ORIGINAL ARTICLE

Hand-Traced versus Digitally Traced Cephalometric Analysis: A Comparative Study

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ABSTRACT

Objective: To determine the accuracy of digitally/computer-traced cephalograms compared to hand-traced cephalograms in terms of differences in mean angular and linear cephalometric measurements.

Study Design: Observational (cross-sectional comparative).

Place and Duration of Study: The study was carried out at the Orthodontics Department of Armed Forces Institute of Dentistry (AFID), Rawalpindi, Pakistan, from June 2020 to December 2020.

Materials and Methods: One hundred and twenty patients aged 12 – 24 years undergoing treatment at the department were randomly selected. Cephalograms were recorded by a digital cephalographic system, keeping the distance between film and object at 5 feet and exposure time at 80 KV/0.5 sec. Both hard and soft copies were obtained. Hand tracings were done using the hard copy with a 0.5 mm lead pencil on 0.003-inch matte acetate paper. Digital tracings were performed using the soft copy of the same digital cephalometric system in the Viewbox software version 4.0. Linear and angular measurements were recorded. Data were analyzed using SPSS version 24. Descriptive statistics were calculated. For comparison between two methods, i.e., vs Computerized tracing, an independent sample t-test was applied while the *p*-value was kept ≤0.05.

Results: No statistically significant difference was observed between cephalometric measurements obtained via the two methods for any of the linear or angular measurements.

Conclusion: Computerized cephalometric analysis is reliable and time-effective, and its accuracy is comparable to manual analysis.

Keywords: *Cephalometry, Computer-Assisted, Dental, Digital, Image, Manual Tracing, Processing, Radiography*.

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Introduction

Since its inception in 1931 by Broadbent, cephalometry has been an indispensable tool for orthodontists perusing dental and skeletal abnormalities in the stomatognathic apparatus.[1] Cephalometric analysis is useful not only for diagnosis and treatment planning but also for evaluating treatment outcomes and predicting growth. Manual cephalometric analysis is achieved by placing acetate sheets over cephalograms, marking cephalometric landmarks, and recording the required linear and angular measurements. Manual cephalometric tracing takes time and the readings attained by hand are subject to faults and imprecision.[2]

Recent advancements in digital dentistry have revolutionized dental radiography, with increasing use of software in cephalometrics.[3] For computer-aided automated cephalometric analysis, conventional landmarks are first "digitised", allowing the software to promptly produce cephalometric readings once location of all desired landmarks has been entered.[4] Computerized cephalometric records can be incorporated with the patient data to establish a computer or cloud-based database capitalising on the benefits of image processing, archiving, and sharing.[5]

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The comparison of hand-traced versus digitized cephalograms has been the subject of many research studies. Meric and Naoumova evaluated traditional hand-traced cephalometric analysis with web-based fully-automated, computerized and app-aided tracings in terms of accuracy and tracing time.[6] They reported that while the fully-automated method required the least tracing time, it showed the greatest variation in measurements. Generally, currently available automated cephalometric analyses require manual corrections and adjustments in order to yield acceptable diagnostic values.[7]

View box software can be regarded as the gold standard in digital cephalometry.[8] It is a Conformité Européene (CE) certified program used for the digital analysis of cephalograms. The software has progressed over time and now allows not only the cephalometric analysis but also morphometrics of any 2D or 3D object.[9] View box was a pioneer in digital cephalometry and has since been used for analysis of cephalograms. However, in developing countries like ours, use of technology for medical and dental diagnosis is still looked down upon. Most old-school clinicians prefer tracing cephalograms with their own hands and do not trust any software's or apps that may help save time. This study was, therefore, undertaken with the aim to compare analysis of manually hand-traced cephalograms with those analysed using View box software. The specific objectives of the study were to evaluate the mean angular and linear measurements of hand and computerized tracings and, to compare the mean difference of angular and linear measurements between hand tracings and computerized tracings of cephalograms.

Materials and Methods

A cross-sectional comparative study was conducted at Orthodontics Department of Armed Forces Institute of Dentistry (AFID), Rawalpindi, Pakistan from June 2020 to December 2020. Prior approval from institute's ethical committee was sought. Sample size was calculated using WHO calculator. Keeping confidence level (1-α) at 95%, population mean 76.2 and SD 3.6,[2] a sample size of 60 was calculated for each group, making the total sample size 120. Patients aged 12 – 24 year who were undergoing treatment at the department were randomly selected provided they were not syndromic patients and the cephalograms were clear and without distortions. Consent was sought from the selected patients to use their data for the study. The cephalograms were recorded by digital cephalographic system, keeping distance between film and object around five feet and 80 Kilovolt/0.5 sec exposure time. Both hard and soft copies were obtained. Hand tracings were done by a single classified specialist using the hard copy with 0.5 mm lead pencil on 0.003-inch matte acetate paper. Cephalograms were traced under a standard view box and protractors were used for measuring hard tissue angles and linear measurements. Digital tracings were performed by the same operator using the soft copy of the same digital cephalometric system in the View box software version 4.0. To minimize intra-operator bias, each reading for both tracings was taken thrice, and a mean value was then used. Moreover, 20% of the cephalograms were retraced after 02 weeks by the same operator. Intra-operator reliability was assessed using intra-class coefficient correlation. A high value of 0.816 was obtained, showing good reliability. Angular and linear measurements recorded for the study are detailed in Figure 1a and 1b respectively.

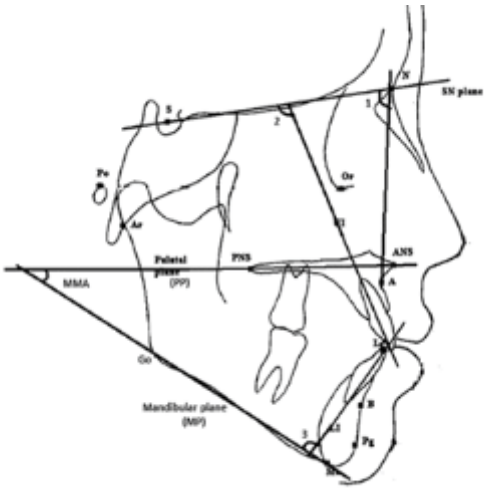

Fig 1a: Angular measurements recorded for the study - SNA, SNB, ANB, IMPA, Interincisal angle, SN-MP, SN-PP, MMA and Gonial angle

Data was analyzed using SPSS version 24. Descriptive statistics were calculated. Frequency and percentages were calculated for gender. Quantitative variables, i.e., age, angular and linear measurements, were measured as mean ± standard

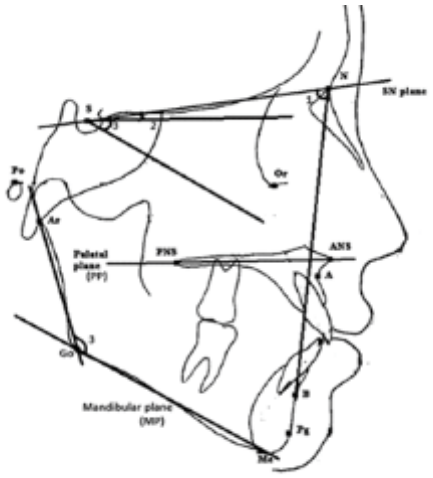

Fig 1b: Linear measurements recorded for the study - anterior c ranial base (N-S), mandibular length (Go-Me), maxillary length (ANS to PNS) and LAFH - lower anterior facial height. (ANS to Me)

deviation and presented in tabulated form. For comparison between two methods, i.e., hand vs computerized tracing, independent sample t-test was applied while *p*-value was kept ≤0.05.

Results

There were 56 (46.7%) males and 64 (53.3%) females among the study subjects. Mean age of the subjects was 17.37 ± 3.89 years. Mean values of all the angular and linear measurements are described in Table 1.

Table 1: Mean values of all liner and angular measurements obtained in the study via hand and computerized tracings

Measurement	Minimum	Maximum	Mean	Std. Deviation
Angular				
SNA	73.8	90.6	81.02	3.54
SNB	63.1	91.0	76.65	4.74
ANB	-6.1	18.0	4.32	3.82
IMPA	81.7	117.8	101.34	6.87
IIA	86.0	163.3	118.06	13.42
SN-MP	14.0	69.0	32.64	9.11
SN-PP	2.0	14.0	8.18	3.27
MMA	8.0	60.0	25.31	8.83
Gonial	100.0	135.3	122.18	6.47
Linear				
N-S	53.0	73.0	60.41	4.23
ANS-PNS	37.0	61.0	46.59	4.36
Go-Me	47.0	72.0	59.51	5.96
LAFH	41.1	70.0	55.99	6.26

No significant difference could be observed between cephalometric measurements obtained via two methods for any of the linear measurements. Similarly, a significant difference could not be observed between the two analytical methods (manual vs digital) for selected angular measurements (Table 2).

Table 2: Comparison of angular and linear measurements between hand-traced and computerized cephalometric analysis

Measurement	Mean ± SD		*P* value
	Hand-tracing	Computerizedtracing	
Angular			
SNA	81.033 ± 3.34	81.010 ± 3.77	0.97
SNB	76.83 ± 4.68	76.48 ± 4.84	0.67
ANB	4.18 ± 3.59	4.48 ± 4.07	0.67
IMPA	101.0 ± 6.59	101.68 ± 7.18	0.59
IIA	118.57 ± 13.11	117.55 ± 13.81	0.68
SN – MP	31.73 ± 9.82	33.55 ± 8.32	0.278
SN – PP	8.28 ± 3.27	8.09 ± 3.30	0.777
MMA	24.63 ± 9.55	25.99 ± 8.08	0.403
Gonial Angle	121.5 ± 7.04	122.86 ± 5.83	0.25
Linear			
N-S	60.33 ± 3.11	60.49 ± 5.15	0.83
ANS – PNS	47.13 ± 3.91	46.04 ± 4.74	0.171
Go – Me	59.83 ± 5.79	59.19 ± 6.14	0.556
LAFH	56.43 ± 5.42	55.55 ± 7.03	0.442

Discussion

The present study compared the mean difference in angular and linear measurements between hand- and computerized-traced cephalograms. The proponents of digital dentistry strongly advocate the use of technology for diagnosis and treatment, claiming that use of technology helps save precious time. Mumtaz et al.[10] compared the two cephalometric analyses methods in terms of the required time to accomplish them. They found a significant difference in the time required for analysis by the two methods, whereby digital analysis only required a minute while manual analysis required over seven minutes by an experienced clinician. Moreover, time constraints in the clinical setup result in pressure on the clinician, introducing error in readings and overall decreased reliability.

The present study failed to highlight any statistically significant difference in cephalometric analysis done by manual tracing and that done by computer software. Comparable results have been reported by Mohan et al. who reported no difference between manual and digital cephalometric analysis, stating that software-based analyses were at par with hand-traced analysis with respect to precision and reliability.[11] Comparable results have also been reported by Farooq et al.[12] who found consistency of

measurements between manual and digital analysis of cephalograms.

Discrepancies in accurate identification of cephalometric landmarks can incorporate major error analysis.[13] Inexperienced and under-trained clinicians are more prone to incorporating such errors. Moreover, conventional radiographs are plagued by poor quality standards, usually in terms of poor visibility of structures.[14] Digital cephalometric analysis allows quicker procurement and evaluation of data than classic manual approaches. Furthermore, the picture can be enhanced digitally and can be seen in contrast, allowing easy landmark identification. In addition to comparable accuracy to manual analysis, the digital analysis also offers the advantages of "archive, retrieval and transmission" of images.[15] The "physical" nature of radiographic films makes them more prone to damage, deterioration and losses over time, and hence, they serve as a relatively less reliable "archive medium". Film deterioration has been cited as one of the leading sources of data loss in dental and medical diagnosis.[16] Therefore, digital cephalograms serve as a valuable archiving tool for orthodontics.

Today a plethora of cephalometric analysis software's and applications are available. One is faced with the confusing decision of which digital tool to use. In a study to compare imaging software's for orthodontic use, Radwan et al.[17] found no difference between various software's, reporting a high positive intra-rater reliability for all selected software programs. Despite new advancements, Viewbox software is time-tested and has progressed over time, keeping pace with the technological advancements. It has been designed by an orthodontist keeping the requirements of the field in mind.[18] It can, therefore, be regarded as the gold standard in digital cephalometry. One drawback of computerized tracing is that armamentarium to do analysis is costly. Nonetheless, the results of the present study also endorse its reliability, accuracy and time efficiency in cephalometric analysis.

Conclusion

No significant difference was found in cephalometric analysis based on manual tracings and digital tracings for any of the selected angular and linear measurements. Computerized cephalometric analysis is reliable and time-effective, and its accuracy is comparable to manual analysis. It is the need of the hour to incorporate technology in medical and dental practice to alleviate some burden and provide relief to the overworked clinicians.

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