ISSN: 1812–1217

Comparison of Lateral Cephalometric Analysis among the Conventional, Digital and Hardcopy Cephalographs

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الخلاصة

الاهداف: تهدف الدراسة الى تقييم مصداقية تمييز النقاط التشريحية وتأثيرها على دقة قياس المسافات والزوايا بين تقنية تصوير أشعة الوجه الجانبية الاعتيادية والرقمية والنسخة المطبوعة عن الأشعة الرقمية. **المواد وطرائق العمل**: الدراسة الحالية أجريت على (110 عينات) من العراقيين الذين تتراوح اعمارهم بين (18–25 سَنَة) بالصنف الأول من الإطباق من علاقة (Angle) وقد اختيرت العينات من المراجعين للمستشفى التعليمي في كلية طب الاسنان في مدينةِ الموصل. وقد اخذت الصور الاشعاعية الجانبية التقليدية والرقمية لكل شخص، ثم أخذت نسخة مطبوعةٍ مِنْ الصورة الإشعاعيةِ الجانبية الرقمية للوجه بخمسة مقاييس (4قياسا زاوي،واحد قياس خطي) وقد اظهرتْ. التحليلات الخاصة بقياسات الرأس نفذت بالطريقة التقليديةِ، والتحليل الرقمي المباشر ببرنامجِ (Planmeca) وتحليل يدوي مباشر على صورةِ النسخة المطبوعةَ. وجرى التحليلُ الإحصائيُ للبياناتِ باستعمال برامجَ الإحصاء الحاسوبي (SPSS). وأظهرت النتائج أن المقاييسِ للزاوية الهيكلية: (SNA, SNB, ANB) لم تظهر أي اختلافات معنوية بين تقنياتِ التحليلاتَ الثلاث. بينما المقياسِ الخطيِّ الهيكلي (الطول الكلي الأمامي للوجه) أظهر دقّةَ أكثرَ ضمن الطريقةِ الرقميةِ، بدون اختلاف هامٍّ مِنْ الطريقةِ التقليديةِ.أما قياس الزاوية السنية (IiA) لم يظهر أي اختلاف هامٍّ في مقياسِها بين الطرائقِ التقليديةِ والرقميةِ.

ABSTRACT

Aims: To evaluate the reliability of landmarks identification and their effect on the accuracy of the linear and angular measurements among the conventional, hardcopy and direct digital cephalographs. **Materials and Methods**: The conventional cephalometric radiographs and their digital, hardcopies counterparts are taken for110 males and females between 18–25 years of age for students of dental college of Mosul University and from the patients who are attending College of Dentistry Teaching Hospital. Seventeen cephalometeric landmarks are selected on original radiographs and their digital, hardcopies cephalographes to evaluate the accuracy of 5 angular and linear measurements derived from the landmarks identified in conventional, hardcopy and direct digital cephalographs and to determine which is the most accurate method to be used in the cephalometric analyses nowadays. **Results:** The SNA, SNB, ANB showed no significant differences among the three analyses techniques. Total anterior facial height skeletal dimension showed more accurate measurements within digital techniques rather than within conventional and hardcopy techniques. Inter-incial angle showed no significant difference in its measurements between conventional and digital methods; although it showed more accuracy in its measurements within digital method rather than in conventional and hardcopy techniques. **Conclusions:** This study has shown that most of cephalometric landmarks have been identified with more precision and reliability within the digital techniques rather than with conventional and hardcopy techniques. However, there was significant difference in some measurements both linear and skeletal, but it can be considered clinically accepted.

Key Words: Conventional cephalometry, digital images, hardcopy images, cephalometric measurements.

Salman KhA, Muhammad RJ. Comparison of Lateral Cephalometric Analysis among the Conventional, Digital and Hardcopy Cephalographs. *Al–Rafidain Dent J*. 2012; 12(1): 80-88.
Received: *22*/9/2010 ***Sent to Referees:*** *26*/9/2010 ***Accepted for Publication:*** 1/11/2010

INTRODUCTION

During the first half of the 20th century, more than 100 cephalometric analyses were successively proposed. Every researcher was hoping, not only to explore and definitively describe the structure and the morphology of the craniofacial complex, but also to reach conclusions by defining "cephalometric norms". These concern average values of cephalometric variables, such as linear and angular

measurements that can be used for orthodontic diagnosis and treatment planning.[1] The major source of error in cephalometric analysis includes radiographic film magnification, tracing, measuring recording, and landmark identification.[2] This error is specific to each landmark and affected by experience and training of observers[3] Various computer programs are available to perform digitally many orthodontic functions, including cephalometric landmark identification and analysis, superimposition of sequentional radiographs, and printed hardcopies of the cephalograms.[4-7] Although one of the advantages of using digital radiography is elimination of the need for hardcopies, the dentist will inevitably need to print images. The most common reason for printing is for patient education, where one or more images are printed for the patient to take away with them, or when a referral is made to another dentist whose office does not have the capability to view digital images. The most common complaint about printed images is poor quality, often rendering the image non-diagnostic. The reason for this may be poor choice of paper (e.g. using regular instead of photo-quality paper) or poor printing technique (e.g.; printer resolution is set too low).[8, 9] Various investigators have evaluated the use of computerized cephalometric and digitizing process of cephalometric radiographs[10] they concluded that in digital radiography x-ray detectors and computers perform the acquisition, archival and display of the radiographic information. In ten years of time digital radiographic technology has matured and, now a day, digital radiographic systems are gradually replacing radiographic film. Digital radiography has multiple applications in contemporary dental practice. Reports have shown that digital radiography is equal or superior to the conventional radiography for caries detection[11] in the observation of periapical lesions.[12] Other study[13] reported that digital radiography was superior to conventional radiography for analyzing apical root resorption through digital subtraction radiography.

This study is designed to evaluate the accuracy of the angular and linear measurements derived from the landmarks identified in conventional, hardcopy and direct digital cephalographs.

MATERIALS AND METHODS

The samples of this study were selected from both the students of Dental College of Mosul University and from the patients who were attending the College of Dentistry teaching hospital (between January to April in 2009), one hundred and ten males and females between 18-25 years of age, the samples were examined to fit the criteria of this study which include ; all the subjects are urban Iraqi in origin, full complement of permanent teeth with normal occlusion with bilateral CL I molar and canine relationship,[14, 15] normal overbite and overjet (2-4mm),[16] no detectable rotation of the teeth,[17] no crowding of dental arches[15] and no history of orthodontic treatment.[18]

Lateral Cephalometric Radiography: Conventional and digital cephalometeric radiographs were taken for each sample, conventional lateral cephalometric X-ray machine, type STRATO-M 505, model-2000, Italy was used to take the conventional radiographs with the screen type film size 8x10 inch was adapted in a cassette with double intensifying screens, type AGFA, Belgium. The exposure factors were chosen according to the age of selected subjects that ranged between 18-25 years were 78 kVp, 12 mA and 0.8 sec. exposure time. All the exposed radiographic films were processed manually in the darkroom and at the room temperature. The examined subject was radiographed in a standing position, and asked the person to occlude in the centric occlusion.

Digital cephalometric X-ray machine, type PLANMECA DIMAXIS PRO, Finland was used to take the digital images with Dimax Classic imaging software, Finland, with the sensor size 13×30 cm. and small pixel size (33,5 µm) high resolution. The exposure value was selected and fixed depending on the age of the subjects, were 78 kVp, 12mA and 23.000 sec. of scanning time. The image were imported into a personal computer, in which all these images were displayed on a high resolution monochromic monitor which is 19 inch LG Electronics with a resolution

of 300 dpi and 32 bit gray levels, the image displayed consisted of 1024 x 768 pixel matrix. The originally saved digital radiographic image for each sample and before doing any image enhancement will be printed as a hardcopy image on the printing paper size A4, with Laser-Jet Printer, type HP 38A-4300, U.K. the selected image was printed in its full size (100% of the original image size).

Tracing and Analysis:

The tracings of the conventional cephalometric radiographs were carried out the tracing paper (0.004 inch) in thickness and (29.5 × 21cm) in dimension in a reduced room illumination to enhance the ability to visualize and locate various skeletal landmarks.

The 17 landmarks were identified on the digital image using a mouse – driven cursor in combination with a computerized cephalometric windows based program for landmark sampling in digital images. The cursor consisted of arrows and when a landmark was recorded, a red dot appeared on the screen over the selected pixel and this procedure will facilitate the identification of landmarks. To enhance the digital radiographic image (Dimaxis Software) in order to identify the landmarks and make the linear and angular measurements to be done with more accuracy, four types of manipulation tools were applied: A zoom function allowed enlargement up to ×4, pseudo – coloring, gradient filter and reverse gray scale. All the skeletal and dental angles were measured to the part of hundred of degree (0.01º), were as the linear measurements were recorded to the part of hundred of millimeter (0.01mm).

Cephalometric analysis in a traditional manner will be done directly on the printed hardcopy image paper, by identifying and localizing the selected points, drawing of planes and angles. The linear and angular measurements are completed by the use of protractor and ruler with 0.5 mm Refill pencil. All linear and angular measurements have been calculated to the nearest half millimeters and half degree respectively as in the traditional method.

The Skeletal Measurements included the angular measurements which were the Sella-Nasion-A point (SNA), Sella-Nasion- B point (SNB), A point-Nasion-B point (ANB) and the skeletal linear measurement was total anterior facial height (TAFH), dimension where as the dental angular measurements included inter-incisal angle (IiA). The data was Statistically analyzed by using SPSS program version 11.5 loaded on Pentium IV Computer, One Way Analysis of Variances (ANOVA), P – value equal or less than 0.05 ($p \leq 0.05$) as the minimum level of significance, Duncan's Multiple Range Test, for more specific significance was used to differentiate between three procedures.

RESULTS

The comparison between the conventional, digital and hardcopy techniques illustrated no significant differences concerning the angles SNA, SNB and ANB at $P > 0.05$ as shown in Tables (1), (2), (3) and Figures (1), (2) and (3). Table (4) and Figure (4) demonstrated that the TAFH showed significantly smaller mean value at the hard copy technique than the conventional and digital techniques at $p \leq 0.05$, whereas, there was no significant difference between the conventional and digital techniques at $p > 0.05$. The IiA showed highest mean value at the conventional technique rather than at the digital and hardcopy techniques at $p > 0.05$ in the table (5) and Figure (5).

Table (1): ANOVA for Comparing SNA Value Measured by Different Techniques

	SS	**d.f.**	**MS**	**F–value**	***p*–value**
Between Groups	14.243	2	7.122	0.569	0.566
Within Group	4089.344	327	12.506		
Total	4103.588	329			

Tabulated F- value at 5% level of significance = 3.07

Table (2): ANOVA for Comparing SNB Value Measured by Different Techniques

	SS	d.f.	MS	F–value	*p*–value
Between Groups	36.659	2	18.330	1.527	0.219
Within Group	3924.086	327	12.000		
Total	3960.745	329			

Tabulated F- value at 5% level of significance = 3.07

Table (3): ANOVA for Comparing ANB Value Measured by Different Techniques

	SS	d.f.	MS	F–value	*p*–value
Between Groups	3.695	2	1.847	0.382	0.683
Within Group	1580.170	327	4.832		
Total	1583.865	329			

Tabulated F- value at 5% level of significance = 3.07

Table (4): ANOVA for Comparing TAFH Value Measured by Different Techniques

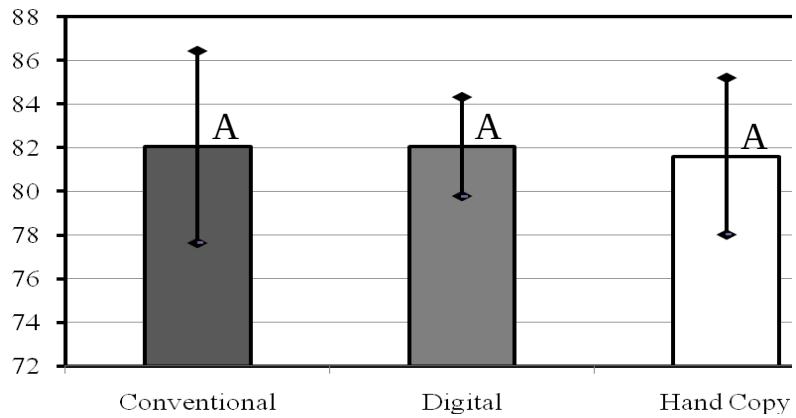
	SS	d.f.	MS	F–value	*p*–value
Between Groups	64182.88	2	32091.44	570.752	0.000
Within Group	18386.09	327	56.227		
Total	82568.97	329			

Tabulated F- value at 5% level of significance = 3.07

Table (5): ANOVA for Comparing IiA Value Measured by Different Techniques

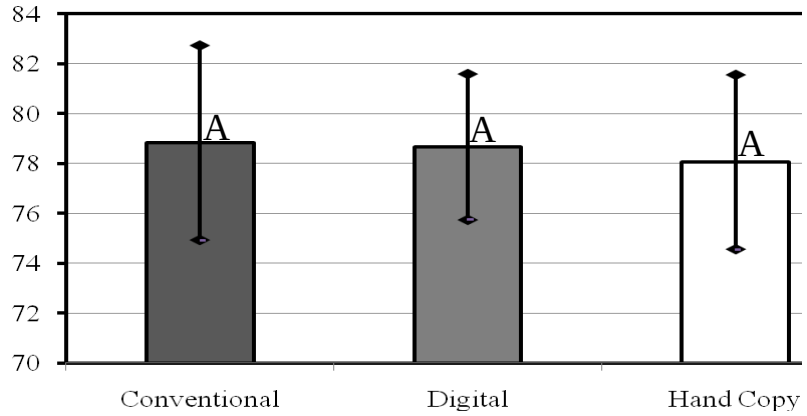
	SS	d.f.	MS	F–value	*p*–value
Between Groups	43.930	2	21.965	0.219	0.803
Within Group	32750.12	327	100.153		
Total	32794.05	329			

Tabulated F- value at 5% level of significance = 3.07



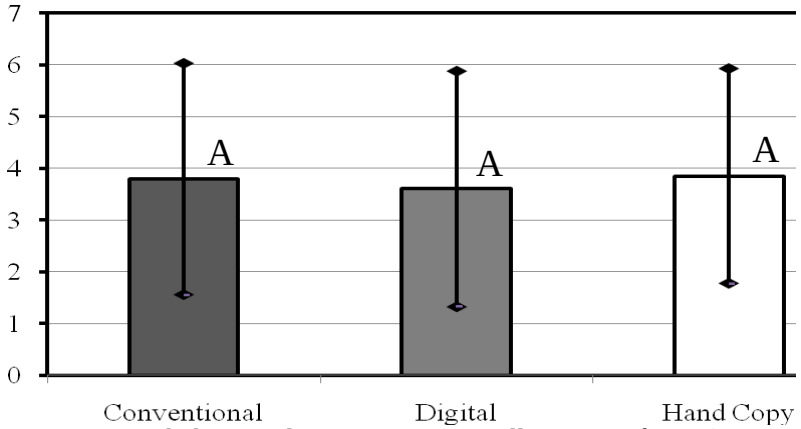
Means with the same letters were statistically not significant ($p > 0.05$).

Figure (1): Duncan's Multiple Range Test for SNA measurements among the three methods.



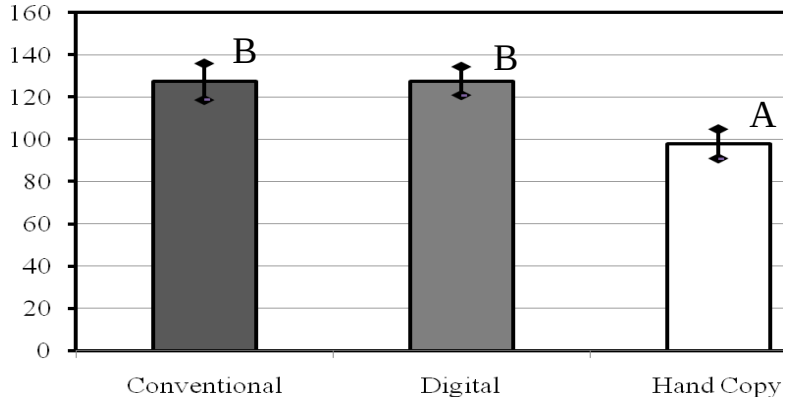
Means with the same letters were statistically not significant ($p > 0.05$).

Figure (2): Duncan's Multiple Range Test for SNB measurements among the three methods.



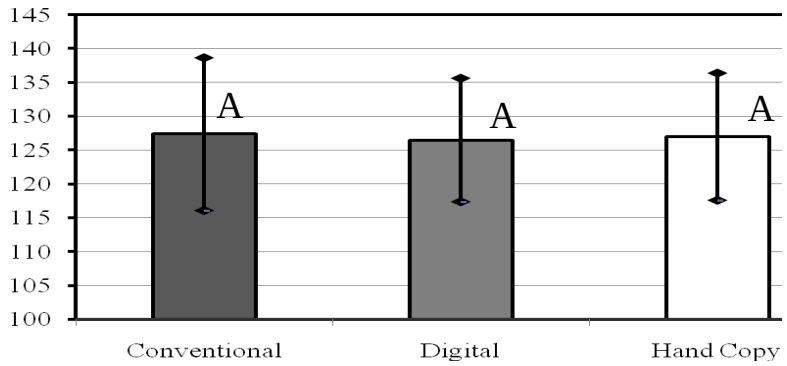
Means with the same letters were statistically not significant ($p > 0.05$).

Figure (3): Duncan's Multiple Range Test for ANB measurements among the three methods.



Means with the same letters were statistically not significant ($p > 0.05$).

Figure (4): Duncan's Multiple Range Test for TAFH measurements among the three methods.



Means with the same letters were statistically not significant ($p > 0.05$).

Figure (5): Duncan's Multiple Range Test for IiAº measurements among the three methods.

DISCUSSION

It is reasonable to evaluate a set of structural relationships by multiple cephalometric parameters rather than by a single parameter, and for this reason in this study as many as 5 measurements have been included to compare the three groups of analyses techniques, in order to reduce the measurement errors which could be considered during the interpretation of multiple cephalometric measurements. Because the present study included only the comparison among three techniques of cephalometric analysis, the results were compared with other studies have been carried out either in Mosul city and with same age groups and similar criteria by other researchers. [19, 20] Also, comparisons with other studies have been done in Netherlands by Ongkosuwito *et al*,[16] and in America by Bruntz *et al*,[7] as showed in Tables(6),(7)and(8). The SNA, SNB, ANB showed no significant difference among the conventional, digital and hardcopy analyses techniques, where the mean value of these angles by the conventional analysis technique coming in comparable with the results of other studies [19, 20]. The measurements of these three angles have comparable accuracy among the three analyses techniques which came in agreement with other study[22], Ongkosuwito *et al.*, [21]and Bruntz *et al.*,[7] who found that the measurements of these three angles are equivalent in both conventional and digital methods, but disagreed with other studies[22, 23] who reported that with the majority of angular and linear measurements there is a systematic error between the digital and conventional radiographic images, the landmarks on poorly defined edges such as nasion and point A which appear to have the greatest error in the digital image.

Table (6): Comparison of the angular and linear measurements of the conventional method of the present study with the other studies

Variable	Present study, 2009 Iraq		Al – Sayagh 1999 Iraq		Al- Hamadani 2000 Iraq		Ongkosuwito *et al*. 2002, Netherlands		Bruntz e*t al.* 2006, America	
	Mean	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**	**Mean**	**± SD**
SNA*	82.04	4.40	83.24	2.97			79.5	3.2	81.45	2.94
SNB*	78.82	3.90	79.85	2.92	79.71	3.48	76.8	3.4	78.21	3.2
ANB*	3.79	2.23	3.41	1.67			2.3	2.6	3.24	2.35
TAFH**	127.37	8.60	127.27	8.10	129.07	7.46	122.5	6.5		
IiA*	127.37	11.32	127.48	8.91			124.9	10.9	129.1	11.15

* Angular measurements = degree.

** Linear measurements = millimeter

Table (7): Comparison of the angular and linear measurements of the digital method of the present study with the other studies

Variable	Present study, 2009 Iraq		Ongkosuwito *et al*. 2002, Netherlands		Bruntz e*t al.* 2006, America	
	Mean	± SD	Mean	± SD	Mean	± SD
SNA*	82.05	2.28	78.8	3.9	81.02	3.7
SNB*	78.66	2.93	76.9	3.6	77.77	3.95
ANB*	3.60	2.27	2.3	2.9	3.25	2.28
TAFH**	127.53	6.76	122.2	6.4		
IiA*	126.48	9.11	125.8	11.1	129.26	10.1

* Angular measurements = degree.
** Linear measurements = millimeter.

Table (8): Comparison of the angular and linear measurements of the hardcopy technique of the present study with the other studies

Variable	Present study, 2009 Iraq		Bruntz e*t al.* 2006, America	
	Mean	± SD	Mean	± SD
SNA*	81.60	3.59	81.74	3.56
SNB*	78.05	3.49	78.8	4.63
ANB*	3.85	2.08	2.94	1.99
TAFH**	97.87	6.98		
IiA*	126.97	9.43	127.92	11.97

* Angular measurements = degree.
** Linear measurements = millimeter

The skeletal linear measurement, total anterior facial height showed no significant difference in its mean value in both the conventional and the digital techniques which agreed with Ongkosuwito *et al*,[2, 21] who indicated that one of the efforts to improve the precision of landmark identification should be directed toward improvement in the image quality and they also suggested that the increased familiarity with the medium of digital cephalometric system may reduce the error and improve the reliability in landmark identification. Also, this agreed with study of Parks and Williamson [24] who demonstrated that the radiographic film is an analogue image in which a continuous gray level represents elements. A digital image is composed of many pictures elements (pixels), so the quality of a digital image strongly depends on both the number of pixels and the number of gray levels, and they reported that the reliability of landmark identification or digital images depends on the pixel's size. So as the size of pixel is small as the resolution of digital image which will be greater and can yield greater reliability than the original radiographs with conventional equipment? But in the hard copy method the TAFH showed the lowest mean value indicating to the distortion that has occurred during the printing of digital image and this agreed with the study of Bruntz *et al*,[7].

The IiAº (Inter incisal angle) did not show any significant difference in its value among the three methods and this in agreement with both studies of Ongkosuwito *et al*, [21] and Bruntz *et al*, [7] and disagreed with the study of Chen *et al*, [2,25] that concluded the relatively larger measurement differences and a wide range of variation were angular measurements reflecting the axis of the upper and lower incisors. The differences in these dental measurements may be due to errors associated with landmarks identification in all techniques and wider range of variation in both original and digital modalities.

CONCLUSIONS

This study has showed the skeletal angular measurements: SNA, SNB, ANB no significant differences among the three analyses techniques, i.e., the conventional or manual, digital and hardcopy methods. The skeletal linear measurement TAFH showed more reliability and precision within the digital method, the dental angular measurement IiA showed more accuracy in its measurement within digital method rather than in conventional and hardcopy technique.

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