The reliability of AutoCAD program in cephalometric analysis in comparison with pre-programmed cephalometric analysis software

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ABSTRACT

Background: This study aimed to evaluate the reliability of AutoCAD program in cephalometric analysis in comparison with Viewbox 3.1.1 cephalometric computer software.

Materials and method: The sample consisted of 30 digital true lateral cephalometric radiographs of some under- and postgraduate students in the College of Dentistry/ University of Baghdad. Seventeen parameters (11 angular and 6 linear) were measured using the Viewbox 3.1.1 cephalometric computer software and re-measured using AutoCAD program. Descriptive statistics were performed for each parameter and paired samples t-test was obtained to evaluate the difference between both of the methods.

Results: The results revealed the presence of non-significant difference between both softwares.

Conclusions: Cephalometric analysis with AutoCAD program was comparable with Viewbox 3.1.1 software and both of them depend on the landmarks identification by the observer. AutoCAD software is available in Iraq unlike the other softwares and it can be used in clinical diagnosis also suited for research projects.
Key words: AutoCAD, computerized cephalometric analysis.

INTRODUCTION

Since Broadbent [1] and Hofrath [2] introduced the cephalometer in 1931, cephalometric analysis has contributed to the analysis of malocclusion and it has become a standardized diagnostic method in orthodontic practice and research [2–4].

Two approaches may be used to perform a cephalometric analysis: a manual approach and a computer-aided approach. The manual approach is the oldest and most widely used. It consists of placing a sheet of acetate over the cephalometric radiograph, tracing salient features, identifying landmarks, and measuring distances and angles between landmark locations. The other approach is computer-aided. Computerized cephalometric analysis uses manual identification of landmarks, based either on an overlay tracing of the radiograph to identify anatomical or constructed points followed by the transfer of the tracing to a digitizer linked to a computer, or a direct digitization of the lateral skull radiograph using a digitizer linked to a computer, and then locating landmarks on the monitor [5–7]. Afterwards, the computer software completes the cephalometric analysis by automatically measuring distances and angles.

The major sources of error in cephalometric analysis include radiographic film magnification, tracing, measuring, recording, and landmark identification. Previous studies revealed that inconsistency in landmark identification is an important source of error in conventional cephalometry [8-10].

This error is specific to each landmark and affected by experience and training of the observers [11].

Rapid advances in computer science have led to its wide application in cephalometry. Computer-aided cephalometric analysis is faster in data acquisition and analysis than conventional methods. Many cephalometric programs have been developed to perform computer-aided cephalometric analysis by digitizing the landmarks. However, digitizing may introduce errors such as head film movement and improper sequencing of digitized points. To take advantage of image processing and computer-based filing systems that can integrate patients' records and images, the original cephalometric radiographic films may be transformed into a digital format by a scanner or video camera. A radiographic system for taking direct-digital lateral cephalograms at reduced radiation dose is presently available [12,13].

Consequently, many commercially available or customized programs have been developed to conduct cephalometric analyses directly on the screen-displayed digital image [14–15]. 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 [15]. Digital cephalometry also has the benefits of image storage, transmission and processing [8].

Great efforts have been made to develop systems for automatic computerized identification of cephalometric landmarks [4,17]. However, automated systems are at present unable to compete with manual identification in terms of accuracy of landmark position. The landmarks lying on poorly defined structures are difficult to automatically identify due to poor signal-to-noise ratio [8]. Earlier studies revealed that computer-aided cephalometric analysis does not introduce more measurement error than hand tracing, as long as landmarks are identified manually [18,19]. Therefore, manually identifying landmarks on screen-displayed digital images for cephalometric analysis may still be the better strategy.

In Iraq, before 2006, the manual tracing was the dominate method for cephalometric analysis, but after transporting to the digital cephalometric X-ray, the need for a software for cephalometric analysis begins. Al-Nasseri [20] compared the accuracy of the computerized procedure from digitizing the radiograph to the final cephalometric analysis on twenty-six lateral cephalograms using Viewbox 3.0.1 cephalometric computer software. His results showed that computerized angular measurements were more comparable to the manual method than with linear measurements, with most of the differences being of low clinical importance. On the other hand, Uthman and Al-Sahaf [21] measured the effect of film digitization on reliability and validity of some angular and linear cephalometric measurements. They used the Dimaxis pro/classic imaging software (version 3.2.1) for landmarks identification and variable calculations and found that the angular and linear measurements in digital images were comparable with that of original radiograph and are clinically acceptable. This work with this software is not easy, so the need for simple and full option software has been aroused.

Mohammed [22] evaluated 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 of 110 Iraqi adults. Lateral conventional and digital cephalometric radiographs were taken for each subject, a hardcopy image from the digital cephalometric radiograph have been printed. Twenty one cephalometric measurements (12 angular and 9 linear measurements) were determined. Cephalometric analyses were made by traditional (manual), direct digital analysis by the Planmeca Software Program (Dimax) and direct manual analysis on the hardcopy image. The results showed that most of cephalometric landmarks have been identified with more precision and reliability within the digital techniques rather than with conventional and hardcopy techniques. With the hardcopy analysis technique, all the linear measurements either skeletal or dental showed a high significant variation, so it cannot be used to make the so good diagnosis or the evaluation of the treatment plan. On the other hand, there was no statistical significance difference between the conventional and digital methods and both techniques could be used as clinical tool in diagnosis and treatment planning evaluation.

Nowadays in Iraq, AutoCAD (Auto Computer Aided Design) program is the best solution. With this software, both digital and conventional X-rays, that can be scanned and entered to this program, can be analyzed. It has the property of measuring the angular, linear parameters and surface area. With it, the image is imported, the magnification is corrected and points and planes can be obtained easily with the property of enlarging the image, snapping the points, determination the mid between two points, drawing the perpendiculars, and measuring the variables with high precision.

Since 2005, AutoCAD program used in cephalometric analysis and no one test its reliability, so the aim of the present study is to evaluate the reliability of AutoCAD program in cephalometric analysis in comparison with Viewbox 3.1.1 cephalometric computer software.

MATERIALS AND METHOD

Sample

The sample consisted of 30 digital true lateral cephalometric radiographs of some under- and postgraduate students in the College of Dentistry/ University of Baghdad.

Equipment

a)Pentium IV portable computer.
b)Analyzing softwares (AutoCAD 2007 by Autodesk, Inc., and Viewbox 3.1.1 by Dhal Orthodontic Software).

Method

Cephalometric Analysis

Every digital true lateral cephalometric radiograph was analyzed by Viewbox 3.0.1 cephalometric computer software one time then by AutoCAD program 2007 on the second time to obtain the angular and linear measurements. After importing the picture to both of these programs, the magnification was corrected, the points were localized, the planes were determined, and the angles and distances were measured by the AutoCAD program while in Viewbox 3.0.1 software the planes and measurements were obtained directly as the program designed.

Cephalometric Landmarks, Planes, and Measurements

I. Cephalometric Landmarks

1. Point S (Sella): The midpoint of the hypophysial fossa [23].
2. Point N (Nasion): The most anterior point on the nasofrontal suture in the median plane [23].
3. Point Ar (Articulare): The point of intersection of the external dorsal contour of the mandibular condyle and the temporal bone [24].
4. Point A (Subspinale): The deepest midline point on the premaxilla between the Anterior Nasal Spine and Prosthion [25].
5. Point B (Supramentale): The deepest midline point on the mandible between Infradentale and Pogonion [25].
6. Point Pog (Pogonion): It is the most anterior point on the mandible in the midline [25].
7. Point ANS (Anterior Nasal Spine): It is the tip of the bony anterior nasal spine in the median plane [23].
8. Point PNS (Posterior Nasal Spine): This is a constructed radiological point, the intersection of a continuation of the anterior wall of the pterygopalatine fossa and the floor of the nose. It marks the dorsal limit of the maxilla [23].
9. Point Me (Menton): The lowest point on the symphyseal shadow of the mandible seen on a lateral cephalograms [26].
10. Point Go (Gonion): A point on the curvature of the angle of the mandible located by bisecting the angle formed by the lines tangent to the posterior ramus and inferior border of the mandible [26].
11. Point Ii (Incisor inferius): The tip of the crown of the most anterior mandibular central incisor [23].
12. Point Is (Incisor superius): The tip of the crown of the most anterior maxillary central incisor [23].
13. Point Ap 1 (Apicale 1): Root apex of the most anterior maxillary central incisor [23].
14. Point Ap 1 (Apicale 1): Root apex of the most anterior mandibular central incisor [23].

II. Cephalometric planes

1. Sella-Nasion (SN) plane: Formed by a line joining Sella turcica and Nasion [23].
2. S-Ar plane: Formed by a line joining Sella turcica and Articulare [23].
3. Ar-Go plane: A line joining Articulare to Gonion [23].
4. N-Pog plane: Formed by a line joining Nasion and point Pogonion [25].
5. N- A line: Formed by a line joining Nasion and point A [25].
6. N- B line: Formed by a line joining Nasion and point B [25].
7. Palatal plane: Formed by a line joining ANS and PNS [23].
8. Mandibular plane (MP): Formed by a line joining Gonion and Menton [23].
9. Long axis of the upper incisor (U1): A line connecting Is and Ap 1 [23].
10. Long axis of the lower incisor (L1): A line connecting Ii and Ap 1 [23].
11. Mandibular incisor- Mandibular plane: A line connecting the long axis of the lower incisor to the mandibular plane [23].
12. Maxillary incisor- Palatal plane: A line connecting the long axis of the upper incisor to the palatal plane [23].

Cephalometric measurements

A. Angular measurements

1. SNA angle: The angle between lines S-N and N-A. It represents the angular anteroposterior position of the maxilla to the cranial base [27,28].
2. SNB angle: The angle between lines S-Nand N-B. It represents the angular anteroposterior position of the mandible to the cranial base [27,28].
3. ANB angle: The angle between lines NA and N-B. It is the most commonly used measurement for appraising anteroposterior disharmony of the jaws [27,28].
4. Gonial angle (Ar-Go-Me): The angle between the posterior border of the ramus and the mandibular plane [23].
5. Saddle angle (N-S-Ar): The angle between the

anterior and the posterior cranial base. This angle formed at the point of intersection of the S-N plane and the S-Ar plane [23].
6. Articular angle (S-Ar-Go): The angle between S-Ar and Ar-Go planes [23].
7. S-N-Pog angle: The angle between S-N and N-Pog planes [23].
8. SN-PP angle: The angle between S-N and palatal planes [23].
9. Maxillary incisor – Palatal plane angle (U1-PP): The angle between long axis of upper incisor and palatal plane, posteriorly [27,28].
10. Mandibular incisor– Mandibular plane angle (L1-MP): That angle formed by the long axis of the most labial mandibular incisor to the mandibular plane, posteriorly [24].
11. Inter-incisal angle (U1-L1): The angle formed by the intersection of the lines representing the long axes of the most labial maxillary and mandibular incisors, posteriorly [27,28].

B. Linear Measurements

1. S-N: A distance from Sella to Nasion [23].
2. S-Ar: A distance from Sella to Articulare [23].
3. Mandibular body length: It represents the distance from Gonion to Menton [23].
4. Ramus length: The distance between Ar and Go [23].
5. Total anterior facial height (TAFH): It's measured from N to Me [29].
6. Posterior facial height (PFH): It's measured from S to Go [29].

Statistical Analyses

All the data of the sample were subjected to computerized statistical analysis using SPSS version 15 (2006) computer program. The statistical analysis included:

1. Descriptive Statistics

a) Means.

b) Standard deviations (SD).

c) Statistical tables.

2. Inferential Statistics

a) Paired- samples t-test for the comparison between both methods.

In the statistical evaluation, the following levels of significance are used:

Non-significant	NS	$P > 0.05$
Significant	*	$0.05 \geq P > 0.01$
Highly significant	**	$0.01 \geq P > 0.001$
Very highly significant	***	$P \leq 0.001$

RESULTS AND DISCUSSION

Different studies had been made to compare between the manual and computerized cephalometric analysis revealed non-significant difference between the methods [6,13].

Baskin and Cisneros [14] conducted a study to determine the reliability and reproducibility of measurements obtained from two popular programs, Dentofacial Planner and Quick Ceph, as compared to manual tracings using the measurements of Steiner's analysis. They found that both Dentofacial Planner and Quick Ceph can produce dependable results.

The result of the present study revealed that the mean values of the measured variables by both softwares were very close with a non-significant difference between both methods (Table 1).

For both methods, the cephalometric analysis depended mainly on landmarks identification by the observer rather than the method of calculating and measuring of the linear or angular variables.

Although the results showed a non-significant difference between both softwares; the differences between them obviously seen in their design. Viewbox was designed as a cephalometric analysis program developed by an orthodontist. Initially it was written for personal computers in the DOS environment and later it was ported to Windows 3.1. Version 3.1.1 incorporates the latest in cephalometric analysis software, including advanced image processing algorithms, Procrustes superimposition and Principal Component Analysis, while AutoCAD program in fact designed for solving engineering purposes rather than orthodontic analysis. One of the most features in the AutoCAD program is that the observer has a full control in locating points that are between two shadows, like Gonion unlike preprogrammed identification by Viewbox 3.1.1 cephalometric computer software.

CONCLUSIONS

AutoCAD program, like Viewbox, is not restricted to cephalometric analyses, however, this program can perform measurements on any diagnostic record that can be scanned with a scanner or photographed with a video or digital camera. Such records might include frontal, submentovertex and panoramic radiographs, orthodontic models, facial and profile photographs, hand-wrist radiographs, animal radiographs, etc. The results of the present study revealed non-significant difference between both methods. Therefore, Auto-CAD program can be used in clinical diagnosis also suited for research projects.

Table 1. Descriptive statistics and methods difference for the measured variables

Variables		Descriptive statistics				Method difference d.f.=29		
		Viewbox		AutoCAD				
		Mean	S.D.	Mean	S.D.	Mean difference	t-test	*p*-value
	SNA	82.67	3.25	82.83	3.17	0.17	1.37	0.19 (NS)
	SNB	79.44	3.15	79.50	2.98	0.06	0.44	0.67 (NS)
	ANB	3.33	1.33	3.28	1.41	-0.06	-0.44	0.67 (NS)
	GA	126.22	3.14	126.22	3.32	0	0	1 (NS)
	N-S-Ar	122.06	5.18	122.56	5.29	0.50	1.84	0.08 (NS)
Angular Measurements (°)	S-Ar-Go	144.50	5.89	143.94	5.92	-0.56	-1.82	0.09 (NS)
	SN-PP	9.28	2.44	9.17	2.20	-0.11	-0.52	0.61 (NS)
	S-N-Pog	80.44	3.01	80.39	3.01	-0.06	-0.37	0.72 (NS)
	U1-PP	111.11	8.78	110.83	8.54	-0.28	-0.77	0.45 (NS)
Linear Measurements (mm)	L1-MP	100.39	6.48	100.61	7.20	0.22	0.44	0.67 (NS)
	U1-L1	124.83	10.72	125.39	10.85	0.56	1.25	0.23 (NS)
	S-N	67.89	2.64	68.32	3.03	0.42	1.26	0.23 (NS)
	S-Ar	33.08	2.94	33.31	2.94	0.23	1.82	0.09 (NS)
	Go-Me	68.22	2.89	68.73	3.03	0.50	1.24	0.23 (NS)
	Ar-Go	45.21	6.22	45.42	6.12	0.21	1.34	0.20 (NS)
	TAFH	113.02	7.29	113.14	7.17	0.12	0.75	0.46 (NS)
	PFH	74.73	6.62	74.87	6.54	0.14	1.76	0.10 (NS)

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