ORIGINAL ARTICLE

ACCURACY OF CEPHALOMETRIC IMAGES ACQUIRED WITH ANDROID SCANNER APPLICATIONS

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ABSTRACT

Objective: The aim of this study was to compare the ability of two scanner applications for capturing the image of the lateral cephalogram films with dimensional accuracy.

Design: Cross sectional study.

Place and Duration of Study: Department of Orthodontics, Rehman College of Dentistry, Peshawar and one year.

Materials and Methods: Thirty lateral cephalogram radiographic films were scanned with two cell phone applications, Camscanner™ and Office Lens™, and were compared with original digital images. The images were imported into Viewbox 4.0™ for common variables of cephalometric analysis. All the images were calibrated digitally, the original cephalometric film scan was considered as gold standard. Repeated measures ANOVA was used to identify any differences between the groups.

Results: No significant differences were found between the original image and scanned images. Camscanner™ performed slightly better in linear measurements while in angular measurements both were found equally accurate.

Conclusion: Both CamScanner™ and Office Lens™ produced accurate image capture of lateral cephalogram and can safely be used for cephalometric scanning.

Key words: *Cephalometry, Scanner Apps, Android Apps*

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INTRODUCTION

Lateral cephalogram is a commonly used radiograph in orthodontics for the purpose of evaluation of different anatomical structures of human skull[1,2]. These include skeletal, dental and soft tissue structures, and are evaluated in relation to each other by means of angular and linear measures on cephalometric tracings. Cephalometric analysis is important in dentistry and orthodontics for diagnosis, orthodontic and orthognathic surgical treatment planning, treatment evaluation and record keeping[3-5]. Mostly this analysis has been performed on manual cephalometric films and hand tracing of the structures. This method is time-consuming for practitioners, there is always a chance of misreading the measuring instruments, and extra storage space is needed to store radiographs and it is difficult to save and retrieve data[1,6,7].

When compared to more conventional cephalometric techniques, digital cephalograms provide a number of benefits[1,4,7-9]. Digital images require less physical space to store, fewer employees to manage the storage, and are simpler to organize than analogue images. It can be easily shared and transferred for discussion purposes. The errors related with measurements (measuring instruments and personal errors) are reduced since the calculations are done automatically in dedicated softwares. Moreover the images can be manipulated (for visualization enhancement) in terms of contrast and brightness and thus the landmark identifications can be made easier[7,10-13].

Several methods exist to digitize the manually obtained films. These include flatbed transparency scanning and photography[9,14,15]. Both methods have been shown to have good accuracy of cephalometric analysis, especially the angular analysis. With the advent of smartphone apps for acquisition of documents, it is logical to be curious about the accuracy of these apps in acquiring the cephalometric image from the manual films [1-3].

Whichever method is used for the acquisition of the cephalometric films, it should be accurate, reliable, economical, safe and reproducible[4-6]. The widespread availability of smartphones and the ease and efficiency with which they can take photographs make them an attractive alternative[1,7]. Moreover, the recently introduced "scanner" apps can potentially reduce the distortions associated with photographing as there are options such as zooming for accurate marking of the corners of the cephalometric image. These apps then automatically correct the image for viewing [1,8,9].

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Recently, many smart phone applications (apps) have been introduced for scanning documents. There is a potential for their use in dentistry for speedy scanning radiographs and digitizing those radiographs on screen. Few Indian studies were found regarding similar apps however no study to our knowledge was done in our country[10,11]. In clinical orthodontics the efficacy of scanner applications needs to be tested before bringing them into routine use. Hence, this study's aim was to compare the ability of two scanner apps to capture dimensionally accurate images of lateral cephalogram films. The null hypothesis was that there was no difference in the measurements between the original image and the images acquired with the apps.

MATERIAL AND METHODS

This study was conducted at the department of Orthodontics, Rehman College of Dentistry, Peshawar, Pakistan.It was a cross-sectional study. Ethical approval was granted by the ethical committee of the RCD. Data collection was done between 1st Nov 2018 and 1st Dec 2018 by convenient sampling technique. Pre-treatment lateral cephalograms radiographic films were randomly collected from the patient files. The images and films with reasonable clarity, brightness and contrast were included in the study. Cephalograms with multiple missing teeth, artefacts obscuring the identification of important landmarks and other structural abnormalities were excluded. Each radiograph was acquired directly via a digital cephalometric machine (CS 8100, Care Stream dental).

A hard film printed at 1:1 ratio of the same radiograph was then scanned by using two scanner applications from an android cell phone (Samsung Galaxy S4) i.e. CamScanner (INTSIG information) and Office Lens (Microsoft corporation). Distance of about 12 inches was maintained from the film for accurate scanning, with the cellphone camera roughly over the center of the film. The edges of the captured image were then adjusted if needed with the edge identification tools. Images acquired were then stored in joint photographic experts' group (JPEG) format (2048x1536 pixels). The scanned images were then imported into Viewbox™ 4.0 (Dhal Software, Italy). All the images were calibrated digitally using the nasion pointer graduation scale (Fig.1). Landmarks were identified and 6 linear and 10 angular measurements from common analysis were taken (Table 1). The landmarks were digitized and analyzed in Viewbox software.

All analyses were carried out using SPSS Software version 22.0. Shapiro wilk test demonstrated the normality of the collected numeric data. Repeated measures analysis of variance was used to identify any differences between the groups using SPSS software. The level of significance was set at $p \leq 0.05$. Clinical significance was set at 2 degrees / mm or more difference between the methods. The data obtained from 3 groups, Original, Camscanner and Office Lens, were compared and tabulated.

Figure 1

CAPSULE SUMMARY

- Scanner apps are a convenient way of digitizing manual cephalometric films
- The images obtained from two scanner apps (Camscanner™ and Office Lens™) were evaluated for linear and angular measurements accuracy
- Both scanner apps demonstrated the same accuracy for linear and angular measurements.

RESULTS

Descriptive statistics are given in Table 2. Number of females in the sample were more (64%) than males (36%).

Means and standard deviations of angular measurements via the three modalities are given in Table 3. The original image values were slightly smaller than the scanned images values but no statistically significant differences were seen in any of the ten angular measurements ($p>0.05$).

Means and standard deviations for the linear measurements are shown in Table 4. There are six linear measurements. Camscanner performed slightly better in linear measurements, but the difference was not statistically significant ($p> 0.05$).

Excellent Reliability was observed for all measurements ($r\geq0.8$) (Figure 2, Figure 3, Figure 4)

DISCUSSION

In this study 30 lateral cephalograms were scanned with two android softwares, CamScanner and Office lens. The original radiograph along with scanned images were analyzed via a software Viewbox for 10 angular and 6 linear measurements. We found no statistically or clinically significant differences among the images.

Table 1: List of angular and linear measurements used in the study.

ANGULAR MEASUREMENTS	LINEAR MEASUREMENTS
SNA: Angle between cranial base 'SN' to point A	Wits: Point A and point B distance perpendicular on occlusal plane
SNB: Angle between cranial base to point B	LAFH: Distance between subnasale to menton
ANB: Angle between Nasion point A line to Nasion point B line	OB: Amount of upper incisors overlap on lower incisors
SNMP: Angle between cranial base to mandibular plane	OJ: Horizontal distance between lower incisor labial surface to upper incisal edge
SNPP: Angle between cranial base to palatal plane	LL-E: Lower lip to E-Line Distance
PPMP: Palatal plane to mandibular plane Angle	UL-E: Upper lip to E-Line Distance
IMPA: Lower incisors to mandibular plane angle	
UIPP: Upper incisors to palatal plane angle	
UISN: Upper incisors to cranial base angle	
NLA: Nasolabial angle	

Table 2: Descriptive statistics

GROUP	GENDER		TOTAL
	Males (36%)	Females (64%)	
Original	11	19	30
Cam Scanner	11	19	30
Office Lens	11	19	30
Total	33	57	90

Table 3: Means and standard deviations for angular measurements

VARIABLES	ORIGINAL IMAGE		OFFICE LENS		CAM SCANNER		P value
	Mean (°)	SD (°)	Mean (°)	SD (°)	Mean (°)	SD (°)	
SNA	80.7	4.0	81.4	4.4	80.9	4.8	.482
SNB	77.2	4.6	77.7	4.4	77.4	4.5	.488
ANB	3.4	3.7	3.6	4.0	3.5	3.8	.626
SNMP	32.9	7.4	33.7	7.9	34.3	7.7	.972
SNPP	7.0	3.3	7.5	2.7	7.6	3.0	.981
PPMP	25.9	7.0	26.2	7.5	26.7	7.4	.503
IMPA	97.4	8.1	96.3	8.7	95.8	8.4	.393
UIPP	114.7	9.7	117.2	8.1	116.7	7.9	.770
UISN	107.7	9.5	109.6	8.3	109.0	8.3	.918
NLA	101.7	12.7	101.2	13.6	100.2	12.4	.597

Table 4: Means and standard deviations for linear measurements

VARIABLES	ORIGINAL IMAGE		OFFICE LENS		CAM SCANNER		P value
	Mean (°)	SD (°)	Mean (°)	SD (°)	Mean (°)	SD (°)	
Wits	1.6	5.2	1.2	5.0	1.9	5.0	.824
LAFH	65.8	9.9	65.6	8.2	64.7	8.1	.522
OB	1.0	2.5	0.89	2.6	0.9	2.5	.592
OJ	5.4	3.7	5.8	3.9	5.6	3.9	.775
LL-E	-1.54	3.1	-1.8	3.3	-1.4	3.4	.513
UL-E	-4.0	2.6	-4.6	2.8	-4.1	2.7	.431

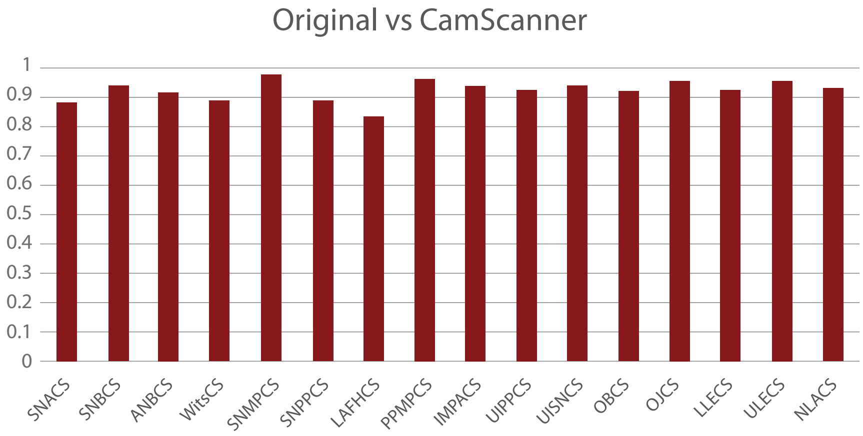

Figure 2

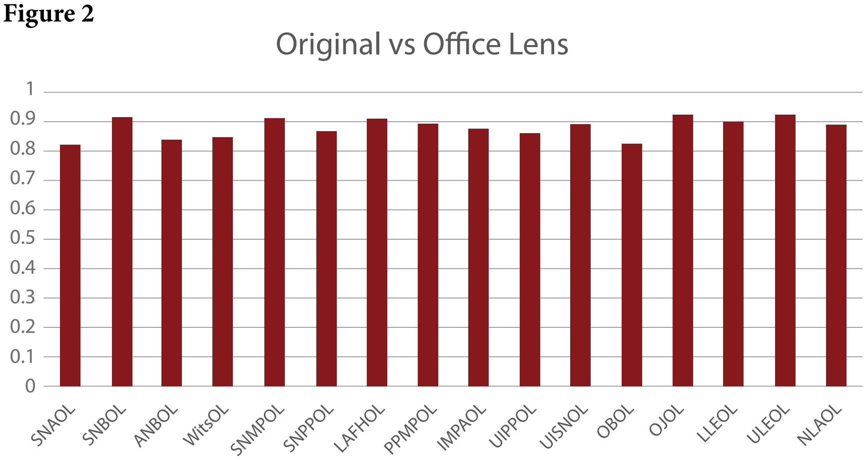

Figure 3

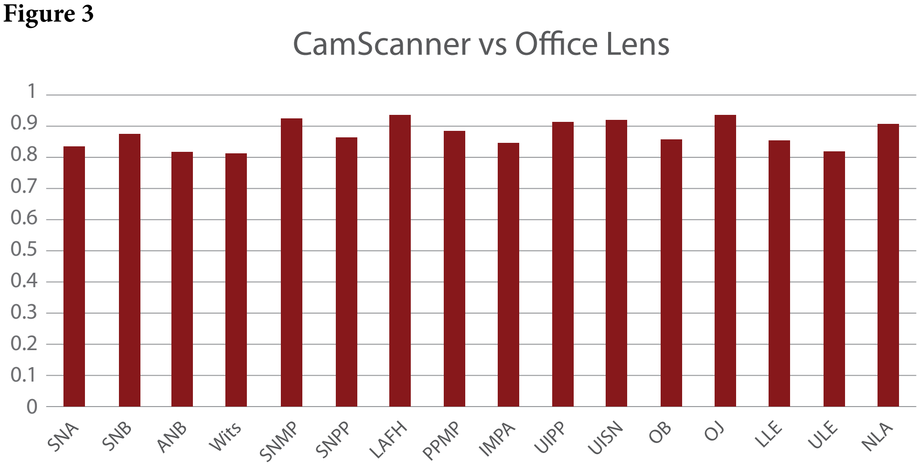

Figure 4

The accuracy of cephalometric analysis depends upon the correct landmark identification, tracing, measurement, and magnification[4,12]. All these factors are in turn a function of clear and visible anatomical landmarks on radiographs. If there is some distortion of the image during acquisition, the landmark position can be affected and hence the resulting analysis may be inaccurate. The experience of the operator also affects the correct recording of the landmarks[13]. The operator in this study had 4 years' experience in cephalometric tracing and analysis.

Many similar studies comparing the manual and digital cephalometric analysis have used fiducial landmarks for standardized linear and angular measurements for the accuracy, along with the cephalometric angles and distances [4,6,14]. We chose to test only the cephalometric measurements because previous such studies have found excellent correlations of these analysis with fiducial landmarks [6,14,15]. We set the clinical significance at 2 point difference (mm or degrees) or more. It is reasonable to assume that at least this much difference is required for labeling cephalometric reading different.

It is important to test the linear and angular measurements separately to definitively assess the amount of distortion and magnification that can occur during the scanning process. Studies using flatbed scanner with transparency adapter reported little or no distortion and hence accurate linear and angular measurements [6,16]. Akshay Mohan et al also compared digital cephalograms taken with OneCeph mobile app with manual cephalograms and found no statistical significant difference in the analysis. They also brought into notice the use of such apps in rural areas for starting timely orthodontic treatment[11] . since it is an era of artificial intelligence and many researchers compared traditional manual cephalometry with fully automated intelligence and found a good correlation in between the two , suggesting the reliable use of them interchangeably [17]. In contrast Collins et al reported limited accuracy for linear measurements with photographed lateral cephalograms[14].

While there are many scanner apps which could perform this function, we chose the most common ones for this study. The scanner apps can be found on both android and iOS platforms; however, we used the android apps. There is no reason to assume that there would be any difference in the apps in iOS.

The gold standard in this study was taken as the original acquired digital image digitized with Viewbox software. There are other softwares available, however Viewbox has been shown to be accurate and reliable in almost all situations [8,18,19].

None of the differences with linear or angular measurements were statistically or clinically significant. This is in accordance with previous studies which were done on different modalities such as photographed, scanned and digitized cephalograms[4,5,14,16]. However, it must be noted that since these apps have not been tested before for this purpose, direct comparisons could not be made with the results of the above mentioned studies. The ability of these apps to minimize the distortion errors most probably account for the better performance of these images in comparison to simply photographed images.

As for the reliability, Fleiss et al[20] noted that a correlation coefficient of 0.75 or more indicates excellent reliability of measurements. In our study, all coefficients were more than or equal to 0.80, indicating excellent reliability.

Digital images are superior to manual films in many ways. The image is obtained is clear, and contrast, brightness and other image parameters can be adjusted for better visualization[14]. Archiving and sharing images is easier, and on screen digitization can efficiently perform required analysis. These advantages prompt for conversion of the previously taken manual cephalometric radiographic films into digital films[4,14,19]. Scanner apps seem to be a reasonably fast and accurate method to achieve this objective.

LIMITATIONS

Our study had several limitations. We did not assess the interrater reliability of measurements. Only one software was used for digital analysis and only two apps were compared. Future studies can focus on increasing the number of scanning apps and multiple measurements for assessing the reliability of the data.

CONCLUSION

Both Office Lens and CamScanner accurately scanned the cephalograms with minimal distortions

Angular and linear measurements were comparable to the original analysis with both scanner apps.

Scanner apps can safely be used for cephalometric image capture, and subsequent digital cephalometric analysis.

AUTHORS' CONTRIBUTION

Rehana Fayyaz	Acquisition of data, Analysis and interpretation of data, Drafting the Article
Sohrab Shaheed	Conception and design, Analysis and interpretation of data, Critical revision

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