

A Comparative Evaluation of Reliability of an Android-based App and Computerized Cephalometric Tracing Program for Orthodontic Cephalometric Analysis

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This study aimed to assess the reliability of the android smartphone-based app OneCeph by comparing it with computer cephalometric tracing program Dolphin Imaging software. 50 cephalometric radiographs were randomly selected. On each cephalogram 20 landmarks were marked. 15 parameters indicating skeletal, dental and soft tissue parameters were selected and measured. The values obtained from Dolphin imaging software and the OneCeph app were compared with respect to the assessment of measurements of various parameters by paired t-test. It was observed that four parameters out of the fifteen showed significant differences between Dolphin imaging software and OneCeph app ($p < 0.05$). For all the other parameters selected, no differences were observed between Dolphin and OneCeph digital methods and also there is a significant and positive correlation between the measures obtained from the Dolphin and OneCeph app for each landmark parameter. The results obtained by the OneCeph app showed most parameters are comparable with the Dolphin Imaging software. Therefore, it can be concluded that this app is reliable, user-friendly which facilitates its use by the clinician on a regular basis. This user-friendly OneCeph app can be utilized with sufficient accuracy for the cephalometric analysis of most of the measurements required in day-to-day clinical orthodontic practice.

Keywords: Cephalometry, Computers, Digital Radiography, Smartphone.

Cephalometric radiography is an essential tool in orthodontics which has been extensively used for orthodontic diagnosis and treatment planning.¹ The conventional cephalometric analysis is carried out on acetate sheets in which the landmarks are marked and linear and angular measurements are determined. In spite of its extensive application in the field of orthodontics, it can be prone to systematic and random error and is also time consuming. Landmark identification, technical

measurements and radiographic acquisition are the main sources of errors. Identification of landmarks, being the major source of errors, is dependent on the experience of the operator, definition of the landmark, density of the image and image sharpness. To add to this difficulty, it is a compression of a three-dimensional (3D) structure to a two-dimensional (2D) image.²

With the rapid advancement of computer radiography, manual method is gradually replaced

by the digital method. Incidence of individual error can be minimized by using computers in treatment planning. It provides fast, precise and standardized evaluation with a high rate of reproducibility.²

Earlier in computerized radiography, the transfer of the analogue data to digital format was done using digitizer pads, digital cameras and scanners. Recent advancements have permitted us to use direct digital images, which provides instant image acquisition, facilitated image enhancement, reduction in radiation doses, image sharing and archiving and removal of technique-sensitive developing procedures. It also reduces potential errors due to operator fatigue.³

Recently there has been a rise in the usage of newer technology in all aspects of our lives. This is true for particularly for smartphones, which are not only meant for phone calls.⁴ An app is typically a small specialized program downloaded on to a smartphone device. It is accessed using a smartphone that connects to a library of apps via the internet and enables the users to find specific apps for their needs that serve their needs. When there is a need for quick reference or desktop computer access is not feasible, these smartphone apps are ideal tools due to their speed, ability to update and portability.⁵

Not only there has been a rise in the use of smartphone apps but also there are apps which have been designed for medical and dental field. These apps have been one of the fastest developing categories of programs and they include various programs which are planned and designed specifically for orthodontics.⁶

Given the rise of computer-assisted cephalometric tracing programs usage in day-to-day orthodontic practice, there is a need to assess the accuracy of these commercially available cephalometric tracing software to allow the clinician to decide the suitable software and methods of analysis.³

Objective

The study was aimed to assess the reliability of the android mobile based app OneCeph by comparing it with the computer cephalometric tracing program Dolphin Imaging software.

MATERIALS AND METHODS

Fifty cephalometric radiographs were taken randomly from patients who had consulted the Department of Orthodontics and Dentofacial Orthopaedics. Patients with unerupted or missing incisors, poor quality of radiographs, craniofacial

Table 1. Landmark selection

Cephalometric Measure	Description
SNA	Angle formed between Sella-Nasion and Nasion-point A
SNB	Angle formed between Sella-Nasion and Nasion-point B
ANB	Angle formed between Nasion- point A and Nasion-point B
Max Mand Plane	Angle formed between Gonion-Gnathion and ANS-PNS
U1/Max Plane	Angle formed between Anterior Nasal Spine-Posterior Nasal Spine and line joining crown tip and the apex of the upper incisor
L1/Mand Plane	Angle formed between Gonion-Gnathion and line joining crown tip and the apex of the upper incisor
U1-L1	Internal angle formed between upper and lower incisors
Lower Lip/E Line	Perpendicular distance from the lower lip to the E line
Ant Cranial Base	Distance between Sella and Nasion points
Wits (mm)	Point A and Point B projected to the occlusal plane and the distance measured
FMA	Angle formed between the Frankfort plane and mandibular plane
Saddle angle	Angle formed between Nasion, Sella and Articulare points
Articular angle	Angle formed between Sella, Articulare, Gonion
Gonial angle	Angle formed between Articulare, Gonion and Gnathion points
Sum of Angles	Total of the Saddle, Articular and Gonial angles

deformity, and non-permanent dentition with impacted teeth were excluded to ensure the accurate and consistent measurement by minimizing the margin of error.

Minimizing Random Error

Each participant was positioned in the cephalostat with the sagittal plane at a right angle to the path of the X-rays with the Frankfort plane parallel to the floor and teeth in centric occlusion and the lips gently sealed. The radiographs were obtained with a magnification of 102.16%.

Calibration for accuracy

The actual size of each image was calibrated in millimeters based on the known distance of 10 mm between the two fixed points on the cephalostat rod in the radiograph. This calibration was standardized for all the images.

Landmark identification was performed manually on digital images and then stored in the Dolphin Imaging program.

All measurements taken on both devices were carried out by the same investigator. The brightness, magnification, contrast and zoom in/out could be enhanced by the observer in both the programs.

Procedure

The digital images (50 cephalograms) were imported into Dolphin Imaging software and the digital tracing was done using Dolphin Imaging Software Version 11.5 (Dolphin Imaging) (Figure 1).

Similarly, digital radiographs were transferred to the OneCeph app (version beta 1.1) on a Vivo v5 android phone and calibrated

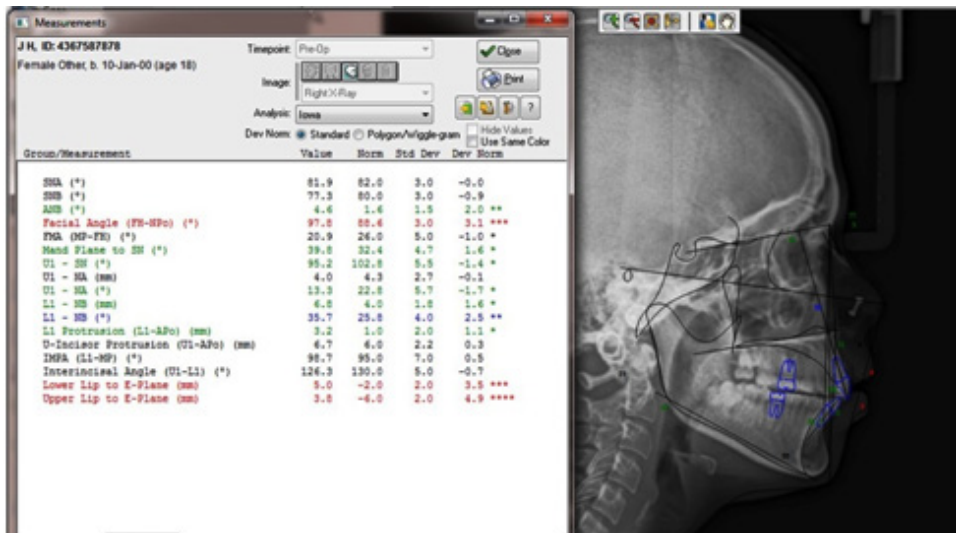


Fig. 1. Digital tracing with Dolphin Imaging Software

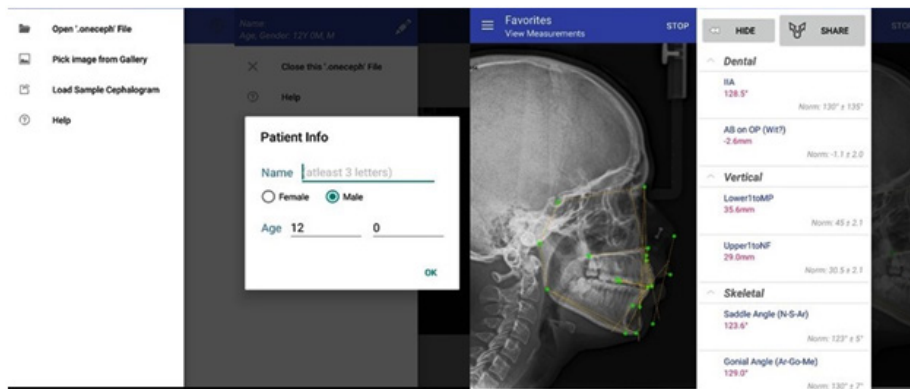


Fig. 2. Digital tracing with OneCeph app

Table 2. Comparison of Dolphin and OneCeph methods with respect to assessment of measurements of various parameters by paired t test (*p<0.05)

Parameters	Methods	Mean	Std. Dv.	Mean Diff.	SD Diff.	% of change	Paired t	P-value
Saddle angle	Dolphin	121.88	5.50					
	Oneceph	122.13	5.93	-0.25	1.83	-0.21	-0.9646	0.3395
Articular angle	Dolphin	146.47	9.18					
	Oneceph	145.93	9.45	0.53	2.37	0.36	1.5863	0.1191
Gonial angle	Dolphin	125.44	8.61					
	Oneceph	125.47	8.08	-0.03	2.40	-0.02	-0.0825	0.9346
SNA	Dolphin	83.53	3.95					
	Oneceph	83.18	4.08	0.35	1.43	0.42	1.7272	0.0904
SNB	Dolphin	79.62	4.82					
	Oneceph	79.20	5.05	0.43	1.26	0.54	2.3860	0.0209*
ANB	Dolphin	3.90	3.96					
	Oneceph	4.05	4.04	-0.15	0.83	-3.84	-1.2850	0.2048
FMA	Dolphin	19.75	6.26					
	Oneceph	17.99	6.02	1.76	2.07	8.90	6.0078	0.0001*
Basal plane angle	Dolphin	28.84	6.13					
	Oneceph	28.19	6.48	0.66	1.30	2.27	3.5774	0.0008*
Anterior cranial base length	Dolphin	63.50	6.70					
	Oneceph	64.04	4.23	-0.55	4.51	-0.86	-0.8562	0.3961
Interincisal angle	Dolphin	113.49	16.53					
	Oneceph	113.92	16.80	-0.43	2.16	-0.38	-1.4190	0.1622
U1-NP	Dolphin	25.59	3.37					
	Oneceph	25.35	3.26	0.24	1.05	0.95	1.6450	0.1064
L1-MP	Dolphin	36.10	4.00					
	Oneceph	35.61	4.05	0.49	1.40	1.35	2.4577	0.0176*
Wits appraisal	Dolphin	1.71	5.56					
	Oneceph	1.99	5.75	-0.28	1.18	-16.49	-1.6834	0.0987
Sum of the angles	Dolphin	393.85	6.42					
	Oneceph	393.72	6.72	0.13	1.97	0.03	0.4530	0.6525
Lower lip to e-line(mm)	Dolphin	1.71	3.53					
	Oneceph	1.70	3.41	0.01	0.43	0.82	0.2284	0.8203

as described above and digital tracing was done (Figure 2).

20 landmarks were marked on each cephalogram and 15 parameters indicating skeletal, dental and soft tissue parameters were selected and measured (Table 1).

Statistical analysis

The values for each analysis done by both Dolphin and OneCeph app was tabulated. All the values were then analyzed. Before the statistical analysis, the normality assumption was tested using Kolmogorov Smirnov test. It showed that the normality assumption had been met, so a parametric test (paired t test) was carried out. The values obtained from Dolphin imaging software and OneCeph app was compared with respect to

assessment of measurements of various parameters by paired t-test.

RESULTS

It is observed that the basal plane angle, SNB, L1 to MP, FMA showed significant differences between manual and digital methods (p<0.05). For all the other parameters selected, no differences were observed between Dolphin and OneCeph digital methods. (Table 2)

A significant and positive correlation between the measures obtained from the Dolphin and OneCeph app for each landmark parameter was found by applying Karl Pearson's method (Table 3).

Table 3. Correlation between the measurements obtained using Dolphin and OneCeph by applying Karl Pearson's method. (*p<0.05)

Parameters	r-value	t-value	p-value
Saddle angle	0.9513	21.3892	0.0001*
Articular angle	0.9680	26.7331	0.0001*
Gonial angle	0.9606	23.9471	0.0001*
SNA	0.9369	18.5596	0.0001*
SNB	0.9684	26.8867	0.0001*
ANB	0.9789	33.1723	0.0001*
FMA	0.9439	19.8062	0.0001*
Basal plane angle	0.9804	34.4487	0.0001*
Anterior cranial base length	0.7493	7.8401	0.0001*
Interincisal angle	0.9917	53.4987	0.0001*
U1-NP	0.9504	21.1633	0.0001*
L1-MP	0.9393	18.9623	0.0001*
Wits appraisal	0.9787	33.0054	0.0001*
Sum of the angles	0.9562	22.6261	0.0001*
Lower lip to e-line(mm)	0.9928	57.3487	0.0001*

DISCUSSION

Lateral cephalometry is a vital tool to assess the relationship between skeletal, dental and soft tissue structures and also to identify the sagittal and vertical discrepancies. Progress in technology has resulted in increased usage of digital cephalometric analysis softwares, which have numerous benefits: reduction in radiation doses, improvement in the data storage and easy manipulation of images.⁷ Whether a digital or a smartphone app is selected, it should be precise, safe, reliable, and highly reproducible.⁸ In the literature of orthodontics, there are many researches which test the reproducibility and reliability of the Dolphin Imaging software. They have proven to be reliable and more frequently used than other digital cephalometric imaging software.^{8,9} The present study compares the reliability of the cephalometric app OneCeph with the Dolphin Imaging software.

The cephalometric software programs can be either completely automated or semiautomated.¹⁰ This study used semiautomated software. Initially manual location of landmarks is done and then the cephalometric analysis is performed by the computer system. This leads to lesser measurement errors than the conventional (manual) cephalometric analysis. Overall, by using

computer programs the errors which result from drawing and measuring with a ruler and a protractor may be eliminated.¹¹

The uncertainty in landmark identification causes significant tracing errors, which needs skills relying on operator's experience,¹² quality of original radiographs, resolution of the digital images, nature of cephalometric landmark.⁷ A study by Erkan and his associates had stated the importance of standardization in comparative studies like this study. The intra-examiner error is lesser than the inter-examiner error, thus, to reduce the possibility of errors, this study was standardized by having only one examiner for both Dolphin cephalometric method and OneCeph app cephalometric method.¹³

In this study SNB, FMA, Basal Plane Angle, L1 to MP showed a difference between dolphin and OneCeph. Sekiguchi and Savara showed that nasion (N) might be challenging to locate when the nasofrontal suture is not clearly seen and it has been reported that menton, nasion and posterior nasal spine were also sources of errors this might have contributed for the difference in SNB.¹⁴

The difference in measurement of Basal Plane angle may be attributed to palatal plane angle, ANS point identification, which shown poor consistency and is often affected by the superimposition of other anatomical structures.² Also the position of gnathion which is used to form a line with gonion to measure the mandibular plane angle. The gonion shows variation in its position in the vertical and horizontal axes. This may be due to the difficulty in identifying the landmark on the curved anatomical region.⁷

It has been found that the gonion, orbitale, porion, menton and lower incisor apex were the most inconsistent and unreliable points^{7,15} this might have contributed to the difference in FMA and L1 to MP.

In general, the study showed statistically significant values on the correlation of Dolphin and OneCeph digital cephalometric methods. It can be said that the OneCeph app is as reliable as the Dolphin cephalometric method and that the minimal variations can be attributed to the variations in the operator's reproducibility of the landmarks and calibration of the cephalometric image in the app.

An android based Oneceph app provides a convenient interface with most commonly used analyses, Burstones cephalometrics for orthognathic surgery, cephalomorphic, Downs, Holdway, Jarabak, McNamara, Ricketts, Steiners, Schwarz, Tweed, Wits Appraisal, Beta angle and Yen angle, etc. This app also demonstrates the potential of a smartphone to simplify a complex, time-consuming diagnostic task such as cephalometric analysis while simultaneously providing structured reference and e-learning capabilities.

CONCLUSION

The results obtained by the OneCeph app showed most parameters are comparable with the Dolphin Imaging software. Therefore, it can be concluded that this app is reliable, user-friendly which facilitates its use by the clinician on a regular basis.

Clinical Significance

This user-friendly OneCeph app can be utilized with sufficient accuracy for the cephalometric analysis of most of the measurements required in day-to-day clinical orthodontic practice.

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