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Original Article

Comparison of five patellar height measurement methods in a Turkish adult cohort

Sercan Capkin, Serkan Guler, Erdem Aras Sezgin

Department of Orthopaedics and Traumatology, Faculty of Medicine, Aksaray Training and Research Hospital, Aksaray University, Aksaray, Turkey

Abstract

Aim: The aim of this study was to investigate the correlation between the methods traditionally used for patellar height measurements [Insall-Salvati (IS), Modified Insall-Salvati (MIS), Blackburne-Peel (BP), Caton-Deschamps (CD)] and the plateau-patellar angle (PPA) in Turkish adult population.

Material and Methods: A cross-sectional retrospective study was conducted. A total of 100 lateral knee radiographs in 30° flexion were analyzed by two blinded orthopedist independently to each other's measurements. The average IS ratio, MIS ratio, BP ratio, CD ratio and PPA measurement were calculated by taking the average of the measurement values of both observers. The inter-observer reliability for two observers was determined using intraclass correlation coefficients (ICC). Spearman rank correlation analysis was performed to analyze correlations between mean ratios/angle measurements.

Results: The mean age at the time of the radiographs was 30.18 ± 5.78 (range:20-40) years, 60% were female, and 58 radiographs were of the right knee. The mean and standard deviations of the patella height measurements were found 1.05 ± 0.12 according to the IS ratio; 1.66 ± 0.29 according to the MIS ratio; 0.91 ± 0.15 according to the CD ratio; 0.84 ± 0.14 according to the BP ratio; 24.74° ± 2.87° according to PPA measurement. There was highest inter-observer agreement between the two observers with an ICC of 0.926 (95% confidence interval: 0.89-0.950), excellent reliability, for the PPA measurement. Inter-observer agreement between two observers was good reliability for other measurements (IS, MIS, CD, BP). The highest correlation was between CD ratio and BP ratio, strong correlation, with a Pearson's correlation coefficient of 0.790.

Conclusion: The PPA appears to be a feasible tool that can assess patellar height with higher reliability compared to the four most commonly used methods, in a Turkish adult population.

Keywords: Measurements; patellar height; radiographs; ratio; reliability

INTRODUCTION

Patellar height measurement has become more popular in recent years concomitant to increasing knowledge on patellofemoral biomechanics, the physiopathology of knee alignment and their respective treatments (1). Patella alta is considered a predisposing factor for the development of patellofemoral pain (2,3). On the other hand, patella baja is an important consideration when performing total or unicondylar knee arthroplasty, as improper technique may cause patella baja which leads to worse outcome (4-6). Various methods have been described for patellar height assessment on radiographs. Many of these methods have been proven to be too complex to be adopted in clinical routine and few have been shown to be significantly more popular. Methods that rely on indirect assessment which relate the position of the patella to the tibia, such as, Insall-Salvati (IS), modified Insall-Salvati (MIS), Blackburne-Peel (BP) and Caton-Deschamps (CD) are more commonly used (7-10). In addition, a recent technique described by Portner and Pakzad in 2011, the plateau-patella angle (PPA) is increasing in popularity. It requires no calculation and is independent of radiographic magnification, knee size, and degree of flexion (11). However, despite the recent studies on comparisons of reproducibility and interobserver and intraobserver variability between indirect methods, none can be perceived as the gold standard (1). Thus, we aimed to determine the consistency and variability between indices commonly used for patellar height measurements (IS, MIS, BP, CD) and the PPA in a Turkish adult population.

MATERIAL and METHODS

This research was conducted in accordance with the 1964 Helsinki declaration and its later amendments. The study was approved by the Institutional Review Board (IRB).

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Corresponding Author: Sercan Capkin, Aksaray University, Faculty of Medicine, Aksaray Training and Research Hospital, Department of Orthopaedics and Traumatology, Aksaray, Turkey **E-mail:** sercancapkn@gmail.com

Given the retrospective design, an informed consent was not deemed necessary.

After approval from the IRB, a retrospective review was performed on the lateral radiographs of all patients with knee pain admitted to our outpatient clinic to knee pain between October and December 2019. Patients between 20 and 40 years old, with non-weight-bearing lateral knee radiographs taken in 30° flexion were included in the study. Patients were excluded in presence of; osteoarthritis or inflammatory arthritis, history of fracture or surgery, technically inadequate lateral knee radiographs with an excessively rotated knee where the joint line cannot be visualized or where knee flexion was less than 30°. Out of 312 records in the database, 212 were excluded due to the aforementioned criteria. A total of 100 radiographs were analyzed by two orthopedic surgeons independently, blinded to each other's measurements.

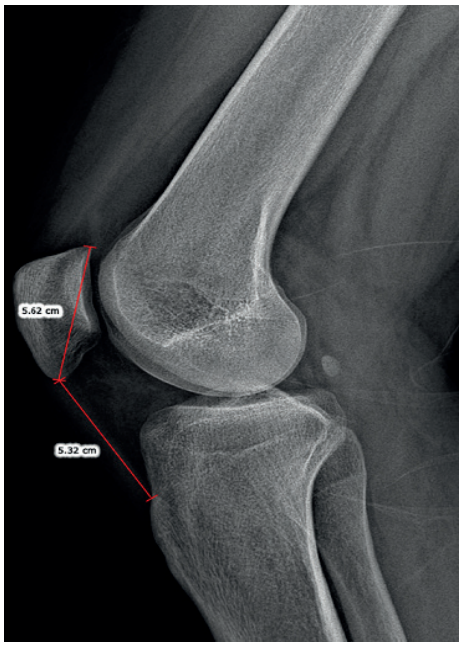

Figure 1. The Insall–Salvati ratio is defined as the length of the patellar tendon divided by the diagonal length of the patella. The patellar height of this knee (5.32 cm ÷ 5.62 cm= 0.95) would be within the normal limits. Normal range has been defined as 0.8–1.2

Each observer measured and/or calculated IS ratio (Figure 1), MIS ratio (Figure 2), CD ratio (Figure 3), BP ratio (Figure 4), and the PPA (Figure 5). All measurements were done according to their original description. The IS ratio consists of ratio of the length of the patellar tendon (measured from the distal pole of the patella to the tibial tuberosity) to the maximum length of the patella (measured from the distal pole to the proximal pole of the patella). Normal values range from 0.8 to 1.2 (7). The MIS ratio consists of ratio of the distance between the distal pole of the patellar articular surface and the tibial tuberosity to the articular surface length of the patella. The ratio higher than 2 indicate a patella alta (8). The BP ratio consists of the ratio of the height of the distal pole

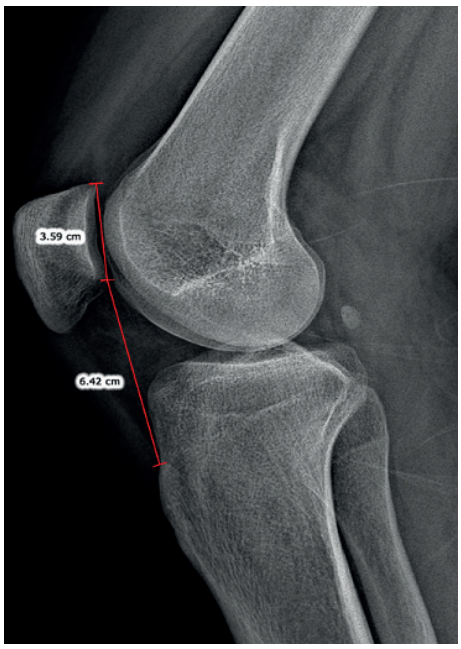

Figure 2. The Modified Insall–Salvati ratio is defined as the distance between the lower end of the articular surface of the patella and patellar tendon insertion in the tibial tubercle divided by the length of the articular surface of the patella. The patellar height of this knee was 6.42 cm ÷ 3.29 cm= 1.95. No values or ranges are available for patella baja. A ratio higher than 2 indicates patella alta

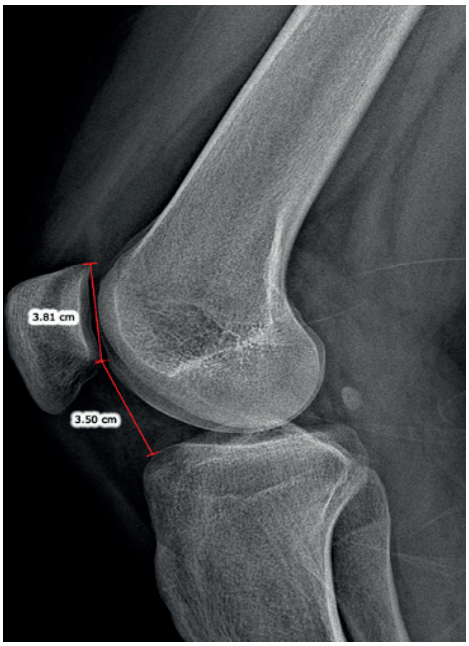

Figure 3. The Caton–Deschamps index is defined as the distance between the lower end of the articular surface of the patella and the anterosuperior corner of the tibia divided by the length of the articular surface of the patella. The patellar height of this knee (3.50 cm ÷ 3.29 cm = 1.06) would be characterized as within normal limits. Normal range has been defined as 0.6 to 1.2

of the patellar articular surface above a tibial plateau line to the articular surface length of the patella. Normal values range from 0.54 to 1.06 (9). The CD ratio consists of the ratio of the distance between the anterosuperior

point of the tibial plateau and the distal pole of the patellar articular surface to the articular surface length of the patella. Normal values range from 0.6 to 1.2 (10). The PPA was measured 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. Normal angular values range from 21°to 29° (11).

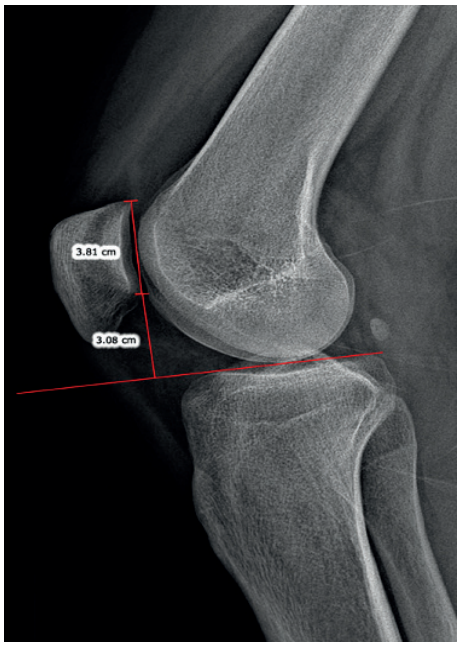

Figure 4. The Blackburne–Peel ratio is defined as the perpendicular height from the anterosuperior corner of the tibia to the inferior aspect of the patellar articular surface divided by the length of the articular surface of the patella. The patellar height of this knee (3.08 cm ÷ 3.29 cm = 0.94) would be characterized as within normal limits. Normal range has been defined as 0.54–1.06

Statistical Analyses

Statistical analyses were performed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics are presented as means, standard deviations, minimum/maximum values and percentages. Mean IS ratio, MIS ratio, BP ratio, CD ratio and PPA were calculated using measurements from each observer. The inter-observer reliability for two observers was determined using intraclass correlation coefficients (ICC). Scores were interpreted as follows: a score of 0–0.50 indicated poor reliability, 0.50–0.75 indicated moderate reliability, a score of 0.75–0.90 indicated good reliability, and a score higher than 0.90 indicated excellent reliability (12). Spearman rank correlation analysis was performed to analyze correlations between mean ratios/angle measurements. It was considered an excellent correlation if greater than 0.9, strong if between 0.7 and 0.9, moderate if between 0.5 and 0.7 and weak if less than 0.5. All tests were two-sided, and p-values of less than 0.05 were considered statistically significant. The most important results are shown in the accompanying tables.

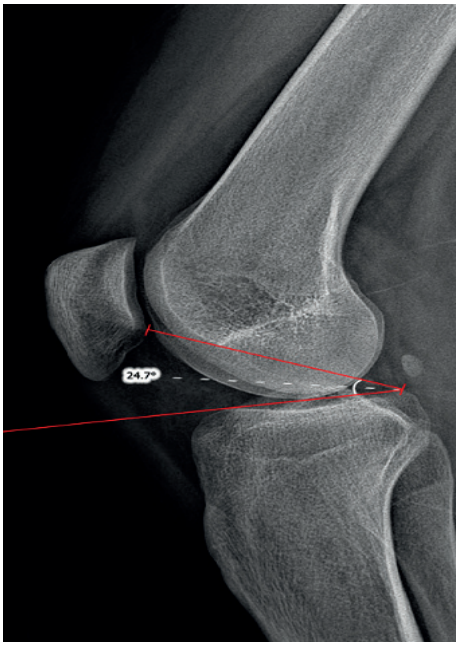

Figure 5. The Plateau- patella angle is measured by a line that is tangential to the medial tibial plateau and a second line that connects the lower edge of the tibial plateau to the lower margin of the patellar joint surface. The PPA in this knee is 24.7° would be characterized as within normal limits. Normal range has been defined as 21°-29°

RESULTS

Of 100 included patients, mean age at the time of the radiographs was 30.18 ± 5.78 (range: 20-40) years. Sixty of the patients were female, and 58 radiographs were of the right knee. Patellar height measurements and calculations are presented in Table 1.

Table 1. Results of five patellar measurement methods

Index/angle	Observer 1	Observer 2	Mean
Insall-Salvati	1.04 ± 0.13	1.06 ± 0.16	1.05 ± 0.12
Modified Insall-Salvati	1.57 ± 0.35	1.75 ± 0.30	1.66 ± 0.29
Caton-Deschamps	0.96 ± 0.16	0.86 ± 0.18	0.91 ± 0.15
Blackburne-Peel	0.84 ± 0.15	0.83 ± 0.15	0.84 ± 0.14
Plateau-patella angle	25.29 ± 2.97	24.20 ± 2.98	24.74 ± 2.87

Table 2. The inter-observer reliability of patellar height measurements

Index/angle	ICC	95% CI	P value
Insall-Salvati	0.897	0.847-0.931	<0.01
Modified Insall-Salvati	0.75	0.628-0.832	<0.01
Caton-Deschamps	0.805	0.710-0.869	<0.01
Blackburne-Peel	0.719	0.583-0.811	<0.01
Plateau-patella angle	0.926	0.890-0.950	<0.01

ICC: Intra-Class Correlation Coefficient; CI: Confidence Interval

Excellent inter-observer reliability was shown with an ICC of 0.926 (95% confidence interval: 0.89-0.950), for the PPA. For other measurements (IS, MIS, CD, BP), inter-observer reliability was good (Table 2). Correlation between patellar height measurement techniques are presented in Table 3. The highest correlation was observed between CD ratio and BP ratio, with a Pearson's correlation coefficient of 0.790 which translates to a strong correlation.

Table 3. Statistical relationships between different patellar height measurement methods

Pearson correlation	IS	MIS	CD	BP	PPA
IS	1.000	.627*	.557*	.535*	.565*
MIS	.627*	1.000	.647*	.626*	.580*
CD	.557*	.647*	1.000	.790*	.615*
BP	.535*	.626*	.790*	1.000	.722*
PPA	.565*	.580*	.615*	.722*	1.000

*Correlation is significant at the 0.01 level (2-tailed)
IS: Insall-Salvati; MIS: Modified Insall-Salvati; CD: Caton-Deschamps; BP: Blackburne-Peel; PPA: Plateau-Patella Angle

DISCUSSION

In all our measurements in the Turkish adult population we found similar values to other studies in the literature (13-15). In addition, IS ratio showed good reliability which was superior compared to other ratios; however, only PPA had an excellent level of reliability. Amongst the 4 ratios, IS having the highest inter-observer reliability with an ICC of 0.897, is in concordance with other studies on patellar height measurement techniques using routine radiographs (15-19). The superior reliability of the IS might be explained by the patellar and tibial landmarks used by the ratio (16). Superior and inferior patellar pole, as used by IS, are easy to identify on plain radiographs. On the other hand, the inferior ridge of the patellar articular surface as used by the MIS, BP and CD is more difficult to determine than the inferior patellar pole. It is not always clear where the articular surface starts and ends distally (15-20).

All classic patellar height indices require two measurements and calculation of a ratio, while the PPA requires only one measurement (11). Furthermore, in a study evaluating patellar height measurement techniques in knees with osteoarthritis, it was stated that no experience is required for measuring the PPA (20). Similar to the original article published by Portner and Pakzad, we found an average PPA of a 24.74° ± 2.87° with an ICC of 0.926 (11). Gracitelli et al., conducted a study to investigate the observer experience of the most commonly used methods (IS, MIS, BP, CD) for patellar height measurement (21). They found that the observer's experience was shown to be important, given that the two more experienced examiners presented higher correlation coefficients. In our study, measurements were made by two experienced orthopedic surgeons.

In a study from Turkey by Seyahi et al., the correlation between the Blumensaat method and patellar height ratios (IS, MIS and BP), and the reliability of each method in patellar height measurement were evaluated (22). They found that the Blumensaat method had a low agreement with widely used patellar height indices. In their study, means and standard deviations of the patellar indices were found 1.12 ± 0.17 according to the IS method; 1.92 ± 0.19 according to the MIS method; and 0.93 ± 0.18 according to the BP method, and correlation analysis of these patellar height indices revealed weak correlations in which the relatively best (moderate) correlation was between MIS and BP methods. In contrast, we have shown a strong correlation between CD ratio and BP ratio with a Pearson's correlation coefficient of 0.790, closely followed by BP and PPA with 0.722. We found a moderate correlation between the rest of the pairs.

We recognize the limitations of our study. We had to exclude 212 of 312 (68%) of radiographs due to not being perfect lateral views which led to a limited number of radiographs to be evaluated. Although our radiology department was committed to take the lateral knee radiographs routinely at 30 degrees of flexion, we found that the majority of them were taken at a flexion ranging from 15 to 60 degrees. It has been reported in the literature that the degree of knee flexion in lateral radiographs affects the patellar measurement methods (8, 22, 23); however, a recent study suggested the contrary (24). Perhaps a larger margin would have been acceptable but we believe there is no strong evidence on this subject yet.

CONCLUSION

Our results from the first Turkish cohort in the literature, has shown a moderate to strong correlation between the five most widely used methods for patellar height measurement; highest being between CD-BP and PPA-BP. We found the reliability of PPA was markedly superior compared to other methods.

Competing interests: The authors declare that they have no competing interest.
Financial Disclosure: There are no financial supports.
Ethical approval: This study was approved by the Institutional Ethics Committee and conducted in compliance with the ethical principles according to the Declaration of Helsinki.

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