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Title: Effects of lateral retinacular release on the lateral stability of the patella

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Abstract

The objective of this cadaveric study was to evaluate quantitatively the effects of lateral retinacular release on the lateral stability of the patella.

A materials testing machine was used to displace the patella of 7 cadaveric specimens 10 mm laterally while measuring the required force, with 175 N quadriceps tension. The patella was connected via a ball-bearing patellar mounting 10 mm deep to the anterior surface to allow rotations. Patellar force-displacement behaviour was tested from 0° to 60° knee flexion.

At 0°, 10° and 20° flexion the mean force required to displace the patella 10 mm laterally was reduced significantly due to lateral retinacular release, by 16 to 19 %. The average force required to displace the patella was also reduced for larger flexion angles, although this was not statistically significant.

These findings suggest that lateral retinacular release may not be appropriate in treatment of patellar lateral instability.

Keywords

Patellofemoral joint, biomechanics, lateral retinacular release

Introduction

Lateral instability of the patella is a common problem and despite the extensive literature devoted to the topic, the optimal treatment remains contentious [7, 9, 11-13, 18]. Patellofemoral joint stability depends on several factors, such as the balance of the quadriceps muscle forces, the articular geometry of the patella and femur, the retinacular structures, and the direction of the patellar tendon [1, 4-5, 8]. The relative contribution of each of these factors to patellar stability remains unclear, so the choice of surgical treatment is difficult.

Lateral retinacular release is a surgical procedure that is sometimes performed to treat patellofemoral pain, maltracking and instability. It has been considered to be a relatively benign procedure which requires minimal surgical intervention, does not require immobilization and can cause only minor complications [10, 12-13, 15]. A number of surgeons have suggested that this is a reasonable procedure to treat patellar lateral instability after the failure of conservative management [9-10, 12-13, 15].

Even though some authors have published satisfactory results for the treatment of recurrent patellar subluxation by lateral retinacular release [12, 14-15], its role and limitations are still not definitively established [2, 10-11]. Desio et al [3] found that patellar lateral stability was reduced 10% by cutting the lateral retinaculum and so release of this structure may worsen the instability.

The aim of this cadaveric study was to evaluate quantitatively the effects of lateral retinacular release on patellar lateral stability, at various degrees of knee flexion, and to answer the clinical question whether the lateral stability of the patella improves or deteriorates after this.

Materials and Methods

The methods and apparatus used are described in full in the literature [16-17]. Seven fresh-frozen cadaveric knees, with no history of knee surgery or disease, were used for this study (mean age 75 years, range 65 – 82). They were obtained at postmortem from donors with ethical committee permission and informed consent from relatives. If not being used immediately, the knees were sealed in polyethylene bags and stored at -20°C . The skin, underlying fat, proximal iliotibial tract and muscles except the distal quadriceps components were removed. Care was taken to preserve the retinaculae and the fascia of the quadriceps muscles. The quadriceps components were then separated, using the indications of the aponeuroses and fascia. The quadriceps muscles were separated into six components as identified by Farahmand et al [4]: Rectus Femoris (RF), Vastus Intermedius (VI), Vastus Lateralis Longus (VLL), Vastus Lateralis Obliquus (VLO), Vastus Medialis Longus (VML) and Vastus Medialis Obliquus (VMO). Each muscle component was wrapped and looped by a cloth tape that was secured by stitching through the whole muscle bulk. The RF and VI were looped together. The tape loop provided a firm attachment for simulating the contraction of individual quadriceps components in active motion of the knee.

The femur and tibia were transected at approximately 20 and 15 cm above and below the knee, respectively. The head of the fibula was fixed to the tibia by two bone screws, to maintain its anatomical position, and then the neck of the fibula was cut through and the distal part removed.

The femoral medullary cavity was excavated and dried, and an aluminium intramedullary rod was secured using polymethylmethacrylate bone cement. A second intramedullary rod was cemented into the tibia, using the same technique. A ball bearing was cemented inside the patella, at the geometric centre of, and 10 mm deep to the anterior surface (Figure 1). This allowed natural tilt and other patellar rotations when the patella was displaced laterally [16-17].

The experimental apparatus consisted of a stability rig mounted in an Instron 1122 materials testing machine (Instron Ltd., Buckinghamshire, England). The stability rig was in two parts, one fixed to the base of the Instron, the other suspended from the load cell in the moving crosshead. The fixed part consisted of a femoral mounting device on a steel base plate with pulleys fixed on to the base of the Instron. The moving part was a three-degree-of-freedom mounting allowing patellar mobility in a sagittal plane: anterior-posterior and proximal-distal translations plus flexion-extension rotation.

The knee was mounted via the femoral intramedullary rod in the mounting device on the Instron base with the rod horizontal and the line joining the most posterior parts of the femoral condyles vertical in a distal-proximal view. The knee was oriented with the lateral aspect uppermost and with the tibia flexing in the horizontal plane. A total load of 175 N was applied to the muscle groups by hanging fixed weights on cables in the directions relative to the femoral axis reported by Farahmand et al [4]: 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 RF+VI 0° lateral and 0° anterior. The quadriceps tension distribution was according to physiological cross-sectional areas (PCSAs) of the muscles: RF+VI 35%, VLL 33%, VLO 9%, VML 14%, and VMO 9%.⁸ The

patella was connected via the embedded ball bearing to the moving rig on the test machine crosshead.

Patellar force-displacement behaviour was tested at 0°, 10°, 20°, 30°, 45°, and 60° of knee flexion, in that order, with 0° defined as the angle at which the tibial and femoral intramedullary rods were parallel in the sagittal plane. The knee was flexed to a chosen test angle against the resistance of the muscle tensions. Knee extension was blocked, at each angle being tested, by a vertical rod anterior to the tibial rod. All other degrees of freedom of tibial and patellar motion were unconstrained. The patella was displaced cyclically 10 mm laterally at 100 mm/min from its stable neutral position (that the patella took in the absence of any externally imposed forces). The fourth load versus displacement cycle was recorded at each knee flexion angle and the maximum force was measured.

Lateral retinacular release was conducted using an outside-inward technique and then the stability tests were repeated. The release extended from the proximal limit (2 cm proximal to the upper pole of the patella) of the lateral retinaculum down to Gerdy's tubercle (Figure 2). Care was taken to preserve the lateral superior genicular artery, and the lateral inferior genicular artery in an effort to simulate operating conditions. The goal was to release only the retinaculum and to preserve all vessels and the capsule.

Statistical analysis

The stability of the patella at each angle of flexion was compared for the intact knee versus the lateral retinacular release using a two-way analysis of variance and Tukey's post-hoc test. A

post-hoc power analysis was used to examine the significant differences. Significance was set at the 5% level.

Results

The restraining force was significantly different after lateral retinacular release ($p = 0.007$; Figure 3) The post-hoc analysis found that this difference was significant at 0° , 10° , and 20° flexion for which the mean force required to displace the patella 10 mm laterally was reduced by 16% ($p = 0.002$), 16% ($p = 0.008$), and 19% ($p = 0.001$ respectively) by the lateral retinacular release. The average force required to displace the patella was also reduced for all other flexion angles, although this was not statistically significant. These data are summarised in Table 1.

Discussion

Using the classic definition of stability of mechanical systems, in which stability is the ability of a system to maintain its equilibrium condition and resist leaving it, the patellofemoral stability can be characterised objectively in terms of restraining force, the force which holds the patella in its stable position or the force which is required to move the patella from this position. This is not the same as the subjective symptom of instability that troubles patients, although these objective and subjective phenomena may be related. This cadaveric study demonstrated that lateral retinacular release reduced the force required to displace the patella 10 mm laterally by 14-20%, in comparison with normal intact knees, from 0 to 30 degrees knee flexion. This was statistically significant at 0° , 10° , and 20° . Using the definition of stability above, this means that lateral retinacular release reduces the stability of the patella.

The main limitations of this study were that the experiments were performed on normal cadaveric knees, without any history of patellar dislocation or subluxation, and that the mean age of the specimens was 75 years. Thus, we could not simulate pathological changes in the soft tissues that may be relevant, such as tight bands in the lateral retinaculum. It could be speculated that the presence of such pathology would magnify the changes produced in this experiment. In addition, the force applied to the quadriceps was limited by tearing of the muscles, and so normal physiological magnitudes were not attained. Despite these limitations, this study has provided evidence that a lateral retinacular release may reduce patellar lateral stability. We believe that this is the first study which has evaluated the effect of this procedure on patellar lateral stability, over a range of knee flexion with the extensor mechanism being loaded ‘physiologically’: the individual components of the quadriceps muscle tensed in physiological directions and in proportion to their physiological cross sectional areas.

Other pathologies that have been treated by lateral retinacular release include trochlear dysplasia. There is no clinical consensus on treatment of this condition: some advocate trochleaplasty, other conduct soft-tissue surgery alone. This study is not addressing this point.

Patellar force versus displacement behaviour near knee extension is of most clinical interest, as this is the position in which symptoms are commonly experienced [9-10, 17]. This is confirmed by earlier work that has shown that the patellar lateral stability is least at 20° flexion [17] and that deficiency of the medial retinaculæ has its greatest effect on patellar lateral stability in the extended knee [6, 16]. The results presented here confirm this earlier work and demonstrate that LRR has a significant effect within the clinical range.

Other work in the literature has not allowed the patella to rotate and translate freely about its centre, thus making comparison with this study difficult. This may be why Desio et al found that the lateral retinaculum contributed less restraint (10%) at 20° flexion than in this study, using an apparatus that induced patellar tilt as well as translation [3]. This can be explained more clearly schematically. Figure 4 demonstrates that when the lateral retinaculæ are sectioned, the tilt may be affected due to the absence of a posterior and slightly medial restraining force to the lateral aspect of the patella. This will affect the length of the medial restraints and therefore reduce the lateralising force that they apply to the patella. Therefore, a lateral retinacular release would reduce the force restraining the lateral translation of the patella.

Shellock et al suggested that LRR may not be the correct treatment for patellar lateral instability, because they found a 23% rate of lateral subluxation of the patella in patients with persistent symptoms after lateral retinacular release [18]. However, this is contradicted by clinical studies, in which significant improvements in symptoms have been reported [10, 13, 14]. Biomechanical studies suggest that lateral retinacular release is not effective when used to treat isolated lateral patellofemoral instability [3, 18], but some clinical studies have suggested that the procedure is useful even in patients with patellar lateral instability [7, 10, 12-15]. A possible explanation for this controversy is that the diagnosis of patellar instability may not have been differentiated from patellar maltracking related to tight lateral retinaculæ or patellar lateral compression syndrome. If lateral retinacular release has beneficial effects on patellar tracking and patellar compression syndrome, this could be the reason for the improvement of the symptoms of the patients in the above clinical studies.

The results of this cadaveric study have direct clinical implications. Lateral retinacular release is a surgical procedure performed commonly in many centres. The finding that lateral retinacular release decreased the lateral stability of the patellofemoral joint in normal elderly knees suggests that further studies of its effects on patellar tracking and patellar compression syndrome are necessary to define the role and limitations of the procedure in patients with patellofemoral problems, and that this procedure should not be applied indiscriminately.

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Figure 1

The ball-bearing patellar mounting that allows unconstrained rotations for defined lateral translations

Figure 2

The extent of the lateral retinacular release

Figure 3

Mean restraining force for 10 mm lateral patellar displacement ($n = 7$, mean $\pm$ 1 s.d.).

* denotes significantly different.

Figure 4

How deficiency of the lateral retinaculæ may reduce the restraint to a lateral displacement

Table 1**Force (in N $\pm$ std. dev.) required to displace the patella 10 mm laterally ($n = 7$)**

Knee Flexion ($^{\circ}$)	0	10	20	30	45	60
Intact Knee	88.0 $\pm$ 10.8	79.1 $\pm$ 17.9	77.4 $\pm$ 14.3	77.8 $\pm$ 18.3	81.2 $\pm$ 21.3	87.7 $\pm$ 22.1
range	70 - 100	47 - 100	55 - 100	57 - 105	60 - 125	72 - 135
Lateral Release	74.1 $\pm$ 13.1	66.7 $\pm$ 15.8	62.7 $\pm$ 17.8	67.2 $\pm$ 19.6	65.5 $\pm$ 15.3	78.8 $\pm$ 16.7
range	56 - 95	42 - 82	43 - 90	47 - 95	50 - 87	55 - 98
p	0.002	0.008	0.001	>0.05	>0.05	>0.05
% Reduction	16	16	19	14	7	10