



## Original Article

# Medial patellofemoral ligament and medial patellotibial ligament reconstruction in children: preliminary results<sup>☆</sup>



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## ABSTRACT

**Objective:** The aim of this study was to evaluate the reconstruction of the medial patellofemoral ligament associated with the medial patellotibial ligament in skeletally immature patients.

**Method:** This is a case series study in patients with patellar instability with open physis. In total, seven patients were evaluated: four males and three females were operated using the proposed technique. Patients with open physis who had more than two episodes of recurring patellar dislocation were included. No patients underwent additional procedures. The distance from the anterior tibial tuberosity to the trochlea groove (TT-TG) was measured in all patients. On physical examination, the inverted J-sign, the apprehension sign, and the knee range of motion parameters were used in the pre- and post-operative period. In addition, the Kujala and Lysholm scores were applied before and 12 months after surgery. The results were analyzed with the Wilcoxon test.

**Results:** The mean age of the patients was 11.28 in both genders. Comparing the data of the pre- and post-operative period, the inverted J-sign was present in six patients (85.7%) vs. absent in one (14.3%). The apprehension sign was absent in cases in the postoperative period; the range of motion was  $117.85 \pm 8.09$  vs.  $148.57 \pm 3.77$ . The Kujala score was  $42.57 \pm 8.9$  vs.  $88.57 \pm 5.09$  and the Lysholm scores were classified as excellent or good in 28.6% and 71.4%, respectively.

**Conclusion:** The combined reconstruction of the medial patellofemoral ligament combined with the medial patellotibial ligament in skeletally immature patients with predisposing factors, presents satisfactory results without episodes of recurrence or residual subluxation; according to these preliminary results, it should be considered as a treatment option.

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## Reconstrução do ligamento patelofemoral medial e ligamento patelotibial medial em crianças

### R E S U M O

#### Palavras-chave:

Luxação patelar  
Instabilidade articular  
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**Objetivo:** Avaliar a reconstrução do ligamento patelofemoral medial associado ao ligamento patelotibial medial em pacientes com esqueleto imaturo.

**Método:** Estudo de série de casos em pacientes com instabilidade da patela com fise aberta. Foram avaliados sete pacientes, quatro do sexo masculino e três do feminino, operados pela técnica proposta. Foram incluídos pacientes com esqueleto imaturo com luxação da patela acima de dois episódios com queixas de instabilidade. Nenhum paciente foi submetido a tratamento adicional. A distância da TA-GT (tuberosidade anterior da tibia ao sulco da tróclea) foi medida em todos os pacientes. No exame físico, foram avaliados os sinais do J invertido, sinal da apreensão e amplitude de movimento, como parâmetros pré- e pós-operatórios de 12 meses, além dos escores de Kujala e Tegner Lysholm. Os resultados foram calculados pelo teste dos sinais de Wilcoxon.

**Resultados:** A média de idade dos pacientes foi de 11,28 em ambos os gêneros. Na comparação dos dados do período pré- e pós-operatório, o sinal do J invertido estava presente em seis (85,7%) pacientes vs. um (14,3%) no pós-operatório. O sinal da apreensão estava ausente em 100% dos casos no pós-operatório. A amplitude de movimento foi de  $117,85 \pm 8,09$  vs.  $148,57 \pm 3,77$ . O escore de Kujala foi de  $42,57 \pm 8,9$  vs.  $88,57 \pm 5,09$  e no escore de Lysholm foram classificados como excelentes ou bons 28,6% e 71,4% respectivamente.

**Conclusão:** A reconstrução do ligamento patelofemoral medial combinada com o ligamento patelotibial medial, em pacientes esqueléticamente imaturos na presença de fatores predisponentes, apresenta resultados satisfatórios, sem episódios de recidiva ou de subluxação residual, devendo ser considerada como uma opção de tratamento a partir destes resultados preliminares.

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## Introduction

Patellofemoral instability in children is a frequent pathology in the orthopedic outpatient clinic. In the 1990s, its correction gained popularity and the attention of orthopedic surgeons worldwide.<sup>1</sup>

Anatomic and biomechanical studies have shown that the medial patellofemoral ligament (MPFL) is the main restrictor to the lateral translation of the patella.<sup>2</sup>

Numerous surgical techniques have been described in the literature for MPFL reconstruction, with favorable clinical results.<sup>3</sup> In addition to the MPFL, the ligaments that contribute to the restriction of the medial patella are the medial patellotibial ligament (MPTL) and the medial patellomeniscal ligament (MPML).<sup>2</sup> These contribute to the restriction of the patella at angles above 30° of knee flexion. Philippot et al.<sup>2</sup> have shown that the contribution of the MPTL increases from 26% in extension to 46% at 90° of flexion. In addition to contributing to patellar dislocation, the MPTL influences tilt and rotation movements. Thus, the combined reconstruction of MPTL and MPFL is important to maintain the normal kinematics of the patellofemoral joint throughout range of motion.<sup>4</sup>

According to a study by the University of São Paulo's knee surgery group (IOT HC-FM-USP), reconstruction combined with a secondary stabilizer (MPTL or MPML) could reduce stress in the MPFL.<sup>4</sup>

Giordano et al.<sup>5</sup> demonstrated the combined MPFL and MPTL reconstruction technique using the semitendinosus and gracilis tendons, with the passage of graft through a longitudinal bone tunnel in the patella and fixation of the femur with metal anchors. The technique was indicated for patients with skeletal immaturity, high patella, trochlear dysplasia, increased TT-TG distance, and ligament hyperlaxity.<sup>5</sup>

The authors developed a variation of the method previously described by Giordano et al.,<sup>5</sup> using only the semitendinosus tendon. The graft was fixated to the tibia, patella, and femur with metal anchors at their respective anatomical sites, using radioscopy and not creating bone tunnels, as described in other previous works.<sup>6-10</sup>

This study aimed to present the preliminary results of MPFL and MPTL reconstruction in children with patellofemoral instability and immature skeleton, through anchor fixation and use of the semitendinosus tendon as a graft.

## Methods

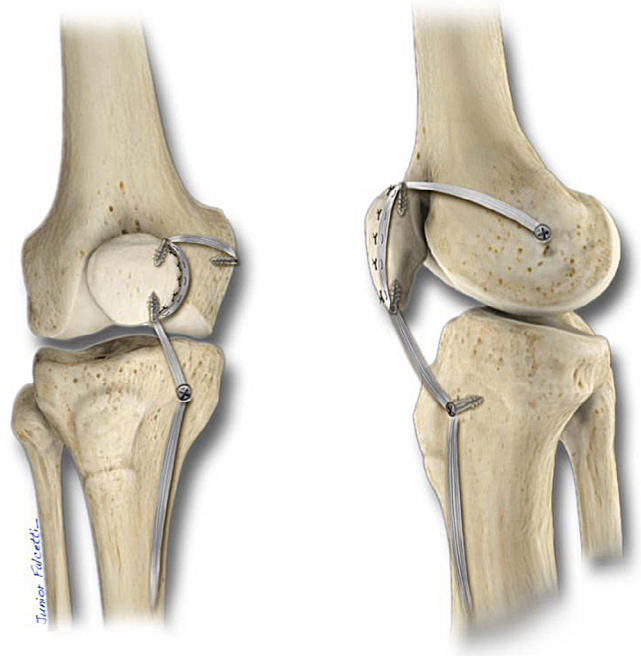
This was a case series of skeletally immature patients diagnosed with patellar instability. The study was approved by the Research Ethics Committee of Plataforma Brasil and of the institution. Seven patients were evaluated in the pre- and postoperative period (12 months after the surgery); four males and three females, with a mean age of 11.28 years.

Only skeletally immature patients diagnosed with patellar instability, who presented more than two episodes of patellar dislocation with complaints of instability in daily activities, and who had magnetic resonance imaging (MRI) demonstrating extensive rupture of the medial retinaculum were included. Exclusion criteria were patients with congenital diseases; osteochondral lesions on the patella; indication of medialization of the anterior tibial tuberosity (ATT); skeletal maturity; inflammatory or post-traumatic arthritis; and presence of osteochondral lesions in the patella or trochlea. No patient underwent further treatment with release of the lateral retinaculum, trochleoplasty, or osteotomy. All patients were assessed by clinical evaluation, physical examination, radiographic assessments, and computed tomography (CT) in the preoperative period. Patellar height was measured by the Caton-Deschamps index; trochlear dysplasia was assessed by the Dejour classification<sup>11</sup>; and the TT-TG distance was calculated through CT examination, in all patients. The physical examination assessed the inverted J-sign, apprehension test, and knee range of motion, as well as the Kujala<sup>12</sup> and Lysholm<sup>13</sup> functional scores in the pre- and postoperative period for all patients.

### Surgical technique

The surgical technique utilizes three small incisions, as described by Giodano et al.<sup>5</sup> First incision is made at the proximal and medial region, toward the ATT, to locate the insertion of the semitendinosus tendon, which is identified and sectioned from the musculotendinous junction, preserving its insertion. The graft must be at least 12–13 cm in length. A second incision is made on the medial border of the patella, the graft fixation site, in the distal and proximal third. A third incision is made in the region between the adductor tubercle and the medial epicondyle, with the aid of radiocopy.

After preparation of the graft with suture in its free end, a metallic anchor is inserted into the tibia, proximal to physal line between the medial edge of the patellar ligament and the superficial medial collateral ligament, forming a 20°-angle with the patellar ligament. The graft is then percutaneously transferred to the distal incision in the medial edge of the patella, which is fixated to a metal anchor with the knee in 90° flexion, at a similar tension to that identified in the patellar ligament, as described by Hinckel et al.,<sup>6</sup> thus reconstructing the MPTL. A third anchor is positioned in the patella at the point between the medial and proximal third of the patella at its medial edge, securing the graft at the periosteum along the patella. Subsequently, the graft is passed to the femur through the second layer of the medial retinaculum of the patella; the fourth anchor is positioned at the distal region to the physis, with the aid of fluoroscopy, in accordance with the anatomical point described by Schöttle et al.,<sup>14</sup> between 5 mm and 6.4 mm distal to the growth plate.<sup>7,14</sup> Prior to the introduction of the anchor, the position must be confirmed in both radioscopic views, front and real profile, in addition to the anatomical recognition. The graft is then fixated with the knee between 45° and 60° of flexion without excessive tension, reconstructing the MPFL.<sup>15</sup> Patellar flexion-extension is tested by observing its mediolateral trajectory, which should



**Fig. 1 – Illustration of the reconstruction technique of the medial patellofemoral and medial patellotibial ligaments using the semitendinosus tendon and fixation with metal anchors.**

allow mobility between 25% and 50% of the patella, without lateral displacement (Fig. 1).

At the end of the surgery, patient is kept on a removable immobilizer for two weeks; physiotherapy is initiated on the second postoperative day with isometric exercises for the quadriceps. Gait is allowed as tolerated until the immobilizer is removed.

### Results

Table 1 describes the study sample regarding age, gender, and affected knee. In total, seven knees were operated on (no bilateral cases were observed); left knee was the most frequent (57.1%). The mean age was 11.28 years, with a standard

**Table 1 – Sample description.**

| Variable            | n = 7 (%) | Mean ± SD (min–max) |
|---------------------|-----------|---------------------|
| Age (years)         |           | 11.28 ± 1.49 (9–13) |
| Sex                 |           |                     |
| Male                | 4 (57.1)  |                     |
| Female              | 3 (42.9)  |                     |
| Affected knee       |           |                     |
| Right               | 3 (42.9)  |                     |
| Left                | 4 (57.1)  |                     |
| Bilateral           | 0         |                     |
| One-year recurrence |           |                     |
| Present             | 0         |                     |
| Absent              | 7 (100)   |                     |

**Table 2 – Primary predisposing factors for patellofemoral instability.**

| Variable                                     | N (%)        |
|--|--------------|
| Patellar height: Caton-Deschamps (mean ± SD) | 1.27 ± 0.7   |
| ≤1.2   | 3 (42.9)     |
| ≥1.3 (high patella)                          | 4 (57.1)     |
| Trochlear dysplasia                          |              |
| Absent                                       | 2 (28.6)     |
| Type A                                       | 3 (42.9)     |
| Type B                                       | 0            |
| Type C                                       | 2 (28.6)     |
| TT-TG distance (mean ± SD)                   | 21.71 ± 1.38 |
| ≤15 mm                                       | 0            |
| ≥16 mm                                       | 7 (100)      |

deviation of 1.49. Most frequent gender was male (57.1%). No patient presented recurrence after one year.

Table 2 lists the primary predisposing factors of patellofemoral instability studied. The mean patellar height, measured by the Caton-Deschamps method, was 1.27, with

a standard deviation of 0.07. Trochlear dysplasia was absent in two cases, type C dysplasia was observed in two cases and type A in three cases, being the most frequent (42.9%). None of the patients with dysplasia presented supratrochlear spur greater than 5 mm. TT-TG distance was greater than 15 mm in all patients.

In the physical examination, shown in Table 3, the inverted J-sign was present in six patients in the preoperative period (85.7%); in the postoperative period, it was present in only one (14.3%). The apprehension sign was present in all patients in the preoperative period, and became absent in all cases in the postoperative period. The mean range of motion, described in Table 4, was 117.85 ± 8.09 degrees preoperatively and 148.57 ± 3.77 in the postoperative period.

The mean Kujala score (Table 4) was 42.57 ± 8.9 in the preoperative period and 88.57 ± 5.09 in the postoperative period. The Wilcoxon signed-rank test was applied, with  $p=0.017$  (0.009–0.019), demonstrating a significant difference. Table 4 presents the Lysholm score with its continuous values. The mean score in the preoperative period was 33.71 ± 9.6 and in the postoperative, 87.71 ± 5.7. The Wilcoxon signed-rank test was statistically significant, with  $p=0.015$  (0.013–0.017). Table 5

**Table 3 – Findings on physical examination.**

| Variable                             | N preoperative (%)     | N postoperative (%)    |
|--------------------------------------|------------------------|------------------------|
| Inverted J-sign                      |                        |                        |
| Present                              | 6 (85.7)               | 1 (14.3)               |
| Absent                               | 1 (14.3)               | 6 (85.7)               |
| Apprehension sign                    |                        |                        |
| Present                              | 7 (100)                | 0                      |
| Absent                               | 0                      | 7 (100)                |
| Range of motion (mean ± SD; min–max) | 117.85 ± 8.09; 110–130 | 148.57 ± 3.77; 145–155 |

**Table 4 – Pre- and postoperative Kujala and Lysholm score.**

| Variable                | Preoperative mean ± SD (min–max) | Postoperative mean ± SD (min–max) | $p^a$ (95% CI)      |
|-------------------------|----------------------------------|-----------------------------------|---------------------|
| Kujala – General        | 42.57 ± 8.9 (34–54)              | 88.57 ± 5.09 (82–98)              | 0.017 (0.009–0.019) |
| Lysholm – General       | 33.71 ± 9.6 (22–50)              | 87.71 ± 5.70 (84–96)              | 0.015 (0.013–0.017) |
| Gender (Kujala)         |                                  |                                   |                     |
| Male                    | 40.66 ± 9.86 (34–52)             | 87.00 ± 4.35 (82–90)              |                     |
| Female                  | 44.00 ± 9.38 (36–54)             | 89.75 ± 5.9 (84–98)               |                     |
| Gender (Lysholm)        |                                  |                                   |                     |
| Male                    | 32.00 ± 8.66 (22–37)             | 88.00 ± 6.92 (84–96)              |                     |
| Female                  | 35.00 ± 11.48 (22–50)            | 87.50 ± 5.74 (84–96)              |                     |
| Affected knee (Kujala)  |                                  |                                   |                     |
| Right                   | 40.00 ± 8.71 (34–50)             | 89.66 ± 8.02 (82–98)              |                     |
| Left                    | 44.50 ± 9.84 (36–54)             | 87.75 ± 2.63 (84–90)              |                     |
| Affected knee (Lysholm) |                                  |                                   |                     |
| Right                   | 36.33 ± 14.01 (22–50)            | 92.00 ± 6.92 (84–96)              |                     |
| Left                    | 31.75 ± 6.65 (22–37)             | 84.50 ± 1.00 (84–86)              |                     |

<sup>a</sup> Wilcoxon test of signs with statistical significance with  $p < 0.05$ .

**Table 5 – Frequency of patients categorized according to the Lysholm score.**

| Score (%)            | Excellent (%) | Good (%) | Regular (%) | Poor (%) |
|----------------------|---------------|----------|-------------|----------|
| Preoperative period  | 0             | 0        | 0           | 7 (100)  |
| Postoperative period | 2 (28.6)      | 5 (71.4) | 0           | 0        |

presents the Lysholm score analysis, indicating that in the preoperative period, all seven cases were categorized as poor; in the postoperative period (12 months after the surgery), two cases were excellent and five, good.

## Discussion

This article aimed to present an alternative technique and its preliminary results. The technique described in this study presented satisfactory results, demonstrating the possibility of combined MPFL and MPTL reconstruction in skeletally immature patients and presence of anatomical risk factors, such as generalized ligament hyperlaxity, knee hyperextension, flexural instability, and patellar subluxation in extension with contraction of the quadriceps. With the combined reconstruction, stabilization of the patella was possible without other associated procedures, such as trochleoplasty or medialization of the ATT through osteotomy.

In skeletally immature patients, physis-preserving procedures are recommended.<sup>5,16,17</sup> In this study, radiological control was made to assess the proper placement of the graft, in order to preserve growth cartilage, and to properly assess anatomy, avoiding positioning errors that can occur due to inadequate interpretation of radioscopy, as described by Burrus et al.<sup>18</sup>

In the tibia, graft fixation in the proximal epiphysis instead of the proximal metaphysis avoids the risk of distal migration of the graft insertion with patient's growth, which could lead to change in tension and function of the ligament.<sup>6</sup>

The use of radioscopy in skeletally immature patients is imperative. The fixation of the graft relative to the distal femoral growth plate remains controversial, due to the study by Shea et al.,<sup>19</sup> which demonstrated that the fixation point in the femur should be proximal to the physis. However, in the present study, graft was fixated distal to the physis, slightly oblique, to avoid the risk of physeal perforation. The authors believe that distal fixation of the physis is more reproducible using radioscopy, in agreement with some authors, such as Kepler et al.,<sup>20</sup> Ladd et al.<sup>21</sup> and Parikh et al.<sup>3</sup> When the fixation is made too distal to the physis, there is the possibility of hypertension of the patellofemoral joint in extension, which can be corrected if the point of attachment is moved anteriorly as far as the distal distance.<sup>3</sup>

The combined MPFL and MPTL reconstruction, using flexor tendons as a graft, has shown satisfactory results in the literature, as can be observed with the technique presented.<sup>22</sup> The single semitendinosus tendon was used as graft due to its greater length, making it possible to preserve its tibial insertion, in accordance with Giordano et al.<sup>5</sup> The difference in the method proposed in the present study was the fact that bone

tunnels were not created in the patella, and fixation was made with metal anchors.

Kang et al.<sup>10</sup> demonstrated the effectiveness of using metal anchors for reconstruction of the two bands of MPFL, not observing reconstruction failures or recurrences. The insertion points are identified with the aid of fluoroscopy, with small incisions and adequate tensioning of MPTL, which must be fixated at 90° of knee flexion, with similar tension to the patellar ligament, as identified by touch.<sup>4</sup> MPFL hypertensioning should be avoided, as it could cause low medial patellar subluxation and hyperpressure of the medial patellofemoral joint.<sup>2</sup>

All patients of the study presented TT-TG distances above 15 mm, as measured by CT scan, showing that the combined technique was suitable for patellar stabilization even in the presence of this predisposing factor. No functional or range of motion limitations were observed.

After MPFL reconstruction, a large proportion of cases may persist with inverted J-sign or residual patellar subluxation in extension, as observed in 33% of the patients in the study by Shah et al.<sup>23</sup> The inverted J-sign was absent in 85.7% of cases in the postoperative period, and the apprehension test was negative in 100% of cases, unlike the results found by Hinckel et al., who observed a persistence of the inverted J-sign.<sup>4</sup> This difference was possibly due to the smaller number of cases with trochlear dysplasia in this series. No patient had trochlear spur greater than 5 mm or type D dysplasia, which would likely be a parameter associated with subluxation when associated procedures, such as trochleoplasty, are not performed.<sup>24</sup>

Preoperatively, all seven patients were categorized as poor by the Lysholm score;<sup>13</sup> postoperatively, two cases were considered as excellent and five cases as good, which demonstrates the effectiveness of the technique for improving function, as observed in similar studies with techniques that combine the reconstruction of MPFL and MPTL in skeletally immature patients.<sup>5,9,22,25</sup>

The procedure presented allowed the creation of small incisions that can be considered cosmetic. For female and young patients, the cosmetic appearance seems to have a significant impact. Furthermore, patellar stabilization can be achieved with minimal exposure of soft tissues, and may be considered as one of the surgical possibilities among the numerous techniques presented in the literature. However, this procedure should be reviewed after skeletal maturity, in view of the possible need for additional procedures, such as ATT osteotomy, osteotomy for correction of angular deviations of the lower limb, or trochleoplasty, according to their indications.<sup>6</sup>

Patients need to be advised about the need for follow-up with an orthopedist, who should review physical examination and imaging studies for patellofemoral joint investigation.

The limitations of the study include the fact that the sample was chosen for convenience, because patients were treated at the hospital. This study should be considered as preliminary; patients are being followed-up, considering the results found in this initial series. The Kujala and Lysholm tests were included after the rehabilitation phase, but dislocation relapse may occur after this period, and a longer follow-up is necessary for a better evaluation in order to compare with the results found.

## Conclusion

The combined reconstruction of the medial patellofemoral ligament with the medial patellotibial ligament in skeletally immature patients with predisposing factors presents satisfactory results, without residual recurrence or subluxation episodes, and can be considered as a treatment option, based on these preliminary results.

## Conflicts of interest

The authors declare no conflicts of interest.

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