ORIGINAL ARTICLE

COMPARISON BETWEEN LINEAR CEPHALOMETRIC MEASUREMENTS TRACING ON MANUAL AND DIGITIZED LATERAL CEPHALOGRAM

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ABSTRACT

Digital Cephalometry needs to be as accurate as conventional cephalometry in order to be taken as a standard of care in contemporary orthodontics. Objective of this study was to compare the accuracy of linear cephalometric measurements on digitized cephalograms with manual tracing as the gold standard.

Cephalometric analysis of linear measurements was performed on 110 cephalometric radiographs manually & digitally with a computer software. Paired sample t tests were used for statistical significance ($p<0.05$).

Cephalometric comparisons between original and digital images showed statistically significant differences for S-Go, N-Me and ANS-Me. None of the means of the difference between the two methods exceeded 2mm.

In general, both methods of manual and digital cephalometric analysis are highly reliable. Although the reproducibility of the two methods showed some statistically significant differences, most differences were not clinically significant.

Key words: *Cephalometry; Cephalometric Analysis; Digital Cephalometry*

This article may be cited as: Hassan N, Mushtaq N, Adnan M, Shamal S, Umer M. Comparison between linear cephalometric measurements tracing on manual and digitized lateral cephalogram. Pak Oral Dent J 2019; 39(4):325-329.

INTRODUCTION

Malocclusion is a developmental condition. The frequency of malocclusion in US population is 65%. Cephalometric radiography is considered to be part of "gold standard" for diagnosis of malocclusion at the start of treatment.[1] Cephalometric radiography holds an important place in the diagnosis and treatment of dental malocclusions and underlying skeletal discrepancies. Cephalometric radiographs provide the means to study and predict growth, orthodontic treatment progress and surgical outcome of dentofacial deformity treatment.[2]

Conventionally, lateral cephalograms have been analyzed by tracing radiographic landmarks and anatomical planes on acetate papers and studying their relationship to each other by different angular and linear measurements.[3] Despite its extensive use the technique is time consuming and has the drawback of being subject to random and systemic errors.[2,4]

With the progress in computer technology, digital tracing has become possible. It can be achieved by transferring the overlay paper tracing to digitizers, direct digitization with photo-stimulatable phosphor plates and capturing of the radiographic image followed by on-screen digitization using computer software.[5] These digitized records are gaining popularity as orthodontics is progressing towards paperless system of patient management.[6] Digital radiographic systems offer various advantages over conventional tracing; measurements can be done quickly, treatment plans can be determined easily, images are easy to save and communication is speeded up between the providers.

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Received for Publication: June 14, 2019
Revised: Nov 2, 2019
Approved: Nov 4, 2019

In addition, quicker superimposition and cost-effective copying of radiographs are possible.[7,8] However, a few disadvantages are also associated such as difficulty in landmarks identification linked to 2D image of 3D structure, superimposition of bilateral structures and the requirement of a digital cephalometric machine as well as a software program. Also, the quality of digital images is altered by their resolution, pixel size, shades of grey (bit) and compression format.[2]

In clinical orthodontics, the efficacy of both commercially available cephalometric tracing software programs and conventionally used cephalometric analysis need to be assessed to allow the clinician to select suitable software and means of analysis.[9]

Although studies have been carried out on the accuracy of digital tracing programs but the results are somewhat contradictory.[10] Research has been conducted on different aspects of cephalometric radiography in Pakistan but few have focused on digital cephalometry and digital cephalometric analysis.[5] Recently digital Cephalometry and cephalometric analysis software has been introduced for the first time in Khyber pukhtunkhwa.

The rationale of the study is that if scanned cephalograms are found to be as accurate as the manually traced cephalograms it will save the time of clinician as the process is quicker and easier, digital storage and archiving will be made easy, the digital image can be displayed on the computer screen and can be magnified, and zoomed for easier and clearer viewing; the image can be communicated over internet without any loss of quality and digital radiographs would be saved avoiding damage to the x-ray films.

MATERIAL AND METHOD

This Cross-sectional correlation study was carried out in the Orthodontic department of Khyber College of dentistry, Peshawar.110 cephalometric radiographs were taken through non-probability consecutive sampling technique. Reasonably clear and good contrast lateral cephalograms of patient's age 18-38 years having permanent teeth were included in the study. Cephalograms with unerupted/missing teeth, evidence of craniofacial syndromes/anomalies or history of trauma that would interfere with locating anatomic points was excluded from the study.

All the lateral cephalograms were taken by the same operator using the same machine (model no 9000c). Participants were positioned in the cephalostat with the sagittal plane at a right angle to the path of the x-rays, the Frankfort plane parallel to the floor, the teeth in centric occlusion and the lips sealed lightly together.

All the radiographs were first traced manually on acetate paper. Tracings were carried out with a lead pencil in a dark room on an illuminator. Landmarks for linear measurements were identified (table 1). Measurements were taken with the help of a standard ruler. The on-screen radiographs were transferred directly to TrophyDicom software and landmarks were identified to get digital tracing. Data was entered and analyzed using SPSS version 19.0. Pearson correlation coefficient test was applied to see relationship between variables on both manual & digital tracings (S-N, S-Go, N-Me, ANS-Me). Keeping P value less than $\leq$ 0.05 will be significant.

RESULTS

The study group consisted of 110 subjects with chronological age range of 18 to 38 years, out of which 44 (40.0%) were males and 66 (60.6%) were females, making it the predominant gender. Gender wise distribution of the study is given in figure 18. Mean age calculated for the overall sample was 23.43 ±3.688. Most of the study participants 71 (64.5%) were in age group 18-24years. thirty-five (31.8%) patients were in age group 25-31 years. And only 4 (3.6%) patients age group was 32-38 years.

Descriptive statistics for variables between Manual & digital linear cephalometric analysis are given in table 2. The result showed that patients scored higher on digital than Manual analysis. The Mean difference for S-Go, S-N, N-ANS & ANS-Me is 1.0918mm, 0.8127mm, 1.1555mm & 1.1664mm respectively.

The data was subjected to paired student t test with p value set at 0.05. Statistically significant differences were found for all linear variables. These results indicate that the mean of manual tracing is statistically different from the mean of digital tracing for variables. The difference was highly significant for N-ANS & ANS-Me ($p<0.000$) (table 3).

Table 4 shows correlation between Manual and digital linear cephalometric variables. There is positive correlation between manual and digital measurements

TABLE 1: LANDMARKS & CEPHALOMETRIC VARIABLES USED IN THE STUDY AND DEFINITIONS

SN (mm)	Distance between points Sella & Nasion
S-Go(mm)	Distance between points Sella & Gonion
N-Me(mm)	Distance between points Nasion & Menton
A N S - Me(mm)	Distance between points Anetrior nasal spine & Menton

TABLE 2: DESCRIPTIVE STATISTICS DIFFERENCE FOR SGO (MANUAL AND DIGITAL) N=110

Process	Mean	Sample Size (N)	Std. Deviation	Std. Error Mean/ Mean Difference
SGo Manual	67.6182	110	7.28324	1.0918
SGo Digital	68.7100	110	7.45344	0.71066
SN Manual	64.0273	110	5.50806	.52517
SN Digital	64.8400	110	5.63311	.53710
NANS Manual	45.7909	110	4.38742	0.41832
NANS Digital	46.9464	110	4.38956	0.41853
ANSMe Manual	59.6545	110	7.12720	0.67955
ANSMe Digital	60.8209	110	7.46728	0.71198

TABLE 3: COMPARISON OF VARIABLES BY TWO PROCESSES (MANUAL AND DIGITAL)

Process	Paired Differences					T	Df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
SGoManual – SGoDigital	1.09182	1.52437	0.14534	- 1.37988	0.80375	7.512	109	< 0.005
SN Manual – SN Digital	-0.81273	1.33939	.12771	-1.06584	-0.55962	6.364	109	< 0.005
NANS Manual – NANS Digital	1.15545	1.83015	0.17450	- 1.50130	-0.8096	6.622	109	0.000
ANSMe Manual – ANSMe Digital	-1.16636	1.76548	0.16833	- 1.49999	-0.83273	- 6.929	109	0.000

Paired t test**

TABLE 4: RELATIONSHIP BETWEEN SGO MANUAL AND SGO DIGITAL USING PEARSON CORRELATION (N=110)

Process	Sample Size (N)	Correlation	Sig
SGo Manual and SGo Digital	110	0.979	< 0.005
SN Manual &SN Digital	110	.971	< 0.000
NANS Manual and NANS Digital	110	0.913	< 0.005
ANSMe Manual and ANSMe Digital	110	0.972	0.000

with r value 0.979, 0.971, 0.913 & 0.972 for S-Go,S-N,N-ANS,ANS-Me. The result shows highly statistically significant difference ($p<0.005$).

DISCUSSION

Cephalometric analysis has been considered as an important aid both in day to day clinical practice as well as research necessitating the accuracy in data obtained from cephalometric analysis. With the technological advancement, a number of commercially available computerized cephalometric analysis softwares have been developed which claim to be accurate and user-friendly.

The manual method is not only time-consuming but also allows more measurement errors caused by doctors. The reproducibility of cephalometric points in conventional method on paper in comparison to the analysis of digital image was controversial for a long time. The complicated process to obtain a digital record of X-ray, loss of data during digitization resulting in reduced quality of the image or complicated and not sufficiently tested software analysis disputable in the past. Nowadays due to the technology advancement and necessity of data

mobility the manual method is becoming a handicap. 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.[11,12] Trophydicom is an indigenous 2D computerized cephalometric analysis software introduced, keeping in mind the need of patients. However, no study has been done so far to evaluate the reliability and accuracy of cephalometric measurements obtained from Trophydicom.

The purpose of this investigation was to determine correlation between linear cephalometric measurements on manual and digitized lateral cephalograms with the help of computer software. As digitization of cephalograms involve many steps such as the hardware, software, computer functions and settings, the likelihood of image distortion is increased. Further distortion can be expected if the storage format of the digital image is to be changed e.g. from TIFF to JPEG format, as it can involve compression and alteration of the image. Similarly, if an attempt is made to have a hard copy print of the digital image, involvement of a peripheral printing device is another potential distortion source. All of these factors need to be considered when assessing the distortion of a digital image.[7,13-18]

The present study showed strong correlation between digital and manual tracing with r= >0.7 for all linear measurements, which means digital method has acceptable clinical reproducibility which was in agreement with the study carried out by Farooq MU et all.[19] The relationship was most significant for S-N and ANS-Me lengths (p= <0.00). P value for S-Go and N-ANS also showed significant relationship (p=<0.005). Highly significant correlations were also found for all measurements in a study by Shaheed S et al.[3] In this study, the analysis of the results obtained when comparing the cephalometric measurements taken in digital and manual tracings revealed values that showed statistically significant difference but clinically unacceptable. These findings support those of AlBarakati[2] et al, Chen et al[16], Bruntz et al[17] and Tanwani, et al.[20]

In the present study, overall a high level of reproducibility was found for all measurements. This finding is in line with the results of Celik et al. Celik et al evaluated the accuracy and reliability of angular and linear cephalometric measurements using a computerized method of direct digital radiographs. This was then compared with the measurements obtained with a computerized method that uses a digitizing pad and hand tracing of printout radiograph. He found cephalometric analysis was highly reproducible for all three of the methods studied.[7] Similar results were found by Baumrind and Frantz, [21,22] Sayinsu et al[13] and Kublashvili et al[23]. Other authors have found greater errors in landmark reproducibility with digital tracing than with manual tracing, but because the magnitude of differences in duplicate measurements were small with both methods, the main conclusions were that the differences were clinically significant.[24]

In the current study mean values for all measurements were better with digital analysis than with manual analysis (table 2). This is in contrast with the findings of a study carried out by Pellicer et al at University of Madrid, Spain. Pellicer et al assessed the variability and reproducibility of a series of preselected cephalometric angular measurements using manual tracing and digitized tracing. In his study he found manual tracing as a more reliable method (an average of 0.90 in intra method correlation) than digital tracing (with an average intra method correlation of 0.81) by showing a higher value. However, he concluded that the superior results achieved using manual tracing compared to digital can be explained by the fact it is the method taught to young orthodontists at university. At the same time, it is the most natural method for them given that drawing is a skill learned from infancy and is conducted on paper with direct visualization using pencil, just like manual tracing. It is therefore not surprising that manual tracing provides superior values when studied in individuals who were raised developing these skills.[25]

CONCLUSION

The following conclusions were drawn from the study:

1. All the measurements showed clinically acceptable reproducibility in the digital method (r>0.7 – strong correlation).
2. Although small discrepancies were found between the hand-tracing and computerized measurements, the differences were minimal and clinically acceptable.
3. Therefore, it can be concluded that the user-friendly and time-saving characteristics of computerized tracing of direct digital images makes this method inherently preferable to hand tracing for cephalometric analysis of radiographs used in diagnosis, treatment planning, and the evaluation of treatment outcome.

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