Comparing the Accuracy of Manual and Digital Tracing for Airway Evaluation: An Original Research

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Abstract

Background: One of the most commonly used diagnostic tools in Orthodontics is a lateral cephalogram. The study was undertaken to compare the linear measurements of the pharyngeal spaces recorded on a lateral cephalogram manually and digitally. **Materials and Methods:** The study was conducted on pre-treatment lateral cephalograms of 48 patients with the measurements made on the digital lateral cephalogram. The said landmarks using McNamara analysis were identified on the digital lateral cephalogram and the values were calculated and the lateral cephalograms were manually traced upon an A4 size acetate paper. A total of 2 parameters were taken in the study. Microsoft Excel software is used to carry out the statistical analysis of data. Data were analyzed with the help of descriptive statistics, namely, mean and standard deviation, and presented by bar diagrams. **Results:** The results of the study show that there are statistically significant differences between both manual and digital tracing methods ($P < 0.001$). **Conclusion:** Both digital and manually traced angular measurements were accurate and reliable and show a significant difference. Although both were equally accurate and reliable as the amount of time taken to register the landmarks is minor.

Keywords: Airway analysis, Digital lateral cephalogram, Lateral cephalogram, Manual tracings.

Introduction

Respiratory function may play a significant role in the development of the face and occlusion.[1] The pharynx is a tube-shaped structure formed by muscles and membranes. It is located behind the nasal and oral cavities, and larynx and extends from the cranial base to the level of the sixth cervical vertebrae and lower border of cricoid cartilage.[2] The pharyngeal airway is an anatomical space divided into the nasopharynx, oropharynx, and laryngopharynx. The nasopharynx forming the upper part of the respiratory system is situated behind the nasal cavity and above the soft palate. Anteriorly, it is connected with the nasal cavity and posteriorly it continues downward as the oropharynx. The oropharynx opening into the oral cavity by an isthmus extends from the second cervical vertebra to the fourth cervical vertebrae. The laryngopharynx joins the oropharynx at the level of pharyngo-epiglottic fold and the hyoid and then continues to the level of sixth cervical vertebrae[2,3] (Figure 1) The nasopharynx and the oropharynx have significant locations and functions because both of them form part of the unit in which respiration and deglutition are carried out and they include lymphoid tissue in their structures.[4] Etiological factors for nasal obstruction are hypertrophied adenoids and tonsils, chronic and allergic rhinitis, nasal traumas, congenital nasal deformities, foreign bodies, polyps, and tumors.[5,6] Nasal obstruction secondary to hypertrophied inferior turbinates, and hypertrophy of the faucial tonsils can cause chronic mouth breathing, loud snoring, obstructive sleep apnea, excessive daytime sleepiness, and even cor pulmonale.[6,7] Maxillary retrusion, mandibular retrognathism, short mandibular body, and backward and downward rotation of the mandible, may lead to a reduction of the pharyngeal airway passage. Decreased space between the mandible and the cervical vertebrae may lead to changes in posture of the tongue and soft palate posteriorly, may impair respiratory function during the day, and may cause possible nocturnal problems such as snoring, upper airway resistance syndrome, and obstructive sleep apnea.[8] If these postural changes continue for a long period, especially during the active growth stage, dentofacial disorders at different levels of severity occur, together with inadequate lip structure and long face syndrome/adenoidal faces.[9,10] Lateral cephalometry is one of the most radiographic techniques for evaluating the facial

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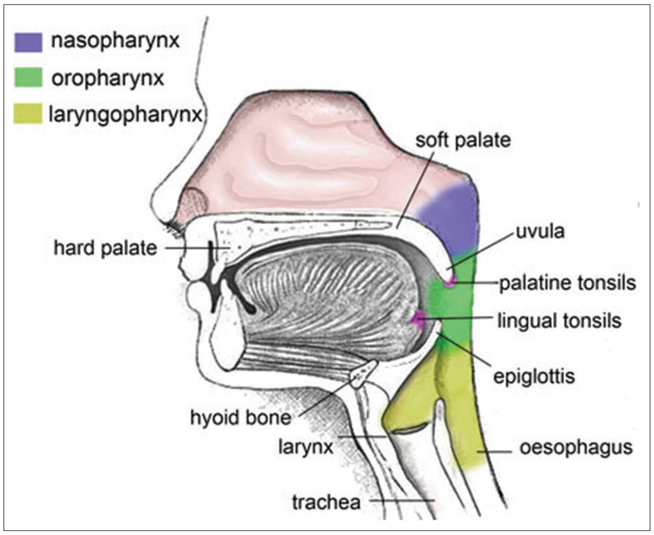


Figure 1: Anatomy of pharynx

characteristics of patients with airway problems. Cephalometric radiographs are considered to be an essential tool in the process of diagnosis, treatment plan, and for the monitoring of the treatment progress. Traditionally, cephalometric images have been analyzed by manually tracing radiographs, which is time-consuming and has the disadvantage of being subjected to random and systematic error. Cephalometric analysis is subjected to error from multiple sources, which include landmark identification, radiographic exposure and development, and technical measurements. Most errors occur in landmark identification, which is based on observer experience, landmark definition, and image density and sharpness.[11,12] The use of digital radiographic systems is gaining in popularity and offers several advantages over conventional cephalograms as measurements can be performed quickly, treatment plans can be determined easily, chemical and associated environmental hazards are eliminated, the images are easy to store, and communication between providers is facilitated. In addition, rapid superimposition of serial radiographs and cost-efficient duplication of radiographs are possible.[13,14] Nemoceph is one such orthodontic and orthognathic online platform that will simplify orthodontic treatment planning. No published data on the accuracy and the reproducibility of cephalometric analysis using this program have been found in the literature. The intended purpose of the present study is to compare the reliability of manual and digitally traced Nemoceph for measuring the nasopharyngeal airway.

Materials and Methods

The present study was conducted on 48 cephalograms in the Department of Orthodontics and Dentofacial Orthopedics at Mallareddy Institute of Dental Sciences, Hyderabad. The study was conducted on pre-treatment lateral cephalograms of 48 patients. No differentiation was made for age or gender. Only good quality radiographs without any artifacts were selected The planes used in this study are (Figure 2).

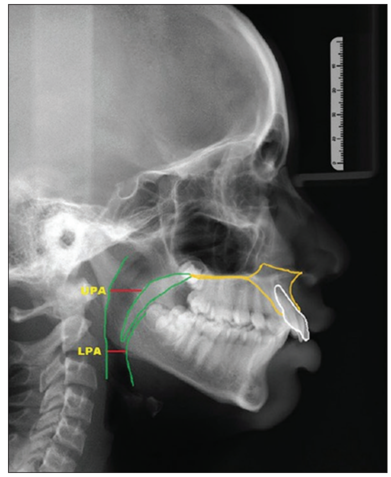


Figure 2: LAT CEPH showing pharyngeal width

Upper pharyngeal width

The upper pharyngeal width is measured from a point on the posterior outline of the soft palate to the closest point on the posterior pharyngeal wall.

Lower pharyngeal width

Lower pharyngeal width is measured from the intersection of the posterior border of the tongue and the inferior border of the mandible to the closest point on the posterior pharyngeal wall.

Methodology

While recording the lateral cephalograms, patients were placed in the standing position with the FH plane parallel to the floor. Subjects were instructed not to move their heads and tongues and not to swallow while cephalogram exposure. All of the cephalograms were recorded with the same exposure parameters and in the same machine. All lateral cephalograms were traced manually on the left side.

Manual hand tracing

A sheet of fine transparent acetate paper of 0.003 inches was taped over the X-ray. The X-ray was secured to the surface of the viewing box. Conventional hand tracing was performed. After landmark identification linear measurements were made and values were obtained from manual tracing using McNamara analysis for both groups of pre-treatment cephalograms.

Digital tracing

Above the same lateral cephalogram images were imported into digital software, which automatically generates measurements after digitizing a set of landmarks manually. All the images were calibrated by digitizing two points on the ruler which is inbuilt in the cephalostat. After digitization, the values were saved. The data obtained were subjected to statistical analysis.

Results

All the measurements were tabulated and assessed. Mean and standard deviation were done to compare the values between manual tracing and digital (Nemoceph) tracing as shown in Tables 1 and 2; Graph 1 for evaluation of the airway. This

Table 1: Mean comparison of upper pharyngeal width

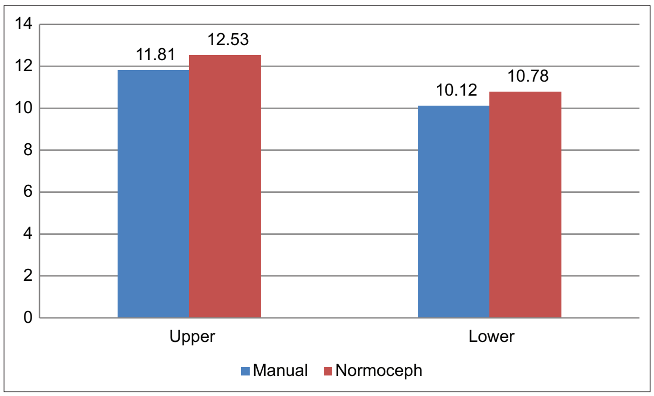
Parameter	*n*	Mean	SD	Test statistic	*P*-value
Manual	48	11.8167	1.87711	−3.660	<0.001*
Nemoceph	48	12.5344	1.81639		

Wilcoxon signed rank test; $P \leq 0.05$ considered statistically significant. SD: Standard deviation

Table 2: Mean comparison of lower pharyngeal width

Parameter	*n*	Mean	SD	Test statistic	*P*-value
Manual	48	10.1292	1.49765	−3.494	<0.001*
Nemoceph	48	10.7875	1.78703		

Wilcoxon signed rank test; $P \leq 0.05$ considered statistically significant. SD: Standard deviation



Graph 1: Mean pharyngeal width comparison within groups according to the type of tracing

indicates that there are statistically significance differences between the both manual and digital tracing methods ($P < 0.05$). Cephalometric data from 48 cephalograms was entered into an Excel sheet. All the data are evaluated within the groups using mean and standard deviation. Table 1 illustrates that there is a significant difference between manual and digital cephalograms in upper pharyngeal width. Table 2 shows that there is a significant difference between manual and digital cephalograms in lower pharyngeal width.

Discussion

Evaluation of the upper and lower airway space is important for diagnosis and treatment planning and to achieve the functional balance and stability of the result after orthodontic or orthognathic treatment.[15-17] According to McNamara, the width of the upper pharyngeal area is determined from the posterior outline of the soft palate to the nearest point on the wall of the posterior pharynx and the width of the lower pharyngeal area is measured from the juncture of the posterior limit of tongue and the lower boundary of the mandible to the nearest area on the wall of posterior pharynx. It has been reported that normal upper pharyngeal airway width is 15–20 mm whereas lower pharyngeal airway width is 11–14 mm.[18,19] In various skeletal types, there can be a narrowing of the anteroposterior dimension of the airway. Other pre-disposing factors may be allergy, environmental irritation, and infection, which can cause narrowing of the airway leads to mouth breathing.[19] Nemoceph is one of the reliability and reproducibility of digital cephalometric software. Nemoceph also provides several advantages such as saving time, reducing the use of paper in the office, easier storage, and retrieval. Hence in our study, we compared the accuracy of cephalometric analysis done using both Nemoceph software and manual tracing to verify the accuracy of the software. According to Chien *et al*., conclude that the accuracy of cephalometric analysis is important for treatment planning so that the clinician can accurately assess various treatment options and provide the patient with a more realistic image of the treatment outcome. Rapid advances in computer science have led to the wide application of computers in cephalometry.[20,21] The focus of interest in the present study is to compare the accuracy of the airway in lateral cephalograms traced manually and with the Nemoceph software using McNamara analysis. The results of the comparison revealed that the values showed statistically significant differences and the reliability and accuracy are good in digital tracing using Nemoceph software compared to manual tracing. Mitra *et al*.[22] compared the cephalometric measurements obtained fromthe computerized tracing of direct digital radiographs using Nemoceph and hand tracing of their digital radiographs and showed statistically significant difference between two techniques, which supports the present study. Tikku *et al*.[23] also found a statistically significant difference in the values when they compared the occlusal plane and also the steiners-line to lower lip line with manual and Nemoceph tracing which shows even the comparison of cephalometric planes showed difference with both techniques. In Mitra *et al*.[22] study where Frankfort mandibular plane angle traced digitally and manually showed a statistically significant difference in their values which clearly states even the cephalometric angles also varied significantly. Hence, the present study is in agreement with all the above studies mentioned and supports the statement of Kabeer *et al*. and Agrawal *et al*.[24-27] who concluded that the digital cephalometric analysis method can be reliably used with good accuracy in routine clinical practice as it includes automated landmark identification, which enhances accuracy and speeds up the tracing process and also reduces human error as compared to the conventional tracing method.

Conclusion

The findings of the study show that there are statistically significant differences between the both manual and digital tracing methods. The user-friendly and time-saving characteristics of computerized tracing make this method inherently preferable to hand-tracing for cephalometric analysis of radiographs used in diagnosis, treatment planning, and the evaluation of treatment outcomes.

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