Orthopaedic Surgery

SCIENTIFIC ARTICLE

Natural Value of Böhler's Angle in Normal Chinese Population

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Objective: To determine the value of Böhler's angle (BA) in a group of Chinese people, analyze possible factors that influence it, and compare BA with that in previous literature.

Methods: A total of 143 cases, aged from 4 to 79 years, were enrolled in the study, including 64 males and 79 females (79 left feet and 64 right feet). Radiographs were independently measured by six observers. Age, sex, body side, subtalar joint congruity (STJC), and X-beam obliquity (TT) were recorded. The database was assessed based on intraobserver agreement, data distribution, the randomness of case selection, and the ratio equality of binomial variables. Then, the normal value of BA was established, as well as the correlation between BA and other parameters.

Results: In the present study, the interobserver reliability of BA, STJC, and TT was excellent. The BA data revealed a normal distribution, and the randomness of case selection was verified for age, sex, and body side. The ratio of sex and body side was equal. Homogeneity of variance was observed when comparing the value of BA between different groups. The value of BA was 31.6° ± 5.19° (range, 20.08°–47.19°), which was not related to age, sex, body side, and minor X-ray beam obliquity. BA application was not suitable for individuals younger than 10 years. The mean value of BA in this study was not identical with those in previous reports. This demonstrated that BA varies for different races.

Conclusion: For Chinese people, 30° to 33° is recommended as the target value of BA for calcaneal fracture reduction, except in children under 10 years of age.

Key words: Böhler's Angle; Calcaneal fracture; Measurement; Statistical analysis

Introduction

Calcaneal fractures are the most common fractures among the tarsal bones, and account for approximately 2% of all fractures. These kinds of fractures are usually secondary to high-energy injuries, such as a fall from height, when the heel directly hits the ground, or injuries from automobile accidents, when the heel is directly impacted. Seventy-five percent of calcaneal fractures are intraarticular fractures due to direct impact and high energy injuries. Most fractures are significantly displaced. With an improper treatment strategy, malunion can occur. The decrease of calcaneal height, the broadening of calcaneal width, the incongruity of the subtalar joint, and the varus of hind foot alignment will potentially lead to a poor functional outcome. The loss of calcaneal height and subtalar joint congruence may induce osteoarthritis and pain. The prominence of the calcaneal lateral wall can impinge on the peroneal tendons, causing discomfort and difficulties with footwear. The malalignment of the hind foot will likely impact the balance of the lower extremities, generate degenerative arthritis of the subtalar or ankle joints, and, ultimately, lead to an abnormal gait. It is reasonable to reconstruct the calcaneal morphology anatomically after fractures[1].

Petit and DeSault were the first, in 1920, to accurately described calcaneal fractures. They recommended rest until the fragments consolidated[2]. Conservative management

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remained the mainstay of treatment until the 1900s. Because of the persistent deformity, the outcome was poor. In 1902, Morestin first reported the open reduction procedure.[3] In 1908, Cotton and Wilson described their closed reduction technique for calcaneal fractures[4]. In 1913, Leriche used plates and screws for internal fixation[5,6]. In 1931, Böhler used a pin traction and clamp technique in an attempt to restore normal anatomy and reduce the disabilities associated with calcaneal fractures. He emphasized the necessity of restoring Bohler's angle (BA)[7]. In 1943, Gallie described primary subtalar arthrodesis[8]. From then on, anatomical reduction of calcaneal fractures became possible. A trend in surgical treatment was motivated. These four therapeutic options, conservative management, closed reduction, open reduction, and primary arthrodesis, are still viable treatment alternatives today[9].

On plain X-ray film, there are several useful measurements to help to assess the displacement and determine the therapeutic options. Böhler's angle (BA), Gissan's angle, and calcaneal width are typically used. Among these parameters, BA is perhaps the most common and efficient measure to determine the treatment scheme and to investigate reduction quality[10].

Bohler's angle is primarily described by Böhler in 1931[7], and is also known as the calcaneal angle or the tuber joint angle. This angle is between a line drawn from the superior–posterior aspect of the calcaneus and a line drawn from the anterior dorsal aspect of the calcaneus on a lateral radiograph. Many previous studies have validated the significance of BA in assessing the displacement, making treatment decisions, and evaluating the reduction quality[9]. In the decision-making procedure for calcaneal fractures, the choice of surgical or nonsurgical treatment remains a subject of debate. To obtain an optimal outcome, the following fracture features should be assessed: loss of height, increase of width, malalignment of hind foot, and involvement of articular facet. With the change of calcaneal width, subtalar join congruence or hind foot alignment, BA will proceed corresponding change, which can be easily observed on X-ray plain film. A decrease of BA reflects the collapse of the posterior facet of calcaneus, which shifts the body weight anteriorly. A significant decrease of BA strongly suggests the displacement of calcaneal fracture and is an indication for surgery. After therapy, either operative or nonoperative, BA is generally used to evaluate whether the calcaneal height is restored; furthermore, the anatomical reduction is obtained.

However, BA fluctuates over a large scale of normal value. In some textbooks, like *Mann's Surgery of the Foot and Ankle*, we can see that the reference value of normal BA is 20° to 40°. However, in other publications, the normal value of BA ranges from 14° to 50°[11]. According to Böhler, BA ranges between 30° and 35°. Furthermore, BA varies in different population (Table 1).

Because BA may have a close correlation with functional outcome after a calcaneal fracture, improper goals of reduction will lead to a poor outcome for calcaneal fractures[1]. Recognizing the normal range of BA is important for appropriate determination of treatment and reduction, thereby allowing more positive prognosis after calcaneal fractures.

To our knowledge, no analysis of the regular range of BA has been reported in Chinese subjects. Therefore, the present study aimed to: (i) investigate the normal BA in the Chinese population; (ii) study the factors that may influence BA; and (iii) hopefully improve the assessment accuracy of displacement and promote the outcome of calcaneal fractures.

Methods

Database Setup

To set up the database, a total of 172 digital records of calcaneus or foot radiographs were taken from 150 "normal foot" patients in the Second People's Hospital of Yunnan Province. Finally, 143 radiographs were deemed eligible for the study, from patients aged 4 to 79 years (mean 44.4 years, SD 18.4 years), including 64 males and 79 females, and 79 left feet and 64 right feet.

Inclusion Criteria

Patients were enrolled who: (i) underwent radiographic screening for health examination or ruling out of calcaneal issues (ii) from January 2017 to August 2018, and (iii) had ever received a radiographic diagnosis of normal.

Exclusion Criteria

The enrolled cases were investigated by two orthopaedists with the following exclusion criteria: (i) the presence of calcaneal fractures; (ii) foot deformity; (iii) tumor; and (iv) pathology conditions altering the morphology of calcaneus.

Variables Examined

The Picture Archiving and Communication System (PACS workstation 3.0, Medi-PACS, Guanzhou, China) was used for measurement. All images were independently investigated by two radiologists, two orthopaedists, and two nursing students. The variables examined were: patient's age, sex, weight-bearing, body side, subtalar joint congruity (STJC), X-ray beam obliquity (talar tilt, TT), and abnormal foot arch (AFA).

Measurement Details

Subtalar Joint Congruity

Subtalar joint congruity (STJC) is defined as the subtalar facet of the talus being parallel to the the posterior facet of the calcaneus, as well as the start-end points of these two facets matching each other (Fig. 1). The congruity is the base of the smooth joint movement. The presence of subtalar joint incongruity illustrates the subluxation of the joint, demonstrates the obstacle of movement, and predicts subtalar arthritis. These issues may result in weight-bearing pain and symptomatic gait[25].

TABLE 1 Normal Böhler's angle in different population

Author	Year	Population	Böhler's angle (°)	
			Mean ± SD	Range
Chen *et al.*[11]	1991	American	30 ± 6	14–50
Didiaet *al.*[12]	1999	Nigerian	32.83 ± 2.84	28–38
Igbigbiet *al.*[13]	2002	Malawian	30.11 ± 6.29	14–45
Igbigbiet al.[14]	2003	Ugandans	35.1 ± 7.5(male)/ 37.6 ± 5.6(female)	20–50
Khoshhalet al.[15]	2004	Saudi1	31.21	16–47
Seyahiet al.[16]	2009	Turkish	33.8 ± 4.8	20–46
Sengodanet al.[17]	2012	Indian	30.62	18–43
Shoukryet al.[18]	2012	Egyptian	30.14 ± 4.18	20–40
Willmottet al.[19]	2012	British	36.48 ± 4.28	16–92
Isaacs et al.[20]	2013	Australian	29.4	Not mentioned
Ramachandranet al.[21]	2015	South Indian	31.32 ± 4.79	19.6–44.8
Rokayaet al.[22]	2016	Nepal	31.3 ± 5.28	18–47
Živanović et al.[23]	2016	Central Serbian	34.06 ± 4.2	25.1–49.5
Šimunovićet al.[24]	2017	Croatian	34 ± 5	21–46

X-ray Beam Obliquity (Talar Tilt)

Talar tilt (TT) refers to the condition when the maximal distance between two lines of projection of the talar dome on plain film is larger than 2 mm (Fig. 2). The double lines sign reflects TT or X-ray beam obliquity. Obliquity of the X-ray beam will result in an error for BA measurement of ±6°. This impacts the accuracy for surgeons in making decisions relating to diagnosis and treatment tactics[26].

Böhler's Angle

Böhler's angle is measured on lateral view. This parameter is a complement of the angle formed by two lines connecting the superior aspect of the anterior calcaneal process with the superior aspect of the subtalar joint facet and the posterior calcaneal tuberosity with the superior aspect of the subtalar joint facet (Fig. 3)[7].

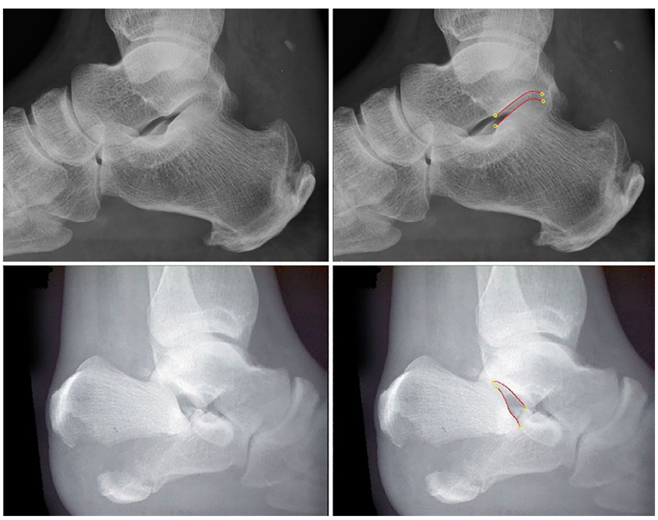

Fig. 1 Subtalar joint congruity (STJC) is defined as the subtalar facet of talus being parallel to the the posterior facet of the calcaneus, as well as the start–end points of these two facets matching each other

Abnormal Foot Arch

Abnormal foot arch (AFA) means Meary's angle is outside of −4°–4°. Meary's angle is the angle between a line drawn from the centers of longitudinal axes of the talus and the first metatarsal on lateral foot radiograph (Fig. 4)[27]. According to the biomechanics of gait, a normal foot arch is crucial for a foot to implement this function the gait. AFA may change the alignment of the lower extremity and alter the foot loading sequence, which induces foot, knee, and lower back pain or discomfort[28].

Statistical Analysis

All statistical analyses were performed using the statistic software SPSS (version 22, IBM, Almonk, USA) with statistical significance set to a *P*-value ≤0.05 (95% confidence interval).

The interobserver agreement and variations of BA were assessed by the interobserver correlation coefficient (ICC). ICC >0.7 was defined as excellent, 0.4 to 0.7 as good, and <0.4 as poor agreement[29]. If the agreement was good or above, an average of six measurements was taken to present the actual BA to

Fig. 2 X-ray beam obliquity (talar tilt, TT) refers to the condition where the maximal distance between two lines of projection of the talar dome on plain film is larger than 2 mm

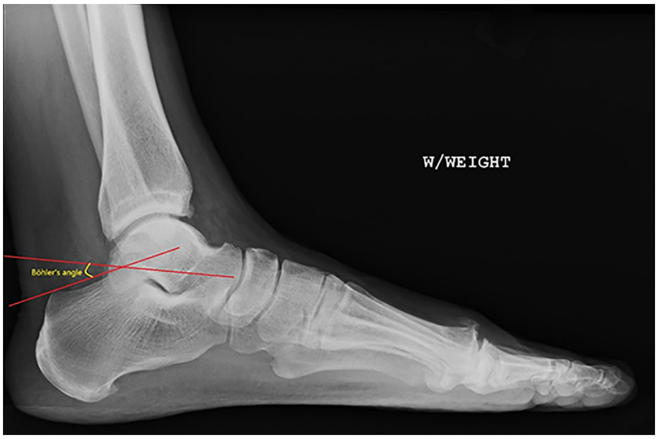

Fig. 3 Böhler's angle (BA) is measured on lateral view. This parameter is a complement of the angle formed by two lines connecting the superior aspect of the anterior calcaneal process with the superior aspect of the subtalar joint facet and the posterior calcaneal tuberosity with the superior aspect of the subtalar joint facet

minimize observer deviation and to determine up the mean value (mean ± SD) and range for the population. The interrater agreement of binomial variables, like STJC and TT, was investigated using Cochran's *Q*-test. Then, the mean values of

Fig. 4 Abnormal foot arch (AFA) means Meary's angle is outside of –4° to 4°. Meary's angle is the angle between a line drawn from the centers of longitudinal axes of the talus and the first metatarsalon lateral foot radiograph

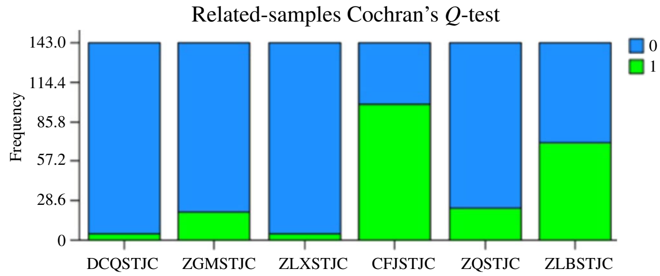

Fig. 5 Cochran's *Q*-test of subtalar joint congruity shows no agreement across observers.

BA were analyzed with respect to the aforementioned factors. *W*-test and quantile–quantile plots were used to assess the data distribution. Variance homogeneity was also evaluated using the Levene test. The runs test was used to assess randomness. The binomial test was used to assess the balance of two-category variables (like sex and body side). An independent Student's *t*-test was used to compare BA for sex, weight-bearing, body side, STJC, TT, and AFA. Furthermore, the correlations between the angle and these binominal parameters were considered using the point-biserial correlation coefficient (r_{pb}) and one-way analysis of variance (ANOVA). Participants were divided into eight age groups, based on 10-year increments. The mean value of BA in different groups was investigated by ANOVA analysis and Scheffe post-hoc test. The Spearman rank test was used to assess the correlation between BA and age group.

Results

Interobserver Reliability

The interobserver reliability of BA was excellent (ICC =0.91, significance = 0.00). Cochran's *Q*-test was used to investigate the reliability of STJC and TT across observers. No interrater agreement presented in STJC ($P = 0.000$, Fig. 5). However, excluding CFJTT (TT that was investigated by CaiFujuan), agreement of TT across observers was excellent ($P = 0.269$, Fig. 6).

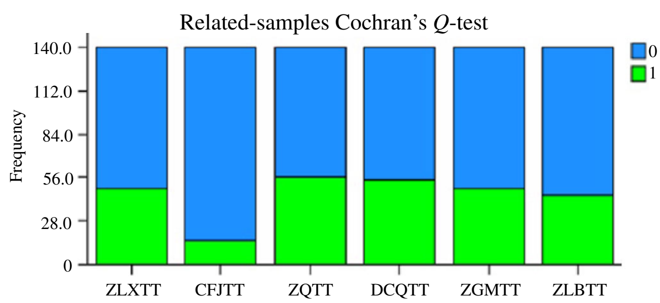

Fig. 6 Excluding CFJTT, Cochran's *Q*-test of TT shows excellent interrater agreement. * ZLX, CFJ, ZQ, DCQ, ZGM, and ZLB are the names of the observers. TT means X-ray oblique.

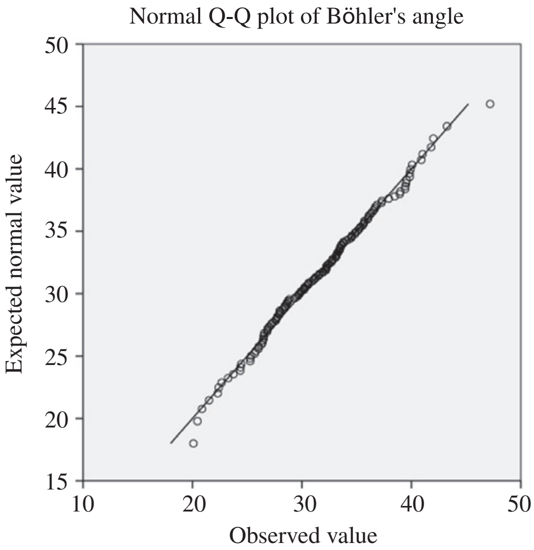

Fig. 7 Q-Q plot reveals normal distribution of Böhler's angle (BA).

Data Distribution and Cases Randomness

Figure 7 shows that the data for BA revealed a normal distribution despite the large range of ages (Shapiro–Wilk coefficient = 0.993). The randomness of case selection was verified using the runs test, for age (P = 0.28), sex (P = 0.42), and body side (P = 0.76).

Equality of Data

The ratio of sex and body side was equal in the study (both P = 0.24). Variant homogeneity was analyzed using the Levene test when comparing the value of BA between different groups,. Similar results were observed. The demographics of participants and the distribution of BA according to sex, body side, STJC, and TT are shown in Table 2.

Value of Böhler's Angle

In the study, the value of BA was 31.6° ± 5.19°, ranging from 20.08° to 47.19°. The 95% confidence interval of BA was 30.75° to 32.40°.

Influencing Parameters

The value of BA was not the same in male (31.84° ± 5.81°) and female (31.4° ± 4.65°) patients, but the difference was not statistically significant (P = 0.628). The angle was independent of sex (rpb = −0.042, P = 0.628). Similar results were found for body side, STJC, and TT (Table 2).

The BA value of age group 0 was different from that of others (P = 0.001). The mean valve of BA showed no significant difference across age groups 1–7 (P = 0.767). Because the angle is a continuous variable, but the age group is a rank categorical variable, Spearman's rank correlation coefficient was applied to investigate the correlation between BA and age group (Table 3). No significant correlativity was revealed in the present study (excluding age group 0, N = 137, r_s = −0.048, P = 0.438).

Discussion

Calcaneal fractures are the most common among tarsal fractures, accounting for approximately 2% of all fractures. Intraarticular fractures comprise over 60% of calcaneal fractures. This kind of fracture requires anatomic reduction to promote functional recovery[30]. After fracture, BA is conventionally used to evaluate the displacement and assess the reduction quality. The decreased value of BA is helpful for diagnosis as well determining the best therapeutic regimen[7]. There are many advantages to such an angle: it is easily measured; only a lateral radiographic view of the foot or ankle can provide BA; a reliable result is provided, regardless of age, sex or region; the normal value of BA is likely always the same[31]; and it is relevant to patients' outcome[10].

However, there are some limits to BA. The range of normal BA is large. According to Böhler (1931), a normal value of BA ranged from 30° to 35°[7]. Various "normal values" of BA have since been suggested in published studies,

TABLE 2 Bohler's angle (BA) according to sex, body side, subtalar joint congruent, and X-ray beam oblique

			Böhler's angle (°)					
Variables	Characteristics	Quantity (%)	Mean	SD	95% CI	Range	Significance	Correlation*
Sex	Male	64 (44.76%)	31.84	5.81	30.46–33.32	20.46–47.19	0.628	−0.042
	Female	79 (55.24%)	31.4	4.65	30.37–32.45	20.08–43.25		
Body side	Left	79 (55.24%)	32.12	4.83	31.04–33.21	20.87–43.25	0.182	−0.112
	Right	64 (44.76%)	30.96	5.56	29.58–32.28	20.08–47.19		
Subtalar joint congruity (STJC)	Yes	121 (84.62%)	31.87	5.23	30.95–32.84	20.08–47.19	0.144	−0.123
	No	22 (15.38)	30.11	4.8	28.09–32.32	20.87–39.85		
X-ray beam oblique (TT)	No	58 (40.56%)	32.26	4.74	31.09–33.48	20.46–42.01	0.211	−0.105
	Yes	85 (59.44%)	31.15	5.45	30.06–32.30	20.08–47.19		
Total	-	143 (100%)	31.6	5.19	30.75–32.40	20.08–47.19	-	-

* Correlation is investigated by point-biserial correlation coefficient (r_{pb}). No significant correlation was revealed between BA and sex, body side, subtalar joint congruity, and X-ray beam oblique.

TABLE 3 Böhler's angle (BA) in different age groups

Age(years)	Sex	Quantity (%)	Böhler's angle (°) Mean	SD	95% CI	Range	Correlation*
<10†	Male	5 (3.50%)	41.14	3.95	37.89–44.60	36.39–47.19	Spearman's rho correlation coefficient = –0.067, Sig = 0.438
	Female	1 (0.70%)	39.93	-	-	-	
	Total	6 (4.20%)	40.94	3.57	38.12–44.00	36.39–47.19	
10 ≦ age < 20	Male	4 (2.80%)	29	5.34	25.05–36.70	24.37–36.70	
	Female	7 (4.90%)	33.98	6.84	28.40–38.54	22.39–40.07	
	Total	11 (7.69%)	32.17	6.56	28.11–35.67	22.39–40.07	
20 ≦ age < 30	Male	6 (4.20%)	29.42	4.5	25.71–32.87	23.25–34.87	
	Female	9 (6.29%)	31.32	2.11	29.95–32.72	27.97–34.49	
	Total	15 (10.49%)	30.56	3.27	28.81–32.26	23.25–34.87	
30 ≦ age < 40	Male	12 (8.39%)	32.66	4.04	30.56–35.25	27.73–42.01	
	Female	4 (2.80%)	32.27	5.82	26.82–39.57	26.82–39.57	
	Total	16 (11.19%)	32.57	4.34	30.58–34.69	26.82–42.01	
40 ≦ age < 50	Male	15 (10.49%)	31.45	5.68	28.31–34.29	22.31–39.86	
	Female	19 (13.29%)	31.02	4.37	28.98–33.10	21.52–37.27	
	Total	34 (23.78%)	31.21	4.91	29.39–32.82	21.52–39.86	
50 ≦ age < 60	Male	9 (6.29%)	29.94	8.11	24.98–35.73	20.46–39.85	
	Female	24 (16.78%)	30.81	3.94	29.21–32.43	20.08–41.03	
	Total	33 (23.08%)	30.57	5.27	28.87–32.39	20.08–41.03	
60 ≦ age < 70	Male	8 (5.59%)	30.33	2.9	28.21–32.32	26.53–34.55	
	Female	7 (4.90%)	30.21	4.82	26.63–33.93	22.66–35.02	
	Total	15 (10.49%)	30.28	3.76	28.26–31.93	22.66–35.02	
70 ≦ age < 80	Male	5 (3.50%)	32.73	4.87	27.78–37.00	25.28–37.93	
	Female	8 (5.59%)	31.49	6.37	27.63–36.22	26.04–43.25	
	Total	13 (9.09%)	31.97	5.66	29.00–35.16	25.28–43.25	
Total		143 (100%)	31.6	5.19	30.67–32.38	20.08–47.19	

* No significant correlation was revealed between BA and age group.; † The BA value of age group 0 is different from others ($P = 0.001$). The mean value of BA showed no significant difference across age groups 1–7 ($P = 0.767$). When investigating the correlation between BA and age group, group 0 is excluded.

such as 25°–40°, 14°–50°, 28°–38°, 20°–50°, 16°–47°, and 20°–40°[11,12,14,15,32–34], especially in different nations (Table 1). Because BA is crucial for the diagnosis and treatment of calcaneal fractures, the variation of BA in different population of this special angle may lead to an incorrect management plan[20]. In the present study, BA in the Chinese population ranged from 20.08° to 47.19°. The mean value was 31.6° ± 5.19° or 26.41°–36.79°. These values concur with values in the previous literature, and also have a wide range. What range of degrees is ideal? Maybe a 95% CI of BA, 30.75°–32.40° ≈ 30°–33°, is more accurate and practicable while applying BA as a parameter to assess reduction quality after calcaneal fractures.

Böhler's angle is generally used as a surgical indication for calcaneal fractures. Several published studies support this idea.[9,35,36] In contrast, some studies report that BA had poor correlation with prognosis after calcaneal fractures.[37] A 15-year follow-up of a randomized controlled trial of calcaneal fracture treatment showed that BA had no relationship with the clinical outcome regardless of whether conservative or operative treatment was followed.[38] A meta-analysis demonstrates that operative treatment is better for achieving anatomical recovery, especially considering BA, for displaced intra-articular calcaneal fractures, but the difference in functional outcome does not seems to be significant between operative and non-operative treatment.[39] Moreover, it is suspicious that operative treatment by open reduction and internal fixation provides better results than nonoperative care.[40] At this point, STJC may be a useful parameter to predict patients' functional outcome.[41,42] However, there is a rare study in this case. The incongruence of STJC value across observers demonstrates the unreliability of the method that has been used in current study. Further analysis of STJC needs to be carried out.

Despite the limitations of BA, it is easy and economical to obtain BA. At the same time, just as the current study showed, the reliability of BA is excellent. For the time being at least, there may be no better parameters to replace BA to investigate the morphology of calcaneus when clinically describing calcaneal height.

In the present study, BA showed no dimorphism in sex, age, body side, STJC, and TT. The mean value of BA in these binomial subgroups indicated no statistically significant difference. These results concur with those of previous studies.[12] Interestingly, there are few studies with results conflicting with these findings. In these reports, BA varies with sex and age, and shows a negative correlation with senility.[14,17,18,23] The representativeness of the sample and statistics management may provide reasons for this kind of confliction. Based on the present study, BA is independent of age and body side. This provides some feasibility for calcaneal fracture reduction referring to a contralateral foot or prior X–ray view, which contributes to individual treatment.

Table 3 shows that the mean value of BA in the age group 0 was significantly different from that of other groups. If group 0 is excluded from the statistical analysis, the calculation demonstrates excellent agreement across age groups based on BA value (P = 0.767). This means people above 10 years of age have the same value of BA. The ossification of bones in a foot is not the same. The calcification center of the calcaneus presents by the 22nd week of gestation.[43] Calcaneal epiphysis appears after 2–8 (female)/4–10 (male) years of age and continues to 10–15 (female)/11–17(male) years of age.[44] The progress of calcification makes a difference to the morphology of calcaneus,[45] plays a role in X-ray measurement, and sometimes is the cause of deformity.[46] Thus, it is not easy to measure BA accurately in children. When interpreting calcaneal radiographs of children, the impact of age on ossification must be taken into account. Based on the current investigation and previous study, it is reasonable to apply BA for individuals over 10 years old.

The results of the current investigation are consistent with previous studies (Table 1). A large range for normal BA presents in the published research. The mean value of BA is different in different populations.[12–14,16,18,19,21–24] It seems reasonable to use a particular reference value for different ethnic groups, enabling precise treatment for calcaneal fractures.

Before the investigation of BA, observers all underwent pre-survey training. Despite the definition of STJC being clear, the observations across observers showed poor agreement. This may be because the osteal mark point was not easy to identify during the survey. However, TT showed excellent interobserver agreement. This demonstrates that operability and accuracy were obtained in the identification of TT. TT is mainly a technical matter, and not typically related to patients' outcome. However, STJC is more likely having impact on patient's outcome.[47,48] Unfortunately, according to the current study, it is hard to obtain STJC measurement reliably. Modifying the identification of STJC or switching it to another measurement may be a resolution.

X-ray beam obliquity may cause deviation of measurement.[26] To reduce this kind of error, X-ray beams should be perpendicular to the sagittal plane and parallel to the axial plane of the ankle joint. Following instruction, a true radiographical lateral view of the ankle join is defined as there is no double line at the talar dome and the distal tibia. Besides, there is no direct parameter to evaluate the true lateral view of the calcaneus, so the double line on the talar dome is a useful feature. In the present study, we defined TT as the maximum distance between double lines of more than 2 mm to demonstrate that the picture is not a lateral view of the calcaneus. At this point, the subtalar joint should be normal; if not, the lateral talus does not indicate lateral calcaneus exactly. According to the definition of dislocation, two matching or parallel articular facets is a sign of a normal joint. STJC may be applied to investigate if the subtalar joint is normal. In this study, weight-bearing and AFA were recorded. However, the number of weight-bearing cases was too few, and foot arch could not be measured by calcaneal view, which made up the majority of subjects in the present study. Therefore, these two parameters were finally excluded. Even so, it is not ridiculous to hypothesize that weight-bearing and foot arch have an effect on BA.[49] Further study is recommended.

There are some limits of the current study. Its retrospective design meant that some key statistics were missed, such as weight-bearing, foot arch, and hindfoot alignment data. In addition, in a retrospective study, biases may affect the selection and distribution of subjects. The relationship of BA with X-ray type, such as ankle view, foot view, and calcaneus view, was not inspected. This factor may play some role in the measurement of BA. The method of measuring STJC needs to be improved to enhance reliability and operability. Further study on the influence of TT on BA is recommended to determine the magnitude of obliquity causing the significant differences in BA.

Conclusion

Böhler's angle in the normal Chinese population was found to be 31.6° ± 5.19° (range 20.08°–47.19°, 95% CI 30.75°–32.40°), which was independent of age, sex, body side, and minor X-ray beam obliquity. X-rays of subjects under 10 years old are not suitable for Böhler's angle measurement. It is reasonable to use a special reference value of BA in different races: 30°–33° can be recommended as a target value of calcaneal fracture reduction for Chinese people.

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Reference

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