

Hallux Angles: A New Medical Software for Smartphone for Data Archiving and Angular Measurements of Foot Operated for Hallux Valgus. Study and Discussion on the Software Reliability*

Hallux Angles : un nouveau logiciel médical destiné aux téléphones intelligents permet d'archiver les données et les mesures angulaires des pieds opérés d'un hallux valgus. Étude et discussion quant à la fiabilité du logiciel

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Abstract Introduction: The purpose of this scientific research was to: 1) Verify the reliability of "Hallux Angles" (<https://itunes.apple.com/it/app/halluxvalgus/id574079547?mt=8&affId=1830849&ign-mpt=uo%3D4>) in terms of archiving of sensitive data about the photos of the deformities of patients, and in terms of the correction index measured on radiographs before and after surgery; 2) Compare the indexes of angular deformities of patients measured with three methods: a) With an iPhone software, "Hallux Angles"; b) With a standard goniometer; c) With a PC software (Agfa CR) commonly used in radiology; 3) test the stability of the application over the time.

Materials and methods: Four observers filed 95 patients affected by hallux valgus, operated on in different clinics

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and hospitals from September 2012 to January 2013, with the application "Hallux Angles" adding personal data for each patient, such as the birthday, gender, and radiographic photos taken in the upright position and angle values measured (distal metatarsal articular angle (DMAA), hallux valgus angle (HVA), and intermetatarsal angle (IMA)) before and after surgery. The photos relative to the post-surgical procedure were taken at 40 days. By the data that emerged from the postoperative angle measurements, we obtained the corrective index. Measurements obtained by the software were then compared with those ones emerged using a standard goniometer and then verified by a reliable PC software (Agfa CR), supervised by a radiologist. This procedure gave us the opportunity to test the reliability of the measurements collected. The variability of the obtained results from the two different methods was similar and superposable among the four observers.

In particular, the deviation between the two methodologies (manual measurement with goniometer and measurement with the application) was 1.50 ± 1.2 for HVA, 1.2 ± 0.90 for DMAA, and 1.4 ± 1.1 for IMA. The final verification of the data through the measurement with radiology equipment by a radiologist produced a correlation coefficient according to the Bland-Altman method and was very satisfactory, and it was close to the statistical measurement of 95%, thus confirming an index correlation very reliable and with very small deviations.

Keywords Hallux valgus · Medical software · Data archiving · Angular measurement · Smartphone · Hallux valgus surgery

Résumé Introduction : L'objectif de cette étude scientifique était de : 1) vérifier la fiabilité de l'application « Hallux Angles » (<https://itunes.apple.com/it/app/halluxvalgus/id574079547?mt=8&affId=1830849&ign-mpt=uo%3D4>) qui propose

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d'archiver les données sensibles concernant les patients, les photos des déformations et les indices de correction mesurés sur les radiographies avant et après l'intervention chirurgicale ; 2) comparer les indices des déformations angulaires des patients mesurés selon trois méthodes : a) à l'aide d'une application iPhone intitulée « Hallux Angles » ; b) à l'aide d'un goniomètre standard ; c) à l'aide d'un logiciel pour PC (Agfa CR) couramment utilisé en radiologie ; 3) vérifier la stabilité de l'application au fil du temps.

Matériel et méthodes : Quatre observateurs ont suivi 95 patients affectés par un hallux valgus, opérés dans diverses cliniques et divers hôpitaux entre septembre 2012 et janvier 2013. Ils les ont suivis à l'aide de l'application « Hallux Angles » en ajoutant les données personnelles relatives à chaque patient, comme sa date anniversaire, son sexe, des photos et des radiographies prises en position debout, ainsi que les valeurs angulaires DMAA, HVA, IMA avant et après l'intervention chirurgicale. Les photos relatives à la procédure postchirurgicale ont été prises à 40 jours. Les données provenant des mesures angulaires postchirurgicales ont fourni l'indice de correction. Les mesures obtenues grâce au logiciel ont ensuite été comparées à celles provenant d'un goniomètre standard, puis rapprochées de celles provenant d'un logiciel fiable pour PC (Agfa CR), le tout sous la supervision d'un radiologue. Cela nous a donné l'occasion de vérifier la fiabilité des mesures recueillies. Les résultats collectés selon ces différentes méthodes se sont révélés similaires et comparables entre les quatre observateurs et pour chacun d'entre eux. En particulier, l'écart entre les deux méthodologies (mesure manuelle à l'aide du goniomètre et mesure avec l'application) est de $1,50 \pm 1,2$ pour HVA, de $1,2 \pm 0,90$ pour DMAA et de $1,4 \pm 1,1$ pour IMA. Le contrôle final des données au moyen des mesures effectuées avec l'équipement de radiologie par un radiologue a établi un coefficient de corrélation jugé très satisfaisant selon la méthode Bland-Altman et proche des mesures statistiques de 95 %, confirmant ainsi une corrélation de l'indice très fiable avec peu de dérive.

Mots clés Hallux valgus · Application médicale · Stockage de données · Archivage de données · Smartphone · Mesures angulaires du pied · Chirurgie de l'hallux valgus

Introduction

Hallux valgus is a complex deformity of the foot that ensues from different and distinct causes.

In addition to a deep clinical examination, some angles referred to by radiographs are taken into consideration to determine its severity and to classify it.

The following angles are usually used for radiographic measurements and surgical strategy: the hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal angle (DMAA). The measurement of these angles can be performed manually with the use of a goniometer or with systems for measuring directly on a computer (very accurate but not always easy to use) or with the use of the latest generation smartphone.

The purpose of this study was to verify the reliability of the application "Hallux Angles" and the comparison of the data collected by the manual measurement with a goniometer against those collected with the smartphone software, through the observation and study of four different orthopedic surgeons.

Finally, the overlapping of the results obtained has been verified by the measurements of a dedicated software for PC (Agfa CR). The four orthopedic surgeons and a specialist radiologist participated in the scientific work from five different observation posts.

Materials and methods

We studied 95 cases of patients operated with different surgical methods from September 2012 to January 2013.

We uploaded feet photos and radiographic photos positioned upright on database software. And we measured for each radiographic photo the angular values HVA, IMA, and DMAA before surgery.

The measurement was obtained using a finger or a stylus on the radiographic image, previously enlarged, in order to draw angle axes (Fig. 1).

Each value obtained was recorded by the software and was showed in its slot.

Afterwards, we uploaded the operated feet photos and radiographic photos (after 40 days of surgery) and we measured the angular values.

Automatically, the software saved both new angles and delta between new and old values, providing corrective index, and it showed them in their slots (Fig. 2).

The subsequent study has demonstrated the measurement reliability effectuated by the smartphone app, comparing the obtained data with standard goniometer measurements effectuated by 4 orthopedics.

The comparison was very significant and encouraging for depositing an effective overlap of the data obtained with the two different methods.

In particular, the deviation between the two methodologies was 1.50 ± 1.2 for HVA, 1.2 ± 0.90 for DMAA, and 1.4 ± 1.1 for IMA.

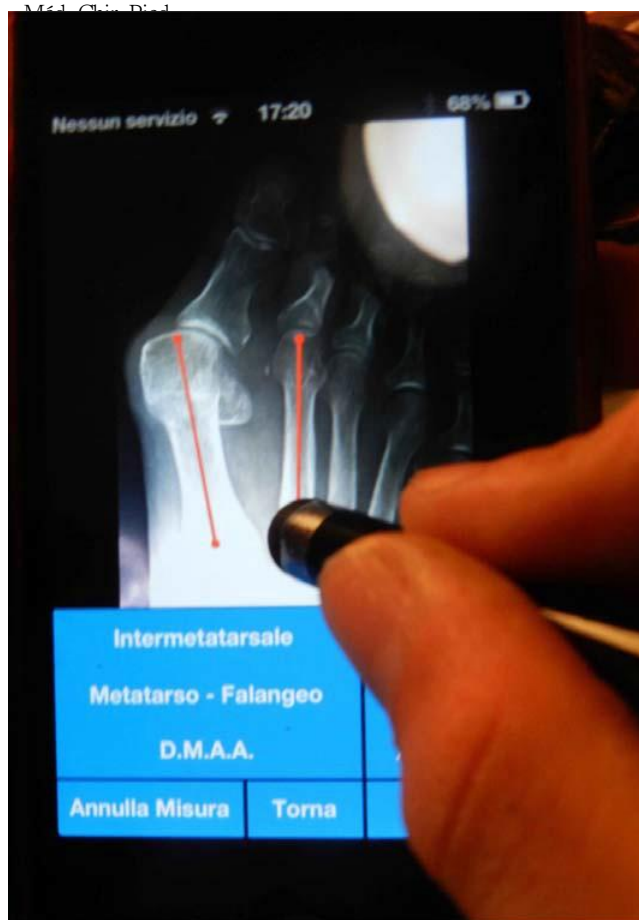


Fig. 1 Tracking of the axes of angular with smartphone, through the use of a stylus or a finger of the hand, with the program Hallux Angles

A very reliable difference was found between the four observers with deviations of values near to zero.



Figs. 3 Measuring process before and after surgery with the PC software (Agfa CR)

Torna
Dettagli
Modifica

muse vittoria

Data di Nascita: 26/10/1958 **Sesso:** F

Diagnosi:
all valg e 2 mrtl

Pre Operatorio

Post Operatorio

	Angoli Pre	$\Delta\mu$	Angoli Post
M1M2	22°	13°	9°
MF	41°	26°	15°
D.M.A.A	16°	12°	4°

Fig. 2 The graphic user interface of "Hallux Angles" with angular measurements before and after surgery and also with correction index

The final verification of the data was carried out by a radiologist with measurements made by a reliable PC software (Agfa CR) and the same measurements were compared with those ones obtained by orthopedics specialist (Figs 3).

The measured values for each patient were matched and analyzed by the method of Bland–Altman (see graphics below – fig. 4) and with linear regression. Then it was calculated the bias, the limits of concordance and the correlation coefficient.

Then the angular measurements were analyzed statistically before and after surgical correction. The correlation coefficient was very satisfying: in fact 95% of them fell within the limits of concordance established by the Bland–Altman method (Table 1).

According to the analysis of the bias, it was clear that the measurements obtained with the PC were slightly higher than the software Hallux Angles regarding all the

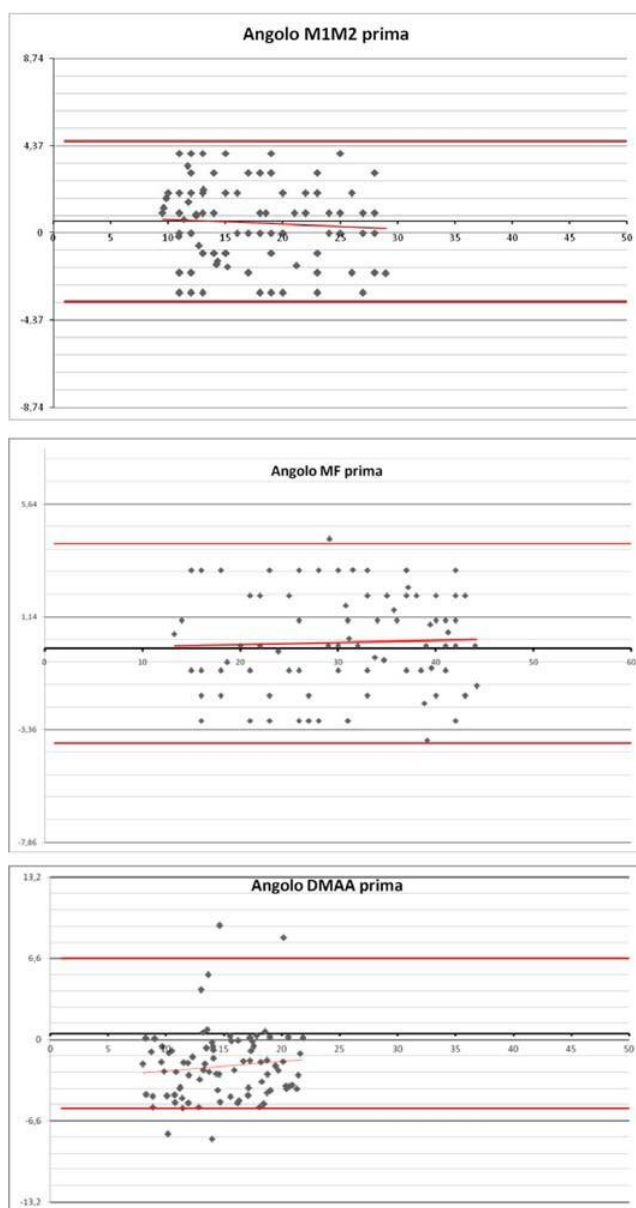


Fig. 4 Development of graphs obtained according to the method of Bland–Altman in which the parameters of the study must fall between the bias and the two-standard deviations

Table 1 Results of the analytical study of the correlation coefficient according to the Bland–Altman method.

Angles	Correlation value	Bias	Limits
HVA before	0.974 ($p < 0.01$)	0.149	4.06; -3.91
IMA before	0.936 ($p < 0.01$)	0.567	2.63; -1.50
DMAA before	0.886 ($p < 0.01$)	0.508	6.60; -5.59
HVA after	0.910 ($p < 0.01$)	2.05	6.17; -2.07
IMA after	0.616 ($p < 0.01$)	-2.47	2.99; -7.92
DMAA after	0.841 ($p < 0.01$)	-1.63	6.18; -9.45

measurements before surgery and for HVA, and they were lower regarding IMA and DMAA after surgery.

The greatest differences were in measurements made after correction.

In all cases the probability according to the correlation coefficient was significant ($p < 0.01$).

Discussion

The use of a smartphone for storing sensitive data of a patient with hallux valgus is, in our opinion, very convenient and effective.

The intuitiveness of the application, in particular, and with high performance has made easy the measurement process of the angles. The automatic computing of the correction index also allows storing the statistic performances of a surgical technique, while the possibility to store the photos of pre- and post-surgery aims to allay the patient about the purely esthetic result of the surgical procedure. The effectiveness of the goniometric measurements of the application, as shown by the study, is very efficient and reliable.

Conclusion

The software “Hallux Angles” has a reliable and easily reproducible method for the measurement of angular deformity of hallux valgus, with more accessory options effective for photographic iconography. We therefore believe that such applications may be an appropriate instrument for the storage of data of surgical patients for scientific and strategic performance using surgery.

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