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Innovative and Affordable Method of Analyzing Lateral Cephalometric Radiographs

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Abstract

Aim: The aim of this study is to establish an easy, accurate and cost-effective semi-digital cephalometric measurement method to aid residents, and orthodontists in diagnosis and treatment planning.

Methods: A retrospective study to compare between software analysis and a manual analysis performed by using the Office Power point software. The lateral cephalometric image was uploaded on Microsoft Office Power Point. Straight lines shape used to create the angles and planes, and then a manual protractor used to read the angles directly from the screen, and then compared them to digital tracing using WebCeph software by the same operator.

Results: PowerPoint is a reliable method in obtaining a correct cephalometric analysis since there was not significant difference between it and the results obtained from the Web Ceph orthodontic online platform.

Conclusion: When it comes to cephalometric tracing and analysis, PowerPoint is a quick, easy to use, cheap, environmentally friendly, and reliable method.

Keywords: lateral cephalometry, manual tracing, digital tracing, lateral cephalometric measurement methods.

Introduction

Lateral Cephalogram is an essential tool for orthodontic practice and research, which provides elaborate information for diagnosis and treatment planning. (1) Traditional cephalometric analysis is performed by tracing radiographic landmarks on acetate overlays and measuring the linear and angular values using a protractor. Despite its widespread use in orthodontics, the technique is time-consuming and has several drawbacks, including a high risk of error during hand tracing, landmark identification, and measurement. (2,3) Recently, third-generation systems have been introduced that transmit digital radiographs directly to a computer database through photo stimulability phosphor plates, charge-coupled device receptors, or direct digital systems. The use of direct digital images offers several advantages, such as instant image acquisition, reduction of radiation dose, facilitated image enhancement and archiving, elimination of technique-sensitive developing processes, and facilitated image sharing. [4,5] Both digital radiography and conversion of conventional analogue film to a digital format require less storage space than conventional cephalometric film. Digital archiving is also a valuable method for overcoming the problem of film deterioration, which has been a major source of information loss in craniofacial biology. [6]

In this present study, we uploaded the lateral cephalometric image on Microsoft Office Power Point and used straight lines shape and read the angles directly from the screen by utilizing a manual protractor, then compared them to digital tracing using WebCeph software by the same operator. This new method is affordable as all laptops/desktops have the Microsoft Office software, which contains the Power Point program. In addition, it will reduce the cost, eliminate tracing on acetate paper and the use of pencils. The method is easy and accurate. It may also be suitable for superimposition.

The aim of this study is to establish an easy, accurate and cost-effective semi-digital cephalometric measurement method to aid residents, and orthodontists for the diagnosis and treatment planning.

Material and method

This is a retrospective study to compare between software analysis and a manual analysis performed by using the Office Power point software.

Sample size calculation

Sample size calculation was based on the outcomes of the paper by Mohammad Khursheed Alam about Cephalometric Evaluation for Bangladeshi Adult by Steiner Analysis And on the formula of sample size calculation.

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$$N = \frac{(Z_{\alpha} + Z_{\beta})^2}{(E/\Delta)^2}$$

Where d is delta/ sd, α is 5% and β = 1- power of the study. Using the information mentioned in the paper and with different scenarios for the power and using level of significant 5% and delta is the difference. Using the delta of SND (1.26) with different scenarios and SE (0.40). 1-β of 90% is found to be 104.

Lateral Cephalograms, like other radiographs, are taken at a specific distance and posture as shown in (Figure 1).

We have used the main cephalometric landmarks (Table 1) to form some linear (Table 2), and angular measurements (Table 3) tracing example shown in (Figure 3) which are used by most of the lateral cephalometric analysis in orthodontics.

Results

One hundred and ten Lateral Cephalograms were obtained from the Oral Radiology department of the College of Dentistry of Ajman University. These radiographs involved all types of malocclusions (Class I, Class II, and Class III). Lateral Cephalograms, regardless the type of malocclusion, were traced and analysed manually using Microsoft PowerPoint 2016 and the results gained were compared to the results attained from WebCeph™; a web based online platform, which analysed the same radiographs. An example of the cephalometric tracing and analysis done using the PowerPoint is seen in Figure 3, while Figure 2 shows the same radiograph traced and analyzed using the Web Ceph.

After evaluating a one hundred and ten samples, regardless their malocclusion, and by using nine angular measurements and three linear measurements for comparison, via two different programs, the study results show no difference between the paired groups. As the mean of the 1st group; the PowerPoint, to the mean of the 2nd group; the WebCeph, for the SNA angle was 81.61±4.22 and 82.77±4.00, respectively. The mean for the Lower AFH Ratio was 56.33±2.53 and 54.68±1.72, respectively. The mean, standard deviation, minimum and maximum of each angular and linear measurement can be retrieved from Table 4.

The intraclass correlation coefficient showed no statistical difference between the two groups. The angular measurements: SNA, SNB, ANB, FH-SN, MMPA, U1/Max Plane, L1/Mand Plane, Interincisal Angle, and L1 to A-Po Line, showed a P-value of 0.854, 0.943, 0.833, 0.689, 0.797, 0.826, 0.744, 0.789, and 0.546, respectively. Similarly, the linear measurements; Wits Appraisal, Lower AFH Ratio, and Lower Lip to E-Line, revealed a P-value of 0.483, 0.518, and 0.753, respectively. (Table 5)

Based on this reliability test we can conclude that the PowerPoint is a reliable method in obtaining a correct cephalometric analysis since there was not significant difference between it and the results obtained from the WebCeph orthodontic online platform.

Discussion

Cephalometric landmarks are set of features in both hard and soft tissue of the skull. Those landmarks measure cephalometric components as angles in degree and distance and/or planes in millimeters to analyse different dental and skeletal anatomical structures. Several analytical methods have been introduced in the literature to aid in conducting a clinical diagnosis from these measurements, such as Down’s analysis, Tweed, Steiner, Björk, McNamara and so many others.[7,9] In this study we used Eastman analysis, which is commonly used by the Royal College of Surgeons. We took nine angular measurements and three linear measurements to make a reliable comparison between the PowerPoint and dental software.

Cephalometric analysis has undergone three stages of development, which are manual stage, computer-aided stage, and computer-automated stage. Broadbent and Hofrath in 1931 have introduced the cephalometric analysis on radiographs. Five steps needed to be done in order to obtain a cephalometric analysis; (i) place a sheet of acetate over cephalometric radiograph; (ii) trace the craniofacial anatomical structures manually; (iii) mark the cephalometric landmarks manually; (iv) using landmark locations, measure the angular and linear parameters; (v) analysis of hard and soft tissues.[10] So in the manual stage, also referred as the traditional method, all what you need is a good printed cephalometric radiograph, acetate paper, sharp pencil, ruler, and a protractor. Unfortunately, this technique is prone to human errors as projection errors during conversion from 3-D to 2-D image, X-ray film errors due to clarity and device resolution, measurements errors due to human eyes limitation, pencil thickness, and unskilful hands.[11] Another drawback of this method is that it is tiresome and time-consuming taking on average of 15-20 minutes from expert orthodontists for each case.[12,13] In addition, storage, transferring, and archiving data may be difficult.[8,9,14,15]

Computerizing cephalometric have been introduced to resolve the above-mentioned issues. In the second stage, the radiograph is digitized, meaning that the first step in traditional cephalometric analysis is no longer needed, the following two steps can be operated by computer, and the measurements can be automatically calculated by a dental software. The drawback of this computer-aided analysis is that its results are not reproducible due to the larger inter- and intra-variability error in landmark annotation and still considered time-consuming. While in the third stage, the computer-automated stage, an image processing algorithm is used to automatically identify the landmarks on the lateral cephalogram, which is the most crucial step.[12] This automatic analysis saves a lot of time for the orthodontist and has high reliability and repeatability. However, fully automated analysis is challenging due to overlying structures and inhomogeneous intensity in the radiographs as well as anatomical differences among patients. [8,9]

Coming to our method; it is a mixture between the traditional (manual) and the computerized cephalometric analysis. It does not require a printed radiograph, acetate sheet, sharp pencil, and others as the radiograph is digitized. The lateral cephalometric radiograph can be transferred directly from the radiology department to the computer and then transferred to the Microsoft PowerPoint where all the other steps can be done there manually, from tracing to marking landmarks to measuring angular and linear parameters using a physical or a digital protractor and a physical or a digital ruler respectively. This technique is relatively faster than the traditional one by saving the time of printing and tracing on acetate sheets, environmentally friendly as the radiograph is digitized, hence eliminating the need of using papers and acetate sheets, more accurate as you can enhance the quality of the radiograph by the correction feature in the PowerPoint (increasing or decreasing contrast and/or saturation and so on) which will enhance the vision of the landmarks. Furthermore, using the advantage of this digital method, you do not need a place to store the cephalometric analysis of patients, you have a better archiving of data, and transferring of data is quick and easy since it is stored in a file in the computer. In addition, you can use it in teaching as you are having it in your presentation, in a conference or a poster, or sharing it with a colleague or having a consultation from another orthodontist.

Tremendous research undertaken to compare the accuracy of digital cephalometric with analogue methods.[16,17] Research have shown that the accuracy of some cephalometric systems is higher compared with the traditional approach, yet some research reported that the manual approach is still more convenient to the orthodontists.[7,18,19]

Paixão et al. in 2010 conducted a study on 50 subjects to compare between manual and automatic process using Dolphin imaging software. The study did not show any significant difference between the two approaches.[20] Another study by Tikku et al. in 2014, where they checked 13 linear and 13 angular measurements on 40 subjects. Only 6 out of 13 measurements were significant.[21] In 2016, Mogeeb et al. conducted a study on 30 patients to compare the manual method with Ceph-X imaging software using 18 parameters; 6 angles and 12 lines. No significant difference between the two groups with Ceph-X obtaining a high accuracy of 96.6% compared to the traditional approach.[7] Similarly seen in our study, where we compared manual landmark identification and analysis on Microsoft PowerPoint (computer-aided) approach with WebCeph imaging software on 110 subjects. The results showed no significant difference between the two groups on all 12 parameters: 9 angles and 3 lines. Proving that the PowerPoint is a reliable method in cephalometric analysis.

Daniel et al. in 2016 used 45 lateral cephalograms to check the reliability of manual tracing to computerized methods (Dolphin and Dentofacial Planner software), the Dentofacial Planner transfers points marked on the manual tracing to the computer using digitizing table, following previously marked points on Ultrathin paper. The Dolphin performs analysis on previously digitized lateral cephalograms. They concluded that the three methods were accurate. Dentofacial Planner shows the highest reliability, followed by the manual tracing, while the Dolphin was the least effective and more likely having problems in identifying landmarks.[22]

Cephalometric analysis on the PowerPoint is (1) free of charge (assuming the one has a desktop/laptop has the Microsoft Office); (2) you can use it for unlimited number of times; (3) relatively faster than the manual approach, takes around 10 minutes to finish one case, however, slower than the computer-automated technique; (4) as accurate as the computer-automated dental software's; (5) easy to use, store and share.

The cost-effectiveness of this approach is very important as when you compare a free of charge method giving you a better quality of cephalometric radiograph than the traditional method and having the same results obtained from an expensive dental imaging software such as the Dolphin, which costs around 10K US dollars. Keeping in mind the poor countries who are seeking knowledge without having the capability to afford these expensive software's.

Conclusion

When it comes to cephalometric tracing and analysis, PowerPoint is a Quick method, easy to use, cheap (affordable), acceptable accuracy, environmentally friendly, and reliable. So, it is good to be used for undergraduate Orthodontic education for anatomic land marking, analysis to replace the old method of digitization through acetate paper and a film.

Recommendation

We do recommend the use of PowerPoint for cephalometric analysis in undergraduate level, private clinics or in any place where people cannot afford buying expensive dental software as the former is a reliable method in measurements, cheap, can be transferred easily, and saves time and effort.

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Legends figures and tables

Table 1. Definition of the Landmarks

The Landmarks	Description
N	Nasion: The most anterior point of the fronto-nasal suture.
S	Sella: The midpoint of the Sella Tursica.
Or	Orbitale: The deepest point on the infra-orbital margin.
Po	Porion: The uppermost, outermost point on the bony external auditory meatus.
A	'A' point: The most posterior point on the premaxilla.
ANS	Anterior Nasal Spine: The tip of the anterior nasal spine.
PNS	Posterior Nasal Spine: The tip of the posterior nasal spine.
B	'B' point: The most posterior point on the symphysis.
Pog	Pogonion: The most anterior point on the bony chin.
Me	Menton: The lower most point on the mandibular symphysis in the midline.
Go	Gonion: The intersection of the line connecting the posterior border of the ramus and the mandibular plane. (Constructive point)

Table 2. Linear Measurements

Linear Measurements	Description
S-N	Sella-Nasion plane. The line through points N and S.
Or-Po	Frankfurt Horizontal Plane. The line through point Or and Po.
ANS-PNS	Maxillary Plane (Nasal Line). The line connecting ANS with PNS.
Occlusal plane	Imaginary plane formed by the occlusal surfaces of the 1st molar teeth.

Me-Go	Mandibular Plane: The line connecting Me to Go.
N-Pog	Anterior facial height. A line joining Nasion to the Pogonion.
S-Go	Posterior facial height. A line joining Sella to the Gonion.
Jarabak ratio	The ratio of the posterior facial height to the anterior facial height.
UAFH	Upper Anterior Facial Height: perpendicular from N to the Maxillary Plane.
LAFH	Lower Anterior Facial Height: perpendicular from Me to the Maxillary Plane.
UPFH	Upper Posterior Facial Height: perpendicular from S to the Maxillary Plane.
LPFH	Lower Posterior Facial Height: perpendicular from Go to the Maxillary Plane.

Table 3. Angular Measurements

Angular Measurements	Definition
N-Pog / S-N	The angle between the nasal plane and Sella-Nasion plane.
MP / S-N	The angle between the mandibular plane the Sella-Nasion plane.
MaxP / MP	The maxillary mandibular plane angle.
FHP / S-N	The angle between Frankfurt horizontal and Sella-Nasion plane.
SNA	Sella-Nasion-A point.
SNB	Sella-Nasion-B point.
ANB	Point A - Nasion - Point B.
U1 / MaxP	Long axis of the upper incisors to the Maxillary plane.
L1 / MP	Long axis of the lower incisors to the Mandibular plane.
U1/L1	The angle formed with long axis of upper and lower incisors.
LI / A-Pog	Lower incisor to the A-Pogonion line
Lower lip to the E-plane	A line from the soft tissue lower lip to the tip of the nose.

Table 4: Shows the descriptive statistics of all the angular and linear measurements used in this study to compare the two groups.

Angular Measurements	Analysis	N	Minimum	Maximum	Mean	Std. Deviation
SNA	PowerPoint	110	70.50	94.00	81.61	4.22
	WebCeph	110	72.57	93.29	82.77	4.00
SNB	PowerPoint	110	70.00	86.50	78.00	3.80
	WebCeph	110	70.32	86.86	78.55	3.91
ANB	PowerPoint	110	-6.50	11.50	3.61	2.98
	WebCeph	110	-2.15	11.15	4.21	2.60
Wits Appraisal	PowerPoint	110	-6.00	4.00	-0.45	2.00
	WebCeph	110	-10.15	11.72	1.75	3.83
FH-SN	PowerPoint	110	2.50	17.50	9.89	3.15
	WebCeph	110	3.00	15.93	9.32	2.69

MMPA	PowerPoint	110	11.50	36.50	24.76	5.58
	WebCeph	110	10.84	35.93	24.11	5.23
U1/Max Plane	PowerPoint	110	98.50	141.50	117.23	8.22
	WebCeph	110	98.92	134.13	116.07	6.64
L1/Mand Plane	PowerPoint	110	79.50	123.00	98.05	8.90
	WebCeph	110	75.88	123.52	94.87	7.84
Interincisal Angle	PowerPoint	110	76.00	150.50	119.96	12.03
	WebCeph	110	96.32	155.24	124.95	10.49
Lower AFH Ratio	PowerPoint	110	49.30	65.30	56.33	2.53
	WebCeph	110	49.73	60.08	54.68	1.72
L1/A-Pog	PowerPoint	110	12.50	46.50	28.48	5.89
	WebCeph	110	10.18	40.25	23.49	5.52
Lower Lip/E-Line	PowerPoint	110	-5.00	4.00	-0.58	2.03
	WebCeph	110	-6.89	6.45	-0.92	2.80

Table 5: The intra-class correlation coefficient between the two groups.

Measurements	Cronbach's Alpha	Intraclass Correlation
SNA	0.940	0.854
SNB	0.976	0.943
ANB	0.919	0.833
Wits Appraisal	0.755	0.483
FH-SN	0.824	0.689
MMPA	0.890	0.797
U1/Max Plane	0.910	0.826
L1/Mand Plane	0.886	0.744
Interincisal Angle	0.928	0.789
Lower AFH Ratio	0.801	0.518
L1 to A-Po Line	0.859	0.546
Lower Lip to E-Line	0.863	0.753

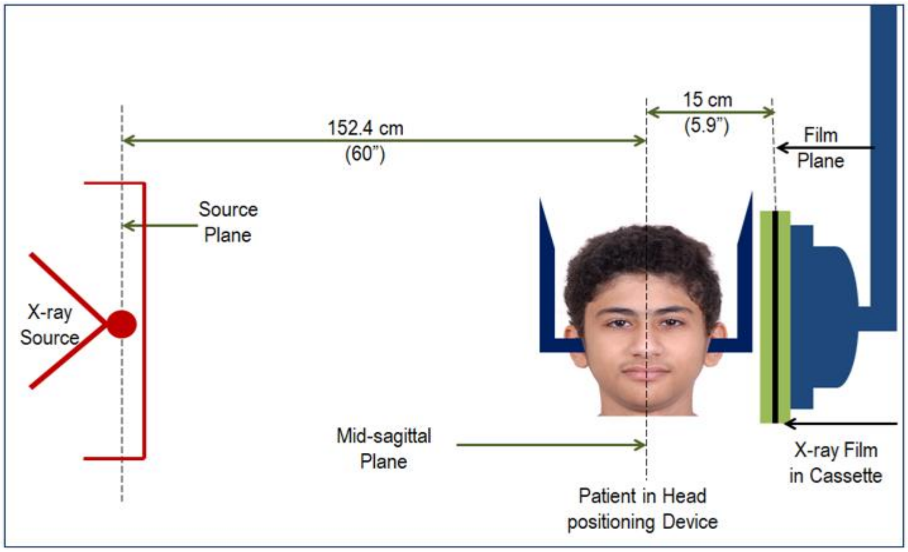

Figure 1: Ideal distances and the position of the patient while generating a lateral cephalogram.

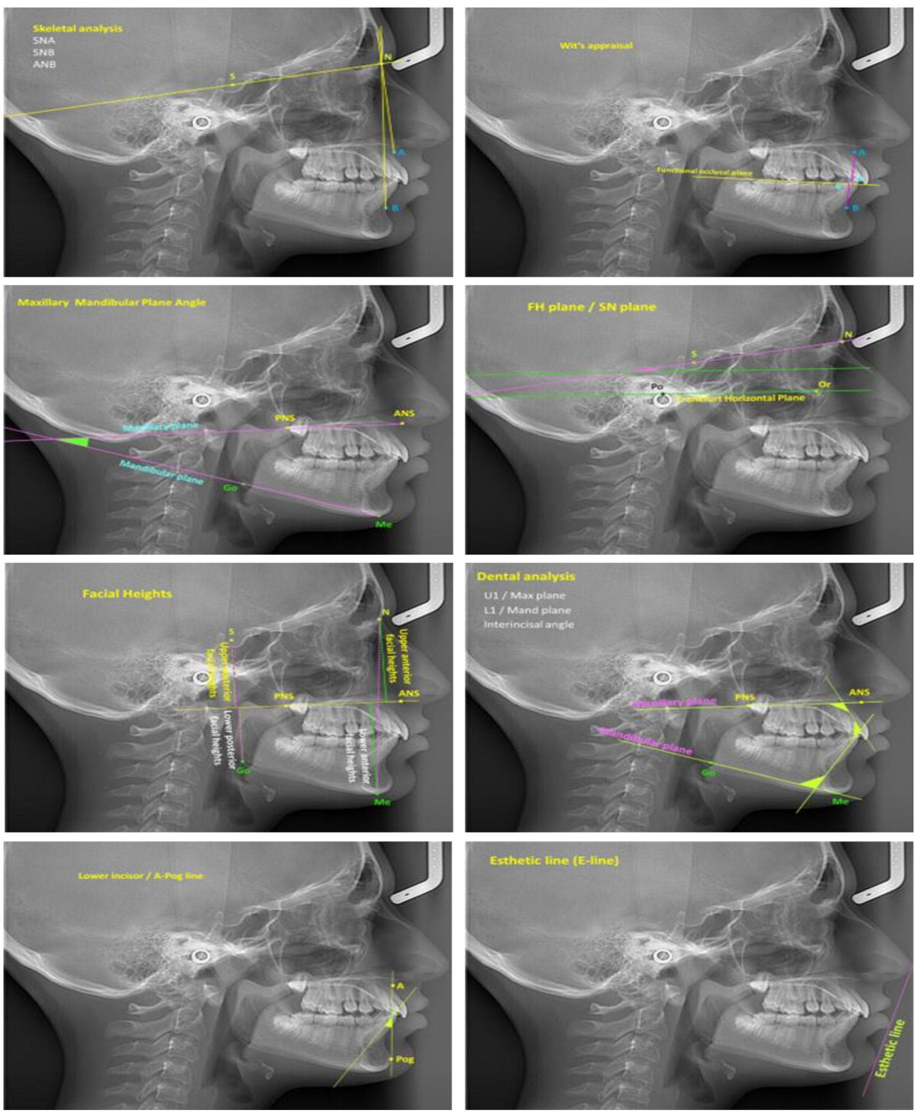

Figure 2: PowerPoint tracing linear and angular measurements.

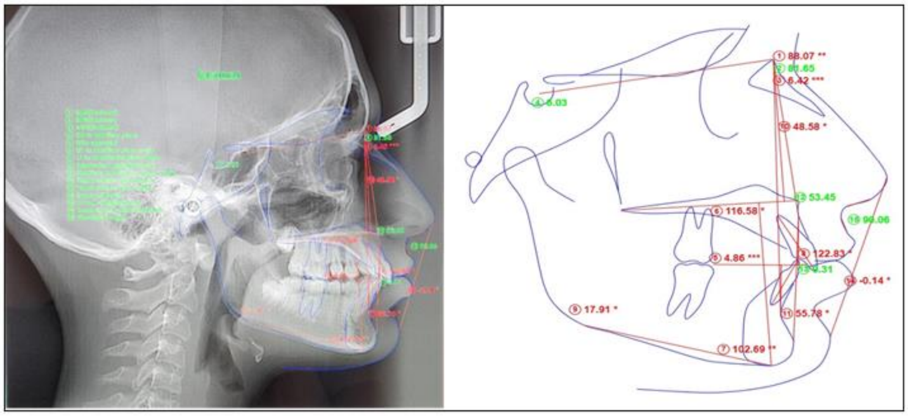

Figure 3: Cephalometric Analysis using WebCeph.