

# Morphometric Analysis of Calcaneal Angles (Bohler's and Gissane's angle) in the North Indian Population

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## ABSTRACT

**Background:** Calcaneal fractures are the most common tarsal bone injuries, accounting for 60–70% of tarsal fractures, and frequently occur due to high-energy trauma such as road traffic accidents and falls from height. These fractures significantly impair mobility and work capacity, particularly among individuals aged 21–45 years. Radiographic assessment using Bohler's and Gissane's angles is essential for determining fracture severity and guiding appropriate treatment planning.

**Methodology:** A study was conducted in the SGT University Hospital Gurugram, Haryana. The study included 100 cases (60M, 40F), with mean age  $41.66 \pm 17.14$  years (Range 15 - 89 years). Ankle lateral radiograph was taken by using CR X-ray machine (Fuji Modality). Lateral ankle radiographs in all the cases were evaluated for the measurement of Bohler's and Gissane's angle with the help of experienced Radiologist and Orthopedician.

**Result:** The mean of Bohler's angle and Gissane's angle in the north Indian population were  $28.70^\circ$  (15 -  $54^\circ$ ) and  $112.18^\circ$  (100 -  $13^\circ$ ) respectively. The mean Bohler's angle was found highest ( $30.57 \pm 5.88^\circ$ ) in age group with age ranged from 15 - 29 years and lowest ( $27.44 \pm 7.36^\circ$ ) in age group with age ranged from 30 - 44 years whereas Gissane's angle was found highest ( $116.56 \pm 10.03^\circ$ ) and lowest ( $109.77 \pm 5.54^\circ$ ) in age group with age range of 75 - 89 years and 30 - 44 years respectively. There was no significant Difference in the Bohler's and Gissane's angle between males and females.

**Conclusion:** In the north Indian population, the mean of Gissane's angle and mean Bohler's angle was found  $28.70 \pm 7.24^\circ$  and  $112.18 \pm 7.09^\circ$  respectively. There was no significant Difference in the Bohler's and Gissane's angle between genders.

**Key Words:** Calcaneal angle, Bohler's angle and Gissane's angle.

## INTRODUCTION

Calcaneum is the frequently fractured bone among tarsal bones due to trauma, road accidents or falling from height as most of the human body's weight is transmitted on it <sup>(1)</sup>. Calcaneal fractures constitute 60% -70% of tarsal fractures and 2% of all fractures <sup>(2,3,4)</sup>. The calcaneal fractures decrease mobility as a result of which the ability to perform work is affected. Calcaneal bone fractures were found commonly in the subjects with age between 21 to 45 years <sup>(5)</sup>. The measurement of the Bohler's and Gissane's angle is a helpful tool in the diagnosis of severity of the Calcaneal fracture on lateral Radiograph and to plan treatment. The calcaneal angles i.e.; Bohler's angle was described by Lorenz Bohler (1931) <sup>(5)</sup> and William Gissane (1947) <sup>(6)</sup> respectively. Bohler's angle is the angle formed by connecting the line drawn from the tip of the posterior calcaneal tuberosity to the

posterior calcaneal facet with the line drawn from the tip of the anterior calcaneal process to the posterior calcaneal facet. The angle is formed by connecting the line drawn from the posterior talar articular surface to the tarsal sinus with the line drawn from the tip of the anterior surface of the cuboid bone to the tarsal sinus <sup>(7)</sup>. The normal range of Bohler’s and Gissane’s angles were from 20°- 40° <sup>(8,9)</sup> and 130°- 145° <sup>(9)</sup> respectively. The objective of the study was to evaluate the Bohler’s and Gissane’s angle among various age groups and genders and to compare the result of the present study with the previous studies.

**METHODOLOGY**

A prospective study was carried out in the Department of Radiology at SGT University Hospital Gurugram, Haryana. The study included 100 cases (60M, 40F) with average age 41.66 ± 17.14 years (40.90 ±18.25 years in M and 42.80 ±15.49 years in F). The Demographic Distribution of the cases included in the study are shown in table 1.1 below. A Computed Radiography X-ray machine (CR Fuji Modality) was used to scan each case for lateral ankle radiographs. Trauma cases, unwilling, post-operative and foot deformity cases were not included in the study. Lateral ankle radiographs of all the cases were evaluated for the measurement of Bohler’s angle and Gissane’s angle in the presence of experienced Orthopedician and radiologist by using the on-screen angle measuring tool (electronic caliper). The Bohler’s and Gissane’s angles were measured in the study as shown in fig. 1.1 and fig. 1.2 respectively. The statistical analysis in the study was carried out by software SPSS (Version 21). Chi Square test were used to evaluate P- value and P < 0.05 was considered statistically significant.

**Table 1.1 Demographic Distribution of cases included in the study**

<b>GENDERS</b>	<b>NO. OF PATIENTS</b>	<b>AVERAGE AGE (Yrs.)</b>	<b>Min. AGE (Yrs.)</b>	<b>Max. AGE (Yrs.)</b>
<b>MALE</b>	60	40.90 ± 18.25 YEARS	15	88
<b>FEMALE</b>	40	42.80 ± 15.49 YEARS	22	78
<b>TOTAL</b>	100	41.66 ± 17.14 YEARS	15	88



**Fig. 1.1 Bohler’s Angle**

(Formed by 2 lines – line drawn from tip of posterior calcaneal tuberosity to the posterior calcaneal facet with Line drawn from tip of anterior calcaneal process to the posterior calcaneal facet).

**Fig. 1.2: Gissane’s Angle**

(Formed by 2 lines – line drawn from tip of the posterior calcaneal facet to the lowest point of posterior cal. facet with the drawn from lowest point of the same Facet to the tip of anterior surface).

## RESULTS

The study included 100 cases (60M, 40F), with an average age 41.66 years. All the cases were studied to evaluate Bohler’s and Gissane’s angle. The mean of Bohler’s and Gissane’s angles were found 28.70° and 112.18° respectively in the study. The range and mean value of Bohler’s & Gissane’s angles obtained in the cases are shown in table 1.2 and fig. 1.3

**Table 1.2 Mean Bohler’s, Gissane’s angle and range of these angles in the study**

ANGLE	MEAN ± Std. DEVIATION	MINIMUM	MAXIUM
<b>BOHLER'S ANGLE</b>	28.70 ± 7.24°	15°	54°
<b>GISSANE'S ANGLE</b>	112.18 ± 7.09°	100°	131°

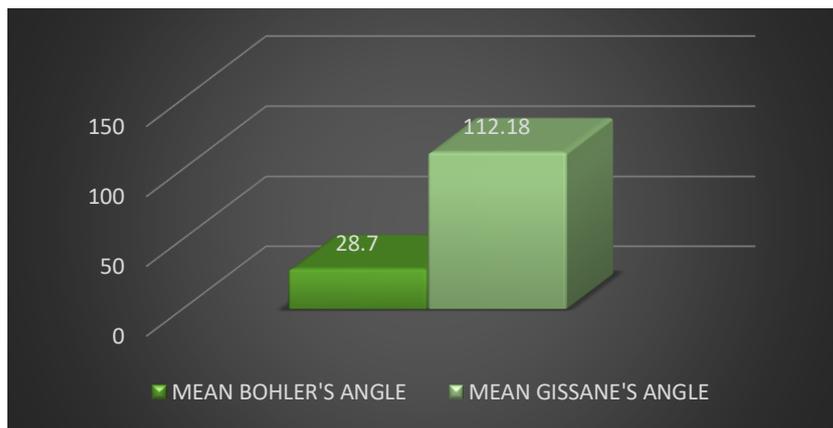


Fig. 1.3 Mean Bohler’s angle and Gissane’s angle in the study

### Comparison of Bohler’s and Gissane’s angle among the genders

There was no significant difference in the Bohler’s and Gissane’s angles among males and females. The mean of Bohler’s and Gissane’s angle in males were 28.67° and 111.78° respectively whereas in females it was 28.75° and 112.78° respectively as shown in fig. 1.4. There were no significant different in the BA and GA among the genders. The Bohler’s and Gissane’s angles range in males were 15° - 47° and 100° - 128° respectively whereas it was 20° - 54° and 102° - 131° respectively in females as shown in table 1.3 below.

**Table 1.3 Comparison of mean, range of Bohler’s and Gissane’s in genders**

ANGLE	SEX	MEAN ± Std. DEVIATION	MINI	MAX	P-Value	t
<b>BOHLER'S ANGLE (BA)</b>	M	28.67 ± 7.69°	15	47	.118	-0.056
	F	28.75 ± 6.60°	20	54		
<b>GISSANE'S ANGLE (GA)</b>	M	111.78 ± 6.62°	100	128	.166	-0.683
	F	112.78 ± 7.80°	102	131		



Fig. 1.4 Comparison of mean Bohler's and Gissane's in males and females

### Comparison of Bohler's and Gissane's angles among various age groups

All the cases included in the study were divided into five groups based on their age (15 - 29, 30 -44, 45 - 59, 60 - 74 and 75 - 89 years). Among various age groups the mean of Bohler's angle was highest (30.57°) in group with age range of 15 - 29 years and lowest (27. 44°) in group with age range of 30 - 44 years. The Gissane's was found highest (116.56°) in age group with age range of 75 - 89 years and lowest (109.77°) in age group with age range of 30 - 44 years. The mean value of Bohler's and Gissane's angle among various age groups in the study are shown in table 1.4 and fig. 1.5 below

Table 1.4 comparison of Bohler's and Gissane's angle among various age groups

AGE GROUPS	NO. OF CASES	ANGLE	MEAN± Std. DEVIATION	MIN.	MAX.
15-29	23	BOHLER'S	30.57 ± 5.88°	20°	40°
		GISSANE'S	111.17 ± 6.19°	10°	122°
30-44	39	BOHLER'S	27.44 ± 7.36°	16°	47°
		GISSANE'S	109.77 ± 5.54°	102°	126°
45-59	20	BOHLER'S	29.05 ± 8.65°	15°	54°
		GISSANE'S	114.70 ± 8.19°	104°	131°
60-74	9	BOHLER'S	29.00 ± 6.22°	21°	39°
		GISSANE'S	115.22 ± 5.63°	102°	122°
75-89	9	BOHLER'S	28.33 ± 7.79°	16°	40°
		GISSANE'S	116.56 ± 10.03°	100°	128°
TOTAL	100	BOHLER'S	28.70 ± 7.23°	15°	54°
		GISSANE'S	112.18 ± 7.09°	100°	131°

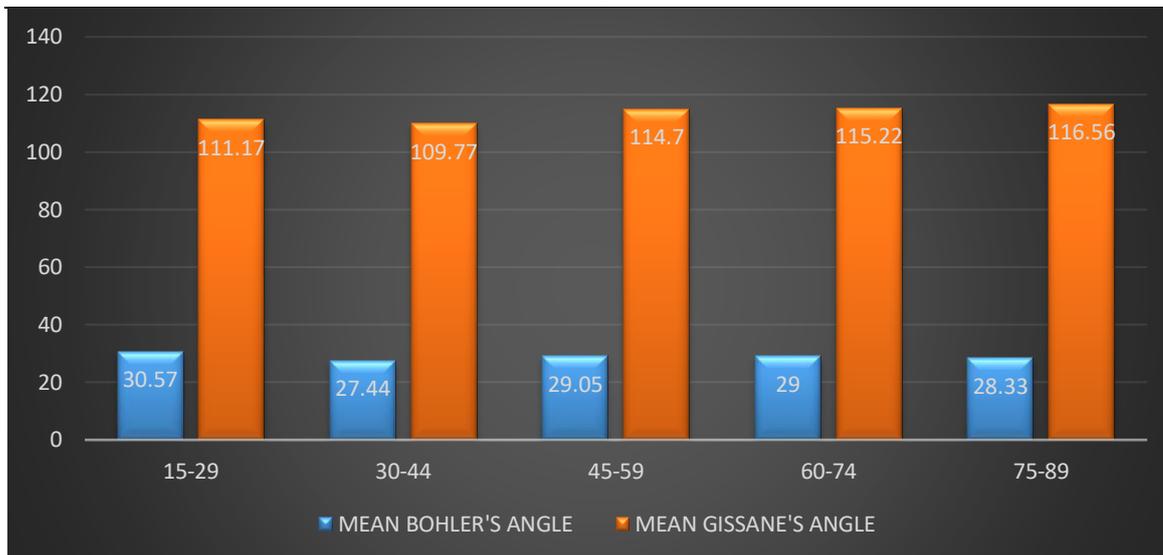


Fig. 1.5 Comparison Gissane’s and Bohler’s angle among various age groups

**Comparison of the result of present study with previous studies**

The comparison of the present Indian study with previous one done in India or other countries were studied. In the present study, the mean of Bohler’s and Gissane’s angle were 28.70° and 112.18° respectively whereas in the previous Indian study done by Vetrivel C. Sengodan et al. It was 30.62° and 126.79° respectively. The mean Bohler’s and Gissane’s angles among the Brazilian population were 32.6 ° and 110.6 ° respectively. The comparison of the present study with the previous studies done in various countries are shown in table 1.5 below.

**Table 1.5 Comparison study with the previous studies (both Indian & other countries)**

AUTHOR	YEAR	NO. OF CASES	BOHLER'S ANGLE		GISSANE'S ANGLE	
			MEAN	RANGE	MEAN	RANGE
Present study (India)	2021	100	28.70 °	15 -54 °	112.18 °	100- 131 °
Fahmy Anwar Shoukry et al. (Egypt)	2010	120	30.14 °	22 - 40 °	122.92 °	108- 138 °
Aksel Seyahi (Turkish)	2008	308	33.18 °	20-46 °	115 °	100-133 °
Vetrivel C. Sengodan et al. (India)	2012	204	30.62 °	18-43 °	126.79 °	100-145 °
Loiro ECS et al. (Brazil)	2017-19	800	32.6 °		110.6 °	-
Rokaya PK et al. (Nepal)	2012-13	140	31.3 °	18-47 °	108.4 °	85-135 °
Pankaj K Mishra et al. (India)	2017- 19	384	33.53 °	16.23-46.35°	115.90 °	90.2- 142.9 °

## DISCUSSION

Bohler’s angle and Gissane’s angle play vital roles in the diagnosis of the calcaneal fractures. The restoration of Bohler’s angle back to the normal range after calcaneal fracture can improve the functional outcomes of injured feet <sup>(10-14)</sup>. The Bohler’s angle in the present Indian study ranged from 15° - 54° (28.70°), whereas in previous Indian studies Bohler’s angle ranged from 18° - 43° (30.62°) <sup>(15)</sup> and 16.23° - 46.35° (33.53°) <sup>(16)</sup>. The mean of Bohler’s angle in Brazilian population was 32.6° <sup>(17)</sup>, in Egypt (30.141°) <sup>(18)</sup>, in Nepal (31.3°) <sup>(19)</sup>, in Nigeria population Bohler’s angle was 32.58° <sup>(20)</sup> and in Turkish population it was 33.8° <sup>(21)</sup>. The mean Gissane’s angle in Brazilian population was 110.6° <sup>(17)</sup>, in Nepal (108.4°) <sup>(19)</sup>, Gissane’s angle in Nigerian population was 212.22° <sup>(20)</sup> and in Turkish population it was 115° <sup>(21)</sup> whereas in the present study mean Gissane’s angle is 112.18°. In calcaneal fractures usually both calcaneal angles (Bohler’s and Gissane’s angle) decrease therefore the lower limit of the Calcaneal angles can be of greater interest <sup>(21)</sup>. The lower limit of Bohler and Gissane angles in the Nepalese population were 18° and 85° respectively (Rokaya PK et al.) <sup>(19)</sup>. In the present study the lower limit of Bohler’s angle was 15° and Gissane’s angle lower limit was 100°. There was no significant difference in the calcaneal angles between males and females in the study done by Aksel Seyahi et. al <sup>(21)</sup>. In this study there was also no significant difference in the calcaneal angles (Bohler’s and Gissane’s angle) among males and females. The mean of Bohler’s was highest (36.88°) in age group with age range of 18 - 20 years and lowest (29.65°) in age group with age range of 30 - 39 years <sup>(22)</sup>. In the present study, mean Bohler’s angle was highest (30.57°) in the age group with age range of 15 - 29 years and lowest (27.44°) in the age group with age range of 30 - 44 years. A study performed by Rahe Ramachandran & Shailaja Shetty found that the mean of Gissane’s angle was highest (113.35°) in the group with age range of 18 - 20 years and lowest in the group with age range of 30 - 39 years <sup>(22)</sup> whereas in our study the mean of Gissane’s angle was found highest (116.56°) and lowest (109.77°) in age group with age range of 75 - 89 years and 30 - 44 years respectively. The comparison of mean Bohler’s and Gissane’s angles between the study performed by Rahe Ramachandran and Shailaja Shetty with the present study are shown in table 1.6 below.

**Table 1.6 comparison of Rahe Ramachandran’s study with the present study**

PRESENT STUDY			STUDY DONE BY RAHE RAMACHANDRAN & SHAILAJA SHETTY <sup>(22)</sup>		
AGE GROUP	MEAN BA IN DEGREE (RANGE)	MEAN GA IN DEGREE (RANGE)	AGE GROUP	MEAN BA IN DEGREE (RANGE)	MEAN GA IN DEGREE (RANGE)
15-29 Yrs.	30.57 (20-40)	111.17 (101-122)	18-20 Yrs.	36.88 (35.0-41.1)	113.35 (102.1-121.8)
30-44 Yrs.	27.44 (16-47)	109.77 (102-126)	20-29 Yrs.	31.04 (25.0-39.1)	111.50 (98.9 -133.6)
45-59 Yrs.	29.05 (15-54)	114.70 (104-131)	30-39 Yrs.	29.65 (23.3-37.0)	106.05 (90.9-124.6)
60-74 Yrs.	29.00 (21-39)	115.22 (102-122)	40-49 Yrs.	30.98 (21.7-41.7)	108.59 (86.6-136.1)
75-89 Yrs.	28.33 (16-40)	116.56 (100-128)	50-59 Yrs.	31.53 (19.6-40.3)	109.2 (95.8-133.1)
-	-	-	≥ 60 Yrs.	32.19 (20.8-44.8)	107.81 (91.4-128.4)
<b>TOTAL</b>	<b>28.70 (15-54)</b>	<b>112.18 (100-131)</b>	<b>TOTAL</b>	<b>31.32 (19.6-44.8)</b>	<b>108.57 (86.9-136.1)</b>

BA = Bohler’s Angle, GA = Gissane’s Angle

## CONCLUSION

In the North Indian population mean of Bohler's angle was  $28.70 \pm 7.24^\circ$  ( $15 - 24^\circ$ ) and Gissane's angle was  $112.18 \pm 7.09^\circ$  ( $100 - 131^\circ$ ). There was no significant difference in the calcaneal angles (Bohler's and Gissane's angles) between genders among the north Indian population.

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**Authors' Contributions:** **Khursheed Ahmad Ganie:** Conceptualized, Designed the Methodology, Performed Data Analysis and Drafted the Initial Manuscript. **Tazim Hussain Padder:** Data collection, Literature Review and Data Interpretation. **Ananya Sharma:** Statistical Analysis, Critical Revision of the manuscript and validation of results. All authors read and approved the final manuscript.

**Conflicts of Interest:** The authors declare that there is no conflict of interest.

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