



# Boehler-Gissane Angles In Patients Who Admitted To Our Hospital: How are Boehler and Gissane Angles in Feet with Pes Planus?

*Hastanemize Başvuran Hastalarda Böhler ve Gissane Açılırları: Boehler ve Gissane Açılırları Pes Planuslu Ayaklarda Nasıldır?*

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## ABSTRACT

**Aim:** This study aims to determine normal ranges on BA and GA of patient population which admitted to our hospital from Kars province and around. The secondary purpose is to reveal the relationship between BA, GA and pes planus deformity.

**Material and Method:** The study groups were divided into two randomized controlled groups as Group A and Group B. Group A consisted patients without pes planus. And Group B consisted patients with pes planus. Group A consisted 107 (37 males, 70) and Group B consisted 26 (12 females, 14 males) patients. The measurements were made by a senior orthopedic specialist 14 year-experienced in Group A. And the measurements for Group B were made by a senior orthopedic specialist 14 year-experienced and by a senior radiologist specialist 25 year-experienced. Group B was evaluated for reliability tests. The Intraclass Classification Correlations (ICC) values were determined.

**Results:** There was no difference between the groups in terms of gender distribution according to the chi-square test ( $p=0.272$ ). In Group A, the mean in BA were  $36,77^{\circ}\pm 3,67^{\circ}$  for right feet;  $33,23^{\circ}\pm 7,20^{\circ}$  for left feet. The mean in GA were  $110,99^{\circ}\pm 10,18^{\circ}$  for right feet;  $108,96^{\circ}\pm 9,18^{\circ}$  for left feet. In Group B, the mean in BA were  $36,01^{\circ}\pm 7,01^{\circ}$  for right feet;  $35,40^{\circ}\pm 6,43^{\circ}$  for left feet. The mean in GA were  $116,02^{\circ}\pm 8,57^{\circ}$  for right feet;  $111,48^{\circ}\pm 6,23^{\circ}$  for left feet. There was no statistical difference between groups and sides ( $p=0.362$ ). The ICC values for BA in right, BA in left, GA in right, GA in left were 0.996, 0.997, 0.993, 0.987 respectively. All values were significant.

**Conclusion:** The values of BA and GA in the population that admitted to our hospital were in normal ranges. No relationships were not found between BA, GA and pes planus deformity. The reliable values on BA and GA between two observers were detected.

**Key words:** Boehler angle; Gissane angle; pes planus; reliability

## ÖZET

**Amaç:** Bu çalışma, Kars ili ve çevresinden hastanemize başvuran hastalarda Böhler (BA) ve Gissane (GA) açılarındaki normal aralıkları belirlemeyi amaçlamaktadır. İkincil amaç BA, GA ve pes planus deformitesi arasındaki ilişkiyi ortaya koymaktır.

**Materyal ve Metot:** İki randomize kontrollü grup, Grup A ve Grup B olmak üzere çalışma grubu olarak iki alt gruba ayrıldı. Grup A, pes planus deformitesi olmayan hastalardan oluşmaktaydı. B grubu ise pes planus olan hastalardan oluşuyordu. A grubunda 107 hasta mevcuttu (37 kadın, 70 erkek). Grup B'de ise pes planus deformitesi olan 26 hasta (12 kadın, 14 erkek) vardı. Ölçümler, Grup A'da 14 yıllık tecrübeli kıdemli bir ortopedi uzmanı tarafından yapıldı ve B Grubu için ölçümler, 14 yıllık tecrübeli kıdemli bir ortopedi uzmanı ve 25 yıllık deneyimli bir radyoloji uzmanı tarafından yapıldı. B grubu güvenilirlik testleri için değerlendirildi. Sınıf İçi Sınıflama Korelasyonları (Intraclass Classification Correlations, ICC) değerleri belirlendi.

**Bulgular:** Ki-kare testine göre gruplar arasında cinsiyet dağılımı açısından fark yoktu ( $p=0.272$ ). Grup A'da sağ ayaklarda BA ortalaması  $36,77^{\circ}\pm 3,67^{\circ}$  idi. BA'da sol ayak için ortalama  $33,23^{\circ}\pm 7,20^{\circ}$  idi. Sağ ayaklar için GA'da ortalama  $110,99^{\circ}\pm 10,18^{\circ}$  idi. Sol ayaklar için GA'da ortalama  $108,96^{\circ}\pm 9,18^{\circ}$  idi. B Grubunda sağ ayaklarda BA ortalaması  $36,01^{\circ}\pm 7,01^{\circ}$  idi. BA'da sol ayak için ortalama  $35,40^{\circ}\pm 6,43^{\circ}$  idi. Sağ ayaklar için GA'da ortalama  $116,02^{\circ}\pm 8,57^{\circ}$  idi. Sol ayaklarda GA'da ortalama  $111,48^{\circ}\pm 6,23^{\circ}$  idi. Gruplar ve taraflar arasında istatistiksel olarak anlamlı fark yoktu ( $p=0.362$ ). ICC değerleri, sağda BA, solda BA, sağda GA, solda GA için sırasıyla 0.996, 0.997, 0.993, 0.987 idi. Güvenilirlik testleri için tüm değerler istatistiksel olarak anlamlıydı.

**Sonuç:** Hastanemize başvuran popülasyonda, BA ve GA'nın değerleri normal aralıklarda tespit edildi. BA, GA ve pes planus deformitesi arasında bir ilişki bulunamadı. BA ve GA'da iki gözlemci arasında güvenilir değerler tespit edildi.

**Anahtar kelimeler:** Boehler açısı; Gissane açısı; pes planus; güvenilirlik

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## Introduction

The calcaneus is the biggest tarsal bone. In all fractures, tarsal fractures are about 2%. Calcaneal fractures account for 50-60% of tarsal fractures. Less than 10% is open fractures<sup>1</sup>. Boehler and Gissane angles are the corner point for calcaneal fractures. Especially, Boehler angle (BA) is the predictor of this fracture type<sup>2-4</sup>. In 1931, Dr. Lorenz Boehler defined this angle as “tuber angle” with a normal range between 30°–35°. BA predicts calcaneal fractures<sup>5</sup>. Also, Gissane angle predicts calcaneal fractures as like Boehler, too. And its normal range is defined between 95°-152°<sup>6,7</sup>. At the literature, there are some studies for BA (20°-46°) and GA (100°-133°) by normal ranges<sup>4,5,8,9</sup>.

This study aims to determine normal ranges on BA and GA of Caucasian people in Kars in Turkey. And also, the secondary purpose is to reveal the relationship between BA, GA and pes planus deformity.

## Materials and Methods

A randomized controlled group was chosen at our clinic between November 2017 and November 2018 for BA and GA measurement. The study groups were divided into two sub-groups as Group A and Group B. Group A consisted patients without pes planus deformity. And Group B consisted patients with pes planus population. Secondary foot deformities as tarsal coalition, deformity or fusion were excluded from the Group A. The study group consisted of 214 pairs digital lateral foot or ankle radiography records of 107 patients. It consisted of 37 males, 70 females and the mean in age was 25,44 (min: 6-max:74). And Group B consisted of 52 pairs foot of 26 patients with pes planus deformity as 12 females and 14 males and the mean in age was 22.52 (min: 6-max: 65).

BA and GA were measured according to referred sources. Boehler’s angle (BA) is referred to as tuber Angle (also called a calcaneal angle, critical angle and tuber joint angle) at the literature<sup>10-12</sup>. BA is drawn by the intersection of two lines as the first one was laid on the most cephalic part of the posterior process of the calcaneus bone and the most cephalic or top point of the posterior facet. The second one was laid on the most cephalic or top point of the posterior facet of the calcaneus and the top point of the calcaneus bone that forms the articular side for cuboid bone. The normal range is 20°-40°. Lesser than 20° angles indicate calcaneal fractures. Another description of Boehler angle is mentioned by tangential methods<sup>13</sup>. At another paper

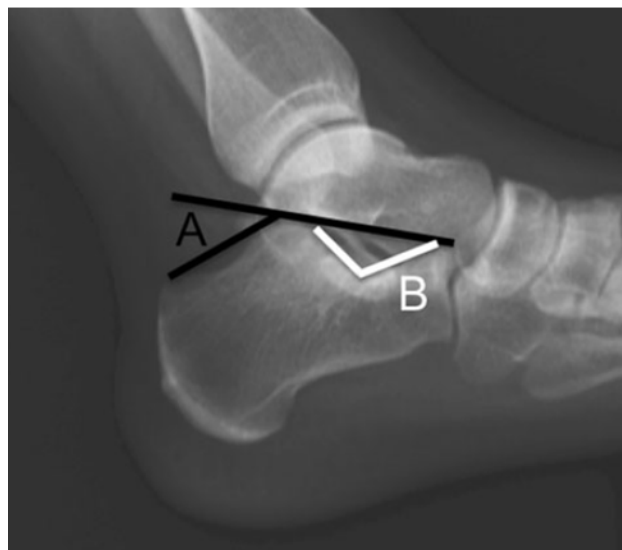


Figure 1. Boehler angle (A) and Gissane angle (B)

described BA as Mortons’ method. BA was given different normal ranges for different ethnic populations at studies<sup>14</sup>.

Gissane’s angle (GA) is drawn from the superior point of the posterior facet of the calcaneus to the inferior point on the posterior facet to the superior surface of the anterior process of the calcaneus at the main source<sup>15</sup>. It helps to define calcaneal fractures. And it reflects the relationship of the anterior, middle and posterior facets. It differs from 120° to 145° in the normal population<sup>15,16</sup>. Boehler and Gissane angles demonstrated on Figure 1.

The measurements were made by a senior orthopedic specialist 14 year-experienced in Group A. And the measurements for Group B were made by a senior orthopedic specialist 14 year-experienced and by a senior radiologist specialist 25 year-experienced. Also Group B was evaluated for reliability tests. The ICC values were determined. Absolute compliance searched as statistically.

The relationship of the angles with gender, age and side were analyzed. SPSS 20.0 (Windows, IL, USA) software was used for the statistical analysis. Kolmogorov-Smirnov test was used to determine whether the data in the groups were normally distributed or not. Mann-Whitney U and Student-t-tests were used to determine whether there is a difference between the mean in BA and GA angles. Mean, standard deviation, minimum-maximum values of normal population and pes

**Table 1.** The gender distribution in the groups

Study Groups	Gender	Count	Percent
Group A (Normal population) N=107	Female	37	34,6%
	Male	70	65,4%
	Total	107	100,0%
Group B (Pes planus population) N=26	Female	12	46,2%
	Male	14	53,8%
	Total	26	100,0%

**Table 2.** Boehler-Gissane angles in the groups

Group		Mean	Std. Deviation	Minimum	Maximum
Group A	Boehler Angle (right) N=107	36,77	3,67	23,5	42,0
	Boehler Angle (left) N=107	33,23	7,20	18,8	49,3
	Gissane Angle (right) N=107	110,99	10,18	87,7	136,4
	Gissane Angle (left) N=107	108,96	9,18	88,5	129,2
Group B	Boehler Angle (right) N=26	36,01	7,01	26,8	55,5
	Boehler Angle (left) N=26	35,40	6,43	26,2	53,2
	Gissane Angle (right) N=26	116,02	8,57	97,9	130,4
	Gissane Angle (left) N=26	111,48	6,23	101,3	124,0

**Table 3.** The ICC values in the reliability study

Reliability Study (orthopaedist and radiologist)	ICC values
Group B Boehler Angle (right)	0.996
Boehler Angle (left)	0.997
Gissane Angle (right)	0.993
Gissane Angle (left)	0.987

planus group were determined via to dependent t-test. Independent t-test was used to compare the unpaired samples as gender. The level of significance for p-value was less 0.05.

## Results

The gender distribution in the groups was as follows on Table 1. There was no difference between the groups in terms of gender distribution according to the chi-square test ( $p=0.272$ ).

BA and GA values were shown on Table 2. In Group A, the mean in BA for right feet were  $36,77^{\circ} \pm 3,67^{\circ}$  ( $23,5^{\circ}$  - $42,0^{\circ}$ ;  $N=107$ ). The mean in BA for left feet were  $33,23^{\circ} \pm 7,20^{\circ}$  ( $18,8^{\circ}$  - $49,3^{\circ}$ ;  $N=107$ ). The mean in GA for right feet were  $110,99^{\circ} \pm 10,18^{\circ}$  ( $87,7^{\circ}$  - $136,4^{\circ}$ ;  $N=107$ ). The mean in GA for left feet were  $108,96^{\circ} \pm 9,18^{\circ}$  ( $88,5^{\circ}$  - $129,2^{\circ}$ ;  $N=107$ ).

In Group B, the mean in BA for right feet were  $36,01^{\circ} \pm 7,01^{\circ}$  ( $26,8^{\circ}$  - $55,5^{\circ}$ ;  $N=26$ ). The mean in BA for left feet were  $35,40^{\circ} \pm 6,43^{\circ}$  ( $26,2^{\circ}$  - $53,2^{\circ}$ ;  $N=26$ ). The mean in GA for right feet were  $116,02^{\circ} \pm 8,57^{\circ}$  ( $97,9^{\circ}$  - $130,4^{\circ}$ ;  $N=26$ ). The mean in GA for left feet were  $111,48^{\circ} \pm 6,23^{\circ}$  ( $101,3^{\circ}$  - $124,0^{\circ}$ ;  $N=26$ ). There was no statistical difference between groups and sides ( $p=0.362$ ).

The reliability tests were applied for measurements in Group B. Absolute compliance searched as statistically. The ICC values were established in Table 3. The ICC values for BA in right, BA in left, GA in right, GA in left were 0.996, 0.997, 0.993, 0.987 respectively. All values were significant as statistically for reliability tests.

## Discussion

Calcaneus is the largest bone among tarsal bones. The load which is bearing to feet transmits to the floor by the calcaneus. Measurement on the BA and GA are the predictor points for calcaneal fractures by a significant decreasing<sup>16</sup>. Studies about BA and GA were declared to literature. Ethnic and geographic variability was reported<sup>7,17</sup>. BA and GA have a wide range and distribution in different populations. Seyahi et al were reported BA and GA for the Turkish 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<sup>8</sup>.

At the difference for BA and GA on gender, Igbigbi found that the mean in BA of women was greater than men<sup>18</sup>. But Seyahi et al did not find any statistically significant BA difference between both genders<sup>8</sup>. Also, other studies have not found a difference. There was no difference relationship on the sides according to literature. At all studies about BA and GA, no significant correlation was found between age and calcaneal angles. There was also no significant difference between the mean in calcaneal angles in the different age groups<sup>7,8,15</sup>.

Rokaya PK et al found an insignificant difference between calcaneal angles and age on the study. By this way, they claimed the relation between calcaneal angles and age may help to diagnose bilateral calcaneal fracture in some conditions<sup>16</sup>. Therefore, keeping angles of BA and GA in hospital memory could help to health professional for regaining the previous anatomic features of calcaneus if bilateral calcaneal fractures were seen.

In our study, we established the mean in BA and GA angles of Caucasian Population as like: BA angles were 36,77°±3,67° for right feet; 33,23°±7,20° for left feet. GA was 110,99°±10,18° for right feet; 108,96°±9,18° for left feet. Our results were consistent with the literature knowledge of our country<sup>8</sup>.

In the second stage of our study, firstly we aimed to determine whether there was the relationship between BA, GA angles and pes planus deformity or not. Two groups as Group A and B were compared for this relation. A second purpose for this stage, we aimed to detect reliability among two observers on calcaneal angles. The measurements on BA and GA made by a senior orthopedist 14 year-experienced and by a senior radiologist specialist 25 year-experienced.

At the literature, there was no study about the relationship between BA, GA and pes planus deformity. As statistical study, we used the Mann-Whitney U test and Student t-test in this comparison. We did not find any relationship between BA, GA angles and pes planus deformity on two groups as Group A and B (p=0.362).

On the searching of reliability on two observers between a senior orthopedist and a senior radiologist specialist were made. Two-way mixed effects were random and measures effects are fixed. The ICC values were statistically significant on the reliability tests. It

was 0.996 for BA in right, 0.997 for BA in left, 0.993 for GA in right, 0.987 for GA in left were.

The forming of a data-bank about the normal anatomical features of the human body can be accepted one of the most important step for medical science of the future. All nations might compose a normal angular configuration for their peoples. These angles might be used to define normals for all body in medical conditions, especially in trauma cases.

In this context, the previous radiographies can be helpful for the diagnosing of the normal angular configuration of the calcaneus. This may be mandatory in medical cases with bilateral calcaneal fractures. We detected the normal values of BA and GA in the Caucasian population in the East region of Turkey. It was consistent with Turkish population. Also, we could not find any relationship between BA, GA and pes planus deformity. We found reliable values on BA and GA with two medical branches on two observers.

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