

TROCHLEA SULCUS AND LATERAL TROCHLEA INCLINATION ANGLES IN KENYANS: AN OSTEOMETRIC STUDY

Lakati Kevin Christopher *, Arisi Kerubo, Yegon Fred, Mwaniki Mark, Mutero Flora.

Department of Human Anatomy, Faculty of Health Sciences, Egerton University, Kenya.

ABSTRACT

Background: The trochlea sulcus and lateral trochlea inclination angles have important implications in the biomechanics of the patellofemoral joint. Abnormalities of these angles have been implicated in patella instability, anterior knee pain and patella complications after both total knee and patellofemoral arthroplasty.

Objective: To measure the trochlea sulcus and lateral trochlea inclination angles on dried unpaired Kenyan femora.

Methods: The angles were measured on end-on digital images of grossly normal femora using an open source image analysis software, ImageJ®. Measures of central tendency were calculated.

Results: Average trochlea sulcus and lateral trochlea inclination angles were 139° and 21° respectively. There was no significant difference between the angles in the right and left femora. There was a negative correlation between the sulcus and lateral trochlea inclination angles. These angles are comparable to values in other populations.

Conclusion: Average sulcus angle in Kenyan femora is 139° and the average lateral trochlea inclination angle 21°, with no significant difference between right and left sides. These can be used as guide when analyzing diagnostic images of the knee for patella instability.

KEY WORDS: Trochlea Sulcus Angle, Lateral Trochlea Inclination, Patella Instability.

Corresponding Author: Lakati Kevin Christopher, Lecturer, Department of Human Anatomy, Faculty of Health Sciences, P.O. Box 536-20115. Egerton University, Kenya.

E-Mail: klakati@yahoo.com

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BACKGROUND

The trochlea sulcus angle, located at the distal end of the femur, is formed at the femoral trochlea groove by the junction of two straight lines that extend from the highest points of both the medial and lateral condyles and intersect within the trochlea groove [1]. The angle has important implications in the biomechanics of the patellofemoral joint. Abnormalities of the sulcus angle and the femoral trochlea have been implicated in patella instability, extensor apparatus malalignment and anterior knee pain [2,3]. In some patients, these abnormalities of

the angle and the patellofemoral joint complex may predispose to osteoarthritis of the joint [4].

The lateral trochlea inclination angle is the angle formed between a line tangential to the posterior aspect of the condyles and a line along the anterior aspect of the lateral trochlea facet [5]. A lateral trochlea inclination angle of less than 11° indicates trochlea dysplasia and is associated with patella instability [5]. The trochlea sulcus and lateral inclination angles have important bearing in both total knee and patellofemoral arthroplasty.

Patellofemoral complications are common after total knee and patellofemoral arthroplasty and are responsible for patient dissatisfaction and revisions. These complications range from maltracking, subluxation, dislocation, pain and loosening [6,7]. In patellofemoral arthroplasty, the morphology of the trochlea has an important bearing on component positioning. Malposition of the component leads to patella maltracking and subluxation [8]. Newer designs of total knee arthroplasty components have a more anatomic trochlear sulcus compared to earlier designs, in an attempt to minimize post-operative patellofemoral complications [9]. This study sought to determine the trochlea sulcus and lateral trochlea inclination angles of adult Kenyan femora and compare them with results of other published studies.

MATERIALS AND METHODS

Dry unpaired femora were obtained from the Department of Human Anatomy, Egerton University, Kenya. Only skeletally mature specimens were used. Specimens that looked grossly deformed, those with previous fractures or surgery and those with postmortem damage were excluded from the study.

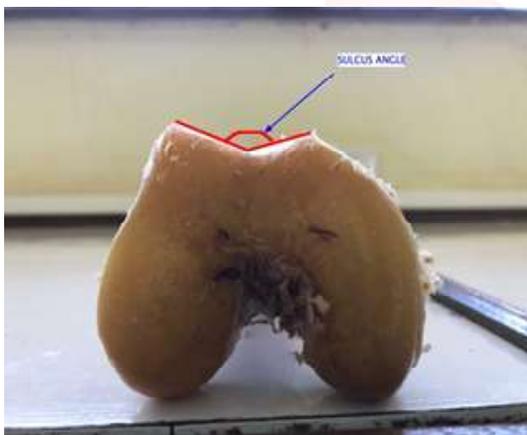


Fig. 1: Measurement of sulcus angle.

The specimens were placed on a flat board and an end-on digital photograph of the distal femur taken. This was adopted from the method by Murshed et al [10]. The pictures were uploaded to a computer and the angles measured using ImageJ® (National Institutes of Health, Bethesda, Maryland), an open-source image analysis software. The angle formed by the intersection of lines drawn from the most prominent points of both the lateral and medial femoral condyles was taken as the sulcus angle

and measured (Figure 1). For the lateral trochlea inclination angle, a line was drawn tangential to the posterior aspect of the condyles and the angle formed between that and a line along the anterior aspect of the lateral trochlea facet was measured (Figure 2). The data obtained was entered and analyzed on an Excel® spreadsheet (Microsoft Corporation). Measures of central tendency were obtained. For comparisons, a *p* value of less than 0.05 was taken as significant.

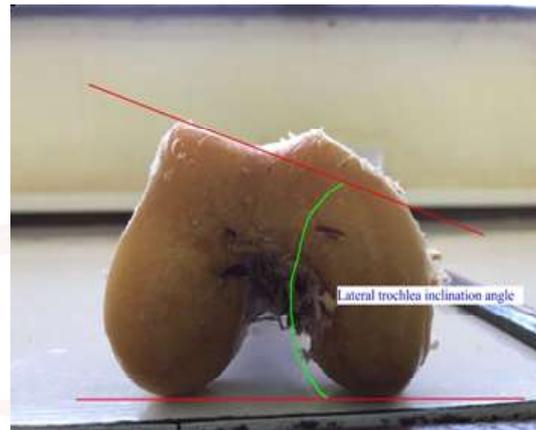


Fig. 2: Measurement of lateral trochlea inclination angle.

RESULTS

A total of 23 unpaired femora, of undetermined sex were obtained. Twelve (12) were right-sided while 11 were left-sided. An average sulcus angle of 139° was obtained for all specimens, with the average angle for right femora being 137° and 141° for the left femora. There was no significant difference between the angles for the right and left femora (*p* value 0.58). The average lateral trochlea inclination angle was 21°, the minimum being 11° and maximum being 27°. There was no significant difference between the trochlea inclination angles for the right and left femora (*p* value 0.58). These values are summarized in Table 1.

Table 1: Sulcus and lateral trochlea inclination angles of Kenyan femora.

	All specimens (n=23)	Right femora (n=12)	Left femora (n=11)
Mean sulcus angle	139°	137°	141°
Minimum sulcus angle	120°	120°	123°
Maximum sulcus angle	161°	160°	161°
Mean lateral inclination angle	21°	20°	21°
Minimum lateral inclination angle	11°	13°	11°
Maximum lateral inclination angle	27°	25°	27°

Table 2: Comparison between results of current study and other populations.

Author	Study type	Ethnicity	Mean sulcus angle (°)	Mean sulcus angle right femora	Mean sulcus angle left femora
Current study	Dry bone study	Kenyan	139	137	141
Murshed et al [10]	Dry bone study	Turkish	141.2-Both gender	142.2	141.2
Mwakikunga et al [11]	Dry bone study	Malawians	142.4	142.9-males	141.8-males
				144.3-females	140.6-females
Qin et al [12]	3D CT images normal subjects	Chinese	154.41		

A plot of the trochlea sulcus angle and the lateral trochlea inclination angle showed a negative correlation, as shown in Figure 3.

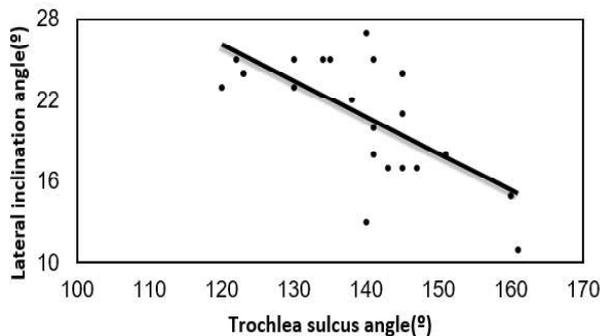


Fig. 3: Relationship between trochlea sulcus and lateral trochlea inclination angles.

DISCUSSION

The current study has shown the average trochlear sulcus in adult Kenyan femora to be 139°, with no significant difference between the right and left sides. These figures are close to those obtained by Murshed et al in a dry bone study in a Turkish population, who found an average sulcus angle of 141.2° [10]. Mwakikunga et al, in an osteological study in a Malawian population found a mean angle of 142.4° [11], which is close to the figures obtained in the current study. A study on normal Chinese subjects using 3D CT images reported a mean angle of 154.41° [12]. This difference in the angles could be due to population differences or differences in the methods of measurement, as the current study utilized analysis of images using image processing software. The angle at which the measurements are taken can also influence the values obtained, with progressive reduction as the angle of knee flexion increases [13,14].

Studies have shown that the osseous sulcus angle is inversely related to age, being flatter in the youngest children and progressively reducing with age [15]. In the fetus, the cartila-

ginous sulcus angle, however, approaches the adult osseous sulcus angle, showing that the bony angle develops progressively as ossification of the distal femur proceeds [16]. Wide sulcus angles are associated with trochlear dysplasia and patella instability [2]. In a comparative study of patients with patella instability and controls in an Egyptian population, Ebrahim et al found patients with patella instability had a mean angle of 152.7° whilst the control group had a mean angle of 134.4° [17]. Similar findings were reported by van Huyssteen et al who found a mean bony sulcus angle of 167.9° in patients with patella instability and dysplastic knees and 138.2° in controls [18]. The same authors found that the cartilaginous sulcus angle was generally shallower compared to the bony sulcus angle, in both dysplastic and normal knees [18]. The implication of their finding, especially in resource-poor settings, is that because many patients are investigated using plain radiography using either the Merchant [19] or Brattstrom [2] views, the bony sulcus angle visualized is narrower than the cartilaginous angle, thus underestimating the angle. A wide angle has also been shown to be associated with patellofemoral pain and lateral patella tilt, which is associated with patella instability [20].

The lateral trochlea inclination angle has been used as a measure of trochlea dysplasia, with an angle less than 11° associated with trochlea dysplasia and patella instability [5]. In the present study, the mean lateral inclination angle was 21° with a minimum of 11°. The trochlea sulcus and lateral inclination angle were found to be negatively correlated, with the inclination angle reducing as the sulcus angle increased. This is not unexpected because as the sulcus angle increases towards a shallow dysplastic angle, the inclination angle would also reduce.

Patellofemoral complications after patellofemoral and total knee replacement can be as a result of surgical technique like errors in implant size, positioning and soft tissue balancing. The geometry of the trochlea in the femoral component i.e. curvature, depth and angle has also been implicated in causation of patello-femoral symptoms after total knee replacement [21]. Earlier designs had wider angles which have subsequently been reduced in newer designs to try and replicate the anatomy of the native femoral trochlea [9]. There is a dearth of local studies on outcomes especially patellofemoral symptoms, which, elsewhere, are responsible for patient dissatisfaction and revisions.

A limitation of the current study is that it was done on dried femora of unknown gender, without a previous medical history like patella instability. It can however form the basis for further local clinical studies on the relationship between the sulcus angle and patella instability and patellofemoral outcomes after total knee replacement. The results can also be useful in designs of both patellofemoral and total knee implants for use in the local population.

CONCLUSION

The current study has found that the average sulcus angle in Kenyan femora is 139° and the average lateral trochlea inclination angle 21°, with no significant difference between right and left sides. This can be used as a guide when analyzing diagnostic images of the knee. Further local clinical studies should be done on the relationship between the sulcus angle, lateral trochlea inclination angle and patella instability.

Conflicts of Interests: None

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