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Original Article

Prevalence of Dens Invaginatus in Maxillary Lateral Teeth and Its Association with Periapical Lesions: A Cone-Beam Computed Tomography

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CLINICAL SIGNIFICANCE

DI is a common developmental anomaly. Accurate assessment of periapical lesions and DI prevalence in maxillary lateral teeth is crucial for diagnosis and treatment planning, enabling clinicians to tailor interventions based on DI subtypes and their associations.

ABSTRACT

Objectives: This study aimed to determine the prevalence of Dens Invaginatus (DI) and examine the association between factors such as age, gender, and DI type with the occurrence of periapical lesions.

Materials and Methods: Cone beam computed tomography (CBCT) images of 250 patients were evaluated. The relationship between gender, tooth number, DI type according to Oehler classification, and periapical lesions (PL) was examined. PL were grouped using Estrela's CBCT Periapical Index (CBCT PAI). Periapical lesion incidence rates were statistically compared using chi-square tests and descriptive statistics. The statistical analysis was performed using SPSS v27.0 software.

Results: 250 CBCT volumes were examined. The study involved 32 patients (average age 29.15 ± 11.50 years). DI was found in 10.0% of maxillary lateral teeth (11.6% right, 8.4% left) with no significant gender or age group differences ($p>0.05$). Type I DI was most common in the 15-20 age group. Most teeth had a CBCT PAI=0, with no significant differences across age groups ($p>0.05$). However, for the right lateral tooth, Type II DI was significantly associated with higher CBCT PAI scores ($p<0.05$), whereas no significant difference was found for the left lateral tooth ($p=0.142$).

Conclusion: DI is a developmental dental anomaly that is relatively prevalent. The presence of associated periapical lesions and the proportion of maxillary lateral teeth impacted by DI should be meticulously assessed during the diagnosis and treatment planning process. Clinicians can more effectively plan and execute treatment by comprehending the prevalence of DI, its subtypes, and their relationship to periapical lesions.

1. Introduction

Dens invaginatus (DI), also referred to as "dens in dente," is a developmental dental anomaly in which enamel and dentin invaginate into the dental papilla prior to the calcification of the dental tissues.[1] The depth of the invagination varies from superficial cases, where only the crown is affected and the cingulum pit is slightly prominent, to deep folds extending to the apex, affecting both the crown and the root. Coronal DI is more common, with a reported prevalence ranging from 0.04% to 12% in all patients.[2-8] The central incisors, premolars, canines, and molars are the teeth most frequently affected, followed by the maxillary permanent lateral incisors. This condition is uncommon in primary teeth and frequently effects both sides. The precise etiology of this developmental anomaly is still uncertain.[9,10]

DI can lead to early tooth decay and predisposition to pulpitis, with advanced stages potentially resulting in periodontal inflammation and pulp necrosis.[10,11] Coronal DI is classified into three primary categories. Type I is characterized by a protrusion that remains above the cemento-enamel junction. Type II extends past the cemento-enamel junction and terminates in a closed pouch, which may or may not have a connection with the pulp. Type III penetrates the root and exits through the apical or lateral radicular region, leaving the pulp unconnected. Type III is further categorized into two distinct subcategories. In Type IIIa, the inward folding of tissue is linked to the periodontal ligament through a pseudo-foramen. In Type IIIb, it establishes communication with the periodontal ligament through the apical foramen. Radicular dens invaginatus, a condition that is less prevalent, is thought to be the consequence of the Hertwig's epithelial root sheath's proliferation, which results in an enamel strip along the root surface. Radiographically, the affected teeth demonstrate root enlargement with an enamel-covered invagination, with the invagination's aperture situated laterally on the root.[9]

Three-dimensional (3D) cone beam computed tomography (CBCT) offers significant advantages over traditional two-dimensional (2D) radiographs in the examination of root canal anatomy and periapical pathologies. In conventional 2D imaging techniques, anatomical structures can overlap, which can make diagnosis particularly challenging in complex cases. CBCT provides high-resolution volumetric images that deliver detailed insights into the morphology of teeth, enhancing the accuracy of diagnosing developmental anomalies such as DI. This technology allows for a thorough examination of the invagination process, not only in cases where the crown is affected but also in those where the root is involved, thereby increasing diagnostic precision.[12,13]

The literature discusses different treatment options for managing DI, ranging from non-surgical endodontic treatments to regenerative endodontic procedures, depending on the type and severity of the condition. Early diagnosis of DI is crucial for initiating prophylactic treatment and preventing complications like pulpal necrosis. The removal of lumen contents and any decayed dentin is necessary for larger invaginations. Subsequently, a calcium hydroxide base is applied to manage micro-connections with adjacent pulp canals. The use of calcium hydroxide or mineral trioxide aggregate for apexification is generally efficacious in teeth with open apices, resulting in a permanent restoration.[9] Three-dimensional imaging techniques have also improved the diagnosis and treatment planning for teeth with complex root canal systems, including those affected by DI. In conclusion, while previous studies have provided insights into various treatment modalities for DI and associated periapical lesions, this study aimed to establish the frequency of DI and investigate how factors like age, gender, and DI type are linked to the occurrence of periapical

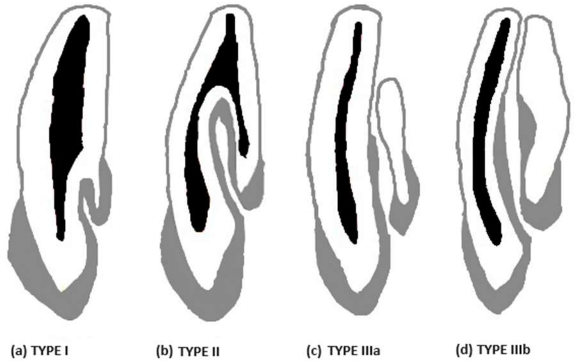

Fig. 1. Classification of dens invaginatus according to Oehlers. Type I (a), type II (b), type IIIa (c) and type IIIb (d).

lesions. The study also aimed to assess the periapical status relative to different DI types.

2. Materials and Methods

2.1. Ethical approval and sample size

The study protocol received approval from the Research Ethics Committee of the Faculty of Dentistry at Necmettin Erbakan University for Non-Pharmaceutical and Medical Device Research (approval no. 2022/169).

Using the G-power 3.1.9.4 software, the required study population was calculated to be at least 43 individuals, based on a 95% confidence level, α=0.05, and a power (1-β) of 0.95, for detecting differences between two independent proportions.[4]

2.2. Study population and selection criteria

This retrospective study examined CBCT images acquired from patients who visited the oral and maxillofacial radiology clinic in the university for diagnostic purposes between 2022 and 2024. The study population consisted of individuals aged between 15 and 64 years (125 female, 125 male), as CBCT records of individuals outside this age range were excluded due to avoid potential biases related to age-related developmental and degenerative changes in dental structures that could impact the accuracy of the study outcomes.

The inclusion criteria required artifact-free images with optimal quality, obtained with an imaging volume of 60x60 mm, 100x100 mm, 140x100 mm, or 170x120 mm, which allowed for full visualization of both lateral teeth. Only scans that met these criteria and allowed for accurate assessment of DI and PLs were included. Images with low resolution, those showing only edentulous areas, or those featuring primary teeth were excluded from the study to maintain the accuracy and consistency of the analysis.

Fig. 2. From left to right, sagittal and axial views of CBCT scans showing A) Type I and B) Type II classifications.

2.3. DI and periapical lesion assessment

All maxillary lateral teeth were classified according to Oehler's DI classification into types I, II, IIIa, and IIIb.[14] Illustrative examples of the DI types are presented in Fig. 1, while corresponding CBCT imaging examples are shown in Fig. 2.

CBCT was employed to evaluate periapical lesions using the following cone beam computed tomography periapical index (CBCT PAI) criteria[15]:

0: Periapical bone structures that are intact;
1: Periapical radiolucency diameters exceeding 0.5–1 mm;
2: The periapical radiolucency diameter exceeds one to two millimeters.
3: Periapical radiolucency diameter exceeding 2–4 millimeters;
4. The periapical radiolucency diameter exceeds 4–8 mm.
5. The diameter of the periapical radiolucency exceeds 8 mm

Scans were analyzed in both sagittal and axial views on a 27" monitor with a resolution of 1920 × 1080 pixels (DellSE2722H; Dell Inc., Round Rock, TX) under consistent illumination conditions. Age, gender, the presence or absence of DI, and the presence or absence of periapical lesions were documented following the CBCT assessment.

All evaluations were assessed by a three-year experienced radiologist (AHS). To assess intra-observer agreement, measurements were repeated after three weeks, blinded to the first measurements. According to the Kappa analysis, a Kappa value of 0.921 for DI and 0.893 for PAI was observed, indicating excellent agreement for both measures.

2.4. Statistical analysis

SPSS 25.0 (IBM, Chicago, IL, USA) was implemented to execute the statistical data analysis. Descriptive statistics were calculated using frequency and percentages. The chi-square test was employed to analyze the data, with a significance level of 0.05.

3. Results

The average age of individuals included in this study was 29.15 ± 11.50 years. The distribution of age groups by gender was homogeneous, with no statistically significant difference (p>0.05) (Table 1).

For the maxillary lateral teeth, DI was detected in 50 out of 500 teeth (10.0%). Of these cases, 29 were found on the right side (11.6%) and 21 on the left side (8.4%). The overall incidence of bilateral DI was higher (78%) compared to unilateral DI (32%). In females, 89.6% of the right lateral teeth showed no DI, while 9.6% had Type I and 0.8% had Type II. On the left side, these percentages were 93.6% and 6.4%, respectively (Table 2). In males,

Table 1. Distribution of age groups according to gender

Age groups	Gender		Total	p value
	Female	Male		
15-20 years	27	37	64	
21-26 years	35	23	58	
27-32 years	22	21	43	
33-38 years	21	15	36	0.152
39-44 years	11	11	22	
45 years and older	9	18	27	
Total	125	125	250	

Table 2. Distribution of dens ınvaginatus presence ın maxillary right and left lateral teeth by gender and age groups

	Dens Invaginatus Presence											
	Maxillary Right Lateral Tooth						Maxillary Left Lateral Tooth					
	None	Type I	Type II	Type IIIa	Type IIIb	p value	None	Type I	Type II	Type IIIa	Type IIIb	pvalue
Gender												
Female	112 (89.6%)	12 (9.6%)	1 (0.8%)	0 (0.0%)	0 (0.0%)	0.840	117 (93.6%)	8 (6.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.370
Male	109 (87.2%)	15 (12.0%)	1 (0.8%)	0 (0.0%)	0 (0.0%)		112 (89.6%)	12 (9.6%)	1 (0.8%)	0 (0.0%)	0 (0.0%)	
Age Groups												
15-20 years	52 (81.3%)	10 (15.6%)	2 (3.1%)	0 (0.0%)	0 (0.0%)	0.795	56 (87.5%)	7 (10.9%)	1 (1.6%)	0 (0.0%)	0 (0.0%)	0.794
21-26 years	52 (89.7%)	6 (10.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		53 (91.4%)	5 (8.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
27-32 years	39 (90.7%)	4 (9.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		39 (90.7%)	4 (9.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
33-38 years	33 (91.7%)	3 (8.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		33 (91.7%)	3 (8.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
39-44 years	21 (95.5%)	1 (4.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		22 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
45 years and older	24 (88.9%)	3 (11.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		26 (96.3%)	1 (3.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	

For the maxillary lateral teeth, DI was detected in 50 out of 500 teeth (10.0%). Of these cases, 29 were found on the right side (11.6%) and 21 on the left side (8.4%). The overall incidence of bilateral DI was higher (78%) compared to unilateral DI (32%). In females, 89.6% of the right lateral teeth showed no DI, while 9.6% had Type I and 0.8% had Type II. On the left side, these percentages were 93.6% and 6.4%, respectively. In males, 87.2% of the right lateral teeth showed no DI, while 12% had Type I and 0.8% had Type II. On the left side, these percentages were 89.6%, 9.6%, and 0.8%, respectively. Across all age groups, the prevalence of DI ranged from 81.3% to 95.5%. Type I DI was more common in the 15-20 age group for both teeth (15.6% on the right; 10.9% on the left). The p-values indicate that the differences between the groups were not statistically significant for either tooth based on gender and age groups (Table 2).

In terms of the CBCT PAI, for the maxillary right lateral tooth, 95.2% of females had a CBCT PAI=0, 4.0% had a CBCT PAI=1, and 0.8% had a CBCT PAI=4. Among males, 42.8% had a CBCT PAI=0, 4.8% had a CBCT PAI=1, 1.6% had a CBCT PAI=2, and 0.8% had a CBCT PAI=4 (Table 3). For the maxillary left lateral tooth, 98.4% of females had a CBCT PAI=0, and 0.8% had both a CBCT PAI=1 and CBCT PAI=2. Among males, 95.2% had a CBCT PI=0, 3.2% had a CBCT PAI=1, and 1.6% had a CBCT PAI=2 (Table 3). The p-values indicate that the differences between the groups for both teeth were not statistically significant (Table 3). Across all age groups, the majority of both teeth exhibited a PI=0 (Table 3). Following this, the highest PI=1 rate was found in the 15-20 age group (maxillary right lateral 12.5%; maxillary left lateral 6.3%) (Table 3). The distribution of PI rates among age groups was not statistically significant ($p>0.05$) (Table 3).

For the maxillary right lateral tooth, 88.9% of Tip I DI cases had a PAI=0, while 50.0% of Tip II cases had a higher occurrence of CBCT PAI=4. These differences were statistically significant ($p<0.05$) (Table 4). For the maxillary left lateral tooth, 90% of Tip I DI cases had a PAI=0, while 100% of Tip II cases had a CBCT PAI=1. However, these differences were not statistically significant ($p=0.142$) (Table 4).

4. Discussion

The anatomical complexity is closely associated with the extent of invagination in DI, particularly in type III.[4] Consequently, CBCT is an invaluable tool for diagnosing DI [16], as it offers a comprehensive understanding of the dental anatomy of complex DI, including the presence of varying degrees of invagination. Endodontic treatment planning that is predicated on inadequate anatomical information may result in deviations from the root canal trajectory, as the delicate enamel of teeth affected by DI is more susceptible to pulpal infection as a result of dehiscence.[2] The objective of this investigation was to assess the prevalence and morphological characteristics of DI using CBCT, as it is frequently linked to endodontic and/or peri-radicular diseases.

CBCT provides significant advantages in identifying DI and deciding on its treatment. The characteristics and extent of invagination may not be fully determined with panoramic and periapical radiographs.[17] CBCT images, however, have been utilized in numerous studies for diagnosing DI as they allow for a precise examination of tooth morphology.[4,7,17-19] One limitation of traditional radiographic classification is its dependence on two-dimensional images, which suffer from structural superimposition.[20] On the other hand, high-resolution CBCT generates volumetric images that furnish comprehensive details regarding the apex features, the presence and dimensions of periapical lesions, the type and extent of invagination, and the relationship with the root canal. These details are instrumental in the planning of treatment.[4,7,16,17,21-23] Within the crown (the enamel lining the invagination), invaginations can seem like pouches with hypodense or hyperdense borders; in DI cases, they can even extend to the root.[24]

The prevalence of each type of DI was estimated in numerous included studies using the Oehlers classification. The prevalence of teeth with DI has been observed to vary between 0.04 and 12%.[2-8] The most prevalent type was type I, followed by type II and type IIIab, as determined by a systematic review and meta-analysis.[18] The overall prevalence of DI was determined to be 10.0% in this study, with type I at 94.0% and type II at 6.0%. This is in contrast to the results of Mabrouk et al.[21] and Hegde et al.[7], which reported that type II was the most prevalent, with prevalences of 47.61% and 61.03%, respectively. The prevalence of DI types was previously ascertained using Oehler's classification. Çakıcı et al.[25] and Gündüz et al.[6] determined that type I DI had the highest rate (69.8-93.8%), followed by type II (3.1-26.6%) and type III (3-12.5%). The prevalence and characteristics of DI vary significantly across different geographic regions, which highlights the importance of

Table 3. Distribution of Periapical Index in Maxillary Right and Left Lateral Teeth by Gender and Age Groups

	Periapical Index											
	Maxillary Right Lateral Tooth						Maxillary Left Lateral Tooth					
	0	1	2	3	4	p value	0	1	2	3	4	p value
Gender												
Female	119 (95.2%)	5 (4.0%)	0 (0.0%)	0 (0.0%)	1 (0.8%)	0.686	123 (98.4%)	1 (0.8%)	1 (0.8%)	0 (0.0%)	0 (0.0%)	0.411
Male	116 (92.8%)	6 (4.8%)	2 (1.6%)	0 (0.0%)	1 (0.8%)		119 (95.2%)	4 (3.2%)	2 (1.6%)	0 (0.0%)	0 (0.0%)	
Age Groups												
15-20 years	54 (84.4%)	8 (12.5%)	1 (1.6%)	0 (0.0%)	1 (1.6%)	0.056	58 (90.6%)	4 (6.3%)	2 (3.1%)	0 (0.0%)	0 (0.0%)	0.325
21-26 years	58 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		58 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
27-32 years	41 (95.3%)	2 (4.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		41 (95.3%)	1 (2.3%)	1 (2.3%)	0 (0.0%)	0 (0.0%)	
33-38 years	34 (94.4%)	1 (2.8%)	1 (2.8%)	0 (0.0%)	0 (0.0%)		36 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
39-44 years	21 (95.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (4.5%)		22 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
45 years and older	27 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		27 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	

Table 4 Distribution of Periapical Index by Dens Invaginatus Types in Maxillary Right and Left Lateral Teeth

Type of Dens Invaginatus	Periapical Index – Maxillary Right Lateral Tooth				p value
	0	1	2	4	
Type I	24 (100.0%)[a]	3 (75.0%)[a]	0 (0.0%)[a]	0 (0.0%)[a]	0.011*
Type II	0 (0.0%)[b]	1 (25.0%)[b]	0 (0.0%)[b]	1 (100.0%)[b]	
Type of Dens Invaginatus	**Periapical Index – Maxillary Left Lateral Tooth**				**p value**
	0	**1**	**2**	**4**	
Type I	18 (90.0%)	1 (5.0%)	1 (5.0%)	0 (0.0%)	0.142
Type II	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	

*p<0.05 Each same superscript letter indicates a subset of right carotid artery calcification categories whose column ratios are not significantly different from each other at the .05 level.

which highlights the importance of conducting research in these areas. Location-specific differences appear to be quite common.[7]

The overall incidence of bilateral DI was higher (78%) in our study than unilateral DI (32%). Studies that have reported prevalent bilateral occurrence in 82.0% [21] and 67.5% [7] of cases are consistent with these findings. Furthermore, Yalcın et al. [26], Capar et al. [17], and Rozylo et al.[27] determined that the frequency of bilateral occurrence of DI was 24.48%, 31.3%, and 24.2%, respectively. CBCT images were the subject of analysis in all of these investigations.

In this study, no significant difference was observed in terms of the prevalence of DI in the right and left maxillary lateral teeth according to gender (p = 0.840 and p = 0.370). Some previous studies also support this finding.[7,19,25,28,29] This finding suggests that the occurrence of DI is not influenced by gender, supporting the notion that DI is a developmental anomaly that arises independently of gender-related factors.[30]

In other studies, no significant differences were observed between age groups in terms of the presence or absence of DI.[31,32] In a study conducted in 2024 in a Turkish population [33], the presence of DI was found to be higher in the 20-30 age group, but no statistically significant difference was also found. The current study also supports these findings. This suggests that the occurrence of DI does not seem to vary significantly across different age groups, indicating that age may not be a major factor influencing the development of this anomaly. The likely reason is that this anomaly occurs during tooth development and is not influenced by factors that change with age. DI is a developmental anomaly that arises during the embryonic stages of tooth formation, meaning that once the tooth development is complete, the presence of DI is established and remains unchanged throughout life. Since DI is determined during the early stages of tooth formation, it does not fluctuate as a person age.[34,35]

Bacterial accumulation in the form of biofilm within the invaginated area can impact the pulp and potentially lead to necrosis. This increases the risk of pulp disease in teeth with DI, which may result in pulp necrosis and subsequent periapical pathology.[9] By using the CBCT PAI index to classify and score DI-related periradicular lesions, we were able to correlate different DI subtypes with the progression of periradicular disease. In our study, type I DI was linked to the absence of periapical lesions, while type II DI was associated with the presence of periapical lesions in the right lateral teeth, with a significant difference noted between the two (p=0.011). Similarly, Çapar et al.[17] found that type I DI was generally not accompanied by periapical lesions, whereas type II DI had a 25% incidence of periapical lesions, and in type III DI, periapical lesions were present in all cases.

In this study, we investigated the prevalence of DI and the relationship between DI types and periapical lesions in a Turkish subpopulation. CBCT imaging, which is more effective than two-dimensional periapical radiographs in classifying DI types and detecting periapical lesions [15], was utilized to enhance diagnostic accuracy. While the use of CBCT provided a distinct advantage, it is important to note that its indications are generally more restricted compared to conventional imaging techniques and do not typically include dental anomalies such as DI. To mitigate this limitation, we analyzed 250 CBCT images obtained for various clinical reasons, allowing us to examine a substantial number of teeth. Notably, among the 25 teeth affected by DI, lesions were detected in only 15 cases, underscoring the need for cautious interpretation of the findings, particularly in light of the relatively small sample size and the limited number of periapical lesions observed. Additionally, a limitation of the study is that it was conducted with a single observer, which may introduce observer bias. Although our results are consistent with those of previous studies, expanding the sample size, including data from diverse populations, and involving multiple observers would strengthen the validity and generalizability of the findings.

5. Conclusion

The prevalence of dental invagination (DI) in maxillary lateral teeth was 10.0% within the constraints of the current study. The incidence of DI was higher on the right side (11.6%) compared to the left side (8.4%), indicating that there was not a statistically significant distinction between the left and right arches. Type I DI was more prevalent in the 15-20 age group, but there were no statistically significant differences in DI prevalence based on gender or age. Specifically, Type I DI was predominantly associated with a PAI of 0, indicating an absence of periapical lesions, whereas Type II DI showed a significant association with higher PAI scores, particularly in the maxillary right lateral teeth, reflecting the presence of periapical pathology. These findings underscore the utility of CBCT in providing detailed insights into the anatomical variations of DI and their clinical implications. Further research in diverse populations is recommended to better understand regional differences in DI prevalence and the association between DI types and periapical outcomes.

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Conflict of Interest
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