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Accuracy and Concordance of Orthodontic Cephalometric Analyses Using the CephNinja® Program Compared to the Traditional Method

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ABSTRACT

Background and Objective: Cephalometric analyses are an important tool for diagnosis and orthodontic treatment planning. Some cephalometric analysis programs cannot be used due to the high cost and inability to use all the facilities due to the sanctions. CephNinja® is an available program for cephalometric analyses. The aim of this study is to evaluate the reliability and accuracy of the CephNinja® program for orthodontic cephalometric tracing and compare it with the common manual method in Iranian society.

Methods: This cross-sectional study included 100 lateral cephalometric radiographs prepared by the 3D Promax device; The patient's teeth were selected to be in maximum intercuspation and the patient's head was in natural head posture. In every 100 lateral cephalometric radiographs, 24 landmarks were identified and then 20 desired variables were measured by traditional manual method based on Steiner's analysis. Also, the digital file of the same 100 lateral cephalometric radiographs was entered into the CephNinja® software (version 3.51). Again, 24 landmarks were determined and then 20 desired variables were measured based on Steiner's analysis. The obtained data were entered into the software and compared.

Findings: The average ANB was 4.02±3.01 degrees in the traditional manual method and 3.08±4.04 degrees in the CephNinja® method. The average Wits was -1.12±3.90 mm in the traditional manual method and -1.13±4.16 mm in the CephNinja® method. The results show that there is no significant difference in the measurements of the two traditional manual methods and the CephNinja® software.

Conclusion: Based on the current study, it can be concluded that CephNinja® software is reliable and can be used similar to traditional manual method for cephalometric analysis in orthodontic patients.

Keywords: *Orthodontics, Cephalometry, Analysis, Software.*

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Introduction

Cephalometric analyses are an important tool for diagnosing and planning orthodontic treatment, examining dentofacial morphology, evaluating treatment results or growth predictions (1). After measuring, cephalometric parameters are compared with standard values and are used in the diagnosis and classification of malocclusions. Manual methods of cephalometric analysis are time-consuming and the use of software related to cephalometric analysis helps clinicians save time (1, 2). Today, computer software such as Dolphin Imaging® is routinely used by orthodontists to perform cephalometric analyses (3). However, Dolphin Imaging® software is expensive and cannot be used by many clinicians in some developing countries, such as Iran (4).

In recent years, we have seen an increase in the use of technology in all aspects of life, such as the use of smart phones and tablets. So that mobile phones are no longer used only as a means of making phone calls and sending text messages. The uses of mobile phones include reading books, performing mathematical calculations, calendars, dictionaries, photography, sound recording, etc., and like other aspects of life, smart mobile phones and tablets can also help in the field of medicine and dentistry (5, 6). Various medical applications can be installed on smart devices such as mobile phones and tablets via internet download, and recently, various programs have been developed in the field of dentistry and orthodontics (7, 8).

Some of these applications help clinicians in performing time-consuming manual cephalometric tracing processes. For example, a cephalometric analysis program called Dolphin Imaging® has been introduced so that it can be used to evaluate skeletal, dental and soft tissue associations. However, Dolphin Imaging® software has not been widely used in Iran due to its high price and inability to use all its features in developing countries. In the past years, researchers have sought to design and introduce alternatives to Dolphin Imaging® software (5-8).

Previously, Nouri et al. in 2015 compared the accuracy of the software designed by researchers and Dolphin Imaging® software in McNamara cephalometric analysis in 150 lateral cephalometric samples in Mashhad and Qazvin. Their results showed that the newly designed software has acceptable validity and reliability and can be used for orthodontic diagnosis, treatment planning and treatment outcome evaluation (9). In 2019, Shettigar et al. investigated the reliability of OneCeph® Android smartphone software and Dolphin Imaging® computer software in cephalometric analysis including 20 landmarks and 15 skeletal, dental and soft tissue parameters in 50 lateral cephalometric radiographs. The results of their study showed that the OneCeph® program is reliable and can be used for the cephalometric analysis of many measurements required in orthodontics with sufficient accuracy on a daily basis (10). In 2020, Kumar et al. compared the accuracy of CephNinja® and NemoCeph® in Down's cephalometric analysis on 100 lateral cephalometric radiographs. In their study, CephNinja® provided a satisfactory result with NemoCeph® and can be confidently used interchangeably (11).

Considering the limitations of using Dolphin Imaging® software due to the high cost of purchasing the software and the inability to use all its features in case of purchasing it due to sanctions, the aim of this study is to evaluate the reliability and accuracy of the CephNinja® program for orthodontic cephalometric tracing and compare it with the common manual method in Iranian society.

Methods

This cross-sectional descriptive study was approved by the ethics committee of Guilan University of Medical Sciences with code IR.GUMS.REC.1398.214. In this study, lateral digital cephalometric radiographs were randomly selected from the archives of orthodontic files of Guilan Dental School, related to the patients who had referred for orthodontic treatment. A number of 100 lateral cephalometric radiographs prepared by the 3D Promax device (Planmeca, Helsinki, Finland) were selected, the patient's teeth were in maximum intercuspation and the patient's head was in Natural Head Posture. It should be noted that with a sample size of 100, a correlation coefficient of 0.30 between cephalometric measurements between two measurement methods can be achieved with a confidence interval of 95% and a test power of 80%. Lateral cephalometric radiographs of low quality or with artifacts, lateral cephalometric of patients with craniofacial deformities, lateral cephalometric of patients with incorrect head position, lateral cephalometric of patients with unerupted or absent teeth and patients with extra gum tissue that can hinder the selection of the correct position of the landmark were excluded from the study. 24 landmarks were determined on each radiograph and then 20 desired variables were measured (12) (Table 1). Among the 20 variables that were measured, 14 were cross-sectional variables and 6 were linear variables.

Table 1. Landmarks and cephalometric variables

Row	Variable	Definition
1	Sella point (Sella= S)	The geometric center of the cavity of the pituitary gland
2	Nasion point (Nasion= N)	The most anterior point at the intersection between the 2 frontal and nasal bones in the midsagittal plane
3	Orbital point (Orbital= Or)	The lowest point on the lower margin of the orbit
4	Anterior Nasal Spine= ANS	Anterior Nasal Spine
5	Point A	The most posterior point on the middle concavity of the face
6	Incisal edge of the upper incisor	The tip of the incisal edge of the maxillary incisor tooth
7	Apex of the upper incisor root	The tip of the root of the maxillary incisor tooth
8	Tip of the nose	Tip of the nose
9	Nose Columella	The middle of the S-shaped curve between the base of the nose and the tip of the nose
10	Sub nasal	The junction with the upper lip in the sagittal plane
11	Upper lip	The most anterior point of the upper lip
12	Lower lip	The most anterior point of the lower lip
13	Incisal edge of the lower incisor	The tip of the incisal edge of the mandibular incisor tooth
14	Apex of the lower incisor root	The root tip of the mandibular incisor tooth
15	Point B	The deepest point on the anterior part of the contour of the mandible
16	Genasion point (Genasion= Ge)	The most anterior-inferior point on the anterior part of the mandible
17	Menton point (Menton= Mn)	The lowest point in the lower jaw symphysis in lateral cephalometry
18	Soft tissue pogonion (Pogonion'= Pog')	The most anterior soft tissue points of the mandibular symphysis
19	Gonion point (Gonion= Gn)	A point on the curvature of the angle of the lower jaw that is formed by the bisector of the tangent lines on the lower edge of the lower jaw and the posterior edge of the ramus
20	Posterior Nasal Spins= PNS	Posterior Nasal Spins
21	Occlusal first molar	The junction of the most posterior molar contact
22	Occlusal premolar	The meeting point of the most anterior premolar contact

Row	Variable	Definition
23	Articular point (Articular= Ar)	The intersection points between the shadow of the zygomatic arch and the posterior border of the mandible ramus
24	Porion point (Porion= Po)	The middle point of the upper contour of the external auditory canal
24	SNA	Angle between S-N and N-A lines
26	SNB	Angle between S-N and N-B line
27	ANB	Angle between line A and B
28	Mandible plane to SN	Angle between ANS-PNS and S-N
29	The angle between the plane of the mandible and the plane of the maxilla	Angle between ANS-PNS and Go-Gn
30	Wits	Linear distance between the images of points A and B on the occlusal plane
31	FMA	The angle resulting from the extension of the mandible plane (GoMe) and the Frankfurt plane
32	Saddle angle	Angle between points N and S and Ar
33	Articular angle	Angle between points S and Ar and Go
34	Gonial angle	Angle between points Ar and Go and Me
35	Sum of angles	The sum of saddle, gonial and articular angles
36	Angle between Upper 1 and maxillary plane	The angle between the ANS-PNS and the line connecting the tip of the crown and the root of the maxillary incisors
37	The ratio of Upper 1 to Lower 1	Internal angle between upper and lower incisors
38	Angle between Lower 1 and mandible plane	The angle between the Go-Gn line and the line connecting the tip of the crown and the root of the mandibular incisors
39	The ratio of the lower lip to the E line	Distance from upper lip to E-line
40	The ratio of the upper lip to the E line	Distance from lower lip to E-line
41	Nasolabial angle	The angle between the tangent line on the upper lip and the base of the nose
42	Anterior height of the face	The linear distance between points N and Me
43	Posterior height of the face	The linear distance between points S and Go
44	Anterior cranial base	Linear distance between S and N

The environmental conditions of specifying landmarks and tracing for the observer were similar in both manual and software methods. All measurements were performed by a researcher through manual tracing with a black pencil on the tracing paper placed on the light box. Also, the digital file of the same 100 lateral cephalometric radiographs was entered into the CephNinja® software (version 3.51). Again, 24 landmarks were determined and then 20 desired variables were measured based on Steiner's analysis. In all the cephalometric samples observed in this software, the brightness, contrast and magnification of the images were equalized. By using the ruler designed in the software and matching it with the ruler embedded in the lateral cephalometric radiographs, the magnification of the images was aligned, then the measurements made and the numbers obtained from each of the variables in the manual method and the software were compared to each other.

To determine the reliability of the observer, tracing was done twice by one observer using both manual and software methods in 10 samples and intraclass correlation coefficient (ICC) was calculated. In this study, the ICC was more than 80%, which represents the accuracy of the observer in the evaluation of landmarks and cephalometric parameters.

The obtained information was entered into SPSS software version 23. Descriptive indices were arranged in the form of mean and standard deviation for all measured parameters. Pearson's and Spearman's correlation coefficient and dependent t-test were used to compare mean cephalometric parameters, and $p<0.05$ was considered significant.

Results

Among the 100 lateral cephalometric radiographs examined in this study, 28 lateral cephalometric radiographs belonged to male patients and 72 cases belonged to female patients. The mean age of the patients was 21.05±5.05 years (minimum 9 and maximum 31 years). There was no significant difference in the measurements of the two traditional manual methods and CephNinja® software (Table 2).

Table 2. Mean variables in manual method and using CephNinja software

Variable	Manual method Mean±SD	CephNinja Mean±SD	Spearman correlation coefficient	p-value	Pearson correlation coefficient	p-value
SNA	78.89±3.48	78.82±3.59	0.93	0.001	0.96	0.001
SNB	74.87±3.44	74.78±3.50	0.94	0.001	0.96	0.001
ANB	4.02±3.01	4.04±3.08	0.98	0.001	0.98	0.001
Mandible plan to SN	10.41±30.3	10.51±3.06	0.91	0.001	0.94	0.001
The angle between the plane of the mandible and the plane of the maxilla	28.87±2.28	30.17±7.21	0.89	0.001	0.96	0.001
Wits	-1.12±3.90	-1.13±4.16	0.96	0.001	0.97	0.001
FMA	33.70±7.90	33.56±7.73	0.93	0.001	0.95	0.001
Saddle angle	123.79±4.80	124.54±4.98	0.92	0.001	0.92	0.001
Articular angle	147.09±7.27	145.76±8.00	0.95	0.001	0.94	0.001
Gonial angle	130.92±6.26	130.56±6.39	0.93	0.001	0.94	0.001
Sum of angles	401.66±7.99	400.78±8.33	0.90	0.001	0.96	0.001
Angle between Upper 1 and maxillary plane	112.73±8.49	112.72±8.61	0.98	0.001	0.98	0.001
The ratio of Upper 1 to Lower 1	121.67±11.20	121.92±11.01	0.98	0.001	0.98	0.001
Angle between Lower 1 and mandible plane	96.45±9.75	95.40±9.71	0.98	0.001	0.98	0.001
The ratio of the lower lip to the E line	0.26±3.28	0.34±3.18	0.96	0.001	0.98	0.001
The ratio of the upper lip to the E line	-2.82±2.79	-2.33±2.60	0.97	0.001	0.97	0.001
Nasolabial angle	101.37±11.62	99.94±11.13	0.95	0.001	0.96	0.001
Anterior height of the face	114.93±9.09	133.17±141.54	0.95	0.001	0.12	0.022
Posterior height of the face	70.29±6.22	69.62±6.72	0.95	0.001	0.95	0.001
Anterior cranial base	63.04±3.63	62.29±3.41	0.80	0.001	0.84	0.001

Discussion

In this study, there was a correlation between the results of two manual methods and analysis through CephNinja® software, and also no significant difference was seen between different linear and angular measurements between manual method and analysis through CephNinja®. This finding shows that the CephNinja® digital system can be used for tracing and cephalometric analyses to investigate the cause of malocclusion before orthodontic treatment and to know the relationship between the teeth and the facial skeleton (13-15).

Meriç et al. stated that digital cephalometric analysis is 13 times faster than the manual method (16). The accuracy of cephalometric analysis software compared to the manual method has been proven in most studies, but the availability and affordability of these commercial applications for clinical use in developing countries and for novice orthodontists is still an unsolved problem.

Aksakallı et al. conducted a study in Turkey in 2016 with the aim of evaluating the accuracy of cephalometric measurements using CephNinja® and Smart Ceph Pro® software and comparing it with Dolphin Imaging® computer software. In their study, 20 digital cephalometric radiographs were randomly selected from the archive and traced using CephNinja®, Smart Ceph Pro® and Dolphin Imaging® programs. They examined 21 landmarks and 16 variables in each program. For both mentioned programs, the measurement was in accordance with Dolphin Imaging®, and both programs showed better results for angular measurements compared to linear measurements (17). Also, Gayatri et al. in 2016 in Indonesia compared Steiner analysis measurements between CephNinja® and manual method in 32 cephalometric radiographs. They examined 10 variables. The results of their study showed that there is no significant difference between the values obtained from CephNinja® software and the manual method, and CephNinja® software can be used for cephalometric analysis of patients (18).

In 2019, Kumar et al conducted a study in India with the aim of comparing the linear and angular measurements of Steiner analysis between CephNinja® and NemoCeph® programs in 100 cephalometric radiographs. The results of their study showed that the dental and skeletal criteria were not significantly different from each other in most cases, but a significant difference was observed in the linear measurements of the upper and lower incisors with the NA and NB lines. However, in our study, there was no significant difference in linear measurements between the two tracing methods, manual method and CephNinja® software (19). In 2020, Kumar et al. conducted another study with the aim of comparing Downs analysis between CephNinja® and NemoCeph® programs in 100 cephalometric radiographs. The results of their study showed that there was no significant difference between 70% of Downs analysis variables between the two mentioned programs. The values of Y-axis, Incisor Occlusal Plane angle, upper incisors with A-Pog were significantly different between the two programs. Nevertheless, Kumar et al concluded that CephNinja® software shows acceptable and satisfactory results and can be used for cephalometric analysis of patients (11).

In 2019, Livas et al. compared the validity and reliability of Steiner's cephalometric analysis between CephNinja® and OneCeph® programs in 50 orthodontic patients. The results of this study showed that OneCeph® has high validity with the traditional method, while CephNinja® has high reliability with the traditional method and can be the best alternative to the manual method (20). In line with the current study and the above studies, Kohli et al. in 2020 in India compared Steiner cephalometric analysis values between the manual method and CephNinja® software in 30 patients and concluded that there was a high concordance between the values obtained by the manual method and CephNinja® software (21).

Based on the current study, it can be concluded that CephNinja® software is reliable and can be used as a traditional manual method for cephalometric analysis in orthodontic patients. In future studies, it is suggested to compare cephalometric analyses other than Steiner between CephNinja® software with manual method and other programs available in the market.

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