



## Original Article

# Total ruptures of the extensor apparatus of the knee<sup>☆</sup>



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## ABSTRACT

**Objective:** This was a retrospective case-control study on total ruptures of the extensor apparatus of the knee, aimed to compare patella fractures with tendinous ruptures.

**Methods:** The sample included 190 patients and 198 total ruptures of the knee extensor apparatus. All patients were evaluated by the same examiner after a minimum one-year follow-up.

**Results:** Tendinous ruptures occurred most frequently in men, in younger patients, and had better clinical and functional outcomes when compared with patella fractures; however, the former presented higher levels of thigh atrophy. Patella fractures occurred most frequently in women and in older patients and caused most frequently residual pain, muscle weakness, and limitations in daily activities. Comminuted fractures were related to high-energy trauma, lower clinical and functional outcomes, and higher levels of residual pain and osteosynthesis failure. Early removal of osteosynthesis material was related to better outcomes. Regarding the tendinous ruptures, over half of the patients presented risk conditions for tendinous degeneration; a longer delay until surgery was related to lower Kujala scores.

**Conclusion:** The surgical repair of bilateral ruptures of the knee extensor apparatus resulted in satisfactory clinical and functional outcomes, which were better for tendinous ruptures when compared with patella fractures. However, these lesions are associated with non-negligible levels of residual pain, muscle weakness, atrophy, and other complications.

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## Roturas totais do aparelho extensor do joelho

## RESUMO

**Objetivo:** Estudo retrospectivo sobre roturas totais do aparelho extensor do joelho que compara as fraturas da patela com as roturas tendinosas.

**Métodos:** Amostra com 190 pacientes e 198 roturas totais do aparelho extensor do joelho. O tempo mínimo de seguimento após a cirurgia foi de um ano e todos os pacientes foram avaliados clínica e radiologicamente pelo mesmo médico.

## Palavras-chave:

Rotura

Joelho

Amplitude de movimento articular

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Patela  
Tendões

**Resultados:** As roturas tendinosas ocorrem mais frequentemente em homens, em pacientes mais novos e estão associadas a níveis clínico-funcionais superiores em relação às fraturas da patela. No entanto, com atrofia da coxa mais frequente. As fraturas patelares ocorrem mais frequentemente em mulheres com idade mais avançada e provocam mais frequentemente dor residual, déficit de força muscular e limitação das atividades da vida diária. A maior cominuição das fraturas da patela esteve associada a resultados clínico-funcionais mais desfavoráveis, a níveis mais elevados de dor residual e de desmontagem do material de osteossíntese. A extração precoce do material de osteossíntese esteve associada a melhores resultados. No grupo das roturas tendinosas, mais de metade apresentava doenças consideradas de risco para degeneração tendinosa e um tempo de espera mais prolongado até a cirurgia demonstrou valores de escore de Kujala significativamente inferiores.

**Conclusão:** O tratamento cirúrgico das roturas totais do aparelho extensor do joelho garante bons resultados funcionais, que são superiores para as roturas tendinosas em comparação com as fraturas da patela. No entanto, estão associadas a níveis importantes de dor residual, fraqueza muscular, atrofia muscular e outras complicações.

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## Introduction

The extensor apparatus of the knee consists of three basic structures: two tendons, the quadriceps and patellar; and one bone, the patella. The total rupture of this apparatus can occur through the bone or tendon, leading to an inability to actively extend the leg. Patellar fractures are more frequent than tendinous ruptures, in ratios ranging from 17:1 to 43:1; ruptures of the quadriceps tendon are more frequent than those of the patellar tendon.<sup>1,2</sup> These injuries require surgical reconstruction of the extensor apparatus in order to recover the extension function.<sup>3</sup> To date, only one study has directly compared clinical and functional results of patellar fractures and tendinous rupture of the extensor apparatus of the knee.<sup>3</sup>

## Material and methods

This was a retrospective study, comprising a mean of 5.1 years (range 1–10); 190 patients were retrieved, corresponding to 198 total ruptures of the extensor apparatus of the knee that were surgically treated. All patients with other associated traumatic injuries and those who could not be followed-up for a minimum of one year after surgery were excluded. The clinical evaluation included functional assessment, measurement of range of motion, and the application of a validated score for patellofemoral pathology, the Kujala score.<sup>4</sup> The degree of patient satisfaction was also assessed in a scale from 0 to 5, were 0 – dissatisfied, and 5 – totally satisfied. Radiologically, patients were assessed for fracture classification (AO classification)<sup>5</sup>; presence or absence of consolidation; patellofemoral arthrosis; patellar height, using the Insall and Salvati index<sup>6</sup>; and whether or not the osteosynthesis material was extracted. The variables were treated statistically using SPSS<sub>v23</sub>, and a 0.05 significance level was adopted. Quantitative values were presented as mean  $\pm$  standard deviation (minimum–maximum), and qualitative values as number (n) or percentage (%). For comparisons between two groups

with quantitative variables, Student's t-test was used; the Mann–Whitney test was used when the values were very low. To compare among three or more groups, ANOVA was used. For comparisons between two groups with nominal variables, the chi-squared test was used; for ordinal variables, the Mann–Whitney test. To study the association between quantitative variables, Pearson's correlation was used; for the multivariate study, the general linear model (GLM) analysis was adopted. The study was approved by the Ethics Committee of the Centro Hospitalar e Universitário de Coimbra and all patients or their respective families signed an informed consent form.

## Results

The sample consisted of 190 patients or 198 ruptures, as eight were bilateral. The mean age was  $58.82 \pm 17.86$  years (range 18–90) and 56.6% were male. Of the total, 67.17% (n = 133) was patellar fractures; tendinous ruptures of the extensor apparatus accounted for the remaining 32.82% (n = 65), which were divided between quadriceps tendon ruptures (56.9%) and rupture of the patellar tendon (43.1%; [Table 1](#)).

In the analysis of the group with patellar fractures, the most common mechanism of injury was low energy (87.1%) direct trauma (86.4%). The predominant types of patellar fracture were C1, C3, and A1 considering the AO classification ([Fig. 1](#)). Comminuted type C patellar fractures (C1 to C3) showed a significant association (p = 0.004) with high-energy trauma. Types of osteosynthesis used were figure-of-eight tension band with Kirschner wires (74.2%), circular tension band with Kirschner wires (9.8%), screws (3%), and double tension band with Kirschner wires (1.5%). In 83% of cases, two Kirschner wires were used. In type A1 fractures, hemipatellectomy was performed, followed by tendon reinsertion. The functional outcomes and complications of the surgical treatment of patellar fractures are presented in [Table 1](#). Statistically significant differences were observed between type C1 and C3 fractures regarding the mean Kujala score ( $74.3 \pm 14.62$

**Table 1 – Comparative data between fractures of the patella and tendon ruptures.**

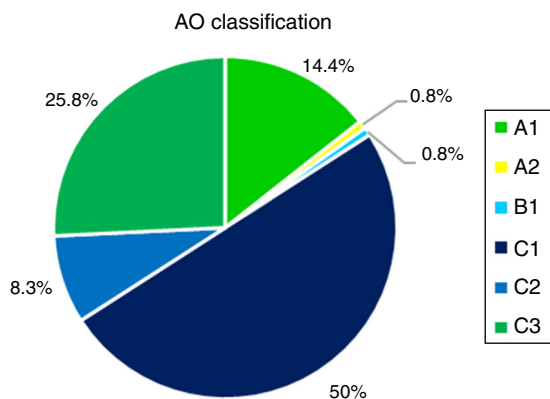
	Fractures of the patella	Tendon ruptures	p
Lesions (n, %)	133 (67.17%)	65 (32.82%)	–
Age (years)	61.45 ± 18.13	53.48 ± 16.13	0.003 <sup>a</sup>
Prevailing gender	56.8% ♀	84.5% ♂	<0.001 <sup>a</sup>
Flexion	99.81° ± 20.75	124.47° ± 15.40	<0.001 <sup>a</sup>
Kujala score	71.89 ± 16.11	89.94 ± 9.75	<0.001 <sup>a</sup>
Satisfaction	Grade 3–33.3%; Grade 5–30.3%	Grade 5–58.7%; Grade 4–28.6%	<0.001 <sup>b</sup>
Limitation of daily activities	42.4%	6.90%	<0.001 <sup>a</sup>
Residual pain	74.20%	41.40%	<0.001 <sup>a</sup>
Deficit in strength	60.60%	20.70%	<0.001 <sup>a</sup>
Thigh atrophy	21.20%	37.90%	0.007 <sup>a</sup>
Patellofemoral arthrosis	37.90%	24.62%	<0.001 <sup>a</sup>
Changes in patellar height	9.10%	36.90%	<0.001 <sup>a</sup>

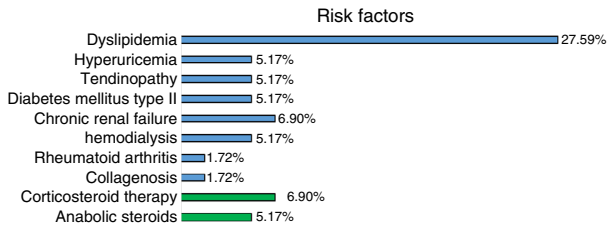
<sup>a</sup> Chi-squared test.<sup>b</sup> Mann-Whitney test.

vs.  $63.88 \pm 16.44$ ;  $p=0.016$ ) and flexion ( $104.32 \pm 17.45$  vs.  $90.61 \pm 23.31$ ;  $p=0.001$ ). An extension deficit from  $1^\circ$  to  $5^\circ$  was observed in 6.06% of cases, and a deficit from  $5^\circ$  to  $10^\circ$ , in 2.27%. Signs of patellofemoral arthrosis were observed in 37.90% of cases, and all changes in patellar height corresponded to low patellae. Complications directly related to the surgical treatment occurred in 23.7% of cases and consisted of painful material (19.7%), osteosynthesis removal (8.3%), infection (3%), non-consolidation of the fracture (1.5%), and other surgical wound problems (3.8%). Compared with type C1 fractures, type C3 comminuted patellar fractures presented higher levels of osteosynthesis removal (11.8% vs. 3%) and residual pain (84.8% vs. 71%). Regarding osteosynthesis techniques, screws led to complications in 75% of cases while circular tension band, 38.5%. These techniques presented the highest rates of complications, as well as higher rates of osteosynthesis removal, particularly in the 25% of the patients who received screws and in 15.4% of those in whom a circular tension band was performed. Regarding the osteosynthesis material, screws were the most symptomatic (50% of cases), followed by circular tension band (in 23.1% of cases). Older individuals had a significantly lower Kujala score ( $r=-0.60$ ;  $p<.001$ ), lower mean flexion ( $r=-0.51$ ;  $p<0.001$ ), and a lower degree of satisfaction ( $p<0.001$ ;  $\rho=-0.42$ ). Moreover, they

presented higher levels of residual pain ( $p<0.001$ ) and more muscular strength deficit ( $p<0.001$ ). In turn, younger individuals presented significantly more thigh atrophy ( $p<0.001$ ) and a trend for higher rates of osteosynthesis removal. The removal of the osteosynthesis material occurred in 50.8% of patients with patellar fractures; these patients, when compared with those in whom the osteosynthesis material was not removed, presented a significantly higher Kujala score ( $74.79 \pm 15.21$  vs.  $64.84 \pm 15.49$ ) ( $p=0.002$ ) and mean flexion ( $104.66 \pm 19.40$  vs.  $93.03 \pm 20.72$ ) ( $p=0.006$ ). Patients who underwent extraction of osteosynthesis material presented lower levels of residual pain when compared with those in whom the material was not removed (69% vs. 84.2%).

Regarding the group of tendon ruptures, falls were the cause of injury in 70.69% of cases, and indirect trauma was the most frequent (91.38%). The predominant mechanisms of injury were knee torsion (67.92%), hyperflexion of the knee (15.1%), and counter-resistance with the knee in semiflexion (9.43%). Five tendon ruptures occurred by direct trauma and consisted of fragments with direct tendon cut. The collapse occurred more frequently at the midpoint of the tendon (43.10%), followed by patellar insertion (39.66%), myotendinous transition (13.79%), and insertion at the level of the anterior tibial tuberosity (3.45%). Recurrence of tendon rupture was observed in 3.45%, ruptures in the context of total knee replacement in 3.45%, and bilateral ruptures in 12.07% of cases of tendinous rupture. Half of the patients with tendinous rupture were considered to be at risk for degeneration and tendinous rupture of the extensor apparatus, and 2.07% presented risk drug intakes (Fig. 2).<sup>7-9</sup> Only 12.07% of the patients with tendinous rupture were healthy. Age was significantly higher ( $p<0.001$ ) in cases of rupture of the quadriceps tendon ( $61.31 \pm 13.47$  years) when compared with those of the patellar tendon ( $44.33 \pm 4.08$  years). Ruptures of the patellar tendon were 10.65 times (odds ratio) more related to the consumption of risk substances when compared with ruptures of the quadriceps tendon (23.4% of patellar tendon ruptures occurred in patients with risk consumption, compared with only 2.8% of those with rupture of the quadriceps;  $p=0.019$ ) and a trend for the former to occur at the midpoint level of the tendon. Surgical treatment options were end-to-end tenorrhaphy (51.72%),

**Fig. 1 – Prevalence of types of patellar fractures according to the AO classification.**



**Fig. 2 – Prevalence of risk factors in the group of tendinous ruptures.**

followed by tenorrhaphy with trans-bone points (24.14%), tenodesis with anchors (17.24%), and other reconstructive graft options for circumstantial cases (6.90%). Protective wiring was used in 64% of cases of patellar tendon rupture; the mean time for its removal was 6.38 months. The mean duration of postoperative immobilization was 45.43 days (range 41–66 days). The functional outcomes and complications of surgical treatment of tendinous ruptures of the extensor apparatus are shown in Table 1. Of the individuals in this group, 13.85% presented extension deficit, always less than 5°. Radiological signs of patellofemoral arthrosis were identified in 36.90% of the knees; high patella, in 15.81%; and low patella, in 21.09%. The waiting time until surgery presented a statistically significant inverse correlation ( $r = -0.03$ ;  $p = 0.008$ ) with the Kujala score. The best results were observed in repairs with trans-bone points, which showed a statistically significant difference in the mean range of flexion ( $126.14 \pm 13.88$ ;  $p = 0.031$ ) and mean Kujala score ( $88.46 \pm 9.33$ ;  $p = 0.006$ ) when compared with the results of reconstruction with tendon grafts (respectively,  $107.50 \pm 22.17$  and  $77.25 \pm 10.50$ ). Recurrent ruptures and those that occurred in the context of total knee replacement presented a significantly lower Kujala score (respectively,  $80.25 \pm 8.62$  and  $91.08 \pm 9.83$ ;  $p = 0.031$ ) when compared with other disruptions. Residual pain was 1.75 times (odds ratio) more present in ruptures of the patellar tendon when compared with those of the quadriceps tendon (50% in patellar tendon rupture vs. 36.1% in the rupture of the quadriceps tendon) and was associated with more ruptures at the level of the site of tendon insertion in the bones (100% in the anterior tibial tuberosity and 44.1% in the patellar insert, compared to 36.7% in the tendinous body). Patients with residual pain had significantly lower flexion amplitudes ( $119.46 \pm 17.60$  vs.  $128.16 \pm 12.54$ ;  $p = 0.031$ ) and lower Kujala score ( $83.43 \pm 9.32$  vs.  $95 \pm 6.62$ ;  $p < 0.001$ ) when compared with those who did not have residual pain. Other complications, observed less frequently, included re-rupture of the tendon (3.08%), knee stiffness (3.08%), and wound dehiscence (3.08%), among others.

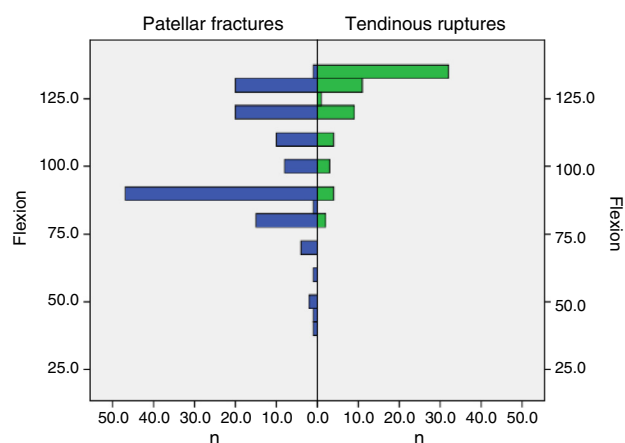
## Discussion

The present study demonstrated that the grade of comminution of patellar fractures was associated with higher-energy trauma and with less favorable clinical and functional results. The comminution, a difficulty to achieve anatomic reduction and stability of osteosynthesis, as well as the need to use circular and double tension bands, likely contribute to the fact that C3 fractures and these types of osteosynthesis

present higher levels of osteosynthesis removal and residual pain, which leads to a worse prognosis of these fractures. Although consolidation is achieved in most cases, allowing for reasonable clinical and functional outcome, the surgical treatment of patellar fractures leads to high levels of residual pain, atrophy, muscle strength deficit, and other complications, which is in agreement with the literature.<sup>10-13</sup> In the present study, osteosynthesis removal and thigh atrophy in patellar fractures were more common in younger individuals, probably due to the higher functional level of this age group and more intensive demand on the extensor apparatus. As this is an osteosynthesis of a prominent bone, which is very mobile and subject to high and repeated forces, together with the need for early joint mobilization, implies that the material often desintegrates, migrates, or becomes prolapsed and painful, delaying functional recovery.<sup>13</sup> Early extraction of the osteosynthesis material should be performed whenever possible, as this procedure is associated with superior clinical and functional results.

Tendon ruptures occurred more frequently at the midsection of the tendon and patellar insertion. This is in agreement with the fact that almost all tendon ruptures of the knee extensor apparatus occur after a degenerative and inflammatory process, which is more pronounced in the tendinous midsection and in osteotendinous junction in which the tendon resistance is significantly reduced and the risk of rupture, increased.<sup>7-9</sup> The older age range observed in patients with rupture of the quadriceps tendon is consistent with the literature.<sup>3</sup> A longer waiting time until surgery presented significantly lower Kujala scores, which is consistent with results obtained by other authors.<sup>2,14-16</sup> Clinical and functional results in the tendon tears were also satisfactory, with near normal mobility and Kujala score; nonetheless, these were less favorable in recurrent ruptures, in patients with knee prostheses, and when there was a need for a tendon graft, probably due to the weakening and changes in the patellofemoral biomechanics.<sup>14-16</sup> Furthermore, nearly half of patients with tendon ruptures had residual pain; this was more present in patellar tendon ruptures and in those at the level of bone inserts.

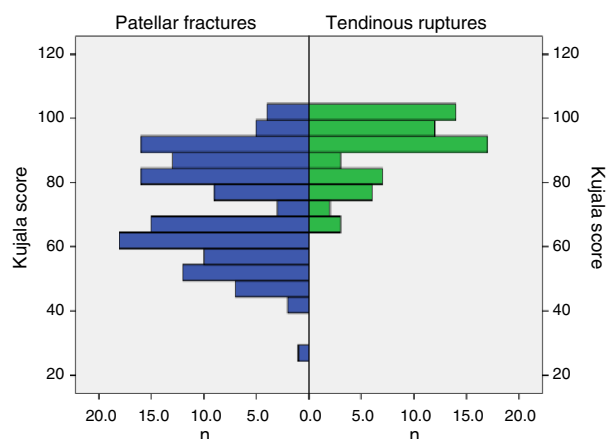
When comparing groups of patellar fractures and tendinous ruptures (Table 1), there were statistically significant differences in age, flexion amplitude (Fig. 3), Kujala score (Fig. 4), degree of satisfaction, limitation of activities of daily life, residual pain, thigh atrophy, muscle strength deficit, and patellofemoral arthrosis (Table 1). Tendon ruptures occurred more frequently in men and in younger patients, and were associated with higher clinical and functional levels (Figs. 3 and 4); nonetheless, thigh atrophy was more common. Patellar fractures occurred more often in women and in older patients; they presented lower clinical and functional levels and more often caused residual pain, muscle strength deficit, and limitation in the activities of daily living. Despite the significant difference in age between Groups with patellar fractures and tendon ruptures, this difference occurred mainly in patellar tendon ruptures ( $44.33 \pm 14.08$  years), as the mean age of patients with fractures ( $61.45 \pm 18.13$ ) was similar to that of patients with quadriceps tendon ruptures ( $61.31 \pm 13.47$  years). The presence of radiological signs of patellofemoral arthrosis was substantial in both groups. However, it was



**Fig. 3 – Amplitudes of flexion: comparison of patellar fractures with tendinous ruptures.**

predictably higher in patellar fractures, not only due to the advanced age, but also because these fractures have joint involvement. In a multivariate analysis, when comparing flexion and Kujala score between patellar fractures and tendinous ruptures, adjusting for age and the presence of patellofemoral arthrosis, these parameters were still found to be significantly higher in tendinous ruptures; the estimated mean flexion was  $98.92^\circ$  in fractures and  $116.62^\circ$  in tendinous ruptures, and the Kujala score was 70.86 in fractures and 82.59 in tendinous ruptures. The only previous study that directly compared results of surgical treatment of patellar fractures ( $n=50$ ) with rupture of the quadriceps tendon ( $n=36$ ) and patellar tendon ( $n=13$ ) did not identify significant differences in range of motion, radiographic signs of arthrosis, and functional Tegner, Lysholm, and SF-36 scores among the different types of rupture.<sup>3</sup>

Limitations of this study are related to the fact that it was an observational retrospective study with a subjective clinical assessment and to the difficulty of controlling the variables that determine clinical and functional results, and complications. The strengths of the present study include the large number of patients in each group, as well as the use of



**Fig. 4 – Kujala score: comparison of patellar fractures with tendon ruptures.**

objective and validated measures for clinical and functional assessment of range of motion and the Kujala score.

## Conclusion

Surgical treatment of total ruptures of the extensor apparatus of the knee provided good functional results, which were superior for tendon ruptures when compared with patellar fractures, probably due to higher age of the latter patients. Nonetheless, rupture of the extensor apparatus is associated with high levels of residual pain, muscle weakness, muscle atrophy, and other complications, which is probably due to a loss of dynamic balance of the patellofemoral joint.

## Conflicts of interest

The authors declare no conflicts of interest.

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