Böhler's and Gissane's angles of the calcaneus in the Saudi population

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ABSTRACT

Objectives: The purpose of this study is to measure Böhler's angle (BA) and Gissane's angle (GA) in the Saudi population and compare their values to the published data.

Methods: Lateral plain radiographs of 229 normal feet and ankles of 158 females and 71 males, with age range of 15-72 years, were studied retrospectively at King Khalid University Hospital, Riyadh, Kingdom of Saudi Arabia between 2002 and 2003. Böhler's angle and GA were measured and the mean and standard deviation of each angle were calculated. The relationship between each angle and age, gender, and side of body was tested, and compared to international figures.

Results: The mean BA in the Saudi population was 31.21° with a range of 16°-47°. The mean GA was 116.16° with a range of 96°-152°. Böhler's angle and GA are not significantly related to age, gender, or side of body. Moreover, the range of both angles was wider than that reported in the literature.

Conclusion: The study shows the difference between the Saudi and various other populations in regard to BA and GA, and reinforces the need to establish the normal ranges of BA and GA in a given population.

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The calcaneus is the largest of the 7 tarsal bones, with multiple articulations and many ligamentous and tendinous attachments. It contributes to the posterior aspect of the longitudinal arch, supports the talus, and shares in weight bearing.

Böhler's angle (BA) is known also as calcaneal angle, tuber joint angle, salient angle, and critical angle. It is a 3-point angle in which all of the points are located entirely on the calcaneus.[1] Böhler's angle ranges from 14°-50° in the populations studied.[2-5] Since all points are on the calcaneus, any fracture allows the posterior part of the calcaneus to move on the anterior part will be manifested by a change in BA.[2] Furthermore, it measures the height of the posterior facet and consequently identifying the degree of compression and deformity in case of calcaneal fractures. Therefore, it is an accepted method of quantifying fracture displacement and predicting the prognosis of calcaneal fractures by using a simple radiographic measurement. Restoration of BA improves outcome; however, this remains controversial.[6] Fractures with a markedly diminished BA demonstrated a much poorer 2-year outcome regardless of treatment.[6] Different studies were performed to establish the normal values for the BA in a given population and to look for the variations of such angle in different ethnic populations. So far, few estimations of this angle have been in Caucasians[2,3] and black Africans.[4,5] Despite its clinical importance, no studies have been conducted to determine the normal BA in Asians or

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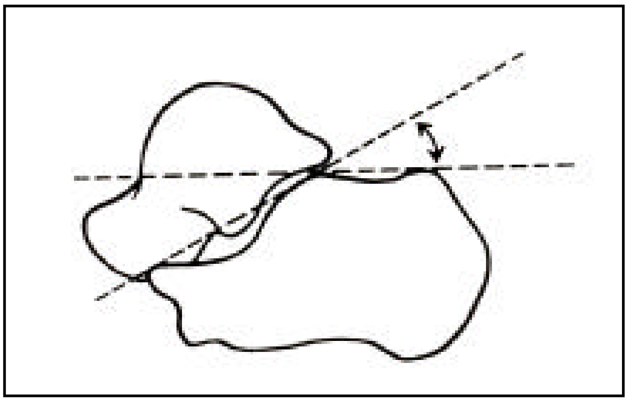

Figure 1 - Lateral view of the calcaneus showing Böhler's angle.

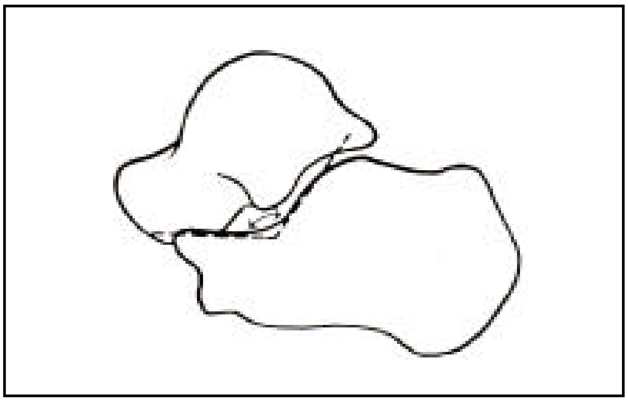

Figure 2 - Lateral view of the calcaneus showing Gissane's angle.

Mediterraneans and particularly, in the Saudi population.

Another angle that also has all its 3 points on the calcaneus is known as Gissane's angle (GA).[7-9] It has been described to help in the assessment of calcaneal fractures, especially by axial compressive forces and reflects the relationship of the anterior, middle and posterior facets. This angle ranges from 120°-145° in the population studied.[9] According to the literature available, the relationship between GA and gender, side of body and age has never been investigated before.

The main purpose of this study is to provide the normal ranges of BA and GA among the Saudi population as it has been shown that these angles may differ from one population to another. The relationship between each angle and age, gender, as well as side of the body was also studied.

Methods. In this retrospective study, the authors reviewed 229 lateral plain radiographs of the foot and ankle, with an age range of 15-72 years (mean 40.26 years), collected from the King Khalid University Hospital, College of Medicine, King Saud University, Riyadh, Kingdom of Saudi Arabia between 2002 and 2003. Of these radiographs, 158 were females and 71 males; 117 were of the right side and 112 were of the left. All radiographs were of normal feet without congenital or acquired deformities and with no arthritic changes. Böhler's angle was measured as the complement of the angle formed by 2 lines: the first line was drawn between the superior aspect of the anterior process and the superior aspect of the posterior articular surface. A second line was drawn between the same point on the posterior articular surface and the most superior point of the calcaneal tuberosity (**Figure 1**). Gissane's angle is formed by the downward portion of the posterior facet where it connects to the upward portion (**Figure 2**).

All computed radiographs were obtained on Digital x-ray system (Advantex, General Electric Medical Systems, Milwaukee, WI, 40 KV, 4 mA). Images were reviewed on a Picture Archiving and Communication System (PACS) Monitor (Centricity, version 1-Ø CSR4 Service Pack 1, General Electric Medical Systems, Milwaukee, WI). All angles were obtained utilizing a virtual Electronic Goniometer by 2 consultants independently.

Statistical analyses. The results were analyzed using the Statistical Package of Social Sciences 8.0 for windows. The mean and SD of each angle were calculated. The relationship between each angle and age was tested, using Analysis of Variance (ANOVA) test. Student's t-test was used to test the relationship between each angle and gender and side of the body. Z-test of percentages drawn from 2 different samples was used to compare the results of the present study with those of Didia and Dimkpa's study on the Nigerian population.[4]

Results. The mean of BA in the Saudi population was 31.21° (range of 16°-47°) and GA was 116.16° (range 96°-152°). **Table 1** shows the distribution of BA and GA according to gender and side of the body. There was no statistically significant difference in comparing BA or GA to either gender or side (independent Student's t test, $p>0.05$). The Student's t-test was used for matched pairs to compare the means of both BA and GA of the right side to that of the left in 101 cases that had both sides measured. There was no statistically significant difference in both angles ($p>0.05$). Measured angles were divided according to age into 5 age groups. The age group 15-20 years had the highest mean for BA (33.11°), while the age group 21-30 years had the lowest mean (29.155°) (**Table 2**). The age group of 15-20 years had the lowest mean for GA (114.65°), while the age group of 21-30 years had the highest mean

Table 1 - Böhler's and Gissane's angles, according to gender and side.

Characteristics	Böhler's angle			Gissane's angle		
	Mean	Range	SD	Mean	Range	SD
Gender						
Male	31.15°	16-47°	6.64°	115.66°	98-136°	7.26°
Female	31.24°	18-43°	5.27°	116.39°	96-152°	9.03°
Location						
Right side	31.37°	18-47°	5.71°	116.36°	96-152°	9.10°
Left side	30.94°	16-43°	5.49°	115.83°	96-149°	7.46°
Total	**31.21°**	**16-47°**	**5.62°**	**116.16°**	**96-152°**	**8.51°**

Table 2 - Böhler's and Gissane's angles in different age groups.

Age groups (years)	n	(%)	Böhler's angle		Gissane's angle	
			Range	SD	Range	SD
15-20	17	(7.4)	33.11°	7.93°	114.65°	8.8°
21-30	21	(9.2)	29.155°	3.77°	117.05°	6.91°
31-40	68	(29.7)	30.67°	5.31°	115.32°	8.97°
41-50	76	(33.2)	31.02°	5.15°	117.02°	7.49°
51-72	47	(20.5)	32.52°	6.22°	116.17°	10.16°

Table 3 - Distribution of Böhler's angles in comparison with the Nigerian study.[4]

Böhler's angle	Subjects within range			
	Present study		Nigerian study	
	n	(%)	n	(%)
<28	66	(28.8)	-	
28-29	33	(14.4)	46	(15.2)
30-31	32	(14)	59	(19.5)
32-33*	36	(15.7)	79	(26.2)
34-35*	18	(7.9)	60	(19.9)
36-38*	20	(8.7)	58	(19.2)
>38	24	(10.5)	-	-
Total	**229**	**(100)**	**302**	**(100)**

*There is a statistically significant difference (p<0.05)

Table 4 - Comparison of ranges of Böhler's angles reported in previous studies.

Study	Year of study	Race	Range
Hauser and Kroeker[2]	1975	Caucasians	20-40°
Chen et al[3]	1991	Caucasians	14-50°
Loucks and Buckley[6]	1999	Caucasians	25-40°
Didia and Dimkpa[4]	1999	Nigerians	28-38°
Igbibi and Mutesasira[5]	2001	Ugandans	20-50°
Present study	2004	Saudi	16-47°

(117.05°) (**Table 2**). Using one way ANOVA test, there was no statistically significant difference (p>0.05) between BA and GA and the different age groups. The frequency of different BA of the Saudi population was compared to that of the Nigerian population (**Table 3**).[4] Z-test of percentages drawn from 2 different samples was used, and there was a statistically significant difference (p<0.05) in the angles between 32°-38°. Compared to the Nigerian study,[4] 28.8% of the readings in the current study were below and 10.5% were above their range.

Discussion.

The present study reported a range of 16°-47° in BA and 96°-152° in GA in the Saudi population. The results of the current study help in the assessment and decision making for the treatment of calcaneal fractures among the Saudi population. This study showed that BA in the Saudi population has a wider range than all of the published data, with the exception of the report of Chen et al[3] (**Table 4**). The results direct the attention to the importance of awareness of the lower limit of the range of BA in normal Saudi population. Otherwise, an incorrect assessment of calcaneal fractures could be made and an incorrect restorative treatment might be offered. The insignificant difference of both BA and GA regarding the side adds a good control for treating unilateral calcaneal fractures by using the normal side. Also, the insignificant difference of both angles regarding age may help in treating bilateral fractures of a patient if a previous x-ray of the calcaneus is available before fracture.

An interesting observation was that the age group of 15-20 years possessed the highest mean for BA and lowest mean for GA. On the other hand, the age group of 21-30 years had the lowest BA and highest GA. The relationship between BA and GA needs further investigations.

The present study compared the frequency of different BA of the Saudi population to that of another study performed on Nigerians.[4] The results of such comparison confirm ethnic variation between Saudis and other populations.

In conclusion, BA and GA are like many other skeletal angles that may have ethnic variation between different populations. Studying the range of each angle in a particular race may help in treatment decisions.

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