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**Research Article/Özgün Araştırma**

# The determination of the Boehler tuber joint angle and Gissane critical angle in Turkish population according to age and gender

# Yaş ve cinsiyete göre Türk populasyonunda Gissane kritik açısı ve Boehler tuber eklem açısının değerlendirilmesi

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**Abstract**

**Aim:** Boehler angle and Gissane angle was aimed to determine in Turkish population aged between 18-79 years.

**Materials and Methods:** It is a retrospective study Boehler angle and the Gissane angle measurements were obtained from lateral ankle-foot radiographs taken from 236 healthy population.

**Results:** The significance wasn't found in both two angle parameters between gender ($p$=0.283 for the Boehler angle; $p$=0.485 for the Gissane angle). Additionally, according to age groups, there was a decrease in Boehler angle from decade 1 to the decade 7, the Boehler's angle increased again. Also, the Gissane angle reached a maximum degree in the decade 7, whereas the lowest value obtained in the decade 2.

**Conclusion:** There were a difference in calcaneal angle reference values in terms of gender, race and age. The knowledge of the calcaneal angles reference values can provide an important data for clinicians, radiologist and orthopedists with reference and normal values for healthy population.

**Keywords:** Calcaneal angle; Gissane angle; Boehler angle.

**Öz**

**Amaç:** Yaşları 18-79 arasında değişen Türk populasyonunda Boehler açısını ve Gissane açısını belirlemek amaçlandı.

**Gereç ve Yöntem:** Bu çalışma retrospektif bir çalışmadır. Boehler açısı ve Gissane açısı ölçümleri 236 sağlıklı kişiye ait lateral ayak bileği ve ayak radyografilerinden elde edildi.

**Bulgular:** Cinsiyet arasında her iki açı parametrelerinde anlamlı farklılık bulunmadı ($p$=0,283, Boehler açısı için; $p$=0,485, Gissane açısı için). Ayrıca, yaş gruplarına göre 1.dekattan 7.dekata kadar Boehler açısında bir azalma vardı ve Boehler açısı 7.dekatta tekrar artış gösterdi. Ayrıca, Gissane açısı 2.dekatta en düşük değerine ulaşırken, 7.dekatta maksimum seviyeye ulaştı.

**Sonuç:** Kalkaneal açı referans değerleri cinsiyet, ırk ve yaş açısından farklılık gösterdi. Kalkaneal açı (Boehler and Gissane açıları) referans değerlerinin bilinmesi klinisyenler, radyologlar ve ortopedistler için sağlıklı populasyonla ilgili referans ve normal değerlerin ortaya konmasını sağlayabilir.

**Anahtar Kelimeler**: Kalkaneal açı; Gissane açısı; Boehler açısı.

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## Introduction

Foot bones occur from 26 bones which are from rear to forefoot: talus, calcaneus, navicular, cuboid, 3 cuneiforms, (medial, intermediate, and lateral cuneiforms), 5 metatarsals, and 14 phalanges.[1,2] The calcaneus is the largest of the seven tarsal bones and constitutes the heel pad of the foot.[3,4] It has many articulations and ligamentous and tendinous attachments. Calcaneus participates to the longitudinal arch posterior side, it plays a significant role supporting of the talus and providing weight bearing.[3,5] The most frequent type of traumatized bone is the calcaneus. Calcaneal fractures account for 60% of the hindfoot fractures, and 2% of all fractures.[6,7] The mainly reasons of calcaneal fractures are fall from height and motor vehicle accidents.[7,8] This type fractures occur are commonly due to high velocity trauma.[9] The calcaneal fractures are the most disabling fractures and common between 21 to 45 years.

Additionally calcaneal fractures is common among industrial workers.[7] So, the treatment of calcaneus fractures are difficult and time consuming and this makes Calcaneal fractures a huge socioeconomic burden to society.[8] The Boehler angle (BA) is a parameter used in evaluate the integrity of the calcaneus. Also, BA is the one of the calcaneal angles and a very useful parameter in evaluation and diagnosis of calcaneal fractures. Additionally, the BA often ranges from 20° to 40°. It is often used in lateral radiograph to evaluation the degree and severity of intraarticular deformity aberration from the calcaneus.[6] If BA is less than 20-28 degrees, calcaneal fractures can think for diagnosis. It was accepted that BA less than 20°-28° made think the presence of calcaneal fracture.[4,9] The BA is an important in determination of calcaneus entirety.[4] In 1931, BA, was introduced by Dr. Lorenz Boehler as the tuber joint angle, and a decrease in this angle indicates that weight bearing posteriorly facet depression when BA decreases in calcaneal fractures or take a negative value. In Boehler's study, the normal range of BA was accepted as 30°-35 degree.[10,11] In studies perfomed with different population BA took various values such as 25°-40°; 14°-50°; 28°-38°;20°-50°; 16°-47°; and 20°-40 degree.[3,11-17] Likewise, the Gissane angle (GA) is other angle used in assesment of the calcaneal fractures. GA is a significant measurement parameter in assessment of calcaneal fractures. In the other studies, the normal limit of GA ranged from 96° to 152°; 100° to 130°; 120° to 145°; 95° to 105°. There were no completely limit for fracture.[11] The knowledge of the normal values of the calcaneal angles may provide to assessment of the calcaneal deformity degree, and quality of reduction, to predict the morbidity after calcaneal fractures to clinicians.[11] In a few studies of the calcaneal angles, the differences between gender and age related changes were observed.[3,11]

The aim of this study is to determine the values of the calcaneal angles of the Turkish population and to determine their distribution according to age and gender.

## Materials and Methods

### The type and sample of the research

This study was carried out from the 236 adult subjects (101 males; 135 females) aged 18-79 years. The study period extended from January 2014 to January 2019. All radiographic records were measured using lateral plain radiographs of the foot and ankle, collected from the Department of Radiology in Adana Medline Hospital (Turkey). The radiograph measurements were taken and reported by the radiologist and their evaluations were performed by radiologist and anatomists. This study is a retrospective observational study.

Healthy adult subjects were selected by criteria of optimal health.

The main exclusion criteria were:

- Adult subjects who were history of fractures regarding with tarsal bones, metatarsal bones or phalanges.
- Adults who were undergone surgery about foot and ankle.
- Adult subjects who have history of congenital or acquired deformities and arthritic changes.

### Ethics committee approval

All the test procedures were conducted after ethic approval. This study was approved by the

Institutional Review Ethics Committee at Cukurova University (Decision no: 2019/93-34). The research study was explained to each participant prior to data collection and volunteers receipted volunteer consent form. All the test procedures were performed after ethics committee approval according to the Helsinki Declaration of Principles.

**Analysis of data**

The data were divided into both two groups as healthy adult female and male subjects, and seven groups according to ages. Age groups were as follows:

- Decade 1: 18-20 years
- Decade 2: 21-30 years
- Decade 3: 31-40 years
- Decade 4: 41-50 years
- Decade 5: 51-60 years
- Decade 6: 61-70 years
- Decade 7: 71-80 years.

Measurement parameters were as follows.

The angle of Boehler (BA): 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.[3,11,14]

The angle of Gissane (GA): The angle between the lines drawn on lateral border of the posterior facet and the line drawn on the linear opacity of the anterior facet.[3,11,14]

**Statistical methods**

The SPSS 22.0 program was used for statistical analysis of the measurement results. From these measurements, means, standard deviations (SD), minimum and maximum values were calculated. Normality were evaluated by Shapiro Wilks test and the data tested were normally distributed. Also, ANOVA test were one of the parametric tests were chosen to determine the significance between gender and age groups. Additionally, the $p<0.05$ value was considered as significant.

**Results**

The means, associated standard deviations, and range of values for the angle measurements from calcaneal region were presented in Table 1-4. There were no significant difference in the GA and the BA between age groups ($p>0.05$) (Table 2). In males, the mean of the BA in the decade 5 was found as the highest value (31.53±5.29°), whereas this angle in the decade 6 was the lowest value (26.23±4.62°) (Table 3). The GA took the highest value (130.10±6.58°) in the decade 6, while the lowest value was obtained in the decade 1 (123.87±4.51°) in males (Table 3). In females, the mean of the BA in the decade 7 was found as the highest value (33.05±3.18°), whereas this angle in the decade 6 was the lowest value (26.04±5.34°). The GA in the decade was the highest value (129.60±3.54°), while the lowest value was obtained in the decade 6 (124.66±5.84°) in females (Table 4). The comparison of the present study and other population's studies related with Boehler and Gissane angles in tables 5-6.

**Discussion**

Calcaneus is the one of the key bones supporting the body weight. Calcaneus fracture is common (slipping from stairways and motor vehicle accidents).[5,7,8] Radiological measurement of the BA and the GA of the calcaneus plays major role in calcaneal fracture diagnosis, management and assessment of prognosis, intra operative reduction and fixation.[5] The BA is called as calcaneal angle, tuber joint angle or salient angle. This angle is used for evaluation the loss of calcaneal inclination or ankle dorsi flexion impingement. Also, in decrease of BA the weight bearing surface of the calcaneus collapses, and this leads to shifting of the weight of the body anteriorly. The reduction of BA indicates mainly the degree of proximal displacement of the calcaneal tuberosity.[5,18] However, BA play an important role as a guide in evaluation outcome following surgical or non surgical treatment of calcaneal fractures.[5,19,20]

**Table 1.** The distribution of the Boehler and Gissane angles according to gender.

| **Measurements** | **Female (135)** **Mean±SD** **(Min.–Max.)** | **Male (101)** **Mean±SD** **(Min.–Max.)** | ***p* value** |
|---|---|---|---|
| The angle of Boehler (degree) | 29.30±5.45 (19.10°-42.40°) | 30.06±5.30 (19.90°-42.30) | 0.283 |
| The angle of Gissane (degree) | 126.46±6.13 (111.80°-142.60°) | 125.91±5.77 (112.50°-143.70°) | 0.485 |

SD: Standard Deviation; Min.: Minimum; Max.: Maximum; *p*=The significance value

**Table 2.** The Boehler and Gissane angles according to age groups.

| **Measurements** | **Decade I (18-20 years) N=39** | **Decade II (21-30 years) N=41** | **Decade III (31-40 years) N=53** | **Decade IV (41-50 years) N=55** | **Decade V (51-60 years) N=24** | **Decade VI (61-70 years) N=18** | **Decade VII (71-80 years) N=6** |
|---|---|---|---|---|---|---|---|
| | **Mean±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** |
| Boehler’s angle | 31.00±5.84 (21.40-42.40) | 30.36±5.07 (20.00-40.00) | 29.93±4.99 (20.00-42.30) | 29.21±5.54 (19.10-41.70) | 28.88±4.99 (19.90-37.00) | 26.07±5.10 (20.30-36.60) | 30.35±5.96 (23.50-38.10) |
| *P* value | | | | 0.056 | | | |
| Gissane angle | 126.39±7.11 (111.80-142.60) | 125.46±6.05 (114.20-135.50) | 127.00±6.27 (112.75-143.70) | 126.03±5.24 (112.50-137.50) | 126.22±5.32 (118.00-136.60) | 125.57±6.12° (117.20-134.40) | 127.28±4.54 (120.60-132.70) |
| *P* value | | | | 0.915 | | | |

SD: Standard Deviation; Min.: Minimum; Max.: Maximum; *p*=The significance value

**Table 3.** The Boehler and Gissane angles according to age groups in males.

| **Measurements** | **Decade I (18-20 years) N=21** | **Decade II (21-30 years) N=18** | **Decade III (31-40 years) N=24** | **Decade IV (41-50 years) N=22** | **Decade V (51-60 years) N=9** | **Decade VI (61-70 years) N=3** | **Decade VII (71-80 years) N=4** |
|---|---|---|---|---|---|---|---|
| | **Mean±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** |
| Boehler’s angle | 30.49±5.57 (21.40-40.00) | 30.33±4.73 (21.90-40.00) | 30.02±4.69 (21.70-42.30) | 29.58±6.22 (20.30-41.70) | 31.53±5.29 (19.90-37.00) | 26.23±4.62 (20.90-28.90) | 29.00±6.96 (23.50-38.10) |
| *P* value | | | | 0.845 | | | |
| Gissane angle | 123.87±4.51 117.10-134.90 | 124.27±5.69 115.10-136.20 | 127.20±6.42 112.75-143.70 | 126.81±5.71 112.50-137.50 | 126.79±6.42 118.00-136.60 | 130.10±6.58 122.50-133.90 | 126.13±4.98 120.60-132.70 |
| *P* value | | | | 0.268 | | | |

SD: Standard Deviation; Min.: Minimum; Max.: Maximum; *p*=The significance value

**Table 4.** The Boehler and Gissane angles according to age groups in females.

| **Measurements** | **Decade I (18-20 years) N=18** | **Decade II (21-30 years) N=23** | **Decade III (31-40 years) N=29** | **Decade IV (41-50 years) N=33** | **Decade V (51-60 years) N=15** | **Decade VI (61-70 years) N=15** | **Decade VII (71-80 years) N=2** |
|---|---|---|---|---|---|---|---|
| | **Mean±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** | **Mean ±SD Min.-Max.** |
| Boehler angle | 31.59±6.24 (24.00-42.40) | 30.38±5.43 (20.00-38.20) | 29.85±5.30 (20.00-40.80) | 28.97±5.13 (19.10-40.80) | 27.28±4.20 (20.10-37.00) | 26.04±5.34 (20.30-36.60) | 33.05±3.18 (30.80-35.30) |
| *p* value | | | | 0.041 | | | |
| Gissane angle | 129.33±8.49 111.80-142.60 | 126.39±6.28 114.20-138.50 | 126.83±6.26 115.40-137.40 | 125.50±4.92 116.80-136.00 | 125.87±4.75 118.50-134.30 | 124.66±5.84 117.20-134.40 | 129.60±3.54 127.10-132.10 |
| *p* value | | | | 0.338 | | | |

SD: Standard Deviation; Min.: Minimum; Max.: Maximum; *p*=The significance value

GA is known as the critical angle of Gissane angle. The normal value ranges between 120 degree and 140 degree.[5] This study present the normal values of Boehler and Gissane angles between both gender and age groups range from 18 to 79. This study reported a range from 19.10° to 42.40° in BA and 111.80° to 142.60° in GA in Turkish females. The same measurements was stated a range from 19.90° to 42.30° in BA and 112.50°-143.70° in Turkish males. The results of the BA and the GA in present study provide the evaluation and decision treatment of calcaneal fractures among Turkish population. Also, these values showed that both the BA and the GA in the Turkish population had a wider range like many published values (Table 5-6). [3,5,7,11,13,14,21-24]

An interesting finding was that the highest value was obtained in the decade 2 for the BA and in the decade 7 for the GA (Table 2). Also, group of the decade 5 had the highest value for the BA; whereas, the lowest value of the GA was obtained in the group of the decade 6 years in males. Also, the highest value was obtained in the decade 7 for both BA and GA in females. Additionally, the lowest means of both the BA and the GA were in the decade 6. In present study, the BA ($p$=0.845) and the GA ($p$=0.268) in males, and the GA ($p$=0.338) in females showed no significant differences between age groups. However, the significant difference were no found in the BA ($p$=0.283) and the GA ($p$=0.485) between gender. Moreover, the BA and the GA results may show the race variation between different populations. A few researches indicated that the BA correlated with age.[21] Although some studies showed a relationship between gender and the BA or the GA.[15] Our study findings were found to be compatible with studies performed with the radiographic method.

In this study, no relationship was found between the BA or the GA and gender. Also, accorrding to age groups, there were no found in the values of the BA and the GA of both gender (except the BA in females; $p$=0.041). When comparing the literature with BA findings in our study, we observed that there were differences between Saudi, Turkish, Nigerians, Indians, New Zeland populations. However, the BA findings are similar to Turkish and American populations. The differences between races may originate from the variation in some activities like built and load bearing.[5] We found significant differences in the mean value of the GA of Indians, Saudi, Turkish, Egyptian, and New Zeland population with our Turkish population; from this data, our results are greater than above studies (Table 6). We consider that these discrepancies could be a result of such factors like race or ethnic differences, and participant age. Interestingly, our angle results indicated that the significant difference was found the Boehler only in females. In total (without taking into account for gender), there were no significant difference in the Boehler angle ($p$=0.056) or the Gissane angle ($p$=0.915).

**Table 5.** The comparison of the present study and other population's studies related with Boehler's angle.

| Study | Year of study | Race | Mean | Range |
|---|---|---|---|---|
| Chen et al. | 1991 | American | 29° (female)<br>30° (male) | 14°-50° |
| Didia and Dimkpa | 1999 | Nigerian | 32.81° (female)<br>32.84° (male) | 28°-38°(total) |
| Kroshhal et al. | 2004 | Saudi | 31.24° (female)<br>31.15° (male) | 18°-43° (female)<br>16°-47° (male) |
| Seyahi et al. | 2008 | Turkish | 33.5° (female)<br>34.3° (male) | 20°-46° (total) |
| Shoukry et al. | 2010 | Egyptian | 30.14° | 22°-40° |
| Boyle et al | 2011 | New Zeland | 39.2° | 26.2°-54.9° |
| Sengodan &Karthikeyan | 2012 | Indian | 31.4°(female)<br>31.6° (male) | 18°- 43° (total) |
| Ramachandran&Shetty | 2015 | South Indian | 31.82° | 18.7°-46.2° |
| Siminovic et al | 2017 | Croatian Caucasian | 33.73° | 20.9°-46.3° |
| Yang et al. | 2019 | Chinese | - | 28.96°-31.26° |
| Present study | 2019 | Turkish | 30.06 (male)<br>29.30 (female) | 19.90-42.30<br>19.10°-42.40° |

**Table 6.** The comparison of the present study and other population's studies related with Gissane angle.

| Study | Year of study | Race | Mean | Range |
|---|---|---|---|---|
| Kroshhal et al. | 2004 | Saudi | 116.39° (female)<br>115.66° (male) | 96°-152° (female)<br>98°-136° (male) |
| Seyahi et al. | 2008 | Turkish | 114.8° (female)<br>115.4° (male) | 100°-133° |
| Shoukry et al. | 2010 | Egyptian | 122.92° | 108°-138° |
| Boyle et al. | 2011 | New Zeland | 113.8° | 97.10°-132.00° |
| Sengodan&Karthikeyan | 2012 | Indian | 119.8° (female)<br>121.4° (male) | 100°-145° |
| Ramachandran&Shetty | 2015 | South Indian | 108.7° | 87.5°-137.8 |
| Present study | 2019 | Turkish | 126.46 (female)<br>125.91 (male) | 111.80°-142.60°<br>112.50°-143.70° |

The normal values of the Boehler and the Gissane angles of Turkish population was shown in present study. The knowledge of the calcaneal angles may be important for in orthopaedic surgeons in the foot fractures.

## Ethics committee approval

This study was approved by the Institutional Review Ethics Committee at Cukurova University (Decision no: 2019/93-34). All the test procedures were performed after ethics committee approval according to the Helsinki Declaration of Principles

## Informed Consent

The research study was explained to each participant prior to data collection and volunteers receipted volunteer consent form.

## Author Contributions

Idea, design, collection of resources, analysis and interpretation of results: SP, AGK, MÖ, YÖ. literature, written and critical: SP, AGK, MÖ, YÖ.


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## Conflict of Interest

There is no conflict of interest among the authors.


## Financial Disclosure

There is no financial disclosure.


## Statements

These research results have not previously been presented.

## Peer-review

Externally peer-reviewed.

## References

1. Bonnel F, Bonnin M, Canovas M, Chamoun M, Bouyyset M. Bone and joint disorders of foot and ankle: a rheumatological approach (1th. Ed) Springer Berlin Heidelberg 2016; pp 357-366.
2. Arıncı K, Elhan A. Anatomi Kemikler, Eklemler, Kaslar, İç Organlar (6th ed) Güneş Tıp Kitabevleri, Ankara 2016.
3. Koshhal KI, Ibrahim AF, Al-Nikshabandi NA, et al. Böhler's and Gissane's angles of the calcaneus in the Saudi population. *Saudi Med J* 2004; 25:1967-1970.
4. Udoaka AI, Didia BC. The Calcaneal Bohler's Angle in Nigerians: A radiologic study. Jour of Med Sc & Tech 2013;2(2):81-83.
5. Ramachandran R, Shetty S. Assessment of Bohler's and Gissane's angles of the calcaneum in a group of South Indian population. A radiological study. *Int J Cur Res Rev* 2015; 7(15):17-20.
6. Labronici PJ, Pinheiro de Faria GG, et al. Böhler's angle comparison between the pre and postoperative in displaced ıntra-articular calcaneal fractures. *Rev Bras Ortop* 2019;54:156-164.
7. Sengodan VC, Amruth KH, Kandasamy K. Bohler's and Gissane Angles in the Indian Population. *J Clin Imaging Sci* 2012:2(77):1-3.
8. Pawar E, Gavhale S, Sharma A, et al. Correlation of Bohler's angle and role of bone graft in the functional outcome of displaced intra-articular calcaneal fractures. *Int J Orthop Sci* 2018;4(1):753-758.
9. Mallya S, Kamath R, Hegde A, Annappa R. Can Bohler's angle predict the functional results of ıntra-articular displaced calcaneal fractures. *J Clin and Diagn Res* 2018;12(11): RC05-RC07.
10. Bohler L. Diagnosis, pathology and treatment of fractures of the os calcis. *J Bone Joint Surg Am* 1931;13:75-89.
11. Seyahi A, Uludag S, Koyuncu LO, et al. The calcaneal angles in the Turkish population. *Acta Orthop Traumatol Turc* 2009;43:406-411.
12. Loucks C, Buckley R. Bohler's angle: correlation with outcome in displaced intraarticular calcaneal fractures. *J Orthop Trauma* 1999;13:554-558.
13. Chen MY, Bohrer SP, Kelly TF. Bohler's angle: a reappraisal. *Ann Emerg Med* 1991;20(2): 122 -124.
14. Didia BC, Dimkpa JN. The calcaneal angle in Nigerians. Relationship to sex, age, and side of the body. *J Am Podiatr Med Assoc* 1999; 89:472-474.
15. Igbigbi PS, Mutesasira AN. Calcaneal angle in Ugandans. *Clin Anat* 2003; 16:328-330.
16. Hauser ML, Kroeker RO. Boehler's angle: a review and study. *J Am Podiatry Assoc* 1975; 65:517-521.
17. Knight JR, Gross EA, Bradley GH, et al. Boehler's angle and critical angle of Gissane are of limited use in diagnosing calcaneus fractures in the ED. *Am J Emerg Med* 2006; 24:423-427.
18. Sanders R. Displaced Intra-Articular Fractures of the Calcaneus. *J Bone Joint Surg Am* 2000; 82:225-250.
19. Bakker B, Halm JA, Van Lieshout EM, Schepers T. The fate of Böhler's angle in conservatively treated displaced intra-articular calcaneal fractures. *Int Orthop* 2012; 36(12):2495-2499.
20. Schepers T, Vogels LMM, Schipper IB, Patka P. Percutaneous reduction and fixation of intra-articular calcaneal fractures. *Oper Orthop Traumatol* 2008; 20(2):168-175.
21. Shoukry FA, Aref YK, Sabry AA. Evaluation of the normal calcaneal angles in Egyptian population. Alexandria *J Med* 2012;48:91-97.
22. Simunovic M, Nizić M, Potočki MPDK, Rados M, Zagreb HR. The Boehler angle in the adult Croatian population. *European Society of Radiology* 2017;1:13.
23. Yang Y, Cheng HW, Xiong ZR, et al. Classification and morphological parameters of the calcaneal talar facet: Which type is more likely to cause osteoarthritis in Chinese Population?. *Hindawi BioMed Research International* 2019:1-6.
24. Boyle MJ, Walker CG, Crawford HA. The paediatric Bohler's angle and crucial angle of Gissane: a case series. J Orthop Surg Res. 2011 Jan 10;6:2