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Original Article

Comparative evaluation of patellar height methods in the Brazilian population☆

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ABSTRACT

Objective: The methods most used for patellar height measurement were compared with the plateau–patella angle method.

Methods: A cross-sectional study was conducted, in which lateral-view radiographs of the knee were evaluated using the three methods already established in the literature: Insall–Salvati (IS), Blackburne–Peel (BP) and Caton–Deschamps (CD). These were compared with the plateau–patella angle method. One hundred and ninety-six randomly selected patients were included in the sample.

Results: The data were initially evaluated using the chi-square test. This analysis was deemed to be positive with $p < 0.0001$. We compared the traditional methods with the plateau–patella angle measurement, using Fisher's exact test. In comparing the IS index with the plateau–patella angle, we did not find any statistically significant differences in relation to the proportion of altered cases between the two groups. The traditional methods were compared with the plateau–patella angle with regard to the proportions of cases of high and low patella, by means of Fisher's exact test. This analysis showed that the plateau–patella angle identified fewer cases of high patella than did the IS, BP and CD methods, but more cases of low patella. In comparing pairs, we found that the IS and CD indices were capable of identifying more cases of high patella than was the plateau–patella angle. In relation to the cases of low patella, the plateau–patella angle was capable of identifying more cases than were the other three methods.

Conclusions: The plateau–patella angle found more patients with low patella than did the classical methods and showed results that diverged from those of the other indices studied.

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Avaliação comparativa de métodos da altura patelar na população brasileira

Palavras-chave:
Patela
Radiologia
Joelho

R E S U M O

Objetivo: Comparar os métodos mais usados de medida da altura patelar, com o método do ângulo platô-patela.

Métodos: Foi feito um estudo transversal no qual foram avaliadas radiografias em perfil do joelho, com os três métodos já consagrados pela literatura, o Insall-Salvati (IS), o Blackburne-Peel (BP) e o Caton-Deschamps (CD) e comparando-as com o ângulo platô-patela (APP). Foram incluídos na amostra 196 seis pacientes, aleatoriamente selecionados.

Resultados: Inicialmente os dados foram submetidos a uma avaliação pelo teste do qui-quadrado. A análise foi positiva com $p < 0{,}0001$. Fizemos comparações entre os métodos tradicionais com a medida do APP com o uso do teste exato de Fisher. Quando comparamos o índice de IS com o APP, não encontramos diferenças estatisticamente significativas em relação à proporção de casos alterados entre os dois grupos. Os métodos tradicionais foram comparados com a medida do APP quanto à proporção de casos de patela alta e baixa pelo teste exato de Fisher. A análise demonstrou que o APP identificou menos casos de patela alta do que os métodos de IS, BP e CD, mas identificou mais casos de patela baixa. Quando comparados os pares, verificamos que os índices de IS e CD foram capazes de identificar mais casos de patela alta que o APP. Em relação aos casos de patela baixa, o APP foi capaz de identificar mais casos que os outros três métodos.

Conclusão: O ângulo platô-patela observou mais pacientes com patela baixa em comparação com os métodos clássicos e resultados discrepantes com os outros índices estudados.

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Introduction

Patellar height measurement is increasingly being used as knowledge of knee biomechanics and the physiopathology of knee diseases and their respective treatments expands.[1]

Over the course of time, a variety of methods have been proposed as means of defining the concept of patellar knee measurement, usually through ratios between anatomical parameters obtained from radiographic examinations. Several indexes have become established in the literature, such as Insall–Salvati (IS),[2] Blackburne–Peel (BP)[3] and Caton–Deschamps (CD),[4] but none of them have yet achieved worldwide acceptance.

The plateau–patella angle is an optional method for evaluating patellar height that, unlike the methods established in the literature, does not use calculation of ratios and supplies whole-number values. It is therefore simpler, faster and more practical.[5]

The objective of this study was to compare the methods most used for measuring patellar height[2–4] with the plateau–patella angle method.[5]

Materials and methods

This study was assessed and approved by our institution's ethics committee.

A cross-sectional study was conducted in which radiographs produced at the National Institute of Traumatology and Orthopedics (INTO) were evaluated using the three methods that have become established in the literature: Insall–Salvati (IS),[2] Blackburne–Peel (BP)[3] and Caton–Deschamps (CD).[4] These were compared with the plateau–patella angle.[5]

The sample comprised 196 patients at the Knee Surgery Center of the National Institute of Traumatology and Orthopedics, who were randomly selected. The patients included in the study had undergone knee radiography between January 2013 and April 2014, consisting at least of the anteroposterior (AP) view under weight-bearing at full knee extension and in lateral view without weight-bearing in a semiflexed position (30°). Patients with osteoarthrosis or inflammatory arthritis and those who had had previous fractures or surgery were excluded from the study.

All the patients underwent radiographic examinations in accordance with the routine established by our institution. A Shimatzu 500 mA X-ray machine was used, at 50 kV and 25 mA. A film of dimensions 30 cm × 40 cm was placed at a distance of one meter from the ampoule of the digital radiographic machine. The images for this study were then obtained.

The radiographs were evaluated by a physician who is a member of the Brazilian Society of Knee Surgery and has a doctoral degree, in order to ensure the reproducibility and reliability of the measurements obtained. These evaluations were made through the MDViewer2000® software, which enables precise digital measurements in relation to anatomical parameters that are easily identifiable and have previously been established in the literature, and minimizes the evaluator's influence in obtaining the measurements.

The Insall–Salvati index consists of the tendon length/patellar length ratio (TL/PL), in which TL is the length of the patellar tendon measured along its posterior surface or the depth from its origin at the lower pole of the

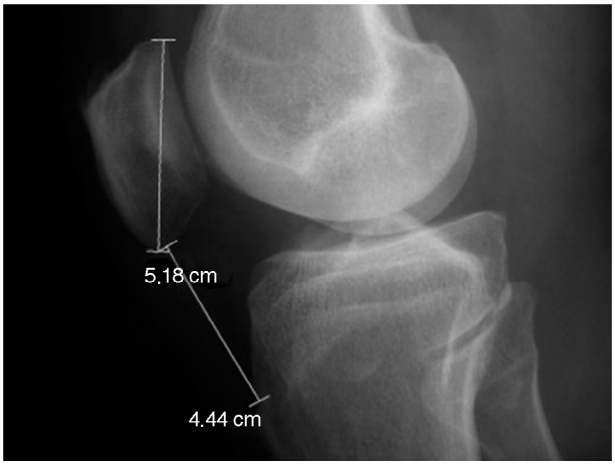

Fig. 1 – Lateral-view radiograph of the knee. Insall–Salvati calculation.

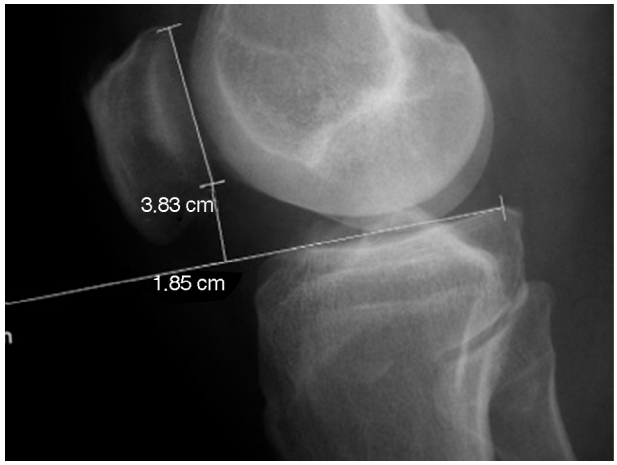

Fig. 2 – Lateral-view radiograph of the knee. Blackburne–Peel calculation.

patella to its insertion in the tibial tubercle, and PL is the greatest diagonal length of the patella. Normal values range from 0.8 to 1.2.[2]

The Blackburne–Peel index[3] consists of the ratio *H*/*B*, in which *H* is the perpendicular height from the distal part of the joint surface of the patella to a line projected anteriorly from the surface of the tibial plateau and *B* is the length of the joint surface of the patella. The values that are considered to be normal range from 0.54 to 1.06.

The Caton–Deschamps index consists of the ratio TJ/PJ, in which TJ is the distance from the lower edge of the joint surface of the patella to the anterosuperior angle of the tibia and PJ is the length of the patellar joint surface. The patellar height is considered to be normal with values ranging from 0.6 to 1.2.[4]

The plateau–patella angle, i.e. the parameter in question here, is formed by a line that is tangential to the medial tibial plateau and a second line that connects the lower edge of the tibial plateau to the lower margin of the patellar joint surface, on lateral-view radiographs with the knee flexed at 30°. The angular values that are considered to be normal range from 21° to 29°. Values lower than 21° define a low patella, while values greater than 29° indicate a high patella.[5]

Measurements of the three indexes: Insall–Salvati (IS)[2] (Fig. 1), Blackburne–Peel (BP)[3] (Fig. 2) and Caton–Deschamps (CD)[4] (Fig. 3), were made on each of the radiographs selected, along with the plateau–patellar angle[5] (Fig. 4).

The data were tabulated in a Microsoft Excel spreadsheet for analysis and were then presented in the form of mean + standard deviation. Findings with *p* values less than or equal to 0.05 were considered to be significant. The statistical analysis was performed using the chi-square and Fisher exact tests, in the GraphPad 5 software for Windows.

Results

A total of 196 radiographs of patients at the Knee Surgery Center of INTO who were being followed up between January 2013 and April 2014 were included in this study, taking the inclusion and exclusion criteria into consideration.

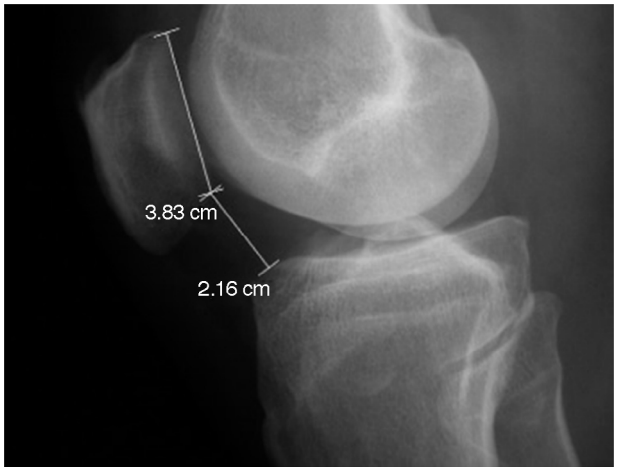

Fig. 3 – Lateral-view radiograph of the knee. Caton–Deschamps calculation.

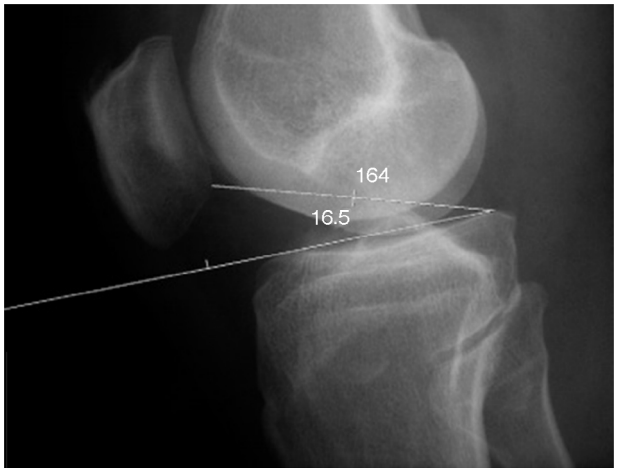

Fig. 4 – Lateral-view radiograph of the knee. Plateau-patella angle.

Table 1 – Distribution of high patella according to the different methods.

	Insall–Salvati (IS)	Blackburne–Peel (BP)	Caton–Deschamps (CD)	Plateau–patellar angle (PPA)
High patella	24	13	23	6
Low patella	8	2	0	33
Normal patella	164	181	173	157

Measurements of the patellar height indices were made on these radiographs, and the cases were then classified as normal, high or low, in accordance with the criteria described previously in the literature.

Table 1 summarizes the distribution of patellar heights according to the methods evaluated.

The data were firstly subjected to evaluation using the chi-square test, in order to ascertain whether data pairs with statistical significance existed within the sample. This analysis was positive, with $p < 0.0001$.

The data were then grouped as altered, referring to the sum of cases of low and high patella, and as cases considered to be non-altered. Table 2 summarizes the results from this analysis.

Once again, an overall analysis was performed, in order to identify significant data pairs, which showed $p < 0.0029$.

From this analysis, comparisons were made between the traditional methods and plateau–patellar angle measurements, using Fisher's exact test.

In comparing the Insall–Salvati (IS) index with the plateau–patellar angle (PPA), we did not find any statistically significant differences in relation to the proportions of altered cases in the two groups (IS 164 vs. PPA 157, p = NS). However, the PPA was capable of identifying more altered cases than were the Blackburne–Peel and Caton–Deschamps indexes, respectively (PPA 39 vs. BP 15, $p = 0.0006$; and PPA 39 vs. CD 23, $p = 0.0373$).

The data were also compared with regard only to identification of cases of high and low patella, as summarized in Table 3.

The traditional methods were compared with the plateau-plate angle measurements regarding the proportions of cases of high and low patella, using Fisher's exact test.

The analysis showed that the PPA identified fewer cases of high patella than did the IS, BP and CD methods (PPA 6 vs. IS 24, BP 13 and CD 23; $p < 0.0001$), but identified more cases of low patella (PPA 33 vs. IS 8, BP 2 and CD 0; $p \leq 0.0001$).

Table 2 – Distribution of the altered and normal cases according to the different methods.

	IS	BP	CD	PPA
Altered	32	15	23	39
Non-altered	164	181	173	157

Table 3 – Distribution of the altered cases according to the diagnoses of high and low patella.

	IS	BP	CD	PPA
High patella	24	13	23	6
Low patella	8	2	0	33

Table 4 – Distribution of the cases of high patella and normal patellar height.

	IS	BP	CD	PPA
High patella	24	13	23	6
Normal patellar height	164	181	173	157

Table 5 – Distribution of the cases of low patella and normal patellar height.

	IS	BP	CD	PPA
Low patella	8	2	0	33
Normal patellar height	164	181	173	157

Lastly, comparisons between the proportions of cases of normal patellar height and those of high patella (Table 4) and low patella (Table 5) were made.

In comparing the pairs, we found that the Insall–Salvati and Caton–Deschamps indexes were capable of identifying more cases of high patella than was the plateau–patellar angle (IS 24 vs. PPA 6, $p = 0.0034$; and CD 23 vs. PPA 6, $p = 0.059$).

In relation to the cases of low patella, the plateau–patellar angle was capable of identifying more cases than were the other three methods (PPA 33 vs. IS 8, $p = 0.0001$; PPA 33 vs. BP 2, $p < 0.0001$; and PPA 33 vs. CD 0, $p < 0.0001$). Furthermore, the Insall–Salvati index identified a higher proportion of cases of low patella than did the Caton–Deschamps index (IS 8 vs. CD 0, $p = 0.0035$).

Discussion

The lack of an ideal method for measuring patellar height has made this a relevant and pertinent topic. Analysis on patellar height is of fundamental importance for patients with patellofemoral complaints, and after operations involving knee arthroplasty, reconstruction of the anterior cruciate ligament or proximal tibial osteotomy. For this reason, there is a need for studies that attempt to validate a simple and reproducible measurement method. Portner and Pakzad[5] reported that because the plateau and patella generate an angle in which the normal range is between 21° and 29°, this presents an advantage in measurements, in comparison with the classical indexes. These traditional methods generate measurements that necessitate calculations of proportions.[5]

Our investigation was conducted using digital radiographs, on the basis of the study by Gracitelli et al.[1] According to these authors, use of digital radiographs is becoming ever more widely disseminated. Moreover, the advantages of this radiography system in relation to the conventional technique are its speed and precision, the elimination of printing and its associated costs and the ease of image display.[1] In our opinion, the most important point that these authors cited is that the x-ray

doses required for digital radiography are lower: the dose is adjusted so that the image has an appropriate signal-to-noise ratio and the radiation absorbed by the patient is diminished.[1] Our thinking is that with digital images, the measurements of the anatomical points through the software become more precise.

In our study, we used lateral-view radiographs with the knee flexed at 30°, without weight-bearing, because this is a standardized examination in our hospital and in order to reproduce the original description of the plateau–patellar angle. Insall–Salvati[2] reported that if the knee was positioned with flexion of 20°, this would generate tension in the patellar tendon. Our thinking is in line with their statement, since we believe that radiographs produced under weight-bearing conditions, even with the knee flexed, may give rise to imprecise positioning of the patella. Seyahi et al.[6] drew attention to the importance of the degree of knee flexion in producing radiographs and subsequent measurements. In their study, several radiographs were excluded due to inadequate flexion.[6] For this reason, the radiographs used in our study were all produced by a single radiology technician, in order to attempt to reduce the bias.

Ellington et al.[7] validated the PPA in comparison with the classical indexes, in patients with knee osteoarthrosis. In our study, we chose to exclude these patients, since infrapatellar osteophytes and those in the in the anterior region of the tibial joint surface might have generated incorrect measurements.

In a study conducted in Brazil by Gracitelli et al.,[1] in which patellar height measurements were compared, it was observed that the observer's experience had an influence in analyses on the reproducibility of the measurements. Thus, we used an observed with great experience in using these patellar indexes and also we did not stipulate a response time, in order to attempt to reproduce the evaluations with greater precision. Seil et al.[8] stated that patellar height classification was extremely dependent on the examiner, and we corroborate and back this point of view. For this reason, we did not conduct any interobserver analysis, in order to attempt to validate the PPA method in relation to the classical methods.

In a study on the patellar height index, Seyahi et al.[6] found poor concordance and weak correlation in comparing the measurements. In our study, we observed a discrepant number of patients with low patella when we used the plateau–patellar angle. Seil et al.[8] reported that the results between the different indexes were contradictory and that the classification of high patella would depend on the method chosen. Seyahi et al.[6] stated that the methods evaluated in other studies had been consistent but that their accuracy had not been informed. Ellington et al.[7] concluded that further studies on the plateau and patella needed to be conducted and that the clinical significance of findings of high or low patella needed to be correlated with these measurements, with investigation of how these measurements related to the classical methods. In this regard, we observed that this topic required further exploration. Future studies should be developed with the aim of generalizing an existing measurement method for high patella, or perhaps with the aim of creating a new index.

We consider that the strong point of our study was the fact that this was the first to make an evaluation of the plateau–patellar angle among Brazilians. The Brazilian population presents great miscegenation, such that it is important to ascertain variations in indexes that are peculiar to our population.

According to Pena,[9] with the miscegenation of the Brazilian population, the term "race" ought to be banned from our dictionary. It was noted in this author's study that the proportion of African ancestry among whites in southeastern Brazil was 32%, while the proportion of European ancestry among blacks in the same region reached 49%.[9] Because of this, our study becomes relevant, since the values of our indexes may not be reproducible, in comparison with other populations.

In our study, there was no intention to make clinical correlations between different patellar height assessment methods. Felicio et al.[10] demonstrated recently that patellar height was not associated with patellofemoral pain syndrome. Thus, our objective was only to make comparisons between the methods traditionally used and the plateau–patellar angle.

Conclusion

Through the plateau–patellar angle method, more patients with low patella were observed than when the classical methods were used. It produced results that were discrepant with those from the other indexes studied.

Conflicts of interest

The authors declare no conflicts of interest.

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