Research Article

Agreement and reliability of AI-based cephalometric analysis (WebCeph) compared with digital manual tracing for skeletal and dentoalveolar measurements (A retrospective comparative study)

Alassfar Afaf [1*], El merouani Idrissi Afaf [1], Harti Imane [2], Zaoui Fatima [1], Benyahia Hicham [1]

1 Department of orthodontics, faculty of Dentistry, University Mohamed V, Rabat, Morocco.
2 Department of removable prosthetics, faculty of Dentistry, University Mohamed V, Rabat, Morocco.
*Corresponding author: afafalassfar@gmail.com

Received date: 02-02-2026
Accepted date: 23-04-2026
Published date: 15-06-2026

Article DOI

Abstract: Background: Cephalometric analysis is essential in orthodontic diagnosis and treatment planning. With the increasing use of artificial intelligence (AI) in clinical practice, automated platforms such as WebCeph have been introduced; however, their accuracy and reliability across different types of measurements remain a concerns. Objectives: evaluate the agreement and reliability between skeletal and dentoalveolar cephalometric measurements obtained using an AI-based platform (WebCeph) and digital manual tracing performed with AutoCAD.Materials and Methods: A total of 100 lateral cephalograms were analyzed using WebCeph (AI-driven software) and digital manual tracing in AutoCAD. Fourteen Steiner and Tweed variables were selected and categorized into skeletal and dentoalveolar measurements. Statistical comparisons were performed using paired t-tests or Wilcoxon signed-rank tests, depending on data distribution. Agreement between the two methods was assessed using intraclass correlation coefficients (ICC) and Bland–Altman analysis. Conclusion: Overall agreement between WebCeph and AutoCAD was good for most variables (ICC ≥ 0.75). Skeletal and dentoalveolar measurements showed comparable reliability, although skeletal measurements demonstrated slightly smaller mean differences and narrower limits of agreement. Greater variability was observed in dentoalveolar variables, particularly those related to mandibular incisor inclination. Conclusion:WebCeph provides clinically reliable cephalometric measurements and can be considered a supportive diagnostic tool. However, selective manual verification is essential.

Keywords: Artificial intelligence; Cephalometry; Orthodontics; Diagnostic imaging; Reliability

Introduction

Cephalometric analysis is still routinely performed by clinicians in orthodontic practices. It provides information about the skeletal and dental relationship present, allows diagnosis, and aids in treatment planning. Historically, cephalometric analysis has been performed by hand tracing methods that require identification of specific anatomical landmarks followed by linear and angular constructions [(1)]. Manual tracing is widely accepted despite being very time-consuming, it is subjective in nature and dependent on an experienced operator when dealing with poorly defined landmarks [(2)].

Artificial intelligence (AI) and machine learning are beginning to be implemented into dentistry. These techniques offer automated processes that can create quantitative data that clinicians can use when making treatment decisions. One such application of AI includes cephalometric platforms, such as WebCeph. These programs allow clinicians to upload cephalometric radiographs and provide landmarks and measurements within seconds [(3)].

Although landmark identification and measurement production by AI is fast, not all measurements may perform similarly [3-8]. Skeletal landmarks tend to be less variable and easier to identify on radiographs while dentoalveolar landmarks can be more moveable and error sensitive to small changes. Digital manual tracing also allows a more standardized and controlled environment but is still operator based which could cause variability between examiners [13-14]. Studies have shown that WebCeph produces acceptable results when compared to traditional tracing methods [15]. Differences may still be present depending on which measurements are being compared.

Thus, the purpose of this study was to determine the agreement and reliability of skeletal and dentoalveolar cephalometric measurements obtained by WebCeph when compared to digital manual tracing in AutoCAD.

Materials and Methods

This retrospective study was carried out at the Centre de Consultations *et* de Traitements Dentaires (CCTD), Ibn Sina University Hospital, Rabat, Morocco, between June and December 2025. The study followed the principles of the declaration of Helsinki, and all applicable data were respected.

This retrospective study was conducted using anonymized radiographic data collected as part of routine clinical care. No identifiable patient information was used, and no additional radiation exposure was required. According to institutional policy and national regulations, formal ethical approval was therefore not required. A priori sample size estimation was performed using G*Power for a paired t-test (difference between two dependent means), assuming a medium effect size (dz = 0.5), $\alpha = 0.05$, two-tailed, and power = 0.90. This corresponds to clinically relevant differences of approximately 2° for angular measurements and 2 mm for linear measurements [16]. The minimum required sample size was 36 paired observations. In this study, 100 lateral cephalograms were included increasing the precision of the analysis.

The selection of lateral cephalograms was based on predetermined inclusion and exclusion criteria. Eligible subjects had no history of previous orthodontic treatment, and only radiographs of good diagnostic quality with clear, sharp anatomical landmarks were included. All images were obtained from the same radiographic center using a standardized cephalometric machine and acquisition protocol.

Cephalograms were excluded if image quality was poor (e.g., blurring, double images, excessive head tilt, or marked artifacts), if key anatomical landmarks were not clearly visible, or if patients presented craniofacial syndromes, facial anomalies, or a history of maxillofacial surgery.

All lateral cephalometric radiographs were acquired at the CCTD radiology unit using a standardized cephalostat (CareStream Dental CS 9600) with fixed focal-object distance. Patients were positioned with the Frankfort horizontal plane parallel to the floor, teeth in maximum intercuspation, and lips in relaxed position. Images were obtained in centric occlusion with natural head position.

AutoCad software was used for digital manual analysis. A web-based, online cephalometric analysis service called WebCeph (WEBCEPH™, Artificial Intelligence Orthodontic &Orthognathic Cloud Platform, South Korea, 2020) was used for AI-based automatic cephalometric analysis.

Digital radiographs were converted to JPG format and imported into AutoCAD software. Landmarks for Steiner and Tweed analyses were manually plotted.

AutoCAD was used as a digital manual tracing tool due to its precision and reproducibility; however, it was not considered a gold standard. Consequently, this study evaluates agreement between methods rather than accuracy, in line with contemporary recommendations for methodological comparisons in cephalometric research. Linear and angular measurements were calculated directly within AutoCAD using measurement tools. All measurements were recorded in the same Microsoft Excel spreadsheet.

All measurements were performed by a trained orthodontic resident (A.A). To assess inter-examiner reliability, a second experienced orthodontist independently repeated the measurements (H.B). A two-week interval was applied between repeated measurements to minimize memory bias. To minimize operator fatigue and potential bias, no more than 10 cephalograms were analyzed per day, and analyses using the two methods were conducted in separate sessions. Magnification was corrected using the calibration ruler (10 mm) visible on each radiograph. Images were scaled accordingly in AutoCAD prior to measurement to ensure accuracy of linear measurements.

Intra- and inter-observer reliability was evaluated using intraclass correlation coefficients (ICC) for all linear and angular measurements. ICC values above 0.75 were considered good to excellent agreement, indicating high reproducibility for both examiners. This step ensured the reliability and consistency of manual landmark placement before comparing results with the AI platform.

Agreement between methods was assessed using paired statistical tests, intraclass correlation coefficients (ICC), and Bland–Altman analysis. No reference method was considered a gold standard.

The same JPG images were imported into WebCeph™ through the Google Chrome browser. Patient profiles were established and calibrated using the 10 mm ruler visible on the cephalostat arm. The AI digitization tool automatically identified landmarks and generated measurements without any manual adjustments to assess the unmodified AI performance. The resulting cephalometric data were exported as PDF files and transferred to Microsoft Excel.

The cephalometric variables were categorized according to their anatomical and clinical nature into skeletal measurements (SNA, SNB, ANB, Wits appraisal, GoGn/SN, SN/OP, FMA) and dentoalveolar measurements (U1–NA angle and mm, L1–NB angle and mm, interincisal angle, IMPA, FMIA) (Table 1).

All measurements from both methods were entered into Microsoft Office Excel 2007 (Microsoft Corp, Redmond, Washington, USA) for statistical analysis. Each radiograph was assigned a unique identification number to ensure proper data matching between the two measurement methods.

Statistical analysis

Statistical analyses were performed after exporting all manual (AutoCAD) and AI-based (WebCeph) measurements to a spreadsheet Microsoft Excel (Microsoft Office, 365, Redmond, Washington, USA) and transferring the dataset into Jamovi version 2.6.44. Continuous variables were summarized as mean ± standard deviation, and the Shapiro–Wilk test with visual inspection of histograms and Q–Q plots was used to assess normality. Depending on distribution, paired t-tests or Wilcoxon signed-rank tests were applied to compare AI and manual measurements.

Table 1. Cephalometric measurements included in this study.

Abbreviation	Full name
SNA	Angle between Sella-Nasion line and Nasion-A point line
SNB	Angle between Sella-Nasion line and Nasion-B point line
ANB	Angle between Nasion-A point line and Nasion-B point line
U1–NA (°)	Angle between upper incisor long axis and Nasion-A point line
U1–NA (mm)	Perpendicular distance from upper incisor edge to Nasion-A point line
L1–NB (°)	Angle between lower incisor long axis and Nasion-B point line
L1–NB (mm)	Perpendicular distance from lower incisor edge to Nasion-B point line
Interincisal Angle	Angle between upper and lower incisor long axes
Wits appraisal	Distance between A point and B point along occlusal plane
GoGn/SN	Angle between Go-Gn (mandibular plane) and S-N (cranial base)
SN/OP	Inclination of occlusal plane to anterior cranial base (SN line)
FMA	Angle between Frankfort Horizontal plane and mandibular plane
IMPA	Angle between lower incisor long axis and mandibular plane
FMIA	Angle between lower incisor long axis and Frankfort Horizontal plane

Results

A total of 100 lateral cephalograms were included. Manual tracing was performed in AutoCAD and compared with AI-based analysis in WebCeph for 14 cephalometric variables. Figure 1 shows the measurements used in the current study.

In this study, the significance level was set at $p < 0.05$ for all statistical tests. For variables in which the Shapiro–Wilk test and visual inspection of histograms/QQ plots indicated

an approximately normal distribution of the AI–manual differences, comparisons between AutoCAD and WebCeph were performed using paired t-tests. For variables with non-normal distributions, the Wilcoxon signed-rank test was applied instead, using the same alpha threshold ($p < 0.05$) to determine statistical significance.

Descriptive statistics and comparisons between AI-based (WebCeph) and manual (AutoCAD) measurements for the total sample are presented in Table 2. Skeletal measurements demonstrated small mean differences and good to excellent agreement, whereas dentoalveolar measurements showed slightly greater variability, particularly for L1-NB°, interincisal angle and U1-NA°.

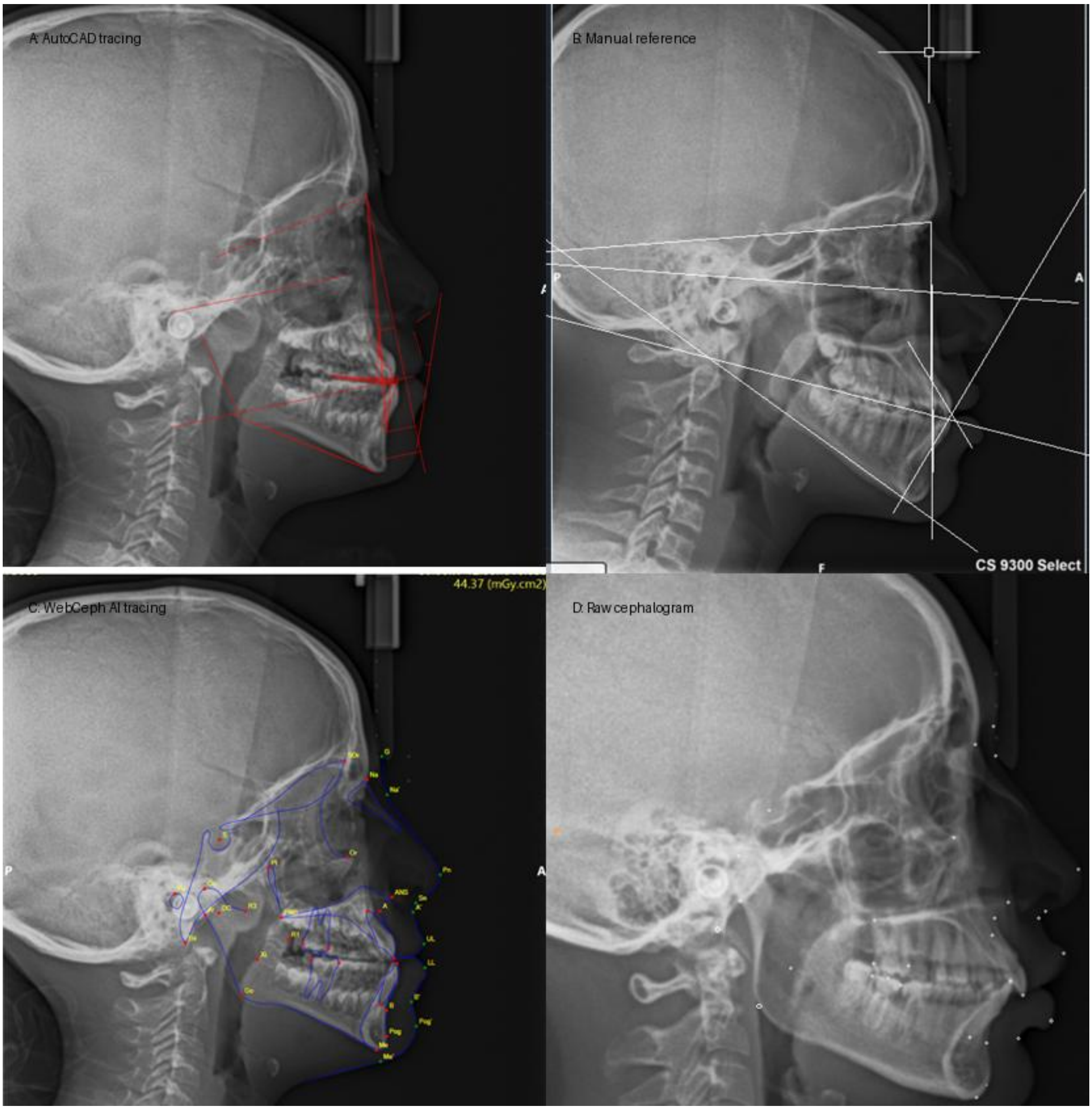

Figure 1: Lateral cephalogram demonstrating different stages of cephalometric analysis: (A) digital manual tracing performed using AutoCAD, (B) reference cephalometric construction, (C) automatic AI-based landmark detection and tracing using WebCeph, and (D) original lateral cephalogram.

Skeletal measurements showed good agreement overall; however, ANB and SN/OP demonstrated moderate ICC values. Dentoalveolar variables showed greater variability, particularly for mandibular incisor inclination (Table 3).

Across the majority of skeletal measurements (ANB, SNA, SNB, Wits appraisal, GoGn/SN, SN/OP, and FMA) and dentoalveolar measurements (U1–NA angle and mm, L1–NB angle and mm, interincisal angle, IMPA, and FMIA), no statistically significant differences were observed between AI and manual measurements (all $p > 0.05$), indicating good agreement between methods.

Table 2: Comparison of skeletal and dentoalveolar cephalometric measurements obtained using AutoCAD (manual tracing) and WebCeph (AI-based analysis) in the total sample.

Variable type	variable	Manual Mean ± SD	AI Mean ± SD	Mean Difference ± SD	Test used	p-value
Skeletal	ANB (°)	4.32 ± 2.73	4.64 ± 2.92	0.32 ± 1.37	Paired t-test	0.021
	Wits appraisal (mm)	0.63 ± 4.56	1.00 ± 4.75	0.37 ± 1.58	Paired t-test	0.022
	SNB (°)	75.7 ± 4.52	75.6 ± 4.12	−0.14 ± 2.41	Paired t-test	0.555
	FMA (°)	29.4 ± 6.43	29.3 ± 6.17	−0.11 ± 3.79	Wilcoxon	0.375
	SN/OP (°)	19.8 ± 4.67	20.0 ± 4.54	0.20 ± 4.35	Paired t-test	0.640
	GoGn/SN	39.1 ± 5.49	37.9 ± 5.01	−1.17 ± 3.66	Paired t-test	0.002
	SNA (°)	79.8 ± 4.19	80.2 ± 3.98	0.35 ± 2.72	Paired t-test	0.200
	SNB (°)	75.7 ± 4.52	75.6 ± 4.12	−0.14 ± 2.41	Paired t-test	0.555
Alveolar	FMIA (°)	57.6 ± 8.40	57.7 ± 8.09	0.12 ± 5.74	Wilcoxon	0.854
	IMPA (°)	93.4 ± 7.50	93.1 ± 8.18	−0.31 ± 5.39	Paired t-test	0.561
	Interincisal angle (°)	123 ± 12.2	125 ± 12.3	1.68 ± 5.11	Paired t-test	0.001
	UI–NA (mm)	5.54 ± 2.65	5.22 ± 2.91	−0.33 ± 2.22	Wilcoxon	0.161
	UI–NA (°)	24.7 ± 7.05	23.2 ± 7.59	−1.49 ± 4.65	Paired t-test	0.002
	LI–NB (mm)	7.32 ± 3.04	7.67 ± 3.26	0.35 ± 1.87	Paired t-test	0.066
	LI–NB (°)	29.2 ± 6.37	27.5 ± 6.85	−1.65 ± 4.70	Paired t-test	0.001

Table 3: Intraclass correlation coefficients (ICC) for skeletal and dentoalveolar cephalometric measurements between WebCeph and AutoCAD.

Variable	ICC	95% CI (Lower–Upper)
Skeletal		
ANB	0.454	0.209 – 0.646
SNA	0.748	0.598 – 0.847
SNB	0.808	0.688 – 0.885
Wits appraisal	0.916	0.858 – 0.951
GoGn/SN	0.793	0.665 – 0.876
SN/OP	0.449	0.203 – 0.642
FMA	0.860	0.768 – 0.917
Alveolar		
U1–Na (mm)	0.804	0.681 – 0.882
U1–Na (angle)	0.828	0.718 – 0.897
L1–Nb (mm)	0.646	0.455 – 0.781
L1–Nb (angle)	0.740	0.587 – 0.842
Interincisal angle	0.904	0.838 – 0.944
FMIA	0.744	0.592 – 0.844
IMPA	0.796	0.670 – 0.878

A statistically significant difference was found for the mandibular incisor inclination (L1–NB angle) (p = 0.009). Acceptable thresholds suggested by previous studies were ≤2 2mm or ≤2 2° for linear and angular measurements [17].

Bland–AltmanAnalyses: Bland–Altman analyses were performed separately for skeletal and alveolar variables to evaluate the agreement between AutoCAD and WebCeph measurements.

Alveolar Measurements: For alveolar variables (U1–Na [mm], L1–Nb [mm], U1-NA°,L1-NB°,IMPA and interincisal angle) (Figure 2), the mean bias was also near zero, with most observations within the 95% limits of agreement

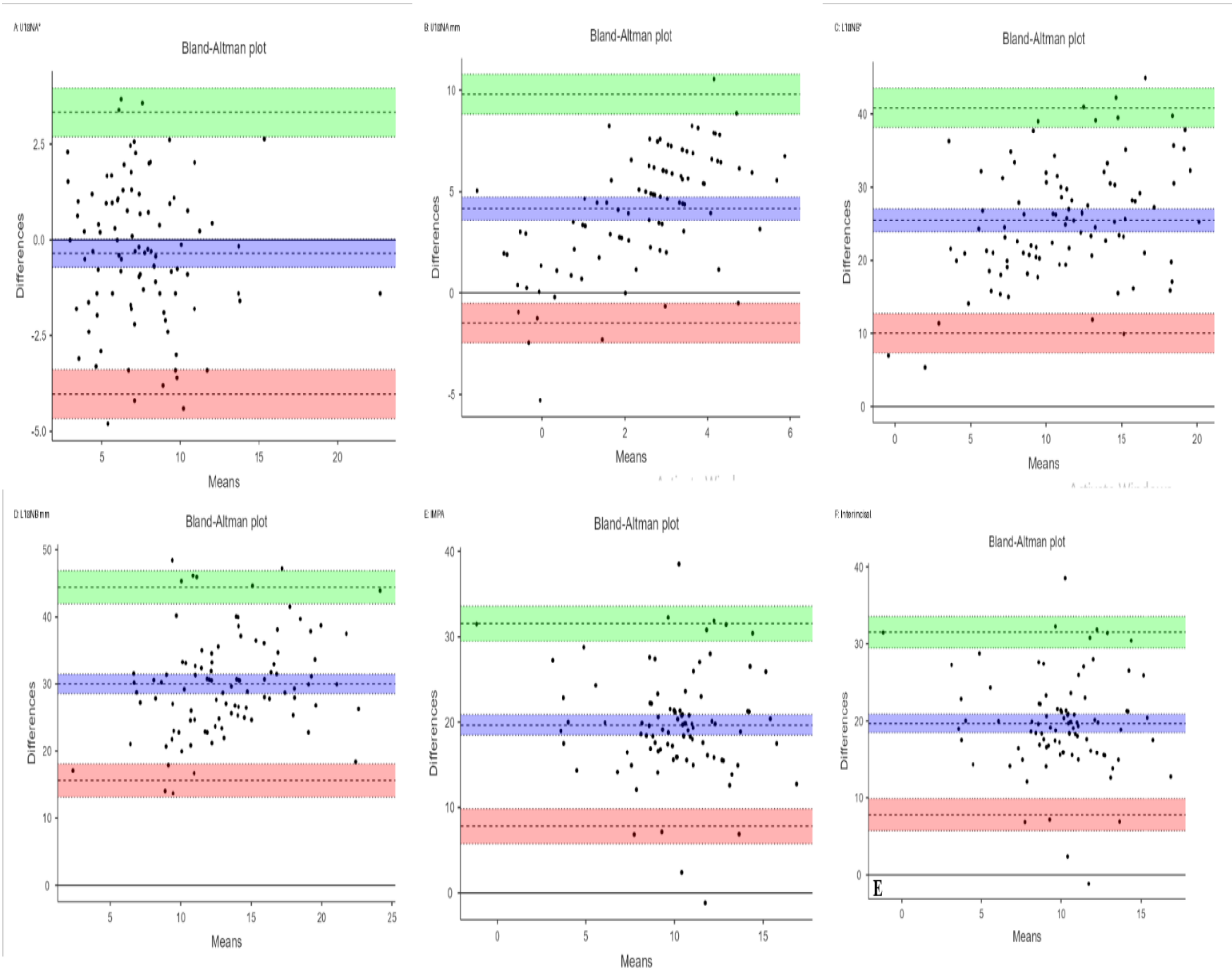

Figure 2: Bland-Altman plot for dento-alveolar indices.

Skeletal Measurements: For skeletal variables (FMA, ANB, SNA, SNB, Witts, and GoGn/SN) (Figure 3), the mean differences were close to zero, and most observations fell within the limits of agreement.

These findings suggest that discrepancies between AI-based and manual measurements are minimal and do not have a significant impact on clinical decision-making.

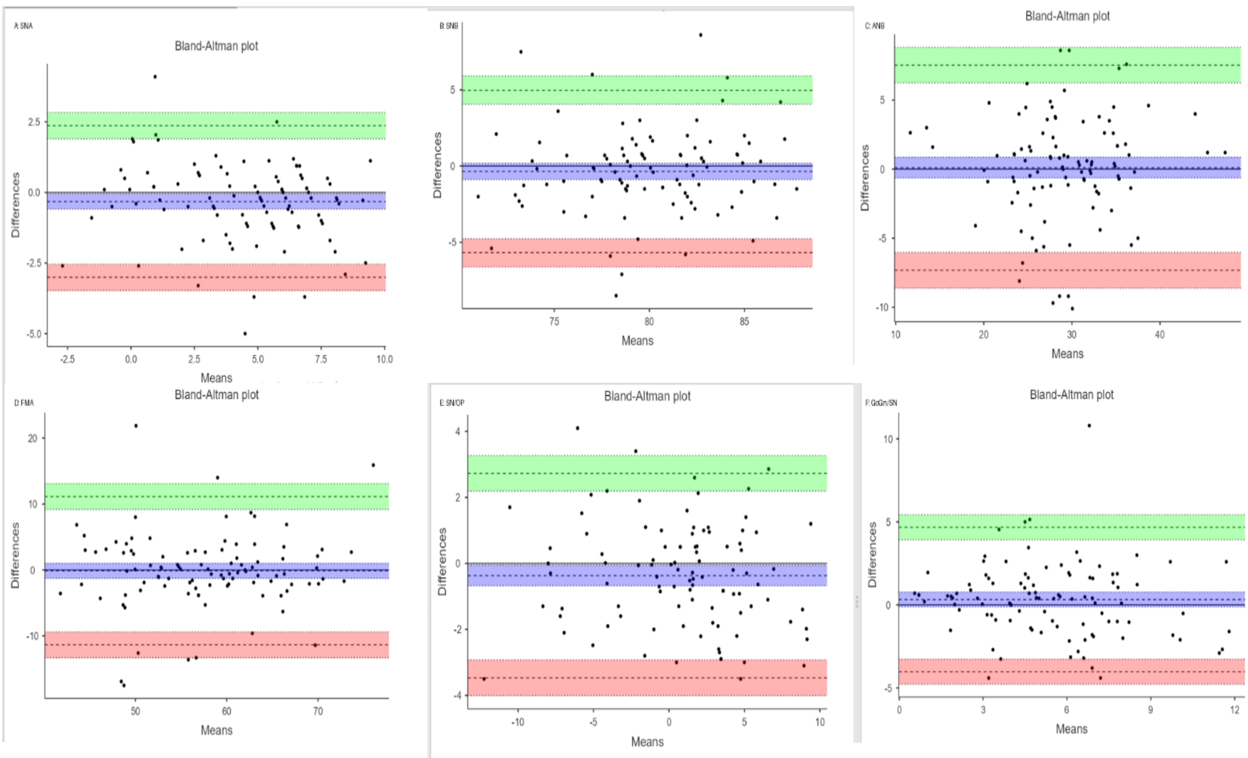

Figure 3: Bland-Altman plot for skeletal indices.

Discussion

Cephalometric analysis is an essential tool in orthodontics, as it provides objective information on skeletal and dental relationships and helps guide treatment decisions. With the growing availability of artificial intelligence tools, there is increasing interest in their potential to simplify and accelerate this process.

Several studies have evaluated the performance of AI-based cephalometric systems. Kunz et al.'s indicated a high level of correlation between WebCeph's accuracy and reliability and those of human orthodontic clinical experts assessing a number of different commercial AI-based cephalometric solutions, although there were differences in landmark performance between WebCeph and other solutions [15]. In parallel Hwang et al., Indermun et al., and Wang et al. have shown that deep learning methods can identify a large number of cephalometric landmarks with an accuracy that is similar to that of a human rater, but the landmark accuracy is derived differently from one study to another based on the specific dataset and landmark used [16-18], studies by Katyal and Mahto, showed there was good agreement between conventional or digital manual tracings and WebCeph for a majority of the historic linear and angular measurement types used in cephalometric analysis [19-20].

In comparison to similar studies where a deviation of less than two millimeters from the mean indicates an acceptable level of difference between AI and manual measurements [21,22] , the majority of our sample demonstrated a clinically acceptable level of discrepancy with respect to the vast majority of linear and angular measurements. These findings are corroborated by the work of Silva et al., who reported high reproducibility for WebCeph with ICC values ≥0.75 for most of the measurements. Other studies report that a limited number of variables within such studies have been documented with poor to moderate reliability [23]. As summarized by Yu et al., both traditional and AI methods of analysis are capable of accurately replicating traditional methodology; caution should be exercised when interpreting those parameters with lower ICC values [24]. The low ICC values for ANB and SN/OP are most likely attributable to the cumulative effect of minor deviations of the cephalometric landmarks from the defined location upon which these measurements are based.

Previous studies by Hwang et al. and Alessandri Bonetti et al. report that modern deep learning algorithms can detect numerous common landmarks with high accuracy when compared to human examiners (i.e. skeletal landmarks defined by angular measurements). However, research has also indicated that the accuracy of different AI software programs on detecting or measuring different landmarks will vary significantly by landmark category with greater discrepancies found for tooth and soft tissue spine related landmarks (25,26). No statistically significant differences were documented between manual and digital measurements of key skeletal angles (i.e., ANB, SNA, SNB, and Interincisal) among related authors of Paixao et al., Bruntz et al., and Uysal et al. demonstrating high reproducibility of WebCeph measurements when compared to those performed manually using AutoCAD software (27-29). A pattern of significantly greater bias in measuring mandible incisor inclination angles (i.e., L1 – Nb angle) was observed in the current study which echoes the results of Gregston et al., Celik et al. and Singh and Davies whom have consistently reported that LI – NB demonstrated the greatest variability between individuals while remaining relatively stable between methods of tracing (30-32).

Curvature of the anatomical planes, lack of superimposition of the roots and variability in constructing the mandible can lead to enlarging any discrepant small landmarking deviations between these variables to make them appear as larger angular differences (33-35).

Future work directions

Future studies should employ a multicenter prospective design, should integrate 3D CBCT into the studies completed and should involve larger and more diverse cohorts of patients while providing long-term follow-up of changes related to treatment from the time of radiographic evaluation. Additionally, subsequent studies could make use of advanced deep learning technologies, in conjunction with AQ-based workflows (a combination of machine and human effort), to improve the quality of the AI output for the identification of dento-alveolar structures through improved diagnostic protocol.

Conclusion

Within the limitations of this study, WebCeph demonstrates good agreement with digital manual tracing for most cephalometric variables Skeletal and dentoalveolar measurements showed overall comparable reliability; however, slightly greater variability was observed in certain dentoalveolar parameters, particularly those related to mandibular incisor inclination. AI-based cephalometric analysis should therefore be regarded as a supportive diagnostic tool**,** with selective manual verification recommended for clinically sensitive measurements

Conflict of interest

The authors have no conflicts of interest to declare.

Author contribution

AA study conception and design. AMD; data collection. BH and IH; statistical analysis and interpretation of results. AAT, AMD and BH; Writing - review & editing. Supervision; FZ and IH. All authors reviewed the results and approved the final version of the manuscript to be published.

Acknoledgement and funding

There was no external support for this study.

Informed consent

Informed consent was obtained from all individuals or their guardians included in this study.

References

1. Forsyth DB, Shaw WC, Richmond S, Roberts CT. Digital imaging of cephalometric radiographs, part 2: image quality. The Angle Ortho. 1996 Feb 1;66(1):43-50.

2. Zaheer R, Shafique HZ, Khalid Z, Shahid R, Jan A, Zahoor T, et al. Comparison of semi- and fully automated artificial intelligence-driven software and manual systems for cephalometric analysis. BMC Med Inform Decis Mak. 2024;24(1):271. https://doi.org/10.1186/s12911-024-02664-3

3. Shan T, Tay FR, Gu L. Application of artificial intelligence in dentistry. J Dent Res. 2021;100(3):232–244. https://doi.org/10.1177/0022034520969115

4. Khanagar SB, Al-Ehaideb A, Maganur PC, Vishwanathaiah S, Patil S, Baeshen HA, et al. Developments, application, and performance of artificial intelligence in dentistry: A systematic review. J Dent Sci. 2021;16(1):508–522. https://doi.org/10.1016/j.jds.2020.06.019

5. Tandon D, Rajawat J, Banerjee M. Present and future of artificial intelligence in dentistry. J Oral Biol Craniofac Res. 2020;10(4):391–396. https://doi.org/10.1016/j.jobcr.2020.07.015

6. Kong SC, Cheung WMY, Zhang G. Evaluating artificial intelligence literacy courses for fostering conceptual learning and empowerment in university students. Comput Hum Behav Rep. 2022;7:100223. https://doi.org/10.1016/j.chbr.2022.100223

7. Lee RS. Artificial Intelligence in Daily Life. Springer; 2020.

8. Liermann VJ. Overview of machine learning and deep learning frameworks. J Big Data. 2021;8:187–224. https://doi.org/10.1186/s40537-021-00444-8

9. Uysal T, Baysal A, Yagci A. Evaluation of speed, repeatability, and reproducibility of digital radiography with manual versus computer-assisted cephalometric analyses. Eur J Orthod. 2009;31(5):523–528. https://doi.org/10.1093/ejo/cjp022

10. Alqahtani H. Evaluation of an online website-based platform for cephalometric analysis. J Stomatol Oral Maxillofac Surg. 2020;121(1):53–57. https://doi.org/10.1016/j.jormas.2019.05.006

11. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod. 1983;83(5):382–390. https://doi.org/10.1016/0002-9416(83)90322-6

12. Histau B, Coreil M, Chapple A, Armbruster P, Ballard R. Comparison of AudaxCeph® fully automated cephalometric tracing technology to a semiautomated approach. Int Orthod. 2022;20:100597. https://doi.org/10.1016/j.ortho.2022.100597

13. Kiełczykowski M, Kamiński K, Perkowski K, Zadurska M, Czochrowska E. Application of artificial intelligence in cephalometric analysis: A narrative review. Diagnostics (Basel). 2023;13(16):2704. https://doi.org/10.3390/diagnostics13162704

14. Kunz F, Stellzig-Eisenhauer A, Widmaier LM, Zeman F, Boldt J. Assessment of different AI-based providers for automated cephalometric analysis. J Orofac Orthop. 2023. https://doi.org/10.1007/s00056-023-00491-1

15. Hwang HW, Park JH, Moon JH, Yu Y, Kim H, Her SB, Srinivasan G, Aljanabi MN, Donatelli RE, Lee SJ. Automated identification of cephalometric landmarks: Part 2. Angle Orthod. 2020;90:69–76. https://doi.org/10.2319/022019-129.1

16. Indermun S, Shaik S, Nyirenda C, Johannes K, Mulder R. Human examination and artificial intelligence in cephalometric landmark detection. Dentomaxillofac Radiol. 2023;52:20230012. https://doi.org/10.1259/dmfr.20230012

17. Wang CW, Huang CT, Hsieh MC, Li CH, Chang SW, Li WC, Vandaele R, Marée R, Jodogne S, Geurts P, Chen C.. Evaluation of anatomical landmark detection methods for cephalometric X-ray images. IEEE Trans Med Imaging. 2015;34:1890–1900. https://doi.org/10.1109/TMI.2015.2428311

18. Katyal BN. Evaluation of the accuracy and reliability of WebCeph: An AI-based online software. APOS Trends Orthod. 2022.

19. Mahto RK, Kafle D, Giri A, Luintel S, Karki A. Evaluation of fully automated cephalometric measurements obtained from a web-based AI platform. BMC Oral Health. 2022;22(1):132. https://doi.org/10.1186/s12903-022-02119-8

20. Bao H, Zhang K, Yu C, Li H, Cao D, Shu H, et al. Evaluating the accuracy of automated cephalometric analysis based on artificial intelligence. BMC Oral Health. 2023;23:456. https://doi.org/10.1186/s12903-023-03108-3

21. Silva TP, Pinheiro MCR, Freitas DQ, Gaeta-Araujo H, Oliveira-Santos C. Assessment of accuracy and reproducibility of AI-driven cephalometric tracing applications. Oral Surg Oral Med Oral Pathol Oral Radiol. 2024;137(4):431–440. https://doi.org/10.1016/j.oooo.2024.01.011

22. Bao H, Zhang K, Yu C, Li H, Cao D, Shu H, et al. Evaluating the accuracy of automated cephalometric analysis based on artificial intelligence. BMC Oral Health. 2023;23:456. https://doi.org/10.1186/s12903-023-03108-3

23. Silva TP, Pinheiro MCR, Freitas DQ, Gaeta-Araujo H, Oliveira-Santos C. Assessment of accuracy and reproducibility of cephalometric identification performed by 2 artificial intelligence-driven tracing applications and human examiners. Oral Surg Oral Med Oral Pathol Oral Radiol. 2024;137(4):431–440. https://doi.org/10.1016/j.oooo.2024.01.011

24. Yu HJ, Cho SR, Kim MJ, Kim WH, Kim JW, Choi J.. Automated skeletal classification with lateral cephalometry based on artificial intelligence. J Dent Res. 2020;99:249–256. https://doi.org/10.1177/0022034519889169

25. Alessandri-Bonetti A, Sangalli L, Salerno M, Gallenzi P. Reliability of artificial intelligence-assisted cephalometric analysis. BioMedInformatics. 2023;3:44–53. https://doi.org/10.3390/biomedinformatics3010004

26. Hwang HW, Moon JH, Kim MG, Donatelli RE, Lee SJ. Evaluation of automated cephalometric analysis based on the latest deep learning method. Angle Orthod. 2021;91:329–335. https://doi.org/10.2319/072220-657.1

27. Paixão MB, Sobral MC, Vogel CJ, Araujo TM.. Comparative study between manual and digital cephalometric tracing using Dolphin Imaging software with lateral radiographs. Dental Press J Orthod. 2010;15(6):123–130. https://doi.org/10.1590/S2176-94512010000600016

28. Bruntz LQ, Palomo JM, Baden S, Hans MG. A comparison of scanned lateral cephalograms with corresponding original radiographs. Am J Orthod Dentofacial Orthop. 2006;130(3):340–348. https://doi.org/10.1016/j.ajodo.2004.12.029

29. Uysal T, Baysal A, Yagci A. Evaluation of speed, repeatability, and reproducibility of digital radiography with manual versus computer-assisted cephalometric analyses. Eur J Orthod. 2009;31(5):523–528. https://doi.org/10.1093/ejo/cjp022

30. Singh P, Davies TI. A comparison of cephalometric measurements: a picture archiving and communication system versus the hand-tracing method. Eur J Orthod. 2011;33(4):350–353. https://doi.org/10.1093/ejo/cjq087

31. Gregston MD, Kula T, Hardman P, Glaros A, Kula K.. Comparison of conventional and digital radiographic methods and cephalometric analysis software. Semin Orthod. 2004;10(3):204–211. https://doi.org/10.1053/j.sodo.2004.05.004

32. Celik E, Polat-Ozsoy O, Toygar Memikoglu TU. Comparison of cephalometric measurements with digital versus conventional cephalometric analysis. Eur J Orthod. 2009;31(3):241–246. https://doi.org/10.1093/ejo/cjn105

33. Polat-Ozsoy O, Gokcelik A, Toygar Memikoglu TU. Differences in cephalometric measurements: a comparison of digital versus hand-tracing methods. Eur J Orthod. 2009;31(3):254–259. https://doi.org/10.1093/ejo/cjn121

34. Moreno M, Gebeile-Chauty S. Comparative study of two software for cephalometric landmark detection. Orthod Fr. 2022;93(1):41–61. https://doi.org/10.1684/orthodfr.2022.73

35. Yassir YA, Salman AR, Nabbat SA. The accuracy and reliability of WebCeph for cephalometric analysis. J Taibah Univ Med Sci. 2021;17(1):57–66. https://doi.org/10.1016/j.jtumed.2021.08.010

مدى الاتفاق والموثوقية لتحليل القياسات السيفالومترية المعتمد على الذكاء الاصطناعي (WebCeph) مقارنةً بالتتبع اليدوي الرقمي لقياسات الهيكل العظمي والأسنان السنخية : دراسة مقارنة استعادي

عفاف الأصفر، عفاف المرواني الإدريسي، إيمان حارتي، فاطمة الزواوي، هشام بن يحيى

المستخلص

تقييم مدى الاتفاق والموثوقية بين القياسات السكلية والسنية السنخية في التحليل السيفالومتري باستخدام منصة تعتمد على الذكاء الاصطناعي (WebCeph) مقارنة بالتتبع اليدوي الرقمي باستخدام برنامج .AutoCAD المواد وطرائق العمل: تم تحليل 100 صورة سيفالومترية جانبية بشكل استعادي باستخدام WebCeph والتتبع اليدوي الرقمي بواسطة .AutoCAD شملت الدراسة أربعة عشر متغيرًا سيفالومتريًا من تحليلي Steiner وTweed، وصُنِّفت إلى قياسات سكلية وسنية سنخية. استُخدمت اختبارات t المزدوجة أو اختبار ويلكوكسون للرتب الموقعة للمقارنة بين الطريقتين، كما تم تقييم الاتفاق باستخدام معاملات الارتباط داخل الفئة (ICC) وتحليل .Bland–Altman النتائج: أظهرت النتائج توافقًا جيدًا إلى ممتاز لمعظم القياسات السكلية والسنية السنخية .(ICC ≥ 0.75) وتميزت القياسات السكلية بفروق أقل وحدود اتفاق أضيق مقارنة بالقياسات السنية السنخية. لوحظت فروق ذات دلالة إحصائية في بعض المتغيرات السنية السنخية، خاصة ميل القاطع السفلي، إلا أن جميع الفروق كانت ضمن الحدود المقبولة سريريًا. الاستنتاجات: يوفر WebCeph قياسات سيفالومترية موثوقة سريريًا لكل من المتغيرات السكلية والسنية السنخية. وتُعد القياسات السكلية أكثر ثباتًا، في حين يُنصح بالتحقق اليدوي الانتقائي للمتغيرات السنية السنخية الحساسة سريريًا.