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Assessing validity & reliability of Cephalometric analysis using Smartphone Application with Computer assisted digital cephalometric analysis system and Conventional tracing

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Abstract

Introduction: Digital cephalometrics enables orthodontist in assessment of growth and development of dentofacial structures. Currently available smartphone application enables us to promote orthodontic diagnosis and treatment planning. This study was conducted with the aim of assessing validity & reliability of cephalometric analysis using smartphone application with computer assisted digital cephalometric analysis system and conventional tracing.

Methods: Lateral cephalogram was obtained by 42 patients and was subjected to Downs, Tweed, Steiners and McNamara analysis using traditional tracing technique, Digital tracing using Dolphin software and OneCeph smartphone software.

Results: Highly significant difference was seen in A-B pane angle & Cant of occlusal plane (Down's Analysis), Soft Tissue- Upper & Lower lip to S-line (Steiner's Analysis) & N perp Pog & Effective maxillary length (McNamara Analysis) and statistical significant difference was found with mandibular plane angle (Down's & McNamara Analysis).

Conclusion: Though the time taken by smartphone application is significant less, an orthodontist much carefully evaluate the reliability and validity of

cephalometric tracing before replacing it with the gold standard manual tracing technique.

Keywords: Cephalometric Analysis, Computer Assisted Digital Cephalometric Analysis System, OneCeph, Smartphone Application

Introduction

Cephalometrics has emerged as a fundamental diagnostic aid in clinical orthodontics and orthognathic surgery. It enables us in evaluating the dentofacial skeletal which helps in assessment of growth and treatment related changes & formulating appropriate treatment plan[1].

With the large scale digitization happening in field of orthodontics, traditional manual tracing also has been replaced by the semiautomatic computer based software enabling the operator to directly view the landmark on a digital screen[2].

This digitization in orthodontics is associated with several advantages, including improved practice productivity, clinical decision making, rapid access to information and multimedia resources, and more accurate patient documentation[3].Teledentistry is an emerging aspect in orthodontics that consist of the combination of telecommunications and dentistry with clinical information and images especially in remote dental consultation and treatment planning[4].Currently many orthodontic applications are available online which are intended to promote orthodontic news, products, diagnostics, and practice management that enables the clinician for patient education, treatment simulators, progress trackers, and elastic wear reminders[5-7].But the available database evaluating the accuracy and evidence base of mobile applications in a systematic manner is still lacking[7].Few studies have stated contradictory results when assessing the validation of these cephalometric analysis apps comparing the manual and computerized cephalometric analysis[8-10].

Thus, this study was designed with the aim to assess validity & reproducibility of Cephalometric analysis using Smart phone application (OneCeph) And Computer Assisted Digital Cephalometric Analysis System against conventional Tracing technique.

Objectives

- To check validity & reproducibility of Cephalometric analysis using OneCeph smartphone android application.
- To check validity & reproducibility of Cephalometric analysis using Computer Assisted Digital Cephalometric Analysis System
- To assess time required for cephalometric tracing within different tracing modalities

Materials and Method

Sample Size Estimation

Sample size was calculated from the reference article No. 11.

With $\alpha = 5\%$ & $\beta = 20\%$ the sample size estimated was 42.

Selection of Cases

Inclusion criteria

Patient with Class I, Class II and Class III malocclusion

Exclusion criteria

a. Patient with previous Orthodontic treatment
b. Patient with the history of Temporomandibular disorders
c. Patient with any Craniofacial abnormalities
d. Patient with the history of Trauma
e. Patient suffering from any pathology related to bone & bone metabolism

Materials

- Manual tracing technique: A4 size tracing sheet, Paper clips, Lead pencil 0.5mm, steel scale, Light source.
- Computer assisted digital cephalometric analysis system (CADCAS) tracing technique: Digital

Cephalogram obtained by X-ray machine [Pax-I (PCH-2500) version 2.6.0.]. Dolphin Software version 11.9 was used for landmark tracing.

- OneCeph version beta 8 free access android software was used tracing in android smartphone.

Methods

- The study was under taken with the approval of the ethical committee [IEC number: BV(DU)MC&H/Sangli/IEC/D-27/19]
- Hard copy and Digital copy of lateral cephalogram of 42 patients coming to the Department of Orthodontics and Dentofacial Orthopaedics was obtained from the retrospective data of the institute.
- All the lateral cephalograms were subjected to various cephalometric analysis using different tracing techniques.
- Manual Tracing (Gold Standard): Lateral cephalogram was taken of the patient coming to the Department of orthodontics & dentofacial orthopedic for orthodontic treatment. Down's, Tweed's Steiner's & McNamara analysis was done on tracing sheet using lead pencil. (Figure:1)
- Digital Tracing: Lateral Cephalogram was taken in Digital JPEG format. 10% magnification error was considered during tracing. Down's, Tweed's Steiner's & McNamara analysis was done & measurements were noted. (Figure: 2)
- OneCeph Tracing: Digital copy of the same patient was taken in JEPG format. Cephalogram was traced on android smartphone Realme 3 Pro. (Figure: 3)
- 10% magnification error was considered during tracing. Down's, Tweed's Steiner's & McNamara analysis was done & measurements were noted.
- 25 cephalograms was traced by the same observer after 15 days to eliminated method error & asses the reproducibility of tracing through these three methods.
- Time taken for tracing was noted for all 42 patients individually with all tracing technique.

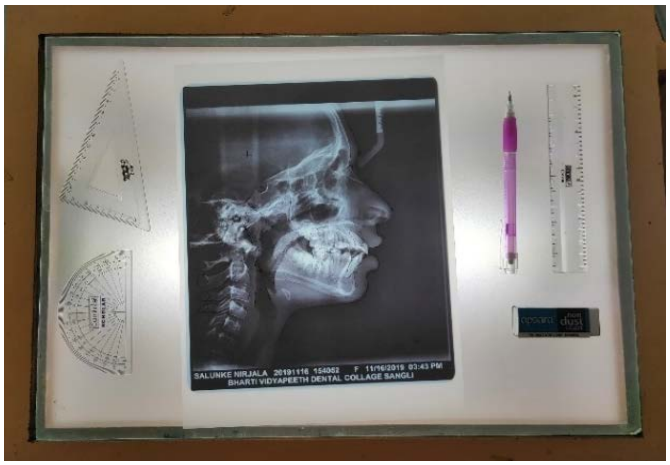

Fig. 1: Manual tracing using light box

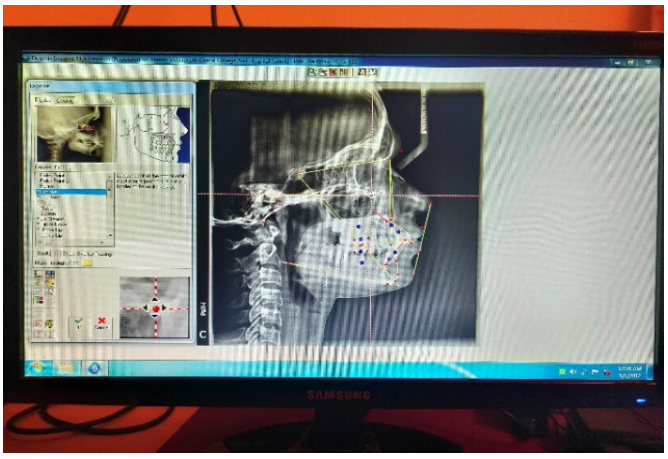

Fig. 2: Digital Tracing using Dolphin Software

Fig: 3 Tracing with OneCeph Smartphone Application

Statistical Analysis

All the data was tabulated in Microsoft word document. The data was subjected to statistical analysis using

Statistical Program for the Social Science (SPSS) software version 16 (SPSS for windows, SPSS Inc., Chicago, IL, USA). Mean, Standard Deviation and Standard Error was calculated for all the parameters of Down's, Steiner's, Tweed and McNamara Cephalometric analysis. Interclass correlation coefficient (ICCs) and Post hoc turkey test was used to assess the significance between three groups. Statistical significance was set at $p<0.05$.

Result

There was a highly significant difference i.e. ($P<0.01$) in A-B pane angle & Cant of occlusal plane (Down's Analysis), Soft Tissue- Upper & Lower lip to S-line (Steiner's Analysis) & N perp Pog & Effective maxillary length (McNamara Analysis), whereas there was statistical significant difference i.e. ($P<0.05$) for mandibular plane angle (Down's & McNamara Analysis). No statistical significance was found for Tweed's analysis. [Table1-4]

Time taken for tracing through Manual method [Mean: 22 min] was significantly higher than time taken for tracing through Computer Assisted Digital Cephalometric Analysis System (Dolphin Digital Software) [12 min] & OneCeph Smartphone application [5 min].

ICC states that highest reliability is seen with Lower incisor to mandibular plane (Downs), Frankfort mandibular incisor angle (Tweeds), SNB (Steiners) & Nasolabial angle (McNamara), whereas lowest reliability is seen with AB plane angle & Interincisal angle (Downs), Frankfort mandibular plane angle (Tweeds), S line to Upper lip (Steiners) & N perp A, N perp Pog (McNamara) in all the three tracing techniques.

Discussion

The study was conducted on radiographs of 42 subjects selected randomly which were taken under same standardized conditions. All the parameters of Downs, Tweeds, Steiners & McNamara analysis were measured using all the three tracing techniques i.e. manual tracing, digital tracing & OneCeph tracing application by the same operator at two different time intervals.

The results indicate that measurements taken by all three techniques are reliable except for few parameters [A-B pane angle, Cant of occlusal plane & mandibular plane angle (Down's Analysis), Soft Tissue- Upper & Lower lip to S-line (Steiner's Analysis) & N perp Pog, mandibular plane angle & Effective maxillary length (McNamara Analysis)]. No statistical difference was found in parameters of Tweed's analysis. Time taken by manual tracing was much higher than time taken by Digital Dolphin Software & OneCeph Smartphone application, thus it is important to weigh up the accuracy & reliability of these tracing techniques against the faster results.

Similar results were seen with a study done by Chen et al[12] who noted that computer-aided cephalometric analysis enables faster data identification and evaluation compared with traditional methods. Furthermore, such analysis enables the operator to alter the visual appearance of the images through the manipulation of brightness and contrast and allows for zooming in, which facilitates accurate and easy landmark identification thus more accurate measurements.

Similar study was done by Shrestha and Kandel[13] who compared cephalometric analysis using manual tracing technique and OneCeph tracing and concluded that there is no statistical significance in cephalometric analysis between the two methods except for lower incisor to NB line. However, the digital tracing with OneCeph software takes significantly lesser time than the manual tracing technique.

Chen et al[12] and Paixao et al[14] found no significant differences in any of measurements acquired with digital cephalometric tracing and manual cephalometric tracing. These authors argued that the computerized method resulted in a lower range of error than the traditional

method and thus increased measurement reliability. Zamrik and Iseri et al[15] compared manual tracing with OneCeph tracing technique and found that there is no statistical significant difference in both the techniques and that cephalometric tracing through both the tracing techniques are reliable. In contrast, Forsyth et al[16] revealed that errors in the angular and linear measurements acquired from digital images are greater than those that occur with traditional manual tracing. Study done by Shettigar et al[17] showed significant difference for SNB, FMA, Basal Plane Angle, L1 to MP parameters when comparing between dolphin and OneCeph. This is in contrast with our study where the above mentioned parameters showed no statistical significant difference & hence are more reliable.

Conclusion

Considering Manual tracing as gold standard A-B pane angle, Cant of occlusal plane & mandibular plane angle (Down's Analysis), Soft Tissue- Upper & Lower lip to S-line (Steiner's Analysis) & N perp Pog, mandibular plane angle & Effective maxillary length (McNamara Analysis) was not accurately measured using Computer Assisted Digital Cephalometric Analysis System (Dolphin digital software) & OneCeph Smartphone application. Tweed's analysis had more accurate reliability in all three tracing techniques. Through time taken for tracing through manual technique is more compared to other two tracing techniques all the parameters are not reliable while tracing with Dolphin & OneCeph.

One of the most significant error in cephalometric tracing is error in landmark identification associated with reproducibility of these landmarks for different analysis. Variation seen in results can be due to subjective perception of every individual in tracing the landmarks. Hence, a more apprehensive outlook is necessary during the tracing through any of the three tracing techniques.

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Legend Tables

Table 1: Downs Analysis in Manual, Digital and OneCeph

	Mean ± SD			
	Manual	Digital	Oneceph	*P* Value
Downs				
Skeletal				
Facial Angle	87.17±4.904	87.51±4.179	87.02±4.339	0.878
Angle Of Convexity	8.52±5.944	6.26±6.928	6.87±6.744	0.264
Ab Plane Angle	1.25±8.334	-6.48±4.648	-6.94±4.599	0.000**
Mandibular Plane Angle	22.69±5.629	22.07±5.348	19.48±5.890	0.024*
Y Axis	58.95±5.089	58.11±3.906	85.40±3.955	0.666
Dental				
Cant Of Occlusal Plane	5.48±4.038	4.63±3.382	8.04±5.365	0.002*
Lower Incisor To Occlusal Plane	27.31±9.527	29.65±9.011	26.38±9.501	0.259
Lower Incisor To Mandibular Plane	11.81±8.997	11.90±8.829	12.73±9.475	0.878
Interincisal Angle	114.19±16.386	113.34±13.897	140.66±155.049	0.293
Upper Incisor To A Pog Line	9.62±3.851	11.05±4.108	10.78±4.839	0.272

Sign *: - indicates *P* value < 0.05; **: - indicates *P* value < 0.001

Table 2: Tweed Analysis in Manual, Digital and OneCeph

	Mean ±SD			
	Manual	Digital	Oneceph	P Value
Tweed Analysis				
Frankfort Mandibular Plane Angle	23.88±5.786	21.84±5.485	22.78±5.615	0.255
Incisor Mandibular Plane Angle	100.83±9.624	101.90±8.829	102.22±9.684	0.778
Frankfort Mandibular Incisor Angle	55.31±13.007	56.26±8.913	54.98±9.928	0.852

Sign *: - indicates *P* value < 0.05; **: - indicates *P* value < 0.001

Table 3: Steiner Analysis in Manual, Digital and OneCeph

	Mean ± SD			
	Manual	Digital	Oneceph	*P* Value
Steiner Analysis				
SNA	82.31±4.646	82.48±4.168	82.59±4.679	0.960
SNB	78.02±5.358	78.29±5.022	78.27±5.221	0.967
ANB	4.36±2.978	4.19±2.878	4.32±3.205	0.966
Occlusal Plane Angle	14.76±6.273	13.14±4.530	16.15±6.463	0.063
Mandibular Plane Angle	28.21±6.167	30.22±6.351	27.08±6.739	0.063
Dental				
Upper Incisor To NA Angle	32±11.125	32.07±8.772	28.42±11.353	0.193
Upper Incisor To NA Linear	7.29±3.691	7.79±4.001	7.87±5.198	0.799
Lower Incisor To NB Angle	29.33±9.172	30.40±8.995	30.7±9.889	0.777
Lower Incisor To NB Linear	7.13±3.267	7.62±3.428	8.06±3.572	0.464
Interincisal Angle	114±16.494	113.34±13.902	115.11±18.789	0.884
Soft Tissue				
S Line: Upper Lip	4.79±4.678	-1.93±2.703	-0.53±2.334	0.000**
S Line: Lower Lip	4.71±4.352	0.71±3.268	1.73±3.227	0.000**

Sign *: - indicates *P* value < 0.05; **: - indicates *P* value < 0.001

Table 4: McNamara Analysis in Manual, Digital and OneCeph

	Mean±Sd			
	Manual	Digital	Oneceph	*P* Value
McNamara Analysis				
N Perp A	2.92±3.421	0.80±3.927	2.76±15.733	0.532
N Perp Pog	4.68±8.572	-2.21±8.349	-4.56±10.153	0.000**
Facial Axis Angle	-0.26±5.644	1.28±4.762	1.78±4.566	0.156
Mandibular Plane Angle	22.31±5.904	19.13±5.535	21.98±5.909	0.024*
Effective Maxillary Length	89.83±6.378	95.40±10.697	98.06±8.233	0.000**
Effective Mandibular Length	114.48±8.025	121.26±14.397	121.03±18.451	0.051
Maxillomandibular Differential	24.33±4.812	25.85±5.717	26.85±4.981	0.085
Lower Anterior Facial Height	67.17±6.570	70.61±8.855	71.39±12.659	0.109
Upper Incisor Point A	8.64±3.252	9.54±3.558	10.15±4.924	0.220
Lower Incisor A Pog	4.43±3.710	4.29±4.343	5.99±10.003	0.433
Nasolabial Angle	94.36±13.812	92.01±12.627	94.88±13.637	0.580
Pharyngeal Analysis: Upper	13.55±2.461	14.49±3.130	13.95±2.383	0.272
Pharyngeal Analysis: Lower	12.48±3.480	13.55±3.973	13.32±3.586	0.376

Sign *: - indicates *P* value < 0.05; **: - indicates *P* value < 0.001