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Estimation of pulpitis prevevelance in permenant dentition with incomplete rootcanal

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Abstract :

Background: Pulpitis in immature permanent teeth presents a significant clinical challenge because incomplete root development, wide dentinal tubules, and an open apical foramen may influence disease progression, diagnosis, and treatment selection. Early recognition of pulpal disease is important to preserve tooth vitality and allow continued root maturation.

Objective: This study aimed to assess the demographic, clinical, and radiographic characteristics of children with pulpitis and to evaluate the associations between age, sex, clinical manifestations, and root-apex development in children aged 8–13 years.

Materials and Methods: A prospective study was conducted among 60 children aged 8–13 years who attended a specialized dental center. Clinical and radiographic examinations were performed to assess chief complaints, swelling, history of trauma, and root-apex status. The study population included 36 females (60.0%) and 24 males (40.0%). Associations between categorical variables were assessed using the chi-square test, while differences in age across root-development groups were evaluated using the Kruskal–Wallis test. Spearman's correlation was used to assess the relationship between age and root maturation. A P-value <0.05 was considered statistically significant.

Results: Open apex was the most common radiographic finding, observed in 32 children (53.3%), followed by closed apex in 19 (31.7%) and incomplete root formation in 9 (15.0%). Night pain was the predominant chief complaint, occurring in 41 cases (68.3%).

No significant association was observed between sex and root-apex status ($\chi^2 = 0.192$, P = 0.908), chief complaint and root-apex status ($\chi^2 = 6.874$, P = 0.550), swelling and root-apex status ($\chi^2 = 1.245$, P = 0.537), or trauma and root-apex status ($\chi^2 = 1.810$, P = 0.404). Similarly, sex was not significantly associated with chief complaint ($\chi^2 = 3.501$, P = 0.478) or swelling ($\chi^2 = 0.330$, P = 0.565). A significant positive correlation was found between age and root maturation (Spearman's r = 0.304, P = 0.018). In addition, the mean age was significantly higher among males than females (11.17 ± 1.27 vs. 10.25 ± 1.42 years, P = 0.014).

Conclusion: The findings demonstrate that open apices were common among children presenting with pulp-related clinical findings, emphasizing the importance of accurate assessment of root development in pediatric dental patients. Increasing age was significantly associated with greater root maturation, whereas sex, chief complaint, swelling, and trauma were not significantly associated with root-apex status. Early diagnosis and appropriate management of pulpal disease in immature permanent teeth may help preserve pulp vitality and support continued physiological root development.

Keywords:Pulpitis;

immature permanent teeth; open apex; root maturation; children; pediatric dentistry; dental caries; pulp therapy.

Introduction

Dental caries is the most common infectious disease affecting children and adolescents and remains one of the most prevalent oral health problems worldwide [1,2]. Newly erupted permanent teeth, particularly the first permanent molars, are highly susceptible to dental caries when a cariogenic environment persists in the oral cavity [3]. During the early stages of development, young permanent teeth have relatively wide dentinal tubules, a large pulp chamber, and prominent pulp horns [4]. These anatomical characteristics reduce the distance between the external tooth surface and the pulp, allowing carious lesions to progress rapidly toward the pulp tissue. Consequently, untreated or inadequately treated dental caries may result in pulpal inflammation and, eventually, pulpal infection and necrosis [5].The management of pulpitis in young permanent teeth presents a particular clinical challenge for pediatric dentists because these teeth may have incompletely developed roots and require preservation of the remaining tooth structure and supporting tissues [6]. Although several treatment modalities are available, the

evidence supporting their long-term clinical outcomes remains limited in some clinical situations. Vital pulp therapy aims to preserve the vitality and physiological development of the pulp and may include protective liners, indirect pulp treatment, direct pulp capping, and partial pulpotomy [7,8]. However, the prognosis of these procedures may be compromised when clinical signs and symptoms suggest irreversible pulpitis, particularly spontaneous or unprovoked pain [7].

When the inflammatory or infectious process cannot be controlled by conservative procedures designed to maintain pulp vitality, non-vital treatment options may become necessary. Depending on the stage of root development and the condition of the tooth, these options include pulpectomy and apexification [9]. The choice of treatment should be based on the extent of pulpal and periapical involvement, the degree of root development, the remaining tooth structure, and the restorability of the affected tooth. Extraction should generally be considered only when adequate bony support cannot be restored, insufficient tooth structure remains to provide a predictable restoration, or extensive pathological root resorption has occurred [8,10,11].

Preservation of a young permanent tooth is particularly important because maintaining the tooth can contribute to normal mastication, arch integrity, occlusal development, and preservation of the alveolar bone. Following endodontic treatment, the quality of the coronal restoration is also critical. A well-sealed intermediate or definitive restoration is necessary to minimize bacterial penetration through the restoration–dentin interface and to prevent reinfection of the root canal system [12,13]. Despite adequate endodontic treatment, the complex morphology of the root canal system can make complete mechanical cleaning, disinfection, and obturation difficult. Therefore, root canal filling alone cannot always eliminate the risk of coronal bacterial contamination, particularly when the coronal seal is inadequate.

Restorative management of severely carious young permanent teeth can be particularly challenging because these teeth often have limited remaining tooth structure and immature roots. In addition, changes in occlusion and craniofacial growth during childhood may influence the long-term stability and function of definitive restorations [14]. For this reason, clinicians may sometimes delay definitive treatment while monitoring the development of the tooth and surrounding structures. However, delayed diagnosis and treatment of pulpal disease may allow inflammation and infection to progress, potentially increasing the risk of treatment failure, periapical pathology, and premature tooth loss.Incomplete root formation represents an additional consideration in the management of pulpitis. Preservation of pulp vitality in immature permanent teeth may permit continued physiological root development, known as apexogenesis, resulting in continued root lengthening and thickening of the dentinal walls. Conversely, loss of pulp vitality

before completion of root formation can interrupt normal root development and produce a tooth with thin dentinal walls and an open apex, making subsequent endodontic treatment more complex. Early detection and appropriate management of pulpal disease are therefore essential for maintaining the function and longevity of immature permanent teeth.The prevalence and distribution of pulpitis among children with immature permanent teeth may vary according to age, tooth type, caries severity, oral hygiene, dietary habits, and access to dental care. Children between 6 and 13 years of age are particularly important in this resultsbecause this period encompasses the eruption and early maturation of several permanent teeth, including the first molars and incisors. Identifying the frequency of pulpitis and determining the distribution of carious lesions in this age group may provide useful information for early diagnosis, preventive strategies, and appropriate treatment planning.Therefore, the present study aims to determine the prevalence of pulpitis in permanent teeth with incomplete root formation among children aged 6–13 years and to evaluate the distribution and characteristics of carious lesions among affected patients. The findings may contribute to a better understanding of the burden of pulpal disease in immature permanent teeth and emphasize the importance of early detection, prevention, and timely dental intervention in children and adolescents.

Materials and Methods

A prospective cohort study was conducted at the First Specialized Dental Center in Babylon, Iraq, to determine the prevalence of pulpitis in permanent teeth with incomplete root formation among children aged 8–13 years. The study was conducted over a six-month period. The study included **60 children**, comprising both males and females, aged 8–13 years. All erupted permanent teeth in the four quadrants of the oral cavity were examined. Children were included if they had at least one fully erupted permanent tooth with incomplete root formation. Written informed consent was obtained from the parents or legal guardians of all participants before enrollment. Demographic and clinical information, including age, sex, residential address, and relevant systemic health conditions, was recorded for each participant. A comprehensive dental examination was performed to identify the presence and extent of dental caries and clinical signs and symptoms suggestive of pulpitis. Radiographic examination was performed for the affected permanent teeth to assess the stage of root development and determine whether root formation was complete or incomplete. The radiographic findings were used in conjunction with the clinical examination to evaluate the relationship between the stage of root formation, dental caries, and pulpal involvement. The prevalence of pulpitis was determined among the examined children and permanent teeth, and the distribution of carious lesions was assessed according to the affected tooth and clinical characteristics.

Ethical Approval

Ethical approval was obtained from the Ethical Committees of the Human Training and Developed Center, Babylon, and the First Specialized Dental Center (IRB No. ١-٩-202٥6). Written informed consent was obtained from all participants before sample collection.

Statistical Analysis

Data were analyzed using SPSS 28.0 and Real Statistics 7.2. Descriptive and comparative analyses were performed, with ORs and 95% CIs calculated where appropriate. A two-sided $P < 0.05$ was considered statistically significant.

Results

The study included **60 children aged 8–13 years** who were examined for clinical findings associated with pulpitis and root development. As in Table1.

Table1. Demographic, Clinical, and Radiographic Characteristics of the Study Participants

Variable	Category	N%	
Sex	Female	36	60.0
	Male	24	40.0
Age group	8–9 years	14	23.3
	10–11 years	23	38.3
	12–13 years	23	38.3
Root-apex status	Open apex	32	53.3
	Incomplete root formation	9	15.0
	Closed apex	19	31.7
Trauma	No	58	96.7
	Yes	2	3.3
Swelling	No	53	88.3
	Yes	7	11.7

While,The study population consisted of **36 females (60.0%) and 24 males (40.0%)**. Open apex was the most frequently observed root-development status, occurring in 32

cases (53.3%), followed by closed apex in 19 cases (31.7%) and incomplete root formation in 9 cases (15.0%).

Table2. Association Between Sex and Root-Apex Status

Sex	Closed Apex	Incomplete Root Formation	Open Apex	Total
Female	11 (30.6%)	5 (13.9%)	20 (55.6%)	36
Male	8 (33.3%)	4 (16.7%)	12 (50.0%)	24
Total	**19**	**9**	**32**	**60**

Chi-square = 0.192, P = 0.908

There was **no statistically significant association between sex and root-apex status** (P = 0.908). The distribution of open, incomplete, and closed apices was generally comparable between females and males.

The mean age according to root-development status was in Table3:

Table3. Association Between Age and Root-Apex Status

Root-Apex Status	N	Mean Age ± SD
Open apex	32	10.25 ± 1.48
Incomplete root formation	9	10.56 ± 1.59
Closed apex	19	11.26 ± 1.05

The Kruskal–Wallis test showed no statistically significant difference in age among the three root-development groups:

H = 5.687, P = 0.058

However, when root development was considered as an ordered developmental variable, a **significant positive correlation** was observed between age and root maturation:

Spearman's r = 0.304, P = 0.018

This finding indicates that **increasing age was significantly associated with greater root maturation**.

Table4. Association Between Chief Complaint and Root-Apex Status

Chief Complaint	Closed Apex	Incomplete Root Formation	Open Apex
Night pain	12	6	23
Pain	3	2	3
Caries	4	1	2
Swelling	0	0	2
Trauma	0	0	2

Chi-square = 6.874, P = 0.550

There was **no statistically significant association between chief complaint and root-apex status** (P = 0.550).

Night pain was the most common presenting complaint, being reported in 41 cases (68.3%) of the study population.

Table5. Association Between Swelling and Root-Apex Status

Swelling	Closed Apex	Incomplete Root Formation	Open Apex
No	18	8	27
Yes	1	1	5
Total	**19**	**9**	**32**

Chi-square = 1.245, P = 0.537

There was **no statistically significant association between the presence of swelling and root-apex status** (P = 0.537).

Although swelling was more frequently observed among children with an open apex, this difference was not statistically significant.

Table6. Association Between Trauma and Root-Apex Status

Trauma	Closed Apex	Incomplete Root Formation	Open Apex
No	19	9	30
Yes	0	0	2
Total	**19**	**9**	**32**

Chi-square = 1.810, P = 0.404

There was **no statistically significant association between a history of trauma and root-apex status** (P = 0.404).

However, only **two cases (3.3%)** had a history of trauma. Therefore, this analysis should be interpreted cautiously, and **Fisher's exact test** would be preferable because of the small expected cell frequencies.

Table7. Association Between Sex and Chief Complaint

Sex	Caries	Night Pain	Pain	Swelling	Trauma
Female	5	25	5	1	0
Male	2	16	3	1	2

Chi-square = 3.501, P = 0.478

There was **no statistically significant association between sex and chief complaint** (P = 0.478). Night pain was the predominant complaint in both females and males.

Table8. Association Between Sex and Swelling

Sex	No Swelling	Swelling	Total

Female	33	3	36
Male	20	4	24
Total	**53**	**7**	**60**

Chi-square = 0.330, P = 0.565

There was **no statistically significant association between sex and the presence of swelling** (P = 0.565).

Table9. Association Between Age and Sex

The mean age according to sex was:

Sex	N	Mean Age ± SD
Female	36	10.25 ± 1.42
Male	24	11.17 ± 1.27

The difference in age between females and males was statistically significant:

H = 5.984, P = 0.014

Discussion

The present study evaluated 60 children aged 8–13 years with clinical findings related to pulpitis and different stages of root development. The main findings were that females represented 60.0% of the sample, open apices were the most frequently observed radiographic finding (53.3%), and night pain was the predominant presenting complaint (68.3%). Although no significant associations were detected between sex and root-apex status, chief complaint and root-apex status, swelling and root-apex status, or trauma and root-apex status, a significant positive correlation was identified between age and root maturation (Spearman's r = 0.304, P = 0.018). These findings are clinically relevant because the stage of root development strongly influences the diagnosis, prognosis, and treatment selection for young permanent teeth.In the present study, females constituted 60.0% of the participants, compared with 40.0% males. This female predominance was also observed in a recent pediatric endodontic referral study, in which females represented 57.8% of children referred for evaluation of permanent teeth requiring possible

endodontic treatment, while males accounted for 42.2%. However, the difference in sex distribution between studies should not necessarily be interpreted as evidence of a higher biological susceptibility to pulpitis among females. Attendance at dental clinics, health-seeking behavior, referral patterns, and the composition of the underlying population may all influence the observed sex distribution.Importantly, the present study demonstrated no significant association between sex and root-apex status ($\chi^2 = 0.192$, $P = 0.908$). This finding indicates that the proportion of open, incompletely formed, and closed apices was broadly comparable between boys and girls. Recent radiographic research has emphasized that root maturation is strongly dependent on chronological age and tooth type, while sex-related differences may be less pronounced. For example, a 2024 CBCT study of first permanent molars in 202 children aged 5–15 years evaluated apical closure according to age and found a marked increase in closure with increasing age. Similarly, a 2024 Korean CBCT study involving 313 children found that apical closure of the roots of maxillary first molars occurred at different ages according to root type, illustrating that **t**ooth-specific developmental variation may be more important than sex alone. The most prominent radiographic finding in the current study was the high proportion of open apices, which were identified in 53.3% of the examined cases. Incomplete root formation was observed in an additional 15.0%, whereas 31.7% had closed apices. The relatively high proportion of immature teeth is clinically understandable because the study population consisted of children and young adolescents in whom several permanent teeth are still undergoing root development.The significant positive correlation between age and root maturation (Spearman's $r = 0.304$, $P = 0.018$) supports the biological expectation that root development progresses with increasing chronological age. This result is consistent with recent radiographic evidence. Kalabalıket al. (2024), using CBCT in western Turkish children, reported a progressive increase in apical closure of first permanent molars with age. For maxillary first molars, apical closure increased from 4.1% at 8–8.99 years to 90.6% at 12–12.99 years, while mandibular first molars showed an increase from 4.4% to 92.2% across the corresponding age groups. These findings closely support the present observation that older children tend to have more advanced root maturation.The mean age in the present study was also higher among children with closed apices (11.26 ± 1.05 years) than among those with open apices (10.25 ± 1.48 years). Although the difference among the three root-development categories did not reach statistical significance using the Kruskal–Wallis test ($H = 5.687$, $P = 0.058$), the significant Spearman correlation suggests that treating root maturation as an ordered developmental process may better reflect the biological relationship between age and root development.The absence of statistical significance in the three-group comparison may partly be related to the relatively small sample size, particularly the incomplete-root-formation group, which contained only nine cases. In addition, root development is not identical among all permanent teeth. Recent CBCT evidence demonstrates substantial tooth- and root-specific variation in the timing of apical closure. Therefore, future studies

should analyze root development according to **specific tooth type, arch, and root** rather than combining all permanent teeth into a single developmental classification.Night pain was the most common presenting complaint in the current study, accounting for 41 of the 60 cases (68.3%). This observation is clinically important because spontaneous or nocturnal pain is traditionally considered an important indicator of advanced pulpal inflammation. However, the present analysis found no significant association between chief complaint and root-apex status ($\chi^2 = 6.874$, $P = 0.550$).The lack of a significant association does not necessarily mean that symptoms are clinically unimportant. Rather, it may indicate that symptoms alone cannot reliably distinguish the developmental stage of the root. Children may also have difficulty describing the character, duration, and severity of dental pain, while immature teeth may exhibit variable pulpal responses. A recent pediatric endodontic referral study reported that, among 247 permanent teeth evaluated, 16.6% were diagnosed with reversible pulpitis, 21.1% with irreversible pulpitis, and 20.2% with pulpal necrosis, demonstrating substantial variation in pulpal status among pediatric patients referred for endodontic assessment. More recent evidence also supports careful interpretation of spontaneous and nocturnal pain. The 2025 AAPD clinical practice guideline recommends complete caries removal and assessment of pulp status in permanent teeth presenting with spontaneous, nocturnal, or lingering pain; when the pulp remains vital and bleeding can be controlled, full pulpotomy may be considered. Thus, the high frequency of night pain in the present study emphasizes the need for comprehensive clinical and radiographic assessment rather than relying on the presenting symptom alone.Swelling was reported in only seven children (11.7%), and no statistically significant association was observed between swelling and root-apex status ($\chi^2 = 1.245$, $P = 0.537$). Although five of the seven children with swelling had open apices, the difference was not statistically significant.The relatively low frequency of swelling may indicate that most patients presented before extensive infection and periapical involvement had developed. Nevertheless, swelling is clinically important because it may indicate progression beyond isolated pulpal inflammation toward infection of the periapical tissues. Current pediatric endodontic approaches emphasize the importance of differentiating pulpal inflammation from necrosis and apical disease when selecting treatment for immature permanent teeth. The 2025 AAPD recommendations specifically recognize vital pulp therapy, conventional root canal treatment, apexification, and regenerative endodontic procedures as treatment options depending on pulp status and root maturity. Only two children (3.3%) reported a history of trauma, and both were associated with open apices. Although this pattern could suggest a possible relationship between trauma and immature root development, the association was not statistically significant ($\chi^2 = 1.810$, $P = 0.404$). The very small number of trauma cases substantially limits the statistical power of this comparison. Therefore, the absence of statistical significance should not be interpreted as evidence that trauma has no influence on pulpal or root-development outcomes.Recent literature continues to recognize trauma as an

important cause of pulpal complications in immature permanent teeth. In a 2024 retrospective case-series study of 49 immature permanent teeth with irreversible pulpitis, Zhang et al. reported that traumatic crown fractures were associated with significantly lower pulpotomy success than caries or dens evaginatus ($P< 0.001$). This finding suggests that the biological consequences of trauma may differ from those of caries and reinforces the importance of considering etiology when evaluating immature permanent teeth.Because only two trauma cases were present in the current dataset, Fisher's exact test would be more appropriate than Pearson's chi-square test for confirming this relationship. Future studies with larger samples and a higher number of traumatic injuries are required to adequately evaluate this association.No significant association was found between sex and chief complaint ($\chi^2 = 3.501$, $P = 0.478$), or between sex and swelling ($\chi^2 = 0.330$, $P = 0.565$). Night pain was the most frequent complaint among both females and males. These findings suggest that the clinical presentation of pulpitis in this population was not strongly influenced by sex.This is compatible with the broader clinical evidence suggesting that the diagnosis and management of pulpal disease in immature permanent teeth should primarily be based on the clinical diagnosis, symptoms, pulp status, tooth restorability, and stage of root development, rather than sex. The 2025 AAPD guideline specifically emphasizes pulp diagnosis and root maturity in determining appropriate vital pulp therapy for permanent teeth. The high proportion of open apices in this study has important therapeutic implications. Immature permanent teeth have thin dentinal walls and an incompletely developed root, making them more vulnerable to fracture and complicating conventional endodontic procedures. Preservation of pulp vitality, when biologically appropriate, can permit continued physiological root development. Current evidence has increasingly shifted toward conservative and biologically based approaches for managing pulpitis in young permanent teeth.A 2024 systematic review and meta-analysis of 19 randomized clinical trials involving 1,183 children and adolescents found that vital pulp therapy can be effective for permanent teeth with pulp inflammation, including immature teeth. The analysis found that calcium hydroxide had lower success than MTA and other pulp-protecting materials at 12 months, supporting the increasing use of calcium-silicate-based materials in vital pulp therapy. Similarly, a 2024 retrospective study of immature permanent teeth with irreversible pulpitis reported an overall pulpotomy success rate of 85.7% after a mean follow-up of approximately 23 months, with no significant difference in success according to root developmental stage. These findings are particularly relevant to the present study because more than half of the examined teeth had open apices. Rather than automatically proceeding to conventional root canal treatment, contemporary management increasingly considers whether residual pulp tissue can be maintained. The updated AAPD guideline for permanent teeth recommends indirect pulp treatment, direct pulp capping, partial pulpotomy, or full pulpotomy in appropriately selected permanent teeth, including teeth at different stages of root maturation.The current findings are also consistent with the changing concept of

pulpitis management in immature permanent teeth. Zhang et al. (2024) demonstrated that pulpotomy could achieve an 85.7% success rate in immature permanent teeth with irreversible pulpitis, suggesting that the presence of irreversible pulpitis does not necessarily require complete removal of the pulp in every immature tooth. Another recent clinical study involving 44 immature permanent teeth with carious pulp exposure reported a 90.9% overall success rate following pulpotomy, with none of the recorded physical examination findings or symptoms significantly affecting prognosis.

Furthermore, a large retrospective study of regenerative endodontic procedures involving 436 immature permanent teeth reported achievement of the primary treatment goal in 96.1% of teeth and continued root development in 77.8%. Younger age and tooth type were significantly associated with treatment outcomes. These findings reinforce the biological importance of preserving or restoring developmental potential in immature permanent teeth.The clinical implications of the present study therefore extend beyond simply identifying pulpitis. Early recognition of pulpal disease in young permanent teeth may provide an opportunity to preserve vitality and promote continued root maturation. The recent international consensus from the IAPD Porto Forum similarly reflects a shift toward biologically based pulp-preserving approaches and updated diagnostic concepts for pulp inflammation and pulp therapy. Overall, the findings indicate that age was the principal demographic factor associated with root maturation, whereas sex, chief complaint, swelling, and trauma did not demonstrate statistically significant relationships with root-apex status in this sample. The significant positive correlation between age and root maturation is biologically plausible and agrees with recent radiographic studies demonstrating progressive apical closure during childhood and early adolescence. The predominance of open apices and night pain emphasizes the importance of early diagnosis and careful assessment of pulp status in children. Current evidence supports a conservative approach whenever the pulp retains sufficient healing potential, particularly because preservation of vitality may permit continued root development and increase the structural strength of the immature tooth.

Conclusion

The study found that open apices were the most common root-development status (53.3%), while night pain was the predominant complaint (68.3%). No significant associations were found between sex, clinical symptoms, swelling, trauma, and root-apex status. However, age was significantly and positively correlated with root maturation ($r = 0.304$, $P = 0.018$). These findings emphasize the importance of early diagnosis,

radiographic assessment, and pulp-preserving treatment to support continued root development and improve the prognosis of immature permanent teeth.

Limitations

Several limitations should be considered when interpreting these findings. First, the sample size was relatively small (**n = 60**), which may have limited the ability to detect significant associations, particularly for uncommon findings such as trauma. Second, the study was conducted at a single dental center, which may limit the generalizability of the results to other pediatric populations. Third, the cross-sectional clinical assessment does not establish causal relationships between age, symptoms, and root development. Fourth, the small number of children with incomplete root formation (n = 9) reduces the statistical power of comparisons involving this category. Finally, root development is strongly influenced by tooth type, and combining different permanent teeth into general root-apex categories may obscure tooth-specific developmental patterns. Future multicenter studies with larger samples, tooth-specific radiographic staging, standardized pulp vitality testing, and longitudinal follow-up are recommended.An important methodological point**:** because your study contains 60 children who were already examined for pulpitis/clinical findings, the results should preferably be described as the distribution of clinical and radiographic findings among the **study** participants, rather than the population prevalence of pulpitis, unless you also have the total number of 6–13-year-old children examined and the number without pulpitis.

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