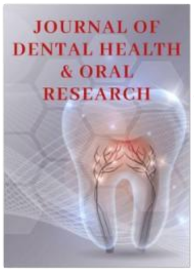

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Arrested Eruption in Human Primary Molars: A Case Series Study, Based on Radiological and Histochemical Investigations on Primary Molars from 24 Children

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Abstract

Aim and objectives: The main purpose of this study is to describe histochemical observations in the human periodontal area of primary molars, with arrested eruption, diagnosed clinically or radiographically.

Methods: 24 primary molars extracted from children 4-10 years old, diagnosed clinically and radiologically with arrestment in eruption are presented. The teeth were forwarded to the Department of Odontology, University of Copenhagen from municipal paediatric dental clinics. In only seven cases, radiographs (orthopantomograms) documenting arrest were enclosed for analysis. The material was divided into two groups. Group 1: The 7 cases containing radiographs. Group 2: The 17 cases without radiographs. All 24 primary molars were fixed in formalin and analysed histochemically. After decalcification, paraffin-embedding and sectioning were performed. Sections were coloured with toluidine blue or according to the Van Gieson method. The sectioning of each tooth allowed observations in the microscope in the cutting plane only.

Results: The study demonstrates that the periodontal membrane in arrested primary molars has the ability to react differently during arrested eruption. The resorption defect in the root dentine was in few cases covered by bone apposition. In one case the periodontal membrane had disappeared between the jawbone and the root dentine. The radiographs did not reveal these differences.

Conclusion: The monocellular hematopoietic precursor cells in the periodontal membrane of the primary molars have the well-known ability to develop to osteoclasts, ex. during resorption, but also the ability to develop to osteoblasts. How and why these different cell developments influence arrestment, is not known.

Keywords: Eruption; Primary Molars; Radiography; Histochemistry; Human

Introduction

The periodontal membrane is crucial for tooth development. The membrane consists of three main tissue layers, separating the root of the primary tooth from the surrounding bone. The layers are identical in primary and permanent teeth, comprising epithelium, mesenchyme and innervation [1-6]. Furthermore, vascular tissue has been described in the membrane [7]. The periodontal membrane is important for the formation of root tissue and the normal eruption process. It is supposed that cellular interactions occur between these cell layers in the periodontal membrane. It is well known that root resorption and resorption of the surrounding bone is initiated from this membrane [8,9]. In this connection, focus has been on the influence from the dentinoclasts and osteoclasts. The difference between these cells has not been clarified [10]. In the following, resorbing cells in the periodontal membrane will be named osteoclasts.

Osteoclasts originate from the monocellular hematopoietic precursor cells, which have the ability to change to osteoblasts as well as to multicellular osteoclasts. This change is regulated specifically by genes and hormones [11]. The normal physiological resorption of the primary teeth during eruption of the permanent dentition has been described. Also, different patterns in this resorption process from apical resorption pattern to more aggressive resorption in the dentine of the primary crown have been published [12,13].

The break-down function from the osteoclast starts with acid secretion from the rough border, followed by digestion [14]. This process is a so-called re-absorption (resorption) process. This resorption process occurs in bone tissue as well as in dentine. It is also well known that severe changes in the periodontal membrane can cause arrest in tooth eruption [15].

The main purpose of this study is to describe histochemical observations in the periodontal area in primary molars with arrested eruption, diagnosed clinically or radiographically. Previous studies on the normal periodontal membranes in primary molars serve as controls for this study on arrested molars [2,7,12,13,16].

Materials and Methods

Materials

From 1990 to 2020, questions from pedodontists and orthodontists in municipal paediatric dental clinics were forwarded to the author at the Department of Odontology, University of Copenhagen for diagnostics and discussions. Questions often raised concerned the aetiology behind arrested eruption. 24 primary molars, extracted from children 4-10 years old, clinically and radiologically diagnosed with arrested eruption were forwarded fixed in 4% neutral buffered formaldehyde. These 24 primary teeth are included in this present study. All 24 primary molars were analysed histochemically. In seven cases, radiographs were included together with the primary molar.

Methods

Radiographic Method: The radiographs were mainly Orthopantomograms (OPGs), taken in seven different clinics and of varying quality.

Histochemical Method: The teeth were forwarded fixed in formaldehyde and then decalcified (equal parts of 2% citric acid and 20% sodium citrate pH=6) in the laboratory. This decalcification process was mild and lasted approx. 6 months. After decalcification, paraffin-embedding and sectioning of each specimen were performed. The sections were coloured with haematoxylin/eosin, toluidine blue, alcian blue and Van Gieson methods. The sectioning of each tooth allowed observations in the microscope in the cutting plane only. The histological sections were analysed using a Leica DM5599 B microscope and photographed using a Leica DM6200 camera.

Results

The sections of arrested primary molars were compared to sections of normal periodontal membranes in primary teeth [2,7,12,13,16]. The histochemical sections were divided into two groups, according to presence of radiograph:

Group 1: Radiographs and histochemical sections were available for each primary molar.
Primary molars from seven children were designated to this group. Radiographs demonstrated different severity of root resorption (Fig. 1-4).

Histochemical sections demonstrated in Fig. 1-4 showed the following:

- Fig. 1 shows root resorption in different morphologies from cone shaped to more or less concave shaped, ages 4-8 years.
- Fig. 2 shows minor bone apposition covering resorption areas, ages 4-7 years.
- Fig. 3 shows total absence of a periodontal membrane, normally covering the 2nd maxillary molar, age 5 years.
- Fig. 4, upper, shows a deep bowl-shaped resorption (in one case) and in another section from the same individual, severe bone apposition, age 5 years.
- Fig. 4, lower, shows total resorption of roots, age 10 years.

Group 2: Histochemical sections from primary molars, where radiographs were not available

This group demonstrated:

- Resorption patterns identical to the ones described in Group 1.
- In addition, resorption with a square-shaped morphology of the resorption defect (Fig. 5 upper).
- Aggressive resorption in the root dentine of a primary molar, where the resorption process has penetrated the root dentine and developed crown resorption (Fig. 5 lower).

The seven cases illustrated in Fig. 1 and 2 demonstrate that arrest of a primary molar can be diagnosed histochemically with root resorption and with areas of root resorption covered by bone apposition. Furthermore, complete absence of the periodontal membrane was observed. These three different histopathological findings might have prohibited eruption.

The radiographs from the seven children (Group 1) did not reveal the differences in the periodontal resorption pattern observed histochemically.

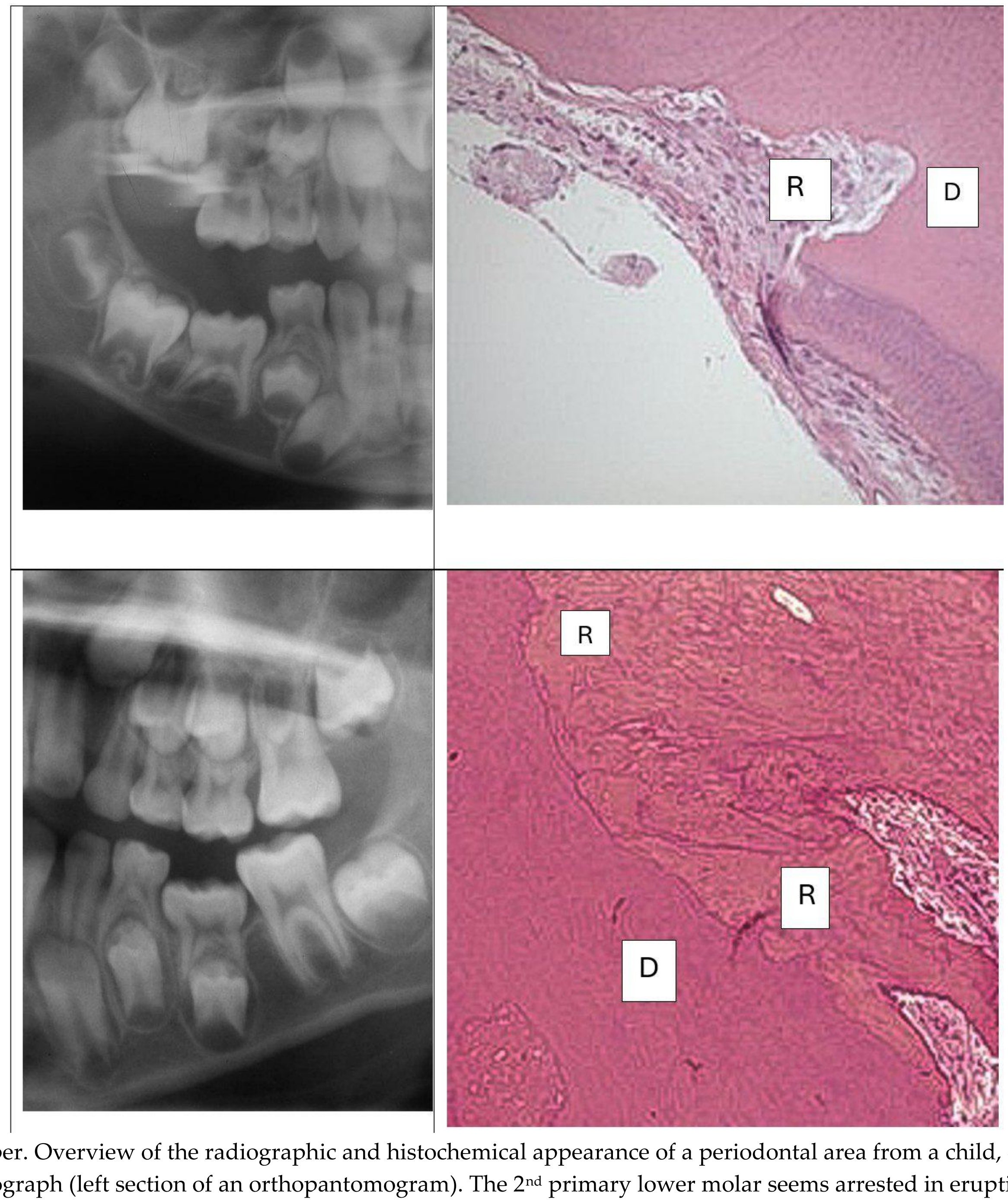


Figure 1: Upper. Overview of the radiographic and histochemical appearance of a periodontal area from a child, 4 years of age. Left. Radiograph (left section of an orthopantomogram). The 2nd primary lower molar seems arrested in eruption. The 1st

primary molar in the maxilla has erupted. Right. Histochemical section from the periodontal region of the arrested molar. The section is stained by the haematoxylin/eosin method. In the lower part of the section, the root morphology appears normal, but in the upper part, a severe cone shaped attack by resorbing cells, marked R have resorbed the root dentine, marked D. Lower. Overview of the radiographic and histochemical appearance of a periodontal area from a child, 8 years of age. Left. Radiograph (right section of an orthopantomogram) from a child, age 8 years. The 2nd primary lower molar seems arrested in eruption. The 1st permanent molars in the mandible and maxilla have erupted. Also, the 2nd primary maxillary and mandibular molars have erupted. Right. Histochemical section from the periodontal region of the arrested molar. The section is stained by the haematoxylin/eosin method. An attack by resorbing cells are marked R. Dentine tissue is marked D.

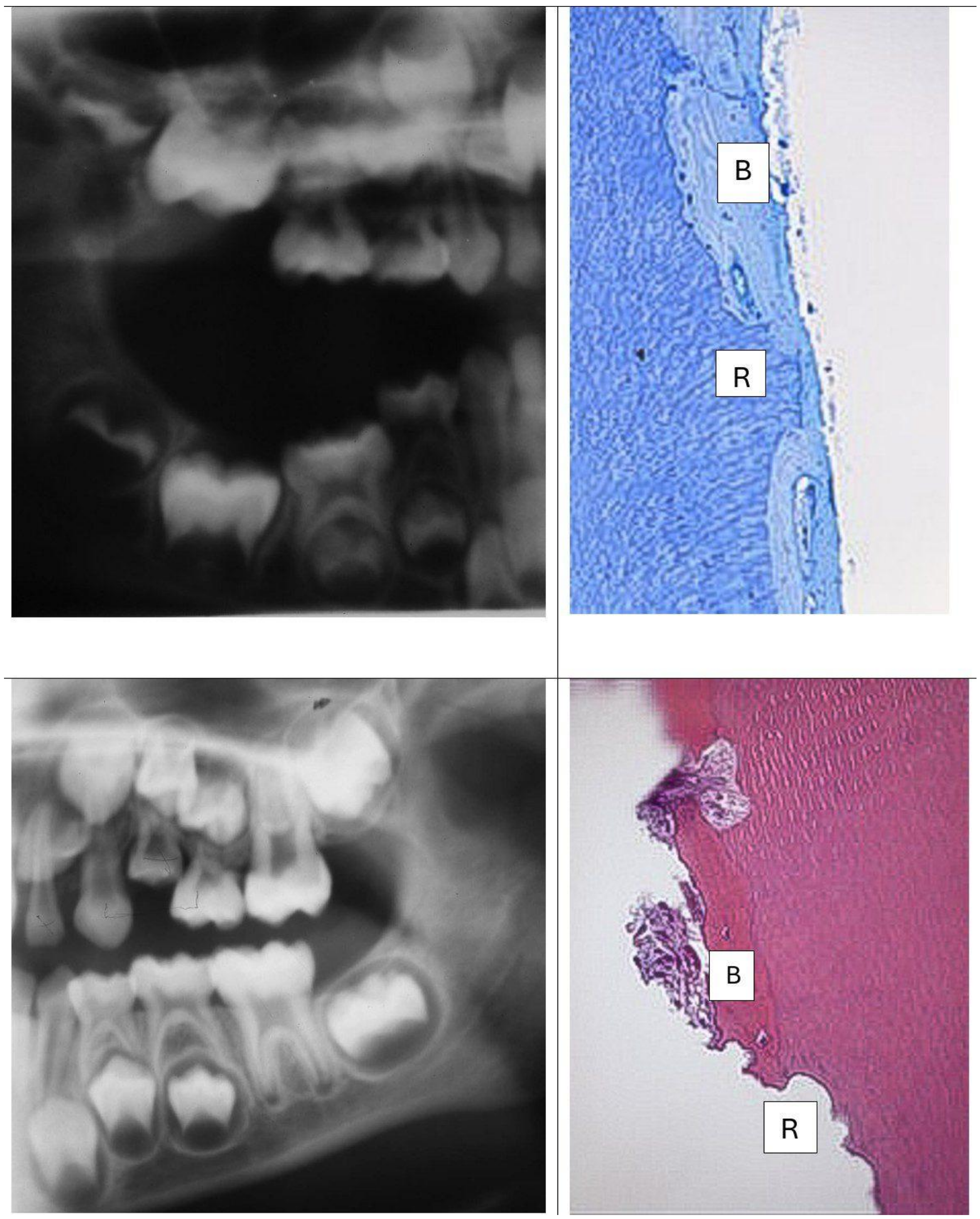


Figure 2: Upper. Overview of the radiographic and histochemical appearance of a periodontal area from a child, 4 years of age. Left. Radiograph (left section of an orthopantomogram). This radiograph was forwarded from the practitioner even though the quality is not optimal. The 2nd primary lower molar seems arrested in eruption. The 1st primary molar in the maxilla has erupted. Right. Histochemical section from the periodontal region of the arrested molar. The section is stained by Toluidine blue method. Bone tissue, marked B, covers resorption of root dentin, marked R. Lower. Overview of the radiographic and histochemical appearance of a periodontal area from a child, 7 years of age. Left. Radiograph (right section of an orthopantomogram). The 1st primary maxillary molar seems to be arrested in eruption. The 1st permanent molars in the mandible and maxilla have erupted. Right. Histochemical section from the periodontal region of the arrested molar. The section is stained by the haematoxylin/eosin method. Resorbing lacunae, marked R is partly covered by bone tissue, marked B.

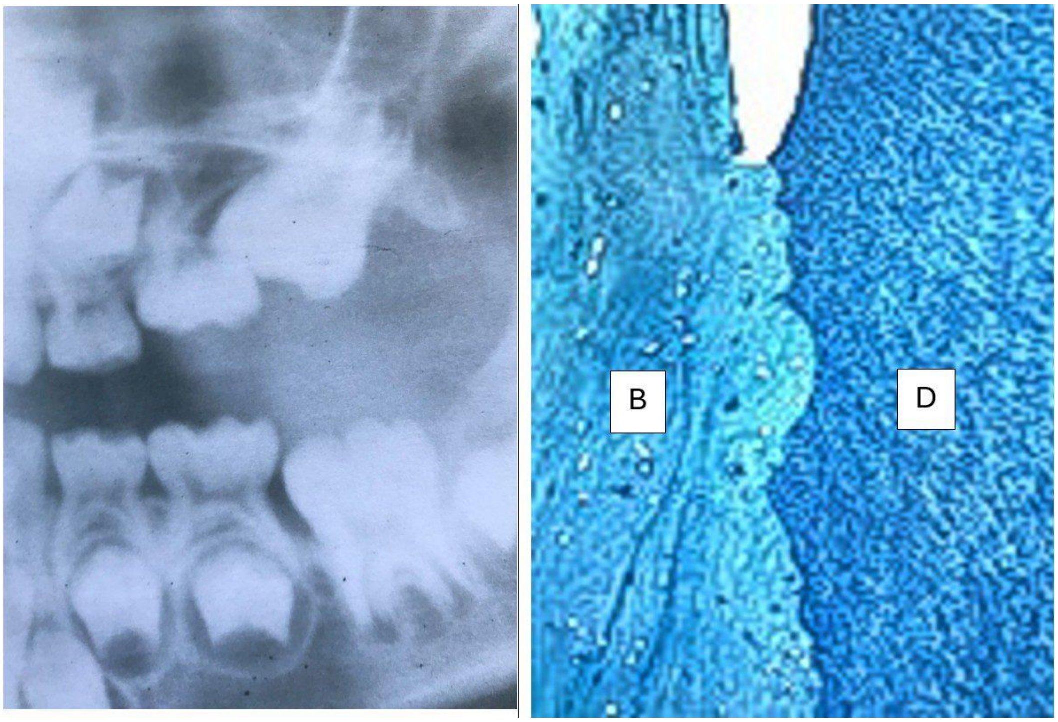


Figure 3: Overview of the radiographic and histochemical appearance of a periodontal area from a child 5 years of age. Left. Radiograph (right section of an orthopantomogram). The 2nd primary maxillary molar seems to be arrested in eruption and partly resorbed from the ectopic 1st permanent maxillary molar. Right. Histochemical section from the periodontal region of the arrested molar. The section is stained by Toluidine blue method. This section demonstrates a complete connection between the bone tissue (B) and the root dentin (D).

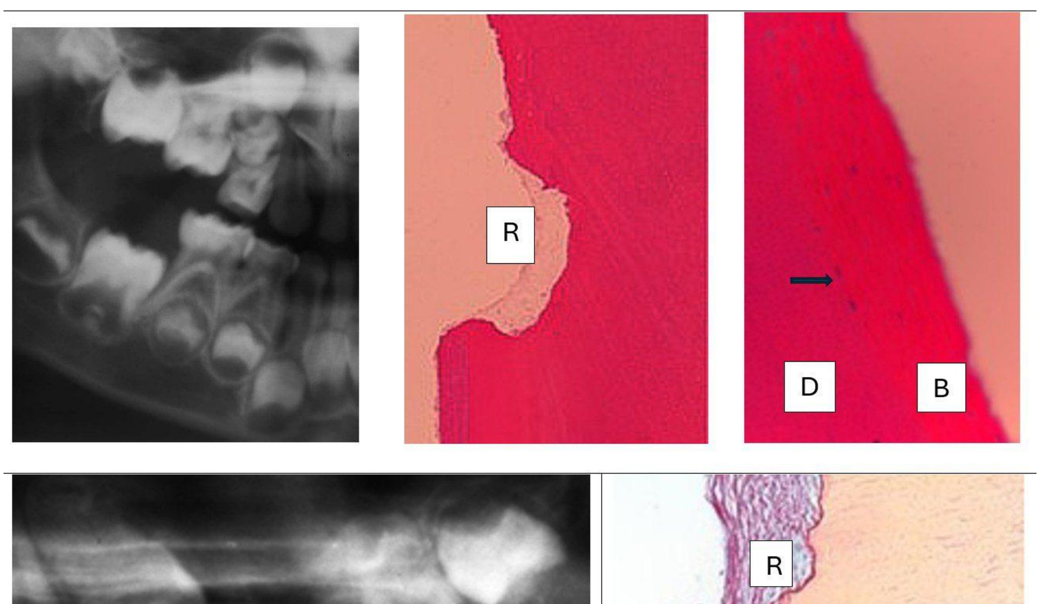
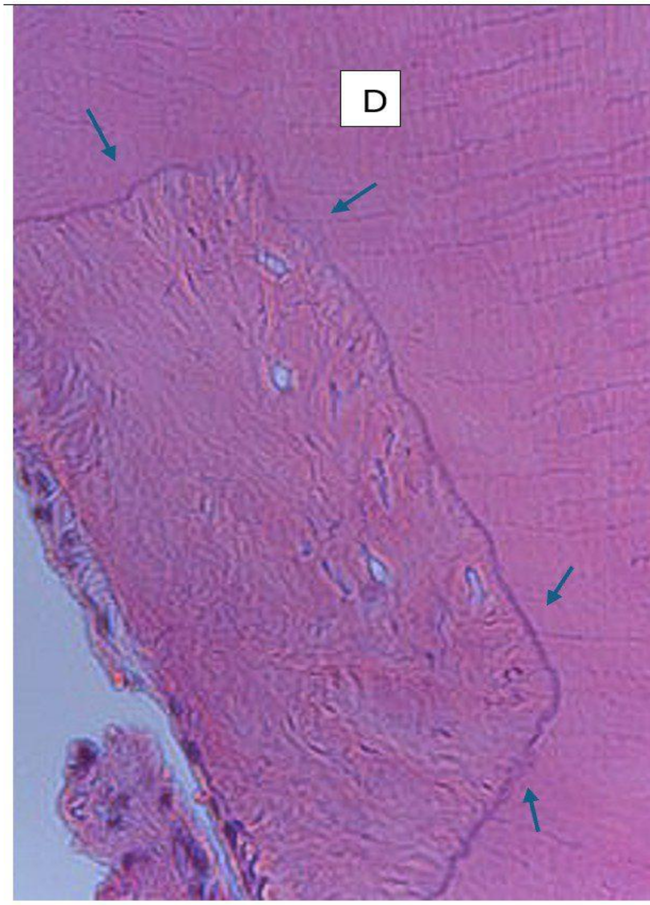


Figure 4: Upper. Overview of the radiographic and histochemical appearance of a periodontal area from a child, 5 years of age. Left. Radiograph (left section of an orthopantomogram). The 2nd primary maxillary molar seems arrested in eruption. The 1st primary molar in the maxilla has erupted. The permanent maxillary and mandibular molars have seemingly not erupted to the

occlusion level. Right. Histochemical sections stained by alcian blue/Van Gieson method from two periodontal regions of the arrested molar. A deep oval-shaped resorption lacuna is marked R in a periodontal region. Close to this oval-shaped lacuna is bone apposition registered. This apposition, marked B, covers the dentine (D). An arrow marks the borderline between dentine and bone. Lower. Overview of the radiographic and histochemical appearance of a periodontal area from a child, 10 years of age. Left. Radiograph (right section of an orthopantomogram). The second primary maxillary molar appears arrested in eruption, which prohibits the second premolar from erupting. The second primary molar has partly been resorbed. Right. Histochemical section from the periodontal region of the arrested primary molar. The section is stained by alcian blue/Van Gieson method. Severe resorption lacuna, marked R appear along the dentine D in the root surface.



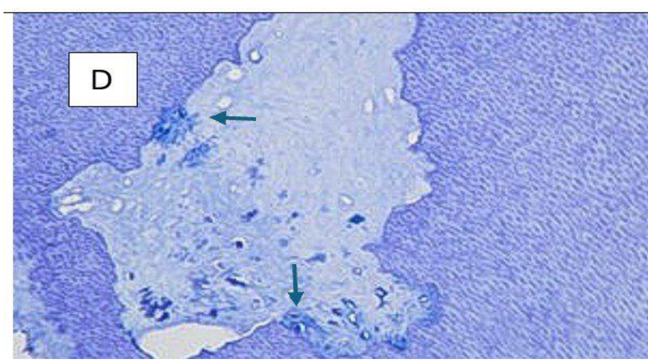


Figure 5: This figure illustrates two different resorption patterns observed in primary molars, where radiographs were not available, Group 2. These patterns were not observed in Group 1. Upper. Histological appearance of a square shaped resorption area in the root dentine D, stained by the haematoxylin/eosin method. The morphology of the square shaped resorption is marked by arrows in the corners of the “square”; Lower. Aggressive resorption in the root dentine of a primary molar, marked D. The section is stained with alcian blue. The resorbing process has penetrated the root dentine and developed resorption lacunae within the crown dentine. Two multicellular osteoclasts are marked by arrows.

Discussion

The investigations based on histochemical sections described in the present study have several limitations. First of all, the histochemical conclusions are drawn from a specific area covering the root. This area is not necessarily representative of the periodontal membrane covering the entire root. This limitation has to be accepted, due to the tissue cutting process. Furthermore, the study relies on different dentists' clinical diagnoses and only few radiographs were forwarded together with the specimen for histological investigation.

In addition, the OPG radiograph is less optimal for this study, but was the only radiograph available in these cases. The OPG is not the most ideal type of radiograph for analysing roots of primary teeth, but the OPGs were the only radiographs available, as they were taken in connection with orthodontic treatment.

The study demonstrates that the periodontal membrane has the ability to act differently during eruption. The reason for this is not known. Factors responsible for change in the periodontal membrane cannot be answered in this study. In the permanent dentition, innervation has been suggested as a factor of importance behind pathologic resorption [3,4,8,9]. The disappearance of the periodontal membrane, as visualized in Fig. 3 might be a result of apoptopic activity [7].

The interrelationship between resorption in the primary teeth and resorption in the permanent teeth has been demonstrated previously [5,6]. This information is of importance for predicting root resorption in the permanent dentition. The findings in the present study, demonstrating minor concave resorption defects as well as bowl- and square-shaped patterns in resorption of the dentine, have seemingly not been reported before. These patterns need further investigation. The patterns might be influenced by the structure in the dentine.

Another previous study has focused on unexpected resorption in two patient cases, where the mandibular bony structure was also affected [17]. The bony structure in these referred children was fine meshed with a light appearance, seemingly not sufficiently calcified. This appearance was in one case identified as hypophosphatasia. As the dentine has the same mesenchymal origin as bone, the resorption process from the periodontal membrane seems to be dependent also of the surrounding bone. In this published study, both children demonstrated a low vitamin D level and one of the two children demonstrated a low value of alkaline phosphatase [18].

This study demonstrates that the ectomesenchyme cells in the periodontal membrane have the ability to develop, not only into osteoblasts, but also into osteoclasts and again reversing to osteoclasts [14]. The finding in the present study of one case demonstrating complete absence of the periodontal membrane, which normally should separate the root from the bone, is interesting. In a previous study apoptotic reactions were documented in the primary periodontal membrane [7]. When this happens and why it happens, as demonstrated in Fig. 3, is not known.
This study needs to be followed by studies on the periodontal membranes in permanent teeth with arrested eruption. Previously reported similarities in periodontal tissues in primary and permanent teeth [15,16] may be valuable for understanding the interrelationship between pathological development in the primary and permanent dentition.

This study needs to be compared with recent studies of the periodontal membranes in permanent teeth with arrested eruption [19]. Similarities in the periodontal tissue components have formerly been reported in primary and permanent teeth [16,17]. Specifically focus on peripheral nerves in the periodontal membranes may be valuable for understanding the relationship between resorption and apposition processes resulting in molar arrest [20,21].

Conclusion

The monocellular hematopoietic precursor cells in the periodontal membrane of the primary molars have the well-known ability to develop to osteoclasts, ex. during resorption, but also the ability to develop to osteoblasts. How and why these different cell developments influence arrestment, is not known.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Data Availability Statement
The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Statement
The project did not meet the definition of human subject research under the preview of the IRB according to federal regulations and therefore was exempt.

Informed Consent Statement
Informed consent was obtained from all participants included in the study.

Authors' Contributions
All authors contributed equally to this paper.

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