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The calcaneal angles in the Turkish population

Türk toplumunda kalkaneus açıları

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Amaç: Kalkaneus kırığı bulunmayan kişilerin radyografilerinde ölçülen kalkaneus açılarının dağılımı ve normal sınırlarının belirlenmesi amaçlandı.

Çalışma planı: Çalışmada, kalkaneus kırığı bulunmayan 268 hastaya ait (106 erkek, 162 kadın; ort. yaş 42; dağılım 18-79) 308 adet dijital yan ayak ve ayak bileği grafisi geriye dönük olarak incelendi. Bu grafiler üzerinde, 1/100 mm duyarlıkta açı ölçümü yapan bir yazılım yardımıyla referans çizgileri çizilerek, Böhler (BA) ve Gissane (GA) açıları ölçüldü. Açıların dağılım özellikleri, cinsiyet, yaş ve taraf ile olan ilişkileri incelendi. Saptanan dağılım özellikleri literatürdeki diğer çalışmaların sonuçlarıyla karşılaştırıldı.

Sonuçlar: Böhler açısı ortalama 33.8±4.8° (dağılım 20°-46°), GA ise ortalama 115.0±6.5° (dağılım 100°-133°) bulundu. Her iki açı için sağ ve sol taraf ortalamaları arasında (BA için p=0.198; GA için p=0.601) ve cinsiyetler arasında (BA için p=0.177; GA için p=0.412) anlamlı fark bulunmadı. En yüksek (35.2°) ve en düşük (32.3°) ortalama BA değerleri sırasıyla 41-50 ve 61-83 yaş gruplarında görüldü. Gissane açısı için en yüksek (115.7°) ve en düşük (114.4°) ortalama değerler sırasıyla 21-30 ve 51-60 yaş grubunda idi. Yaş grupları arasında anlamlı farklılık saptanmadı (BA için p=0.086; GA için p=0.955). Ortalama BA değeri literatürdeki diğer sonuçlardan anlamlı derecede farklı bulundu. Korelasyon analizinde BA ve GA arasında anlamlı ilişki saptanmadı (r=0.018; p=0.76). Kalkaneus açılarıyla yaş arasında da anlamlı bir ilişki yoktu (BA için: r=-0.092; p=0.11 ve GA için: r=-0.070; p=0.22).

Çıkarımlar: Kalkaneus açıları farklı ırk ve toplumlarda farklı normal sınırlar; yaş, cinsiyet ve tarafa göre farklı dağılım gösterebilir. Örnek grubumuzda saptanan BA için 20°-46°, GA için 100°-133° aralığı Türk toplumu için referans değerleri olarak kullanılabilir.

Anahtar sözcükler: Erişkin; kalkaneus/anatomi ve histoloji/radyografi; referans değeri; Türkiye.

Objectives: The purpose of this study was to determine the calcaneal angles on radiograms of individuals without a calcaneal fracture.

Methods: We retrospectively analyzed a total of 308 digital records of lateral ankle or foot radiographs taken from 268 patients (106 males, 162 females; mean age 42 years; range 18-79 years) without a calcaneal fracture. On these radiographs, the reference lines were drawn with the use of an angle measurement software with a sensitivity of 1/100 mm and the Böhler (BA) and Gissane (GA) angles were measured. The distribution characteristics of the angles with respect to age, gender, and side of the body were analyzed and compared with those of previous studies.

Results: The mean BA was 33.8±4.8° (range 20° to 46°) and the mean GA was 115.0±6.5° (range 100° to 133°). There were no significant differences for both angles with respect to measurements obtained from the right and left sides (for BA, p=0.198; for GA, p=0.601) and from both sexes (for BA, p=0.177; for GA, p=0.412). The highest (35.2°) and lowest (32.3°) means of BA were seen in the age brackets of 41-50 and 61-83 years, respectively. The corresponding age brackets for GA were 21-30 and 51-60 years with 115.7° and 114.4°, respectively. There were no significant differences between the age groups for both angles (for BA, p=0.086; for GA, p=0.955). Of note, the mean BA was significantly higher than those reported in previous studies. There was no correlation between BA and GA (r=0.018; p=0.76), nor between the calcaneal angles and age (for BA, r=-0.092; p=0.11 and for GA, r=-0.070; p=0.22).

Conclusion: The calcaneal angles show considerable variations in diverse ethnic groups and populations in terms of normal range, age, gender, and side. The ranges herein reported (20-46° for BA, 100-133° for GA) can be used as reference values for the Turkish population.

Key words: Adult; calcaneus/anatomy & histology/radiography; reference values; Turkey.

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Fractures of the calcaneus are the most common tarsal fracture and they account for approximately 2% of all fractures. The degree of comminution and the Böhler Angle (BA) at the time of initial presentation are among the most important predictors of the outcome in calcaneal fractures.[1-3]

Böhler Angle was introduced by Dr. Lorenz Böhler in 1931 as the "tuber angle" and a decrease in this angle indicates that the weight-bearing posterior facet of the calcaneus has collapsed (Figure 1). [4] In his original article Böhler reported the normal range of the BA between 30°–35°.[4] Since then various ranges such as 25°–40°, 14°–50°, 28°–38°, 20°–50°, 16°–47° and 20°-40° were mentioned in several studies (Table 1).[2,5-10]

Gissane angle (GA) is another calcaneal angle in the assesment of calcaneal fractures (Figure 2). Again various ranges, such as 96° – 152°, 100°–130°, 120° – 145° and 95° – 105° were reported in different studies.[8,11] While a GA beyond these ranges can suggest a fracture of calcaneus, there is no strict limit for fracture.

Recognizing the normal limits of the calcaneal angles is important in determining the degree of deformity and quality of reduction, and can thus help to predict the morbidity after calcaneal fractures.[1-3,12]

The previous studies performed in the American, African and Saudi populations revealed a wide variability of the calcaneal angles among these different populations.[2,5-10] No study about the normal ranges of the calcaneal angles in the Mediteranean and Turkish populations was to our knowledge at the time of preparation of this manuscript.

The aim of our study was to determine the normal ranges of the calcaneal angles in the Turkish population and to compare the results with the data in the literature.

Materials and methods

The digital records of the lateral X-rays of the foot or ankle taken between January 2005 and July 2007 were retrospectively analyzed. The records with radiographic evidence of tarsal coalition, deformity or fusion were excluded and only the X-rays with the exact superposition of the malleoli were included into the study. Thus the study group consisted of 308 digital lateral foot or ankle X-Ray records of 268 patients (106 male, 162 female; mean age: 41.98 (18-79); 145 right and 163 left side).

The same investigator measured on all digital records the Böhler and Gissane angles using the angle measurment macros of the Hipax (version 4.1.4) software, with a sensitivity of 1/100 millimeters.

Böhler angle was measured as the angle between the line connecting the uppermost points of the posterior facet and tuber calcanei and the line connecting the uppermost points of the posterior facet and anterior process (Figure 3a). Gissane angle was measured as the angle between the lines drawn on the lateral border opacity of the posterior facet and

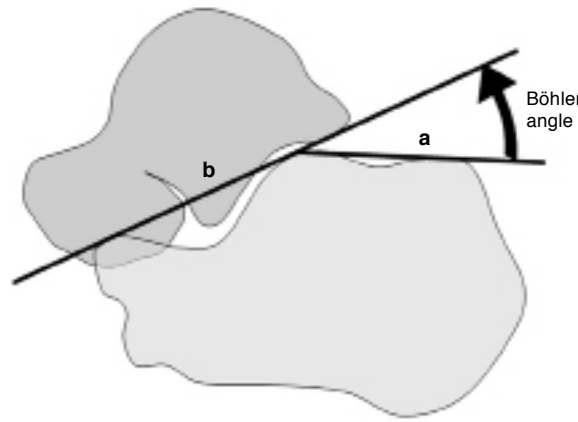

Figure 1. Böhler angle: Böhler angle was measured as the angle between the line connecting the uppermost points of the posterior facet and tuber calcanei **(a)** and the line connecting the uppermost points of the posterior facet and anterior process **(b)**.

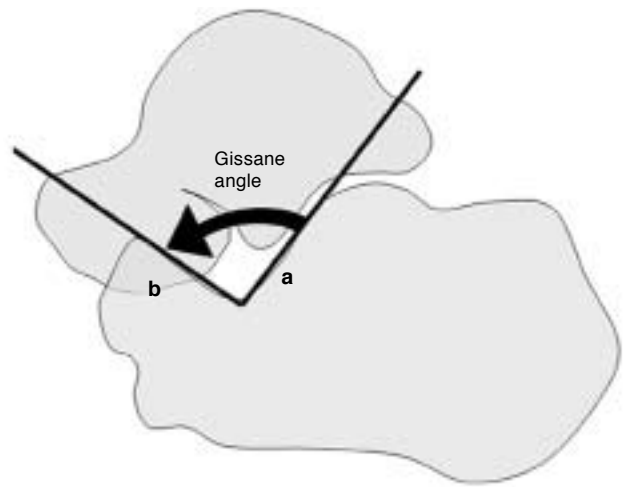

Figure 2. Gissane angle was measured as the angle between the lines drawn on the lateral border opacity of the posterior facet **(a)** and the line drawn on the linear opacity of the anterior facet **(b)**.

Table 1. Normal ranges of the calcaneal angles reported in previous studies (BA: Böhler angle; GA: Gissane angle.)

	Reported limits (°)	Range (°)
Hauser and Kroeker,[9] 1975 (American)	BA: 20-40	20
Chen et al.,[5] 1991 (American)	BA: 14-50	36
Loucks and Buckley,[2] 1999 (Canadian)	BA: 25-40	15
Didia and Dimkpa,[6] 1999 (Nigerian)	BA: 28-38	10
Igbigbi and Mutesasira,[7] 2003 (Uganda)	BA: 20-50	30
Khoshhal et al.,[8] 2004 (Saudi Arabian)	BA: 16-47	31
	GA: 96-152	56
Present study, 2008 (Turkish)	BA: 20-46	26
	GA: 100-133	33

the line drawn on the linear opacity of the anterior facet (Figure 3b).

Distribution of the angles was analyzed with descriptive methods. The relations of the angles with gender, age and side were analyzed. The results were compared with results of the previous studies.

Statistical analysis: SPSS 13.0 software was used in statistical analysis. In addition to the descriptive methods (median, mean, standard deviation), dependent t-test was used to compare paired samples (comparison of the angles according to the side), independent t-test was used to compare the unpaired samples (comparison of the angles according to the sex). Distribution of the angles within different age groups was compared with one way analysis of variance. Chi-Square test to compare qualitative data (in the comparison with the foreign studies). The level of significance was set at $p<0.05$

Results

The mean Böhler angle (BA) of the whole group was 33.8° ± 4.8° (20° - 46°). The mean BA was 34.3° ± 4.8° in men, and 33.5° ± 4.8° in women. There was no statistically significant difference between the mean of the sexes (t-test, p=0.177). Forthy patients had X-Ray for their both feet. In these patients the mean BA was 34.0° ± 5.0° for the right side and 33.5° ± 5.5° for the left side, with no statistically significant difference between the sides (paired sample t-test; p=0.198) (Table 2).

The mean Gissane angle was 115.0° ± 6.5° (100-133). The mean was 115.4° ± 6.6°, in men and 114.8° ± 6.4°, in women. There was no statistically significant difference between the mean of the sexes (t-test, p=0.412). In 40 patients with bilateral X-rays, the mean GA was 115.5° ± 6.5° for the right side and 115.1° ±

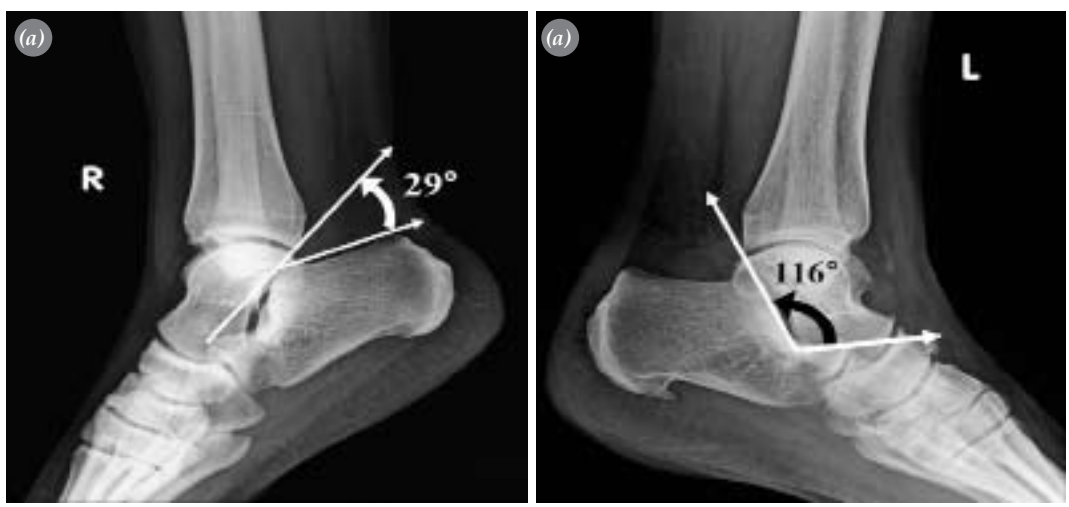

Figure 3. (a) Measurement of the Böhler angle on the digital X-Ray record. **(b)** Measurement of the Böhler angle on the digital X-Ray record

Table 2. Distribution of the Calcaneal angles according to sex and side

		Böhler angle (°)	Gissane angle (°)
	n	Mean±SD	Mean±SD
Total	308	33.8±4.8	115.0±6.5
Right	40	34.0±5.0	115.5±6.5
Left	40	33.5±5.5	115.1±7.0
p		0.198	0.601
Male	106	34.3±4.8	115.4±6.6
Female	162	33.5±4.8	114.8±6.4
p		0.177	0.412

7.0° for the left side, with no statistically significant difference between the sides (paired sample t-test; p=0.601) (Table 2). The results were divided into 6 groups according to the age of the patients (Table 3). The highest mean for BA was 35.2°, for the group with the range 41-50 years of age; the lowest mean BA was 32.3°, for the group with the range 61-83 years of age. The highest mean for GA was 115.7° for the group with the range 21-30 years of age; the lowest mean GA was 114.4°, for the group with the range 51-60 years of age. There was no statistically significant difference between the age groups (ANOVA test; BA p=0.086, for BA; p=0.955, for GA).

There was a statistically significant difference between the mean BA in our series and the results of the previously reported series (Table 4). The mean BA in the Turkish population (33.8º) was found to be greater than the results of the studies conducted in American (30º), Nigerian (32.8º) and Saudi Arabian populations; while lesser than the results of the study conducted in Uganda population (35.1º ve 37.6º).

The distribution of BA was compared with the results of Nigerian and Saudi Arabian studies using the Chi-Square test. When compared with the Nigerian and Saudi Arabian series, the frequency of 3 out of the 5, and 4 out of the 7 angle groups were significantly different respectively. (Table 5).

There was no correlation between the Böhler and Gissane angles (r=0.018; p=0.76). There was also no correlation between the calcaneus angles and age (BA-Ya_ korelasyonu için: r=-0.092; p=0.11 for BA-age correlation and r=-0.070; p=0.22 for GA-age correlation).

Discussion

Our study revealed a wide range for calcaneal angles in the Turkish population, as previously reported for other populations in previous studies (Table 1). BA was between 20-46° and GA was between 100-133°.

As both calcaneal angles generally decrease during calcaneal fractures, the lower limit of the angles should be of greater interest. However, after some fractures the angles may remain in normal limits especially in the individuals with a wide Böhler or Gissane angle. In such cases the degree of displacement may be misjudged and an inappropriate correction may be planned. Thereby their wide ranges probably reduce the utility of calcaneal angles in clinical practice. Didia and Igbigbi who assessed the calcaneal angles in Black Africans showed an ethnic and geographic variability for these angles.6, 7 Igbigbi found that the mean BA in women was greater than those of men and he noted that the previous studies failed to show this relation because of their limited sample sizes. Our series involved a larger group of subjects and did not reveal a statistically significant BA difference between the sexes. This result was in agreement

Table 3. Calcaneal angles at different age groups.

			Böhler angle (°)		Gissane angle(°)	
Age group	Cases	%	Mean.±SD	%95 GA	Mean.±SD	%95 GA
15-20	19	6.2	34.6±4.5	32.39 - 36.77	114.8±7.8	111.08 - 118.60
21-30	61	19.8	33.5±5.0	32.21 - 34.78	115.7±6.4	114.01 - 117.30
31-40	86	27.9	34.1±4.6	33.12 - 35.07	115.0±6.7	113.57 - 116.45
41-50	56	18.2	35.2±4.7	33.97 - 36.50	115.0±4.7	113.43 - 116.60
51-60	41	13.3	32.9±4.3	31.55 - 34.25	114.4±5.2	112.73 - 116.00
61-83	45	14.6	32.3±5.1	30.80 - 33.87	114.7±7.6	112.45 - 117.02
p			0.086		0.955	

Table 4. The comparison of the mean Calcaneal angles with the previous studies conducted on American, African and Saudi Arabian populations

Population	Cases	Mean (°)	t-test
Chen et al.,[5] 1991 (American)	120	BA: 30±6	**p<0.0001**
Didia and Dimkpa,[6] 1999 (Nigerian)	302	BA: 32.8±2.8	**p=0.0018**
Igbigbi and Mutesasira,[7] 2003 (Uganda)	114	BA: 35.1±7.5 (E)	p=0.33
	92	BA: 37.6±5.6 (K)	**p<0.0001**
Khoshhal et al.,[8] 2004 (Saudi)	229	BA: 31.2±5.6	**p<0.0001**
		GA: 116.2±8.5	p=0.065
Present study, 2008 (Turkish)	308	BA: 33.8±4.8	
		GA: 115.0±6.5	

with all the previous studies except Igbigbi's one. Comparison according to the side should be done on the same subject. That is one must compare the right and left side angles of the subjects whose both feet X-Rays are available, rather than comparing the mean of all of the right sided and left sided X-Rays in the study group. Only the study of Khoshhal evaluated the relation of the calcaneal angles and the side in this manner, and did not reveal any relation according to the side.8 We also compared the sides on the same subjects and did not find any relation (Table 2). This result suggest that in unilateral calcaneal fractures the calcaneal angles of the intact side may be taken as an individual reference value.

The relation of the calcaneal angles with age should ideally be assessed on the X-Rays of the same individual, taken at different ages. Our cross sectional study enabled only to make an analyze between the different age groups and no significant correlation was found between age and calcaneal angles. There was also no significant difference between the mean calcaneal angles of the different age groups. These results suggest that an old X-Ray of a patient with calcaneus fracture can be considered to assess the normal cancaneal angles for this individual.

The mean BA of our series was significantly different than those of the previous series, confirming the previously reported ethnic and geographic variability for this angle.6-8 The distribution of the BA was significantly different from Nigerian and Saudi Arabian series. The mean GA was not significantly different from the previous report of Khoshhal. Calcaneal angles have a wide range of normal limits and distribution in different populations. Therefore their normal limits and distribution of should be defined for a given population. The range of 20-46° for the BA and 100-133° for the GA can be taken as the normal ranges for the Turkish population. Because of the wide ranges of their normal limits assessment of the other side can be helpful for unilateral fractures. The old X-Rays also can be helpful for the assessment of the normal angular configuration of the calcaneus, especially for bilateral calcaneal fractures.

Table 5. The distribution of the Böhler angle means in comparison with the studies conducted on Nigerian and Saudi populations

	Present Study		Nigerian[6]		Saudi Arabian[8]	
Böhler angle (°)	n	(%)	n	(%)	n	(%)
<28	29	9.4	–		66	28.8***
28-29	24	7.8	46	15.2**	33	14.4
30-31	42	13.6	59	19.5*	32	14.0
32-33	51	16.6	79	26.2**	36	15.7
34-35	50	16.2	60	19.9	18	7.9**
36-38	59	19.2	58	19.2	20	8.7**
>38°	53	17.2	–		24	10.5*
Total	308		302		229	

Statistically significant difference: *p<0.05; **p<0.01; ***p<0.0001.

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