PLATEAU-PATELLA ANGLE: AN OPTION FOR ASSESSING PATELLAR HEIGHT ON PROXIMAL TIBIA OSTEOOTMY

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ABSTRACT

Objective: To compare the plateau-patella angle method to the methods already established for patellar height measurement in patients undergoing high tibial osteotomy. Methods: This is a retrospective study of 13 patients undergoing medial opening tibial osteotomy. The patellar height was measured in pre and postoperative radiographs by the methods from Insall-Salvati, Caton-Deschamps, Blackburne-Peel and patella-plateau angle, as well as the tibial slope and length of the patellar tendon. Measurements were performed by two knee surgeons at two different times. Results: The mean age was 41.33 ± 0.09 years old. The average rates of Caton-Deschamps, Blackburne-Peel, Insall-Salvati and plateau-patella angle were, respectively, 1.00; 0.89; 1.10; and 23.15° preoperatively, and 0.89; 0.78; 1.11; and 20.46°, postoperatively. The correlation of Caton-Deschamps, Blackburne-Peel, and Insall-Salvati indexes and plateau-patellar angle interobserver was 0.72 (p < 0.001), 0.54 (p < 0.001), 0.65 (p < 0.001), and 0.67 (w < 0.001), respectively. Conclusion: The plateau-patella angle method undergoes changes that are correlated with changes in tibial slope after osteotomy, unlike the classical methods. This fact may lead to overestimate the reduction of patellar height after osteotomy. Level of evidence IV. Case Series.

Keywords: Patellar ligament. Osteotomy. Knee.

INTRODUCTION

Historically the measurement of patellar height was widely studied for its causal relationship to various diseases of the patellofemoral joint.¹-⁸ The patella is associated with anterior knee pain, chondromalacia and patellar instability.¹-³ On the other hand, low patella presents association with patellar overpressure and patellofemoral arthrosis.⁷-⁹ After high tibial osteotomies there may be change in the patellar height. One of the first methods to assess patellar height was proposed by Blumensat in 1938,¹⁰ based on the evaluation of the profile radiograph, with the knee in 30° flexion. Drawing up a radiographic line of the intercondylar ceiling and projecting it anteriorly, it should cross the inferior pole of the patella in height considered normal. If the inferior pole found the top of the line, the patella would be considered high. This method was subsequently considered inaccurate, especially due to the difficulty in obtaining radiographs with perfect 30° flexion, essential for the assessment.¹¹ Radio graphic evaluation methods of patellar height most commonly used are those by Caton et al.¹² Insall-Salvati¹³ and Blackburne-Peel.¹ These methods involve calculating the ratio between these measurements. In order to eliminate calculations, Portner-Pakzad¹⁴ proposed a method called “plateau-patellar angle”. This method requires only a single angle measurement, eliminating additional calculations. Because it is an angular evaluation, there is no interference due to radiographic magnification and size of the patient, requiring only a minimum 30° knee bending on the radiograph. (Figure 1)

Although there are new validation studies of the method proposed by Portner-Pakzad,¹⁴ namely plateau-patella angle, it has not been studied as patellar height measurement method in postoperative high tibial osteotomies. The aim of this study is to compare the plateau-patella angle with classic measurement methods of patellar height, and validate it as a measuring method after high tibial osteotomies.

MATERIALS AND METHODS

We performed a retrospective review of all medial opening osteotomy of the tibia held in a single center from December 2012 to June 2015. Knee profile digital radiographs were assessed immediately before and three months after surgery. Radiographs with inadequate rotation, poor definition of radiographic
According to the Blackburne-Peel method, the perpendicular of the patella was measured in its largest diagonal length up to its insertion into the anterior tibial tuberosity. The length of the deepest portion from its origin at the inside pole of the patella was the ratio between the length of patellar tendon divided by the length of the articular surface of the patella.

The plateau-patellar angle described in the Introduction was measured between a first line tangent to the medial plateau of the tibia (same line used by Blackburne and Peel) and a second line from the posterior end of the medial plateau towards the lower end of the articular surface of the patella. Ranges were considered normal between 0.6 and 1.2 for the Caton-Deschamps index, 0.8 and 1.2 for Insall-Salvati index and 0.5 to 1 for the Blackburne-Peel index, and 21° and 29° to the plateau-patella angle.

For qualitative assessment we used a classification as high, normal or low patella, according to previously mentioned normal intervals and compared preoperative to postoperative scores.

STATISTICAL ANALYSIS
We used the Pearson correlation coefficient to evaluate the association between continuous variables. For the evaluation of differences between pre- and postoperative period in each method we used the paired Student’s t-test.

RESULTS
The average rates of Caton-Deschamps, Blackburne-Peel, Insall-Salvati and plateau-patella angle were, respectively, 1.0 / 0.89 / 1.10 and 23.15° preoperatively and 0.89 / 0.78 / 1.11 and 20.46° postoperatively. (Table 1) The mean tibial slope pre and postoperative was, respectively, 7.58° and 9.18° (p<0.05). The mean tendon patellar length was, respectively, 502.71mm and 507.46mm (p = 0.56), a not statistically significant difference. (Table 1)

The absolute mean change and percentage of each method were -0.11 (18%); 0.01 (2%); -0.11 (-22%) and -3.01° (-38%), respectively, for Caton-Deschamps, Blackburne-Peel, Insall-Salvati and plateau-patella angle. (Table 2) The difference in the percentage change at pre and postoperative was significant between the Insall-Salvati index and other methods and between the plateau-patella angle and the other methods. (Table 3)

The correlation between the change of the plateau patella angle between the pre- and postoperative period and the change of the slope after surgery was -0.67 (p<0.001).

Regarding qualifying assessment of methods, we noticed a change trend to a lower patellar height postoperatively compared to preoperative. For Caton-Deschamps index,
DISCUSSION

Phillips et al.\(^4\) concluded, in his review in 2010, that there is clear room for improvement in existing evaluation methods of patellar height available at that time. The three most classical methods of measuring patellar height presented some difficulties. The Insall-Salvati index can be changed by a patella with a larger non-articular portion,\(^3\) and it is often difficult to precise the exact location of insertion of the patellar tendon. The method, thus, depends on a perfect knee profile. On the other hand, the Blackburne-Peel\(^4\) index does not use the length of the patellar tendon, but also depends on mathematical calculation, building lines and more complex measurements. Regarding Caton-Deschamps index, identifying the superior-anterior tibial angle presents a grid variability in patients with osteoarthritis and this figure becomes even more difficult to assess.\(^9\) The plateau-patella angle is a simpler method, which avoids mathematics calculations for patellar height measurement, with easier to identify radiographic landmarks, already validated by Portner et al.,\(^14\) but also depends on absolute profile x-rays with at least 30° flexion. In the present study the method showed good intra- and interobserver correlation, demonstrating that the simplicity of the angle improves its reproducibility.

The proximal osteotomy of the tibia tends to change the patellar height and the medial opening osteotomy, specifically, has a tendency to lower the patella, a finding confirmed in this study.\(^15\) However, the extent of height variation can change between the different methods of patellar height assessment. The plateau-patella angle is an already validated method to measure patellar height,\(^13\) however, to our knowledge, there is study comparing traditional measuring methods of patellar height in patients undergoing medial opening osteotomy of the tibia.

Our results showed a clear trend of reduction of patellar height after medial opening osteotomy of the tibia, except only regarding Insall-Salvati index, which showed no significant change in patellar height after surgery. This exception can be explained by the fact that Insall-Salvati uses the length of the patellar tendon and patellar diameter to calculate its index and none of those parameters is directly changed with the surgery. Thus, the Insall-Salvati index is not prone to elevation of the articular line that occurs with the medial opening osteotomy and does not identify the reduction in the patellar height in these cases. Therefore, we believe that the method should not be used in the evaluation of patients submitted to this surgery.

The reduction of patellar tendon length resulting from fibrosis, despite having already been demonstrated in previous studies,\(^16\) was not found in our evaluation. Since we used x-rays performed only 3 months after surgery, it is still possible that some variation may have occurred regarding the shortening of the tendon. Assessing the three methods that demonstrated changes of the patellar height after surgery, Blackburne-Peel index,\(^4\) Caton-Deschamps index and plateau-patella angle, the change is more significant on the plateau-patella angle. Considering the normal range of each of the methods, the percentage change was 22%, 18% and 34%, respectively. But only the plateau-patella angle method showed significance when compared to the others, showing that the method has a greater change after tibial high osteotomy as compared to...
conventional methods. This difference was also observed in the qualitative evaluation, in which we observed a change of 46.2% on the preoperative ratings as compared to postoperative by the plateau-patella angle. Another change observed after medial opening osteotomy in the study was the increase of tibial slope. Theoretically, the tibial slope should not be changed with this type of osteotomy, unless the surgeon seeks to protect the Anterior Cruciate Ligament or Posterior Cruciate Ligament with slight slope variations. But this finding is not uncommon, being one of the most prevalent technical errors, and the surgeon should always pay attention to gross changes that may generate significant mechanical changes in the knee.

When we associate these two postoperative changes, alteration of the plateau-patella angle and the change of the tibial slope, we found a significant correlation of -0.67. Thus, we found that the slope increase after the osteotomy has a significant correlation with the reduction of the plateau-patellar angle. Therefore, although the plateau-patella method follows the same trend of reduction of patellar height methods of Caton-Deschamps and Blackburne-Pell, perhaps this one overestimates this reduction, due to changes in tibial slope after osteotomy.

In evaluating the correlation coefficients, all methods achieved a quite satisfactory intra-observer correlation. Regarding the inter-observer correlation, the Blackburne-Peel\(^1\) method had the worst coefficient (0.54), while the plateau-patella angle obtained a 0.67 index, quite similar to that achieved by Caton-Deschamps method that best correlated between observers, with a coefficient of 0.72. These values demonstrate an adequate reproducibility of the method, probably due to its simple implementation.

The small number of patients included in the study is an important limitation of this study, mainly caused by the need of perfect radiographs for the application of the four methods studied. Future prospective studies with more rigorous x-rays, with a larger number of patients, may bring new information.

**CONCLUSION**

We conclude that for patients undergoing high tibial osteotomy, the plateau-patella angle method undergoes changes that alter the tibial slope, with major changes after osteotomy when compared to conventional methods used to assess patellar height. Therefore, its use in patients undergoing this type of procedure can overestimate the reduction of patellar height.

**AUTHORS’ CONTRIBUTION:** MBB (0000-0002-4468-9693)* and JAPT (0000-0001-8347-6415)* were the main contributors to drafting the manuscript. CPH (0000-0003-1139-2524)*, RGG (0000-0002-1715-4343)* and MKD (0000-0003-1999-9478)* performed the surgeries, followed up the patients and collected clinical data. MBB, JAPT and VFM (0000-0002-4899-9242)* assessed data from statistical analysis and performed bibliographic search. RG and MKD contributed with the intellectual concept of the study and reviewed the manuscript. *ORCID (Open Research and Contributor ID).

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