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Normal reference values of Caton Deschamp ratio in knee joint for patellar height in Indian population

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ABSTRACT

Background: The patella, which is located in the quadriceps tendon, is the biggest sesamoid bone in humans. The most essential factor in determining patellar stability is patellar height. Hence, various ratios were created to determine the normal values of height of patella. Squatting position is commonly used practise in Indian population. The aim of our study was to ascertain the normal reference values of the Caton Deschamp ratio in the Indian population and to find if any significant difference exists for Indian population as compared to Caucasian population, which can be used as a baseline for reporting patella alta and patella baja. **Methods:** This was retrospective research that used 200 normal lateral radiographs of Indian knee joints. Visualization of the tibial insertion is better in 30° flexion of knee. The Caton Deschamp ratios were calculated. **Results:** The mean Caton Deschamp ratio for Indian population is 0.80 ± 0.21 which in comparison to the Caucasian values (patella baja: <0.5 , normal: 0.8 , patella alta: >1.0) were similar ($P > 0.05$). **Conclusion:** No statistically significant difference was found between the normal reference values of Caton Deschamp ratios among different human races and hence these values can be used for restoring knee kinematics in diseased states irrespective of the race.

Keywords: Caton Deschamp ratio, Knee joint, Patella alta, Patella baja, Patellar height

1. INTRODUCTION

The patella, also known as knee cap, is a small bone located anteriorly in the knee. It is embedded in the quadriceps muscle tendon, which is the large muscle group that runs along the anterior aspect of the thigh and is responsible for extending the knee. When the contraction of quadriceps muscle occurs, it pulls the tendon of the patella, which in turn pulls the patella, causing it to move upwards. Patellar height is a crucial structural parameter (Upadhyay et al., 2013). Radiographically measuring height of the patella can be done using variety of techniques (Ryan et al., 2021).

The earliest and widely used radiographic method for determining height of patella was described by Insall and Salvati, (1971) who calculated the IS ratio which includes patellar tendon length along with length of the patella. However, studies have shown that this method has limitations and is liable to both intra and interobserver variability, which can affect the precision and reliability of the measurements (Insall and Salvati, 1971). A radiographic measurement called the Caton Deschamp ratio is used to determine the location of patella with respect to the knee. It is calculated by dividing the patellar length by the distance between the patella's bottom edge and the top edge of the tibial plateau. The resulting index provides patellar height measurement.

The CD ratio is seen to provide a more practical measure of patellar height than other techniques like the IS ratio. This is important because patellar height can affect the physiological function of knee joint and lead to the development of certain knee disorders, such as patello-femoral pain syndrome (Thevenin-Lemoine et al., 2011). MRI and radiography both can be used to measure the CD ratio. It's a common practise to obtain lateral radiographs of knee joint with the knee to be imaged kept in a flexed position at 30° when the patient is bearing weight (Charles et al., 2013).

Squatting and sitting cross-legged are frequent behaviours in Indian culture (Upadhyay et al., 2013). Caton Deschamp ratio which is most often used is usually limited to chair bound western ethnicity and may not be applied to others like Indian population. Therefore, the current study was undertaken to develop reliable reference values of Caton Deschamp ratio in the Indian population as well as to determine whether there is a substantial difference between the reference values in Western population and Indian population.

2. MATERIAL AND METHODS

Data collection

Present is a retrospective study in the department of Radiodiagnosis of a tertiary care hospital in central India, in the year 2021-2022. The study duration was from September 2021 and February 2022. 200 subjects with age ranging from 18-60 years were assessed.

Inclusion criteria

All subjects with age of 18-60 years, who had no lower limb trauma, underlying knee pathology or pain in the knee during walking and/or squatting.

Exclusion criteria

Patients with previous knee surgery, underlying pathology of knee, pain in knee while walking and/or squatting and distal limb injury.



Figure 1 Positioning for Radiograph of knee joint

Methods of measurement and Statistical Analysis

Siemens 600 mA X-ray machine was used to obtain lateral X-ray of knee in fixed flexion of 30°. The opposite limb was extended and placed behind or above the knee being examined (Figure 1). Visualization of the tibial insertion is better in 30° flexion of knee. Knee radiograph was performed with 60-70 kVp and 10-12 mAs. Central ray was focused at a distance of 15-20 mm distal to medial femoral epicondyle.

The 2019 Microsoft Excel Analysis application was used to process the data. In order to compute CD ratio, the length of the PAS and the distance between inferior margin of patella and tibial plateau were measured (Figure 2).



Figure 2 Calculating Caton Deschamp ratio on lateral X-ray of knee joint. Ratio was calculated to be: $3.30/3.33 = 1.0$



Figure 3 Calculating Caton Deschamp ratio on lateral X-ray of knee joint. Ratio was calculated to be: $3.4/3.4 = 1.0$



Figure 4 Calculating Caton Deschamp ratio on lateral X-ray of knee joint. Ratio was calculated to be: $3.3/3.3 = 1.0$

3. RESULTS

The study included 86 males and 114 females. The demographic details of participants are in (Table 1). All the results were presented as mean and as standard deviation (SD). The calculated ratio was deemed acceptable if it was within 30% of the 95% confidence interval. For the level of significance, a p value of 0.05 was used. The mean values of Caton Deschamp ratio as described were 0.8 ± 0.21 . The p value calculated was >0.05 .

Table 1 Gender distribution of subjects

Variables (n=100)	N	%
Gender		
Male	86	86
Female	114	114

Table 2 Number of subjects for different ranges of Caton Deschamp ratio

RANGE	N
<0.6	11
0.6-0.8	118
0.8-1.0	50
1.0-1.2	16
>1.2	05

4. DISCUSSION

A crucial factor in determining patellar stability is patellar height. Different conditions frequently have an impact on patellar height (Choudhary and Bahre, 2017). For decades, scientists have worked to create an easy-to-use, reliable and consistent index to measure patellar height (Miller et al., 1996).

In the 1930s, the German radiologist devised a method for determining patellar height using lateral radiographs of the knee. He established a reference line which extends forward from the femur's intercondylar notch. The patella should ideally be positioned on or just above this line in a normal knee (Blumensaat, 1938). The ratio of patella length to maximal femoral condyle width was determined to be 0.95 ± 0.07 . A number of researchers discovered that both the elements shared an identical dimension. Blumensaat, (1938) line ratio originated from Ahmed, (1992).

The Insall-Salvati ratio was introduced by Insall and Salvati, (1971) as a method to evaluate patellar height on a lateral knee radiograph with the patella under stress. It entails measuring both the lengths of the patella and the patellar tendon and estimating the ratio of the two. The level of the patella, as determined by the ratio, is believed to have clinical significance in various conditions, including patellar dislocation and chondromalacia. The original research proposed by Insall and Salvati, (1971) stated that a normal Insall-Salvati ratio falls within the range of 0.8 to 1.2.

In the 1975 study, they found that different disorders were associated with distinct Insall-Salvati ratio values. Disorders like patellar dislocation and chondromalacia tended to have lower ratios (closer to 0.8), suggesting a relatively higher location of the patella. On the other hand, Osgood-Schlatter disease, a condition characterized by inflammation of the patellar tendon at its insertion point on the tibia, was associated with a higher ratio (around 1.2), indicating a relatively lower position of the patella. As a result, the Insall-Salvati ratio became popular (Blackburne and Peel, 1977).

The easy-to-remember standard value of 1 for the Insall-Salvati ratio contributes to its popularity as a quick and accessible method for assessing patellar height. Also, it has been used for a longer period of time than other ratios (Diederichs et al., 2010). However, Berg et al., (1996) discovered that it is not easily replicated. Grelsamer and Meadows, (1992) devised the Modified Insal Salvati index, which considers the length of the PAS rather than the patellar length. However, identifying inferior end of the articulating surface can be challenging, and can increase the interobserver error of this method compared to the original ratio. For correct measurement of the IS and the MIS, the patellar tendon's exact distal insertion point must be known (Seil et al., 2000).

Caton et al., (1982) updated the numerator by measuring the distance between the inferior border of the patella's articular surface and the anterosuperior angle of the tibial plateau. Cultural and lifestyle differences, such as sitting habits, can potentially affect the measurement and interpretation of patellar height. The IS ratio, which is commonly utilized in Western populations, may not necessarily be applicable or generalize well to populations with different sitting habits, such as the Indian populace or Asians in general.

Studies conducted in different populations, such as the study conducted by Leung et al., (1996) in China and Upadhyay et al., (2013) in India, have highlighted the need for caution when applying patellar height ratios generated from Western populations to other ethnic or cultural groups. These studies have suggested that there may be variations in patellar height and its measurement among different populations. As a result, applying such Western population ratios to the Indian population may be counterproductive (Upadhyay et al., 2013; Leung et al., 1996).

In our investigation, we used the Caton-Deschamps ratio to measure patellar height. This ratio is calculated based on radiographs of knees in lateral position with the knee flexed at approximately 30 degrees. The classification of patellar height as patella baja, patella norma or patella alta based on this ratio provides a way to categorize the relative position of the patella (Ahmed, 1992).

This study examined the patellar height ratios in Indians and found them to be straightforward, useful and repeatable regardless of ethnic variances. Understanding normal patellar height is indeed important during surgery, as patellar height restoration plays a crucial role in achieving optimal knee function and kinematics (Khakharia and Scuderi, 2012).

Limitations

Small sample size may be a limiting factor in external validation of results; however multicentre studies with higher sample size may enhance the reliability of Caton Deschamp ratio.

5. CONCLUSION

In our study, as compared to Caucasian study, there was no significant difference between the patellar height ratios considering the ethnicity of patient and hence these values can be used for reviving knee kinematics in diseased states irrespective of the race. Caton Deschamp ratios typically range from 0.6 to 1.2; values greater than 1.2 suggests patella alta, while values lower than 0.6 suggest patella baja. Hence, in Indian population, the upper limit of normal reference values for patella alta was the same as that in the western population.

Abbreviations

CD: Caton Deschamp

IS: Insal Salvati

SD: Standard deviation

MIS: Modified Insal Salvati index

PAS: Patellar articular surface

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Author contributions

All authors made significant contributions to conception and design, data collection and analysis along with the interpretation of the same. They also participated in writing the paper and critically revised it for key intellectual content.

Ethical approval

The study was approved by The Medical Ethics Committee of NKP Salve Institute of Medical Sciences and Research Center (Ethical Approval Code: IEC/83/2021 on 30/09/21).

Informed consent

Not applicable.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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