



Evaluation of Normal Calcaneal Angles in Chennai Population

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Background: The calcaneus bone (heel bone) has angles called the Bohler's angle (BA) and the Gissane angle (GA). Estimation of the normal values of these angles can help in their surgical reduction and in restoring the function of the bone in calcaneal fractures. **Aim:** Our aim is to evaluate the normal limits of BA and GA from lateral view radiographs of the foot of patients presenting to a tertiary care center and also assess the distribution of these parameters with respect to age, sex, and side of the body and also compare them with literature. **Methods:** A retrospective study was done on 100 randomly selected patients with intact calcaneus bone attending the Department of Orthopedics of our Tertiary Care Hospital between January 2020 and March 2020. Lateral plain radiographs of both feet are obtained and the angles are calculated by two observers using a goniometer and pencil. Mean BA and GA were calculated and their relationship with age, sex, and side of the body were assessed. The SPSS (Statistical Package for Social Sciences. IBM corp, Armonk, NY, USA) software was used. Unpaired *t*-test for correlation between the mean of angles with gender and with side of the body and one-way ANOVA test was done for correlation between the mean of angles with age. **Results:** The mean value of BA in our study was $30.03^\circ \pm 5.09^\circ$ (range: 20.2° – 42.3°) and mean GA was $123.57^\circ \pm 7.53^\circ$ (range: 101.5° – 135.3°). No statistically significant variations were found for sex (BA: $P = 0.2108$; GA: $P = 0.2172$), age groups (BA: $P = 0.6003$; GA: $P = 0.2275$), and side of body (BA: $P = 0.1819$; GA: $P = 0.0602$). **Conclusion:** Variations of statistical significance were present between the results of our study with that of other studies in the past. The values obtained from our study can be used as a reference standard for use by orthopedic surgeons in the treatment of calcaneal fractures for Chennai population.

Key words: Calcaneal angles, calcaneus fracture, Bohler's angle and Gissane angle

INTRODUCTION

The foot is divided into three parts: the forefoot, midfoot, and hindfoot. Seven bones, called tarsals, make up the hindfoot and midfoot. The hindfoot and midfoot consist of seven bones called tarsals. Fracture of calcaneus may be due to a fall from a height, twisting injury to the ankle or a motor vehicle accident. Calcaneal fractures are also called "Lover's fracture" or "Don Juan" fracture. Calcaneal angles such as Bohler's angle (BA) and the crucial angle of Gissane angle (GA) may be disrupted during the fracture and their estimation can give details about the degree of deformity, measure of fracture severity, and the quality of restoration to normal levels is a prerequisite for a good prognosis.

BA (Tuber joint angle or salient angle): it is the complementary angle formed by intersection of two lines

on plain lateral view X-ray of foot.¹ The first line is drawn from highest point of anterior process to highest point of the posterior facet. The second line runs tangential to superior edge of the tuberosity.¹ Decrease in this angle means the posterior facet which bears the weight of the body has collapsed and the body will be displaced anteriorly [Figure 1].

The crucial angle of GA is the angle between two thick cortical struts from front of bone to posterior facet.¹ This angle supports the lateral process of talus. Any axial compression force may disrupt the subtalar joint and distort the crucial angle [Figure 2].¹

Studies conducted in different countries have shown varying results. However, no study on estimation of normal calcaneal

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Figure 1: Bohler's angle

angles or its correlation with age and sex has been conducted on the population of Chennai, an urban cosmopolitan city in South India.

The objective of our study is to evaluate the normal range of BA and GA from lateral view radiographs of the foot of patients presenting to Tertiary Care Center in Chennai and also assess the distribution of these angles with respect to age groups, gender, and side of body and also compare them with data acquired from literature.

MATERIALS AND METHODS

Ethical approval

The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee of the institute (IRB institutional name: Saveetha Medical College and Hospital Institutional Ethics Committee (smch-iec) Saveetha Nagar, Thandalam-602105, IRB approval number: SMC/IEC/2020/03/541, IRB approval date: 24/03/2020). Informed written consent was obtained from all patients prior to their enrollment in this study.

Study design

A retrospective study was conducted between January 2020 and March 2020. Plain lateral radiographs of the foot and ankle were obtained on patients with no calcaneal fractures.

Study area

Patients residing in and around Chennai, attending the Orthopedics Department of our tertiary care hospital were randomly selected using multistage random cluster sampling.

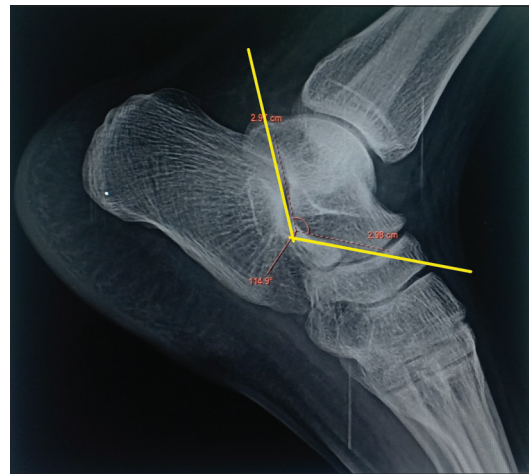


Figure 2: Crucial angle of Gissane

Sample size

Bilateral radiographs of 100 study participants (200 ankles) with no calcaneal fractures, selected by multistage random cluster sampling calculated by the statistician from the available data, were collected between January 2020 and March 2020. Of these 100 participants, there were 70 males and 30 females. Twenty patients were <20 years of age, 66 were between ages 21–49 years, and 14 patients were above 50 years of age. The patients were in the age range of 8–80-years-old.

Inclusion criteria

Patients with no calcaneal or any tarsal bone fractures or diseases of the foot were selected.

Exclusion criteria

Any patient with any fracture of tarsal bones or any congenital or acquired pathology of the foot and leg was not included in the study.

Data collection

Lateral view plain X-ray of bilateral ankles of each participant obtained using a digital X-ray machine was collected. The BA and critical angle of Gissane of each calcaneus bone of both sides were measured by two independent observers using goniometer and pencils. The BA is the complementary angle formed by intersection of two lines, of which the first line is drawn from the highest point of anterior process to the highest point of the posterior facet. The second line runs tangential to superior edge of the tuberosity. GA is the angle between lines drawn on linear opacity of anterior facet to lateral border opacity of posterior facet. The angles were measured twice, the first time, and repeated after a month by the same observers to reduce any errors of observations and to ensure accuracy.

The arithmetic mean value of the twice measured angle was considered the final angle.

Data analysis

Data analysis was done using the Statistical Package for Social Sciences software. The mean, standard deviation, and ranges of BA and GA were calculated. The association between these angles and age was tested using ANOVA test, and the relation of angles with that of sex of the person and side of the body was calculated by independent sample *t*-test. $P < 0.05$ was obtained to be significant. The results obtained were compared to that of published results of other studies conducted in different countries.

Table 1: Mean values of Bohler's angle and Gissane angle of our study

Mean±SD	
Bohler's angle	Gissane angle

Table 2: Correlation of calcaneal angles with gender (by unpaired *t*-test)

Sex	Percentage of participants	Mean±SD	
		Bohler's angle	Gissane's angle
Male	70	30.74±5.18	122.70±7.72
Female	30	28.78±4.53	125.59±6.89
<i>P</i>		0.2108	0.2172
<i>T</i>		1.268	1.2505

SD=Standard deviation

Table 3: Correlation of calcaneal angles with age groups (by one way ANOVA test)

Age group (years)	Percentage of participants	Mean±SD	
		Bohler's angle	Gissane's angle
<20	20	28.32±5.94	127.11±4.16
21-49	66	29.9±4.85	122.42±8.10
>50	14	31.8±5.49	123.92±7.66
<i>P</i>		0.6003	0.2275
<i>f</i>		0.5158	1.5281

SD=Standard deviation

Table 4: Comparison of calcaneal angles with side of body (by unpaired *t*-test)

	Bohler's angle		Gissane angle	
	Left	Right	Left	Right
Mean	29.46±3.40	30.60±7.81	122.50±6.72	124.64±9.11
<i>P</i>	0.1819		0.0602	
<i>T</i>	1.3398		1.8904	

RESULTS

The mean value of BA obtained from our study was $30.03^\circ \pm 5.09^\circ$ (range: 20.2° – 42.3°) and mean GA was $123.57^\circ \pm 7.53^\circ$ (range: 101.5° – 135.3°) [Table 1].

Distribution of the two angles with respect to sex was done by unpaired *t*-test, results of which are given in Table 2. No statistical significance was present between BA and sex ($P = 0.2108$) and GA with sex ($P = 0.2172$).

Correlation of angles with ages was done by separating the population into three age groups: <20 years, 21–49 years, and >50 years old, and their correlation were checked through one-way ANOVA test is given in Table 3. There seemed to be no statistical significance. The *P* value of Bohler's is 0.6003 and that of Gissane's is 0.2275.

Correlation of the values of angles with the left and right side of each participant calculated by unpaired *t*-test is given in Table 4. It was not statistically significant BA ($P = 0.18$) and GA ($P = 0.06$).

DISCUSSION

This study was set out to estimate the normal values of calcaneal angles in intact calcaneus bone, namely, BA and GA required for anatomical reduction, surgically during calcaneal fracture. The reduction of the fracture to normal angle limits enhances their functional recovery.

The mean BA in our study is 30.03 ± 5.09 . The lowest value we found was 20.3° and the highest was 42.3° . The lower limits are important as mostly; there is a decrease in both angles during the fracture.¹ The mean critical angle of Gissane is 123.57 ± 7.53 . The lowest is 101.5° and the highest was 135.3° . An increase in GA occurs in the fracture of subtalar joint surface.

The variation between the angles of the left and right foot was statistically insignificant. This shows that, in unilateral calcaneal fractures, the angles of the patient's intact foot can be used as a reference value.¹

The variation according to age was also statistically insignificant. Comparing three different age groups, the variations were negligible. This shows that the patient's previous X-ray of calcaneus bone without any fractures can be used as a reference to identify their normal levels and is helpful during bilateral calcaneal fractures.²

The variations with respect to sex were also statistically insignificant. This shows that, in case of nonavailability of previous X-rays to be used as a reference for surgical reduction, the mean BA and GA values from literature from that geographical region can be used as a standard irrespective of gender.

Our study yielded values similar to the results of the Study in Egypt (Table 5).¹ However, there was statistically

Table 5: Comparison of calcaneal angles with those of different studies conducted on unfractured calcaneus bone²

Study	Year	Range (degree)
Didia and Dimkpa (Nigerian) ⁷	1999	BA: 28-38
Igbigbi and Msamati (Malawian) ⁸	2002	BA: 14-45
Igbigbi and Mutesasira (Ugandan) ⁹	2003	BA: 20-50
Khoshhal <i>et al.</i> (Saudi Arabian) ⁶	2004	BA: 16-47 GA: 96-152
Seyahi <i>et al.</i> (Turkish) ³	2009	BA: 20-46 GA: 100-133
Shoukry <i>et al.</i> (Egypt) ¹	2012	BA: 22-40 GA: 108-138
Sengodan <i>et al.</i> (India) ⁴	2012	BA: 18-43 GA: 100-145
Ramachandra and Shetty (India) ⁵	2015	BA: 18.7-46.2 GA: 86.3-137.8
Rokaya <i>et al.</i> (Nepal) ²	2017	BA: 18-47 GA: 85-135
Our study (Chennai, India)	2020	BA: 20.2-42.3 GA: 101.5-135.3

BA=Bohler's angle, GA=Gissane angle

significant variation between both BA and GA values of our study and that of Turkey³ (both $P < 0.0001$), whereas only GA values showed extremely statistically significant variations from that of other 2012 study in India⁴ ($P = 0.0003$), 2015 study in India⁵ ($P < 0.0001$), Nepal² ($P < 0.0001$), and Saudi Arabia⁶ ($P < 0.0001$), whereas BA variations were not statistically significant. This shows that the range of angles varies according to the different population groups.⁵

The normal values of these angles are essential to estimate the degree of deformity, disease severity, and the level of correction required by the Orthopedic surgeon to restore the bone and its function.

CONCLUSION

The normal limits of BAs and GAs obtained in our study can be considered reference value upon which further studies can be conducted and as a reference value for population in and around Chennai, South India for use by Orthopedic surgeons for

calcaneal fracture treatment, the results obtained on sex, age, and side of body correlation can be used for specific individual-based treatment. As this was a short-term study, we conducted this on a small scale of 100 participants, we hope to encourage further studies with a larger scale population to be conducted in the future on the participant of calcaneal angles and calcaneal fractures.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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