Validity & reliability of cephalometric measurements in traditional versus digitized cephalometry

Ass. Prof. Asmaa Tahseen Uthman B.D.S, M.Sc .*
Ass.prof. Nagham Al-Sahaf B.D.S, M.Sc. **

Abstract

Aim: Film digitization is generally used to prevent potential damage or loss of original films. The method of film processing has been changing from wet to dry processing due to recent trends toward digitization of medical imaging.

Materials & Methods: 50 Lateral cephalometric radiograms were used in this study. All radiographs were viewed under standardized conditions& traced. Eleven landmarks were selected to calculate 12 variables (9 angles&3 linear measurements).

These traced radiographs were photographed when digitized using scan jet scanner & the same variables were measured using Dimaxis pro\ classic imaging software.

Results: There were no statistically significant differences between traditional &digitized Linear & angular measurements except for upper incisor-Frankfort plane angle & upper incisor-lower incisor angle.

Conclusion: Angular & linear measurements in digital images were comparable with that of original radiograph & are clinically acceptable. This will substantiate the benefits of digitized cephalometry in term of reliability of cephalometric analysis.

Keywords: Digital Imaging, Cephalometry, Film digitization

Introduction

Radiographs are used not only in diagnosis, but also for various purposes, such as education, presentation & recording medical histories [1]. In these cases, film digitization is generally used to prevent potential damage or loss of original films.

The storage of cephalometric radiographs requires space & staff-time; this could be reduced with the archiving of digital images. Archiving cephalometric radiographs would be of particular benefit in studying craniofacial growth or assessing the effect of treatment, where large numbers of radiographs analyzed [2].

Computer-based filing systems for patient's records have the benefits of image storage, transmission & processing [1]. Computer-aided cephalometric analysis on digitized cephalogram could substantially reduce the potential mechanical errors, since it can totally eliminate it in drawing line between landmarks & in measurements with protractor [3]. However the inconsistency in landmark identification is still an important source of random error in computer-aided digital cephalometry. For digitized cephalometry to be better tool in clinical orthodontics, the cephalometric analysis, represented by widely used linear & angular measurements, must be as comparable & reliable as it is on conventional

* Dept.of Oral Diagnosis. College of Dentistry/University of Baghdad
** Dept of Orthodontic, College of Dentistry/ University of Baghdad

radiographic film.

The aim of this study was to measure the effect of film digitization on reliability & validity of some angular & linear cephalometric measurements.

Materials and methods

Fifty lateral cephalometric radiograms were used in this study. They were selected from the records of the post-graduate clinic of the orthodontic department in college of dentistry, university of Baghdad.

The selected radiographs were of good quality to get better digitization, providing that all radiograms having a standardized millimetric ruler.

All radiographs were viewed under standardized conditions & traced on to acetate overlays with 0.3mm HB lead pencil.

Eleven landmarks were selected in this study as shown in fig. (1)& table (1).

From these landmarks (12) variable were calculated (9 angles & 3 linear measurements)

In both horizontal & vertical planes as shown in table (2).

Image capturing

Radiographs are mounted on a light box & captured using photographic camera (Minolta

SLR).The camera & radiograph are enclosed in a light-proof box to ensure maximum contrast during image capturing.

Two photographs were taken for the cephalograms, one with tracing & the other without

Tracing using a stand in a fixed distance (1 meter).

The processed photographic color films (negative) were then converted into digital (positive) images through using HP scanjet 5530 photosmart scanner at 200 dpi resolution.

The captured images are then manipulated by the computer using Dimaxis pro|classic imaging software (version 3.2.1) for landmarks identification & variable calculations.

The results of measurements were transferred to a Microsoft Exel XP^{TM} spreadsheet program.

The mean & standard deviation of some angular & linear parameters between the original films & digitized images were calculated for each of the (12) variables.

The statistical significance of difference between the two groups was checked with paired student t-test.

Results

The mean & standard deviation for each of the (12) angular & linear measurements on original radiographs & their digitized counterparts are presented in table (3 & 4). There was no statistically significant difference between conventional & digitized measurements among all angles examined except for upper incisor-Frankfort plane & upper incisor- lower incisor angles (table 3).

However, the mean differences were less in linear measurements which showed non-significant statistical differences between conventional & digital methods of analysis with & without tracing (table 4).

Generally, the mean values & standard deviation of cephalometric measurements in digitized images was comparable with those in the original radiographs. The mean difference in the original radiograph ranged from zero to 2.48 degree for angular measurements & from 0.2 to 0.7 mm. for linear measurements. It was noted that the mean differences between the two methods were less than one

millimeter or degree in 10 out of 12 cephalometric measurements which is generally within one standard deviation of norm values.

Discussion

In clinical orthodontics, cephalometric analysis has long been used as an important clinical tool in diagnosis, treatment planning & evaluation of growth or treatment results. Many parameters were proposed to analyze the relationship of teeth to teeth, teeth to jaws & jaws to cranial base & the inter jaw relationship [5].

Linear measurements may be affected by the inclination of the reference line & angular measurements can not indicate correctly the jaw relationship in the case of extreme facial divergence [6]. Therefore, it is reasonable to evaluate a set of structural relationship by multiple cephalometric parameters rather than a single parameter.

The major error associated with conventional cephalometry includes projection errors & tracing errors. The most important source of tracing errors is uncertainty in landmark identification [7]. The mechanical errors introduced by drawing lines between landmarks manually & by measuring with a ruler & a protractor were common in conventional cephalometric analysis. When we take advantage of digital cephalometry, it is important to be certain that the digitized image yields the similar performance to conventional film in terms of cephalometric measurements.

The results of the present study are at least partly in agreement with the findings of Macri & Wenzel [8]. They reported that it was possible to achieve reliability in digital images comparable to that obtained with conventional radiographs with good quality. In contrast, Geelen et al [9] reported that the precession of landmarks recording was lower for enhanced monitor-displayed images than for film-enhanced hardcopies.

In this study, the differences in dental measurements were generally larger than those in the skeletal measurements especially the angular dental measurements (upper incisor-Frankfort plane & upper incisor-lower incisor angles) which are in agreement with the findings of Chen et al [5]. The differences in these dental measurements may be associated with wider range of variation in both original & digitized modalities.

The cephalometric radiographs used in this study were randomly selected & represented the quality of daily routine work. Chen et al [5] expected that the powerful tool of digitized image processing could help with landmarks identification on poorly defined structures. However, it was reported that the landmark reliability in digitized radiographs of lower quality could not be improved by digital processing [8]. There are several ways of acquiring a digitized cephalometric images & the image quality would depend on how the image was acquired [1,3,5,8,9,10]. In this study, the digitized images were secondarily captured by a film scanner. Inevitably, image signal deterioration would occur in the digitization process. In this case the quality of the digitized images would be less than that of the original images on film. However, the results of this study imply that that the parameter setting for our digitized cephalographs was almost adequate in term of performance of cephalometric analysis, which was demonstrated by the low level of measurement differences between the conventional & digitized radiographs. The inferiority of the digitized images in two out of 12 measurements may have

little impact in our application of digitized cephalometry.

Conclusion

The reliability of landmarks identification, angular & linear measurements in digitized images was comparable with that of original radiographs except for 2 angles. So these 2 angles should be scrutinized more carefully when we take potential advantages of the use of digital cephalometry. Moreover, this simple method of film digitization can be applied for archiving all radiographs in a computer to be used as baseline data & to conserve the old data from deterioration or loss.

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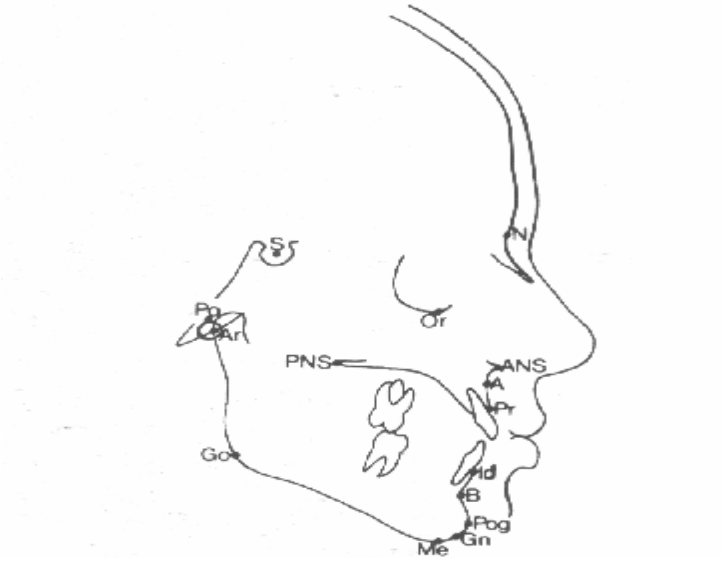

Figure (1): Landmarks Identification.

Table (1): Landmarks Identification [4]

	Landmark	Definition
1	S	Sella: the midpoint of hypophyseal fossa.
2	N	Nasion: the most posterior point of fronto-nasal suture in the median plane.
3	A	Point A: the most posterior point on labial surface of maxilla between anterior nasal spine & alveolar process.
4	B	Point B: the most posterior point in the outer contour of the mandibular alveolar process in the median plane.
5	Or	Orbitale: the lowest point on the infraorbital margin.
6	Po	Porion: the upper most point of the bony external auditory meatus.
7	Me	Menton:the lowest point on the bony outline of the mandibular symphysis.
8	Go	Gonion: the most lateral external point at the junction of ascending ramus & mandibular body.
9	ANS	Anterior nasal spine: the tip of anterior nasal spine.
10	PNS	Posterior nasal spine: the tip of the posterior spine of palatine bone in the hard palate.
11	Ar	Articulare: the point of intersection of the posterior margin of ascending ramus & the outer margin of the cranial base.

Table (2) Angular & Linear variables definition:

	Angular variables	Definition
1	SNA	Angle between S-N & N-A
2	SNB	Angle between S-N & N-B
3	ANB	Angle between A-N & N-B
4	Frankfort-Mandibular plane	Angle between Frankfort & Mandibular planes.
5	Maxillary-Mandibular plane	Angle between Maxillary & Mandibular plane.
6	Upper incisor-Frankfort plane	Angle between the long axis of upper incisor & Frankfort plane.
7	Upper incisor-Maxillary plane	Angle between the long axis of upper incisor & Maxillary plane.
8	Lower incisor-Mandibular plane	Angle between the long axis of Lower incisor & Mandibular plane.
9	Upper incisor-Lower incisor	Angle between the long axis of upper incisor & the long axis of

		lower incisor.
	Linear variables	.Definition
1	S-N (Anterior cranial base)	Distance between S & N.
2	Go-Me (Mandibular body)	Distance between Go & Me.
3	Ar-Go (Ramus height)	Distance between Ar & Go.

Table (3): Comparison between conventional (manual) & digitized angular measurements:

Variables	Analysis	Mean	SD	P-value	Significance
SNA	Conventional	81.37	5.17	0.07	N.S
	Digital	81	5.05		
SNB	Conventional	79	4.09	0.05	N.S
	Digital	79	4.38		
ANB	Conventional	2.37	2.7	0.07	N.S
	Digital	2.75	2.8		
Frankfort-Mandibular plane	Conventional	32.46	6.43	0.07	N.S
	Digital	33.06	6.35		
Maxillary-Mandibular plane	Conventional	29.35	6.11	0.08	N.S
	Digital	32.93	18.9		
Upper incisor-Frankfort plane	Conventional	109.56	12.01	0.001	H.S
	Digital	108.52	12.16		
Upper incisor-Maxillary plane	Conventional	112.51	10.6	0.4	N.S
	Digital	112.44	10.84		
Lower incisor-Mandibular plane	Conventional	93.13	7.56	0.19	N.S
	Digital	93.08	7.28		
Upper incisor-Lower incisor	Conventional	125.82	13.7	0.005	H.S
	Digital	125.22	14.07		

Table (4): Comparison between Conventional (Manual) & Digital linear measurements

Variables	Digital with tracing		Conventional		Digital without tracing	
S-N	**71.62 ± 2.98**		**72.01 ± 2.04**		**72.99 ± 2.3**	
		P≥ 0.05		**P≥ 0.05**		
Me-Go	**71.18 ± 6.37**		**71.42 ± 5.98**		**72.47 ± 6.37**	
		P≥ 0.05		**P≥ 0.05**		
Ar-Go	**49.33 ± 5.28**		**50.05 ± 5.8**		**49.95 ± 5.37**	
		P≥ 0.05		**P≥ 0.05**		