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Reliability and Validity of Use of A Smartphone Application For The Measurement of Gissane and Bohler's Angles in Calcaneal Fractures

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Abstract

Objective: Calcaneus is the most often fractured bone of all the tarsal bones in the human skeleton. Initial evaluation of a suspected calcaneal fracture is often assessed with Böhler's and Gissane's angles. The aim of this study was to compare the reliability and consistency of measurements of Gissane and Böhler's angles by using a smartphone application (iPinPoint) and a computer-based program

Methods: A total of 41 patients were included. The measurement of fracture angulation was done by two orthopaedic surgeons twice one month apart using iPinPoint and Sectra. The inter- and intraobserver reliability was measured using intraclass correlation coefficients (ICCs). The intraobserver variabilities between the SECTRA and iPinPoint measurements for each participant were evaluated. Interobserver variability was also determined by comparing the results of Böhler's and Gissane angles among the surgeons

Results: The mean difference between the two techniques were 0.9° and 0.4° for Gissane and Böhler's angles, respectively. The intraobserver reliability of Gissane and Bohler's angles between smartphone and computer for each observer was very good (ICC=0.938 vs. 0.943, ICC= 0.970 vs 0.979, respectively). Interobserver reliability between two observers for SECTRA and iPinPoint results were very good (ICC=0.955, ICC=0.905 respectively).

Conclusion: iPinPoint application can be used for the measurement of Gissane and Bohler's angles safely. In addition, there are very good results that support it as a reliable and reproducible tool for SECTRA measurements.

Keywords: Calcaneus, fracture, measurement, smartphone, Interobserver reliability, Interobserver reliability

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Kalkaneus Kırıklarında Gıssane ve Böhler Açılarının Ölçümünde Mobil Telefon Uygulaması Kullanımının Güvenirliği ve Geçerliliği

Öz

Amaç: Kalkaneus, tüm tarsal kemikler arasında en sık kırılan kemiktir. Şüpheli kalkaneus kırığının ilk değerlendirmesi genellikle Böhler ve Gissane açıları ile değerlendirilir. Bu çalışmanın amacı, bir akıllı telefon uygulaması (iPinPoint) ve bilgisayar tabanlı bir program kullanarak Gissane ve Bohler açılarının ölçümlerinin güvenilirliğini ve tutarlılığını karşılaştırmaktır.

Yöntemler: Çalışmaya toplam 41 hasta dahil edildi. Kırık açılarının ölçümü iki ortopedi cerrahı tarafından bir ay arayla iki kez iPinPoint ve Sectra kullanılarak yapıldı. Gözlemciler arası ve gözlemciler içi güvenilirlik, sınıf içi korelasyon katsayıları (ICC'ler) kullanılarak ölçüldü. Her katılımcı için SECTRA ve iPinPoint ölçümleri arasındaki gözlemci içi değişkenlikler değerlendirildi. Cerrahlar arasında Bohler ve Gissane açılarının sonuçları karşılaştırılarak gözlemciler arası değişkenlik de belirlendi.

Bulgular: İki teknik arasındaki ortalama fark, Gissane ve Bohler açıları için sırasıyla 0.9° ve 0.4° idi. Gissane ve Bohler açılarının akıllı telefon ve bilgisayar sistemlerinde ölçülen değerleri her gözlemci için değerlendirildiğinde gözlemci içi güvenilirliği çok iyiydi (sırasıyla ICC=0.938'e karşı 0.943, ICC= 0.970'e karşı 0.979). SECTRA ve iPinPoint sonuçları için iki gözlemci arasındaki gözlemciler arası güvenilirlik çok iyiydi (sırasıyla ICC=0.955, ICC=0.905).

Sonuç: Gissane ve Bohler açılarının güvenli bir şekilde ölçülmesi için iPinPoint uygulaması kullanılabilir. Ayrıca bu ölçümlerin SECTRA ölçümleri kadar güvenilir ve tekrarlanabilir araçlar olduğunu destekleyen çok iyi sonuçlar elde edildi.

Anahtar kelimeler: Kalkaneus, kırık, ölçüm, akıllı telefon, Gözlemciler arası güvenilirlik, Gözlemciler arası güvenilirlik.

INTRODUCTION

The calcaneus takes the first place in fractures of tarsal bones in the human skeleton, accounting for 60 to 75 percent of all tarsal fractures[1]. Though, fractures of the calcaneus are a relatively rare issue, with an informed incidence that changes from 11.5 to 13.7 per 100,000 persons per year[2-4]. Calcaneus fractures are well-known for their high potential for osteoarthritis and long-term disability that influence the daily lives of the affected individual negatively. Furthermore, the sequelae of the injury may create a substantial economic burden on the patient and the healthcare system[5-7].

With the suspect of calcaneus fracture, evaluation usually starts with conventional radiographic imaging. In conventional radiographic images, Bohler's and Gissane angles are frequently measured. The decrease of Bohler's angle represents the collapse of the posterior facet. Normal values of the angle are between 20 and 40 degrees. There are two main lines in the formation of this angle. The first line starts from the tip posterior facet and ends in the superior surface of the anterior facet. The second line starts from the tip of the posterior calcaneal tuberosity and ends at the posterior facet. Negative values of angle in a displaced and articular surface involvement of calcaneal fracture is associated with an unfavorable outcome[5]. The increase of the Gissane angle also gives information of posterior facet collapse. The angle is measured by the lines along the superior surfaces of the anterior process and the posterior facet of the calcaneal bone to meet at the calcaneal sulcus. Normally, it is between 120 and 145 degrees[8,9].

The presentation of smartphones provides the integration of new mobile technologies into daily life and the clinical applications. Smartphones are portable and practical, thus can quickly help physicians in the diagnosis and treatment of diseases. In a study, it was reported that 53% of orthopedic surgeons use

smartphones in their clinical practice[10]. iPinPoint (version imartSolutions, Greece) is a mobile application that enables the user to perform quick calculations with the aid of the camera. The user would take a picture (or use one from the album), and calculate distances or angles by simply tapping on the screen to pinpoint the angle or object of interest.

Currently, with the support of technological progress, radiological assessment of the fracture angulation is dealt with digital instruments. Despite this, it is still difficult to have these digital instruments in some cases and physicians would need other useful choices. In these conditions, mobile phone applications may exhibit as a practical alternative instrument in the assessment of angulation of fracture instead of computer-based solutions or conventional methods. However, for widespread usage of these applications, their accuracy and reliability must be proven. For this reason, it is necessary to compare the results with the usual methods.

The reliability of smartphone applications has previously been evaluated for Cobb angle analysis in scoliosis and kyphosis, pediatric forearm fractures angulation, and first-ray angular deformity assessments[11-15]. On the other hand, no paper has investigated the assessment of Gissane and Bohler's angles in calcaneal fractures by using a smartphone application. The main goal of this manuscript was to exhibit the comparison of the reliability and consistency of measurements of Gissane and Böhler angles by using a smartphone application (iPinPoint) and a computer-based measurement program (SECTRA, version 20.2.10.3376, Sweden).

METHODS

Radiographic Evaluation

Digital scenes of foot lateral roentgenography of 103 patients with calcaneal fractures, consulted to our emergency department between 2018 – 2020 were retrospectively analyzed. Nondisplacement fractures and unclear images and patients with a previous surgery or history of fracture at the same place were excluded. A total of 41 patients were included in this study. The evaluation of fracture line angles was made by two orthopaedic surgeons twice one month apart using iPinPoint and Sectra (Figure 1 and Figure 2). The fracture angulation values which were measured on digital radiographs on the computer were accepted as reference to analyse and compare with smartphone measurements. The distinction between the measurement on the computer and iPinPoint, for each round were noted. Smartphone evaluations were performed using an Apple iPhone model XR (Apple Inc. Cupertino, CA, USA). The iPinPoint application was downloaded in full version from the Apple iTunes store. The average of two rounds was calculated and used as a main value. The intraobserver variabilities between the SECTRA and iPinPoint measurements for each participant were evaluated. Interobserver variability was also determined by comparing the results of Bohler's and Gissene's angles among the surgeons.

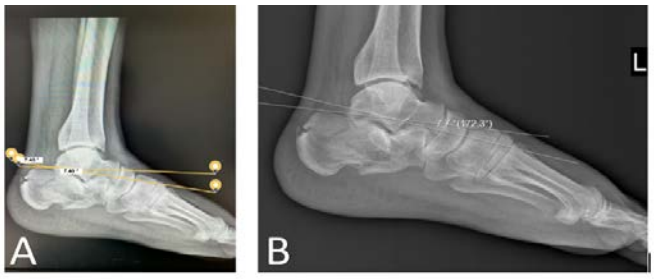

Figure 1. Measurement of Gissane angle in lateral radiographs by (A) iPinPoint and (B) SECTRA.

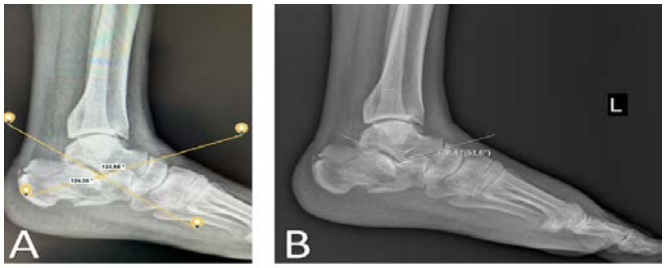

Figure 2. Measurement of Bohler's angle in lateral radiographs by (A) iPinPoint and (B) SECTRA.

Statistical Analysis

SPSS for Windows (version 23.0; IBM Corp, NY, USA) was the main program for statistical assessment. The distributions of the data were controlled with the Kolmogorov-Smirnov normality test. Continuous variables are presented as the mean ± standard deviation (SD) The inter and intraobserver reliability was determined using intraclass correlation coefficients (ICCs) for two participants. Values of 0–0.20 regarded poor reliability, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 good, 0.81-1.0 very good reliability[16]. A p-value of <0.05 was considered to be a statistically significant result.

Ethics Committee approval was obtained from the Dokuz Eylul University Non-Interventional Clinical Research Ethics Board with protocol number 2022/33-01 on October 19, 2022.

RESULTS

Patients were at 46,9 years old on average (17-69). Male sex was more than female (M 82.9%). The mean Gissane and Bohler's angle assessments of the 2 observers for both instruments were shown in Table 1. The mean difference between the two techniques were 0.9° and 0.4° for Gissane and Bohler's angles respectively.

Table I: Mean Gissane and Böhler' angles in calcaneal fractures of All Observers for Each Technique

	SECTRA	iPinPoint
Observer 1 Gissane Bohler's	 118.7 ± 9.2 20.8 ± 8.2	 119.7 ± 8.5 21.1 ± 8.2
Observer 2 Gissane Bohler's	 119.6 ± 9.1 20.7 ± 8.1	 120.4 ±9.1 21.1 ± 8.6

Table 2 demonstrated the intraobserver reliability of Gissane and Bohler's angles between smartphone and computer for each observer was very good. Interobserver reliability between two observers for SECTRA and iPinPoint results were very good and shown in Table 3 (ICC=0.955, ICC=0.905 respectively).

Table II: Intraobserver Values

	Gissane ICC (95% CI)	Bohler's ICC (95% CI)
Observer 1	0.938 (0.884 – 0.967)	0.943 (0.894 – 0.970)
Observer 2	0.970 (0.944 – 0.984)	0.979 (0.960 – 0.989)

ICC: intraclass correlation coefficient, CI: confidence interval

Table III: Interobserver Values

	Gissane ICC (95% CI)	Bohler's ICC (95% CI)
SECTRA	0.983 (0.968 – 0.991)	0.990 (0.982 – 0.995)
iPinPoint	0.978 (0.960 – 0.989)	0.959 (0.923 – 0.978)

ICC: intraclass correlation coefficient, CI: confidence interval

DISCUSSION

We did an intra- and interobserver reliability study using the iPhone application, iPinPoint, to analyse the usefulness of this tool in evaluating Gissane and Bohler's angles in calcaneal fractures against the standard procedure using the SECTRA system. This study showed that the usefulness of the mobile phone tool in comparison with the standard technique on the computer for measuring Gissane and Bohler's angles on calcaneal fractures was very good.

Mostly, computer-based assessment of digital radiographs through hospital-based instruments takes the place of manual measurement of Gissane and Bohler's angles on conventional radiographs. Besides, mobile phones are used to consult about patients by sending the images in daily clinical practice, whereas consultant surgeons may not access computer-based systems at that time. In such circumstances, smartphones suggest a useful way to assess the fracture angles directly on the computer screen. In this study, we showed that while assessing the calcaneal fractures by mobile phones, using the PinPoint application was safe and had compatible results.

In this study, there is a fine distinction between iPinPoint and computer-based values which is compatible with the study conducted by Shaw et al. which has revealed just over 2° difference.

There are some previous reports on the reliability of smartphone applications in the assessment of scoliosis, kyphosis, first metatarsophalangeal issues, and pediatric forearm fractures by comparing them with other traditional techniques [1–6]. Shaw et al.[11] found that the goniometer and smartphone measurements of Cobb angles in scoliosis were equivalent to manual measurements with regard to reliability and compatibility. Jacquot et al.[12] measured kyphotic angles with the iPhone application and got good results that appeared to be a valid procedure. Ege et al.[13] and Walter et al.[14] compared smartphone and PACS evaluation of hallux valgus angles and reported that usage of smartphones is as compatible as computer systems. Ketenci et al.[15] reported that the iPinPoint application may be a practical tool to exhibit digital PACS assessments while analyzing the fracture angulations of pediatric forearm fractures.

There were some limitations. Smartphone applications have an inclination to make measurement mistakes. For iPinPoint evaluation, to decrease the parallax errors, the smartphone screen should be kept parallel to the computer monitor while taking photos. The time consumption for both measurement techniques was not evaluated. However, as known, reaching and using mobile devices can be done very fast, and intrinsically we do not expect a slowdown in the measurement after the training period.

In conclusion, the iPinPoint application can be used for the measurement of Gissane and Bohler's angles safely. In addition, there are very good results that support it as a reliable and reproducible tool as SECTRA measurements. They may be useful when hard copy radiographs or digital images without measuring tools need to be assessed. It will be unnecessary to carry extra devices for the measurements.

Ethics Committee Approval: Ethics Committee approval was obtained from the Dokuz Eylul University Non-Interventional Clinical Research Ethics Board with protocol number 2022/33-01 on October 19, 2022.

Conflict of Interest: The authors declared no conflicts of interest.

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