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RESEARCH ARTICLE

A Comparative Study of Reliability and Accuracy of Manual and Digital Lateral Cephalometric Tracing

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ABSTRACT

Objective: The aim of this study was to assess the reliability and accuracy of several types of lateral cephalometric attributes commonly used: Angular measurements, linear measurements, and ratio when using digital cephalometric software (Nemoceph) with manual tracing method.

Materials and methods: Sample size consisted of 26 lateral cephalometric radiographs. All cephalograms were subjected to both manual and digital cephalometric analysis by the same examiner. Digital analyses were performed on Nemotec digital imaging software. Cephalograms were assessed for a total of 17 cephalometric attributes. The results were assessed using Student's t-test.

Results: Six out of 17 measurements, i.e., sella, nasion, B point, ANB, incisor mandibular plane angle, mandibular plane angle, L1-NB, and Jarabak ratio, showed statistically significant difference between the manual and digital methods.

Conclusion: Digital measurements obtained with Nemotec digital imaging software were found to be comparable to the manual method for most of the variables used in clinical practice.

Keywords: Cephalometric measurements, Cephalometric tracing, Digital imaging.

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INTRODUCTION

The assessment of craniofacial structures forms an integral part of orthodontic diagnosis. In 1931, orthodontics ushered in the age of radiographic cephalometry by the historical work of Broadbent[1] in the United States and Hofrath in Germany, who simultaneously developed techniques for obtaining standardized radiographs of the head. Cephalometric radiography is a valuable tool in diagnosis, prognosis, treatment planning, and evaluation, as well as in studies on the growth and development of the dental and craniofacial complex.[2]

Cephalometric analysis can be performed on cephalograms by a manual approach or a computer-aided approach.[3] Cephalometric analysis performed manually using a tracing sheet is the oldest and the most widely used method. Radiographic film is quite stable and can retain its information for many years but it is not always a dependable archive medium due to its physical nature. Film deterioration has been the major source of information loss in craniofacial biology.[4]

Computerized cephalometric analysis involves direct digitization of the lateral skull radiograph using a digitizer linked to a computer, and then locating landmarks on the monitor.[5-7] The computer software then completes the cephalometric analysis by automatically measuring distances and angles. Computerized or computer-aided cephalometric analysis eliminates the mechanical errors when drawing lines between landmarks as well as those made when measuring with a protractor.

Computerized cephalometric analysis may use either a manual or an automatic identification of landmarks. Automated systems at present are unable to compete with manual identification in terms of accuracy of landmark position. The landmarks lying on the poorly defined structures are difficult to automatically identify.[8] For digital cephalometry to be a better tool in clinical orthodontics, the cephalometric analysis must be comparable and reliable, as it is on a conventional radiographic film.

The aim of this study was to assess the reliability and accuracy of several types of lateral cephalometric attributes commonly used: Angular measurements, linear measurements, and ratio when using digital cephalometric software (Nemoceph, Nemoceph is Software for orthodontics and orthognathic surgery and is manufactured by nemotec (the digital dentistry company)), with manual tracing method.

MATERIALS AND METHODS

Twenty-six pretreatment cephalometric radiographs of adequate diagnostic quality with identifiable craniofacial structures and landmarks were selected for the study. All of these lateral radiographs were obtained from the Radiology Department of MGM Dental College and Hospital and were performed with the patient's head

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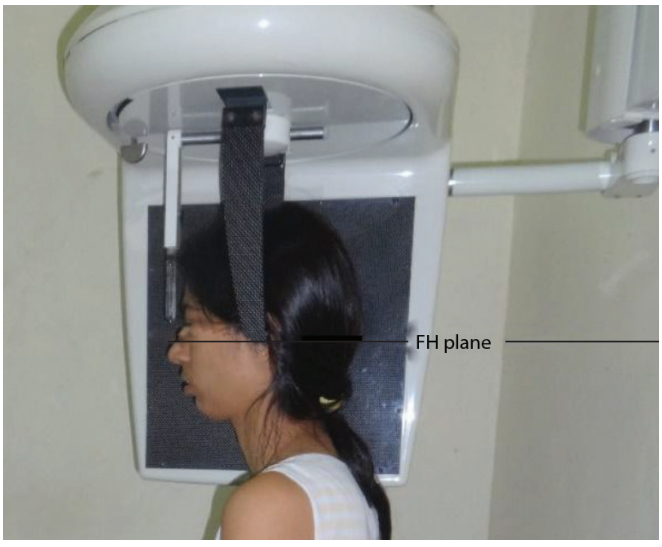

Fig. 1: Orientation of patient in cephalostat

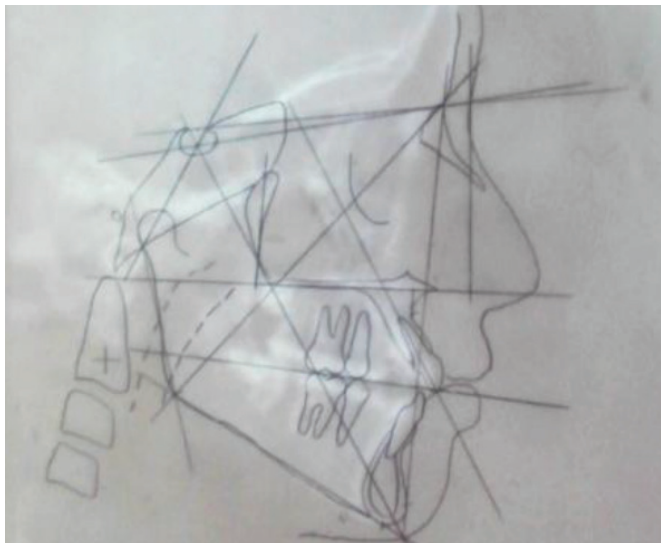

Fig. 2: Manual tracing

immobilized by a cephalostat guided by the Frankfort horizontal plane, parallel to the floor and perpendicular to the mid-sagittal plane (Fig. 1).

Manual Method

Each lateral cephalogram was traced using a 0.3 mm lead pencil on an acetate tracing paper, 0.003″ thick, 8″ wide, and 10″ in length. The tracings were done on a view box with the tracing paper securely positioned over the radiograph. All linear measurements were rounded to nearest 0.5 mm and all angular measurements to nearest 0.5° (Fig. 2).

Digital Method

The digital image of each film was acquired using a digital camera (Sony dscw830) after placing it over the view box. The images were then imported to the Nemotec digital imaging software version 6.0. The images were calibrated using two fixed points common to all cephalograms 10 mm apart. The landmarks were identified manually on the calibrated image and all the measurements were calculated automatically by the software (Fig. 3).

A total of 17 cephalometric measurements were selected for this study in such a way that skeletal, dental, as well as soft tissue parameters could be studied: 10 angular measurements, eight linear measurements, and one ratio.

- The 10 angular measurements selected were sella, nasion, A point (SNA), sella, nasion, B point (SNB), ANB, mandibular plane angle (Go-Gn to SN), basal plane angle, articular angle, U1 to NA, L1 to NB, interincisor angle, and incisor mandibular plane angle (IMPA).
- The eight linear measurements selected were U1 to NA, L1 to NB, anterior cranial base (ACB) length, mandibular length (Go to Pog), L1 to Apog line, Wits analysis, lower lip to S line, and lower lip to E line.
- The ratio used was Jarabak ratio, which is derived as:
  1. Posterior facial height (PFH)
  2. Anterior facial height (AFH).

The measurements obtained from both manual and digital methods were subjected to statistical evaluation.

Statistical Analysis

The measurements derived from manual and digital tracings were compared by using paired samples t-test. A p value of 0.05 was used as the minimal level of statistical significance.

RESULTS

A comparison of angular measurements, linear measurements, and ratio is presented in Table 1.

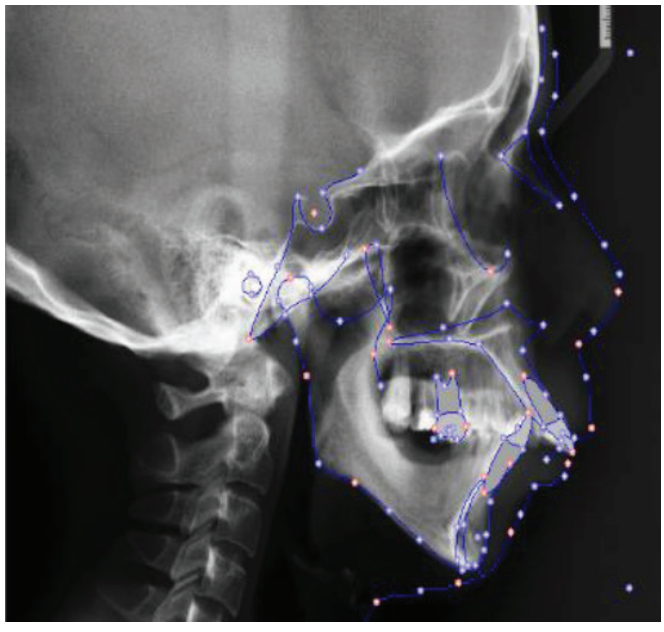

Fig. 3: Digital tracing in Nemoceph

Table 1: Comparison of hard tissue cephalometric measurements obtained by manual and digital methods using Student's t-test

Sl. no.	*Parameter*	*Manual (mean ± SD)*	*Digital (mean ± SD)*	*Difference (mean ± SD)*	*t-value*	*p-value*
Angular measurements						
1	SNA	81.77 ± 4.67	81.84 ± 4.60	–0.07 ± 0.82	–0.457	0.652
2	SNB	78.11 ± 4.51	77.77 ± 4.66	0.34 ± 0.68	2.582	0.016*
3	ANB	3.58 ± 2.91	4.09 ± 2.49	–0.51 ± 0.94	–2.767	0.01*
4	MPA	28.80 ± 6.13	28.17 ± 6.36	0.63 ± 1.47	2.208	0.037*
5	BPA	23.27 ± 4.54	23.21 ± 4.64	0.06 ± 1.57	0.200	0.843
6	IMPA	100.12 ± 9.44	100.77 ± 9.05	–0.65 ± 1.48	–2.270	0.032*
7	U1-NA	34.23 ± 9.78	34.72 ± 9.75	–0.49 ± 1.78	–1.399	0.174
8	L1-NB	29.15 ± 8.34	28.83 ± 8.35	0.32 ± 1.34	1.218	0.235
9	U1-L1	113.31 ± 14.20	112.68 ± 14.08	0.63 ± 1.89	1.687	0.104
Linear measurements						
10	Aa	141.96 ± 4.39	141.45 ± 4.86	0.51 ± 2.61	1.006	0.324
11	Wits	1.04 ± 2.19	1.10 ± 2.42	–0.06 ± 0.45	–0.704	0.488
12	ACBL	63.38 ± 3.52	63.48 ± 4.25	–0.10 ± 1.76	–0.302	0.765
13	MnL	64.96 ± 4.05	64.33 ± 4.21	0.63 ± 2.04	1.586	0.125
14	U1-NA	7.65 ± 3.60	7.80 ± 3.34	–0.15 ± 0.85	–0.905	0.374
15	L1-NB	5.77 ± 2.47	6.15 ± 2.34	–0.38 ± 0.84	–0.385	0.027*
16	L1-Ap	3.35 ± 2.08	3.12 ± 2.07	0.23 ± 0.68	1.728	0.096
17	Ll-Sl	1.85 ± 2.57	1.75 ± 2.64	0.10 ± 0.45	1.125	0.271
18	L-El	1.37 ± 2.53	1.22 ± 2.57	0.15 ± 0.47	1.636	0.114
Ratio						
19	JR	66.99 ± 5.19	68.10 ± 5.67	–1.11 ± 1.15	–4.892	< 0.0005**

*p < 0.05: significant, **p < 0.001: highly significant

Angular Measurements

Among the 10 angular measurements that were selected, SNA, basal plane angle, articular angle, U1 to NA, and L1 to NB did not show any statistically significant difference between manual and digital methods. However, SNB, ANB, mandibular plane angle, and IMPA showed statistically significant differences in the two methods ($p > 0.05$).

Linear Measurements

Among the eight linear measurements that were selected in this study, U1 to NA, ACB length, mandibular length, L1 to A-Pog line, Wits analysis, lower lip to S line, and lower lip to E line did not show statistically significant difference between manual and digital methods. However, one linear measurement, L1 to NB, showed statistically significant difference in the two methods ($p > 0.05$).

Ratio

It was observed that Jarabak ratio showed a statistically significant difference between manual and digital methods.

DISCUSSION

Cephalometrics includes measurement, description, and appraisal of dentofacial growth and changes in skull by measuring certain planes, lines, and angles between anthropometric landmarks and points specified by orthodontics.

In this study, six out of 17 parameters assessed showed statistically significant difference in manual and digital methods. These six parameters were four angular measurements (SNB, ANB, IMPA, and mandibular plane angle), one linear measurement (L1-NB), and Jarabak ratio. A majority of these measurements depend on landmarks such as gonion, gnathion, porion, orbitale, point A, and point B, which lie on poorly defined outlines or low contrast areas.

Forsyth and Shaw[8] found that errors in the identification of points, angular, and linear measurements tend to occur more often in digital images than in conventional radiography.

Gregston et al[9] in their study on manual and digital tracings have found difficulties in locating certain landmarks Ar, Gn, Me, Go, Or, Po, Pog, Point A, and lower incisor apex. While different reference planes can be considered for locating point Gn and Go in manual tracings, this is not possible with digital tracings. Baumrind and Frantz[5], and Gravely and Benzies[10] have reported difficulties in tracing incisor position and variation of angular measurements related to incisors between the two tracing methods.

In this study, the significant difference obtained in the two tracing methods for Jarabak ratio can be explained by the difficulty in locating Me and Go in digital tracings. According to Chen et al,[11] the difficulties in locating Me point can be caused by difficulty in locating the landmark on a curved anatomical boundary.

Chen et al[11] stated that the measurement differences of less than 2 units (mm or degree) are generally within one standard deviation of norm values in conventional cephalometric analysis. The parameters with measurement variance of more than 2 units would be considered as a clinically significant difference. In this study, however, no parameter showed a measurement variation of more than 2 units. The largest measurement difference was seen in Jarabak ratio and it was noted to be 1.2 units.

Thus, from the results of this study, it can be inferred that manual and digital cephalometric methods for cephalometric analysis can be used with a reasonably good reliability and accuracy. This is in agreement with the study of Schulze et al[12] wherein they found that although statistically significant differences existed between values obtained from manual and digital tracings, they were clinically insignificant.

Hence, it can be said that digital method can be considered sufficiently reliable for use in orthodontics.

Further research is required to evaluate the reliability of measuring growth changes or treatment effects by superimposition of radiographs by digital method.

CONCLUSION

Digital measurements obtained from digital photographs of analog cephalograms were found to be comparable to manual method, as the differences among the measurements undertaken in this study, though statistically significant, were clinically insignificant. Thus, digital radiography can be reliably used with good accuracy for the measurements of most of the parameters used in routine clinical practice.

REFERENCES

1. Broadbent BH. A new x-ray technique and its application to orthodontia. Angle Orthod 1931 Apr;1(2):45-66.
2. Paixao MB, Sobral MC, Vogel CJ, de Araujo TM. Comparative study between manual and digital cephalometric tracing using Dolphin Imaging software with lateral radiographs. Dental Press J Orthod 2010 Nov-Dec;15(6):123-130.
3. Collins J, Shah A, McCarthy C, Sandler J. Comparison of measurements from photographed lateral cephalograms and scanned cephalograms. Am J Orthod Dentofac Orthop 2007 Dec;132(6):830-833.
4. Leonardi R, Giordano D, Maiorana F, Spampinato C. Automatic cephalometric analysis. Angle Orthod 2008 Jan; 78(1):145-151.
5. Baumrind S, Frantz RC. The reliability of head film measurements landmark identification. Am J Orthod 1971 Aug; 60(2):111-127.
6. Richardson A. A comparison of traditional and computerized methods of cephalometric analysis. Eur J Orthod 1981;3(1): 15-20.
7. Turner PJ, Weerakone S. An evaluation of the reproducibility of landmark identification using scanned cephalometric images. J Orthod 2001 Sep;28(3):221-229.
8. Forsyth DB, Shaw WC. Digital imaging of cephalometric radiology: advantages and limitation of digital imaging (Part I). Angle Orthod 1996;66:37-42.
9. Gregston M, Kula T, Hardman P, Glaros A. A comparison of conventional and digital cephalometric methods and cephalometrics analysis software: hard tissue (1). Semin Orthod 2004;10(3):204-211.
10. Gravely JF, Benzies PM. The clinical significance of tracing error in cephalometry. Br J Orthod 1974 Apr;1(3):95-101.
11. Chen YJ, Chen SK, Yao JC, Chang HF. The effects of differences in landmark identification on the cephalometric measurements in traditional versus digitized cephalometry. Angle Orthod 2004 Apr;74(2):155-161.
12. Schulze RK, Gloede MB, Doll GM. Landmark identification on direct digital versus film-based cephalometric radiographs: a human skull study. Am J Orthod Dentofac Orthop 2002 Dec;122(6):635-642.