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Comparative Evaluation of Accuracy of Conventional Hand Tracing and Digital Tracing Using Two Software: Nemoceph and Onyxceph

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1. INTRODUCTION

Currently, cephalometric analyses for orthodontic diagnosis, treatment planning, research, evaluation of treatment results and prediction of growth are often performed on digital images by means of computer softwares.[1,2] Digital technology has introduced several benefits in cephalometrics, as it enables instantaneous image acquisition, requires lower radiation dose, avoids developing process, and simplifies image storing and sharing.[1]

Hand traced cephalometric analysis on traditional radiographic films has been the gold standard for analyzing a cephalometric radiograph for the past few decades. Despite its widespread use in orthodontics, the technique is time consuming and has several drawbacks including, high risk of error during hand tracing, landmark identification and measurements.[2]

Nowadays various software programs are available for cephalometric measurements on digital cephalograms. They also simulate and predict multiple treatment options, thereby enabling the clinician to select the best treatment option according to the patient's desire and need. With the help of facial photographic morphing technique we can predict the profile change of the patient after orthognathic surgical procedures. This demonstration of VTO (Visual treatment objectives) also helps in achieving acceptable motivation of the patient for any particular orthodontic treatment. Thus in comparison with conventional tracing the computer aided cephalometric software programs are an effective diagnostic tool and also a powerful consultation and presentation tool.[2]

The present study will be done to evaluate and compare the various cephalometric measurements of monitor-displayed images with the help of cephalometric software program, namely "Nemoceph" and "onyxceph", and the manual tracing on its hard copy.

2. MATERIALS AND METHODS

The present study was conducted on pre-treatment digital lateral cephalograms (both soft and hard copies) of 33 subjects, irrespective of the type of malocclusion, who came for the orthodontic treatment to the Department of Orthodontics and Dentofacial Orthopedics, Manubhai Patel dental college, Vadodara. The study was approved by the ethical committee of the institution.

The inclusion criteria for the analog and digital cephalograms were as follows:

- Cephalogram with good quality.

The exclusion creteria for the analog and digital cephalograms were as follows:

- Avoid severe skeletal discrepancy.
- Improper contrast in cephalogram digital image.

- Under developed or over developed cephalogram image.

Digital lateral cephalograms of the subjects were taken on a digital cephalometric machine in a standing position with relaxed lips, teeth in centric occlusion and the subject's head in such a position that the Frankfort horizontal plane was parallel to the floor. All lateral cephalograms were then transferred to a computer loaded with software and the hard copies were printed with the help of an X-ray printer.

Digital radiographs were calibrated by the use of ruler incorporated in the cephalostat at the time of radiographic exposure. This avoids any magnification errors in linear measurements. The soft copies of all lateral cephalograms were transferred to Nemoceph and onyxceph cephalometric software program.

The images were calibrated by identifying two crosshairs 10 mm apart. The image enhancement features of the software, like brightness, contrast adjustment and magnification was used as needed to identify individual cephalometric landmarks as precisely as possible with the help of mouse/cursor. And Conventional radiographs were traced manually over a view box in dark room using 0.7mm pencil and protractor.

After placing registration points on the hard copies of the lateral cephalograms, hard and soft tissue landmarks (Fig. 1) were traced manually on tracing paper.

All the tracings were done by the same investigator and same cephalometric landmarks and angular and linear measurements were recorded by second observer also. Once all the landmarks were marked, these landmarks were again adjusted and corrected for accurate measurements. All angular and linear measurements were automatically calculated by the tracing software. The data so obtained were subjected to statistical analysis.

Landmarks	Description
Sella (S)	The midpoint of Sella Turcica
Nasion (N)	Junction of the frontal and nasal bones at the naso-frontal suture
Point A (A)	The deepest point in the concavity of the anterior maxilla between the anterior nasal spine and the alveolar crest
Point B (B)	The deepest point in the concavity of the anterior mandible between the alveolar crest and Pogonion
Porion (Po)	The most superior point on the bony external auditory meatus
Orbitale (Or)	The most inferior point on the infraorbital margin
Pogonion (Pog)	The most anterior point on the bony chin
Menton (Me)	The most inferior point on the bony chin
Gonion (Go)	The most outward point on the angle of the mandible formed by the junction of the ramus and the body of the mandible
Gnathion (Gn)	Midpoint between Me and Pog
Anterior nasal spine (ANS)	Tip of the anterior nasal spine
Posterior nasal spine (PNS)	Tip of posterior nasal spine
Upper incisor tip (U1)	Tip of the crown of the upper central incisor
Upper incisor apex (U1R)	Root apex of the upper central incisor
Lower incisor tip (L1)	Tip of the crown of the lower central incisor
Lower incisor apex (L1R)	Root apex of the lower central incisor
Lower first molar (LM)	Tip of the mesial cusp of the lower first molar
Upper first molar (UM)	Tip of the mesial cusp of the upper first molar

Fig. 1

Angular measurements	
SNA	Angle determined by points S, N, A
SNB	Angle determined by points S, N, B
ANB	Angle determined by points A, N, B
SND	Angle determined by points S,N,D
SN to Go-Gn	Angle between the anterior cranial base plane and the mandibular plane
U1-NA	Angle between U1 to point NA
L1-NB	Angle between L1 to point NB
Interincisal angle	Angle between U1 to L1
Occlusal plane - SN	Angle between occlusal plane to SN

Linear measurements	
U1 to A-Pog	Perpendicular distance from the upper incisor tip to the A-Pog line
L1 to A-Pog	Perpendicular distance from the lower incisor tip to the A-Pog line

Fig. 2

3. RESULT

The Intraclass correlation coefficients (ICC) values calculated for repeated measurements with each tracing technique was reported that , ICCs exceeded 0.9, and most values were nearer to1.00, thus providing an indication of very high intrarater reliability. All the cephalometric parameters had ICC 1.00, indicative of a high agreement among the tracing methods.

ICCs exceeded 0.85, and most values were above 0.9, thus providing an indication of very high intrarater reliability.[8]

In the Goracci C; Ferrari M's study all the cephalometric parameters had ICC .0.8, indicative of a high agreement among the tracing methods.

Table 1

Angle	NEMOTEC	ONYX	HAND
ANB	0.999	0.997	0.995
INTERINCISAL ANGLE	1.000	1.000	0.999
L1-NB Angular	1.000	1.000	1.000
L1-NB Linear	1.000	1.000	1.000
OCC PLANE-SN	1.000	1.000	1.000
SNA	1.000	1.000	1.000
SNB	1.000	1.000	0.998
SND	1.000	1.000	0.995
Sn to Go-Gn	1.000	1.000	0.999
U1 TO NA	1.000	1.000	0.998
U1-NA	1.000	1.000	1.000

Most of the ICCs actually exceeded 0.9. The nearer values of correlation were noticed for the INTERINCISAL ANGLE, L1-NB Angular, L1-NB Linear, OCC PLANE-SN, SNA, SNB, SND, Sn to Go-Gn, U1 TO NA Angular, U1-NA Linear. The lowest ICCs occurred for ANB.

Non parametric test named Wilcoxon Signed Rank test revealed that for all the assessed cephalometric parameters, statistically significant difference was found between manual and nemotech (P<.05) whereas it was not significant between manual tracing and onyxceph software (P > .05).

4. DISCUSSION

Cephalograms have been used widely for both clinical tool as well as research technique for the study of craniofacial growth and orthodontic treatment.

Precision and reproducibility in data obtained from cephalometrics is important for the orthodontist. Errors in conventional methods arise from radiographic acquisition, landmark identification, and measurement.

To overcome the errors of conventional radiography, digital cephalometry, which allowed the operator to manipulate data on the computer thereby facilitating the complex analysis and organization became popular.

The differences between the superimpositions are due to error derived from several sources. Many investigators have illustrated that the process of landmark identification represents the largest source of error in cephalometric analyses.[9,10] Another source of error would be associated with superimposition. The range of error of cranial base and regional superimposition varies in the literature.[11,12]

Most of the studies done previously compared the digital cephalometric analysis of either scanned or photographed images to their analog hard copy by manual tracings or comparison of soft copy to its analog hard copy, where cephalograms were taken by using sandwich technique.

In this study, the cephalograms were taken by direct digital radiography with the help of charged couple device (CCD) technique and its soft copies and digital printouts were obtained. The different software (nemotech,onyxceph) and manual(hand tracing) were used in this study to evaluate intra error and inter error which is not significant statistically.

Table 2

		NEMOTEC1	ONYX1	HAND1	NEMOTEC2	ONYX2	HAND2	NEMOTEC	ONYX	HAND
Mean		43.202755	42.526639	42.581267	43.212397	42.527190	42.595041	43.207576	42.526915	42.588154
95% Confidence Interval for Mean	Lower Bound	39.188813	38.528854	38.593619	39.199625	38.526582	38.598664	39.194222	38.527724	38.596190
	Upper Bound	47.216697	46.524424	46.568916	47.225169	46.527798	46.591418	47.220929	46.526105	46.580119
Median		29.400000	26.300000	27.700000	29.500000	26.200000	27.700000	29.450000	26.250000	27.700000
Std. Deviation		3.8888561E1	38.7320255	38.6338204	38.8772269	38.7593745	38.7183844	38.8828587	38.7456461	3.8675635E1
Minimum		-6.9000	-6.2000	-9.0000	-6.6000	-7.2000	-8.0000	-6.7500	-6.7000	-8.5000
Maximum		144.6000	147.9000	145.2000	144.7000	148.0000	144.2000	144.6500	147.9500	144.7000
Range		151.5000	154.1000	154.2000	151.3000	155.2000	152.2000	151.4000	154.6500	153.2000
Interquartile Range		70.0000	70.1000	70.4000	70.0000	70.2000	71.0000	70.0000	70.1500	70.8000
Skewness		.722	.742	.731	.722	.743	.734	.722	.742	.732
Kurtosis		-.595	-.617	-.537	-.593	-.611	-.534	-.594	-.614	-.536

Mutual comparison of results between two different softwares and manual method, wilcoxon signed rank test was applied.

- cephalometric measurements obtain from nemotech, onyx and manual hand is presented in form of median(IQR). Median value in nemotech was 29.45 (70.0) whereas in onyx was 26.25 (70.15) and for manual hand 27.70 (70.8).
- Significant difference was found between manual and nemotech(P<.05) whereas it was not significant between manual tracing and onyxceph software (P > .05). Difference between two software also shows significant difference (P<.05).
- Before and after comparison was done by wilcoxon signed rank test.

Table 3

Ranks				
		N	Mean Rank	Sum of Ranks
ONYX2 - ONYX1	Negative Ranks	49	51.01	2499.50
	Positive Ranks	55	53.83	2960.50
	Ties	259		
	Total	363		
NEMOTEC2 - NEMOTEC1	Negative Ranks	66	76.73	5064.00
	Positive Ranks	86	76.33	6564.00
	Ties	211		
	Total	363		
HAND2 - HAND1	Negative Ranks	25	28.00	700.00
	Positive Ranks	30	28.00	840.00
	Ties	308		
	Total	363		

No significant differance was found between before and after observations of all three methods (p- value > 0.05).

ICCs exceeded 0.85, and most values were above 0.9, thus providing an indication of very high intra rater reliability.[8]

In the Goracci C; Ferrari M's study all the cephalometric parameters had ICC .0.8, indicative of a high agreement among the tracing methods.[1]

5. CONCLUSION

Digital records are being used more today in line with a "paperless" model of storage. Cephalometric radiographs have received much attention on the part of software development and developer in attempt to design the ideal program for cephalometric analysis. Computer aided cephalometry and manual tracing showed good agreement and might be preferred when user-friendliness and portability are prioritized. In our study Onyxceph shows better result as compared to Nemotech software. The main advantage for using a software is the speed with which it performs this procedure, but this model still presents a digital error of prediction, because it represents two dimensions of an anatomical structure of three dimensions.

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