



# Characteristics of Patellofemoral Measurement in Indonesian Population Using Magnetic Resonance Imaging

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## Abstract

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**BACKGROUND:** The patellofemoral joint is a unique complex joint formed by articulation of the patella and the femoral trochlea. Normal measures for patellofemoral parameters have been published.

**AIM:** This study aimed to describe the characteristics of patellofemoral measurements in Indonesian population using magnetic resonance imaging (MRI).

**METHODS:** This descriptive total sampling study was conducted from May 2019 to August 2020. The parameters of the measurements in this study include Insall-Salvati ratio, Caton-Deschamps index, trochlear angle, lateral trochlear inclination, TT (tibia tubercle) – TG (trochlear groove) distance, and trochlear depth. The mean results of the measurements were compared with the normal value measurements that are internationally used.

**RESULTS:** A total of 100 normal knees MRI scan from patients consisting of 54 (54%) males and 46 (46%) females, with an average age of  $35.09 \pm 12.77$  (19–60) years old. The average body mass index (BMI) was  $28.07 \pm 3.0$  (22–34). Based on ethnicity, subjects were mostly Javanese (66%), Sundanese (12%), Madura (4%), Minangkabau (7%), and the others (11%). The mean of Insall-Salvati ratio was  $1.09 \pm 0.17$  (0.49–1.60). The mean of Caton-Deschamps index was  $0.97 \pm 0.16$  (0.62–1.64). The mean of trochlear angle was  $138.97^\circ \pm 119.7$  ( $122^\circ$ – $160^\circ$ ). The mean of lateral trochlear inclination was  $20.37^\circ \pm 4.56$  ( $11.0^\circ$ – $30.6^\circ$ ). The mean of TT-TG distance was  $13.76 \pm 5.86$  (4.9–41), and the mean of trochlear depth was  $5.18 \pm 1.87$  (1.05–8.6). Those values were within normal range of international values. There were no significant differences between comparison of males and females.

**CONCLUSION:** The means of Insall-Salvati ratio, Caton-Deschamps index, trochlear angle, lateral trochlear inclination, and TT-TG trochlear depth of the Indonesian people were within the international normal range, and higher than other countries' published measurements.

## Introduction

The patellofemoral joint (PFJ) is a unique complex joint formed by articulation of the patella and the femoral trochlea [1]. The bony morphology of the joint, the quadriceps/patella tendon, and the capsuloligamentous attachments together play a role in the stability of the PFJ [1], [2]. It has multiple contacting pressure points that are influenced by the degree of knee flexion [3].

Such complex structures will eventually suffer from a wide range of problems. First and foremost, there is commonly patellofemoral instability with incidence reaching 5.8/100,000 population [1]. The next common complaint that may arise is patellofemoral pain that constitutes almost 25% of knee problems [4]. Both of these problems are correlated to each other but the exact pathomechanisms are not fully understood yet because there are so many factors affecting these pathologies. One concern is improper alignment which

causes dysfunction of the patellofemoral joint that can lead to abnormal contact pressures, which may explain some of the patients' symptoms [5].

Many radiological studies have been conducted rigorously by an abundance of authors to better understand the anatomy and biomechanics of the PFJ and its pathologies. Imaging modalities are useful for characterization of patellar malalignment, maltracking, underlying morphologic abnormalities, and stabilizing soft-tissue injuries [6].

Four factors which are relevant in knees with symptomatic patellar instability are trochlear dysplasia, quadriceps dysplasia, patella alta, and the tibial tuberosity-trochlear groove (TT-TG) distance [7], [8], [9]. Patellofemoral dysplasia is a major predisposing factor for instability of the PFJ. The biomechanical effects of patellofemoral dysplasia, with different anatomical and demographic risk factors have been suggested in an attempt to identify the recurrent dislocations [3]. However, it is still presenting an extremely challenging condition to

manage. Therefore, a comprehensive evaluation of all the radiographic parameters can help the clinicians to assess their patients.

Magnetic resonance imaging (MRI) evaluation of the knee forms an integral part of investigation of patients with knee pain or knee instability because it can provide useful information about the bony morphology of the femur and patella as well as the condition of the articular cartilage [9], [10]. MRI assessments can evaluate some of the factors as measurable parameters such as Insall-Salvati ratio, Caton-Deschamps index, trochlear depth, lateral trochlear inclination, TT-TG distance, and trochlear (Sulcus) angle.

Most of studies relating to PJK and its pathologies were conducted in western countries. We are aware that each country has its own anatomical uniqueness due to race and cultural differences. As the fourth most populated country in the world, Indonesia has many patients with knee pain. But to date, Indonesia does not have any study regarding this important matter. This study aimed to describe the characteristics of patella femoral measurements in an Indonesian population using MRI.



Figure 1: Insall-Salvati ratio and Caton-Deschamps index measurements

## Materials and Methods

This descriptive total sampling study was conducted from May 2019 to August 2020. Human research ethics approval was obtained from the local institutional review board before the initiation of any study activities. Patients were included of this study if they are healthy with age 18–65 years old and

Indonesian people. We consecutively collected the MRI of normal knees of the right side. The exclusion criteria were the patients with the histories of knee abnormalities, knee disease, or had previous knee surgery.

## Outcome measures

The parameters of the measurements in this study included Insall-Salvati ratio, Caton-Deschamps index (Figure 1), trochlear angle (Figure 2), lateral trochlear inclination (Figure 3), trochlear depth (Figure 4), and TT–TG distance (Figure 5). Then, the mean results of the measurements were compared with the international normal values.

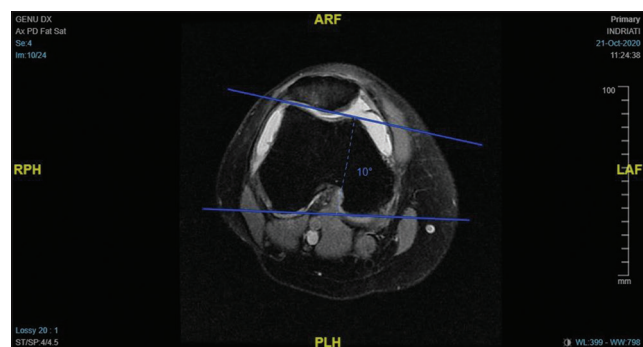


Figure 2: Trochlear angle

Descriptive statistics were generated for demographic data. Repeated measures t tests were used to compare values. All analyses were performed using SPSS 26.0 (IBM SPSS, Atlanta, GA). Statistical tests were considered significant at  $\alpha = 0.001$ .

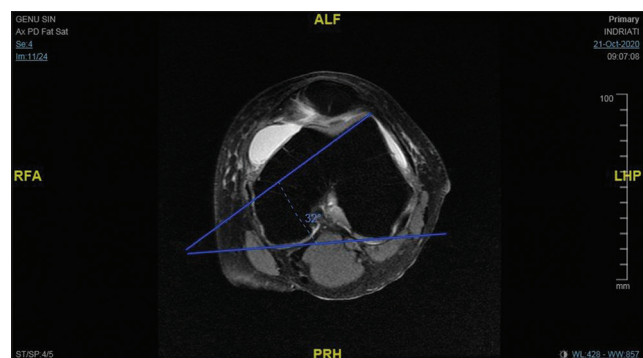


Figure 3: Lateral trochlear inclination angle

## Results

A total of 100 normal knees MRI scan from patients consisting of 54 (54%) males and 46 (46%) females were assessed in this study, with an average age of  $35.09 \pm 12.77$  (19–60) years old. The average body mass index (BMI) at the time of assessment

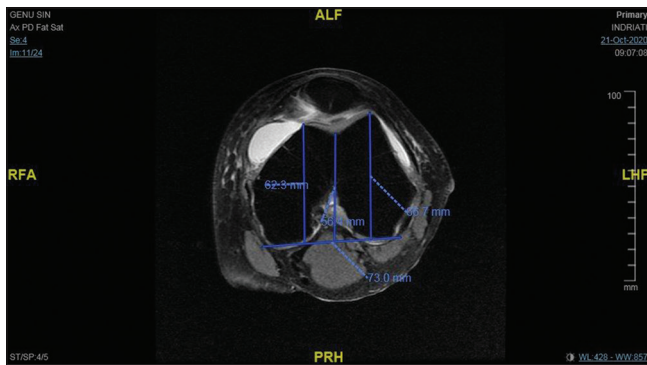


Figure 4: Trochlear depth

was  $28.07 \pm 3.0$  (22–34) (Table 1). The composition of the subjects based on ethnicity was mostly Javanese (66%), Sundanese (12%), Minangkabau (7%), Madura (4%), and the others (11%) (Table 2 and Figure 6).

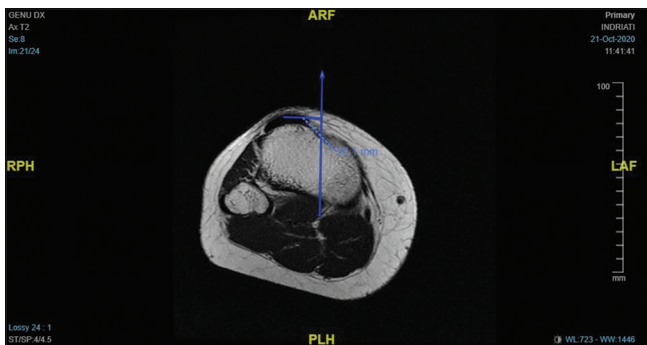


Figure 5: TT-TG

The mean of Insall-Salvati ratio was  $1.09 \pm 0.17$  (0.49–1.60). The mean of Caton-Deschamps index was

Table 1: Demographic data of the study population

|                 |                       |
|-----------------|-----------------------|
| Age             | 35.09 ± 12.77 (19–60) |
| Gender          | Male: 54, Female: 46  |
| Body mass index | 28.07 ± 3.0 (22–34)   |

$0.97 \pm 0.16$  (0.62–1.64). The mean of trochlear angle was  $138.97 \pm 119.7$  (122°– 160°). The mean of lateral trochlear inclination was  $20.37 \pm 4.56$  (11.0–30.6). The mean of TT-TG distance was  $13.76 \pm 5.86$  (4.9–41), and the mean of trochlear depth was  $5.18 \pm 1.87$  (1.05–8.6). Those values were within the range of normal international values (Table 3).

Table 2: Composition of subjects

| Ethnicity   | Number | Percentage |
|-------------|--------|------------|
| Java        | 66     | 66         |
| Sundanese   | 12     | 12         |
| Madura      | 4      | 4          |
| Minangkabau | 7      | 7          |
| Others      | 11     | 11         |

There were no significant differences in the comparison between males and females (Table 4). Comparison of our results with other published studies showed that the TT-TG of Indonesian people was higher than other Asian, Europe, and American countries (Table 5).

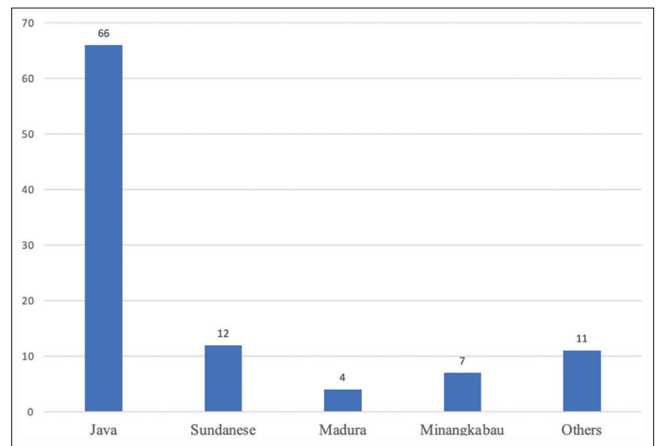


Figure 6: Composition of subjects

## Discussion

The biomechanical effects of patellofemoral dysplasia on patellar stability have not been fully investigated. Furthermore, different anatomic and demographic risk factors have been suggested in attempts to identify the sources of some of the problems.

Table 3: Measured patellofemoral indices

| Parameters                         | International normal value | Result of measurement (Mean ± SD, Range) |
|------------------------------------|----------------------------|--|
| Insall-Salvati ratio [11]          | 0.8 – 1.2                  | 1.09 ± 0.17 (0.49–1.60)                  |
| Caton-Deschamps index [12]         | 0.6 – 1.3                  | 0.97 ± 0.16 (0.62–1.64)                  |
| Trochlear Angle [13]               | 135° ± 10                  | 138.97 ± 119.7 (122–160)                 |
| Lateral trochlear inclination [14] | >11°                       | 20.37 ± 4.56 (11.0–30.6)                 |
| TT-TG distance [13]                | 12.7 ± 3.4                 | 13.76 ± 5.86 (4.9–41)                    |
| Trochlear depth [13, 15]           | >3                         | 5.18 ± 1.87 (1.05–8.6)                   |

SD: Standard deviation

In patellofemoral study, there were several aspects that have been adjusted to Indonesian values and characters such as the Indonesian version of the Kujala [20]. Some countries also adapted, validated and translated the scales in accordance with their language including Chinese, Persian, Turkish, Thai, and German [20]. However, some parameters of patellofemoral measurements from the Indonesian people have not been investigated yet.

Table 4: Comparison of males’ and females’ patellofemoral values

| Parameters                    | Males (Mean ± SD, Range) | Females (Mean ± SD, Range) | 95% CI     | p value |
|-------------------------------|--------------------------|----------------------------|------------|---------|
| Insall-Salvati ratio          | 1.09 ± 0.17 (0.49–1.60)  | 1.09 ± 0.18 (0.49–1.60)    | -0.77–0.67 | 0.89    |
| Caton-Deschamps index         | 0.97 ± 0.16 (0.62–1.64)  | 0.97 ± 0.16 (0.62–1.64)    | -0.06–0.06 | 0.94    |
| Trochlear angle               | 139.04 ± 7.02 (123–160)  | 138.44 ± 7.45 (122–160)    | -3.01–3.66 | 0.84    |
| Lateral trochlear inclination | 20.20 ± 4.54 (11–30)     | 20.57 ± 4.62 (11.3–30.6)   | -2.27–1.52 | 0.69    |
| TT-TG distance                | 13.57 ± 5.95 (4.9–41)    | 13.99 ± 5.81 (5–41)        | -2.67–2.15 | 0.82    |
| Trochlear depth               | 5.15 ± 1.83 (1.05–8.60)  | 5.22 ± 1.94 (1.05–8.60)    | -0.92–0.68 | 0.76    |

CI: Confidence interval; SD: Standard deviation

Based on the 2010 population census, the composition of the majority of Indonesia’s population is Javanese (41.71%), Sundanese (15.41%), Madura



(3.37%), and Minangkabau (2.72%) [21], almost the same with our study, that had most of subjects from Javanese (66%), Sundanese (12%), and Minangkabau (7%) ethnicity.

**Table 5: Comparison with other studies**

|                          | Alemparte<br><i>et al.</i> [16] | Song<br><i>et al.</i><br>[17] | De Jour<br><i>et al.</i> [18] | Raja<br><i>et al.</i> [19] | Our Study |
|--------------------------|---------------------------------|-------------------------------|-------------------------------|----------------------------|-----------|
| Place of study           | Chile                           | Korea                         | France                        | India                      | Indonesia |
| Method                   | CT Scan                         | CT Scan                       | CT Scan                       | CT Scan                    | MRI       |
| Number of knees          | 60                              | 100                           | 100                           | 67                         | 100       |
| TT-TG                    | 13.6                            | 10.24                         | 12.7                          | 13.1                       | 13.76     |
| TT-TG standard deviation | 8.8                             | 0.8                           | 3.4                           | 2.84                       | 5.86      |

Patellar height of Indonesian people according to the Insall-Salvati ratio and the Caton-Deschamps was  $1.09 \pm 0.17$  and  $0.97 \pm 0.16$ , respectively. These values were within the range of the normal international values. The trochlear angle of the patients assessed in this study  $138.97^\circ \pm 119.7$  was within the normal value. The lateral trochlear inclination assessed in this study  $20.37 \pm 4.56$  was within the normal value ( $>11^\circ$ ) but mostly in the very high value. TT-TG and the trochlear depth of the patients assessed in this study  $13.76 \pm 5.86$  and  $5.18 \pm 1.87$ , respectively, were within the normal values.

Previous study that measured TT-TG in normal Indian population using computed tomography (CT) of knees showed result 13.01 mm, which was not different between males and females and was similar to the Western population but this result was lower than our study [19]. In Korea, Song *et al.* reported the value of TT-TG Korean people of  $10.24 \pm 0.8$  mm, which was lower than our study [17]. Other study in Chile by Alemparte *et al.*, using CT scan, reported the mean Insall-Salvati and Caton-Deschamps indexes were  $1.09 \pm 0.24$  and  $0.95 \pm 0.29$ , respectively. These results were a similar with our finding in Indonesian people ( $1.09 \pm 0.17$  and  $0.97 \pm 0.16$ , respectively) [16]. Other parameters that Alemparte *et al.* investigated were sulcus angle and TT-TG values of  $139.7 \pm 20.4$  and  $13.6 \pm 8.8$  mm, respectively, which were similar with our study ( $138.97^\circ \pm 119.7$  and  $13.76 \pm 5.86$ ) [16]. In the study conducted by Dejour *et al.*, the mean TT-TG distance for the control group was  $12.7 \pm 3.4$  mm and the mean TT-TG distance for the patellar instability group was  $19.8 \pm 1.6$  mm, while 20 mm was determined as the cutoff value for patellar instability [13].

All of those parameter measurements were used to detect whether there was any patellar dysplasia or not [9], [14], [15]. The research conducted by Resorlu *et al.* found that any abnormalities in those trochlear morphological values influence chondromalacia in the patella [22].

Hsu *et al.* showed that gender plays a role in trochlear morphology, specifically male trochlear generally have greater height and width compared to females. This phenomenon was also reflected in our study that showed the male group has bigger values in trochlear depth and angle. However, these differences were not able to be evaluated statistically [22].

## Conclusions

The means of Insall-Salvati ratio, Caton-Deschamps index, trochlear angle, lateral trochlear inclination, and TT-TG trochlear depth of the Indonesian people were within the international normal range, and higher than other countries' published measurements.

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