BIOMEDIKA
ISSN: 2085-8345, E-ISSN: 2541-2582
Vol 17, No. 2 Agustus 2025
doi: 10.23917/biomedika.v17i2.11756

PATELLAR HEIGHT EXAMINATION WITH VARIOUS METHODS ON GENU X-RAY: IN A SEARCH OF THE MORE PRECISE COMBINATION

Notariana Kusuma Astuti[1,2], Muchtar Hanafi[1,2*], Amelia Tjandra Irawan[1,3], Anistyaning Wahyu Adhie[1,3]

AFFILIATIONS

1. Radiology Department, Faculty of Medicine Universitas Sebelas Maret, Surakarta, Indonesia
2. Radiology Department, Universitas Sebelas Maret Hospital, Sukoharjo, Indonesia
3. Musculoskeletal Subdivision, Radiology Department Dr. Moewardi Hospital, Surakarta, Indonesia

ABSTRACT

Patellar height, which represents distance formed by the patella and the length of patellar tendon, can predict various knee joint problems. The Insall-Salvati (IS), Caton-Deschamps (CD), and Blackburne-Peel (BP) ratios are widely used to measure patellar height. Those methods conveyed various levels of variability and reproducibility. However, no method perfectly defines the true patellar height in relation to the tibiofemoral joint with high reproducibility and minimal variability. The study involved x-rays of 15 left-knee joints of Indonesian women across various ages without any history of knee injury. Patellar height was measured using the IS, CD, and BP methods (three times of measurement for each method). Patellar height was classified into infera, norma, and alta based on Indonesian measurement standard. The average measurement ratios were analyzed descriptively to obtain the conclusion. The IS ratio identified a patella norma in 14 subjects and a patella infera in 1 subject. The CD ratio indicated 12 subjects with a patella norma, 2 subjects with a patella alta and 1 subject with a patella infera. The BP ratio resulted in a patella norma in 8 subjects and a patella alta in 7 subjects. Discrepancies in the subgroups were varied. Patella norma from IS ratio confirmed by CD and BP ratios resulted in a percentage of 33%. The IS method combined with the CD method yielded a percentage of 67% with p(IS-CD) = 0.915. The combination of IS-BP and CD-BP methods yielded 53% with p(IS-BP) = 0.02 and 40% with p(CD-BP) = 0.052 respectively. The results show a method-dependent disparity in patellar height measurement. Single IS ratio provides a smaller percentage than its combination with CD or BP ratio. The combination with the highest percentage was obtained between IS and CD ratios. This study implied the measurement of patellar height precisely in various genu joint problems, such as predicting progression of patellofemoral osteoarthritis, pain of the genu joint, and luxation or subluxation of the patella. A future study can involve a larger number of subjects.

KEYWORDS:

Patellar Height, Insall-Salvati, Caton-Deschamps, Blackburne-Peel

CORRESPONDING AUTHOR:
Muchtar Hanafi
muchtar.hanafi@staff.uns.ac.id

INTRODUCTION

One important aspect related to optimal function of the genu joint is the position of the patella because it is an essential sesamoid bone. The patella is a bone component that is often involved in many physiological movements. Patellar height - shift - tilt describes the position of the patella in relation to the tibiofemoral joint which has a biomechanical role to increase and concentrate the strength of the quadriceps femur muscle[1]. The resulting force is then transmitted to the tibial tuberosity via the patellar tendon.

Patellar height is the result of measuring the distance between the top and bottom ends of the patella bone and the length of the patellar tendon. The height of the patella is evaluated using a lateral x-ray projection of the genu with

the genu flexed at an angle of 20°-30° to 90°. The height of the patella can cause a change in the direction of the force transmitted to patellofemoral junction if the patella is misaligned[2]. In addition, patellar height measurement is also used as a parameter in various orthopedic reconstruction operations.

Patellar height measurement can be used as a parameter in various genu joint problems, such as progression of patellofemoral osteoarthritis, pain in the patellofemoral and anterior aspect of the genu joint, and luxation or subluxation of the patella. Several methods for estimating patellar height have advantages and disadvantages, as well as varying degrees of reliability and reproducibility[3]. However, there is essentially no method that precisely defines the height of the patella relative to the tibiofemoral joint with high reliability and reproducibility. This study investigated three patellar height measurement methods and confirmed coherent values among them. Next, researchers compared combinations between methods to find out which combination was more precise that made this study different to the previous. The other novelty was on the targeted populations which included subjects from Java Ethnic.

METHODS

This study involved 15 x-rays of the left genu of female patients aged 21 to 63 years who had no history of genu fracture, injury, or surgery. Subjects with patellar anatomical abnormalities were not included as research subjects. Data from June 1 to July 31 2023 were collected through Picture Archiving Communication System (PACS) at Dr. Moewardi Hospital Surakarta, Indonesia. The Insall-Salvati (IS), Caton-Deschamps (DS), and Blackburne-Peel (BP) procedures were used to measure patellar x-ray results and are shown in figures 1, 2 and 3.

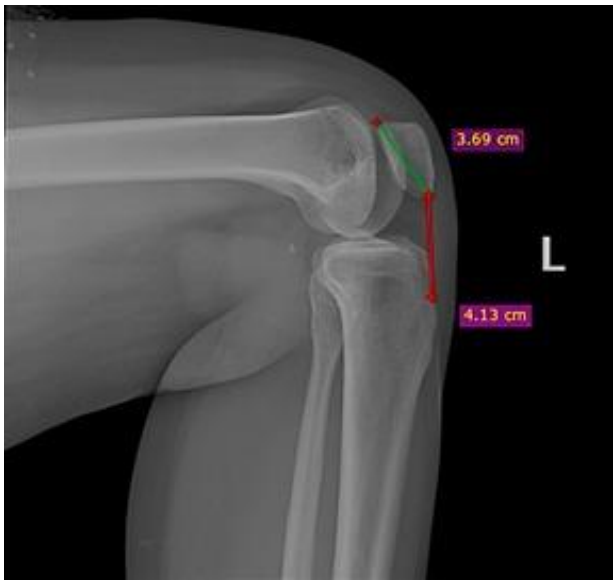

Figure 1. Measurement of patellar height using the Insall Salvati method [4]

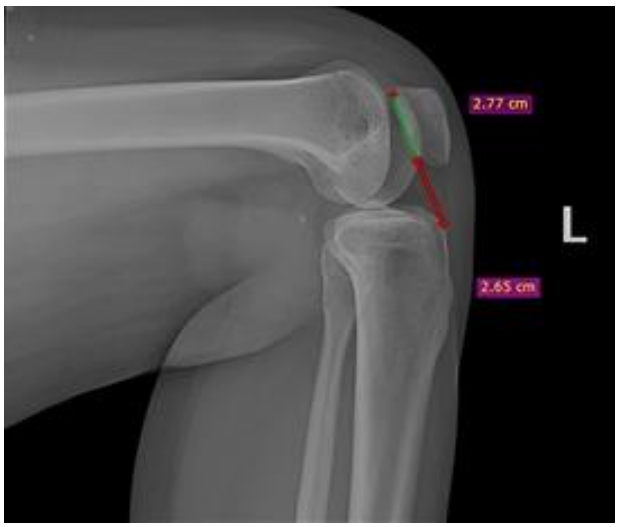

Figure 2. Measurement of patellar height using the [5]

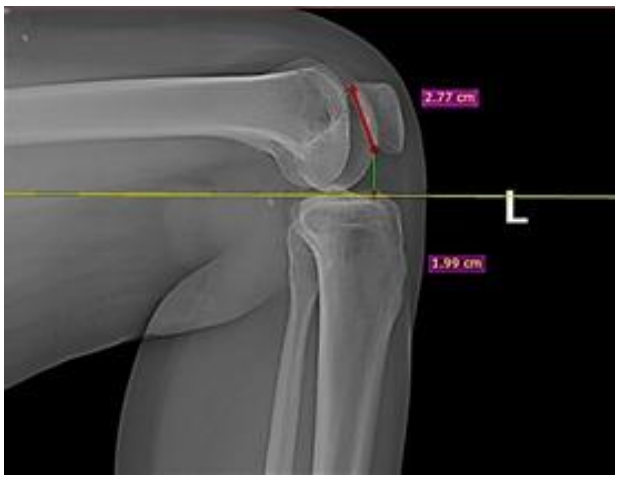

Figure 3. Measurement of patellar height using the Blackburne Peel method [6]

Each examination method was performed three times and carried out by an examiner with experience in reading genu x-rays more than 3 years and the measurement had been confirmed by an experienced sub-musculoskeletal radiologist. The measurement reliability of IS, CD, and BP methods was confirmed by the Kappa value with the degree of agreement 0.82, indicating practically perfect agreement[7]. Patellar heights are then classified into patella infera, patella norma, and patella alta based on measurement standards for the Indonesian population. Data tabulation was presented to describe the classification similarities between the three methods in the form of percentages. Then, the data were proceeded with statistical analysis using the Kruskall-Wallis test and post-hoc test to confirm the similarity between the two methods. Finally, a combination of two methods was calculated and compared to other combinations to obtain the highest percentage.

RESULT AND DISCUSSION

In Indonesian population, the normal value of the IS ratio is 0.78-1.26; the normal value of the CD ratio is 0.79-1.23; and the normal value of the BP ratio is 0.70-1.10[3]. The average of three measurements on the research subjects in each method was compared with the normal values and is displayed in Table 1.

Table 1. Mean patellar height measurements and classification

Subject	Insall Salvati		Caton Deschamps		Blackburne Peel	
	Average	Classification	Average	Classification	Average	Classification
1	0.88	*Norma*	1.10	*Norma*	0.94	*Norma*
2	0.83	*Norma*	1.12	*Norma*	0.95	*Norma*
3	1.10	*Norma*	1.00	*Norma*	1.15	*Alta*
4	0.76	*Infera*	1.19	*Norma*	0.94	*Norma*
5	1.07	*Norma*	1.16	*Norma*	1.00	*Norma*

Subject	Insall Salvati		Caton Deschamps		Blackburne Peel	
	Average	Classification	Average	Classification	Average	Classification
6	0.78	*Norma*	0.93	*Norma*	1.19	*Alta*
7	1.18	*Norma*	1.05	*Norma*	1.26	*Alta*
8	0.98	*Norma*	1.56	*Alta*	0.77	*Norma*
9	0.82	*Norma*	1.22	*Norma*	0.93	*Norma*
10	1.19	*Norma*	0.91	*Norma*	1.09	*Norma*
11	1.00	*Norma*	0.93	*Norma*	1.56	*Alta*
12	1.11	*Norma*	0.62	*Infera*	2.98	*Alta*
13	0.98	*Norma*	1.42	*Alta*	0.84	*Norma*
14	1.06	*Norma*	1.06	*Norma*	1.19	*Alta*
15	1.40	*Alta*	1.20	*Norma*	1.30	*Alta*

The IS ratio identified the patella norma in 14 subjects and the patella infera in 1 subject. The CD ratio showed 12 subjects with patella norma, 2 subjects with patella alta and 1 subject with patella infera. The BP ratio resulted in a patella norma in 8 subjects and a patella alta in 7 subjects. Differences within subgroups varied. Patella norma of IS ratio confirmed by CD and BP ratios yields a percentage of 33%.

The results of patellar height measurements in each method were analyzed statistically using the Kruskall Wallis Test followed by the Post-Hoc Test with the results as listed in Table 2.

Table 2. Comparison between patellar height measurement methods.

Measurement Method	Comparison	*p*
Insall Salvati	Caton Deschamps	.915
	Blackburne Peel	.020
Caton Deschamps	Insall Salvati	.915
	Blackburne Peel	.052
Blackburne Peel	Insall Salvati	.020
	Caton Deschamps	.052

The IS method combined with the CD method produces a percentage of 67% with p(IS-CD) = 0.915. The combination of IS and BP methods produces a percentage of 53% with p(IS-BP) = 0.02. Meanwhile, the combination of CD and BP methods produces a percentage of 40% with p(CD-BP) = 0,052.

Changes in patellar height are the result of various orthopedic disorders and are associated with subsidence range of motion (ROM). Patella infera was discovered post-total nor unicompartemental knee replacement, osteotomi high tibial, and anterior cruciate ligament reconstruction[8]. Meanwhile, patella alta is associated with neurological disorders associated with pain in the anterior genu and femoropatellar instability[9].

The clear etiology of changes in patellar height is not completely known but based on several studies it is associated with various phenomena. The cause of patella infera is explained as a biological adaptation mechanism of extension, scarring and shrinkage of scar tissue, the formation of new bone formations, due to immobilization, patellofemoral fibrosis,

intra-articular fiber fibrosis, ischemia, and trauma to the patellar tendon [10]. In contrast to patella alta, the cause of which may be idiopathic or may be associated with neurological disorders. Patella alta is a cause or complication of post-patellar dislocation[11].

As a radiologist, this should be one of concerns because very small changes in normal patellar height are associated with changes of motion joints and the appearance of symptoms. Based on patellar height measurements, data was obtained that shortening of the patellar tendon by 1 mm is estimated to cause a loss of genu flexion ability of around 1° [10]. In a genu model it was shown that when the patellar tendon is short, the patella contacts the femur at a smaller flexion angle than when the tendon is of normal length. However, not every method is universally ideal for measuring patellar height. Some methods can be affected by changes in the morphology of the patella or proximal tibia as in the IS method [11]. Other ratios, such as BP, are influenced by the position of the joint line and thereby it requires precise identification of the proximal tibial joint surface in the assessment[6]. Therefore, BP is not accurate enough to measure and classify patellar height post-unicompartemental or total genu arthroplasty [9]. In addition, BP is also not suitable for measuring post-osteotomy due to changes in inclination angle of tibial plateau that affect the measurements.

Several studies have shown disparities regarding the results of measuring normal patellar height. For example, in the same genu, the IS ratio indicates patella alta while the BP and the CD ratios indicate patella infera.[1] Radiologists and clinicians, especially orthopedic surgeons, need to know these facts and make decisions. Therefore, carrying out a combination of examinations could be an idea to reduce doubts regarding the results of the patellar height examination and its classification. On the other hand, factors such as inter- and intraobserver variability, reliability and reproducibility can also play an important role in the assessment of actual patellar height [12].

Apart from that, in this study, we also considered gender and body side (right/left). Based on anatomical studies, the female genu has a different anatomy from the male genu [13]. Differences in quadriceps femur muscle strength between the right and left sides also

cause differences in patellar height when measured using four different methods [14]. The more dominant side of the leg experiences a decrease in tension in the extension mechanism so that it has a greater proportion of patella infera [2]. Therefore, this study only took samples on the left side which is adjusted to the side of the body that is generally not dominant.

In this research, the authors are aware of several limitations. The author did not know the daily activity history and differences of intensity of the right and left knee use. In addition, although the examination was carried out by two people with certain qualifications and confirmed by a sub-musculoskeletal radiologist, plus a frequency of three examinations for each measurement, the authors did not carry out related analyzes interobserver variability [15]. This study also only involved a small number of subjects with no history of genu trauma without considering degenerative changes even though comparisons between methods were carried out linearly on the same subjects. In addition, the subjects in this study were women with the possibility of different results if carried out on male subjects. Further research on a larger and more varied scale is needed to follow up on the results of this study.

CONCLUSION

The research results show disparities related to the method of measuring patellar height with standard ratios based on the Indonesian population. The IS ratio applied without combination produces a smaller percentage (confirmation of patella norma) compared to the combination of IS and CD, CD and BP, or IS and BP. The combination of IS and CD produces the highest percentage. The involvement of a larger number of subjects and several research centers needs to be done to get better representation of the population.

FUNDING

This study received no specific grant from any funding institution of the not-for-profit, public, or commercial sectors.

ACKNOWLEDGEMENT

We would like to acknowledge the Director of Dr. Moewardi Teaching Hospital, the Head of Radiology Department, and staffs for granting access to the data.

REFERENCES

1. V. G. Igoumenou, L. Dimopoulos, and A. F. Mavrogenis, "Patellar Height Assessment Methods: An Update," *JBJS Rev.*, vol. 7, no.

1, pp. e4–e4, Jan. 2019, doi: 10.2106/jbjs.rvw.18.00038.
2. K. Anagnostakos, O. Lorbach, S. Reiter, and D. Kohn, "Comparison of five patellar height measurement methods in 90° knee flexion," *Int. Orthop.*, vol. 35, no. 12, pp. 1791–1797, Dec. 2011, doi: 10.1007/s00264-011-1236-4.
3. E. Mustamsir, Y. Isnansyah, and K. Y. Phatama, "Patellar height measurement in Indonesian normal adult population," *Ann. Med. Surg.*, vol. 82, Oct. 2022, doi: 10.1016/j.amsu.2022.104411.
4. J. Insall and E. Salvati, "Patella Position in the Normal Knee Joint," *Radiology*, vol. 101, no. 1, pp. 101–104, Oct. 1971, doi: 10.1148/101.1.101.
5. J. Caton, G. Deschamps, P. Chambat, J. L. Lerat, and H. Dejour, "[Patella infera. Apropos of 128 cases]," *Rev. Chir. Orthop. Reparatrice Appar. Mot.*, vol. 68, no. 5, pp. 317–325, 1982.
6. J. Blackburne and T. Peel, "A new method of measuring patellar height," *J. Bone Joint Surg. Br.*, vol. 59-B, no. 2, pp. 241–242, May 1977, doi: 10.1302/0301-620x.59b2.873986.
7. M. L. McHugh, "Interrater reliability: the kappa statistic," *Biochem. Medica*, vol. 22, no. 3, pp. 276–282, 2012.
8. E. E. Berg, S. L. Mason, and M. J. Lucas, "Patellar Height Ratios: A Comparison of Four Measurement Methods," *Am. J. Sports Med.*, vol. 24, no. 2, pp. 218–221, Mar. 1996, doi: 10.1177/036354659602400218.
9. R. Narkbunnam and K. Chareancholvanich, "Effect of patient position on measurement of patellar height ratio," *Arch. Orthop. Trauma Surg.*, vol. 135, no. 8, pp. 1151–1156, Aug. 2015, doi: 10.1007/s00402-015-2268-9.
10. J. J. Stefanik, A. C. Zumwalt, N. A. Segal, J. A. Lynch, and C. M. Powers, "Association Between Measures of Patella Height, Morphologic Features of the Trochlea, and Patellofemoral Joint Alignment: The MOST Study," *Clin. Orthop.*, vol. 471, no. 8, pp. 2641–2648, Aug. 2013, doi: 10.1007/s11999-013-2942-6.
11. R. P. Grelsamer and S. Meadows, "The Modified Insall-Salvati Ratio for Assessment of Patellar Height," *Clin. Orthop.*, vol. 282, p. 170???176, Sep. 1992, doi: 10.1097/00003086-199209000-00022.
12. G. Aparicio, J. C. Abril, J. Albiñana, and F. Rodríguez-Salvanés, "Patellar height ratios in children: an interobserver study of three methods," *J. Pediatr. Orthop. Part B*, vol. 8, no. 1, pp. 29–32, Jan. 1999.
13. S. Conley, A. Rosenberg, and R. Crowninshield, "The Female Knee: Anatomic Variations," *J. Am. Acad. Orthop. Surg.*, vol. 15, pp. S31–S36, 2007, doi: 10.5435/00124635-200700001-00009.
14. H.-T. Hong, Y.-G. Koh, J.-H. Nam, P. S. Kim, Y. H. Kwak, and K.-T. Kang, "Gender Differences in Patellar Positions among the Korean Population," *Appl. Sci.*, vol. 10, no. 24, p. 8842, Dec. 2020, doi: 10.3390/app10248842.
15. R. Seil, B. Müller, T. Georg, D. Kohn, and S. Rupp, "Reliability and interobserver variability in radiological patellar height ratios," *Knee Surg. Sports Traumatol. Arthrosc.*, vol. 8, no. 4, pp. 231–236, Jul. 2000, doi: 10.1007/s001670000121.
16.