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Original Research Article

Accuracy and reliability of webceph on posteroanterior cephalogram-A retrospective study

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A B S T R A C T

Background and Objectives: Lateral cephalogram plays a vital role in orthodontic diagnosis and treatment planning, from the advent of cephalometric radiography, whereas limited attention was given to posteroanterior cephalogram which evaluates skeletal discrepancies in transverse dimension. Thus, our study focuses on comparing the accuracy and reliability of fully automated AI driven software 'WebCeph', a semi-automated software 'EasyCeph' and manual tracing on posteroanterior cephalogram.

Materials and Methods: A sample of 30 pretreatment posteroanterior cephalometric radiographic digital images were collected and analyzed using manual tracing, WebCeph and EasyCeph with 18 landmarks (16 linear and 2 angular measurements). For manual tracing, hard copies of digital images were obtained, whereas for EasyCeph and WebCeph, direct digital images used for analysis. ANOVA Test was done to compare the measurements of each parameter among WebCeph, EasyCeph and manual tracing. Bonferroni post hoc test was performed for individual comparison among 3 groups. The intraoperator reliability were evaluated by correlation coefficient test after 1 month by retracing 5 randomly selected cephalograms.

Results : On comparing three methods, 6 out of 18 parameters showed statistically significant differences. On individual comparison, EasyCeph shows significant differences with its counterparts, whereas WebCeph and manual tracing values shows no statistically significant difference. The intraclass correlation coefficient shows strong correlation for manual tracing (0.84 to 0.95) and EasyCeph (0.78 to 0.89)

Conclusion: The automated cephalometric measurements from WebCeph are reasonably consistent, accurate and reliable when compared with Manual tracing and EasyCeph.

1. Introduction

In 1931, with the pioneering work of Broadbent and Hofarth, the introduction of cephalometry marked a significant milestone in the field of orthodontics.[1] Since then, cephalometric radiograph has become a cornerstone in facilitating comprehensive orthodontic diagnosis and treatment planning.[2]

Traditional manual tracing of cephalograms, involving acetate tracing paper, scale and protractor, has been a longstanding procedure.[3] In spite of its extensive application, it can be more prone to systematic and random error and the potential for misinterpretation due to inaccurate landmark identification or radiographic magnification. These limitations have driven the evolution of digital and computerized cephalometry which has rapidly supplanted manual methods.[4]

Digital cephalometric analysis offers numerous advantages including streamlined image acquisition, faster

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measurements, enhanced sharing, archiving capabilities, expedited treatment planning and reduction of radiation dose. Additionally it allows for concurrent multiple analyses and quicker superimposition of serial radiograph.[5] Nonetheless the challenge of inconsistent landmark identification remains an issue in both computers aided digital cephalometry and manual.

cephalometric analysis. To overcome this automated cephalometric analysis is introduced with the aim of reducing the time required to obtain results and improving accuracy of landmark identification and reducing the errors,[6–8] Cohen initiated the first automated cephalogram tracing endeavor in 1984.[7]

From the time lateral cephalogram was invented, it continues to be one of the important supplemental diagnostic aids in orthodontics. However, posteroanterior cephalometric projections and their associated analyses represents equally important dimension in orthodontic diagnosis. These assessment serves as vital adjuncts for both quantitative and qualitative evaluations of the dentofacial region and to diagnose various transverse discrepancies, several asymmetric, syndromic cases and functional mandibular displacement. However very limited attention given on posteroanterior cephalometric analysis.

To date there is no existing literature has undertaken a comprehensive comparison of WebCeph, an Artificial intelligence based fully automated software with EasyCeph, a semi-automated digital cephalometric tool alongside traditional manual tracing on posteroanterior cephalogram. This research deals about evaluation of accuracy and reliability of fully automated artificial intelligence driven web based software[9–11] on posteroanterior cephalogram in comparison with semi-automated and manual tracing. The null hypothesis proposed is that there is no statistically significant difference among the three methods in terms of their capacity to deliver accurate cephalometric analysis.

2. Materials and Methods

This study was approved by the institutional research committee, xxxx. This retrospective study was carried out on pre-treatment posteroanterior cephalograms selected randomly from the dental imaging and archiving software from the department of orthodontics, out of 65 radiographs procured over a period of one month 30 posteroanterior cephalograms were selected based on the inclusion and exclusion criteria. The sample size calculation was based on a previous study done by Katyal et al.[9]

Inclusion criteria mandated high quality radiograph of non-growing individual with complete permanent dentition ensuring proper head position, centric relation of teeth and relaxed lips that are taken using same dental cephalostat. Cephalogram was obtained with a calibration ruler to determine magnification. Exclusion criteria encompassed poor quality or distorted radiograph with artifact, that could hinder landmark identification, unerupted or missing teeth and skeletal deformity.

All the radiographs were analyzed both manually and digitally by a final year student under the supervision of an experienced orthodontist as landmark identification is an important source of an error. The analysis includes 8 linear and 1 angular measurement bilaterally as mentioned in.Table 1

Once the measurements are done, all the values are transferred to excel spreadsheet. To mitigate operator fatigue-induced error only five manual tracing were undertaken per day. since manual tracing is considered the gold standard for comparison, one more observer was included in this study for reperforming manual tracing and the mean measurements were taken. To assess intraoperative error, 5 radiographs were randomly selected and retraced by the same operator after a month.

Table 1: Description of cephalometric parameters

Parameter	Description
Z distance (R)	Distance from zygomaticofrontal suture on right side to Mid saggital reference line
Za distance (R)	Distance from zygomatic arch on right side to Mid saggital refernce line
J distance (R)	Distance from Jugular process on right side to Mid saggital refernce line
Ag distance (R)	Distance from Antegonial notch on right side to Mid saggital refernce line
U6 vertical height from J (R)	Distance between Jugular process and buccal cusp tip of molar (on right side)
CO-AG distance (R)	Distance between Condylion and antegoial notch (on right side)
CO – ME distance (R)	Distance between Condylion and Menton (on right side)
ME – AG distance (R)	Distance between Menton and Antegonial notch (on right side)
Ag angle (R)	Angle formed at antegonial notch (on right side)
Za distance (L)	Distance from zygomaticofrontal suture on left side to Mid saggital reference line
Za distance (L)	Distance from zygomatic arch on left side to Mid saggital refernce line
Ag distance (L)	Distance from Jugular process on left side to Mid saggital refernce line
Ag distance (L)	Distance from Antegonial notch on left side to Mid saggital refernce line
U6 vertical height from J (L)	Distance between Jugular process and buccal cusp tip of molar (on left side)
CO-AG distance (L)	Distance between Condylion and antegoial notch (on left side)
CO – ME distance (L)	Distance between Condylion and Menton (on left side)
ME – AG distance (L)	Distance between Menton and Antegonial notch (on left side)
Ag angle (L)	Angle formed at antegonial notch (on left side)

Table 2: ANOVA test done for comparing the mean, standarddeviation of various linear and angular cephalometric measurements done among Webceph,Easyceph and manual tracing with p value.

Measurements	Webceph		Easyceph		Manual tracing		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	*P Value*
Z Distance (R)	43.3767	2.01575	43.5467	2.28967	*43*	2.08443	0.599
Z Distance (L)	43.0033	1.80621	42.6133	2.47564	42.5667	1.8696	0.671
ZA Distance (R)	62.28	3.17939	60.9933	3.61672	61	3.41397	0.248
ZA Distance (L)	61.98	2.42322	59.6967	3.0129	61.2	2.49689	0.005**
J Distance (R)	31.68	2.0133	31.0167	2.3439	30.8667	2.02967	0.296
J Distance (L)	31.66	1.82504	30.4067	2.26258	31.1	1.74889	0.051*
AG Distance (R)	40.4933	2.60926	41	2.74603	40.0333	2.87058	0.398
AG Distance (L)	41.3767	3.09089	40.4033	2.54782	40.7	2.74364	0.391
U6 Vertical Height From J (R)	19.9033	3.0571	17.13	2.4266	18.9	2.48235	0.001**
U6 Vertical Height From J (L)	19.5233	2.83922	17.8067	2.65329	18.8	2.49689	0.049*
CO-AG Distance (R)	67.8333	6.53686	67.4133	6.79862	67.8667	7.17627	0.960
CO-AG Distance (L)	66.9867	5.73554	67.3367	6.15027	66.8333	5.35681	0.942
CO-ME Distance (R)	102.2433	6.75419	102.0633	7.72026	102.2667	6.87792	0.993
CO-ME Distance (L)	101.7233	6.63895	101.5433	7.53944	101.5333	6.25732	0.993
AG-ME Distance (R)	47.3833	3.23836	46.699	3.83044	46.9333	3.39303	0.744
AG-ME Distance (L)	46.5333	3.52951	46.09	4.19156	45.8667	3.44146	0.781
AG Angle (R)	121.49	17.3499	233.2967	7.56874	127.0333	6.98019	0.000***
AG Angle (L)	123.9167	17.09299	233.7333	8.62412	127.4333	8.1142	0.000***

The unit of measurements for the angle is the degree (°) and linear measurements are inmillimeters (mm). Mean , standard deviation and P value (P 0.05) of the linear and angular measurements of manual tracing , Easyceph and Webceph

Table 3: Bonferroni post hoc test done for individualcomparison among Webceph, Easyceph and manual tracing with p value.

Landmarks	Bon ferroni post hoc test P value		
	Webceph vs easyceph	Webceph vs manual tracing	Manual tracing vs easyceph
Z Distance (R)	0.949	0.773	0.584
Z Distance (L)	0.747	0.694	0.996
ZA Distance (R)	0.314	0.318	1.00
ZA Distance (L)	0.004**	0.494	0.07
J Distance (R)	0.454	0.307	0.960
J Distance (L)	0.040	0.512	0.361
AG Distance (R)	0.755	0.793	0.364
AG Distance (L)	0.374	0.620	0.912
U6 Vertical Height From J (R)	0.00***	0.318	0.032**
U6 Vertical Height From J (L)	0.038**	0.547	0.024**
CO-AG Distance (R)	0.969	0.994	0.939
CO-AG Distance (L)	0.970	0.994	0.939
CO-ME Distance (R)	0.995	1.00	0.993
CO-ME Distance (L)	0.994	0.994	1.00
AG-ME Distance (R)	0.730	0.872	0.964
AG-ME Distance (L)	0.890	0.769	0.971
AG Angle (R)	0.00***	0.162	0.00***
AG Angle(L)	0.00***	0.496	0.00***

*Significant, ** Highly Significant, *** Very Highly Significant

For manual tracing, Hard copies of digital pictures of the same posteroanterior cephalograms was obtained on 8x10 radiographic film for manual tracing. In a dark room, manual tracings were performed on a view box with transilluminated light. Over the X-ray film was taped a sheet of fine grade 0.003′′ 8x10 matte acetate tracing paper. Using lead pencil, the landmarks were traced and then using ruler and protractor, the linear and angular measurements are marked (Figure 1).

For semi-automated tracing, EasyCeph, an application available in playstore on smart phones were used. The cephalometric radiograph saved as .jpeg files were imported to EasyCeph application. Landmark identification was carried out manually using cursor, and the measurements was performed automatically by the application (Figure 2 a and b).

For fully automated tracing, a software named WebCeph was used. After login to the website www.webceph.c om, patient profile was created and radiographs were uploaded in .jpeg format, by clicking AI digitization, all the landmarks were identified by the software itself and analysis was performed and measurements were taken (Figure 3).

2.1. Statistical analysis

All Statistical analysis were performed using the statistical package for the social sciences, version 26.0 software (SPSS. INC., Chicago, Illinois, USA). One way ANOVA was done to compare the measurements of each parameter among manual tracing, EasyCeph and WebCeph.

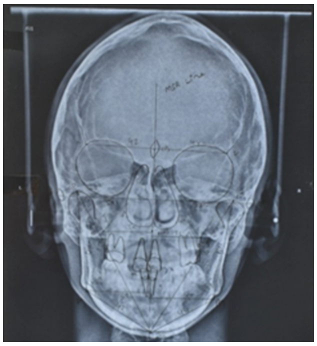

Figure 1: Cephalometric tracing done manually on posteroanterior cephalogram

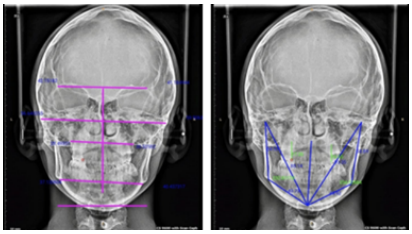

Figure 2: a) Cephalometric tracing doneon posteroanterior cephalogram using EasyCeph- Linear **b)** Cephalometric tracing done on posteroanterior cephalogram using Easy Ceph-Angular

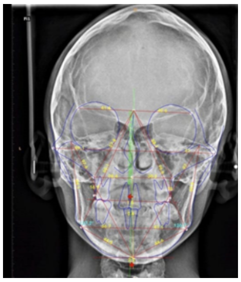

Figure 3: Cephalometric tracing done on posteroanterior cephalogram using Web Ceph

Bonferroni Post Hoc test was performed for individual comparison. Out of 30 radiographs, 5 were randomly selected and retraced after 1 month to check intraoperator reliability using Cohens kappa value.

3. Result

The mean and the standard deviation of the measurements were compared among manual tracing, EasyCeph and WebCeph (Table 2). ANOVA test shows statistically significant differences on variables, Za distance (L) (P 0.005), J distance (L) (P 0.051) , U6 vertical height from J(R & L) (P 0.001 & 0.049), Ag angle (R & L) (0.00 & 0.00). On individual comparison of the above variables using Bon ferroin post hoc test, the EasyCeph shows statistically significant difference with its counterparts (p value < 0.05) whereas WebCeph and manual tracing have no statistically significant differences (Table 3). The intra-operator reliability was assessed by using Cohens kappa value which shows 0.73 – 0.78 for manual tracing and 0.78 – 0.80 for EasyCeph.

4. Discussion

In today's scientific landscape, artificial intelligence (AI) holds significant sway across various branches of dentistry, including orthodontics. Initially utilized for clinical diagnosis and treatment planning, AI has steadily advanced, leaving its mark on cephalometric landmark identification as well.[12,13] This evolution has given rise to a plethora of AI-driven cephalometric platforms such as Ceph X, Ceph bot, and WebCeph, alongside software like Oneceph, Cephninja, Nemoceph, EasyCeph, and Autoceph, which combine digital and manual approaches.[14,15]

The reliability and accuracy of these semi-automated digital tracing methods have been likened to manual tracing, making them popular choices in clinical settings. However, their efficacy hinges on the precision and dependability of lateral cephalograms for evaluation.

Among supplementary radiographs, the Posteroanterior cephalogram stands out for its role in identifying transverse discrepancies and facial asymmetry, posing challenges even for seasoned clinicians in landmark identification. Yet, no studies have delved into the accuracy and reliability of digital cephalometric tracing on Posteroanterior cephalograms until now.

Our study bridges this gap by comparing the accuracy and reliability of WebCeph, an AI-driven fully automated software, with EasyCeph, a recently developed semi-automated software, and manual tracing. The sample size for this study was determined using previous study done by Katyal et al.[9] and Mahto et al.[10] we employed direct digital images for automatic landmark identification, ensuring enhanced accuracy over scanned analog images. Similarly, for EasyCeph, direct digital image with calibration is used for tracing

The findings of this study are in concurrent with those of Alqahtani et al, who evaluated the accuracy and reliability of cephalometric measurements using CephX, an online based platform in comparison to FACAD on lateral cephalogram. He found that statistically significant differences among few parameters such as SNA, FMA and Pg to B values, and also found that there is no statistically significant difference between the angular and linear measurements. Similarly Katyal et al. compared cephalometric measurements obtained from the WebCeph software an AI driven web base software with FACAD, they found that statistically no significant difference among the respective parameters.[9] Similarly, smartphone applications like CephNinja have shown promise as rapid alternatives to manual tracing, as observed in studies by Sayar and Kilinc et al. and Aksakalli et al.

Fully automated cephalometry powered by AI offers several advantages, including streamlined image acquisition, faster measurements, improved sharing, reduced time consumption, and heightened precision.[4–8] However, oversight by experienced orthodontists remains crucial for ensuring the accuracy of landmarks and tracings, with options for manual correction provided by some software like WebCeph.[10]

Despite advancements, challenges persist in consistent landmark identification across both semi-automated and manual tracing methods. Nevertheless, digital cephalometric analysis stands as a reliable and accurate tool for routine clinical practice, significantly reducing execution time while enhancing precision and reproducibility compared to traditional methods.

4.1. Limitations

Since EasyCeph is newly launched semi-automated tracing software, it is available only in the android playstore, few refinements and comparison with other software need to be done for seamless application in cephalometric analysis. Although Time required for digital cephalometric tracing was less than manual tracing methods, we didn't assess the time taken for tracing in this study. Based on the result of our study WebCeph is more accurate and reproducible, but it is a payable one.

5. Conclusion

This study suggested that the automated cephalometric measurements from WebCeph are reasonably accurate and reliable when compared to manual tracing, whereas EasyCeph needs further improvement. Therefore, the null hypothesis is rejected as there is statistically significant differences in few parameters. Artificial intelligence driven software is simple, precise, more reliable and has various benefits such as cloud-based storage, effective online archiving and adaptability to diverse operating systems. All these elements collectively contribute to making WebCeph a dependable, expedient and versatile tool for conducting cephalometric analysis.

6. Source of Funding

None.

7. Conflict of Interest

None.

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