Cephalometric Digitization: Converting Analog Cephalograms into Digital Format—A Comparative Study between Two Different Methods of Digitization

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ABSTRACT

Introduction: Study was carried out to compare the accuracy in producing digital formats of analog lateral cephalograms by taking a digital photograph and by scanning with a flatbed scanner.

Aim: To investigate whether taking a digital photograph of an analog lateral cephalometric radiograph is as accurate as using a flatbed scanner to scan the same radiograph for digitization.

Methods: Twenty lateral cephalograms were randomly selected from the records at a Dental College and Hospital in Belgaum. They were photographed with a digital camera and scanned with a flatbed scanner. Both images were then digitized with imaging software (Facad digital imaging program version 3.5). Set of predetermined measurements were transferred on all analog cephalograms. They were then measured on the imaging software. Student t test was used to test for statistically significant differences between the measurements.

Statistical analysis used: Student paired t test.

Results: Angular measurements were deviating less from the original values after digitizing with both methods, but linear measurements were significantly changed.

Conclusion: It is acceptable to take photographs of analog cephalograms if only angular measurements are to be considered. However, these images cannot be accepted when considering linear measurements.

Key words: Cephalograms, Comparison, Digital, Digitization.

INTRODUCTION

The analysis of cephalometric radiographs plays an important role in orthodontic diagnosis, treatment planning and record keeping. The older methods for analyzing cephalometric radiographs were traditional tracings and hand measurements, and direct digitization of radiographs using computerized programs.[1]

Recently, on-screen digitization of digital cephalograms and the digitization of enhanced video images have become popular.[2] The second method is not still used often, but the on-screen digitization of cephalograms has become more common.

Earlier all the institutions would be using conventional cephalostat for taking lateral cephalograms. Nowadays, most of the dental institutions are buying digital imaging softwares like FACAD, Dolphin, etc. for analyzing cephalometric radiographs. These softwares specifically need digital format of cephalograms which can be obtained by using digital cephalostat.

Digital cephalograms have several advantages over the traditional methods of cephalometry. Digital images are easier to store and significantly reduce the amount of physical space needed and the number of people required to organize the storage. Digital images also remove the need for chemicals and a dark room for processing. The information stored in digital form can be transferred easily to other centers; this allows for ease of access to data and facilitates treatment planning at different sites. In addition, with digital imaging, the patient has less radiation exposure.[1]

However, all these advantages of digital cephalostat come with a high investment cost. Thus the conversion of analog cephalograms into digital format is the need of the hour for the institutions as well as practitioners who want to reap the advantages of various digital imaging softwares without changing over to digital cephalostat.

Various modalities have been proposed for transforming an analog cephalogram into digital format.[2] However, scanning the analog cephalogram or taking a digital photograph of the same appear to be the most practical approaches.

Therefore, the aim of my study was to investigate whether taking a digital photograph of an analog lateral cephalometric radiograph is as accurate as using a flatbed scanner to scan the same radiograph before digitization.

Thus, my null hypothesis was that there is no difference between the measurements taken from digitization of a flatbed scanned image of an analog lateral cephalometric radiograph compared with digitization of an image recorded with a digital camera.

MATERIALS AND METHODS

Twenty lateral cephalograms were randomly selected from the records of patients being treated at a Dental College and Hospital in Belgaum, Karnataka.

Each radiograph was marked at 5 locations (A, B, C, D and O) to identify 5 landmarks **(Figure 1)**. This was done to
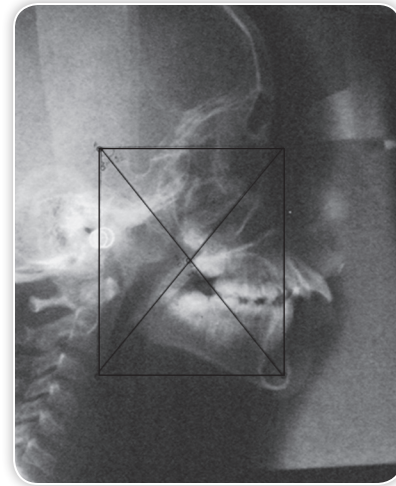

Figure 1 Points and measurements transferred on the cephalograms
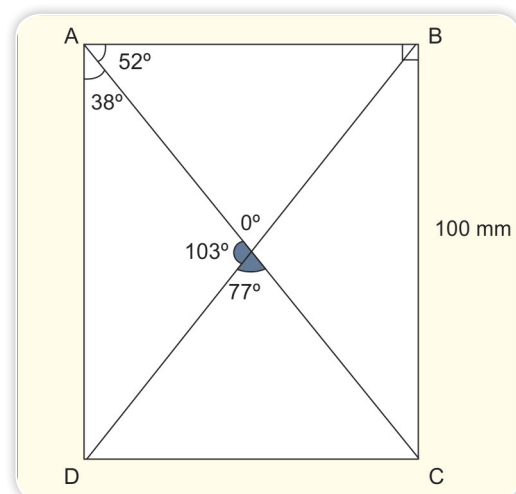
Figure 2 Five points and 6 linear measurements, and 5 angular measurements used to assess distortion

measure the linear distances and angular measurements if they distort during the recording of images. A rectangle measuring 8×10 cm was drawn on a blank paper and corners were labeled as A, B, C, and D. The diagonals AC and BD were intersecting at point O. The distances AB and CD were 8 cm, and the distances BC and DA were 10 cm. Both diagonals measured 12.8 cm in length.

The angular measurements included <BAO, <DOA, <DAO, <DOC and <ABC. The exact linear and angular measurements as measured on the template are given in **Figure 2**, **Tables 1 and 2**.

Each of the 20 radiographs was photographed with a camera (S6500fd; Finepix, Fujifilm, Tokyo, Japan) hand held at a pre-

determined distance of 180 mm from the view box. The area that was not covered by the cephalogram was covered with a

brown paper to reduce the amount of light going towards camera. Photographs were taken in a relatively dim light without any artificial light source. Super Macro mode was selected which does not use flash and gives sharper image quality. The procedure was standardized by using the same focal length for all photographs. The film speed was ISO 400, and the aperture was set to F2.8. The high-quality images were saved in JPEG format and imported onto a computer to be digitized.

The same 20 radiographs were then scanned with a flatbed color scanner (HP DeskJet 4625; Hewlett Packard). The software used to scan the radiographs was Software HP DeskJet Series 4620. The scanner resolution was 600dpi.The scanned images were saved in JPEG format.

The 40 images were then viewed on a system, and an operator digitized them. A digital imaging program (Facad digital imaging program version 3.5; Ilexis AB Blåklintsgatan 4 • SE-582 46 Linköping • Sweden) was used for digitization. A special cephalometric analysis was created specifically for the study which took into the consideration the parameters set for this study. The angular and linear parameters were then measured by the operator.

The data collected in the study is given in **Tables 3 to 6**.

Table 1

Linear measurements on template

Parameter	Measurement
AB	80 mm
BC	100 mm
CD	80 mm
DA	100 mm
AC	128 mm
BD	128 mm

Table 2

Angular measurements on template

Parameter	Measurement
<BAO	52°
<DOA	103°
<DAO	38°
<DOC	77°
<ABC	90

Table 3

Scanned cephalograms (Linear measurements)

X-ray film No.	AB (mm)	BC (mm)	CD (mm)	DA (mm)	AC (mm)	BD (mm)
1.	80.3	99.6	80.4	100.4	129.9	130.0
2.	80.2	99.6	80.0	100.6	128.7	129.1
3.	79.8	100.4	80.0	100.3	128.3	129.2
4.	80.4	99.6	80.2	100.0	129.9	129.0
5.	80.4	98.8	80.6	100.0	129.7	128.5
6.	80.6	99.6	80.0	99.6	128.7	128.9
7.	80.2	99.3	80.0	100.4	129.9	128.5
8.	80.2	98.4	80.4	100.0	128.8	129.2
9.	80.4	98.8	80.2	100.9	129.3	129.9
10.	80.6	100.1	80.6	100.0	128.3	130.0
11.	79.8	100.4	80.4	100.0	129.8	130.0
12.	79.6	100.0	80.2	99.6	129.4	129.1
13.	80.4	100.0	80.8	100.0	128.7	129.8
14.	80.0	99.2	80.6	100.0	128.0	129.1
15.	80.0	99.6	79.8	100.3	128.9	129.4
16.	80.8	99.3	79.6	100.0	128.4	129.0
17.	79.8	99.6	79.6	100.0	129.5	129.9
18.	79.6	100.1	79.8	100.9	128.8	129.9
19.	79.8	100.0	80.4	100.0	128.2	129.2
20.	79.8	100.0	80.4	100.0	129.5	129.2

Table 4

Scanned cephalograms (Angular measurements)

X-ray film No.	<BAO (˚)	<DOA (˚)	<DAO (˚)	<DOC (˚)	<ABC (˚)
1.	51.8	103.1	38.1	77.0	89.9
2.	51.9	102.9	38.3	77.0	89.9
3.	51.5	102.9	37.9	77.4	89.0
4.	51.8	102.8	38.0	76.8	90.0
5.	51.9	103.0	38.0	76.9	90.0
6.	51.9	103.0	37.8	77.0	90.0
7.	51.9	102.7	38.4	77.2	90.0
8.	51.7	102.5	38.5	77.2	89.8
9.	51.5	102.8	38.1	77.4	89.7
10.	51.9	102.9	38.3	77.4	90.3
11.	51.8	103.1	38.6	77.0	89.8
12.	51.7	103.1	38.5	77.0	89.8
13.	51.7	102.9	38.0	76.8	89.9
14.	51.4	102.8	38.0	76.9	90.0
15.	51.5	102.8	38.4	76.9	90.0
16.	51.5	102.9	38.2	76.9	89.6
17.	51.9	102.9	38.2	76.9	89.3
18.	51.9	102.8	38.4	76.8	89.6
19.	51.9	102.5	38.0	77.1	89.3
20.	51.9	102.5	37.6	77.4	89.8

Table 5

Photographed cephalograms (Linear measurements)

X-ray film No.	AB (mm)	BC (mm)	CD (mm)	DA (mm)	AC (mm)	BD (mm)
1.	80.7	99.6	81.1	100.0	128.7	128.3
2.	80.9	99.6	80.1	100.0	128.0	129.1
3.	83.3	100.8	79.7	100.3	128.8	130.1
4.	83.6	99.6	79.6	99.6	128.6	128.7
5.	81.7	99.6	80.9	100.4	128.9	129.2
6.	82.1	99.2	80.1	100.4	128.8	128.5
7.	80.8	99.3	80.1	100.3	128.2	129.0
8.	81.4	98.4	80.0	100.0	127.5	129.4
9.	81.6	99.7	80.4	100.0	128.3	129.1
10.	81.9	99.2	80.3	99.6	127.7	127.5
11.	81.9	99.3	79.8	100.0	128.1	128.9
12.	80.7	98.6	79.7	99.6	128.9	128.5
13.	81.7	100.4	80.8	100.4	128.6	127.9
14.	82.3	100.1	81.1	100.0	129.5	128.8
15.	81.7	99.2	81.3	100.9	128.6	129.3
16.	82.4	100.0	81.2	100.0	128.9	129.9
17.	81.9	98.8	79.6	100.0	127.4	129.9
18.	82.7	100.1	80.7	99.6	129.5	129.2
19.	81.6	99.2	79.8	99.6	128.6	128.8
20.	80.7	99.3	80.3	100.0	127.5	129.0

Table 6
Photographed cephalograms (Angular measurements)

X-ray film No.	<BAO (˚)	<DOA (˚)	<DAO (˚)	<DOC (˚)	<ABC (˚)
1.	51.1	101.3	39.0	78.3	89.4
2.	51.5	103.1	38.5	77.8	89.0
3.	51.5	102.0	37.8	78.6	89.0
4.	51.1	103.1	37.8	77.8	88.4
5.	51.8	101.6	38.4	78.6	90.3
6.	51.9	101.8	37.8	78.2	88.8
7.	51.5	101.5	39.1	79.1	89.7
8.	50.8	101.7	38.9	78.1	89.0
9.	51.0	101.7	38.8	77.9	89.3
10.	50.7	101.9	39.2	78.1	89.3
11.	50.7	101.7	38.9	78.5	88.7
12.	51.1	103.1	37.8	77.8	90.3
13.	51.9	102.6	38.8	78.2	89.3
14.	51.2	102.1	38.3	79.0	89.0
15.	51.3	101.8	38.6	78.4	89.4
16.	50.8	101.9	38.5	79.0	88.9
17.	50.9	102.6	39.2	79.4	88.6
18.	50.9	101.8	38.5	78.1	89.0
19.	51.3	102.1	38.8	77.8	88.7
20.	51.5	101.7	38.8	78.1	88.7

STATISTICAL ANALYSIS

Descriptive statistics were calculated for the 2 sets of data. The paired student t test was used to determine whether there was any statistically significant difference between the photographed and scanned images of the cephalograms.

RESULTS

The results of descriptive statistics with paired t tests are shown in **Tables 7 and 8**. **Table 7** gives the results or the angular measurements. Generally, the means of photographed images are slightly larger for all variables when compared with the scanned images. Also the standard deviations for scanned images were less than that of the photographed images from the actual values. **Table 8** shows the results for the linear measurements. As for the angular measurements, the means of photographed images are slightly larger for all variables when compared with the scanned images. The standard deviation for angular measurements in both the cases is not measurably deviated.

DISCUSSION

The results in **Table 7** show that the differences between angular measurements when the radiograph isscanned or photographed before digitization are notstatistically significant. Photographing an image before digitization rather than the much more time-consuming process of using a flatbed scanner makes no significant difference with regard to the angular measurements. Therefore, photographing and digitizing a cephalogram can be considered an acceptable technique.

The results in **Table 8** show that the difference in linear measurements taken was significantly deviated from actual values when radiographs were photographed. This means that it might not be acceptableto take a photograph of an image before digitization when linear measurements are the primary measurements required.

Thus, the null hypothesis can be rejected, and it can be stated that there is a statistically significant difference between the linear measurements taken from digitization of a flatbed scanned image of alateral cephalometric radiograph compared with digitization of an image recorded with a digital camera.

Table 7

Descriptive analysis of angular measurements

	Scanned images		Photographed images	
Variable	Mean (°)	SD	Mean (°)	SD
<BAO	51.8	0.17	51.23	0.38
<DOA	102.8	0.17	102.05	0.55
<DAO	38.1	0.22	38.5	0.47
<DOC	77.05	0.20	78.4	0.48
<ABC	89.7	0.31	89.14	0.51

Table 8

Descriptive analysis of linear measurements

	Scanned images	Photographed images		
Variable	Mean (mm)	SD	Mean (mm)	SD
AB	80.1	0.35	81.8	0.79
BC	99.6	0.53	99.5	0.60
CD	80.2	0.34	80.3	0.58
DA	100.1	0.35	100.3	0.35
AC	129.0	0.64	128.4	0.58
BD	129.3	0.50	128.9	0.65

The primary reason for taking the angular measurements from the predetermined rectangle was to minimize the error of sample, as the age group of patients was not preset. Patients from different age groups will have significantly different positions of skeletal landmarks which would have produced a false positive result.

Coming to the scanner settings, to get high quality images one has to scan the image in a higher settings (>1200 dpi). However, this scanning takes a longer time and also the image produced will be consuming a larger space while storing. And also, each value of photographed image showed magnification in different directions and regions of cephalometric radiograph. This could be because of the cephalometric radiograph and camera lens were not absolutely parallel to each other.

CONCLUSION

It is found out that the digital format of cephalometric radiographs was magnified after taking the digital photographs. If, only angular measurements are to be considered, then there is no difference in the digital format produced after taking the photograph or after scanning the radiograph. Taking a photograph will be a convenient and time saving method for digitization. However, further studies have to be carried out to standardize the limitations of photography stated in this article.

Scanned format of analog cephalometric radiographs can be dependable for analyzing it with digital imaging softwares. However, the quality and the time factor have to be considered if this method is used in day to day practice. The size of the scanned files becomes very large to store on a personal computer, because the radiographs have to be scanned at a higher resolution. The whole point of converting the analog films into a digital format is to save storage space and also for further references like for pre-and post-treatment comparison. And also for any legal requirements in the future.[3-5]

The purpose of this study was to find out a reliable method, which can be used chair-side, in a daily practice for taking various cephalometric measurements on a software. It is not possible for every clinician to invest in a digital OPG machine or a cephalostat to produce digital cephalograms. Hence, from the two methods that were compared here, taking a photograph proves to be advantageous for both reasons, practicality and reliability.

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