ACCURACY OF COMPUTER-ASSISTED CEPHALOMETRIC MEASUREMENTS: A COMPARATIVE STUDY

Mihnea IACOB¹, Sorana ROȘU², Irina ZETU³

¹, ³. Lecturer, PhD, Department of Orthodontics and Pedodontics, „Grigore T. Popa” University of Medicine and Pharmacy - Iasi
². PhD Student, Department of Preventive Dentistry, „Grigore T. Popa” University of Medicine and Pharmacy - Iasi
Corresponding author: mihneaiacob@yahoo.com

Abstract

Aim. The aim of the present study was to comparatively evaluate the accuracy of the results obtained by manual and computer-assisted tracing of a group of cephalometric radiographs.

Methods. A group of 60 initial cephalometric radiographs from 60 orthodontic patients, obtained on the same radiological device, was selected. The cephalometric radiographs were traced and measured using the classical (manual) method and the Orthalis cephalometric software, by the same examiner, using the parameters of Steiner and Tweed analysis.

Results. With a few exceptions, the computer-assisted tracing technique gave results with an accuracy similar to that of the manual, clinically acceptable technique.

Conclusions. The cephalometric tracing software represents a useful tool in both orthodontic diagnosis and treatment processes.

Keywords: cephalometric radiographs, computer-assisted measurements

1. INTRODUCTION

The cephalometric radiography, simultaneously introduced by Broadbent and Brodie in the USA, and by Hofrath in Europe, allows the orthodontist to evaluate the direction and quantity of the growth and development processes, as well the modifications owed to the different types of orthodontic treatment [1,2].

The most frequent interpretation technique for cephalometric radiographs is the manual procedure, involving the use of acetate paper and manual marking of the cephalometric landmarks and anatomical structures. The measurements are made with a ruler and a protractor. Although this technique has been long time utilized by orthodontic practitioners, it was observed that it presents an appreciable degree of error (projection errors, landmark identification and measurement errors) [3-6].

Steiner cephalometric analysis offers a series of specific measurements, useful in orthodontic diagnosis and treatment planning. Steiner also measured the necessary compromise of incisors position, as a function of intermaxillary discrepancy [7].

Charles Tweed determined the final position of the lower incisors on the mandible, determining the Tweed diagnostic triangle, which is the main element in total space analysis, performed to evaluate the need of orthodontic extractions [8].

In the final decades of the XXth century, a new tracing technique emerged, in which the orthodontist benefits from computer assistance. The cephalometric landmarks are identified by the human operator, yet all measurements are computerized [9].

The aim of the present study is to comparatively evaluate the accuracy of manual and computer-assisted cephalometric measurements, using the parameters of Steiner and Tweed cephalometric analysis.

2. METHODS

A group of 60 initial cephalometric radiographs, obtained from 60 untreated orthodontic patients (38 females, 22 males), with ages between 8 and 23 years, was randomly selected. The radiographs were taken with the same radiological device. The exclusion criteria were: poor head position, impacted or absent incisors, poor film quality.

All radiographs were traced on a light-box, in a dark room, using 0.003 inch acetate paper and a 0.5 mm pen. The contours of the soft tissues and the anatomical structures were traced, and the cephalometric landmarks were marked. For
each radiography, the parameters of Steiner and Tweed analysis were measured using a ruler and a protractor.

Prior to computer-assisted tracing, all radiographs were digitized by scanning (UMAX Powerlook 1000 scanner), at 300 DPI, 60 digital images, JPEG format, 2548x3510 pixels thus resulting. In the first stage, the digital images were calibrated by marking two points on the scale present in the radiography. The cranial and soft-tissue landmarks were marked on-screen by the same operator. The measurements were taken with the Orthalis cephalometric software. The obtained data were introduced into an Excell (Microsoft, Seattle, USA) spread sheet, and evaluated statistically with the SPSS version 17 (SPSS Inc., Chicago, Illinois, SUA) software.

All 60 radiographs were retraced, both by the manual and computer-assisted technique, by the same operator, at a 30 day interval. No statistically significant differences were identified between the two tracings.

For each cephalometric measurement (variable), the mean, standard deviation, standard error mean, 95% confidence interval of the difference were calculated. The t Student test was used to compare the manual tracing and computer-assisted mean values.

3. RESULTS

Evaluations of manual and computerized tracing measurements by Steiner and Tweed analysis are presented comparatively in tables 1, 2.

Table 1 – Differences between manual and computerized tracings, Steiner analysis

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 SNA - SNA_M</td>
<td>-1.700</td>
<td>3.346</td>
<td>.432</td>
<td>-2.564</td>
<td>-3.838</td>
<td>-3.935</td>
<td>59</td>
<td>.000</td>
</tr>
<tr>
<td>Pair 2 SNB - SNB_M</td>
<td>-850</td>
<td>2.065</td>
<td>.267</td>
<td>-1.384</td>
<td>-3.316</td>
<td>-3.188</td>
<td>59</td>
<td>.002</td>
</tr>
<tr>
<td>Pair 3 ANB - ANB_M</td>
<td>-1.056</td>
<td>2.087</td>
<td>.284</td>
<td>-1.625</td>
<td>-4.868</td>
<td>-3.717</td>
<td>59</td>
<td>.000</td>
</tr>
<tr>
<td>Pair 4 SND - SND_M</td>
<td>-.883</td>
<td>1.984</td>
<td>.256</td>
<td>-1.396</td>
<td>-3.71</td>
<td>-3.449</td>
<td>59</td>
<td>.001</td>
</tr>
<tr>
<td>Pair 5 1/NA mm - 1/NA mm</td>
<td>-.117</td>
<td>3.499</td>
<td>.452</td>
<td>-1.020</td>
<td>.787</td>
<td>-2.258</td>
<td>59</td>
<td>.797</td>
</tr>
<tr>
<td>Pair 6 1/NB mm - 1/NB mm</td>
<td>.033</td>
<td>2.393</td>
<td>.309</td>
<td>-5.85</td>
<td>.652</td>
<td>.108</td>
<td>59</td>
<td>.797</td>
</tr>
<tr>
<td>Pair 7 1/NA grade - 1/NA grade</td>
<td>.517</td>
<td>4.942</td>
<td>.638</td>
<td>-7.60</td>
<td>1.793</td>
<td>.810</td>
<td>59</td>
<td>.421</td>
</tr>
<tr>
<td>Pair 8 1/NB grade - 1/NB grade</td>
<td>-.729</td>
<td>6.888</td>
<td>.897</td>
<td>-2.524</td>
<td>1.066</td>
<td>-8.13</td>
<td>59</td>
<td>.420</td>
</tr>
<tr>
<td>Pair 9 PG/NB - Pg/NB</td>
<td>.200</td>
<td>2.276</td>
<td>.294</td>
<td>-3.88</td>
<td>.788</td>
<td>.681</td>
<td>59</td>
<td>.499</td>
</tr>
<tr>
<td>Pair 10 SNOc - SNOc_M</td>
<td>-.2533</td>
<td>3.149</td>
<td>.406</td>
<td>-3.347</td>
<td>-1.720</td>
<td>-6.232</td>
<td>59</td>
<td>.000</td>
</tr>
</tbody>
</table>

Table 2 – Differences between manual and computerized tracings, Tweed analysis

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error</th>
<th>Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1 FMIA - FMIA_M</td>
<td>-.2267</td>
<td>8.309</td>
<td>1.073</td>
<td>-4.413</td>
<td>-1.120</td>
<td>-2.113</td>
<td>59</td>
<td>.039</td>
</tr>
<tr>
<td>Pair 2 FMA - FMA_M</td>
<td>.933</td>
<td>4.769</td>
<td>.616</td>
<td>-.299</td>
<td>2.165</td>
<td>1.516</td>
<td>59</td>
<td>.135</td>
</tr>
<tr>
<td>Pair 3 IMPA - IMPA_M</td>
<td>2.745</td>
<td>5.653</td>
<td>.792</td>
<td>1.155</td>
<td>4.335</td>
<td>3.468</td>
<td>59</td>
<td>.001</td>
</tr>
<tr>
<td>Pair 4 SNA - SNA_M</td>
<td>-.450</td>
<td>3.181</td>
<td>.411</td>
<td>-1.272</td>
<td>.372</td>
<td>-1.096</td>
<td>59</td>
<td>.278</td>
</tr>
<tr>
<td>Pair 5 SNB - SNB_M</td>
<td>-.367</td>
<td>2.617</td>
<td>.338</td>
<td>-3.09</td>
<td>1.043</td>
<td>1.085</td>
<td>59</td>
<td>.282</td>
</tr>
<tr>
<td>Pair 6 ANB - ANB_M</td>
<td>-.683</td>
<td>2.432</td>
<td>.314</td>
<td>-1.312</td>
<td>-.055</td>
<td>-2.176</td>
<td>59</td>
<td>.034</td>
</tr>
<tr>
<td>Pair 7 Ao/Bo - AoBo_M</td>
<td>1.183</td>
<td>2.819</td>
<td>.364</td>
<td>.455</td>
<td>1.912</td>
<td>3.251</td>
<td>59</td>
<td>.002</td>
</tr>
<tr>
<td>Pair 8 Z - Z_M</td>
<td>-.2983</td>
<td>7.299</td>
<td>.942</td>
<td>-4.869</td>
<td>-1.098</td>
<td>-3.166</td>
<td>59</td>
<td>.002</td>
</tr>
<tr>
<td>Pair 9 UL - UL_M</td>
<td>2.000</td>
<td>2.123</td>
<td>.274</td>
<td>1.451</td>
<td>2.549</td>
<td>7.296</td>
<td>59</td>
<td>.000</td>
</tr>
<tr>
<td>Pair 10 TC - TC_M</td>
<td>-.200</td>
<td>2.413</td>
<td>.312</td>
<td>-.823</td>
<td>.423</td>
<td>-.642</td>
<td>59</td>
<td>.523</td>
</tr>
<tr>
<td>Pair 12 Ha - Ha_M</td>
<td>13.400</td>
<td>5.126</td>
<td>.662</td>
<td>12.076</td>
<td>14.724</td>
<td>20.248</td>
<td>59</td>
<td>.000</td>
</tr>
</tbody>
</table>
4. DISCUSSION

Accuracy represents a critical aspect of every scientific measurement. In orthodontic clinical situations, a degree of accuracy below 2°, respectively 2 mm, is considered acceptable [10].

Investigations on the accuracy of both manual and computer-assisted cephalometric measurements have been developed by numerous researchers [11-18].

The initial studies were focused on testing the repeatability of each landmark position, the landmark identification errors being the most frequent.

More recent researches aim at comparing the measurements results, rather than landmark position [19-28].

A comparative evaluation revealed that, for Steiner analysis, five parameters: SNA, SNB, ANB, SND and SNOcl angles, presented statistically significant differences between the manual and computer-assisted tracings. The differences seem to be caused by the difficult identification of point A, and especially Na (involved in all five measurements), as also reported by other authors. With the exception of the SNOcl angle, all other measurements evidenced differences below ±2°, which are clinically acceptable.

Statistically significant differences for SNA, SNB an ANB angles were also reported by Gregston and McClure [7, 18, 29].

For Tweed analysis measurementts, the statistically significant differences involved : FMIA, IMPA, ANB, Z angles and AoBo UL, Hp and Ha distances.

The mean differences for FMIA, IMPA and Z angles are higher than the clinical acceptance interval.

The large differences reported for the linear measurements might be caused by magnification.

These results agree with those reported by Saynsu, Kublashvili, Uysal, Polat and Celik [9, 20, 21, 29].

The Orthalis computer-assisted tracing grants a definite time economy, the operator assessing that the time needed for computer tracing is only 20% of the time allocated for manual tracing. On the other side, when working with Orthalis, the operator must identify a considerable amount of cranial and soft-tissue landmarks, 59 for Steiner and 55 for Tweed analysis, respectively. Even when all landmarks had been correctly drawn, the automatically traced bony and soft-tissue contours did not always perfectly superpose on the real ones. It is not possible to mark two landmarks placed at a distance smaller than 0.5 mm one from the other.

Previous comparative researches showed that the two tracing techniques gave similar, clinically acceptable results. For each cephalometric landmark, a specific indentifing error pattern exists, some landmarks (Na, Po, Ar, Ba, Go, Gn) being more difficult to identify [4, 10, 13, 23, 26, 27, 30, 31].

5. CONCLUSIONS

1. The computer-aided tracing technique measurements had an accuracy degree similar to that of the manual technique. With some minor exceptions, the results were clinically acceptable.

2. In the computer-assisted technique, Steiner analysis parameters showed a higher accuracy degree than Tweed analysis.

3. The cephalometric tracing sofware represents a useful tool for both orthodontic diagnosis and treatment processes. The main advantages are time economy and elimination of mathematical errors.

References


