

Evaluation of Accuracy of Manual and Digital Tracing with Lateral Cephalometric Radiograph: A Comparative Study

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Abstract

Objective: To assess the accuracy of cephalometric measurements performed with (WEBCEPH analysis software 1.0.0) with lateral cephalometric radiographs based on measurement obtained from manual tracing. **Materials and Methods:** 50 patients' pre-treatment lateral cephalograms using the same digital cephalometer was collected. Tracings were performed digitally and by hand. eight angular measurements (FMA, IMPA, SNA, SNB, ANB, 1.NA, 1. NB, Y-Axis) and six linear measurements (1-NA, 1-NB, Co-Gn, Co-A, E Line-Lower lip and LAFH). The same investigator performed all of the tracings; **Results** were assessed using Student's t-test. **Result:** There was no statistically significant difference between Hand and digital tracing ($p>0.05$). **Conclusion:** WEBCEPH cephalometric tracing showed good agreement with manual tracings.

Keywords: Cephalometry. Orthodontics. Computerized diagnosis.

1. Introduction

The lateral cephalometric radiograph is a standard component of clinical records taken for orthodontic diagnosis and treatment planning.^{(1) (2)}

Although its original intent was to longitudinally assess growth and development in the craniofacial complex, the cephalometric radiograph was adopted by clinical orthodontists to diagnose any skeletal imbalances underlying the dental features of a malocclusion. Cephalometric analyses were developed to characterize a patient's dental and skeletal relationships relative to population norms. The normative data on growth were derived from several longitudinal studies undertaken between the 1940s and 1960s (3, 4). Traditional cephalometric analysis is performed by tracing radiographic landmarks on acetate overlays and using these landmarks to measure the desired linear and angular values. This traditional hand-tracing process can be It is time-consuming, and the linear and angular cephalometric Measurements are obtained manually with a ruler and protractor may be prone to error. Rapid advances in computer science have led to the wide application of computers in cephalometry.⁽⁵⁻⁷⁾ Early developments in computerized radiography relied on digitizer pads, scanners, and digital cameras to transfer in a matter of seconds, analogue data is converted to digital format. Recent improvements They have enabled the use of direct digital images, which offer advantages, including instant image acquisition and reduction in aided in image enhancement and archiving and image sharing, and the elimination of technique-sensitive developing processes (8) The unprecedented evolution of computer technologies has paved the way for the use of digital programmes in the production of cephalometric tracings.⁽⁹⁾

Image enhancement aids in the improvement of

landmarks. features in software programs, and most Final tracing is quickly completed by the software. after landmark identification. Various cephalometric Analyses are available, Digital radiographic images are easy to store and To facilitate communication between providers, depending They may also require lower levels depending on the system of radiation (10)

Since the cephalometric analysis method is frequently used by orthodontists and researchers and due to continuous advances in Cephalometric software, the need was felt to assess and compare the accuracy of cephalograms by comparing between the manual and digital tracing (11)

2. Objective

Evaluation of the accuracy of a computer software (WEBCEPH) in digital cephalometric analysis based on hand tracing.

3. Materials and Methods

a random sample of 50 cephalograms with permanent dentition, Patient identifiers (iename, age, gender, and date of examination) were cropped out of the original lateral cephalograms to maintain patient privacy. These lateral radiographs were obtained in the same radiological clinic and were performed with the patient's head immobilized by a cephalostat guided by the Frankfort Horizontal plane, parallel to the ground and perpendicular to the mid-sagittal plane.

Manual tracing

After sample selection, a single examiner performed the cephalometric tracings manually. The radiographs were divided into five groups of ten to avoid examiner fatigue during the course of anatomical tracing and landmark marking needed for the study. These were performed over a period of ten

days and then the cephalometric measurements were taken. A sheet of Ultrathin transparent tracing paper measuring 8X10-in and 0.003-in thickness was placed over each tooth, and the tracings were performed using a mechanical pencil with 0.3 mm thick lead.

After completion of the cephalograms using the manual and digital methods the following cephalometric landmarks were traced as described by Araujo (12) and Ferreira (13).

- Point S (Sella); point N (Nasion); point ANS (Anterior Nasal Spine); point Po (Porion); point or (Orbitale); point A (Subspinale); point B (Supramentale); point Pog (Pogonion); Point Me (Menton); point Go (Gonion); point Gn

(Gnathion); point Co (Condylion); point Pn (Nose tip), Li (Lower lip); point Pog' (Soft Tissue Pogonion).

Once the landmarks had been traced, the lines and planes, could be obtained. For this evaluation 14 measurements were selected, eight angles derived from the Tweed (14) (FMA and IMPA); Steiner (15) (SNA, SNB, ANB, 1.NA, 1.NB) and Downs (16) (Y axis) analyses, and six linear measurements taken from the Steiner, (1-NA, 1-NB); McNamara, (17) (Co-Gn, Co-A, LAFH) and Ricketts (18) (LE-Li) analysis. After performing the tracings, the angular and linear measurements were obtained with the aid of a protractor. The data were then tabulated for subsequent statistical analysis.



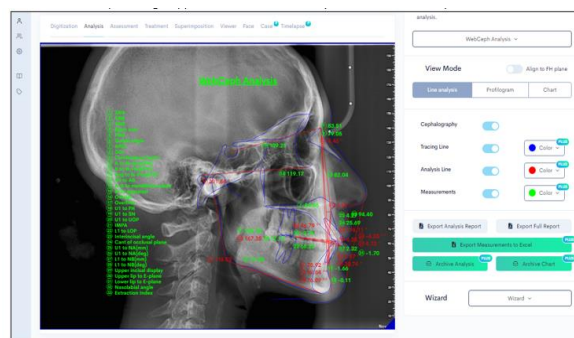
Digital tracing

The 50 cephalometric radiographs soft copy exported to the (WEBCEPH) software by opening the software then we login the private account of the clinician to open a new patient with different I patient ID for each cephalometric x-ray, the tracing is done in systematic manner, the 1st step (digitization) which is an auto recognition of anatomical landmarks on the x-ray the clinician is able to modify the digitized land marks before the second step (analysis)

When necessary, images were enhanced with brightness, contrast and magnification to identify areas with greater accuracy. The program illustrates all points and their tracing sequence and allows users to magnify any specific areas. The software also provides the clinician with additional options that may help the clinician in treatment planning and follow up the treatment outcomes by x-ray superimposition and the time laps of each case.

Once the landmarks had been traced, the lines cephalometric measures were compared to hand tracing cephalometric measurements as (control group). From the statistical analysis of the data, the

cephalometric variables were gathered.



4. Statistical analysis

Power analysis showed that a sample size of at least 50 patients would give an 80% probability of detecting a real difference of 0.17 mm between groups at a statistically significant level of 5%.

Evaluation of statistical differences between angular and linear measurements by the manual and digital methods was performed using Minitab software, version 14, and applying Student's t-test. Intraexaminer error was assessed by means of ten new, randomly selected tracings (five manual and five digital) after 20 days. The data obtained at T1 and T2 were compared using Student's t-test.

5. Result

Intraexaminer error results showed no statistically significant difference at T1 and T2, as depicted in Tables 1 and 2.

Comparison of angular and linear measurements between the digital and manual groups is described in Tables 3 and 4.

There was no statistically significant difference between (Hand tracing) and (Webceph) where ($p > 0.05$). (Hand tracing) had the highest mean value, whereas (Webceph) had the lowest mean value.

Table 1 - Comparison between the means and standard-deviations of linear and angular measurements obtained from manual tracings at T1 and T2.

Variables	Manual Tracings (T1)	Sd	Manual Tracings (T2)	sd	p value
FMA	26.6	5.09	27	5.38	0.906
IMPA	95.2	4.65	95	4.19	0.943
SNA	82.8	5.27	82.8	4.67	1.000
SNB	77.2	3.85	77.7	3.27	0.853
ANB	5.3	2.67	4.9	2.90	0.826
1.NA	21.6	11.0	22	12.4	0.957
1.NB	28	7.90	29.4	8.71	0.796
Y Axis	59.5	2.37	60.4	1.50	0.501
1.NA	5.2	2.86	5.2	3.83	1.000
1.NB	6.6	3.45	6.4	3.19	0.925
GO-GN	129.7	9.07	130.9	9.24	0.840
CO-A	101.9	1.65	102.2	2.05	0.806
LE-Li	1.3	3.62	1.1	3.73	0.932
LAFH	79.1	8.23	78.6	8.54	0.926

Table 1 - Comparison between the means and standard-deviations of linear and angular measurements obtained from digital tracings at T1 and T2.

Variables	Digital tracings(T1)	sd	Digital Tracings (T2)	sd	p value
FMA	27.1	5.15	26.68	5.59	0.86
IMPA	93.84	4.08	93.26	2.68	0.78
SNA	81.94	5.76	81.82	4.58	0.95
SNB	77.32	3.65	77.34	3.48	0.97
ANB	5.02	2.80	4.26	3.23	0.69
1.NA	20.56	11.10	21.14	13.38	0.92
1.NB	27.74	7.79	26.56	6.73	0.78
Y Axis	60.08	8.07	60.2	2.70	0.93
1.NA	5.62	3.25	6.52	4.58	0.71
1.NB	6.72	3.50	6.6	3.11	0.94
GO-GN	130.18	8.89	130.46	9.70	0.94
CO-A	101.42	3.05	100.02	1.85	0.42
LE-Li	1.76	2.63	1.78	3.15	0.97
LAFH	79.86	8.07	60.2	7.94	0.90

Table 3 - Comparison between the means and standard-deviations of angular measurements obtained from manual and computerized tracings.

Variables	Manual measurements mean (DP)	webceph measurements mean (DP)	p value
FMA	27.26(5.31)	27.39(5.09)	0.88 n.s.
IMPA	96.07(7.32)	95.30(7.71)	0.59 n.s.
SNA	82.55(3.61)	82.36(3.59)	0.76n.s.
SNB	78.55(3.47)	78.35(3.41)	0.75n.s.
ANB	3.89(2.84)	3.80(2.82)	0.96n.s.
1.NA	27.53(8.89)	26.75(8.88)	0.64n.s.
1.NB	30.76(7.18)	29.86(7.64)	0.52n.s.
Y-Axis	59.37(4.01)	59.95(3.96)	0.45n.s.
1.NA	8.03(3.18)	7.82(3.20)	0.72n.s.
1.NB	7.77 (3.42)	7.71 (3.39)	0.91n.s.
Co-GN	125.17(7.53)	124.89(7.79)	0.83n.s.
Co-A	96.09(5.21)	95.48(5.69)	0.55n.s.
LAFH	73.91(7.35)	74.43(7.39)	0.79n.s.
LE-Li	1.92(3.74)	2.33(3.54)	0.55 n.s.

6. Discussion

Justifications between the two methods of tracing can be made with regard to the selection of landmarks and cephalometric measurements. As exemplified in this type of work, In terms of the ease of locating the landmarks, providing higher reliability and precision, which can directly influences the measurement. (19-21) The increasing use of digital cephalometrics has highlighted the need to evaluate the accuracy of these new computerized software programs and compare them with traditional manual measurement techniques. (22)

According to Albuquerque-Junior and Almeida (23) examiners can interfere significantly with systematic effects, affecting the reproducibility of cephalometric values. Silveira and Silveira (24) argue that one method to control errors in the replication of cephalometric measurements consists in calibrating examiners directly, and further suggest that such direct calibration be included in any scientific experiment. Tables 1 and 2 display a comparison between measurements taken by the examiner in manual and digital cephalometric tracings at different times (T1 and T2), showing that no statistically significant difference was found in any of the measurements in both groups.

In this study, the analysis of the results obtained

when comparing the angular and linear cephalometric measurements taken in digital and manual tracings revealed values that were very close to the means and standard deviations, reflecting a nonsignificant p value for all magnitudes (Tables 3 and 4). These findings support those of Chen (25), Correia et al (26) and Vasconcelos et al. (27) Conflicting results were found by other authors (28, 29) whose data showed statistically significant differences, although accepted in clinical practice.

Nowadays, digitizing X-rays has become the preferred method to perform cephalometric measurements. As technology evolves it becomes increasingly easier for professionals to adapt to the many routine tasks of clinical practice. This scientific investigation supports other studies published in the literature, (25-27, 30) which confirm the enhanced effectiveness provided by today's technological resources.

This study evaluated the accuracy of linear measurements in manual and computerized cephalometric tracings performed with the aid of webceph software. However, further studies should be performed using this computer program since it features other tools for cephalometric tracing that help the orthodontist in diagnosis and treatment planning.

7. Conclusion

There was no statistically significant difference

found in the current study as seen in the majority of cephalometric parameters between manual and the digital apps, **Althoug**, (Hand tracing) had the highest mean value, whereas (Webceph) had the lowest mean value and the manual tracing was time consuming in comparison to digital tracing. hence webceph software is available tool that can aid in diagnosing, planning, monitoring and evaluating orthodontic treatment both in clinical and research settings

8. References

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