Interobserver Variability of the Insall-Salvati Ratio

Nimish R. Kadakia, MD
Omer A. Ilahi, MD

Abstract

Thirty-six patients presenting with knee pain were enrolled in a prospective study to assess the variability of the radiographic measurement of patellar height by the traditional and modified Insall-Salvati ratios. The traditional and modified Insall-Salvati ratios were measured from a lateral knee radiograph using a standard hand-held ruler by four physicians in varying order. The observers were in agreement in classifying the radiographs in two thirds of the cases when the traditional method was used but in less than one-half of the cases when the modified ratio was used. The source of the difference in the two ratios is a greater variability in measuring the distance from the inferior margin of the articular surface to the tibial tubercle.

Patellar height has been described as a contributor to recurrent patella dislocation as well as anterior knee pain and chondromalacia patella. Patella alta has been reported to be more common in patients with patellofemoral osteoarthritis. The radiographic measurement of patella alta is used routinely in conjunction with the physical examination in the diagnosis of patellofemoral disorders. The evaluation of patellar height on lateral knee radiographs as described by Insall and Salvati has been used to aid in the clinical and surgical decision making process regarding these conditions.

A variety of measurements have been described for measuring patellar height on a lateral radiograph. The traditional Insall-Salvati method, described in 1971, divides the patellar tendon length by the length of the patella itself. Recently, a modification to this measurement technique has been proposed to avoid differences in patellar morphology. The modified method divides the distance from the inferior margin of the patella’s articular surface to the tibial tubercle by the length of the articular surface of the patella.

Although in wide use, the interobserver reliability of the traditional or modified Insall-Salvati ratios has not been firmly established. Berg et al compared four different patellar height ratios and determined the standard error for each. A higher standard error was reported for the modified Insall-Salvati ratio compared to the traditional Insall-Salvati ratio. However, this study consisted of only 15 patients and the results have not been reproduced. Furthermore, the source of the increased error in the modified ratio is unclear.

This study assessed the variability of the radiographic measurement of patellar height by the traditional and modified Insall-Salvati ratios. The reason for any difference in the variability of the two ratios also was determined.

Materials and Methods

Thirty-six consecutive patients (16 women and 20 men), aged 19-64 years, presenting with a primary complaint of knee pain were prospectively enrolled. Prior to enrollment, each patient demonstrated the capacity to fully extend and bear full weight on both knees. Each patient was informed of the study protocol and signed a consent form approved by the authors’ institutional review board.

For each patient, a lateral radiograph
of the involved knee was obtained at an angle of 30° of knee flexion according to a predetermined protocol that was reviewed with the radiograph technician to ensure consistency. Each radiograph was reviewed independently by four physicians, including an orthopedic resident, two orthopedic surgeons completing a sports medicine fellowship, and one sports medicine fellowship-trained orthopedic surgeon. Every measurement was performed with the same hand-held goniometer to minimize the measurement instrument as a source of error.

The traditional and modified patellar tendon ratios were measured and recorded for each radiograph. The traditional ratio is obtained by dividing the length of the patellar tendon by the length of the patella, with alta being a ratio >1.2 and baja being a ratio <0.8. The modified ratio is obtained by dividing the distance between the inferior articular surface of the patella and the tibial tubercle by the length of the articular surface of the patella, with alta being a ratio >2.0.7

**RESULTS**

Each of the 36 radiographs was measured by 4 observers for a total of 144 observations. The average for each of the parameters measured is shown in Table 1. The average value for the Insall-Salvati ratio and the modified ratio was 1.18 and 1.81, respectively. Among the observers, 54 cases of patella alta were measured by the traditional Insall-Salvati ratio and 30 cases by the modified Insall-Salvati ratio (Table 2). To identify specific sources of variability, the specific parameters in each ratio were evaluated individually. To assess the interobserver variability of measuring the patellar height and patellar tendon length in the Insall-Salvati ratio, the measurement of each observer was compared to the measurements of the other 3 observers. Among the observers, 95% of the measurements for patellar length and patellar tendon length were within 9 mm and 9.8 mm of each other, respectively.

The modified ratio was assessed in a similar fashion, revealing that 95% of the measurements among the observers for length of the patella’s articular surface and the distance between the inferior articular surface of the patella and the patellar tendon insertion were within 8 mm and 14.5 mm of each other, respectively.

Using the traditional ratio, the observers classified patellar height uniformly in 24 (67%) of 36 radiographs. Patella alta was measured in 10 cases and normal in 14 cases. Using the modified ratio, the observers classified patellar height uniformly in 17 (47%) of 36 cases. In no instance did all 4 observers measure patella alta on a single radiograph using the modified ratio (Table 3).

The relative morphology of the patella was determined by dividing the ratio of the length of the articular surface to the length of the patella itself. The average ratio for all observers for all cases was 0.72±0.07. The ratio was >0.6 in >96% of the radiographs measured. No case had a ratio <0.5, indicating that for the radiographs used in this study, the distal nonarticulating portion of the patella was not longer than the articular surface.

**DISCUSSION**

The radiographic measurement of patellar height is used as an adjunct to the physical examination of patients with patellofemoral pain. Patella alta has been postulated to be a contributor to the development of chondromalacia patella and subluxation of the patella.14

The original Insall-Salvati method for measuring patellar height involves dividing the patellar tendon length, as measured from the inferior pole of the patella to the tibial tubercle, by the length of the patella. This method is the most commonly used technique and allows the determination of patella alta and patella baja. This ratio is used in clinical decision-making regarding surgical intervention in cases of recurrent subluxation or dislocation. When the cause of symptoms is believed to be due to patella alta, distal tibial tubercle transposition has been recommended. When the ratio is normal, a distal transposition of the tibia is not considered necessary.

Simmons and Cameron6 described 100% success rate in 14 cases of distal patellar tendon transposition when the preoperative radiographs measured patella alta. These authors used the Insall-Salvati ratio to evaluate patellar height measured pre- and postoperatively.8

More recently, Grelsamer and Meadows7 described a modification to this method of measuring patellar height to account for differences in patellar morphology. The authors believed that
in cases when the patella has a long distal nonarticulating facet, the Insall-Salvati ratio is falsely low and cases of patella alta are not identified. The proposed modification to the ratio involves measuring the articulating portion of the patella rather than the length of the entire patella and comparing it to the distance from the inferior articular margin of the patella to the tibial tubercle. The authors concluded that this modified ratio was more sensitive in identifying patella alta than the traditional Insall-Salvati ratio. The current study was designed to compare the modified and traditional techniques for measuring patellar height as would be seen in the routine clinical setting using routinely available goniometers and imaging studies.

The results show that all observers were in agreement in classifying the knee as having or not having patella alta in two thirds of the cases when the traditional method was used, but in less than one-half of the cases when the modified ratio was used. Furthermore, the results of this study show that for the patellar length, patellar tendon length, and the length of the patellar articular surface, the observers measured within 1 cm of each other on 95% of all observations (8-9.8 mm). However, the distance from the inferior margin of the patellar articular surface to the tibial tubercle demonstrated an approximately 50% increased observer difference (14.5 mm). From this study, it appears that the measurement of patellar height using the traditional Insall-Salvati ratio is more reproducible among observers. Overall, 54 radiographs were classified as patella alta using the traditional ratio and 30 were classified when using the modified ratio. This increased sensitivity of the traditional ratio in diagnosing patella alta compared to the modified ratio is in agreement with the recent investigation by Simon et al.² and contrary to the findings of Grelsamer and Meadows,¹ who reported that one-half of their cases of patella alta were missed using the traditional ratio, but identified by the modified ratio. These authors stated their modification would identify cases of patella alta in situations where the patellar morphology produced a falsely low traditional Insall-Salvati ratio. However, no instances in the current study occurred when all four observers measured patella alta on a particular radiograph using the modified Insall-Salvati ratio. Furthermore, the data showed that measurement of patellar length, patellar tendon length, and the length of the articular surface of the patella is reproducible to within 1 cm. The source of the difference in the two ratios is a greater variability in measuring the distance from the inferior margin of the articular surface to the tibial tubercle, i.e., the length of the patellar tendon.

The modified Insall-Salvati ratio may offer some potential advantages to account for differences in patellar morphology. However, in the routine measurement of patellar height, it seems to provide more variable results than the traditional Insall-Salvati ratio. The radiographs in this study lacked the long distal nonarticulating portion of the patella for which the modified ratio is reported to be more applicable than the traditional ratio. Perhaps the modified ratio should be used specifically in cases of abnormal patellar morphology, while the traditional ratio is still the gold standard in normal cases.

From this study, it appears that more research is required before a modified ratio can be used to supplant the traditional ratio in measuring patellar height on routine lateral knee radiographs. Furthermore, additional study into patellar morphology and in particular, it's affect on the measurement of patellar height, is warranted.

REFERENCES

EDITORIAL DISCUSSION
ORTHOPEDICS: What role should this calculation or others like it play in the evaluation of patellofemoral disorders?

Kadakia & Ilahi: The Insall-Salvati ratio is an important calculation when concern regarding the patellofemoral articulation exists. Although we agree with Seil et al.¹ that other patellar height ratios such as the Blackburne-Peel index may also have a role in determining patellar height, we believe there is intrinsic value in determining the relative length of the patellar tendon itself. In severe patellar baha as a result of pathologic shortening of the patellar tendon, proximal advancement of the tibial tubercle can be limited by anatomy, post-surgical changes, or both, such as a total knee implant. Consequently, the tendon itself may need to be lengthened to help restore more normal kinematics. Alternatively, as shown by Simmons and Cameron,² an increased Insall-Salvati ratio can help predict success in treating patellofemoral disorders with distal patellar tendon transposition.

ORTHOPEDICS: Should the clinician be obligated to determine this ratio for all painful knees, or should the surgeon place a greater emphasis on other factors, such as the overall alignment of the extremity and clinical symptoms?
Kadakia & Ilahi: The calculation of the Insall-Salvati ratio is only necessary if a patellofemoral etiology of discomfort is a concern. Therefore, the clinical symptoms are of paramount importance. Furthermore, we believe it is important to get a sense of the overall alignment of the extremity when treating patients with knee symptoms.

ORTHOPEDICS: Does an Insall-Salvati ratio within normal limits prohibit a distal realignment procedure?

Kadakia & Ilahi: A normal Insall-Salvati ratio should not affect decisions on whether to perform a distal realignment procedure. This should be more dependent on the status of the quadriceps angle. However, if the Insall-Salvati ratio is normal, care should be taken when performing any distal realignment procedure so as not to translate the tibial tubercle further distally, as this may lead to patella baja and resultant knee pain and stiffness.

ORTHOPEDICS: Should more uniformity exist in determining measurements based on radiographic structures?

Kadakia & Ilahi: The most difficult aspect of determining any patellar height ratio is in picking the points to be measured on the radiograph. Carrying out measurements using a ruler is fairly straightforward, dependent more on the differences between different rulers rather than different observers. However, as far as picking the points to measure, we noted significant variability among all four observers in our study. Not only was it difficult to determine which part of the tibial tubercle to measure (the most proximal portion or the highest portion of the tubercle), but also picking the end of the articulating surface of the patella can be difficult if a sharp demarcation of this structure does not exist, such as in peritellar osteophyte formation.

REFERENCES (EDITORIAL DISCUSSION)