CEPHALOMETRICS: AN OVERDUE EVALUATION

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ABSTRACT

The purpose of this study was to evaluate the accuracy and reliability of some cephalometric soft tissue linear measurements obtained from conventionally traced cephalograms with equivalent taken directly out from the patients’ faces. This study was conducted on eleven orthodontic patients. Small pieces of orthodontic wires were fixed on five soft tissue landmarks located in the midline of the face of each patient. Five linear measurements were taken directly on each patient’s face using electronic Boley gauge to the nearest 0.05mm. Lateral cephalometric view was taken for each patient with the small pieces of wires fixed on his face. Using the same caliper, the previously mentioned linear measurements were retaken out from the traced cephalograms as these points would appear as distinct radio opaque points on each radiograph. The two sets of readings of both the direct and the cephalometric measurements were statistically analyzed using the Concordance Correlation Coefficient and Pearson Correlation Coefficient. Based on the results obtained from this study, the following conclusions could be drawn: A) Soft tissue analysis showed that we could not rely on linear soft tissue measurements extracted from lateral cephalometric radiographs as a representation of a particular patient. B) A single magnification factor could not be applied as a correction agent for the lateral cephalometric soft tissue measurements for all the patients and even within the same patient.

INTRODUCTION

Cephalometry, “scientific measurement of the head dimensions” was the first method to prove of value in orthodontics. A further method for the analysis of craniofacial dimensions that developed on the basis of cephalometry is “cephalometric radiography”.

Credit for standardizing and popularizing the cephalometrics goes to Broadbent (1931)¹ whose classic paper was received with great interest throughout orthodontics. Hofrath simultaneously and independently developed the same standardized methods for the production of cephalometric radiographs, using special holders (cephalostats), to permit assessment of growth and treatment response².

Cephalometric radiography has become quite important for both clinicians and researchers, especially
those studying craniofacial growth. Over the years, a variety of methods have been established for the analysis of lateral cephalograms (Tweed, 1946; Downs, 1948; Graber, 1952; Ricketts, 1966). However, because of the erroneous assumptions that are inherent to traditional two dimensional cephalometry, use of this method for deriving clinical information as a basis for determining treatment plans has been questioned.

First of all, a conventional head film is a two-dimensional representation of a three-dimensional object. When a three-dimensional object is represented in two dimensions, the imaged structures are displaced vertically and horizontally. The amount of structural displacement is proportional to the distance of the structures from the film or recording plane.

Moreover, cephalometric analyses are based on the assumption of perfect superimposition of the right and left sides about the midsagittal plane. Perfect superimposition is observed infrequently because facial symmetry is rare and because of the relative image displacement as described previously. These inherent technical limitations do not produce an accurate assessment of craniofacial abnormalities and facial asymmetries.

Another important factor in this issue is the significant amount of external error, known as radiographic projection error, that is associated with image acquisition. These errors include size magnification, error in patient positioning, and projective distortion inherent to the film-patient-focus geometric relationships. In addition, manual data collection and processing in cephalometric analysis have been shown to have low accuracy and precision.

A significant error is also associated with ambiguity in locating anatomic landmarks because of the lack of well-defined anatomic features, outlines, hard edges and shadows, and variation in patient position.

Such landmark identification errors are considered major source of cephalometric errors. Landmark identification errors may arise due to the uncertainty involved in locating specific anatomic landmarks on the radiograph.

Despite these limitations of cephalometry, many cephalometric analyses have been developed to help diagnose skeletal malocclusions and dentofacial deformities. However, several investigators have questioned the scientific validity of such analyses with the existence of these limitations.

The aim of this investigation was to evaluate the accuracy and reliability of some linear cephalometric soft tissue measurements obtained from conventionally traced cephalograms with equivalent taken directly out from the patients’ faces.

**MATERIAL AND METHODS**

Eleven Orthodontic patients were selected randomly from the outpatient clinic of Orthodontic Department, Faculty of Oral and Dental Medicine, Cairo University to participate in this study.

Small pieces of orthodontics wires were fixed on five soft tissue landmarks using sticky transparent tape located in the midline of the face of each patient (Fig.1) which are:

- **G**: glabella: The most prominent anterior point in the midsagittal plane of the forehead.
- **N**: soft tissue nasion: The point of greatest concavity in the midline between the forehead and the nose.
- **SLS**: superior labial sulcus: The point of greatest concavity in the midline of the upper lip between subnasale and labrale superius
- **ILS**: inferior labial sulcus: The point of greatest concavity in the midline of the lower lip between labrale inferius and soft tissue pogonion.
- **ME**: soft tissue menton: The lowest point on the contour of the soft tissue chins.

Five linear measurements were taken directly on each patient’s face using the electronic Boley gauge to the nearest 0.05 mm, G-N, N-SLS, N-ILS, N-ME and SLS-ME. (Fig. 2)
Lateral cephalometric view was taken for each patient with the small pieces of orthodontics wires fixed on his face using the same electronic Boley gauge, the previously mentioned linear measurements were retaken while tracing the cephalometric radiographs as these points would appear as distinct radio opaque points on each radiograph. (Fig.3)

For reliability of the testing, replication of the measurements was done by the same observer. These intra-observer measurements were done one day after the first set of measurements was attained for both the direct and the cephalometric measurements.

The data were collected, tabulated and analyzed. A reproducibility index, called the Concordance Correlation Coefficient (CCC), introduced by Lin was used. It evaluates the agreement between 2 readings (from the same sample) by measuring the variation for the 45° line through the origin (the concordance line). CCC contains the measurements of accuracy and precision. Concordance Correlation Coefficient (CCC) and the Pearson Correlation Coefficient (PCC) were used to evaluate the equivalence and association respectively, between the direct and cephalometric measurements. Reproducibility of measurements for intra-examiner measurements were assessed with the CCC and PCC statistical test.
RESULTS

The results and consequent comparison between the direct measurements and the cephalometric measurements are represented in Table (I), and Fig (4). Results were compared for conformity and equivalency using Concordance Correlation Coefficient (CCC) and Pearson Correlation Coefficient (PCC) tests respectively.

For all the five linear measurements the CCC and PCC revealed a fair agreement between the two measuring modalities (direct and cephalometric measurements).

For the G-N measurements the CCC test was 0.633 while the PCC test was 0.941.

For the N-SLS measurements the CCC test was 0.306 while the PCC test was 0.935.

For the N-ILS measurements the CCC test was 0.342 while the PCC test was 0.938.

For the N-Me measurements the CCC test was 0.108 while the PCC test was 0.177.

For the SLS-Me measurements the CCC test was 0.486 while the PCC test was 0.894.

Intra-observer error assessment represented in Tables (II), and Fig. (5) depicted an excellent correlation between the intra-observer measurements for the direct and cephalometric measuring techniques. The CCC for the intra-observer values ranged from 0.978 to 0.998, while the PCC for the same parameter ranged from 0.978 to 0.998.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>CCC</th>
<th>PCC</th>
</tr>
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<tbody>
<tr>
<td>D</td>
<td>11</td>
<td>34.931</td>
<td>4.103</td>
<td>0.633**</td>
<td>0.941</td>
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<td>5.197</td>
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<td>6.616</td>
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<td>58.360</td>
<td>5.223</td>
<td>0.486**</td>
<td>0.894</td>
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</table>

All measurements are represented in millimeters. SD = Standard Deviation

**= 0.4 > p < 0.75 = Fair agreement

***= p < 0.4 = Poor agreement

CCC = Concordance Correlation Coefficient

PCC = Pearson Correlation Coefficient

D = Direct measurement

CEP = Cephalometric measurement

Fig. (3) Showing measuring the same linear measurements on cephalometric radiographs using electronic Boley gauge.

TABLE (I) Represents Concordance Correlation Coefficient (CCC) and Pearson Correlation Coefficient (PCC) tests of the 2 methods.
TABLE (II) represents Concordance Correlation Coefficient (CCC) and Pearson Correlation Coefficient (PCC) tests of intra observer error assessment.

<table>
<thead>
<tr>
<th>Measurements</th>
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<th>S.D.</th>
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<th>PCC</th>
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*Obs1 = First observation  Obs2 = Second observation  * = Excellent agreement

On measuring the percentage of magnification, the results showed that the magnification factor was not constant between different patients and even within the measurements of the same patient Table (III).

TABLE (III): Percentage of magnification between the direct and cephalometric measurements.

<table>
<thead>
<tr>
<th>Subject</th>
<th>G-N</th>
<th>N-SLS</th>
<th>N-ILS</th>
<th>N-Me</th>
<th>SLS-Me</th>
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<td>1</td>
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<tr>
<td>4</td>
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<td>13.47</td>
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<tr>
<td>5</td>
<td>14.43</td>
<td>14.79</td>
<td>13.92</td>
<td>14.19</td>
<td>13.64</td>
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<tr>
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<td>10.66</td>
<td>11.19</td>
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<td>11.61</td>
<td>11.53</td>
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<tr>
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DISCUSSION

In contemporary orthodontics, quantitative, systematic, and objective measurements based on hard and soft tissue landmarks determined on cephalometric films are used on a daily basis. Precision and reproducibility in data obtained from cephalometrics is important for the orthodontist. Errors in conventional methods arise from radiographic acquisition, landmark identification, and measurement\textsuperscript{18-20}.

In cephalometry, the validity of the measurements must be ascertained by comparing the measurements from cephalograms with measurements made directly on the same skull in case of hard tissue measurements and directly on the same face in case of soft tissue measurements\textsuperscript{21}.

In this study, the five selected soft tissue landmarks were all located in the midline of the face; in order to avoid superimposition of these landmarks while cephalometrically imaging the patients. Moreover, only five soft tissue linear measurements were tested for their accuracy between the two methods since the accuracy would not be clear for the angular measurements that would be relatively unchanged.

Magnification, inherent to the technique of radiographic projection, must be considered when comparing cephalometric data from different sources. This applies to linear dimensions only, because magnification resulting from radiographic projection is proportional and hardly affects angular values. The literature is excellent for single radiograph methodology\textsuperscript{22-23}, yet the issue of linear magnification between lateral cephalograms from different sources is largely ignored\textsuperscript{24}.

In this study, greater variability in repeated linear soft tissue cephalometric measurements was found when landmarks were identified directly on the patients’ faces compared to those taken out from the traced conventional films. Surprisingly, the percentage of magnification in our data was not constant, not only between the different cases, but even within the measurements of the same patient.
**CONCLUSIONS**

Based on the results obtained from this study, the following conclusions could be drawn:

1. Soft tissue analysis showed that we cannot rely on linear soft tissue measurements extracted from lateral cephalometric radiographs as a representation of a particular patient.
2. A single magnification factor cannot be applied as a correction agent for the lateral cephalometric soft tissue measurements for all the patients and even within the same patient.

**REFERENCES**