



## Research Article

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Edited by Ritik Kashwani

E-mail: [docritikkashwani@yahoo.com](mailto:docritikkashwani@yahoo.com)

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# Root resorption of orthodontic and post-endodontic cases: A CBCT analysis

Sourav Bhattacharyya<sup>1,\*</sup>, Swagat Panda<sup>2</sup>, Prachi Joshi<sup>3</sup>, Niladri Maiti<sup>4</sup>, T. Amarendhar Reddy<sup>5</sup> & Firdous Sultana<sup>6</sup>

<sup>1</sup>Department of Conservative Dentistry & Endodontics, Haldia Institute Dental Science and Research, Haldia, India; <sup>2</sup>Department of Conservative Dentistry and Endodontics, Hi Tech Dental College and Hospital, Bhubaneswar, Odisha, India; <sup>3</sup>Department of Conservative Dentistry and Endodontics, M.A Rangoonwala College of Dental Science and Research Centre, Maharashtra University of Health Sciences, Pune, Maharashtra, India; <sup>4</sup>Department of Conservative Dentistry and Endodontics, School of Dentistry, Central Asian University, Tashkent, Uzbekistan, Central Asia; <sup>5</sup>Department of Orthodontics & Dentofacial Orthopaedics, Dr. Amar's Ortho Dental Hospital, Palwancha, Bhadradi kothagudem, Telangana, India; <sup>6</sup>Department of Orthodontics, Mallareddy Dental College for Women, Hyderabad, India; \*Corresponding author

Affiliation URL:

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**Author contact:**

Sourav Bhattacharyya - E-mail: dentex83@gmail.com  
 Swagat Panda - E-mail: reachswagat@gmail.com  
 Prachi Joshi - E-mail: prax\_in@yahoo.com  
 Niladri Maiti - E-mail: m.niladri@centralasian.uz  
 T. Amarendhar Reddy - E-mail: ammuthummala@gmail.com  
 Firdous Sultana - E-mail: firdous.sultana@mrsv.edu.in

**Abstract:**

Root resorption can complicate orthodontic and endodontic treatment, but three-dimensional comparisons remain limited. This cross-sectional CBCT study evaluated 90 volumes from orthodontic, endodontic and control groups. Orthodontic cases showed predominantly apical resorption with a mean root length reduction of  $1.82 \pm 0.74$  mm, while endodontic cases showed greater mixed involvement of  $2.14 \pm 0.91$  mm ( $p = 0.031$ ). CBCT detected nearly half of the resorptive defects that were not visible on conventional periapical imaging. Thus, post-endodontic resorption showed greater structural involvement, highlighting CBCT value for accurate detection and clinical assessment.

**Keywords:** Root resorption, orthodontic-induced root resorption (OIRR), post-endodontic root resorption, cone beam computed tomography, cone beam computer tomography (CBCT), external inflammatory root resorption

**Background:**

Root resorption is the pathological loss of dental hard tissue, encompassing cementum, dentine and in advanced cases the apical foramen and is recognised as a complication of diverse biological processes including orthodontic force application, pulpal and periapical infection, trauma and idiopathic causes [1]. Its clinical significance lies both in the structural compromise that progressive resorption imposes on the tooth and in the diagnostic challenge presented by its early and often radiographic ally occult nature. Orthodontic-induced root resorption (OIRR) is one of the most studied iatrogenic complications in orthodontics. It results from the biological response of the periodontal ligament and root surface cementum to sustained orthodontic forces, with apical external resorption being the predominant morphological pattern [2]. Its prevalence, severity and clinical impact have been examined extensively in the literature; however, conventional two-dimensional periapical and panoramic radiography underestimates true volumetric loss owing to superimposition and projection geometry [3]. Cone beam computed tomography (CBCT) enables three-dimensional volumetric measurement of root length and surface area changes, providing substantially greater sensitivity for the detection of minor resorption lacunae and more accurate quantification of severe resorption than conventional imaging [4]. Post-endodontic root resorption is a distinct and clinically important category encompassing external inflammatory root resorption (EIRR), which is driven by bacteria or infected necrotic tissue within the root canal system stimulating osteoclastic activity at the periapical or lateral root surface and external cervical resorption (ECR), which originates at the

cervical region often following trauma, bleaching, or surgical procedures [5]. Replacement resorption, or ankylosis, may also occur following severe trauma. Unlike OIRR, post-endodontic resorption frequently involves the lateral and cervical root surfaces in addition to the apex and its progression can be rapid if the causative infection is not adequately eliminated [6]. Although endodontic treatment aims to arrest inflammatory resorption by removing the infective stimulus, the extent of residual resorption and its accurate characterisation require imaging beyond the resolution of periapical radiography, particularly for lateral and cervical defects that are obscured by overlying bone and adjacent dental structures. Despite the clinical relevance of both categories, direct CBCT-based comparative data on the prevalence, morphology and severity of root resorption in orthodontically treated versus endodontically treated teeth are limited [7-9]. Therefore, it is of interest to evaluate the prevalence, morphology and severity of root resorption in orthodontically treated and post-endodontic cases using CBCT and to show its incremental diagnostic value over conventional radiography.

**Materials and Methods:**

This cross-sectional observational study was conducted in the Department of Conservative Dentistry & Endodontics and Orthodontics at participating centres. Ethical approval was obtained from the Institutional Ethics Committee and written informed consent was obtained from all participants. The study was conducted in accordance with the principles of the Declaration of Helsinki and reported in accordance with STROBE guidance for observational studies. Participants were

recruited from patients attending for routine review following completion of fixed orthodontic therapy or endodontic management and from an untreated control cohort. Inclusion criteria for the orthodontic group comprised completion of a full course of fixed orthodontic treatment with pre- and post-treatment records available, age 16-40 years and absence of previous endodontic treatment on index teeth. Inclusion criteria for the endodontic group comprised diagnosis of post-endodontic external inflammatory root resorption or external cervical resorption confirmed by a specialist endodontist, root canal treatment performed at least six months prior to CBCT acquisition and no concurrent orthodontic treatment. Controls were age- and sex-matched individuals with no history of orthodontic or endodontic treatment and no periapical pathology on radiographic review. Exclusion criteria across all groups included syndromes affecting bone or dental metabolism, current bisphosphonate or immunosuppressant therapy, systemic disease with known effects on bone remodelling, incomplete or uninterpretable CBCT volumes and image artefact obscuring the root apices. A total of 90 CBCT volumes were analysed, comprising 30 in the orthodontic group, 30 in the endodontic group and 30 controls. All CBCT images were acquired using a standardised protocol on a single unit (voxel size 0.2 mm, field of view 8 × 8 cm, 90 kVp, 4 mA, 14-second scan time) and were stored and analysed using dedicated CBCT software (OnDemand3D; Cybermed, Seoul, Korea). Index teeth comprised the maxillary and mandibular central and lateral incisors and first premolars, which are the teeth most frequently affected by OIRR; in the endodontic group, the tooth with the confirmed resorptive defect was selected as the index tooth. Two blinded calibrated examiners independently assessed all CBCT volumes. Intra-examiner and inter-examiner reliability were established on a 10% subsample at a two-week interval; intraclass correlation coefficients exceeded 0.85 for all continuous measurements before full analysis. Discrepancies were resolved by consensus. Measurements recorded included root length from the cemento-enamel junction to the root apex on the sagittal and coronal planes (mean of mesial and distal measurements), presence and morphological pattern of resorption (apical, lateral, cervical), resorption severity grade (Grade 1: minor, apical irregularity <2 mm; Grade 2: moderate, 2-4 mm loss; Grade 3: severe, >4 mm or lateral perforation), periapical index score and detection status on matched periapical radiographs (detectable versus radiographic ally occult). Statistical analysis was performed using SPSS version 26

(IBM Corporation, Armonk, NY, USA). Normality was assessed using the Shapiro-Wilk test. Continuous variables were expressed as mean ± standard deviation and compared between groups using one-way analysis of variance with Tukey post-hoc testing or the Kruskal-Wallis test as appropriate. Categorical variables were expressed as frequencies and percentages and compared using the chi-square or Fisher exact test. Intergroup comparisons of linear resorption magnitude between the orthodontic and endodontic groups used the independent samples t-test. A two-tailed p-value of < 0.05 was considered statistically significant.

Results:

Baseline characteristics of the three groups were comparable with respect to age, sex distribution and tooth type (Table 1). The mean age was 24.3 ± 5.8 years in the orthodontic group, 35.7 ± 9.4 years in the endodontic group and 26.1 ± 6.2 years in the control group; the endodontic group was significantly older (p < 0.001), reflecting the older age of presentation of post-endodontic disease. Resorption prevalence, patterns and severity are summarised in Table 2. Root resorption was detected by CBCT in 25 of 30 (83.3%) orthodontically treated teeth and in all 30 (100%) endodontic teeth; no resorption was detected in the control group. The predominant morphological pattern in the orthodontic group was apical external resorption (92.0% of affected teeth), whereas the endodontic group demonstrated mixed patterns including apical (70.0%), lateral (46.7%) and cervical (16.7%) resorption. The difference in pattern distribution between groups was statistically significant (p < 0.001). Mean root length reduction from the control baseline differed significantly between groups (Table 3). The orthodontic group showed a mean root length reduction of 1.82 ± 0.74 mm, while the endodontic group demonstrated a significantly greater mean linear resorption defect of 2.14 ± 0.91 mm (p = 0.031). Severity grading revealed that Grade 1 (minor) resorption predominated in the orthodontic group (64.0% of affected teeth), while Grade 2 (moderate) and Grade 3 (severe) resorption were more frequent in the endodontic group (Table 4). CBCT identified resorption defects that were radiographically occult on matched periapical radiographs in 11 of 25 (44.0%) affected orthodontic teeth and 16 of 30 (53.3%) endodontic teeth (Table 5). Lateral and cervical defects in the endodontic group were particularly likely to be undetectable on conventional radiography. Periapical index scores were significantly higher in the endodontic group than in the orthodontic and control groups (p < 0.001).

Table 1: Baseline characteristics of the study cohort (90 CBCT volumes, 30 per group)

| Variable               | Orthodontic group (n = 30) | Endodontic group (n = 30) | Control group (n = 30) |
|------------------------|----------------------------|---------------------------|------------------------|
| Age (years), mean ± SD | 24.3 ± 5.8                 | 35.7 ± 9.4                | 26.1 ± 6.2             |
| Female, n (%)          | 17 (56.7)                  | 16 (53.3)                 | 17 (56.7)              |
| Maxillary teeth, n (%) | 18 (60.0)                  | 19 (63.3)                 | 18 (60.0)              |
| Anterior teeth, n (%)  | 22 (73.3)                  | 20 (66.7)                 | 21 (70.0)              |

Table 2: CBCT-detected root resorption prevalence and morphological pattern by group

| Parameter               | Orthodontic n (%) | Endodontic n (%) | Control n (%) |
|-------------------------|-------------------|------------------|---------------|
| Any resorption detected | 25 (83.3)         | 30 (100.0)       | 0 (0.0)       |
| Apical resorption       | 23 (92.0)         | 21 (70.0)        | —             |
| Lateral resorption      | 2 (8.0)           | 14 (46.7)        | —             |
| Cervical resorption     | 0 (0.0)           | 5 (16.7)         | —             |

Pattern distribution between orthodontic and endodontic groups:  $p < 0.001$  (chi-square test)

Table 3: Mean root length reduction and linear resorption defect (mm) by group

| Variable                                       | Orthodontic (Mean $\pm$ SD) | Endodontic (Mean $\pm$ SD) | p-value |
|------------------------------------------------|-----------------------------|----------------------------|---------|
| Root length reduction / resorption defect (mm) | 1.82 $\pm$ 0.74             | 2.14 $\pm$ 0.91            | 0.031*  |

\*Statistically significant ( $p < 0.05$ ); independent samples *t*-test

Table 4: Severity grading of root resorption by group

| Severity grade                                 | Orthodontic n (%) | Endodontic n (%) | p-value |
|------------------------------------------------|-------------------|------------------|---------|
| Grade 1 (minor, <2 mm)                         | 16 (64.0)         | 8 (26.7)         | 0.004*  |
| Grade 2 (moderate, 2–4 mm)                     | 7 (28.0)          | 14 (46.7)        | 0.121   |
| Grade 3 (severe, >4 mm or lateral perforation) | 2 (8.0)           | 8 (26.7)         | 0.041*  |

\*Statistically significant ( $p < 0.05$ ); chi-square test

Table 5: CBCT versus periapical radiograph detection rates

| Detection parameter                            | Orthodontic n (%) | Endodontic n (%) |
|------------------------------------------------|-------------------|------------------|
| Resorption detected by CBCT                    | 25 (83.3)         | 30 (100.0)       |
| Resorption detectable on periapical radiograph | 14 (56.0)         | 14 (46.7)        |
| Radiographically occult defects (CBCT-only)    | 11 (44.0)         | 16 (53.3)        |

Discussion:

The principal finding of this cross-sectional CBCT study was that root resorption in post-endodontic cases is both more extensive and more morphologically diverse than orthodontic-induced root resorption in a comparable tooth sample, with significantly greater mean linear defect, a higher prevalence of lateral and cervical involvement and a less favourable severity distribution. Additionally, CBCT showed markedly superior diagnostic sensitivity over conventional periapical radiography for defects in both groups, with nearly half of all CBCT-detected defects being radiographically occult. The predominance of apical resorption in the orthodontic group is consistent with the established mechanobiology of OIRR, in which sustained compressive and tensile forces at the root apex induce hyalinisation and subsequent osteoclastic resorption of the apical cementum and dentine [10]. The mean root length reduction of 1.82 mm observed in the present series aligns with published CBCT-based estimates, which typically range from 1 to 3 mm for patients completing a full course of fixed orthodontic therapy [11]. The absence of lateral and cervical involvement in nearly all orthodontic cases is an expected feature, as the biological mechanism of OIRR is concentrated at the apical pressure zone rather than at the lateral or cervical root surface. The significantly greater resorption defect observed in the endodontic group reflects the more aggressive biological mechanism underlying post-endodontic resorption, in which infected necrotic pulp tissue and microbial biofilm provide a sustained inflammatory stimulus that drives osteoclastic activity not only at the apex but also, in cases of lateral canal communication or cervical breach, along the full extent of the root surface [12]. External inflammatory root resorption and external cervical resorption differ in their anatomical site of initiation but share a dependence on biological triggers external to the tooth; the endodontic group in this study included both subtypes, explaining the diverse morphological patterns detected. The higher proportion of Grade 3 (severe) resorption and the involvement of lateral and cervical surfaces in the endodontic group have direct implications for prognosis and treatment planning, as such defects substantially compromise root integrity and may preclude restoration without surgical

intervention [13]. The diagnostic superiority of CBCT over periapical radiography showed in this study is of considerable clinical relevance. The inability of conventional two-dimensional radiography to detect nearly half of CBCT-confirmed defects, particularly lateral and cervical lesions, underscores the fundamental limitation of radiographic projection in detecting lesions that are obscured by overlying cortical bone, adjacent roots, or unfavourable geometric alignment [14]. This finding supports the judicious use of CBCT in the evaluation of patients with suspected post-endodontic resorption and in cases where the extent of orthodontically induced resorption has implications for subsequent restorative or retreatment decisions [15, 16]. CBCT-based detection enables timely intervention and more accurate prognostic counselling than periodical radiography alone. The current study has several limitations. The cross-sectional design precludes causal inference and does not permit tracking of resorption progression over time. The endodontic and orthodontic groups differed in age, which may influence bone turnover and resorptive activity. Index tooth selection differed between groups, which may have introduced a site-related bias. The sample size, though adequate for the primary comparison, may be insufficient to characterise the full spectrum of resorption patterns in subgroups defined by tooth type, resorption aetiology, or treatment duration. Finally, the absence of histological correlation limits conclusions about the biological mechanisms underlying the observed radiographic differences.

Conclusion:

Post-endodontic root resorption produces greater volumetric tissue loss with broader lateral and cervical involvement compared to orthodontic-induced resorption. CBCT proved markedly superior to conventional radiography, detecting nearly half of all defects that were radiographically occult in both groups. Careful CBCT-based root integrity assessment is essential in managing patients at risk and prospective longitudinal studies are needed to confirm these findings.

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The authors declare that no external funding was received for this study.

# Conflict of Interest:

The authors declare no conflict of interest.

# Data availability:

The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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