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Prevalence and Anatomical Distribution of Lateral Canals in Maxillary Premolars Assessed Using Cone-Beam Computed Tomography

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Abstract

Aim: To evaluate the presence, frequency, and anatomical location of lateral canals in extracted maxillary premolars using cone-beam computed tomography (CBCT).

Materials and Methods: Three hundred extracted human maxillary premolars were subjected to CBCT imaging under standardized parameters. Axial, sagittal, and coronal sections were evaluated for root canal configuration according to Vertucci's classification and for the presence of lateral canals. Data were recorded and analyzed using descriptive statistics.

Results: The majority of maxillary premolars exhibited Vertucci Type I canal configuration. Lateral canals were identified in 1.0% of specimens (3 out of 300 teeth). When present, lateral canals were predominantly located in the middle and apical thirds of the root. Complex canal configurations including Vertucci Types II, IV, V, VI, and VIII were also observed.

Conclusion: Lateral canals in maxillary premolars are relatively rare but clinically significant anatomical variations. CBCT is a reliable non-destructive imaging modality for detecting lateral canals and complex root canal morphology, thereby aiding in improved endodontic diagnosis and treatment planning.

Keywords: CBCT, Lateral canals, Maxillary premolars, Root canal morphology, Vertucci classification

Introduction

Successful endodontic therapy depends on thorough knowledge of the internal anatomy of teeth. Variations in

root canal morphology, particularly the presence of lateral canals, accessory canals, and complex canal configurations, pose significant challenges to effective cleaning, shaping, and obturation of the root canal system. [1,2]

Lateral canals are defined as small channels branching from the main root canal to the external root surface and are commonly located in the apical and middle thirds of the root. These canals may harbor residual microorganisms and necrotic tissue, contributing to persistent periapical inflammation and endodontic treatment failure.[3,7,9]

Maxillary premolars exhibit considerable anatomical variability, often presenting with multiple roots and canals. Conventional two-dimensional radiography has limitations in identifying such complexities due to superimposition and distortion. Cone-beam computed tomography (CBCT) provides three-dimensional visualization of root canal anatomy and has been shown to be superior in detecting anatomical variations compared to conventional radiography.[11,10]

Despite several studies evaluating root canal morphology, limited literature exists specifically addressing the prevalence of lateral canals in maxillary premolars using CBCT. Therefore, the present study was undertaken to evaluate the presence and distribution of lateral canals in extracted maxillary premolars using CBCT imaging.[12,15]

Materials and Methods

Study Design: An in vitro, observational descriptive study conducted in a private CBCT center Jaipur, India.

Sample Selection: A total of 300 extracted human maxillary premolars were collected from the Department of Oral and Maxillofacial Surgery. Teeth were extracted for orthodontic or periodontal reasons.

Inclusion Criteria

- Fully developed roots
- Intact crowns and roots
- No previous endodontic treatment

Exclusion Criteria

- Teeth with root fractures or resorption
- Teeth with gross caries involving the pulp
- Teeth with obliterated or calcified canals

Sample Preparation

All teeth were cleaned of adherent soft tissue and calculus using ultrasonic scalers and stored in normal saline until imaging. Teeth were mounted in wax blocks to simulate dental arch positioning during CBCT scanning. CBCT Imaging Protocol- machine Carestream 8200 3D, CBCT scans were performed using a dedicated CBCT unit under standardized conditions. Images were obtained with a limited field of view and reconstructed in axial, sagittal, and coronal planes.[11,16]

Image Evaluation

CBCT images were independently analyzed by two calibrated observers. Root canal configurations were classified according to Vertucci's classification. The presence and anatomical location of lateral canals were recorded. Any disagreement between observers was resolved by consensus.

Statistical Analysis -Data were tabulated and analyzed using descriptive statistics. Results were expressed as frequencies and percentages.

Results

Root Canal Configuration: Among the 300 maxillary premolars examined, Vertucci Type I canal configuration was the most prevalent, followed by Types II and IV. Less frequent configurations included Types V, VI, and VIII, indicating significant anatomical variability.

Prevalence of Lateral Canals: Lateral canals were detected in 3 out of 300 teeth (1.0%).

Location of Lateral Canals: Middle third 2 teeth**,** Apical third 1 tooth**,** Coronal third: None observed

Associated Canal Morphology: Teeth exhibiting lateral canals were associated with complex canal configurations, particularly Vertucci Type VIII and Type I variants with additional anatomical branches.

Discussion

A comprehensive understanding of root canal anatomy is fundamental to the success of endodontic therapy. Anatomical complexities such as lateral canals, accessory canals, and multiple canal configurations may compromise complete debridement and obturation, thereby contributing to persistent periapical pathology. The present in vitro CBCT study evaluated the prevalence, location, and morphological association of lateral canals in extracted maxillary premolars.[1-8]

In the current study, lateral canals were identified in 1.0% of the examined teeth, indicating that lateral canals in maxillary premolars are relatively uncommon. This finding is in agreement with the classical anatomical observations by De Deus and Vertucci, who reported a lower prevalence of lateral canals in premolars compared with molars. The reduced occurrence may be attributed to the comparatively simpler root canal system of premolars, especially those exhibiting Vertucci Type I configuration.[10-12]

The predominance of Vertucci Type I canal configuration observed in this study is consistent with previously published literature. Cleghorn et al. and Pécora et al. reported Type I morphology as the most frequent configuration in maxillary premolars, followed by Types II and IV. The presence of complex canal configurations such as Types V, VI, and VIII in the present study reinforces the anatomical variability inherent to maxillary premolars and highlights the need for thorough radiographic evaluation before and during endodontic treatment.[12]

Lateral canals detected in this study were predominantly located in the middle and apical thirds of the root, which correlates with histological findings by De Deus and Ricucci and Siqueira. These regions represent areas of increased vascular communication during tooth development and are commonly associated with persistent microbial colonization. Clinically, lateral canals located in the apical third are of particular concern, as they may serve as pathways for the spread of infection to the periodontal ligament, even after adequate obturation of the main canal.[15,16,17]

The low prevalence of lateral canals reported in the present study may be partially explained by the resolution limitations of CBCT imaging. Although CBCT provides three-dimensional visualization of the root canal system, its spatial resolution remains inferior to micro-computed tomography (micro-CT). Studies by Ordinola-Zapata et al. and Versiani et al. demonstrated that micro-CT detects a significantly higher number of accessory and lateral canals compared to CBCT. Nevertheless, CBCT remains the preferred modality in clinical practice due to its non-destructive nature, lower radiation dose compared to medical CT, and applicability in vivo.[20,21]

Another important observation of the present study is the association of lateral canals with complex canal morphologies, particularly Vertucci Type VIII and Type I variants with additional anatomical branches. This finding suggests that teeth exhibiting increased anatomical complexity are more likely to harbor lateral canals, emphasizing the importance of careful evaluation of canal morphology during treatment planning.[23,24]

From a clinical standpoint, the presence of lateral canals underscores the importance of effective irrigation protocols. Mechanical instrumentation alone is

insufficient to disinfect lateral canals due to their small diameter and oblique orientation. Advanced irrigation techniques such as passive ultrasonic irrigation, negative pressure systems, and the use of irrigants with proven tissue-dissolving and antimicrobial properties may enhance cleaning efficacy in such anatomical complexities.[1,3,7]

Despite its strengths, the present study has certain limitations. Being an in vitro study, the findings may not fully replicate clinical conditions such as periodontal ligament simulation and surrounding bone attenuation. Additionally, the inability to perform histological validation limits confirmation of extremely fine lateral canals that may fall below CBCT resolution thresholds. Future studies employing micro-CT or correlating CBCT findings with histological analysis may provide further insights into the true prevalence of lateral canals.

Clinical Significance

- Awareness of lateral canals is critical for endodontic success
- CBCT aids in identifying hidden anatomical variations
- Improved irrigation and obturation strategies may be planned preoperatively

Limitations

- In vitro study design
- CBCT resolution limitations compared to micro-CT
- Absence of histological validation

Conclusion

Although lateral canals in maxillary premolars are relatively rare, their presence has significant clinical implications. CBCT is a valuable diagnostic tool for assessing root canal anatomy and detecting lateral canals, thereby enhancing endodontic treatment outcomes. [12,15]

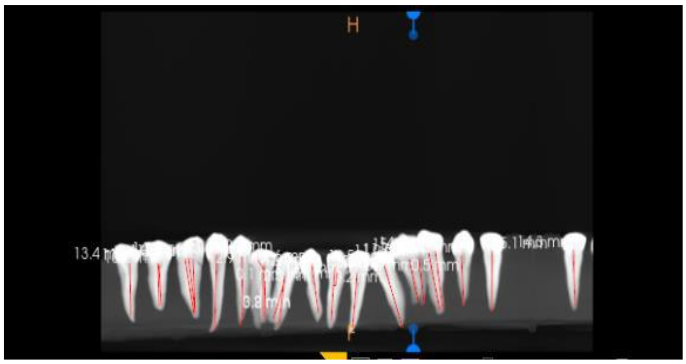

Figure 1:

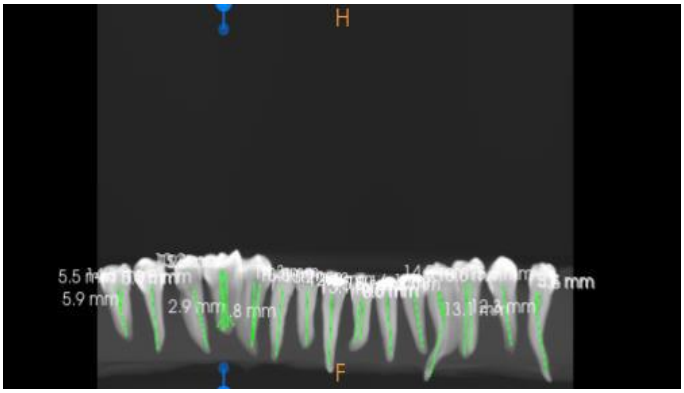

Figure 2:

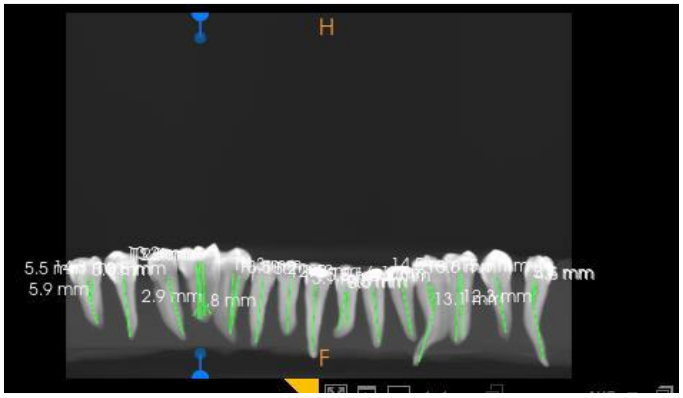

Figure 3:

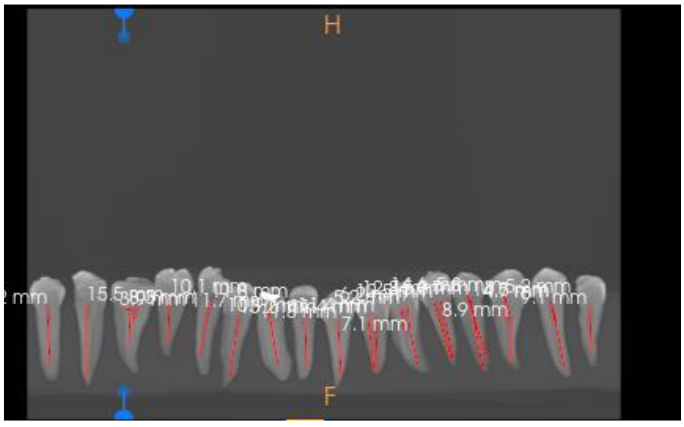

Figure 4:

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