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Comparison of Artificial Intelligence Supported and App-Aided Cephalometric Analysis

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Abstract

Background: The reliability and repeatability of the cephalometric analysis programs are important for orthodontic diagnosis. The aim of this study was to compare the accuracy and reproducibility of the artificial intelligence-supported WebCeph (AssembleCircle Corp. South Korea) cephalometric analysis program and the app-aided OneCeph (Dr. M. Pavan Kumar NXS Corp. Hyderabad, India) program.

Methods: Lateral cephalometric radiographs of a total of 30 cases, 11 boys and 19 girls, with an average age of 14 years, in the permanent dentition, were used. A total of 12 parameters, 8 angular and 4 dimensional, were measured with the artificial intelligence-supported WebCeph cephalometric analysis program and the app-aided OneCeph program. In order to determine intraobserver reliability, 1 month after the completion of the measurements, the cephalometric analysis of 20 randomly selected cephalometric radiographs were repeated by the same researcher using both methods.

Results: Both analysis methods were found to be highly compatible with each other. It is seen that there is full agreement between the clinician's first and second measurements in both the WebCeph program and the OneCeph application.

Conclusion: The artificial intelligence-supported WebCeph cephalometric analysis program and the app-aided OneCeph program can be used safely interchangeably. Both cephalometric analysis programs were found to have a high degree of reproducibility.

Keywords: Cephalometry, cephalometric analysis, artificial intelligence, application

INTRODUCTION

The most important stage of orthodontic treatment is the correct diagnosis of malocclusion. During the formation of the concept of orthodontic treatment, diagnosis was made through clinical examination and plaster models obtained from the patient. With the introduction of x-rays, which began to be used in dentistry under the leadership of Broadbent in the early 1900s, made the skeletal diagnosis of malocclusions easier.[1] For many years, lateral cephalometry has been a crucial component of orthodontic diagnosis and treatment plan development. It can assess the growth patterns in the craniofacial complex in addition to elucidating the dentofacial morphology and the anatomic foundation for malocclusion. Consequently, it is critical that orthodontists accurately identify cephalometric landmarks.[2,3]

Cephalometric analysis, which have been done by manual method for years, have started to be done very quickly and error-free with the development of programs that allow for digital analysis. With the development of technology, cephalometric analysis programs have begun to be used in which anatomical reference points are automatically determined. In these programs, artificial intelligence (AI) technology determines reference points automatically instead of manually determining anatomical reference points. These fully automated software programs reduce the time orthodontists spend on diagnosis. Since the definition of anatomical reference points is one of the most significant sources

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of error in cephalometric analysis, the accuracy and reliability of fully automatic cephalometric analysis are subjects of debate.[4] The use of AI applications in the field of orthodontics, which has developed in recent years, has enabled cephalometric analysis to be performed within minutes, with the aim of minimizing physician errors. One of the most accepted AI-supported cephalometric analysis programs is WebCeph (AssembleCircle Corp. South Korea). Due to its many appealing features that can simplify orthodontic treatment planning and patient record gathering, WebCeph is an AI-based orthodontic and orthognathic online platform that has been gaining popularity recently. These consist of picture archiving, automatic superimposition, visual treatment simulation, automated tracing, and analysis of the cephalometric structure. WebCeph also permits manual landmark modification with measurement computations done automatically.

Nowadays, cephalometric analysis can be easily performed in a very short time through easy-to-access app-aided cephalometric analysis programs that we download to smartphones. The most important of these app-aided cephalometric programs is the OneCeph program developed by Pavan Kumar Mamilapalli (Dr. M. Pavan Kumar NXS Corp. Hyderabad, India).[5]

The reliability and repeatability of the AI-supported and app-aided cephalometric analysis programs are important for orthodontic diagnosis.[6] Mahto et al.[7] compared the manual analysis method with the WebCeph program, and Çoban et al.[8] compared the Dolphin computerized analysis program with the WebCeph program. They concluded that the reliability and repeatability of these methods were found to be high.

Due to the lack of precision in commercially accessible software and the proliferation of apps and computer-assisted cephalometric tracing applications, there is a need for comparative studies to enable medical professionals to select appropriate software and analysis techniques with knowledge. The null hypothesis of this study was that the WebCeph program is as reliable as the OneCeph program. Therefore, the aim of this study was to compare the accuracy and reproducibility of the AI-supported WebCeph (Assemble Circle Corp. South Korea) cephalometric analysis program and the app-aided OneCeph (Dr. M. Pavan Kumar NXS Corp. Hyderabad, India) program.

MATERIAL AND METHODS

This retrospective study received approval from the Ethics Committee of Ankara Yıldırım Beyazıt University (Approval no: 10, Date: 9 June, 2022). The study material consists of pretreatment lateral cephalometric radiographs of patients who applied to Ankara Yıldırım Beyazıt University Faculty of Dentistry Department of Orthodontics. Informed consent was taken from all patients in the Department of Orthodontics. The study's sample size was calculated using G*Power software (version 3.1.9.213) developed by the Institute of Experimental Psychology at Heinrich Heine University in Dusseldorf, Germany. With an alpha error of 0.01, a power of 80%, and an effect size of 0.25, a sample size of 30 patients is recommended for this study.

The lateral cephalometric radiographs used in the study were selected from images of high diagnostic quality that were sufficient to show the anatomy of the craniofacial structures. The lateral cephalometric radiographs used in this study were obtained under standard conditions with the Planmeca Promax 2D (Planmeca OY Asentajankatu 6, 00880 Helsinki, Finland) device, with the patient in the natural head position and the patient's midsagittal plane parallel to the film.

The inclusion criteria were as follows: Individuals should not have craniofacial deformity, should not have received orthodontic or orthognathic surgical treatment, should not have impacted or missing teeth, should be in the permanent dentition period, and should have maximum intercuspation of the teeth at the time of radiograph acquisition. No distinction was made between skeletal or dental malocclusions in the present study. Cephalometric radiographs of 11 males and 19 females (mean age: 14 years) were included in the study by considering the inclusion criteria. While determining the anatomical landmarks, hard tissue points, dental points, and soft tissue points were chosen to evaluate the hard tissues, dentition, and soft tissues.

Anatomical Landmarks Marked on Lateral Cephalometric Radiographs

Sella: Geometric midpoint of sella turcica.

Nasion: The deepest point of the nasofrontal suture.

Point A: The deepest point of the maxillary bone under the anterior nasal spine.

Point B: The deepest point of the bone concavity extending from the lower incisor to the tip of the jaw in the middle oxal plane.

Gonion: The point where the bisector of the angle formed by the tangents drawn to the ramus mandible and the corpus mandible intersects the outer border of the mandible.

Gnathion: Midpoint between menton and pogonion.

Upper incisor (U1) apex: The root tip point of the upper first incisor.

Upper incisor (U1) incisal: The incisal edge point of the upper first incisor.

Lower incisor (L1) incisal: The incisal edge point of the lower first incisor.

Lower incisor (L1) apex: The point of the root tip of the lower first incisor.

Mesiobuccal tubercle of the upper first molar.

Mesiobuccal tubercle of the lower first molar.

Pronasale: The most anterior point of the tip of the nose.

Subnasale: The deepest point of the base of the nose.

Labium superior: The most anterior point of the upper lip.

Labium inferior: The most anterior point of the lower lip.

Soft tissue pogonion: The most anterior point of the soft tissue chin.

Measurements Made on Lateral Cephalometric Radiographs

Eight angular and 4-dimensional, a total of 12 parameters, including SNA angle, SNB angle, ANB angle, GoGn-SN angle, SN-Occlusal plane angle, U1-NA angle, U1-NA distance, L1-NB angle, L1-NB distance, interincisal angle, upper lip-E line distance, and the lower lip-E line distance were measured.

Lateral cephalometric radiographs were uploaded to the computer (MacBook Air 2017) in JPEG format with a minimum resolution of 300 dpi. Afterward, calibration was performed using the WebCeph program. After the upload to the relevant site was completed, the "Artificial intelligence digitization" tab was clicked, and the program automatically determined the anatomical points. The determined points were recorded by clicking the "save" tab. Afterward, the analysis list was opened by clicking on the "Analysis" tab and the desired measurements were selected (Figure 1). The measurements were transferred to an Excel table.

The same radiographs were uploaded to a smartphone with a 5.7-inch screen size (Samsung Note FE) by the same researcher (S.K.) in JPEG format with a resolution of 1250 × 1592 pixels. Calibration was conducted using the OneCeph application. Cephalometric analysis proceeded with the researcher marking anatomical reference points (Figure 2). The measurements were then recorded by inputting the obtained values into a prepared Excel table.

Statistical Analysis

The data obtained in this study were analyzed using the Statistical Package for Social Sciences version 22.0 software (IBM Corp.; Armonk, NY, USA). The compatibility between the AI-supported WebCeph cephalometric analysis program and the app-aided OneCeph program was examined with the inter-class correlation method. A significance level of 0.05 was applied.

Method Error

In order to determine intrameasurer reliability, 1 month after the completion of the measurements, the cephalometric analyses of 20 randomly selected cephalometric radiographs were repeated by the same researcher (S.K.) using both methods.

RESULTS

SNA angle, SNB angle, ANB angle, GoGn-SN angle, SN-Occlusal plane angle, U1-NA angle, U1-NA distance, L1-NB angle, L1-NB distance, interincisal angle, upper lip-E line distance, and in terms of lower lip-E line distance, a high agreement was found between the AI-supported

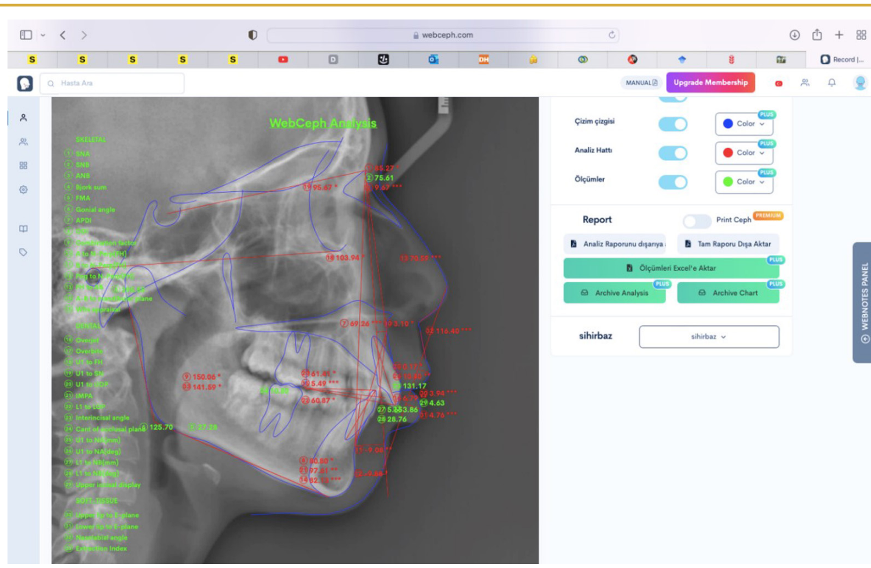

Figure 1. Analysis screen of WebCeph program.

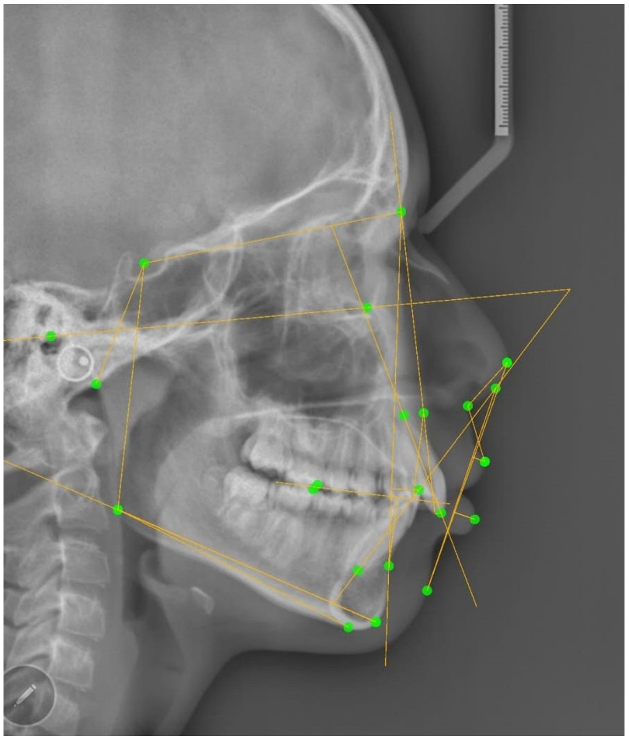

Figure 2. Analysis screen of OneCeph application.

WebCeph program and the app-aided Oneceph program and it was observed to be statistically significant (P < .05) (Table 1).

When the AI-supported WebCeph program is evaluated, it can be seen that the intraobserver correlation coefficients are high (0.885-1) and that there is full agreement between the clinician's first and second measurements in the WebCeph program (Table 2).

Table 1. Compatibility of WebCeph Cephalometric Analysis Program and OneCeph Application (c=significance of cue **)

Cephalometric Variables	Interobserver Correlation	95% CI Lower Bound	95% CI Upper Bound	P
SNA (°)	0.837[c]	0.655	0.923	.000
SNB (°)	0.837[c]	0.655	0.923	.000
ANB (°)	0.844[c]	0.319	0.945	.000
GoGn-SN (°)	0.911[c]	0.810	0.958	.000
SN-Occlusal plane angle (°)	0.729[c]	0.408	0.873	.000
U1-NA angle (°)	0.928[c]	,849	0.965	.000
U1-NA distance (mm)	0.642[c]	0.264	0.828	.002
L1-NB angle (°)	0.896[c]	0.736	0.954	.000
L1-NB distance (mm)	0.955[c]	0.901	0.979	.000
Interincisal angle (°)	0.926[c]	0.845	0.965	.000
Upper lip-E line distance (mm)	0.978[c]	0.869	0.993	.000
Lower lip-E line distance (mm)	0.984[c]	0.967	0.992	.000

Table 2. Intraobserver Correlation Evaluating the Repeatability between the Researcher's First (1) and Second (2) Measurement in the WebCeph Program (c=significance of cue **)

Cephalometric Variables	Intraobserver Correlation	95% CI Lower Bound	95% CI Upper Bound	P
SNA 1-2	0.958[c]	0.895	0.983	.000
SNB 1-2	0.885[c]	0.713	0.954	.000
ANB 1-2	0.991[c]	0.978	0.997	.000
GoGn-SN 1-2	0.962[c]	0.905	0.985	.000
SN-Occlusal plane angle 1-2	0.982[c]	0.955	0.993	.000
U1-NA angle 1-2	0.985[c]	0.962	0.994	.000
U1-NAdistance 1-2	0.992[c]	0.981	0.997	.000
L1-NB angle 1-2	0.980[c]	0.951	0.992	.000
L1-NB distance 1-2	0.998[c]	0.994	0.999	.000
Interincisal angle 1-2	0.974[c]	0.936	0.990	.000
Upper lip-E line distance 1-2	1.000[c]			
Lower lip-E line distance 1-2	1.000[c]			

When the app-aided OneCeph program is evaluated, it is observed that the intraobserver correlation coefficients are high (0.754-0.995) and that there is full agreement between the clinician's first and second measurements in the OneCeph program (Table 3).

DISCUSSION

Power analysis was used to calculate the sample size of the study, and according to the analysis results, 30 cephalometric

Table 3. Intraobserver Correlation Evaluating the Repeatability between the Researcher's First (1) and Second (2) Measurement in the OneCeph Application (c=significance of cue)

Cephalometric Variables	Intraobserver Correlation	95% CI Lower Bound	95% CI Upper Bound	P
SNA 1-2	0.865[c]	0.664	0.946	.000
SNB 1-2	0.754[c]	0.356	0.904	.001
ANB 1-2	0.848[c]	0.069	0.957	.000
GoGn-SN 1-2	0.901[c]	0.655	0.965	.000
SN-Occlusal plane angle 1-2	0.510[c]	−0.150	0.800	.053
U1-NA angle 1-2	0.920[c]	0.789	0.969	.000
U1-NAdistance 1-2	0.799[c]	0.217	0.933	.000
L1-NB angle 1-2	0.938[c]	0.838	0.976	.000
L1-NB distance 1-2	0.935[c]	0.839	0.974	.000
Interincisal angle 1-2	0.981[c]	0.951	0.992	.000
Upper lip-E line distance 1-2	0.995[c]	0.987	0.998	.000
Lower lip-E line distance 1-2	0.992[c]	0.979	0.997	.000

radiographs were found to be sufficient. Similarly, Zamrik and İşeri also used 30 radiographs in their study.[9]

All of the lateral cephalometric radiographs measured in our study are digital radiographs obtained by direct digital imaging. Digital radiographs must have sufficient clarity, contrast, and brightness to easily identify anatomical reference points.[10] Studies have shown that the JPEG image format does not negatively affect image quality.[11] Therefore, JPEG format was preferred for the radiographs used in our study. The image quality of radiograph is also crucial for accurate analysis. Ongkosiwito et al.[12] stated that the image quality should be at least 300 dpi for a healthy analysis to be made. For this reason, the image resolution of the radiographs in our study was determined to be at least 300 dpi.

One of the most important factors to ensure standardization is calibration. In many studies conducted on this subject, dimensional measurements have been found to be more unreliable than angular measurements.[13,14] In order to eliminate this factor in our study, care was taken to make calibration before proceeding with the measurements in both analysis methods with the help of a ruler on the radiography.

While selecting the cephalometric analysis programs to be used in the study, care was taken to ensure that they were free, easily accessible, practical, and reliable. WebCeph program and OneCeph application, which are one of the most preferred programs, were chosen.

Considering the intra-observer reliability in the present study, a high degree of correlation was observed in the repeated measurements for two cephalometric analysis methods (Tables 2 and 3).

In this study, both analysis methods were found to be compatible with each other in terms of angular and dimensional measurements (Table 1). Chen et al.[14] stated that angular measurements were more inaccurate than dimensional measurements. Researchers attributed this error to the close proximity of anatomical reference points to each other. On the contrary, in the study conducted by Aksakallı et al.[13] in 2016, they compared the SmartCeph Pro and CephNinja applications and found dimensional measurements less reliable than angular measurements. In their 2019 study, where they compared the manual analysis method and the OnyxCeph application, Izgi and Beijinger found dimensional measurements less reliable than angular measurements and cited image distortion as the reason for this.[15] Barbhuiya et al.[16] found angular measurements to be statistically different compared to dimensional measurements, although they were clinically insignificant. Similar to our study, Paixao et al.[17] found both angular and dimensional measurements to be compatible with each other.

In this study, both analysis methods were found to be compatible with each other in terms of dental measurements (Table 1). Barbhuiya et al.[16] found the ANB and U1/NA angles to be statistically different in their study in 2021. Mahto et al.[7] compared the manual analysis method with the WebCeph program and found a statistical difference in ANB, IMPA, and L1-NB distance measurements. Livas et al.[18] compared the OneCeph and CephNinja applications and found a statistical difference in the U1/NA angular measurement. They attributed this to errors in determining the Nasion point, A point, and lower incisor apex point. Mohan et al.[19] compared the manual analysis method with the OneCeph application and concluded that both analysis methods were compatible in terms of dental measurements, as in our study.

In this study, both analysis methods were found to be compatible with each other in terms of measurements of skeletal parameters (Table 1). Shettigar et al.[20] compared the Dolphin computerized analysis program with the OneCeph application and found the FMA angle to be incompatible with skeletal measurements. Livas et al.[18] compared the computerized analysis program with OneCeph and CephNinja applications and found the GoGn/SN measurement to be incompatible. Mahto et al. compared the manual analysis method with the WebCeph program, and found the analysis methods incompatible in terms of FMA and GoGn/SN measurements.[7] Mohan et al.[19] compared the manual analysis method with the Oneceph application and Sayar and Kilinc[21] compared the manual analysis method with the CephNinja application. They found the methods compatible with our study in terms of skeletal measurements.

In this study, both analysis methods were found to be compatible with each other in terms of soft tissue measurements of the distance of the upper lip and lower lip to the E line (Table 1). Mahto et al.[7] compared the manual analysis method with the WebCeph program and found a statistical difference in terms of upper lip-E Line distance and lower lip-E Line distance measurements. Researchers attributed this difference to the AI program's ability to determine the anatomical reference point.

Meric and Noumava compared the accuracy of cephalometric analyses made with fully automated tracings, computerized tracing, and app-aided tracings with equivalent hand-traced measurements. They concluded that manual correction of web-based fully automated CephX landmarks provides equivalent results to digital tracings using app-aided CephNinja and software Dolphin, with significantly shorter analyzing time.[22]

Prince et al.[23] tested linear and angular measurements using WebCeph, Autoceph, and manual tracing methods. According to their findings, the intraclass correlation coefficient between the 3 groups was > 0.830, showing good level of agreement, and the value within each group was >0.950, indicating high intraobserver reliability. This finding is consistent with the findings of our study.[23]

Shettigar et al.[20] compared the manual analysis method, the Dolphin computerized analysis program, and the OneCeph application, and they concluded that the measurements are highly compatible. İşeri and Zamrik assessed the reliability and reproducibility of linear and angular measurements of the cephalometric Android application OneCeph in comparison with the conventional method. They concluded that both tracing methods were reliable for daily clinical practice.[9] Mohan et al.[19] compared the manual analysis method with the OneCeph application and stated that the measurements to be highly compatible, as in our study.

The results showed that the AI-supported WebCeph analysis program and the app-aided OneCeph program were found to be highly compatible. The null hypothesis was accepted.

The findings of the numerous studies examined in a systematic review written by Junaid et al.[24] indicated that the applications of AI systems are promising and reliable in cephalometric analysis. Despite its limitations, almost all of the investigations found that AI-based automated algorithms performed admirably well, with accuracy and precision comparable to orthodontists. It can simplify cephalometric analysis and produce quick results in practice, saving practitioners time and improving their performance.

- Using 12 measurements to compare the 2 cephalometric analysis programs, the results showed that the AI-supported WebCeph analysis program and the app-aided OneCeph program were found to be highly compatible.
- Both cephalometric analysis programs were found to have a high degree of reproducibility.
- Both cephalometric analysis programs were reliable for daily clinical practice.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of Ankara Yıldırım Beyazıt University (Approval no: 10, Date: 9 June, 2022).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

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