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## Original Article

# Mechanical testing of patellofemoral instability after induced failure of the patellofemoral ligament reconstruction using four different cadavers grafts



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## ABSTRACT

**Purpose:** To ascertain whether differences exist in joint instability after experimentally induced failure of medial patellofemoral ligament (MPFL) reconstruction in the cadaver knee with the four graft types most widely used for this procedure, and whether any of these grafts are associated with decreased risk in the event of failure.

**Methods:** Between March 2011 and March 2012, eight cadavers obtained from the local medical examiner's office were randomly allocated into four groups (four knees each). In each group, a different graft technique was used for MPFL reconstruction. The forces required to induce lateral dislocation of the patella before reconstruction and after experimental failure of surgical reconstruction were recorded. The tested graft techniques were then compared to assess which was associated with the least instability after failed reconstruction.

**Results:** When we compared the groups I (semitendinosus) and II (patellar tendon), the mean differences of the force required to produce a dislocation of the patella before and after the failure were 0.5 N and 12.5 N, respectively ( $p = 0.028$ ). In comparison between groups I and III (medial third of the quadriceps tendon) the mean differences of the force required to produce dislocation before and after the failure caused were 0.5 N and 22 N, respectively ( $p < 0.001$ ). In comparison between groups I and IV (Medial third of the quadriceps tendon) we found the mean differences of the force required to produce dislocation before and after the failure caused were 0.5 N and 5 N, respectively ( $p > 0.999$ ).

**Conclusions:** There were differences in residual instability after simulated MPFL reconstruction failure depending on graft type. Use of the free semitendinosus graft technique was associated with the least risk of residual instability in case of reconstruction failure.

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## 1. Introduction

Patellar dislocation is characterized by a breakdown in the stability of the patella between the femoral condyles. Dislocation may be due to torsional strain, when a patient's body rotates while the foot remains planted on the ground; less commonly, direct trauma to the medial aspect of the patella may lateralize it to the point of dislocation. Medial dislocations are rare in patients without a history of lateral retinacular release surgery.<sup>1</sup>

The medial patellofemoral ligament (MPFL) is a retinacular band of organized fibrous tissue that connects the medial femoral condyle to the medial border of the patella. This ligament is the main structure responsible for restricting lateralization of the patella,<sup>2</sup> accounting for 60% of total restraint.<sup>3</sup> The integrity of the MPFL is compromised since the very first episode of dislocation. Repair is very poor, and only rarely will the ligament recover full function. MPFL reconstruction is a valuable technique in cases of recurrent dislocation. Since it was first described in 1992,<sup>4</sup> over 100 techniques for this procedure have been reported in the literature.<sup>5–8</sup>

The incidence of first-time (primary) patellar dislocation is 5.8 per 100,000, increasing to 29 per 100,000 among children in the 10-to-17-year age group. The recurrence rate ranges from 15% to 44% after non-operative treatment. If the patient has a subsequent patellar dislocation after the primary episode, there is a 50% of recurrence.<sup>9</sup>

The natural history of non-operative treatment of patellar dislocation involves recurrent dislocation in 1 out of 6 cases and residual symptoms in 2 out of 6, with the 3 remaining patients following an asymptomatic course.<sup>10</sup>

Treatment of patellar instability is similar to that of acute dislocation, that is, non-operative at first and surgical if this approach fails. The available methods for repair may be classified into proximal realignment, distal realignment, proximal and distal realignment, lateral retinacular release, and medial retinacular imbrication.<sup>11,12</sup>

The patellar and quadriceps tendons provide a strong posterior force vector during flexion of the knee, thus increasing stability during this motion.<sup>2</sup> Therefore, surgical procedures that use these structures for MPFL reconstruction<sup>13</sup> actually carry the risk of aggravating patellar instability in the event of reconstructive failure, leading to a further decline in the patient's condition, whereas techniques employing structures that do not play a primary role in patellofemoral stability<sup>4</sup> should be comparatively safer. Therefore, this experiment compared preoperative and post-simulated failure patellofemoral instability in cadavers subjected to these procedures.

The purpose of this study was to assess, using a paired experimental design, patellar stability outcomes after simulated failure of medial patellofemoral ligament reconstruction with the four graft techniques most widely used for this procedure. The study hypothesis was that reconstruction techniques which employ structures from the extensor apparatus are associated with poorer stability outcomes in the event of reconstruction failure. This same hypothesis could have been tested with flexor or adductor magnus tendon grafts. However, as irregular size and consistency have been reported with the latter in previous studies, we chose to use semitendinosus grafts alone as the comparator.

## 2. Methods

Sample size was calculated for a statistical power of 80%, a significance level of 5%, a 100% likelihood of preserved patellar stability after simulated failure of patellar reconstruction with a semitendinosus graft, and a 100% likelihood of decreased patellar stability after simulated failure of patellar reconstruction with a patellar tendon or quadriceps tendon (central or medial third) graft. The minimum sample size was calculated as four specimens (knees) per technique, for a total of eight cadavers.

Our criteria for defining outcomes as successful or unsuccessful were based on comparison between the traction loads used before the surgical procedure (immediately after release of the MPFL) and after simulated failure of the procedure. The outcome was considered unsuccessful when the load measured after simulated repair failure was less than the load measured immediately after MPFL release, and successful when the load measured after simulated failure remained the same as shortly after MPFL release.

Between March 2011 and March 2012, eight male cadavers meeting the following criteria were obtained from the office of the medical examiner:

### Inclusion criteria:

- Age 15–50 years at the time of death, no more than 18 elapsed since death (rigor mortis), and intact knees (good flexion, extension, and resistance to maneuvers for assessment of patellar dislocation).

### Exclusion criteria:

- Signs suggestive of prior ligament injury, knee surgery, or recurrent patellar dislocation; clinical history of ligamentous laxity.

The next of kin of selected cadavers provided informed consent for their use in the study. Sixteen knees from eight cadavers were selected. These were then randomly allocated (by envelope randomization after a computer-generated drawing) across four groups:

- Group I. Semitendinosus tendon graft technique (n = 4);
- Group II. Patellar ligament graft technique (n = 4);
- Group III. Medial quadriceps tendon graft technique (n = 4);
- Group IV. Central quadriceps tendon graft technique (n = 4).

All knees were inspected (to detect a potential history of knee surgery or knee trauma, including ligament injury) and subjected to joint stability tests, to ensure that the knee joint was free of pathological conditions such as decreased range of motion, patellar laxity (using the glide test and dislocation tests), and osteoarthritis (using the facet tenderness test).

### 2.1. Operative technique

All surgeries were performed by the same operator. In all knees, a parapatellar arthrotomy was performed, accompanied of macroscopic assessment of the patellofemoral joint,

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