Reliability of mobile application-based cephalometric analysis for chair side evaluation of orthodontic patient in clinical practice

Maruf H. Barbhuiya, Piush Kumar, Rachit Thakral, Krishnapriya R and Madhurima Bawa

Abstract:

OBJECTIVES: The purpose of this study was to evaluate the accuracy and reliability of Mobile Application-Based Software for chair side cephalometric analysis.

MATERIALS AND METHOD: Pretreatment lateral cephalograms of 20 patients (10 males and 10 females) were selected randomly and were traced manually and also using Application-based software (One Ceph). 20 angular and three linear parameters were measured both manually and with the software in all the patients. Inter and intra-operator reliability of one ceph was evaluated and the measured parameters were statistically compared with the manual method (Gold Standard).

RESULT: The accuracy of angular and linear values was compared for all 23 parameters and our results showed no significant difference in the two methods used for most of the measurements. Three of the measurements [Angle of convexity (N-A; A-Pog); ANB angle; Upper Incisor to NA (Angular)] did show a statistically significant difference though these were clinically irrelevant.

CONCLUSION: Application-based cephalometric analysis can be an effective clinical diagnostic tool for chair-side cephalometric evaluation of orthodontic patient.

Keywords:

Cephalometry, mobile application, OneCeph

Introduction

Cephalometric analysis is an essential diagnostic tool for treatment planning and to study growth and development of teeth and skull.[1] Even though it is an integral part of orthodontic treatment planning, manual cephalometric analysis which is considered the gold standard, is a time-consuming process requiring elaborate armamentarium. With the rapid advancements in the field of technology it would be a disadvantage for us not to apply these in dental field and in line with this various cephalometric software

were developed.[2] With the introduction of digital software like Nemoceph and Dolphin, orthodontists have managed to integrate cephalometrics in their clinical practice. Computer-based softwares for cephalometric analyses are largely replacing the manual cephalometric analysis.[3] These softwares are not only reliable but also simple to perform and require minimal time. They are also much more presentable to the patient and record keeping is easier. Though advantageous in every aspect, one of the drawbacks of these softwares is the high initial cost and the hardware (laptop/desktop) required.

Today mobile phones are one of the most integral equipment used by humankind.

Department of Orthodontics and Dentofacial Orthopaedics, I.T.S. Center for Dental Studies and Research, Muradnagar, Ghaziabad, Uttar Pradesh, India

Address for correspondence:
Dr. Maruf H. Barbhuiya, Department of Orthodontics and Dentofacial Orthopaedics, I.T.S. Center for Dental Studies and Research, Muradnagar, Ghaziabad, Uttar Pradesh - 201 206, India.
E-mail: marufborbhuyan925@gmail.com

How to cite this article: Barbhuiya MH, Kumar P, Thakral R, Krishnapriya R, Bawa M. Reliability of mobile application based cephalometric analysis for chair side evaluation of orthodontic patient in clinical practice. J Orthodont Sci 2021;10:16.

Be it home, office, or any outing, people always carry their mobile phones with them. Taking advantage of this, a plethora of mobile applications have been introduced in the market. Today, a lot of people are using different applications for their everyday work and an exponential growth can be seen in usage of these applications. In the field of orthodontics also, application based software are available as tools for chairside evaluation and treatment planning.[4] Although various software applications are available in the market (CephNinja, OneCeph), there have been only a few studies to evaluate the accuracy and validity of these app-based cephalometric analysis and the results of these studies have been contradictory.[5-7] Also most of the studies done were exploratory in nature. Thus, we have little in the orthodontic literature regarding the efficacy and reliability of these applications.[8] Therefore, the aim of this study was to compare the accuracy of cephalometric values obtained by app-based cephalometric method (OneCeph) as compared with the manual method of cephalometric analysis. We used both angular and linear parameters in our study and these parameters were derived from Downs Analysis, Steiners Analysis, and Tweeds Analysis.

Materials and Method

The present study was conducted in the Department of Orthodontics using a total of 20 pretreatment lateral cephalograms which were selected from the archives of the department. The cephalograms were selected on the following criteria:
- High-quality digital radiographs without any artifact.
- Absence of any obvious craniofacial deformity or asymmetry.
- Patient bite in maximum intercuspation.
- All lateral cephalograms were taken under the same circumstances with the same digital device.
- All cephalograms had the same magnification.

The cephalograms were selected by an Orthodontist who was not part of the study and who had no knowledge of why the radiographs were required. This was done to prevent any bias in the selection process.

Manual tracing
All the cephalograms were traced by a single operator on acetate cellulose paper of 0.003 inches thickness which was attached to each radiograph and viewed on viewbox. 0.3 mm microtip lead pencil was used

Table 1: Various Angular and linear measurements evaluated in the study

Skeletal Parameter	Dental Parameter
Downs Analysis	
Facial Angle	Cant Of Occlusal Plane
(Angle Between N-Pog and FH Plane)	(Angle Between Occlusal Plane and FH Plane
Angle Of Convexity	Inter Incisal Angle
(Angle Between N- Point A and Pog-Point A)	(Angle Between Long Axis Of Upper and Lower Incisor)
Mandibular Plane Angle (FH plane to Go-Me)	Incisor Occlusal Plane Angle (Angle Between Occlusal Plane and Lower Incisor)
AB Plane Angle	Incisor Mandibular Plane Angle
(Angle Between N-Pog and AB Line)	(Angle Between Go-Me and Lower Incisor)
Y Axis	Upper Incsior To A-Pog
(Angle Between FH Plane and S-Gn)	(Distance From Incisal Edge Of Upper Incisor To A-Pog)
Steiners Analysis	
SNA	Upper Incisor To NA
(SN Plane To Point. A)	(Upper incisor long axis -NA Angle)
SNB	Upper Incisor To NA
(SN Plane To Point B)	(Upper incisor long axis -NA Linear)
ANB	Lower Incisor To NB
(Difference between SNA - SNB)	(Lower incisor long axis -NB Angle)
SN- Occlusal Plane	Lower Incisor To NB
(Anatomical Occlusal Plane To SN)	(Lower incisor long axis -NBAngle)
Mandibular PlaneAngle	Interincisal Angle
(SN-Go-Gn)	(Angle Between Long Axis Of Upper and Lower Incisor)
Tweeds Analysis	
Frankfort Mandibular Plane Angle (FMPA)	
(Angle Between Frankfort Plane and Mandibular Plane)	
Incisor Mandibular Plane Angle (IMPA)	
(Angle Between Mandibular Plane and Lower Incisor)	
Frankfort Mandibular Incisor Angle (FMIA)	
Angle Between Frankfort Plane and Long Axis Of Lower Incisor	

for tracing. The contours of the following structures were identified on cephalogram and traced for the study: Nasion (Frontonasal suture), Orbitale, Sella, Porion, Point A, Point B, Pogion, Menton, Gnathion, Gonion, Long axis of upper and lower incisors, Incisal and root tip of upper and lower incisors, Mandibular plane, FH plane, SN plane. Various landmarks and points used in Downs Analysis, Steiners Analysis, and Tweed analysis were identified and marked. Various angular and linear measurements were recorded as given in Table 1.

Digital tracing

One Ceph Application was downloaded from the Google Play Store.[9] A smartphone with 6.39-inch Amoled display and a resolution of 1,080 × 2,340 pixels was used to view the parameters and analyze the cephalogram. Furthermore, if needed, software features such as brightness and magnifications were used by the operators to make landmarks more accurate.

After radiographic selection and before landmark identification, the starting point and end point of the ruler (30 mm) for each radiograph were determined to calibrate the images. After specifying the landmarks, the software performed all measurements based on the predefined analysis, and the data was moved to Excel using the export analysis system.

As the vast majority of smartphones are not equipped with a stylus, identification of landmarks was performed directly on the touch screen by a finger to represent mainstream use.[10]

Furthermore, 10 radiographs were randomly selected to evaluate for intra-observer and inter-observer errors in Digital tracing. For the inter-observer error, the radiographs were traced by a separate operator and compared while for intra-operator error the radiographs were traced by the same operator after 2 weeks and evaluated statistically.

Statistical analysis

Statistical analyses were performed with SPSS 16.0. To check the distribution, normality test was done. Student's t-test was used to compare the measurements by manual and digital methods.

Results

Inter-observer and intra-observer error was calculated for all the parameters and the results showed no significant difference between either of them. Thus, the reproducibility of the points was good; both for the same observer over a time period and for different observers [Table 2].

Table 2: Inter-observer and intra-observer error for all the parameters for App based cephalometric analysis

Variable	Inter-observer Error (P)	Intra-observer Error (P)
Down's analysis		
Facial Angle	0.363	0.06
Angle Of Convexity	0.525	0.206
Mandibular Plane Angle	0.931	0.152
AB Plane Angle	0.576	0.276
Y Axis	0.697	0.158
Cant Of Occlusal Plane	0.396	0.101
Inter Incisal Angle	0.976	0.751
Incisor Occlusal Plane Angle	0.890	0.933
Incisor Mandibular Plane Angle	0.697	0.815
Upper Incsior To A-Pog	0.896	0.709
Steiners analysis		
SNA	0.857	0.191
SNB	0.917	0.772
ANB	0.336	0.109
SN- Occlusal Plane	0.673	0.582
SN- Mandibular Plane	0.815	0.993
Upper Incisor To NA (Angular)	0.938	0.331
Upper Incisor To NA (Linear)	0.263	0.209
Lower Incisor To NB (Angular)	0.992	0.835
Lower Incisor To NB (Linear)	0.824	0.808
Interincisal Angle	0.932	0.756
Tweeds analysis		
Frankfort Mandibular Plane Angle (FMPA)	0.949	0.066
Incisor Mandibular Plane Angle (IMPA)	0.972	1.00
Frankfort Mandibular Incisor Angle (FMIA)	0.993	0.330

This was followed by comparison of the manual and digital methods of measurements. The results indicated that the P value for most of the parameters was greater than 0.05 indicating no significant difference between the measurements done manually or with the Application-based software.

The values which showed a significant difference were Angle of convexity ($P = 0.04$), ANB angle ($P = 0.049$), and upper incisor to NA angular value ($P = 0.024$) [Table 3].

Discussion

Lateral cephalometry is an essential diagnostic aid for sagittal and vertical discrepancy and also to evaluate the relationship between soft tissue and dental structures. The present study evaluated the accuracy and reliability of the cephalometric app-based analysis as compared to the gold standard of manual cephalometric analysis.

The present study consisted of two parts:

First part was evaluation of the reproducibility of the landmarks. Inter-observer and Intra-observer errors were

Table 3: Comparison of the manual and digital methods of measurements

Variable	Manual		Digital		P*
	Mean	Standard Deviation	Mean	Standard Deviation	
Down's analysis					
Facial Angle	86.7	3.74	87.6	3.62	0.42
Angle Of Convexity	7.62	4.64	10.9	4.86	0.04**
Mandibular Plane Angle	23.2	7.23	20.8	6.62	0.28
AB Plane Angle	8.1	5.11	8.87	3.63	0.59
Y Axis	63.4	5.4	58.4	4.45	0.21
Cant Of Occlusal Plane	10.47	6.60	9.16	4.69	0.473
Inter Incisal Angle	117.5	17.09	119.4	15.64	0.718
Incisor Occlusal Plane Angle	25.03	9.51	24.20	6.56	0.821
Incisor Mandibular Plane Angle	100.72	8.38	98.62	8.19	0.428
Upper Incsior To A-Pog	9.82	3.62	9.80	3.8	0.983
Steiners analysis					
SNA	82.12	4.38	84.42	3.4	0.072
SNB	77.67	2.99	78.42	3.41	0.465
ANB	4.60	2.25	6.09	2.37	0.049**
SN- Occlusal Plane	18.07	11.01	16.98	5.9	0.698
SN- Mandibular Plane	29.74	8.2	29.18	7.01	0.819
Upper Incisor To NA (Angular)	30.75	7.77	24.67	8.53	0.024**
Upper Incisor To NA (Linear)	7.67	3.50	5.79	3.35	0.091
Lower Incisor To NB (Angular)	29.52	10.34	29.97	9.70	0.889
Lower Incisor To NB (Linear)	5.65	2.10	6.49	3.42	0.353
Interincisal Angle	117.55	17.10	119.47	15.64	0.713
Tweeds analysis					
Frankfort Mandibular Plane Angle (FMPA)	25.22	6.01	24.76	7.06	0.826
Incisor Mandibular Plane Angle (IMPA)	98.87	9.00	97.85	8.89	0.720
Frankfort Mandibular Incisor Angle (FMIA)	55.90	10.48	56.87	9.89	0.764

*t-test. **Significant values

checked for digital tracing by using Student *t*-test. None of the values were significant. Therefore, we can state that the landmarks were reproducible not only by the same operator over a period of time but also by different operators.

The second part of the study included comparison of the values received by the application-based software and the manual method. Out of 23 parameters used in the present study,- 20 of them were not significant. But, for three measurements [Angle of convexity (N-A; A-Pog); ANB angle; Upper Incisor to NA (Angular)], the difference was statistically significant. If we further evaluate our results, we will find that Angle of convexity (N-A; A-Pog), ANB (SNA – SNB), and Upper Incisor to NA (Angular), all the above-mentioned parameters have point A in common. We can thus reflect that there might be a discrepancy in identification of point A in app-based analysis. Previous studies have shown that the reason for incorrect identification of Point A is soft tissues near anterior nasal spine which cast shadows in X-ray, making it more difficult to identify the point.[11]

Studies have also shown that one of the most significant causes of tracing error is uncertainty in landmark identification, which requires skills dependent on an examiner's experience.[2] Landmark identification,

tracing,[12] measuring, and magnification are all major areas in cephalometrics where errors can take place. It has also been reported that there are significant differences in landmark identification between trained and untrained operators.

In order to minimize these sources of errors, ONE CEPH app allows the operator to zoom in, zoom out, move the point and reposition to choose the ideal place for a landmark.

Also in the present study, the SNA and upper incisor to NA linear (which are based on point A) were not statistically different. This may indicate that there might have been just a minor variation in identification of point A. Also we must realize that although some values were statistically different, this may not translate into a significant clinical value.

Conversely, if we look at the benefits of the application-based software, then we would realize that hardly any time is required for analysis and we do not need any extra storage and additional equipment or instruments. Multidisciplinary consultation using smart-phone cephalometric analysis applications may be beneficial in distant rural areas with a high need for

orthodontic and orthognathic surgery care and rare or total unavailability of specialized oral health services. Given the increasing exposure of young generations to technology and the widespread use of dentistry-related mobile apps by students, practitioners, and patients to obtain information, applications can supplement traditional teaching methods. In this way, training in cephalometrics can take place away from traditional learning locations. In addition, the flexibility of the mobile platform enhances a more interactive and personalized education.[10]

The present study was done as an initial study in the field and further research can be done to evaluate these applications. Despite software features such as brightness and magnification which were used to make landmarks more accurate, a bigger screen and a better resolution can improve the app-based cephalometrics as it makes landmark identification more accurate for the operator. Also the sample size taken into consideration in our study was small. Furthermore, we also need to evaluate the time taken to perform the analysis when using software as compared to manual tracing. Although we did not keep a track of it, but we did observe that using the App was much quicker than manual method. The present study was done using OneCeph app but there are a wide variety of other cephalometric analysis applications which may also be evaluated.

Conclusion

The results of the study showed that the app-based cephalometrics (One Ceph) had the same reliability and reproducibility as the manual tracing method. Also the accuracy of Mobile App-Based Software for chair side cephalometric analysis was found to be good.

Although there was some ambiguity of point A, more experienced operator, a bigger screen and a stylus may be able to decrease the error.

Conflicts of interest

There are no conflicts of interest.

References

1. Proffit WR, Fields HJ Jr. Cephalometric analysis. **I**n: Proffit WR, Fields HJ Jr, Sarver DM, editors. Contemporary Orthodontics. St Louis, Mo: Mosby; 2007. p. 202.
2. Chen Y-J, Chen S-K, Yao JC-C, Chang H-F. The effects of differences in landmark identification on the cephalometric measurements in traditional versus digitized cephalometry. Angle Orthod 2004;74:155-61.
3. Keim RG, Gottlieb EL, Vogels DS 3rd, Vogels PB. 2014 JCO study of orthodontic diagnosis and treatment procedures, Part 1: Results and trends. J Clin Orthod 2014;48:607-30.
4. Statista. Mobile app usage: Statistics & facts. Statista. The Statistics Portal. Available from: https://www.statista.com/topics/1002 /mobile-app-usage/. [Last accessed on 2018 Oct 03].
5. Goracci C, Ferrari M. Reproducibility of measurements in tablet-assisted, PC-aided, and manual cephalometric analysis. Angle Orthod 2014;84:437-42.
6. Aksakallı S, Yılancı H, Görükmez E, Ramoğlu SI. Reliability assessment of orthodontic apps for cephalometrics. Turk J Orthod 2016;29:98-102.
7. Sayar G, Kilnic DD. Manual tracing versus smartphone application (app) tracing: A comparative study. Acta Odontol Scand 2017;75:588-94.
8. Fiore P. How to evaluate mobile health applications: A scoping review. Stud Health Technol Inform 2017;234:109-14.
9. Mamillapalli PK, Sesham VM, Neela PK, Mandaloju SP, Keesara S. A smartphone app for cephalometric analysis. J Clin Orthod 2016;50:694-33.
10. Livas C, Delli K, Spijkervet FKL, Vissink A, Dijkstra PU. Concurrent validity and reliability of cephalometric analysis using smartphone apps and computer software. Angle Orthod 2019;89:889-96.
11. Jacobson RL, Jacobson A. Point A revisited. Am J Orthod 1980;77:92-6.
12. Davis DN, Mackay F. Reliability of cephalometric analysis using manual and interactive computer methods. Br J Orthod 1991;18:105-9.