Hand Tracing Verses Digital Tracing with PACS Method

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ABSTRACT

Introduction: Traditionally, cephalometric analysis has been carried out using a hand-tracing manual method. In imaging, picture archiving and communication systems (PACS) are information management systems used for the capture and measurement of medical and dental radiographs. Although not customized for lateral cephalometry, this study aimed to evaluate the cephalometric measurements made on screen with Nemoceph NX 2006 software using PACS compared with the conventional hand-tracing method.
Material and methods: All the subjects were positioned in the cephalostat with the sagittal plane at right angles to the path of the X-rays and to the Frankfort plane parallel to the floor. That digital cephalogram was sent to printer via Image Dent software to print the hard copy through Laser printer and it is also transferred to the personal computer of Department of Orthodontics and Dentofacial Orthopaedics by PACS (picture archiving and communication systems) method.
Results: In this study the total time taken in manual tracing is 30 min, while digital tracing takes around 35 min. So, Time taken in manual tracing is less than digital tracing that might be because only few parameters has been included in this study. The results showed no statistically significant differences in any of the assessed measurements ($p > 0.05$).
Conclusion: Conventional and computerized methods showed consistency in all angular and linear measurements. The computer program Nemotech dental studio NX 2006 can be used reliably as an aid in diagnosing, planning, monitoring and evaluating orthodontic treatment both in clinical and research settings.

Keywords: Cephalometric Analysis, Hand Tracing, Digital Tracing, PACS method,

INTRODUCTION

With the onset of computer age and nowadays ever changing technological environment, digital imaging system has been gaining popularity over conventional film based radiography. These days it is possible to perform cephalometric tracing both through the use of digitizers and directly on screen displayed digital images.[1]

Cephalometry is an important tool in orthodontic diagnosis, treatment planning, for evaluation of treatment results and prediction of growth. With standardized radiographs, the orientation of various anatomical structures can be studied by means of angular and linear measurements. Hand traced cephalometric analysis on traditional radiographic films has been the gold standard for analyzing a cephalometric radiograph for the past few decades.[2]

Despite its widespread use in orthodontics, the technique is time consuming and has several drawbacks including, high risk of error during hand tracing, landmark identification and measurements.[3] Digitally acquired cephalometric imaging has numerous advantages, including elimination of chemical processing and dark room, reduced radiation exposure, improved landmark identification through image enhancement techniques, faster cephalometric data acquisition, with efficient storage and archiving, that is a step towards a paperless system of maintaining patient's records. The other advantages of digital imaging include the possibility of teleradiology and ability to duplicate radiographs easily at lesser expenses.[4,5]

The original purpose of cephalometrics was for research on growth patterns and the craniofacial complex, but cephalometrics radiographs came to be recognised as valuable tool in evaluating dentofacial proportions and clarifying the anatomic basis of malocclusion. Cephalometric measurements on radiographic images are subject to errors that may be caused due to radiographic projection errors; errors within the measuring system; and errors in landmark identification.[6]

Consequently, many commercially available or customized programs have been developed to conduct cephalometric analyses directly on the screen-displayed digital image. Such applications could substantially reduce the potential errors in the use of digitizing pads and totally eliminate the need of hardcopies of digitally born images for conventional cephalometric analysis.[7,8]

The errors in cephalometric analysis are composed of systematic errors and random errors; the latter involves tracing, landmark identification, and measurements. Computer-aided cephalometric analysis can totally eliminate the mechanical errors in drawing lines between landmarks and in measurements with a protractor. When using computer-assisted software programs for cephalometric analysis, the landmarks are usually digitized first. The software program can then generate the values of cephalometric measurement instantaneously, when the locations of all the required landmarks are entered.[9,10]

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The digital cephalometric images can be integrated with patient's records to establish a computer-based filing system and to take advantage of image processing, storage, and transmission. The accuracy of computer-based tracing software must be established by comparing them to hand tracing on acetate paper, the current gold standard. Although studies showed an improvement in image quality of digital cephalograms after digital enhancement, whether this degree of resolution translates into improved accuracy of outline tracing and landmark identification remains to be evaluated.[11] Hence, the aim of the present study was to evaluate and compare linear and angular measurements between manual tracing and computer aided cephalometric tracing using 'Nemoceph nx' software and to evaluate the time needed to perform the analysis.

MATERIALS AND METHODS

The present study was a prospective study which was conducted among 55 lateral cephalometric radiographs. Cephalostat (VATECH, PAX 400 Ceph Sensors) was used in this study with soft copy of lateral cephalogram (.JPEG format) followed by lateral cephalogram of Konica Minolta, Medical Film Dry (8 inch X 10 inches/ 20.2 X 25.3 cm), matte acetate paper (Libral traders) and X-ray view box Laptop (HP Resolution 1366×786). Nemoceph software (Nemoceph NX 2006; Nemotec, Madrid, Spain) was used in the present study.

Mathematical drawing instruments used were as follows:

- HB pencil (0.5 mm diameter)
- Eraser
- Scale
- Set square
- Divider

The film of sufficient was considered as a quality to permit identification of the landmarks. Patient biting in occlusion and any un-erupted or partially erupted teeth that can hinder landmark identification were included in this study. Developmental abnormality such as cleft palate and cleft lip were not included in the present study. Patients with age below 11 years with arc effect in the lateral cephalogram and conventional lateral cephalogram was also not taken in this study.

Procedure

All subjects were positioned in the cephalostat with the sagittal plane at right angles to the path of the X-rays and the Frankfort plane parallel to the floor. The subjects were asked to place their teeth in centric occlusion. The lateral cephalograms are taken on the digital x- ray machine and a digital cephalograms is achieved on the monitor of PC, which was saved.

In the same way, 55 lateral cephalometric digital radiographs and hard copy of cephalograms were selected from the records of patients who reported for the orthodontics assessment in Department Of Orthodontics and Dentofacial Orthopaedics at Buddha Institute of Dental sciences and Hospital and Research institute, Patna.

Furthermore, that digital cephalogram was sent to printer via Image Dent software to print the hard copy through Laser printer and it was also transferred to the personal computer of Department of Orthodontics and Dentofacial Orthopaedics by PACS (picture archiving and communication systems) method.

Procedure for manual tracing

Hard copy of cephalograms for desired subjects was taken. Matte acetate paper was placed over it and manual tracing was done with pencil, over the x-ray view box. Hard and soft tissues were drawn. Cephalometric analysis was done that consisted of 5 linear and 6 angular measurements with the help of ruler, protector and set squares. One cephalogram was traced in a single day to minimize the error due to examiner fatigue. After taking the linear measurements, the magnification in hard copy of cephalograms was calculated to be 10% in this study which was deducted and final linear measurement was achieved.

Procedure for digital tracing

Soft copy of the same radiograph was collected from personal computer of Department Of Orthodontics and Dentofacial Orthopedics and was used in Nemoceph Nx software in laptop, for tracing and measurement on the same day after manual tracing. At the start of tracing, captured digital cephalogram was calibrated, and then hard tissue landmarks and soft tissue landmarks were illustrated by operator. Then Adjustment of structures and soft tissue was done, for this area of interest was zoomed, brightness and contrast were adjusted, to locate the landmarks precisely and with the help of control points, structures were also adjusted. Then save and continue with treatment plan should were opted, and from tracing measurements column, desired analysis was opted and desired measurements were taken.

Time spent in manual and digital tracing

Time used in manual tracing was calculated from beginning of the tracing to taking measurements. Time used in digital tracing was calculated from adding patient's details in Nemoceph software to opting save and continue option.

Description of the measurements used in the study

SNA: angle between points S, N, and A;

SNB: angled between points S, N, and B;

ANB: angle between points A, N, and B;

LL to E line: lower lip to E line

UFH: linear measurement from N to ANS with the Frankfort plane horizontal

LFH: linear measurement from ANS to Me with the Frankfort plane horizontal

UI: angle between the upper incisor long axis (UI edge to UI root) and the maxillary plane

LI: angle between the lower incisor long axis (LI edge to LI root) and the mandibular plane

II: angle formed the upper incisor long axis and the lower incisor long axis;

MAX: linear measurement from Co to the inferior surface of ANS where it is 2 mm thick

MAND: linear measurement from Co to Gn.

RESULTS

In the present study, table 1 shows the descriptive data for manual method. Mean score of SNA, SNB, ANB, II, MAX, MAND followed by LL, UFH, LFH, U1 AND L1 was found to be 82.89, 78.15, 4.93, 112.4, 81.27, 102.67, 3.29, 47.54, 56.78, 121.25 and 103.006 respectively. With the software method, the mean score of SNA, SNB, ANB, II, MAX, MAND followed by LL, UFH, LFH, I1 AND L1

Parameter	N	Mean	Std. Deviation	Minimum	Maximum	Median
SNA	55	82.89	3.66	76.00	90.50	83.00
SNB	55	78.15	3.72	71.50	85.00	77.25
ANB	55	4.93	2.44	.00	9.50	4.50
II	55	112.4	9.15	96.00	133.00	114.75
MAX	55	81.27	4.73	68.40	90.90	81.00
MAND	55	102.67	4.23	94.50	113.00	101.95
LL	55	3.29	2.29	-.90	10.00	3.32
UFH	55	47.54	2.91	43.20	52.20	46.80
LFH	55	56.78	5.14	46.80	69.40	55.80
U1	55	121.25	7.403	108.00	138.10	120.00
L1	55	103.006	7.209	89.00	117.00	103.20

Table-1: Shows the distribution of data based on the parameters recorded through manual method among the study subjects

Parameter	N	Mean	Std. Deviation	Minimum	Maximum	Median
SNA	55	82.92	3.76	77.20	91.50	82.95
SNB	55	78.35	3.66	70.60	84.90	77.2
ANB	55	4.57	2.43	0.80	9.50	4.15
II	55	113.26	8.97	94.80	135.30	115.75
MAX	55	81.24	4.403	68.20	90.60	81.95
MAND	55	103.46	4.69	94.70	114.30	103.8
LL	55	3.03	2.25	-1.30	9.10	3.15
UFH	55	47.706	2.95	41.90	52.60	46.9
LFH	55	57.31	4.88	47.80	66.20	56.4
U1	55	120.97	7.01	106.50	140.10	120.3
L1	55	102.38	7.53	87.30	118.10	102.00

Table-2: Shows the distribution of data based on the parameters recorded through software method among the study subjects

Parameter	Types of method	N	Mean rank	P value
SNA	Manual	55	30.38	0.95
	Software	55	30.62	
SNB	Manual	55	29.95	0.8
	Software	55	31.05	
ANB	Manual	55	32.23	0.44
	Software	55	28.77	
II	Manual	55	29.87	0.77
	Software	55	31.13	
MAX	Manual	55	30.23	0.9
	Software	55	30.77	
MAND	Manual	55	28.83	0.45
	Software	55	32.17	
LL	Manual	55	31.17	0.76
	Software	55	29.83	
UFH	Manual	55	29.62	0.69
	Software	55	31.38	
LFH	Manual	55	28.92	0.48
	Software	55	32.08	
U1	Manual	55	30.82	0.88
	Software	55	30.18	
L1	Manual	55	31.32	0.71
	Software	55	29.68	

Table-3: Shows the comparison of data based on the parameters recorded through manual and software method among the study subjects was found to be 82.92, 78.35, 4.57, 113.26, 81.24, 103.46, 3.03, 47.706, 57.31, 120.97, 102.97and 102.38 respectively (Table 1 and 2). Table 3 shows the comparison of manual and software method in study variables. It was found that minute differences gave non-significant results.

The result demonstrated that training in cephalometric analysis reduces the time needed for cephalometric hand tracing and landmark identification but not in the process of measurement. Consequently, the computer is a very helpful tool in determining measurements of this kind, because once the landmarks are chosen on the digital images and identified, the data processing can be executed and completed immediately.

DISCUSSION

The major errors in conventional cephalometrics may include projection errors and tracing errors. The most important source of tracing errors is uncertainty in landmark identification, and intra-observer error is generally less than inter-observer error. When we take advantage of digital cephalometrics, it is important to question whether the digital image yields the same level of performance in terms of landmark identification as conventional radiographic film. Digital imaging offers several advantages over conventional radiography including faster processing, easy storage, retrieval and image enhancement.

In previous studies conducted by various authors such as Geelenet, Chen et al, Roden-Johnson et al, Naoumova-Lindman, Polat-Ozsoyet al, the author noted that the differences between electronic and hand-tracing methods for cephalometric measurements were found to be clinically acceptable. However, these electronic methods included customized cephalometric software programs in which landmarks can be placed on operators will and measurements that were made used the tools available in the software program.[12,13,14,15,16]

The quality of a digital image strongly depends on both the number of pixels and the number of gray levels. In this study the manual and electronic method showed the value for II, U1, and L1 to be statistically significantly different between two methods; however, no significant differences were found for any of the other variables. Other authors have noted significant differences for when comparing digital and hand-tracing methods by Polat-Ozsoyet al however, not all studies as seen in the study done by Celik E et al have found this to be the case as it can be seen in this study.[16,17]

The lower incisor is difficult to locate, in particular, lower incisor apex as observed in the studies done by Baumrind et al, Oliver et al., Polat-Ozsoyet al. The difficulty in constructing reference planes when using software programs may explain why variables requiring constructed planes are difficult to record consistently was seen in the study done by Geelenet al.[18,19,16,12]

In this study, the electronic method permit the outlining of structures such as the upper and lower incisor but U1 and L1 is dependent on the accurate depiction of the upper and lower incisor outline and the difficulty in constructing a line through the long axis of incisors may partly account for the significant result.

However, it has been suggested that the digital method allows better visualization of difficult-to-locate landmarks such as incisor apices since the view is not obscured by a sheet of tracing paper or no proper contrast of radiograph as seen in the study done by Sandler et al. Both procedure obtained consistent measurements when using the hand-tracing method compared with the electronic method. In this study experience has been considered an important factor in landmark identification and suggestions have been made that it may be as important as the tracing method itself as observed in the study done by Naoumova and Lindman et al.[20,15]

Hence, direct digital cephalograms, image enhancement by altering brightness and contrast can increase reliability of some landmark identification and this may lead to more accurate cephalometric analysis. The head films used in this study were randomly selected from the patients' files. They were representative of the films that we considered satisfactory for routine clinical use.

The time required for different procedures in traditional cephalometric analysis was measured in this study. The focus of interest was the time needed for making measurements with a ruler and protractor in the traditional manner. The result demonstrated that training in cephalometric analysis reduces the time needed for cephalometric hand tracing and landmark identification but not in the process of measurement. Consequently, the computer is a very helpful tool in determining measurements of this kind, because once the landmarks are chosen on the digital images and identified, the data processing can be executed and completed immediately.

In this study, the total time taken in manual tracing was found to be 30 minutes, while digital tracing takes around 35 minutes. So, time taken in manual tracing was less than digital tracing that might be because only few parameters has been included in this study. Hence, if we compare overall time taken in manual and digital tracing for all the different analysis, defiantly digital procedure produces much more information than manual technique.

CONCLUSION

Cephalometric program (Nemoceph NX 2006 software) can be used reliably as an aid in diagnosis, planning, monitoring and evaluating orthodontic treatment both in clinical and research settings at the expense of less time.

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