Comparison of measurements from photographed lateral cephalograms and scanned cephalograms

Jill Collins, Anwar Shah, Caroline McCarthy, and Jonathan Sandler

Chesterfield and Sheffield, United Kingdom

Introduction: In this study, we investigated whether a digital photograph of a lateral cephalometric radiograph can produce measurements as accurate as those from a digital image created with a flatbed scanner. Methods: Twenty pretreatment lateral cephalograms were randomly selected from the patient files at Chesterfield Royal Hospital. Each radiograph was photographed with a digital camera and scanned with a flatbed scanner. Both images were digitized with imaging software (Dolphin, Chatsworth, Calif). Common cephalometric analyses were performed on both images, and the measurements were recorded. The paired Student t test was used to test for statistically significant differences between the measurements of the images. Results: Angular measurements were not significantly different between the photographed and scanned images, but linear measurements were. Conclusions: It is acceptable to use digital photographs of cephalograms if angular measurements are primarily required. However, these images might not be acceptable if linear measurements are needed. (Am J Orthod Dentofacial Orthop 2007;132:830-3)
Our null hypotheses were (1) that there is no difference between the angular measurements taken from digitization of a flatbed scanned image of a lateral cephalometric radiograph compared with digitization of an image recorded with a digital camera, and (2) there is no difference between the linear measurements (distortion) taken from digitization of a flatbed scanned image of a lateral cephalometric radiograph compared with digitization of an image recorded with a digital camera.

MATERIALS AND METHODS

Twenty pretreatment lateral cephalograms were randomly selected from the files of patients treated at Chesterfield Royal Hospital in the United Kingdom.

Each radiograph was marked at 4 locations (A, B, C, and D) to identify 4 landmarks (Fig). This was done to measure the linear distances to determine any distortion in the recording of the images. A pin was used to mark these points on the actual radiograph. Each point was at a standard predetermined distance from the other points. Once marked with a pin, a small white circular sticker was placed over the hole, and the sticker was punctured in the same place with the pin. The white sticker was used to identify the exact landmark once the radiographs were scanned or photographed. A template of the predetermined distances—AB, BC, CD, and DA—was used for calibration. The pinholes were a standard distance apart and identified on the scanned and photographed images. The distances AB and CD were 7 cm, and the distances BC and DA were 9 cm.

Each of the 20 radiographs was photographed with a camera (S1; Fuji, Tokyo, Japan) hand held at a predetermined distance of 107 cm from the light box. The light box was illuminated, the camera flash was turned off, and the fine setting (1440 × 880 pixels) was used. The procedure was standardized by using the same focal length for all photographs. The film speed was ISO 400, and the aperture was set at F8 to allow a shutter speed of 1/90 second to avoid camera shake. The images were changed to gray scale by using Adobe Photoshop (version 7; Adobe, Edinburgh, United Kingdom) and saved with minimum compression. 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 (UMAX Astra 2400s; UMAX Technology, Fremont, Calif). The software used to scan the radiographs was Software ImageFolio LE (version 4.1.7; ImageFolio, Dallas, Tex). The scanner speed was 42.2 seconds/A4 at 600 dpi resolution. After initially being saved as TIFF documents, they were converted to JPEG format. Compressing a TIFF document to a JPEG format saves storage space, and they do not lose enough detail to significantly affect the diagnostic quality of the image when standard compression settings are used.2

Again, these high-quality images were converted from color to gray scale in Adobe Photoshop with minimum compression. Gray scale is important because landmarks are more easily identified by evaluation of the differing shades of gray rather than by looking at color images; also, these images are less memory hungry when stored on the computer.

The 40 images were then randomly viewed on a screen, and an operator (C.M.) blind to the study digitized them. An imaging software program (version 9; Dolphin, Chatsworth, Calif) was used for digitization. A modified version of the Chesterfield cephalometric analysis was used; it included commonly used angular measurements. The operator then repeated the measurements on 10 images with a 1-week interval between the measurements.

The cephalometric measurements included the following angular measurements: SNA angle, SNB angle, ANB angle, upper incisor to maxillary plane angle (UI: MxPl), lower incisor to mandibular plane angle (LI:
MnPl), and maxillary to mandibular plane angle (MxMn).

The linear measurements to test for distortion were made with the 4 points A, B, C, and D; the linear measurements were AB, BC, CD, DA, AC, and BD. AC and DC were diagonal measurements (Fig).

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. The intraclass correlation coefficient test was used to check the reliability of the measurements.

RESULTS

The results of the intraclass correlation coefficient test for the reliability of measurements showed SNA angle = 88°, SNB angle = 94°, U1:MxPl = 96°, L1:MnPl = 88°, Mx:Mn = 98°. Thus, agreement of the first and second measurements was very good.

The results of descriptive statistics with paired t tests are shown in Tables I and II. Table I gives the results for the angular measurements. Generally, the means of photographed images are slightly larger for all variables when compared with the scanned images. However, no variable was significantly different, as shown by the P values (<.05).

Table II 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. All variables were significantly different, as shown by the P values. Only variable BC approached significance (P = .10).

DISCUSSION

The correlation coefficients showed that our results were good. Fleiss7 stated that error variations below 25% might be considered excellent reliability, error variations between 25% and 60% represented good to fair reliability, and values above 60% showed poor reliability. In our study, the errors were between 2% and 12%, and the intraclass correlation coefficients ranged from 0.88 to 0.98.

The results in Table I show that the differences between angular measurements when the radiograph is scanned or photographed before digitization are not statistically 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 first null hypothesis can be accepted—that there is no difference between the angular measurements taken from digitization of a flatbed scanned image of a lateral cephalometric radiograph compared with digitization of an image recorded with a high-quality digital camera.

When interpreting the standard deviations, one must remember that the maxillary and mandibular planes were constructed on the radiograph, drawn between 2 points, and these are sometimes difficult to locate. Also, there are 4 points to digitize to measure the MxMn, U1:MxPl, and L1:MnPl angles, instead of 3 points to measure the SNA, SNB, and ANB angles. This, together with the fact that incisor apices are notoriously difficult to identify, might cause the variation in results to increase.

The results in Table II show that the difference in linear measurements recorded were statistically significant (P >.05) when the radiograph was scanned or photographed before digitization. Only 1 difference in measurement was not statistically significant: the measurement BC. This means that it might not be acceptable to take a photograph of an image before digitization when linear measurements are the primary measurements required. The null hypothesis can be
retested, 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 a lateral cephalometric radiograph compared with digitization of an image recorded with a digital camera.

The measurements AB and CD are horizontal components, and BC and DA are vertical components. The measurements AC and BD have both horizontal and vertical components and can be described as transverse measurements. The total mean differences in the horizontal components AB and CD were 1.01 and 1.61 mm, respectively, and the vertical measurements BC and DA had total mean differences of 0.50 and 1.20 mm, respectively. The total mean differences for the transverse measurements AC and BD were 1.78 and 1.40 mm, respectively. In each instance, the photographed images were magnified. The percentage of magnification varied over different directions and regions of the cephalometric image. This could be because the cephalometric radiograph and the camera lens were not absolutely parallel to each other when the image was captured.

The aim of these linear measurements was to check for any distortion introduced with either technique used for recording the digital images in this study. One can interpret the results as demonstrating distortion when the digital camera was used.

No direct comparison of our results of photographed image magnification is possible because no data are available in the literature. However, a recent study reported a vertical enlargement of 0.5% and a horizontal reduction of 0.3% when an analog film was converted to digital format with an Expression 1600 scanner. This is different from our results, which showed magnification in both the horizontal and vertical components of the photographed images.

The identification of fiducial points themselves has been found to be accurate only to within 0.5 mm when identified with a mouse and a crosshair on a digitized image. Taking this into account and the fact that, for the horizontal and vertical measurements, the standard deviations are all greater than 1.0 ($P < .05$, except for BC), it can be stated that photographed images should not be used for cephalometric analysis when linear measurements are required.

CONCLUSIONS

There is magnification of the cephalometric images when a digital photograph is taken with a camera. When recording angular measurements from cephalograms, there is no difference in the values whether the radiograph is scanned or photographed before digitization. With linear measurements, however, the magnification introduced because the images were photographed can affect the linear measurements significantly.

Photographing a lateral cephalogram radiograph before digitization should be done with caution, because linear measurements might not be accurately recorded.

REFERENCES