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Research article

Impact of primary molars with periapical disease on permanent successors: A retrospective radiographic study

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ABSTRACT

Objective: To clarify the effects on the development, position and morphology of the permanent successors of primary molars affected by apical periodontitis (AP).

Method: A total of 132 panoramic radiographs of children aged from 4 to 10 were screened out and a total of 159 mandibular second primary molars with chronic apical periodontitis (AP) (93 males and 66 females) were analyzed. The maturation values of permanent successors were interpreted and scored according to Nolla's method and compared with normal ones'. The proportion of abnormalities in the morphology and orientation of permanent successors were counted, and the differences between men and women was analyzed. The distribution of various abnormalities in different age groups was also analyzed.

Result: There were significant differences in development of permanent successors in this study compared with the normal ones' in all age groups, among which the differences were statistically significant in males aged in 4,5,7 groups and females aged in 4,6 ($P < 0.05$). The proportions of permanent successors involved with dental follicle broken, malposition and malformation were 78.94%, 42.1%, 8.42% and 82.50%, 38.75%, 15.00%, respectively, with no gender difference. And the highest proportion of these three were all found in 9 years old age group.

Conclusion: AP of primary teeth can lead to accelerated or delayed development of permanent successors to some extent, and may also lead to changes in their shape and direction.

1. Introduction

In recent years, children's oral prevention has made some progress, but apical periodontitis (AP) of primary teeth is still a challenge for children's oral diagnosis and treatment due to factors like the longevity of primary dentition, the integrity of the coronal structure, root canal anatomy and morphology as well as physiologic resorption [1]. The main cause is dental caries [2]. Data from a systemic review concerning 2410 identified publications showed that the prevalence of early childhood caries (ECC) ranged from 23% to 90%, and most of them (26/37) were higher than 50% [3]. The analysis of the characteristics of the treatment needs of children's dental clinics shows that AP of primary teeth accounts for a considerable proportion of the reasons for children's dental clinic visits [4].

It is crucial to remember that the follicular tissues of the succedaneous teeth are very close to the bifurcation and apices of primary molars and an infection may easily reach the follicle of a developing tooth causing inflammation of the follicular tissues or

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development of a cyst [5]. Many studies have shown that chronic AP of primary teeth can affect the growth, development and eruption of permanent teeth to varying degrees, including enamel hypoplasia, abnormal tooth morphology, misplaced eruption, and even the formation of odontogenic cysts and cause permanent tooth germ necrosis, etc [6–9].

Due to the anatomy of the primary teeth and the particularity of the patient population, subjective symptoms are not obvious [10]. And there are mostly loose primary teeth, red and swollen gums, or fistulas during clinical visits. Imaging manifestations are low-density images of the apex of primary teeth and varying degrees of root resorption [11]. As there are multiple root canals and accessory canals at the bottom of the pulp cavity of primary molars, infections are more likely to reach the apex and bifurcations, causing dentoalveolar abscess as well as certain bone damage [12]. It can be seen that the low-density image affects the permanent tooth sac, the white blocking rays on the periphery of the tooth germ are discontinuous, and even the direction of the tooth germ is changed and the morphology is abnormal (Fig. 1, a-c).

Based on this, this article uses imaging analysis to study the influence of AP of primary teeth on the growth and development of permanent successors, and provides references for the prevention and treatment strategies of AP of primary teeth.

2. Materials and methods

2.1. Materials

The subjects of this study is the mandibular second primary molar with chronic AP. The criteria for establishing the diagnosis of chronic AP is primary molar teeth with at least one canal which is necrotic or has abscess or sinus tract as well as radiolucent area(s) in the furcal region or peri-radicular region. A total of 132 panoramic radiographs of children within the age range of 4–10 years were collected from the outpatient case system stored in the Department of Stomatology, Jiangsu University Affiliated Hospital from September 2019 to January 2020. And 159 lower second primary molar with chronic AP from 132 panoramic radiographs (93 males and 66 females) were analyzed and then grouped according to age and gender (Fig. 2). The radiographer was a senior attending doctor in the same imaging department, and the equipment used was an ORTHOPHS XG5 curved tomography machine (Siemens, Germany, 90Kv/12 mA). Sample inclusion criteria: (1) The mandibular second primary molar is diagnosed as chronic apical periodontitis; (2) The radiograph is clear, and the difference in crown width between the left and right first permanent molars does not exceed 20%; (3) There is no inherited permanent tooth loss (4) The child has normal physical development, no chronic diseases or genetic diseases; (5) The child has no jaw deformities, no cleft lip or palate, temporomandibular joint stiffness, jaw tumors and other diseases that affect jaw development. All children and their families gave informed consent and passed the review of the Biomedical Research Ethics Committee of Jiangsu University Affiliated Hospital (Theory approval number: KY2021068).

2.2. Methods for determining the primary teeth, and permanent successors

2.2.1. Primary teeth

No root resorption or root resorption <1/3 of the root, count as 1 point; Root resorption> 1/3 but complete pulp bottom, count as 2 points; Penetration or residual root, count as 3 points; Early loss, Counted as 4 points.

2.2.2. Permanent successors

- Dental follicles

  The dental follicle is not involved, count as 1 point; Dental follicle damage is less than 1/3, count as 2 points; 1/3<dental follicle damage<2/3, count as 3 points; Dental follicle damage>2/3, count as 4 points.

- Maturation The maturation of permanent successors is scored according to Nolla's permanent teeth calcification stage method [13].
- Malposition

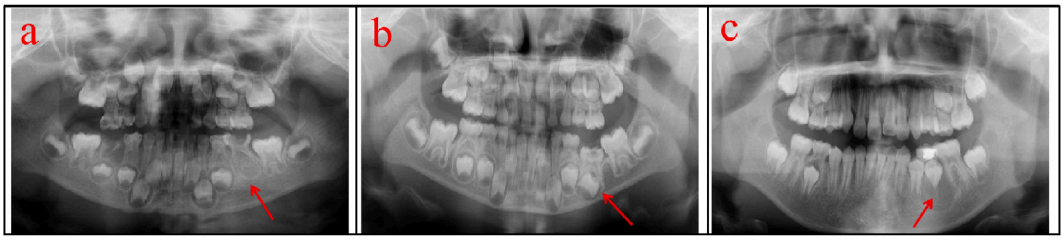

Fig. 1. Dental anomaly of permanent successors in panoramic radiographs (a. The development of the lower left second premolar in a 66-month-old girl was significantly delayed; b. The crown of the lower left second premolar in a 79-month-old boy was obvious distally inclined; c. The lower left second premolar in a 111-month-old girl looks like a sphere with no root.).

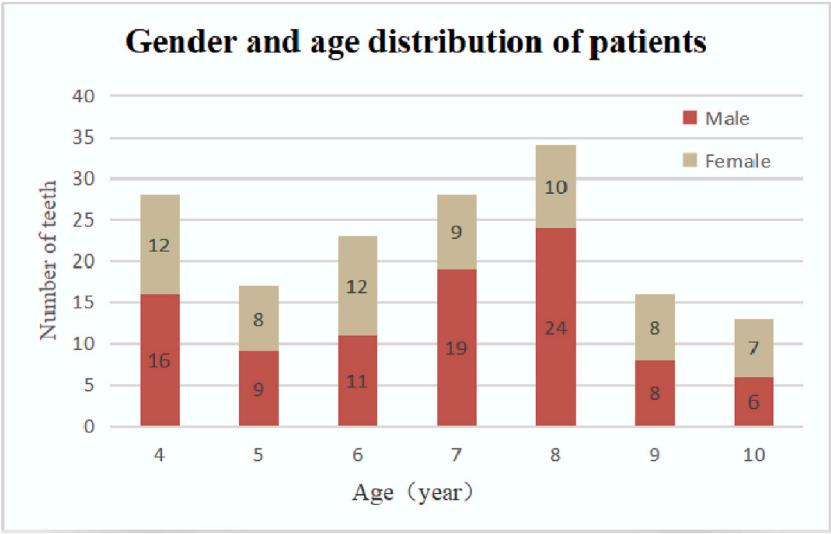

Fig. 2. The gender and age distribution for teeth involved.

The direction is normal, count as 0 point; There is deviation in the mesiodistal direction, count as 1 point (the maturation score is still required to be interpreted if the direction is 1 point).

● Malformation

The morphology is normal, count as 0 point; The morphology is abnormal, count as 1 point (the maturation value will not be interpreted if the morphology is counted as 1 point).

2.3. Experimental reliability test

Two dentists were trained in radiographs reading. All the radiographs were staged and evaluated by one observer. After fifteen days, 30 radiographs were randomly selected from the sample and reevaluated by the same as well as a second observer. High intra and inter observer reliabilities were obtained for both the permanent successors as well as the primary teeth.

2.4. Statistical analysis

SPSS 24.0 statistical software was used for statistical processing on the scores of diseased primary teeth and permanent successors.

(1) The average maturation scores of involved permanent successors in different age groups was calculated and compared with the average of normal permanent teeth in the same age and gender in previous studies [14]. A single sample T-test was conducted to study the development of primary teeth with periapical disease.

Table 1
Maturation scores of permanent successors and difference value compared with normal permanent teeth for each age.

Age (years)	Male				Female			
	N	Mean	Mean difference	*P Value**	N	Mean	Mean difference	*P Value**
4~	16	3.34	0.52	0.01*	10	3.78	0.92	0.001*
5~	8	4.21	0.83	0.01*	8	4.31	0.40	–
6~	11	4.34	−0.07	–	10	5.61	0.89	0.005*
7~	17	5.71	0.53	0.01*	9	5.63	0.05	–
8~	21	5.93	−0.10	–	9	6.20	0.03	–
9~	7	6.70	0.48	–	6	6.80	−0.14	–
10~	6	6.65	−0.31	–	7	7.21	−0.42	–

Mean difference is the value of the maturation scores in this study minus the maturation scores of normal permanent teeth. Therefore, the positive value indicates that the development rate of permanent successors of AP patients is faster than that of normal permanent teeth; otherwise, it is slower than that of normal permanent teeth.
* : $P < 0.05$: the difference was statistically significant.

(2) Statistical analysis was made on the proportion of dental follicles broken, malposition and malformation of permanent successors, and chi-square test was performed between male and female to compare the differences between genders. And the distribution of these three in different age groups was also analyzed.

3. Results

3.1. The development of permanent successors

A total of 14 permanent successors with abnormal morphology (7 males, 7 females) were excluded. And the development of 145 (86 males, 59 females) permanent successors with normal morphology were evaluated. Maturation scores of permanent successors and difference value compared with normal permanent teeth for each age are showed in Table 1 and Fig. 3(a and b). The differences were statistically significant in males aged 4, 5 and 7 years and females aged 4 and 6 years ($P < 0.05$).

3.2. Proportion of abnormalities of permanent successors

The proportion of different types of permanent successors abnormalities is shown in Table 2 and Fig. 4. The proportions of dental follicle destruction, abnormal direction and abnormal morphology were 65.6%, 36.6%, 7.5%, and 68.2%, 28.7%, and 10.6% in males and females, respectively. The difference in the ratio between males and females was not statistically significant. Among them, the highest proportion of these three are all emerging in the 9-year-old group.

4. Discussion

Many studies have confirmed that due to a long period of periapical disease of primary teeth, most of the affected teeth have imaging changes during clinical treatment, including absorption of primary teeth apical and projection of alveolar bone destruction at root furcation, as well as discontinuous rigid plate of inherited permanent tooth embryo, that is, dental follicle destruction, etc [15–17]. In this study, the scoring of primary teeth was mainly based on the indications for root canal treatment of primary teeth established by the American Academy of Pediatric Dentistry (AAPD). It is generally believed that the primary teeth is no longer suitable for root canal treatment if the internal or external absorption exceeds 1/3 of the root length [18]. More serious ones include extensive bone destruction in the apex and furcation area, inflammation involving the dental follicle of permanent successors; perforation of the pulp chamber floor; primary teeth with crowns so damaged that they could no longer be repaired [19]. All these were scored in order of severity. The method of calculating the maturity of permanent teeth by using panoramic radiographs is widely used in the world, reliable and accurate. Even so, it still has some limitations [20]. As for the judgement of position for permanent successors, because the panoramic film is a two-dimensional image, it is impossible to accurately determine the buccal-lingual displacement. Therefore, this situation is not in the scope of this study, and only the mesio-distal direction displacement is scored. Thus, in fact, the proportion of abnormal position of the involved permanent successors should be higher than the data in this study (if the buccal-lingual displacement is included).

In this study, 145 normal permanent successors with normal morphology were studied. It was found that the calcification degree was slower or faster than that of normal permanent teeth, and it was not a single developmental advance or lag. These results suggest that AP of primary teeth can interfere with the development of permanent successors, and the direction of action is uncertain. Some scholars believed that once inflammation occurs involves the inherited permanent tooth capsule, it may lead to abnormal development of permanent teeth, which may lead to early or delayed development of permanent teeth [21]. The results of this study confirmed this point of view, and also explained to some extent the reasons for the inconsistent results of some studies on the impact of permanent tooth eruption. Some results showed that periapical inflammation of primary teeth could accelerate the eruption of permanent

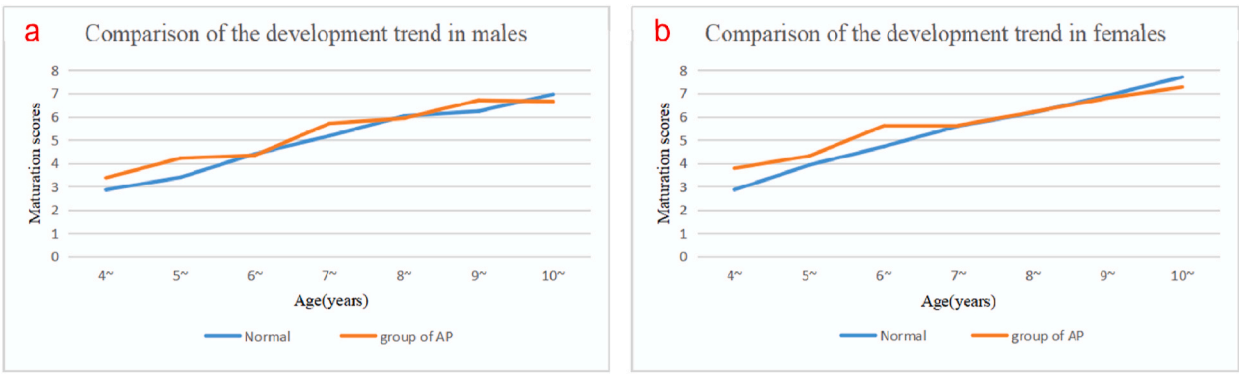

Fig. 3. Comparison of the development trend of the involved permanent successors and normal permanent teeth (a. Comparison of the development trend in males; b. Comparison of the development trend in females).

Table 2
Proportion of different types of permanent successors abnormalities in different genders.

Status of permanent successor (score)	Male (n,%)	Female (n,%)	Chi-square value	*P Value*
Dental follicle damage (>1)	61 (65.6)	45 (68.2)	0.117	0.733
Malposition (1)	34 (36.6)	19 (28.7)	1.049	0.306
Malformation (1)	7 (7.5)	7 (10.6)	0.456	0.500

Chi-square test showed no significant difference between male and female ($P > 0.05$).

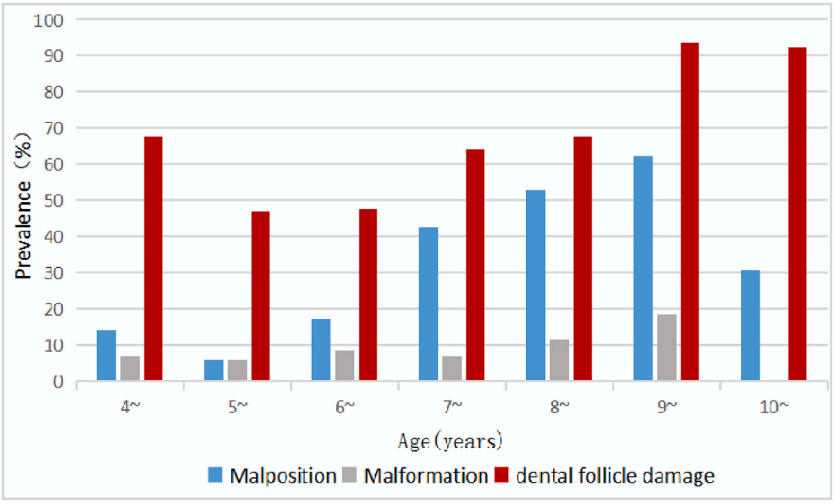

Fig. 4. Proportion of abnormalities of permanent successors in different ages.

successor, while others could slow down the eruption [8,22]. It has been observed that the severity of the effects of primary tooth inflammation or trauma on permanent successors depends on its stage of formation. Hypocalcific defects (qualitative) are most likely to occur during Nolla's 2 and Nolla's 3 stages (beginning of crown mineralization). Our previous studies have found that the age of local children corresponding to this developmental period is 4–5 years old. In this study the difference in the maturation permanent successors is statistically significant among the groups of 4, 5, and 7-year-old for male and 4, 6-year-old group for female. The difference is very obvious among the groups of 4 and 5 for female and the difference in the increase in follow-up age has decreased. The results of these studies confirm this conjecture.

The damage of dental follicles in this study accounted for more than half in both males and females (65.6% for males and 68.2% for female). Most of the periapical diseases of primary teeth have involved the dental follicles, resulting in the hard bone plates of permanent tooth germs no longer being continuous. A certain proportion of teeth with changes in the mesio-distal direction of the inherited permanent tooth germ (36.6% for male and 28.7% for female) suggested that AP of primary teeth has a great influence on the direction of eruption of permanent successors [23–25]. Some studies have also shown that periapical disease of primary teeth is one of the important reasons for the eruption of malposition of permanent successors. The data showed that the peak period of abnormal position and morphological deformity was in the 8 and 9-year-old group. After the age of 10, the proportion of abnormal position decreased significantly, and the proportion of abnormal morphology was 0. Considering that there is a delay in AP of primary teeth from onset to treatment, that is to say, after the teeth have completed crown formation and calcification (Nolla's stage 6), that is, after 8–9 dental age, the impact of AP on permanent successors will be greatly reduced, which also shows that the impact is related to the stage of formation of permanent successors. The earlier the injury time comes, the greater the impact is. Some scholars pointed out that unerupted permanent successors with completed crowns (Nolla's stage 6) are unaffected by inflammation (abscesses or cysts) from their corresponding primary molars or from the extraction of such teeth. The results of this article confirm this view. In this study, the proportion of permanent successors deformity is 14/159, which is equivalent to the teratogenic rate of primary tooth trauma [22]. However, because the psychological impact of AP of primary teeth is less than that of dental trauma, it does not get the attention of parents. Due to negligence, its impact may be greater than dental trauma.

In this study, the condition of 159 primary molars and the damage of the dental follicle are studied and analyzed, and there is no obvious correlation between the two. This is different from our impression that the more severe the damage of the primary teeth, the larger the scope of damage to the dental follicles. Clinically, it is generally believed that the longer the primary tooth has been ill, the more severe the damage of the root tip, and the greater the impact on the growth and development of permanent teeth, including malmineralization of enamel, abnormal tooth morphology, and abnormal pulp cavity and root canal morphology, even odontogenic cysts, etc [26]. However, in actual research, it is found that although the apical resorption of some primary teeth is less than 1/3, the damage range of the dental follicle is larger than 1/3, or even more than 2/3, that is, the dental follicle of permanent successor has been

greatly affected in the early stage of periapical disease. The development and replacement of permanent teeth is an extremely complex process. The primary teeth and permanent teeth are in an interdependent and interactive relationship. The primary teeth with living pulp are the prerequisites for the healthy development and normal replacement of permanent teeth [27]. This study also supports this view. Once a primary tooth loses its vital pulp, regardless of the length of the disease, it may have an irreversible impact on the inherited permanent tooth germ. In addition, a survey of the results of root canal treatment for periapical periodontitis of primary teeth showed that even after root canal treatment, some primary molars presented a new radiolucent defect or enlargement of existing periapical radiolucency [28]. As we all know, the role of a pedodontist is to maintain the primary teeth in its position until exfoliation without signs of infection, thus preserving the integrity of the dental arches [29]. But this study suggested that attention should be paid to oral prevention in children and try to avoid the occurrence of periapical inflammation of primary teeth. Dentists should pay attention to the impact of periapical disease of primary teeth on permanent successors. It is necessary to strengthen the follow-up of patients with such diseases, especially the evaluation of permanent successors development and eruption, and adjust the treatment plan in time. The teeth that are confirmed to have a great negative impact on permanent teeth should be removed in time, rather than barely retained.

Of course, this study still has some limitations. In rare cases, the adjacent teeth of the subjects were also accompanied by apical low-density images, which can interfere with the determination of blame for inherited permanent tooth abnormalities. Moreover, as a two-dimensional image, panoramic radiograph has its limitations. The buccal-lingual displacement cannot be determined. Finally, the sample size of some age groups in this study is small. In the future, we will expand the sample size and adjust the research methods to continuously improve such studies.

5. Conclusion

The AP of primary teeth can affect the maturity development of permanent successors, leading to early or late development. It may also cause abnormal position and morphology of permanent successors.

Author contribution statement

Ling Li and Xueming Yang: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Wei Ju and Jun Li: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Xihu Yang: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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