ISSN- O: 2458 - 868X, ISSN–P: 2458 – 8687
Index Copernicus Value: 49. 23
PubMed - National Library of Medicine - ID: 101731606

*International Journal of Medical Science and Innovative Research (IJMSIR)*
*IJMSIR : A Medical Publication Hub*
*Available Online at: www.ijmsir.com*
*Volume – 3, Issue – 5, September - 2018, Page No. : 95 - 101*

# Determination of Association between Osteoarthritis and Patellar Morphology on Knee Radiographs

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**Type of Publication:** Original Research Paper

**Conflicts of Interest:** Nil

**Abstract**

The aim of this study was to determine the association between osteoarthritis and patellar morphometry on knee radiographs in a Turkish population. Each patella was classified according to its shape, using the descriptions of Wiberg and Baumgartl as a type I, type II, type III, type IV. The association of patella types with grades of osteoarthritis were determined. The Kellgren and Lawrence system was used to determination of osteoarthritis grades. In addition, the patellofemoral sulcus angle was measured. The length of the patella and patellar tendon were measured and Insall-Salvati index was calculated and classified as patella norma, patella alta, patella baja. One hundred and eighty (90 left, 90 right) knee radiographs were used for these classifications and measurements.

Type I patella was observed in 12.2%, type II in 52.2%, type III in 35.6% and type IV in 0% of radiographs. Association of patella types and grades of osteoarthritis were; 53,84 % type II in grade 0; 54,20% type II in grade I; 69,60 % type II in grade II; 75,00 % type III in grade III; 100 % type III in grade IV. The patellofemoral sulcus angles were 126.17 ± 7.290 on the left and 126.71±7.400 on the right sides. The patella lengths were 4.0 ±0.43 mm on the left and 3.91±0,50 mm on the right, while the lengths of patellar tendon were 4.63±0.58 mm on the left and 4.56±0.81 mm on the right sides. According to the Insall-Salvati index patella norma were 79.5% and 71.2%, patella alta 1.3% and 5.5%, and patella baja 19.2% and 23.3% on the left and right sides respectively.Understanding association of patellar morphometry with grades of osteoarthritis on knee radiographs is important for clinicians

**Keywords:** Insall-Salvati index; knee radiograph; osteoarthritis; patellofemoral sulcus angle; types of patella.

## Introduction

The patella is the largest sesamoid bone of the body, articulating with and protecting the femur and anterior aspect of the knee joint: it plays a major role in flexion and extension of the knee. It is embedded in the tendon of quadriceps femoris and consists of dense cancellous tissue covered by a thin compact lamina. It is a flattened roughly triangular bone with anterior and posterior surfaces, three borders, a rounded superior pole and pointed apex inferiorly. The patellofemoral joint (PFJ) has been extensively studied anatomically, biomechanically and clinically [1]. The articular surface of the patella is covered by articular cartilage, which has a smooth median vertical crest dividing it into medial and lateral concave facets, with the lateral facet being the larger. The medial facet has been classified according to its shape [2]. According to this classification: Type I has concave medial and lateral facets of equal length; Type II has a more prominent lateral facet compared to the medial facet, which is plane or concave; Type III has a smaller convex medial facet; and Type IV has no medial facet or central rim [3,4]. The relationship between patellar alignment and frequently observed patellofemoral diseases, such as osteoarthritis (OA), chondromalasia patellae, lateral compression syndrome, has been established [5,6]. Knee OA is one of the most common orthopaedic disorders, which has negative impact on functional ability and quality of life. The most widely used classification system of knee OA severity is the Kellgren and Lawrence system, which defines OA in to one of five grades (0, normal to 4, severe). [7]. has combined radiological signs for the evidence of OA to define a grading scale for severity. The patellofemoral sulcus angle is defined as the angle between two lines tangential to the medial and lateral facets of the femoral trochlea: it's normal range is $<145^{o}$ [8]. The measurement of patellar height is also important in evaluating knee conditions and can be important in planning treatment: it can be assessed on radiographs using various methods either related to the position of the patella with respect to the femur (direct assessment) or the position of the patella with respect to the tibia (indirect assessment). Direct assessment methods are not widely applied as they can be complex. Consequently, indirect assessment methods are the most commonly used: these measure patellar height by ratios based on the length of the patellar tendon or some reference points on the proximal tibia such as the Insall-Salvati, modified Insall-Salvati, Blackburne-Peel and Caton-Deschamps methods [9,10]. In the present study the Insall-Salvati index is used as it is the most popular index used in the literature and can be readily measured from lateral radiographs**.** The Insall-Salvati index is a ratio (TL/ PL), between the length of the patellar tendon (TL) and length of the patella (PL). If the index is between 0.8-1.2 the classification is patella norma, greater than 1.2 as patella alta, and less than 0.8 as patella baja [10-12]. Knowledge of the anatomy and biomechanics of the patella is fundamental to understanding the different pathologies of the anterior knee [13]. PFJ diseases are common in all age groups, varying from anterior knee pain to retropatellar or peripatellar knee pain. These syndromes are often multifactorial and therefore hard to evaluate, diagnose and treat. Anterior knee pain can be caused by chondral lesions of the PFJ due to trauma, osteoarthritis, osteochondritis dissecans, chondromalacia patellae, patellar ligament rupture, patellar and quadriceps tendinitis, Osgood-Schlatter disease, patella alta, patella baja (which may be associated with quadriceps tendon rupture), neuromuscular disorders, achondroplasia and postoperative advancement of the tibial tuberosity [6]. Knee OA is a serious health problem and leading cause of disability. Research into risk factors and treatments for knee OA has focused on the PFJ and a common source of

symptoms [11]. Patella baja, an abnormally low patella, may be observed with anterior knee pain and limitation of range of motion of the knee [13]. In the current study, the association between patellar morphometry and OA was assessed. The resulting detailed anatomic information will be a valuable reference source for knee surgery, as well as nonsurgical approaches. The aims of the current study were to determine (i) the morphometry of the patella, and (ii) the grade of osteoarthritis (OA) visible on knee radiographs in a Turkish population.

**Material and Methods**

This retrospective observational study was undertaken to assess radiological measurements taken from 180 knee radiographs (90 left, 90 right) accessed from the radiological archives of Department of Physical Therapy and Rehabilitation Baskent University Adana Research and Education Hospital. Each radiograph was examined and assessed by a physiotherapist. Each patella was classified according to its shape, using the descriptions of Wiberg, (1941) and Baumgartl, (1964) as described above (Fig 1). The presence of OA was also detected on the radiographs in accordance with the features of OA as classified using the Kellgren and Lawrence system:

Grade 0: no radiographic features of OA are present; Grade 1: doubtful joint space narrowing (JSN) and possible osteophytic lipping; Grade 2: definite osteophytes and possible JSN on anteroposterior weight-bearing radiograph; Grade 3: multiple osteophytes, definite JSN, sclerosis, possible bony deformity; Grade 4**:** large osteophytes, marked JSN, severe sclerosis and definite bony deformity [7]. The association between patella type and OA grade was also determined. The patellofemoral sulcus angle was measured using a goniometer on tangential patella radiographs (Fig. 2). The following were also measued on lateral radiographs: length of the patella; distance from the apex of the patella to its most posterior superior point (a); length of patellar tendon; distance from the tibial tuberosity to the inferior pole of the patella (b) (Fig. 3). From these measurements an Insall-Salvati index (b/a) was calculated and the patella classified as a patella norma (index between 0.8 and 1.2), patella alta index greater than 1.2), and patella baja (index less than 0.8).

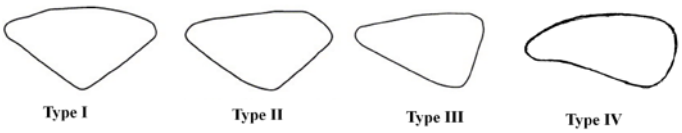


Figure 1. Classification of patella according to its shape.

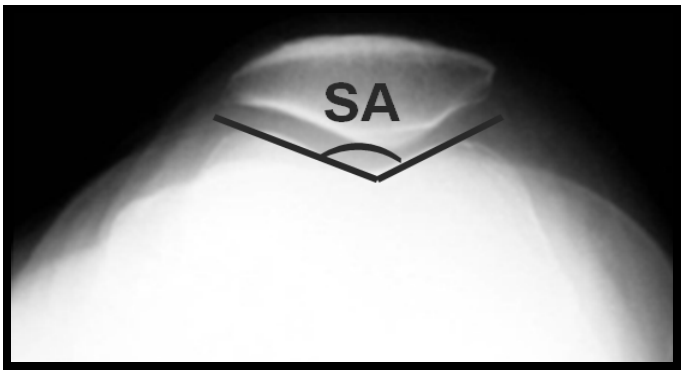


Figure 2. SA: sulcus angle**.**

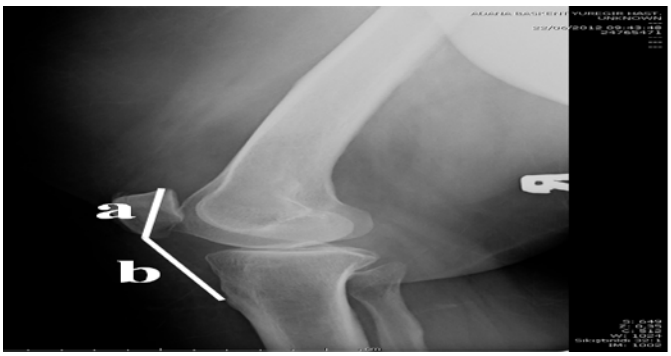


Figure 3. Insall-Salvati index (b/a); a:the length of the patella, b: the length of the patellar tendon

**Results**

Type I patella was observed in 11 (12.2%), type II in 47 (52.2%) and type III in 32 (35.6%) of radiographs: Type IV patella was not observed (Fig 4). Grade 0 OA was observed in 26 (28.9%), grade I in 24 (26.7%), grade II in

23 (25.6%), grade III in 16 (17.8%) and grade IV in 1(1.1%) of radiographs: Type IV patella was not observed (Fig 5). The association between patella type and OA grade were observed as follows: 19.2% type I, 53.8% type II, and 26.9% type III were associated with grade 0; 12.5% type I, 54.2% type II and 33.3% type III were observed with grade I; 13.0% type I, 69.6% type II and 17.4% type III were observed with grade II; 0.0% type I, 25.0% type II and 75.0% type III were observed with grade III; 0.0% type I and type II and 100% type III were observed with grade IV (Table 1, Fig 6). The mean patellofemoral sulcus angles were 126.2 ± $7.3^0$ on the left and 126.7 ± $7.4^0$ on the right (Table 2). Mean patella length was 4.05 ± 0.43 cm on the left and 3.91 ± 0,50 cm on the right, while mean length of patellar tendon was 4.63 ± 0.58 cm on the left and 4.56 ± 0.81 cm on the right (Table 2). According to the Insall-Salvati index patella norma was observed in 79.5% and 71.2%, patella alta in 1.3% and 5.5%, and patella baja 19.2% and 23.3% on the left and right sides respectively (Fig. 7).

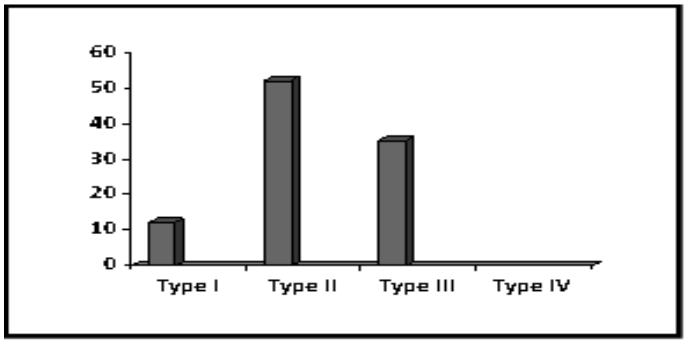


Figure 4. Frequency of patella types.

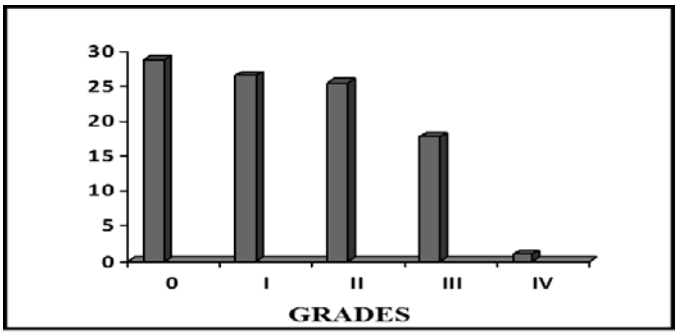


Figure 5. Frequency of OA grades.

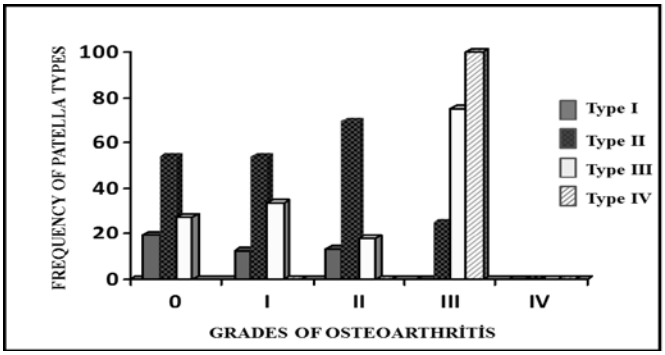


Figure 6. Frequency of patella types according to OA grades.

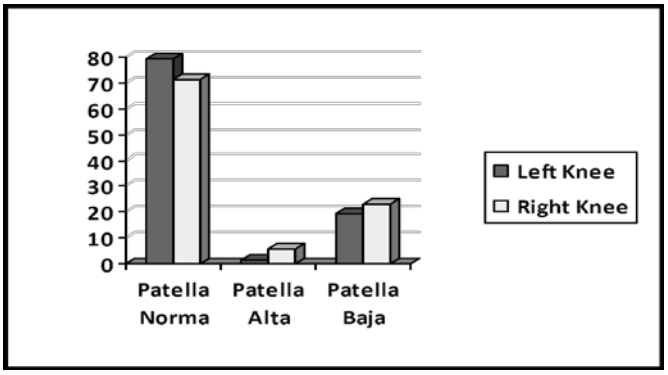


Figure 7. Frequency of patella norma, patella alta and patella baja.

Table 1. Frequency of patella types according to grades of osteoarthritis.

| Grades of Osteoarthritis | Frequency of Patella Types (%) | | | |
|---|---|---|---|---|
| | Type I (n=11) | Type II (n=47) | Type III (n=32) | Type IV (n=0) |
| Grade 0 (n=26) | 19.2 | 53.8 | 26.9 | - |
| Grade I (n=24) | 12.5 | 54.2 | 33.3 | - |
| Grade II (n=23) | 13.0 | 69.6 | 17.4 | - |
| Grade III (n=16) | - | 25.0 | 75.0 | - |
| Grade IV (n=1) | - | - | 100.0 | - |

Table 2. Measurements of patellofemoral alignment.

| Parameters | Left Side | | Right Side | |
|---|---|---|---|---|
| | Ranges | Mean±SD | Ranges | Mean±SD |
| Patellofemoral sulcus angle ($^0$) | 110-142 | 126.2±7.29 | 110-142 | 126.7±7.40 |
| Length of patella (cm) (a) | 3.10-5.20 | 4.05±0.43 | 2.80-5.20 | 3.91±0.50 |
| Length of patellar tendon (cm) (b) | 2.20-5.80 | 4.63±0.58 | 2.50-6.90 | 4.56±0.81 |
| Insall- Salvati Index (b/a) | 0.67-1.64 | 0.88± 0.13 | 0.57-1.40 | 0.89± 0.17 |

**Discussion**

Morphometric measurements are valuable tools in understanding patella and knee morphology on knee radiographs. During the evaluation of patellofemoral joint problems, the position of the patella with respect to the femur must be taken into account. Ideally, the method used should be able to assess patellar height directly using a femoral reference landmark. However, most methods assess patellar height using ratios using a number of tibial reference points. In the literature it appears that there are few studies which compare patellar height assessment methods. The measurement of patellar height is important in evaluating knee conditions, as well as being important in planning treatment. On radiographs patellar height can be assessed using a variety of methods and corresponding ratios; however none are accepted as the gold standard. The methods used are either associated with the position of the patella to the femur (direct assessment) or with the position of the patella to the tibia (indirect assessment). The direct assessment methods are too complex therefore not widely applied. The methods that use an indirect assessment, such as the Insall-Salvati (IS), modified Insall-Salvati (MIS), Blackburne-Peel (BP) and Caton-Deschamps (CD) are most widely used. Ideally, patellar height ratios use a distal femoral reference point to represent the true patellofemoral articulation. Patellar height should not be used despite its reliability as it is mainly assessed in patients with patellofemoral symptoms. The effect of weight-bearing and knee flexion might be greater due to a potentially longer and lax tendon in the extended knee or a potentially more pliable patellar tendon in patients with patella alta [9]. Comparison between the current data on patellar height and those previously reported show differences in the mean value of maximum patellar height reported by Abdel Moneim *et al*., (2008) for males (48.4± 0.56) mm compared with Introna *et al*., (1998) (40.12± 0.29) mm in males and that of O'Connor, (1996) (44± 3) mm in males. The mean value of maximum height, for female patella reported by Abdel Moneim *et al*., (2008) was 45.4 ± 0.23 mm, higher than that reported by Introna *et al*., (1998) (37.0 ± 0.29) mm and O'Connor, (1996) (40 ± 3)mm. In the current study the mean patella height was 4.05± 0.43 cm on left, 3.91± 0.50 cm on right [14-16]. Jawhar *et al*., (2014) investigated the mean preoperative, 1 week postoperative and 1 year postoperative ratios for the Insall-Salvati index and reported values of 1.07, 1.08, 1.07, respectively. Jawhar *et al*., (2014) reported values of 1.78, 1.79 nd 1.76 for the same ages[18]. In the current study the Insall-Salvati Index was 0.88 ± 0.13 on the left and 0.89 ± 0.17 on the right, less than those reported by Jawhar *et al*., (2014). According to the Install-Salvati Index patella norma were observed in 79.5% and 71.2%, patella alta in 1.3% and 5.5% and patella baja in 19.2% and 23.3% on the left and right sides respectively in the current study. Hayırlıoğlu *et al*., (2015) gave the distribution of chondromalacia patella in patella types as: type I 34%, type II 39%, type III 64% and type IV 60 % [5]. It is suggested that association between patella type and patellofemoral diseases can be demonstrated more clearly by comprehensive future studies. The current findings, combined with the results of previous research, will serve as a valuable guide for orthopaedists and clinicians involved in surgical procedures.

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