patellar instability; SD, standard deviation.
[a]*t*-Test.
[b]Fisher's exact test.

Table 2 Patient-reported outcome data

Score	Patella alta PPI ($n = 19$)	Patella alta OPI ($n = 7$)	p-Value
Kujala preop	61.6 (±14.6)[a]	48.6 (±13.8)[a]	n.s.[b]
Kujala postop	88.8 (±11.6)[a]	85.6 (±8)[a]	n.s.[b]
Kujala increase	27.2 (±17.3)	37(±14.8)	n.s.[b]
Instability preop	15 (78.9)[a]	7 (100)	< 0.05[c]
Instability postop	3 (15.8)[a]	5 (71.4)	< 0.05[c]
VAS preop	7.2 (±1.9)[a]	7.6 (±0.9)[a]	n.s.[b]
VAS postop	2.1 (±2.4)[a]	2.7 (±2.3)[a]	n.s.[b]
Tegner preop	4 (3.5–5)	3 (3–5)	n.s.[d]
Tegner postop	4 (3–5)	3 (3–5)	n.s.[d]

Abbreviations: n.s., nonsignificant; OPI, objective patellar instability; PPI, potential patellar instability; SD, standard deviation; VAS, visual analogue scale.
Note: Kujala and VAS are expressed as mean (±SD). Instability is expressed as *n* (%). Tegner is expressed as median (interquartile range). Postop refers to the latest follow-up. Fourth column refers to the statistical significance among PPI and OPI groups.
[a]Preop statistically significantly different from postop.
[b]*t*-Test.
[c]Fisher's exact test.
[d]Wilcoxon sum rank test.

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The postoperative Kujala score was similar between the two groups. Even though the increase in the Kujala score was not significantly different between the groups, there was a trend toward a greater increase in the OPI group.

No specific postoperative patellofemoral complications were reported, albeit some patients required subsequent procedures. Knee stiffness requiring manipulation under anesthesia was reported in one case. Four patients complained a little nuisance on the proximal tibia that required screw removal.

Discussion

The main finding of the study was that the DMTT could provide an effective pain reduction, and a proper functional recovery, allowing patients to regain their previous activity level. Comparing PPI and OPI patients at the follow-up, similar scores were obtained. However, some differences were noted: PPI patients showed a significant decrease in the subjective feeling of instability, while OPI patients did not. Moreover, OPI patients had a greater Kujala score increase even though it did not reach statistical significance.

The feeling of patella instability, which caused most of the reported functional impairment, decreased from 80% to 15% in PPI patients. On the other hand, patient who sustained an actual dislocation (OPI) had a higher rate of persistence of this symptom at the follow-up (70%). This percentage was higher than that described by Magnussen et al.[4] They stated that when patellar distalization was adopted to treat patellar dislocation, it solved the dislocation problems in the majority of the cases, but leaving a persistent feeling of patellar instability rate of approximately 25% (according to a positive apprehension sign test). Similarly, Mayer et al[7] treated patients affected by episodic patellar dislocation with TT distalization and patellar tendon tenodesis, with or without TT medialization. They obtained good results in terms of function and patella stability, despite the medialization procedure. The authors reported that the apprehension sign remained positive in one-third of the cases.[7] The differences between those studies and this may be explained by the fact that those authors performed an objective test (apprehension sign test), while in this study it was asked to the patients about their subjective feeling of instability with a simpler "yes or no" question. This choice was seen as a more useful outcome tool, providing important information about patient's residual disability during his/her everyday life, instead of a clinical test that, due to the way it is performed (exerting a far greater stress on the joint), represents a "one-time" event that is unlikely to happen.

Persistent subjective patella instability might be due to quadriceps inhibition or unnoticed low-grade chondral lesions. Other possible explanations, such as medial dysfunction or trochlear dysplasia, are rather debatable because of the double effect of the DMTT procedure. In fact, distalization anticipates patellofemoral engagement, thus decreasing the instability range of the joint. At the same time, medialization adjusts patellofemoral tracking to the new alignment. With this combined effect, the patella articulated in a different part of the trochlea, deeper and more congruent even in the presence of a low-grade trochlear dysplasia, thus neutralizing the negative effects deriving from such a condition. For this reason, the procedure performed in this study implies lateral release in each case (to reduce lateral restraints), and a variable (but never null) medialization with a fixed distalization.

Even though the increase in the Kujala score did not significantly differ between the two groups, there was a trend toward a greater increase in the OPI group. This may indicate that patients who suffered from a frank patellar dislocation may have the best functional benefit from this procedure.

Scuderi stated that the tubercle realignment procedure may be detrimental in patellofemoral pain syndrome without patella dislocation (PPI).[13] Similarly, Grelsamer reported that when tibial tubercle transposition was used for "poorly defined" patellofemoral pain syndrome, it may led to poor results.[12] However, other authors suggested that a distal realignment procedure can be used successfully to treat PPI patient. AL-Sayyad and Cameron evaluated patients with patella alta without patellar dislocation having undergone a distalization procedure with a follow-up of more than 2 years. The author reported that the procedure was beneficial in patients with patella alta without OPI.[14] Pritsch et al performed a tailored tibial tubercle transfer basing on passive and active intraoperative patellar tracking tests. They performed an average medialization of 1.4 cm and an average distalization of 0.9 cm. The authors found better results with male gender, low grade patellar chondral damage, and instability as the dominant preoperative subjective symptom (rather than pain). However, no significant differences were found among OPI and PPI patients.[8] Similarly, Palmer et al did not find any significant difference in the outcomes of patients with OPI and PPI.[17] Moreover, in a study similar to this, Diks et al[11] compared OPI patients with an increased TT-TG (27 knees, 20 of whom with patella alta) and PPI patients with an increased TT-TG (16 knees, 7 of whom with patella alta). They performed tibial tubercle medialization with and without distalization and they showed that OPI patients had 63% excellent or good results and PPI patients had 81% excellent or good results. PPI patients had 2.6 times greater chance of pain relief than OPI patients.

Slight differences in patient selection, surgical treatment, and outcome evaluation between this study and the others in the literature[8,11,13,17] make comparison difficult; however, it can be stated that PPI patients may benefit from the DMTT as much as, or even more, than OPI patients.

This study showed that medializing the tibial tuberosity in patients with PPI and patella alta may be beneficial. Since the TT-TG distance values were not recorded, a direct relationship between preoperative TT-TG distance, the amount of tubercle medialization, and clinical benefit may not be established. In this study, the TT-TG distance was visualized preoperatively with MRI (overlapping of mid-trochlear and tibial tubercle images),[18] but the definitive tubercle fixation was established by checking the intraoperative patellar tracking. In this regard, it has recently been reported that the TT-TG distance may not differ significantly among affected and nonaffected knees, in patients suffering from unilateral recurrent instability (OPI),

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thus making the role of TT-TG distance in surgical decision rather questionable.[19] Moreover, Saranathan et al showed in a cadaver study that medializing the tibial tuberosity by 10 mm may underload the lateral patellar facet, with little or no effect in overloading the medial patellar facet.[20] The authors suggested that, if in doubt when assessing patellar tracking before tubercle fixation, a small amount of medialization may be beneficial without any risk of medial overload.

Patellar distalization is known to have complications. Overcorrection is possible, and a CDI or Insall–Salvati index < 1 was often reported. Radiographic evidence of patellofemoral osteoarthritis was approximately 15% with a follow-up within 4.5 and 9.6 years; when adopted to treat patellar dislocation, it has an overall risk of recurrence of 1.75%, and the patellar apprehension sign occurs in about one-fourth of the treated patients.[4] In this study, the occurrence of a postoperative patella baja was not noted, and in the OPI group no recurrences were reported. Specific perioperative and postoperative complications were not reported, apart from a case of arthrofibrosis successfully treated with mobilization under general anesthesia. In this case, defined as a failure due to the postoperative pain increase and the functional status decrease, there could have been an overestimation of the need for surgical treatment. Clinical conditions also deteriorated because of the scarce adherence of the patient to rehabilitation protocol.

This study is affected by some limitations. This is a retrospective study, and radiographic measurements of patellofemoral alignment were not recorded nor analyzed. Other limitations are the short follow-up period and the small number of patients.

In conclusion, this study showed that patients who never suffered from patellar dislocation, and with a high riding patella associated with anterior knee pain and subjective feeling of knee instability, may benefit from a distalization and medialization of the tibial tubercle. This study also found that patients with PPI or OPI have similar postoperative outcomes. However, while PPI patients demonstrated a statistically significant decrease in the feeling of subjective instability, OPI patients did not, demonstrating a higher percentage of subjective instability's persistence even in the absence of true dislocations.

Conflict of Interest
None.

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