Original Article

Validation of an AI-aided 3D method for enhanced volumetric quantification of external root resorption in orthodontics

Teresa Baena-de la Iglesia[a]; Estrella Navarro-Fraile[a]; Alejandro Iglesias-Linares[b]

ABSTRACT

Objectives: To compare and validate two tridimensional diagnostic methods for quantifying and categorizing external root resorption using an artificial intelligence (AI)-aided, automatic, or manual digital segmentation process.
Materials and Methods: 40 teeth were segmented from 10 cone beam computed tomography (CBCT) records from five patients. Stereolithographic files were created, and automatic, manual, or AI-aided segmentation of each incisor was performed by two double-blinded operators. Two quantification methods were used and compared by analyzing final segmented regions of the tooth. This study followed QAREL (Quality Appraisal of Diagnostic Reliability) and COSMIN (COnsensus-based Standards for the selection of health Measurement Instruments) guidelines. Reproducibility was assessed using the Dahlberg formula, coefficient of variation, and intraclass correlation coefficient (ICC) (P value $< .05$).
Results: Intra- and interobserver correlations were high (ICC: > 0.736; $P < .01$). Statistically significant differences were found between the two measurement methods for high-quality CBCT images of central incisors, mainly at the level of the apical third. Specific differences were found between methods when root resorption was evaluated in the middle and apical thirds using AI segmentation of the central incisor ($P = .043$). When referring to total volume loss of the lateral incisor, differences ($P = .021$) were observed between methods when segmented by manual or AI-aided procedures. Highest specificity (100%) was observed for AI-aided segmentation and Method 2 for evaluation of root resorption at the apical third volume.
Conclusions: Assessment of root resorption with CBCT is highly dependent on CBCT definition, type of segmentation, and measurement method. Three-dimensional (3D) measurement method described by three landmark points yielded satisfactory results using any tested segmentations. (*Angle Orthod*. 0000;00:000–000.)

KEY WORDS: Root resorption; CBCT; Root volume; Root length; Apical third; Coronal third

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INTRODUCTION

External root resorption (ERR) is an undesirable, secondary effect of orthodontic tooth movement due to multifactorial causes, including duration of treatment, magnitude of force, intrusive movement, and amount of root movement.[1]

Clinical diagnosis requires two- or three-dimensional (2D or 3D) radiographic imaging.[2,3] In particular, 2D radiographic methods, such as panoramic and periapical radiographs,[4,5] have traditionally been used in clinical and research settings for diagnosis and quantification. Nevertheless, certain limitations have been described for 2D radiographs, such as magnification and image distortion, which pose difficulties in accurately measuring the extent of ERR. Histological studies have shown root resorption in regions where 2D radiographs fail to detect any signs of root shortening, revealing several discrepancies between histological findings and 2D radiographic assessments after orthodontic treatment.[6]

To overcome the diagnostic limitations of 2D radiographs, 3D imaging has been suggested to offer superior precision and reproducibility for the accurate diagnosis of

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Accepted: April 20, 2025. Submitted: September 23, 2024.
Published Online: June 6, 2025
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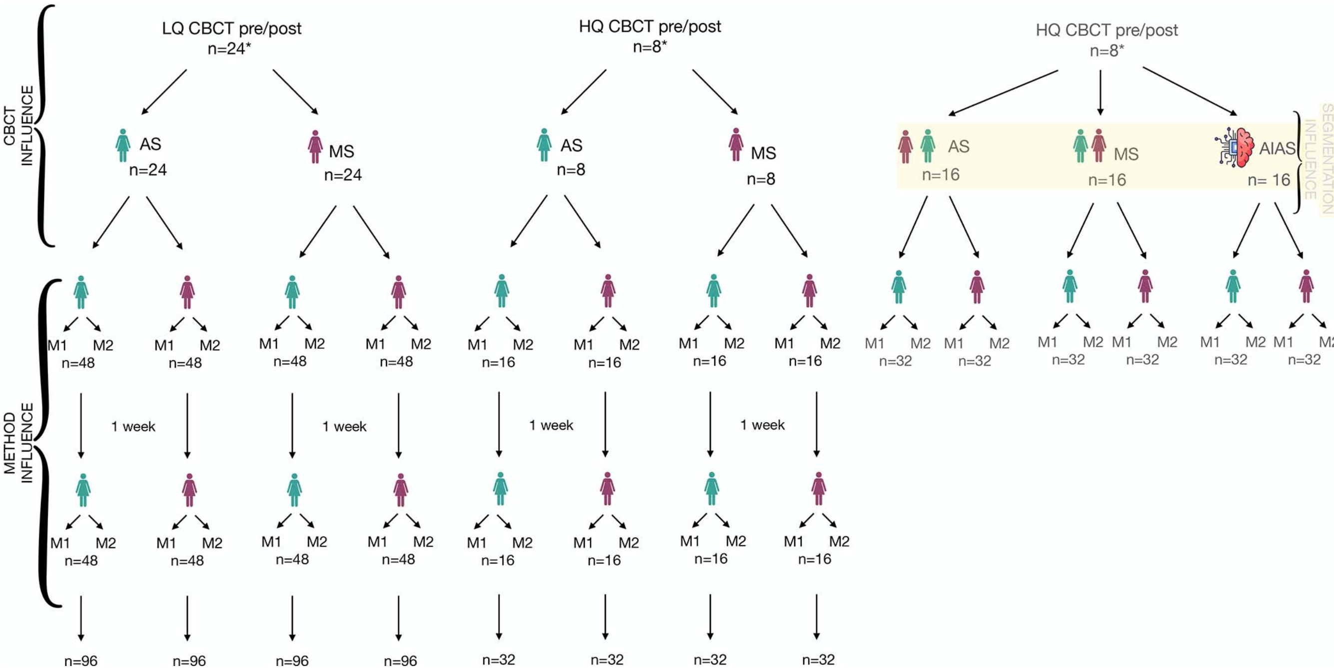

Figure 1. Method validation design.

root resorption.[7] Although root resorption typically results in shortened root length, some studies[8] have reported that root length in millimeters may not be significantly affected when root volume changes. In this context, CBCT records have been recommended[9] for their adequate precision and good comparability in volumetric quantification. Specifically, the precision offered by this type of radiographic record has been shown to be quite good for detecting resorption craters larger than 3.47 mm,[3] and as small as 1.07 mm.[3]

Several methods for qualitatively analyzing ERR have been described[10,11], with certain limitations. For example, the grayscale similarity on cone beam computed tomography (CBCT) between a tooth and the surrounding tissue makes automatic segmentation with specific software challenging, especially in regions of the lower incisors and upper canines where the roots of these teeth are very close to the cortex of the alveolar bone. In addition, the time consumption of current manual segmentation methods for tooth roots significantly limits their routine use in the clinical setting.[12] There is a lack of a standardized and validated methods to quantify apical root resorption or other types of root attrition in organized sections of different root regions.[13–15] It was hypothesized that artificial intelligence (AI)-aided linear/volumetric root resorption quantification might provide differences compared to manual or automatic methods. Therefore, the present study aimed to develop and compare two measurement methods and validate a new 3D AI-aided method for ERR.[16]

MATERIALS AND METHODS

Study Design

Forty tooth roots were segmented from 10 CBCT records obtained from five adult patients (pre- and post-treatment) from a database. As previously published by other authors, a tentative number of patients was randomly selected[17] to distribute randomly for confounding factors for those patients that exhibited severe ERR vs no apparent ERR.

A total of 704 measurements were obtained by two experienced examiners (TBI and ENF). Specifically, four upper incisors were analyzed (Figure 1).

CBCT Records

To evaluate the impact of CBCT accuracy on root resorption detection, this study analyzed 10 records (five pre- and five post-orthodontic) from low- and high-definition CBCTs. Low-definition scans were obtained using the NewTom 10.1 machine, with a 16 × 16 field of view (FOV), 0.2–0.4 mm voxel size, 9.01 mA, 110 kV, and 3.5 s exposure time. High-definition records were taken with a Carestream cone beam (model 93000), featuring a 5 × 5 FOV, 180 μm voxel size, 10 mA, 90 kV, and 8 s exposure time. Three patients exhibited severe ERR in upper incisors on panoramic radiographs, whereas two showed no apparent ERR on 2D records.

Manual, Automatic, and AI-aided Digital Segmentation

Digital Imaging and Communications in Medicine datasets were imported into a free, open source, and

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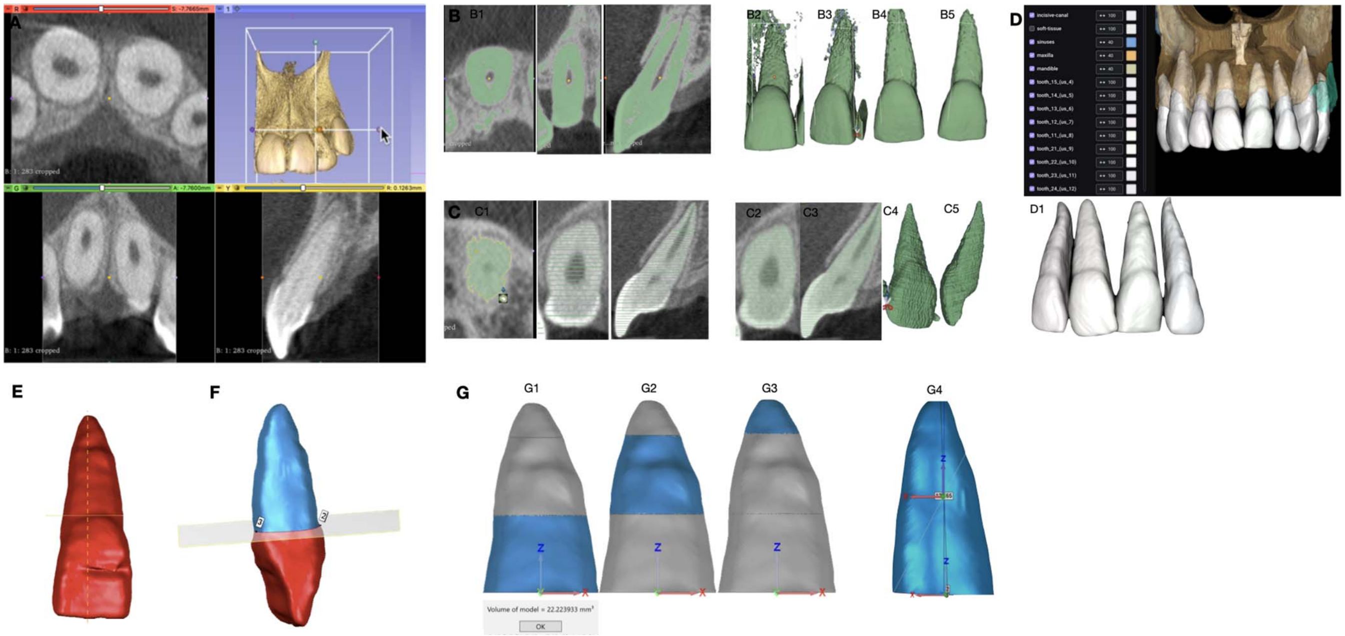

Figure 2. Segmentation and quantification process.

multi-platform software distributed under a BSD (Berkeley Source Distribution) style license (3DSlicer®, version 4.11.20200930, http://www.slicer.org) to generate stereolithographic (STL) data (Figure 2A).

Automatic and manual segmentation (Figures 2B and 2C) of each incisor was conducted by two double-blinded operators. Automatic segmentation was performed using the "threshold" tool until a complete filling of the tooth to be segmented was obtained. Subsequently, tooth segmentation was completed utilizing the "paint" and "erase" tools. To perform manual segmentation, the "level tracing" tool was applied, making cuts every 0.09 mm from the apex to the incisal edge, resulting in a total of 15 cuts per piece. The gaps were then filled using the "fill between slices" tool. The "paint" and "erase" tools were then used to refine the details of each tooth (Multimedia Resource 1-2).

Finally, a third type of digital segmentation was implemented in the same sample: AI-assisted root segmentation (Figure 2D) based on deep learning (DL) algorithms, specifically models based on convolutional neural networks (CNNs), was performed to analyze and process CBCT images (Diagnocat) (Multimedia Resource 3).

ERR Quantification Methods

The reference plane was traced using two different types of landmarks and methods. The crown and root from the original segmented STL file were divided in two different ways using *Geomagic wrap* software (Geomagic, Cary, NC, USA). (Multimedia Resource 4-5). Method 1: A reference plane was generated perpendicular to the central axis of the tooth through the highest point of the amelo-cemental junction[8] (Figure 2E); Method 2: A reference plane was generated by three reference landmarks: two points extremely close at the highest amelo-cemental junction in the buccal and another at the highest in the palatal (Figure 2F).

The final segmented regions of the tooth enabled calculation of the following variables to fully characterize and quantify ERR: Root length (RL), total volume (RV), volume by thirds (coronal, middle, apical), total root loss (TRL), root loss by thirds (coronal 1/3 RL, middle 1/3 RL, apical 1/3 RL), and total root length loss (LL) were measured. Root volume loss was calculated as the difference between T_1 and T_0.

Validation of the Tested Methods

The influence over ERR measurement of 40 factors was quantified, specifically CBCT definition, type of digital segmentation, and type of quantification method (reference plane used). The QAREL (Quality Appraisal of Diagnostic Reliability) and COSMIN (COnsensus-based Standards for the selection of health Measurement Instruments) guidelines were followed as the standards for reliability and measurement error studies. (Supplementary Appendix 1 and 2; Supplementary Table 1).

Statistics

Reproducibility analyses were conducted by grouping direct (volume and length) and indirect measurements (loss of volume and length due to treatment) taken by both researchers at different times. The analyses used the Dahlberg formula, coefficient of variation, intraclass

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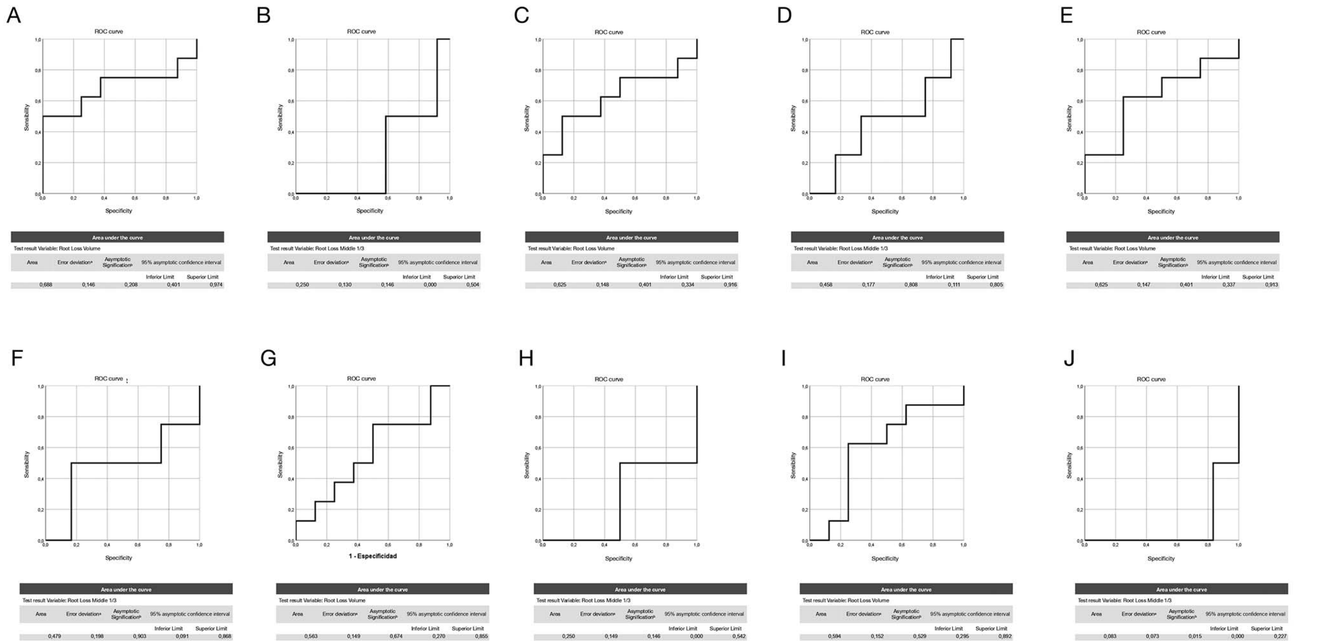

Figure 3. ROC curves. ROC indicates receiver operating characteristic.

correlation coefficient (ICC), and Student's *t*-test to compare means. A 5% significance level ($\alpha = 0.05$) was applied, and all analyses were performed using SPSS version 25.

Method Error

Measurements of 32 teeth of the four selected patients were repeated consecutively after 1 week and were used to calculate the methodological error (Student's *t*-test for paired samples) and absolute ICC.

A second operator took the same measurements to assess the methodological error and interobserver accuracy. Measurements were performed twice weekly by two double-blinded operators. The Kolmogorov–Smirnov test was used to determine the normality of the sample.

Spearman's correlation was used for paired measurements performed 1 week apart. Categorical variables and continuous variables (RV, RL, LL, VL, coronal 1/3 RL, middle 1/3 RL, apical 1/3 RL) were analyzed using the Mann–Whitney *U* test for comparisons between the two groups. For comparisons among the three groups, the Kruskal–Wallis test was applied. It was used to calculate the sensitivity, specificity, precision, and ROC curves (Figure 3). The level of significance used in the analyses was 5% ($\alpha = 0.05$).

RESULTS

Intra- and Inter-observer Correlation

Adequate agreement was observed between the examiners (0.877–0.736; $P < .001$). The ICC for total root volume loss was 0.870. A coefficient of 0.864 was obtained for linear measurement in the length loss variable (Table 1). The intra-observer correlation after 1 week of repeated measurements was adequate, and a significance of $P < .01$ with an effect size (≥ 0.3) was obtained for both observers.

Influence of CBCT

No statistically significant differences were found in the longitudinal measurements between the low- and high-definition CBCT scans. However, regarding volumetric measurements, statistically significant differences were found between the two measurement methods for

Table 1. Interexaminer Comparison[a,b]

	Total Root Volume Loss ICC	Coronal 1/3 RV Loss ICC	Middle 1/3 RV Loss ICC	Apical 1/3 RV Loss ICC	Root Length Loss (mm) ICC
VC (%) Examiner 1	0.870 ($P < .01$)	0.838 ($P < .01$)	0.877 ($P < .01$)	0.736 ($P < .01$)	0.864 ($P < .01$)
VC (%) Examiner 2					
Effect size (Cohen's d)	$\geq$0.3	$\geq$0.3	$\geq$0.3	$\geq$0.3	$\geq$0.3

[a] ICC indicates intraclass correlation coefficient; RV, root volume mm^3; VC, variation coefficient.
[b] The ICC for total root volume loss was 0.870 ($P < .01$). Adequate concordance was observed between the examiners (0.877–0.736; $P < .001$); Cohen's d = big effect size.

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Table 2. Impact of CBCT Quality on the Diagnosis of Root Resorption[a,b]

	CBCT Low Quality			CBCT High Quality			
	Method 1 Mean ± SD	Method 2 Mean ± SD	*P* value	Method 1 Mean ± SD	Method 2 Mean ± SD	*P* value	Effect size (Cohen's d)
Root Volume Loss (mm³)							
12							
Coronal	17.34 ± 23.88	17.81 ± 26.11	.954	−9.94 ± 11.56	−9.06 ± 10.67	.821	
Middle	16.92 ± 17.55	18.11 ± 18.67	.954	−1.33 ± 8.19	−3.21 ± 9.51	.291	
Apical	18.73 ± 8.11	22.06 ± 11.35	.488	2.80 ± 6.50	−1.21 ± 5.02	.076	
Total	53 ± 44.25	58.00 ± 47.71	.862	−8.48 ± 20.81	−13.51 ± 23.09	.366	
11							
Coronal	16.68 ± 22.54	22.34 ± 25.09	.564	−6.94 ± 9.92	−7.73 ± 9.63	.880	
Middle	23.51 ± 23.29	21.33 ± 22.92	1.000	0.43 ± 9.43	−3.56 ± 6.81	.163	
Apical	21.67 ± 8.23	20.22 ± 14.27	.908	2.90 ± 8.96	−3.13 ± 5.62	.024*	≥0.80
Total	61.86 ± 45.88	64.40 ± 43.50	.817	−3.61 ± 26.07	−14.42 ± 18.70	.122	
21							
Coronal	24.82 ± 23.11	20.63 ± 23.55	.773	−5.23 ± 5.84	−6.68 ± 6.24	.572	
Middle	33.88 ± 26.17	27.38 ± 20.78	.525	1.22 ± 8.14	−3.12 ± 5.82	.065	
Apical	26.10 ± 11.55	28.49 ± 16.86	.817	1.90 ± 9.70	−2.65 ± 7.86	.038*	0.50–0.79
Total	84.80 ± 52.71	76.50 ± 47.24	.686	−2.12 ± 21.16	−12.88 ± 17.58	.122	
22							
Coronal	12.35 ± 22.26	11.00 ± 17.65	.908	−6.54 ± 6.74	−6.79 ± 7.45	.940	
Middle	21.32 ± 14.44	20.85 ± 11.60	.817	−2.30 ± 7.21	−6.11 ± 6.46	0.142	
Apical	15.15 ± 6.63	19.58 ± 10.16	.184	2.25 ± 6.38	−3.04 ± 5.63	.060	
Total	48.82 ± 36.01	51.41 ± 31.09	.908	−6.91 ± 16.36	−16.01 ± 16.90	.113	
Root Length loss (mm)							
12							
Total	2.88 ± 1.07	2.40 ± 1.31	.419	0.14 ± 0.41	0.06 ± 0.49	.734	
11							
Total	2.70 ± 0.95	2.49 ± 1.36	.908	−0.15 ± 0.34	−0.13 ± 0.51	.910	
21							
Total	3.15 ± 0.76	2.94 ± 0.60	0.525	−0.12 ± 0.42	−0.11 ± 0.70	.585	
22							
Total	2.48 ± 1.97	2.29 ± 1.95	.729	0.29 ± 0.62	0.13 ± 0.64	.637	

* Sig. < 0.05.

[a] Comparison of both Methods 1 and 2 in low- and high-quality CBCT in all the incisors analyzed, total volume in mm3 and by thirds (coronal, middle, apical) as well as their length in mm.

[b] Big effect size d ≥ 0.80; moderate effect size d = 0.50–0.79.

high-quality CBCT in the central incisors, mainly at the level of the apical third with a moderate and big effect size (≥0.80 and 0.50–0.79) (Table 2).

Influence of the Segmentation

No statistically significant differences were found in root length loss between any segmentation types using either quantification method. Similarly, volume loss quantification was consistent for both methods with automatic segmentation. However, differences were observed in root volume loss when measuring specific tooth roots in the apical third and total RRE ($P = .037$; $d \geq 0.80$) using manual segmentation. Differences were also noted in root resorption analysis of the middle and apical thirds using AI-aided segmentation for central and lateral incisors ($P = .043$; $d \geq 0.80$) (Table 3).

Influence of the Measurement Method

No statistically significant differences were found in terms of length loss between Methods 1 and 2 for the three types of segmentation. Differences ($P = .021$) were only observed in terms of total volume loss at the level of the central incisor between Methods 1 and 2 when segmented with either the Manual or AI-aided procedure. These results showed similar performance for both methodologies, with minor differences in total volume detection (Figure 4).

Sensibility, Specificity, Precision, Receiver Operating Characteristic Curves

The specificity was 100% in five comparisons of linear root resorption measurements based on root length loss in mm. Specificity and precision were both 100%, whereas sensitivity was 50% for total volume resorption when comparing Method 2 to the gold standard. For apical third resorption, specificity was 93.8%. The highest specificity (100%) was found using AI-aided segmentation with Method 2 for apical third volume resorption. Lower values (up to 62.5% and 93.8%) were

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Table 3. Impact of Type of Digital Segmentation on the Diagnostic of Root Resorption[a–d]

	Manual Segmentation				Automatic Segmentation			Artificial Intelligence-Aided Segmentation			
Tooth	Method 1 Mean ± SD	Method 2 Mean ± SD	*P* value	Effect size (Cohen's d)	Method 1 Mean ± SD	Method 2 Mean ± SD	*P* value	Method 1 Mean ± SD	Method 2 Mean ± SD	*P* value	Effect size (Cohen's d)
Root Volume loss (mm^3)											
12											
Coronal	−1.28 ± 4.20	−1.38 ± 2.12	1.000		−23.68 ± 4.25	−21.48 ± 6.13	.873	−2.33 ± 1.96	−1.94 ± 2.21	.773	
Middle	4.46 ± 5.32	4.76 ± 7.11	1.000		−9.63 ± 5.81	−13.36 ± 3.52	.200	2.43 ± 2.93	0.07 ± 0.36	.386	
Apical	1.95 ± 3.99	1.50 ± 3.95	1.000		2.63 ± 10.30	−5.13 ± 4.96	.150	4.32 ± 1.84	0.60 ± 3.06	.083	
Total	5.13 ± 7.77	4.79 ± 6.52	.873		−30.68 ± 16.88	−39.97 ± 13.94	.423	4.42 ± 3.44	−1.27 ± 1.13	.021*	≥0.80
11											
Coronal	2.25 ± 4.99	0.31 ± 3.67	.522		−18.31 ± 2.30	−19.17 ± 2.47	.522	−3.67 ± 0.30	−2.63 ± 2.28	.248	
Middle	7.98 ± 5.99	2.39 ± 2.58	.109		−9.32 ± 5.70	−11.20 ± 3.19	.631	3.74 ± 3.41	−1.02 ± 2.74	.083	
Apical	7.49 ± 7.33	−1.84 ± 6.82	.037*	≥0.80	−3.44 ± 9.67	−5.84 ± 4.74	1.000	5.52 ± 4.91	−1.02 ± 4.38	.149	
Total	17.73 ± 15.25	0.85 ± 5.76	.025*	≥0.80	−31.07 ± 15.80	−36.20 ± 7.63	.337	5.59 ± 8.04	−4.67 ± 7.39	.248	
21											
Coronal	−4.50 ± 9.15	−6.74 ± 9.19	.749		−6.74 ± 3.67	−8.86 ± 3.86	.262	−4.05 ± 1.10	−3.31 ± 2.08	.564	
Middle	1.00 ± 8.20	−3.88 ± 8.63	.423		−0.11 ± 10.59	−3.29 ± 4.84	.337	3.56 ± 4.60	−1.74 ± 1.64	.043*	≥0.80
Apical	0.43 ± 10.12	−2.84 ± 11.79	.423		1.04 ± 11.76	−2.76 ± 6.54	.423	5.39 ± 6.88	−2.23 ± 2.40	.043*	≥0.80
Total	−3.06 ± 25.41	−13.57 ± 25.25	.522		−5.85 ± 23.74	−15.93 ± 15.25	.337	4.90 ± 11.30	−7.26 ± 5.85	.248	
22											
Coronal	−4.36 ± 6.80	−3.96 ± 5.57	.873		−10.55 ± 7.48	−11.39 ± 9.32	1.000	−3.79 ± 2.15	−4.15 ± 3.67	.773	
Middle	−0.58 ± 9.33	−4.38 ± 7.54	.423		−5.49 ± 6.42	−9.08 ± 6.91	.337	−0.10 ± 3.59	−4.27 ± 2.50	.083	
Apical	4.14 ± 5.57	−2.58 ± 6.16	.150		−0.24 ± 7.51	−5.84 ± 6.06	.200	3.14 ± 6.11	0.47 ± 1.37	.564	
Total	−1.64 ± 15.76	−10.91 ± 16.41	.337		−16.28 ± 18.67	−26.47 ± 18.84	.262	−0.74 ± 7.82	−7.96 ± 5.58	.149	
Root Length loss (mm)											
12											
Total	0.20 ± 0.62	0.06 ± 0.71	.575		−0.05 ± 0.21	−0.02 ± 0.42	.873	0.33 ± 0.07	0.17 ± 0.20	.248	
11											
Total	0.09 ± 0.42	−0.07 ± 0.79	.522		−0.30 ± 0.17	−0.27 ± 0.20	.631	−0.27 ± 0.27	0.00 ± 0.32	.248	
21											
Total	−0.29 ± 0.57	0.14 ± 1.00	.631		0.03 ± 0.33	−0.21 ± 0.48	.173	−0.11 ± 0.17	−0.33 ± 0.39	.561	
22											
Total	0.45 ± 0.59	0.10 ± 0.68	.631		0.10 ± 0.32	−0.10 ± 0.56	.423	0.34 ± 1.02	0.53 ± 0.64	.885	

* Sig. < 0.05.
[a] All measurements are made with high-quality CBCT.
[b] Comparison of volumetric and linear root resorption for all incisors, total and by thirds between Method 1 and 2 analyzed according to the type of segmentation performed (Manual, Automatic or with AI) in high-quality CBCT.
[c] Cohen's d ≥ 0.80 big effect size.
[d] CBCT indicates cone beam computed tomography.

observed for Methods 1 and 2, respectively, with manual or automatic segmentation. (Supplementary Table 2).

DISCUSSION

The 3D reconstruction of dentofacial structures has significantly improved treatment planning and follow-up evaluations in digital dentistry. Traditionally, ERR was diagnosed using 2D records, which have limitations in accurately representing volume loss.[18] The incorporation of 3D imaging has enhanced precision in diagnosing ERR in orthodontic patients, although validation studies for volumetric quantification are limited. This study introduced and validated an in vivo method for volumetric quantification of ERR, utilizing two operator-dependent segmentation methods and a novel automated AI approach.

CBCT scan quality affects tooth segmentation accuracy and ERR diagnosis precision, with voxel size being a key factor. Larger voxels reduce noise but lower image sharpness, whereas smaller voxels increase resolution but require longer scanning times, leading to higher radiation exposure.[19] In this study, NewTom CBCTs had voxel sizes of 0.2–0.4 mm, and Carestream had 180 μm.

Scattered X-rays, resulting from photons diffracting after interacting with matter, also impact diagnosis. These diffracted photons can alter tooth volume based on tissue density,[20] affecting root resorption diagnosis, bone thickness quantification in implant dentistry, and the detection of endodontic lesions often misdiagnosed in CBCTs.

Field of view (FOV) is another critical factor affecting volumetric measurement accuracy. A smaller FOV requires more radiation but produces fewer scattered X-rays, improving ERR diagnosis accuracy.[21] In this study, the CBCTs had a FOV of 16 × 16 cm for NewTom and 5 × 5 cm for Carestream, with the smaller FOV yielding higher resolution. This consistency emphasizes the importance of resolution in diagnosing ERR, particularly in the apical third, where accurate diagnosis is challenging.[22]

Distortion from various anatomical structures also contributes to variability in tooth volume loss quantification. When different tissue densities are included in a single voxel, defining distinct edges (eg, alveolar bone vs periodontal ligament) becomes difficult, leading to imprecise segmentation.[23]

Artifacts from high-density materials, such as fillings or braces, can further distort images.[24] An upper lateral

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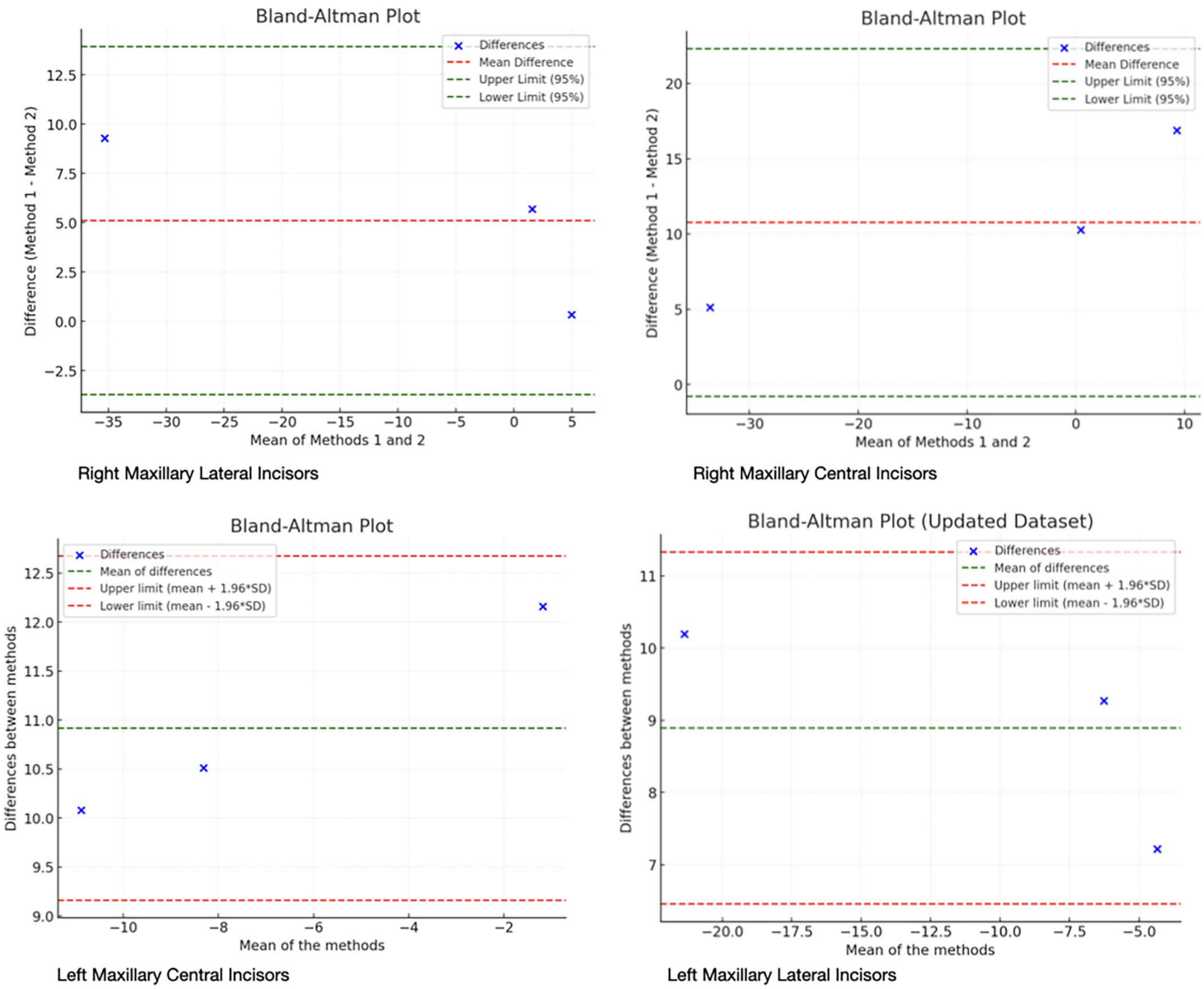

Figure 4. Bland–Altman plots.

incisor with root canal treatment was included in the final record; the filling material may have influenced volume loss quantification due to examiner differences and challenges in identifying the apical area.[25]

This study demonstrated two validated 3D tooth segmentation methods and two measurement techniques for analyzing ERR post-segmentation. The manual segmentation method exhibited higher intraobserver reliability than the automatic method, attributed to uniform threshold values in automatic segmentation, which can lead to data loss due to varying tissue densities.[9]

The tables of this study demonstrate considerable root length reduction across all teeth examined. Interestingly, the middle third region showed greater volume loss than the apical third in several specimens. This unexpected pattern warrants further investigation through correlation analysis between root length and volume measurements, which could reveal important patterns in root resorption distribution.

Despite advancements in segmentation, traditional methods remain time-consuming and prone to human error due to required manual corrections.[23] Recent AI developments have led to convolutional neural networks for individual tooth segmentation; however, only two studies have compared manual and AI methods.[26] Results from this study indicated that AI measurements are equivalent to those obtained through operator-dependent methods.

The revolution brought about by AI in dentistry is now a reality, particularly in the field of diagnostic imaging. The continuous advancement of AI algorithms supporting diagnosis and treatment processes enables result visualization and facilitates decision-making during treatment, placing orthodontics among the disciplines that have benefited. However, due to the

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considerable complexity and unpredictability that AI still entails, these tools should be approached with caution, and their results must continue to be manually validated.

Limitations

Limitations included operator experience in segmentation and root analysis, which are crucial for accuracy and reproducibility.[12] Manual methods are highly dependent on skill, and inexperience can introduce bias, as well as AI training bias,[27] especially in volumetric segmentation. Both operators were experienced orthodontists who underwent calibration prior to analysis. Overall, this research provides a valuable approach to evaluating ERR using 3D methods, enhancing routine clinical assessments in orthodontics and dentistry.[28,29] The present research analyzed up to 704 measurements; however, it would be interesting to consider the need for further validation in larger cohorts with additional types of tooth root morphology.

CONCLUSIONS

- Assessment of ERR with CBCT is highly dependent on the CBCT definition, segmentation, and measurement method.
- The AI segmentation method provided some differences regarding methods and reproducibility but showed superiority in terms of time consumption and daily clinical use.
- The 3D measurement method described by the three landmark points yielded satisfactory results using any of the tested segmentations.
- The implementation of AI in daily clinical practice represents a benefit in terms of diagnosis, treatment planning, interprofessional communication, as well as with the patient.

SUPPLEMENTAL DATA

Supplementary Tables 1 and 2 are available online. Multimedia Resources 1 through 5 are available online. Supplementary Appendix 1 and 2 are available online.

ACKNOWLEDGMENTS

The authors of the BIOCRAN Research Group aknowledge the finantial support of the Department of Dental Clinical Specialities, UCM to perform the professional English revision services. The authors declare no conflict of interest.

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