IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 16, Issue 9 Ver. IX (September. 2017), PP 71-76
www.iosrjournals.org

"Evaluation of the Accuracy of Measurements Using Digital Versus Manual Tracing Method In Orthognathic Patients" -A Cephalometric Study

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Abstract: ***Aim:*** *The aim of this study was to compare pre and post cephalometric measurements in orthognathic patients acquired with digital tracing software (Dolphin 11.0) with equivalent hand traced measurements in regard to the Reproducibility of each method, Accuracy of various soft/hard tissue landmarks, Accuracy of linear measurements, Accuracy of angular measurements. Materials & Methods: The study consisted of 40 lateral cephalometric radiographs of patients treated by orthognathic surgery. Forty cephalograms were traced both manually and digitally by a single examiner. Three analysis namely Steiner's, Holdaway and Cephalometrics for Orthognathic surgery (COGS) analysis were assessed. The values were analysed using the Leven's Test. Results: The results showed no statistical significance in measurements using Steiner's and COGS analysis but significance was seen in Soft tissue facial angle(0.024) and Sub-nasale to H-line (0.055) P value: <0.05 in Holdaway analysis. Conclusion: Conventional and computerized methods showed consistency in all angular and linear measurements. The computer program Dolphin Imaging 11.0 can be used as a reliable aid in diagnosis, planning, monitoring and evaluating orthodontic treatment both in clinical and research settings.*

Keywords: *Cephalometric tracing, manual method, digital method, orthognathic patients*

Date of Submission: 18-09-2017 Date of acceptance: 25-09-2017

I. Introduction

Cephalometric tracings can be performed by manual and computerized methods. The manual method was the only method used for obtaining cephalometric tracings for a long time until the digital interpretation revolutionized the diagnostic field. The main drawback of the manual method was that it involved considerable time for tracing particularly for orthodontists[1].The ever evolving technology in the computing scenario combined with scientific advances in dental radiology resulted in the innovations of computer programs designed to perform cephalometric tracings and measurements. The constant refinement in both software and hardware has made it essential for professionals to constantly upgrade their knowledge.

Cephalometric data is a valuable tool in diagnosis and also to evaluate the pre and post surgical changes in orthognathic surgery patients. Maxillofacial surgeons often find manual tracing method more tedious and prefer to use the digital version. Hence, both the orthodontist and maxillofacial surgeon need to be oriented to the digital method of acquiring data so that they can synchronize the treatment planning. Owing to the increasing awareness and the convenience in usage of this module, this study intends to assess and compare the accuracy of cephalograms by manual methods and digital imaging.

The aim of this study was to compare pre and post cephalometric measurements in orthognathic patients acquired using a digital tracing software with equivalent hand traced measurements in regard to the reproducibility of each method, accuracy of various soft/hard tissue landmarks, accuracy of linear measurements and accuracy of angular measurements.

II. Subject And Methods

In orthognathic patients the skeletal discrepancies between the pre and post cephalograms reflect more in magnitude which mirrored on the soft tissue parameters hence, it was convenient to compare the manual with the digital data. The sample consisted of forty patients consisting of 31 males and 9 females who underwent orthognathic surgery in our institute. The selection criteria of patients considered were as follows:

Age group between 18 to 30 years.

Severe skeletal malocclusion requiring orthognathic treatment approach.

Patients presenting good oral hygiene and absence of any chronic debilitating diseases or loss of periodontal support.

The patients were subjected to cephalometric radiographs using Planmeca ProMax digital unit. The radiographs were taken under standardized protocol.

An observer manually plotted 26 landmarks using a 0.5 mm mechanical graphite pencil on a 0.003inch matte acetate tracing paper.

Manual tracing and digital tracing were numbered and denoted as,

M=Manual(M I , M2, M3, M4…….. M40)

D = Digital (D l , D2, D3, D4…… D40)

To reduce the error introduced by operator fatigue, there was an intervening time interval of at least two days between each manual and digital tracing session. All manual tracing and digital tracing landmark identification sessions took place without disruption for as long as each observer needed to complete identification for each landmark.

All the measurements on each digital radiograph were carried out by the principal investigator. To avoid any error, measurement of each landmark was carried out three times by the principal investigator. A mean average of these three reading was the input in final data.

The cephalometric analysis used for evaluation was Steiner's, Holdaway and COGS.

Dolphin Imaging 11.0 software was used to perform the analysis. The investigator was made to trace two sequential tracings and the average of the readings was taken for the study. Subsequently these values were treated statistically.

The values were analysed using Levene's Test

III. Results

The pre and post cephalograms were assessed, both manually and digitally and the numerical data which denoted the changes were tabulated. The values obtained using the three cephalometric analysis both manually and digitally were compared and analyzed statistically by Levene's test.

The results showed no statistical significance with regard to Steiner's and COGS analysis. Statistical significance was seen in Holdaway analysis with regard to soft tissue landmarks namely soft tissue facial angle (P=.024) and subnasale to H line (P=.055)

IV. Discussion

Cephalometric landmark measurements have a potential to be affected by several sources of error and this could vary to a great extent. As the measurements include geometric calculations, precise identification of landmarks is necessary. Studies carried out by Perilloet al[2], Broch et al[3], Major et al[4,5] and Cohenet al[6] has shown that the identification of cephalometric landmarks had increased incidence of error due to individual anatomical variation of points. Among the factors contributing to the errors in identification of landmarks, Bjork and Solow[7] stated that the observer experience landmark definition, and the density and sharpness of the image were of substantial significance.

With the introduction of computer programs and digitizers, the field of digital radiography has revolutionized clinical and research practice in the field of cephalometry. A good quality radiograph assists in precise identification and accurate measurement of the landmarks, thus serving as a valuable diagnostic tool in orthodontics asserted by Baurmind[8], Kaomen[9] and Stabrun[10].

Visual identification was itself considered an error. Several authors have investigated the difficulty in landmark identification in studies that compared cephalograms traced from two consecutive methods obtained from the same patient by computerized and manual methods[11 12 13.] They concluded that computerized identification of landmarks reduced the probability for identification error considerably. Yet, the cost efficient manual tracing of landmarks remained the gold standard and is practiced worldwide.

The focus of interest in this study was therefore to compare the accuracy of lateral cephalograms taken for orthognathic patients traced manually and digitally with the Dolphin imaging 11.0 software.Landmark

identification is greatly affected by operator experience, which might be as critical as the tracing method. Because inter-operator error has in general been found to be greater than intra-operator error (Sayinsu*et al.*, 2007)[14], all measurements in this study were carried out by one examiner to minimize error.

Other authors have also found greater errors in landmark reproducibility with digital tracing than with manual tracing. The magnitude of differences on duplicating the measurements was negligible with both methods. The differences were clinically significant (Cooke and Wei, 1991[15]; Chen *et al.*, 2000[12]; Loh*et al.*, 2001[16]; Gossett *et al.*, 2005[17]; Santoro *et al.*, 2006)[18]. Greater error with the digital technique can result from poor quality analogue cephalometric radiographs that often appear even poorer on screen. Other possible explanations for greater errors obtained with the digital method could be: using digital photographs with unknown format and lower quality parameters unknown grey shades (Macrì[19] and Wenzel, 1993[20]), or unknown parameters.

The direct digital cephalogram could totally eliminate the need for scanning the traditional radiographic film which not only required an additional time-consuming step but also could introduce magnification errors.
In this study, the results obtained when comparing the angular and linear cephalometric measurements taken utilizing digital and manual methods revealed values that were very close to the mean and standard deviation, reflecting a non significant p value for all parameters. These findings support those of Chen[12] ,Mariane et al[21.]

Some researches show a significant difference in measurements involving maxillary incisors, mandibular incisors, or both. Brangeli et al and Martins et al argued that dental structures are difficult to locate and measurements of such structures have low reliability in both methods (manual and digital). In our study, the significance was found in Y-axis also in incisor-related angular measurements hence, can be considered reliable in the evaluation methods.

The location of the soft tissue landmarks are more challenging in digital method due to the presence of gray shades that merge in this region. Even when software features such as filtering and zooming, the task of locating these points is even more difficult than in X-ray films[21]. Forsyth et al. in 1996 stated that errors in the identification of points, angular and linear measurements often occurs more in digital images than in conventional radiography.

On the other hand, according Chen et al[12] the computerized method is reliable as it exhibits lower error variance than the conventional method. No significant differences were found in this study. Assessment of the linear values obtained in digital and manual tracings showed no significant statistical significances. Significance was observed in the Soft Tissue Facial Angle and H-Line angle. Thus, the landmarks tend to be less reliable when it involves soft tissue points, which is similar to Nimkam[22] and Julia Naoumova Rolf Lindman (2009)[23]. Collins et al [24.]

This study found that the digital method to be reliable compared to manual method when applied in orthognathic treatment planning. This was in concordance with most studies[23] [21] which compared different cephalometric tracing methods and programs and indicated its use in orthodontic practice.

V. Summary And Conclusion

Digital method was as reliable as the manual method when used for orthognathic treatment planning
Steiner's and COGS analysis showed no statistical significance when assessed manually and digitally as they were pertaining to skeletal parameters.
Statistical significance was observed in Holdaway analysis with regard to soft tissue parameters.

VI. Tables

Table: 1 Steiner's analysis

Cephalometric Measurement	No. of Patients	P - Value
SNA	40	.963
SNB	40	.374
ANB	40	.619
GOGN to SN	40	.997
OCCL. PL. TO SN	40	.956
PP – SN pre	40	.780
U1 – NA (mm)	40	*.064*
U1 – NA (angle)	40	.794
L1 – NB (mm)	40	*. 060*
L1 – NB (angle)	40	.983
Inter Incisal Angle	40	.958
U1 – SN	40	.870

Significant P value:< 0.05

Table: 2 Hold away Analysis

Cephalometric Measurement	No. of Patients	P - Value
Covexity	40	.989
Lower lip – H Line	40	.695
Soft Tissue Facial Angle	40	.024
Subnasale - H Line	40	*.055*
Upper Lip Thickness	40	.528
Upper Lip Thickness at Verm Border	40	.717
H angle	40	.934
Infr Sulcus H Line	40	.767
Chin Thickness	40	.320
Nasale Prominence	40	.565

Significant P value:< 0.05

Table: 3 Cogs Analysis

Cephalometric Measureme		No. of Patients	P – Value
Cranial Base	Ar. Ptm (\\HP)	40	.778
	Ptm. N (\\HP)	40	.591
Horizontal (Skeletal)	N.A.Pg (Ang)	40	.905
	N.A (\\HP)	40	.847
	N.B (\\HP)	40	.921
	N.Pg (\\HP)	40	.820
Vertical (Skeletal & Dental)	N.ANS (T HP)	40	.707
	ANS.GN (T HP)	40	.802
	PNS-N (T HP)	40	.990
	MP - HP (Ang)	40	.522
	1. NF (TNF)	40	.884
	1. MP (TMP)	40	.666
	6. NF (TNF)	40	.822
	6. MP (TMP)	40	.914
Maxilla & Mandible	PNS - ANS (\\HP)	40	.863
	Ar.Go (lin)	40	.876
	Go-Pg (lin)	40	.946
	B. Pg (\\MP)	40	.943
	Ar.Go-Gn (Ang)	40	.866
Dental	1. NF (Ang)	40	.926
	1. MP (Ang)	40	.414

Significant P value:< 0.05

FIGURES

Fig. 1 – Digital radiographic machine

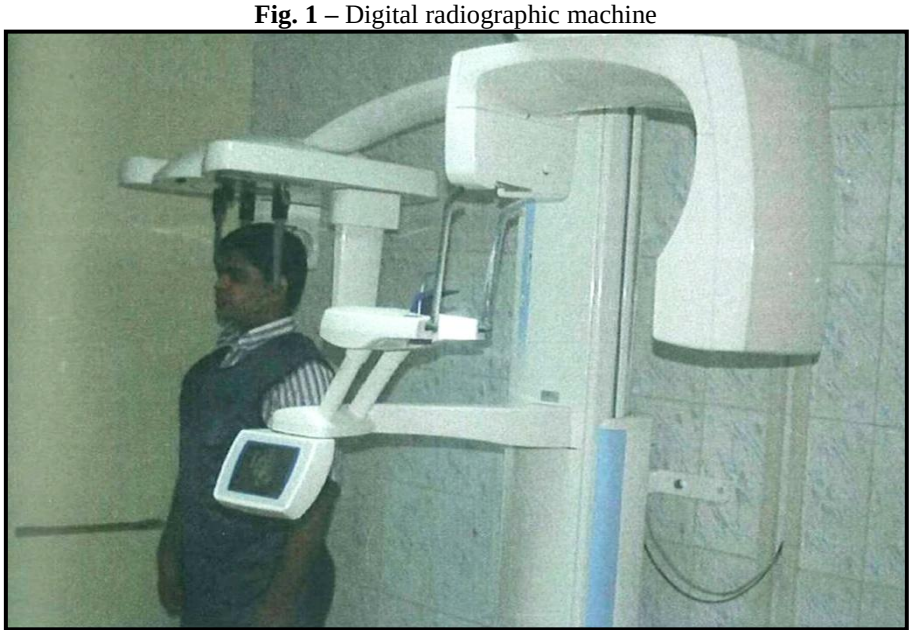

Fig. 2 – Digital radiograph- KODAK Imaging Printer

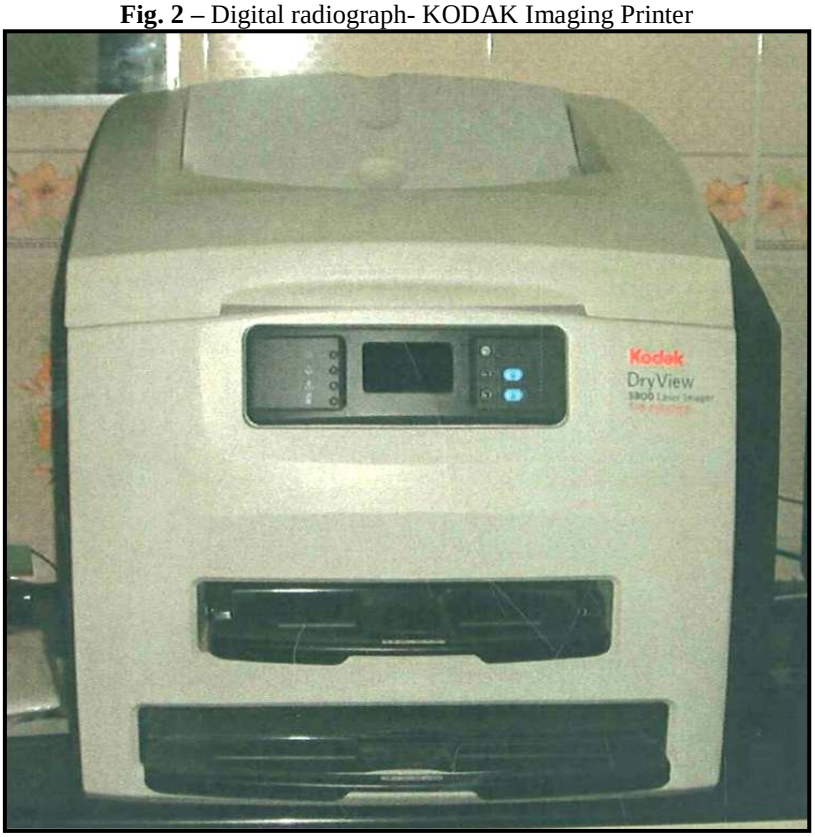

Fig. 3 – Manual tracing

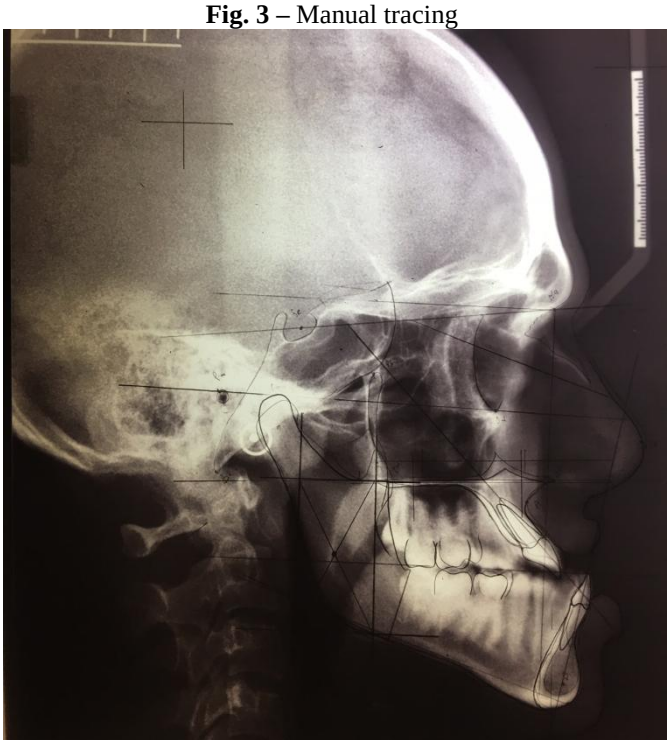

Fig.4 – Digital tracing

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