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RESEARCH BRIEF

Comparison of Digital Cephalometric Tracing by Onyx Ceph Software versus Manual Method

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Abstract

Background: Cephalometric radiography is a valuable method for diagnosis, treatment design, and also for the study of growth and development of teeth and craniofacial complex. In addition to the above features, Onyx Ceph software has the ability to predict soft and hard tissue changes after jaw surgery and can be useful for orthodontists and surgeons. **Aim:** The purpose of this study was to compare the accuracy of linear and angular measurements between these programs and manual measurements.**Materials and Methods:** For this study, 30 cephalograms from 30 different patients of orthodontic candidates were selected. Initially, cephalometric analysis of printed stereotypes was performed manually and then using Onyx ceph v. 3.6 software. Eight angular measurements (FMA/IMPA/SNA/SNB/PNB/1.NA/1.NB/Y-AXIS) and four linear measurements (Co-Gn, Co-A, E-line lower lip, and LAFH). 10 lateral cephalograms were randomly selected and re-traced (5 cases manually and 5 digitally). Data were analyzed by *t*-test. **Results:** Regarding the results of the *t*-test, it was found that the measurements of the variables between the two groups were not statistically significant and these differences are significant only for the three variables: FMA, 1-NA, and 1-NB. Furthermore, there was no significant difference between any of the variables in these two different times for both manual and digital tracing methods. **Conclusion:** In this study, comparing the manual method and the digital method, there was only a significant difference between the FMA variables and there was no significant difference between the two periods of initial and recurrent trace. The results of this study showed that the digital tracing with the Onyx Ceph software had a same accuracy in comparison to manual tracing and could be used instead of the traditional methods. **Clinical Significance:** Due to the fact that digital tracing facilitates the tracing process and does not reduce accuracy, the use of these software could be recommended.

Keywords: Cephalometric measurements, digital tracing, lateral cephalometry, manual tracing, Onyx software

Introduction

5 years after the discovery of X-rays in 1900, price introduced radiography as an orthodontic diagnostic tool. From this, cephalometric radiographies of craniometric and anthropometric studies were adopted using the Burundi-Bolton Cephalometry which was designed in 1931.[1]

Cephalometric radiography is a valuable method for diagnosis, treatment design, and the study of the growth and development of teeth and skull.[2] Digital radiography has advantages over old methods, including reduced radiation dose, immediate radiographic image, darkroom removal and saving time and cost, storage and easy switching, facilitating consultation with other professionals, and the ability to improve images to meet specific needs.[3] These benefits can help in choosing a standard method for future cephalometric measurements.[4]

Murali and Sukumar conducted a study in 2011 on 80 patients with the aim of evaluating the accuracy of skeletal, dental, and soft tissue parameters in digital radiography using manual and computerized tracing techniques. According to the results of this study, most measurements between two manual tracing methods and the computer are not different.[5]

Mariane Bastos and Marcio Costa, in 2010, compared the linear and angular variables for cephalometrics, which were performed by hand and digital tracings using Dolphin11.0 software on lateral cephalometrics. There was no statistically significant difference for any of the variables between manual and digital tracings, and there was no difference between the manual and the angular variables of both the conventional and the computerized methods.[6]

A study in 2009 by Gallerano was conducted with the purpose of comparing the detected landmarks between two methods of manual and digital tracing, comparing measurements Software Quick Ceph 2000 with manual methods for variable angles, and comparing the superimposition of software Quick Ceph 2000 by Hand-drawn Tracing, accepted by the American Board of Orthodontics. The results of this study showed that there is no difference in the detection of cephalometric landmarks between the manual method and Quick Ceph 2000 software.[7]

The Onyx ceph software was first introduced in Germany. The computer program has the cutting edge graphic software, which provides an alternative way to run cephalometric tracing without the use of conventional cephalometric radiographs.[8] More than 120 linear and angular measurements used in orthodontics and surgery can be done with this software. The Onyx ceph software, in addition to the capability mentioned, allows archiving of all patient information, such as photographic and radiographic sets, quick access to information, and prediction of soft and hard tissue changes following maxillofacial surgery and can be useful for both orthodontists and surgeons.

The aim of this study was to compare the digital cephalometry with Onyx Ceph software and hand-held cephalometry, which is provided by the private radiology center archive in Mashhad.

Materials and Methods

A total of 30 lateral cephalogram radiographs were selected from the archives of the private radiology center with the following criteria:

- High-quality radiographs without any artifact which might interrupt with the locating of anatomic landmarks.
- Absence of any craniofacial deformity or asymmetry.
- Patient bite must be in maximum intercuspation.
- Patient must have all permanent teeth.
- In radiographs which have no interruption with locating anatomic landmarks.

All lateral ceph radiographs were taken under the same circumstances (Frankfort plane parallel to the earth and perpendicular to the sagittal plane) with the same digital device. All radiographs had the same magnification. After choosing the samples, all manual and digital tracings were done by one operator.

Manual tracing

To do manual tracing, at first, digital images printed on radiographic films with Fujifilm® FM-PDL printer. The acetate cellulose paper was attached to each radiograph and tracing was completed after placing them on a tracing negatoscope in a dark room using HB pencil. Despite the many details that could be traced, only the contours of the following structures were identified on radiography. A sample of tracing is shown in Figure 1. These structures were included:

- Anterior margin of the frontal bone.
- Frontonasal suture.
- Orbit (posterior inferior contour).
- Machine pouring.
- *Sella turcica*.
- Palatal bone (from autonomic nervous system to parasympathetic nervous system).
- Anterior contour of the maxilla.
- Posterior border of the mandibles ramus.
- Inferior border of the mandible.
- Anterior and posterior contour of the symphysis.
- Upper and lower central incisors which had the most protrusion.

Next, anatomical landmarks include machine pouring, Gn،Go،Me،Or،ANS،PNS،S،N،A،B،Co،Li, labial prominence of the central maxilla and mandible, and soft tissue Pog. The most prominent point of the nose was determined on any radiograph. After completing the tracing, lines and angles were drawn and linear measurements were made using ruler and angular measurements using the conveyor.

Digital tracing

Digital images are stored in JPEG quality format after being converted by Onyx Ceph V. 3.6 software. 19-inch LCD and a resolution of 1360 × 1018 pixels were used to view the image. Furthermore, if needed, software features such as brightness, contrast, and magnification were used to make landmarks more accurate. After radiographic selection and before landmark identification, the starting point and end of the ruler (30 mm) for each radiograph were determined to measure the calibrations based on the actual size of the images.

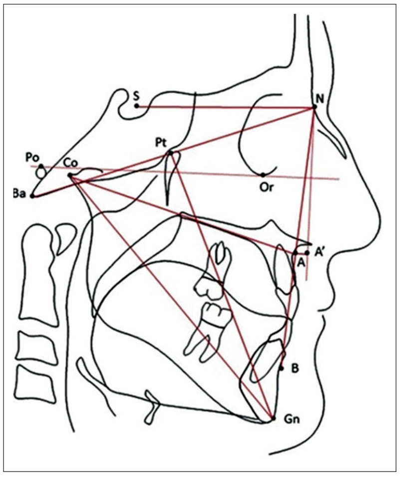

Figure 1: A template of tracing by which cephalometric measurements were evaluated

After specifying the landmarks, the software performed all measurements based on the predefined analysis, and after completing the data trending, the data were moved to Excel using the Export analysis item.

Measurement

Eight angular measurements (1.NA, 1.NB, SNA, SNB, ANB, IMPA, FMA, and Y-axis) and four linear measurements (Co-Gn, Co-A, E-line lower lip, and LAFH). Furthermore, 10 radiographs (5 samples for manual method and 5 samples for digital method) were selected randomly, and 20 days after the initial tracing, again by the same operator, to determine the other operator error in tracing, and the ability to repeat the measurements.

Statistical analysis

t-test was used to compare the measurements by manual and digital methods. Furthermore, measurements were performed again and compared with the initial measurements in both manual and digital methods by the paired *t*-test.

Results

Comparison between manual and digital variables, as well as data on primary and re-tracing (manual and digital), was performed using independent *t*-test.

Regarding the results of the *t*-test, it was found that the measurements of the variables between the two groups were not statistically significant and these differences are significant only for the three variables: FMA, 1-NA, and 1-NB. The results are shown in Table 1.

Comparison of initial and second manual tracing

20 days after the initial tracing, five radiographs were selected randomly and again traced manually. Data related to these measurements as well as the statistical comparison results are presented in the following table. The results of the paired *t*-test indicated that there were no significant differences in the measurements of any of the variables in the initial and second tracing with manual and digital methods. Results are shown in Table 2.

Compare initial and second digital tracing

After completing initial tracing with digital method, five lateral cephalograms were randomly selected, and 20 days later, they were again traced with the same method. Measurement data were compared using the paired *t*-test, which showed the results of this comparison. There was no significant difference between any of the variables in these two different times. Results are shown in Table 3.

Landmark diagnosis on digital images can be affected by various factors such as contrast, spatial resolution of the monitor, background luminescence, luminescence system, screen size, extra light in the room, and use of magnifying tools.[9]

Table 1: Comparison between the values of linear and angular variables obtained from manual and digital methods

	Digital tracing	Manual tracing	
Variable	Mean±SD	Mean±SD	***P*** value
SNA	75.55±5.31	81.07±4.57	0.624
SNB	74.84±4.15	77.33±17.03	0.335
ANB	0.71±1.18	3.74±2.1	0.051
FMA	29.65±6.23	3.67±6.4	0.019
IMPA	91.85±6.13	89.19±7.65	0.588
Y-axis	63±13.42	54.67±4.56	0.116
1-NA	8.95±2.22	5.37±2.92	0.0086
1-NB	5.01±2.05	5.95±2.16	0.036
CO-GN	109.77±6.99	104.14±16.33	0.411
CO-A	84.01±20.53	77.38±15.36	0.603
E Line-lower lip	2.42±1.82	2.73±1.49	0.099
LAFH	73.31±4.86	64.86±11.05	0.325

SD: Standard deviation

Table 2: Comparison between values of linear and angular variables obtained from manual method at T1 and T2 times

Variable	Mean±SD		***P*** value
	Initial tracing (T1)	Second tracing (T2)	
SNA	76.72±3.58	74.38±4.25	0.225
SNB	74.82±3.31	74.76±3.17	0.231
ANB	2.43±2.44	1.26±1.05	0.231
FMA	30.22±5.08	29.08±6.31	0.463
IMPA	90.98±7.78	92.72±7.98	0.246
Y-axis	63.84±2.42	62.16±4.82	0.345
1-NA	8.61±4.12	9.3±4.53	0.617
1-NB	5.6±2.49	4.4±1.53	0.247
Co-Gn	112.08±29.48	107.46±5.22	0.417
Co-A	90.85±28.9	77.18±30.33	0.382
E line-lower lip	2.66±1.76	2.18±1.78	0.183
LAFH	75.07±20.93	71.56±14.04	0.777

SD: Standard deviation

Manual measurements can also be affected by errors in drawing lines between landmarks and inaccurate reading of sizes on the ruler and conveyor, so it is better to examine a series of structural relationships with multiple cephalometric parameters instead of a single parameter. Therefore, in our study, 13 variables including all three dental, skeletal, and soft tissue variables were studied. These variables were the most commonly used variables in orthodontic diagnosis and treatment plan and treatment outcomes.

In our study, when we examine the results of linear and angular measurements performed with manual and digital tracing, it is determined that the measured values for most variables are close to the mean and standard deviation, which are in relevance with

Table 3: Comparison between linear and angular values obtained from the digital method at T1 and T2 times

Variable	Mean±SD		*P* value
	Initial tracing (T1)	Second tracing (T2)	
SNA	81.7±5.23	80.44±5.47	0.655
SNB	77.67±5.81	77±4.65	0.81
ANB	4.02±1.29	3.32±2.18	0.289
FMA	33.2±8.7	32.3±8.49	0.883
IMPA	88.56±7.3	89.82±6.03	0.797
Y-axis	46.7±6.07	62.64±6.9	0.657
1-NA	5.11±1.98	5.64±2.91	0.746
1-NB	6.24±2.22	5.66±1.51	0.678
Co-Gn	104.5±8.16	103.78±8.37	0.91
Co-A	77.74±6.11	77.02±7.02	0.897
E line-lower lip	2.63±2.78	2.84±2.9	0.889
LAFH	64.97±9.28	64.76±9.36	0.97

SD: Standard deviation

the non-significant *P* value obtained for the most of the paired comparisons.

These findings are similar to those of the Chen *et al*. study,[10] correia,[11] and vasconcelos,[12] while the study of some of the other authors[13,14] shows significant statistical differences in data. In our study, the difference between manual and digital tracing was only significant for three variables such as FMA ($P = 0.019$), 1-NA ($P = 0.0086$), and 1-NB ($P = 0.036$).

The FMA is the angle obtained from the Frankfurt and mandibular plane; Frankfurt plane is the connecting line between the two Gn and Go landmarks, which is less reliable due to the presence of both landmarks on curved anatomical boundaries. Chen *et al*.[15] also stated in their study that landmark Gn has less ability than other landmarks in cephalometric measurements. Other researchers in their studies also showed significant differences in measurements including maxillary incisor, mandibular incisors, and both.[16,17]

Brangeli *et al*.[18] and Martins *et al*.[19] also argued in their study that dental structures are difficult to identify, and measurements related to such structures, both in digital and in manual methods, are less reliable. Comparison of linear values to the results obtained in manual and digital tracing showed that there were no significant statistical differences. In linear measurements, the lowest *P* value was related to the E-line lower lip ($P = 0.099$), which was also compared in the study of Mann and Hunt.[5] The results of our study show that digital tracing has a significant difference in most measurements with manual tracing. Hence, it can be used safely. Almedia[20] and Chen *et al*.[10] described the computer method as a reliable method. Forsyth *et al*.[21] stated that errors in detecting points, angles, and linear measurements occur more in digital radiography than in conventional radiographs.

Conclusion

In this study, comparing the manual method and the digital method, there was only a significant difference between the FMA variables and there was no significant difference between the two periods of initial and recurrent trace. The results of this study showed that the digital tracing with the Onyx Ceph software had a same accuracy in comparison to manual tracing and could be used instead of the traditional methods. Due to the fact that digital tracing facilitates the tracing process and does not reduce accuracy, the use of these software could be recommended.

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