The effect on patellofemoral joint stability of selective cutting of lateral retinacular and capsular structures

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1. Introduction

The function of the lateral retinaculum remains incompletely understood. In contrast to the medial patellofemoral ligament, objective data on the biomechanical properties of the lateral retinaculum are lacking. Lateral retinacular release has been favoured because it is a relatively simple procedure. However, identifying the patient who will benefit from this surgery is not straightforward. Inappropriate lateral release can cause medial subluxation of the patella; this is a recognised complication (Brinker et al., 2001; Hughston and Deese, 1988; Hughston et al., 1996; Nonweiler and Delee, 1994). Maintaining vastus lateralis obliquus (VLO) muscle support has been advised to reduce the complication of medial patellar subluxation (Fulkerson, 2002). It is preferable to minimise the extent of a surgical procedure while not compromising its effectiveness; at present, there is a lack of biomechanical data to guide the surgeon who may wish to reduce the extent of a lateral retinacular release.

The clinician pushes the patella medially to gauge the tightness of the lateral retinaculum (Ford and Post, 1997) and the effectiveness of a release. A similar approach was used in a biomechanical comparison of lateral retinacular releases (Marumoto et al., 1995) in which increased medial translation of the patella with constant force was found when the release was extended distally to the tubial tubercle. Patellar stability can be quantified by measuring the force that opposes the linear displacement of the patella from its initial position of equilibrium (Farahmand et al., 1998b; Senavongse et al., 2003). This provides a more direct method to quantify patellar stability than inferring it indirectly from changes of joint contact pattern or patellar tracking. Patellofemoral joint stability depends on factors that interact in a complex manner, including the extensor mechanism, the retinacular restraints, the articular geometry and the limb alignment. Patellar medial stability should decrease with a lateral found in all cases of iatrogenic medial subluxation in one series (Nonweiler and Delee, 1994). Maintaining vastus lateralis obliquus (VLO) muscle support has been advised to reduce the complication of medial patellar subluxation (Fulkerson, 2002). It is preferable to minimise the extent of a surgical procedure while not compromising its effectiveness; at present, there is a lack of biomechanical data to guide the surgeon who may wish to reduce the extent of a lateral retinacular release.

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release; this is a reflection of its effectiveness. However, lateral release also decreases lateral stability (Christoforakis et al., 2006; Desio et al., 1998), so it may not be suitable for the treatment of lateral patellar maltracking or instability (Christoforakis et al., 2006). These studies, however, failed to investigate its contribution to medial stability. The clinical evidence (Brinker et al., 2001; Hughston and Delee, 1988; Hughston et al., 1996; Noweiler and Delee, 1994) shows that it is important not to reduce medial stability excessively. To characterise the role of lateral retinacular release in patellar stability fully, both medial and lateral stability need to be examined. Patellar lateral instability is a common clinical problem, while medial instability is unusual and has been linked with inappropriate lateral retinacular releases. Thus, it is important that the surgeon should not inadvertently trigger either medial or lateral patellar instability, this study was designed to quantify the contribution of the various parts of the lateral retinaculum to patellar stability and to test the hypothesis that the dominant component is the transversely oriented ITB-P fibres of the mid-part of the lateral retinaculum.

2. Methods

Nine fresh-frozen cadaveric knees with no history of knee surgery or disease were used (mean age 65±16 years; range 41–85). These were obtained from the International Institute for the Advancement of Medicine (Jessup, PA, USA). The institute undertook screening and consent for use in research. The study was approved by the Riverside Research Ethics Committee. The knees were stored at –20°C and thawed a day prior to experimentation.

The skin and subcutaneous tissue were removed. The deep fascia, retinaculae and ITB were preserved. The femur and tibia were cut approximately 20 and 15 cm from the proximal pole and distal pole of the patella. The VLO tendon was not cut but the quadriceps tendon proximal to the level of the proximal pole of the patella.

The stability rig was composed of two parts. The fixed part was attached to the base of an Instron materials testing machine (Instron Ltd., High Wycombe, UK) and the moving part was a three degree-of-freedom mounting attached to the Instron load cell (Fig. 1). The knee was mounted sideways (lateral aspect upwards) in the fixed part of the stability rig by locating the cemented femoral sleeve onto a rod. The knee was aligned with the anatomical axis of the femur perpendicular to the femoral condyles vertical in a distal–proximal view.

The lower end of the three degree-of-freedom mounting was snap-fitted into the polyethylene patellar socket to form a ball and socket joint (Fig. 1). The mounting allowed for patellar mobility in a sagittal plane: anterior–posterior and proximal–distal translations, and flexion–extension rotation and the ball and socket joint allowed unimpeded tilt and rotations when the patella was displaced medially and laterally.

The components of the quadriceps were separated and loaded with hanging weights using cables and pulleys. A total load of 175 N was applied to the muscle groups (Fahamand et al., 1998b). This was done according to the directions and physiological cross-sectional areas (PCSAs) of the muscles (Fahamand et al., 1998a; VLL: 14 lateral and 0 anterior; VLO: 35 lateral and 33 posterior; VML: 15 medial and 0 anterior; VMO: 47 medial and 44 posterior; and BF: 0 lateral and 0 anterior. The tension distribution was: BF: 15%, VLL: 33%, VLO: 9%, VML: 14%, and VMO: 9%. Thirty Newtons tension was applied to the ITB, directed 0° lateral and 0° posterior to the femoral axis (Bull et al., 1999). For the passive knee, nominal tensions were used to keep the muscle taut and to minimise the effect of gravity on the patella. The muscle was loaded in the same directions and proportions with 30 N in total and the ITB with 5 N.

The knee was tested at 0°, 20°, 30°, 60°, and 90° flexion. It was flexed against the muscle tension and at the chosen test angle a vertical rod was placed anterior to the tibial rod to block knee extension. The interface was greased allowing the tibia to rotate axially and translate during testing. The patella was displaced cyclically 10 mm laterally and medially at 100 mm/min from its stable neutral position. This displacement was repeated four times in each test and the fourth load vs. displacement curve was recorded. The data analysed were the forces measured by the load cell at the medial and lateral limits of the displacement cycle. These forces defined the patellar medial and lateral stability, respectively, for that particular knee flexion angle. Testing was repeated after each stage of lateral release.

The anatomy of the lateral retinaculum has been re-examined by the authors (Merican and Amis, 2008) and the stages of the lateral release were based on this.

2.1. Proximal release (PR)

The lateral extension of the quadriceps aponeurosis anchored the deep fascia close to where it thickened to form the iliotibial band and thus was the proximal beginning of the interaction of the quadriceps aponeurosis and the iliotibial band. This was incised releasing the connection between lateral retinaculum and quadriceps tendon proximal to the level of the proximal pole of the patella.

2.2. Middle release (MR)

The lateral retinaculum was incised lateral to the patella from the level of the proximal pole to the distal pole of the patella. The VLO tendon was not cut but the connection between ITB and the distal edge of this tendon was disrupted. This release cut the thickest part of the retinaculum, which was reinforced by the deeper transverse fibres that connected the ITB to the lateral patella (ITB-P fibres) and the VLO.

2.3. Distal release (DR)

The distal part of the retinaculum, predominantly longitudinal in orientation, was cut from the level of the distal pole of the patella to Gerdy’s tubercle. There was no connection between ITB and the patella or quadriceps mechanism (Fig. 2).

2.4. Capsular release (CR)

The lateral capsule was incised. Cutting the thickenings of the capsule; the lateral patellofemoral and patellomeniscal ligaments. The stability of the patella was examined at each flexion angle and stage of the lateral retinacular release using a two-way repeated-measures analysis of variance. Bonferroni post-hoc tests were used to determine the knee flexion angles and stages of the lateral release which caused significant changes in patellar stability. Significance level was set at p < 0.05.

3. Results

Generally, there was a decrease in medial and lateral stability with progressively more extensive release. The decrease in medial stability was larger than in lateral stability. After proximal release, the reductions in medial and lateral stability were not statistically significant in the loaded or passive knee across the range of flexion.
Medial stability in the intact loaded knee increased progressively with knee flexion, from a mean of 78 N at 0° to 171 N at 90° flexion. After the proximal release, a statistically significant effect on medial stability was not seen. When the release was extended distally to the level of the distal pole of the patella (MR), there was a significant reduction in medial stability, at 20°, 30°, and 90° flexion. There was a reduction of 6 N ± 4 at 20° and 30° flexion and 11 N ± 13 at 90° flexion compared to the intact knee. This corresponds to a 7% decrease in medial stability compared to the intact knee at 20°, 30°, and 90° flexion (Fig. 3b). A significant reduction compared to the intact knee was seen at 0° when the release was extended distally (DR); 6 N ± 4 or 8%. There was no change in medial stability at 20° and 30° flexion when the lateral retinacular release was extended distally from a middle release to a distal release (Fig. 3a). The addition of a capsular release caused significant change in the medial stability at 0°, 20°, and 90° compared to the stability of the knee with a middle release (Fig. 3a). At 0° and 20° flexion, on average, after a capsular release there was a reduction of medial stability of 13 N ± 9 or 16% compared to the intact knee (Fig. 3b). At 30°–60°, there was no significant change in medial stability with a capsular release as compared to a middle (MR) or complete retinacular release without the capsule (DR) (Fig. 3a). With the knee extended, the main lateral retinacular restraint to patellar medial translation was the lateral joint capsule. However, if the whole lateral retinaculum was released, a comparable reduction in medial stability was also achieved. At 20° flexion, the deeper transverse fibres (ITB-P) and the capsule had comparable contributions to restraining patellar medial translation and by 30° flexion, the transverse fibres were the main contributor (Fig. 3b). In the passive condition, the effect of capsular release was exaggerated (Fig. 4).

The mean lateral stability for the intact loaded knee ranged from 76 to 100 N across 0°–90° flexion, being lowest at 20°. The trend was similar with the passive knee, when the mean stability ranged from 33 to 55 N. For the loaded knee, there was a statistically significant reduction in the lateral stability (compared to the intact knee) between 30° and 90° flexion for the middle release, 20° and 90° for the distal release and 0° and 90° for the complete release including the capsule (CR). After a middle release, the lateral stability reduced by an average of 5% ± 5 of the stability of the intact knee across 30°–90° (Fig. 5b). When the retinaculum was completely released (DR) there was no significant change compared to the middle release (Fig. 5a). However, the change in stability compared to the intact knee was now statistically significant at 20° too. The decrease of patellar lateral stability after releasing the retinaculum but not the joint capsule (DR) was on average 6% ± 6 of the intact knee stability. Releasing the capsule (CR) reduced the lateral stability further, but the change was not significant compared to the stability after the middle release (Fig. 5a). On average, the reduction in lateral stability across 0°–90° was 7% ± 4% compared to the intact knee for the retinacular plus capsular release.

For the passive knee, a middle release caused a significant reduction in lateral stability compared to the intact knee at 0° as well as from 30° to 90°. On average across the range of flexion, the reduction in lateral stability compared to the intact knee was
7% after the middle release and 12% for the complete release including the capsule (CR) (Fig. 6).

4. Discussion

This study found that staged release of the lateral retinacula reduced the medial stability of the patellofemoral joint progressively, making it easier to push the patella medially. The finding that the mid-part of the retinaculum, lateral to the patella, contributed significantly to the medial stability of the patella is in keeping with the anatomy and our hypothesis. In this region, the retinaculum is dense and thicker, with fibres that are predominantly transverse in orientation (Merican and Amis, 2008). These fibres anchor the lateral patella and the VLO tendon to the ITB, resisting medial translation of the patella. The retinaculum distally is less thick and predominantly longitudinal in orientation, which may explain its smaller contribution to medial-lateral stability. The lateral capsule of the knee is relatively thin but is reinforced by thickenings, although these are variable and not universally present (Blauth and Tillmann, 1983; Fulkerson and Gossling, 1980; Merican and Amis, 2008). It was, therefore, not expected that the capsule would contribute so much to lateral restraint, particularly in extension.

In-vitro work has not shown a change in patellofemoral contact area or pressure with lateral retinacular release (Hille et al., 1985; Huberti and Hayes, 1988; Lewallen et al., 1990). Ostermeier et al. (2007) found that with lateral release, the patella was lateralised in the 0–60° flexion range and medialised beyond 60°. There was no significant change in contact pressure. These measurements, however, are only indirect indicators of patellar stability. Patellar stability can be described quantitatively as the...
displacement induced by an applied load (Fithian et al., 1995; Marumoto et al., 1995; Skalley et al., 1993) or, as in this study, the force needed to displace the patella by a fixed amount. Marumoto et al. (1995) found that lateral retinacular release was more effective when it extended distally to the level of the tibial tubercle, allowing significantly more medial displacement of the patella. That finding differs from this study, possibly because the quadriceps was only loaded to 10 N parallel to the femur. Furthermore, the ITB was not loaded in that experiment and its quadriceps loading have been used in other works (Bull et al., 1999; Kwak et al., 2000; Yamamoto et al., 2006). These knees were normal for age: in diseased knees pathological bands or other changes may alter the relative contributions of restraint of the capsule and lateral retinaculum.

In these "normal" experimental knees, the largest reduction in medial stability in the loaded knee at 30° flexion was obtained with the release of the deep transverse fibres that linked the iliotibial tract to the patella and VLO, with no further increase with subsequent releases. It is difficult to say at what point the reduction of medial stability attained from release is too effective and there is a danger of medial subluxation. The marked reduction in medial stability with a retinacular and capsular release in the passive extended knee (Fig. 4) reflects the absence of bony constraint on the medial side in extension. This helps to explain why in the cases of misdiagnosis, an extensive lateral release can lead to medial subluxation.

**Conflict of interest**

None

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