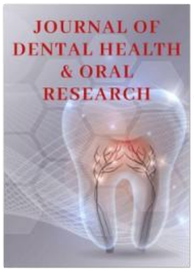


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*Research Article*

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# Arrested Eruption of 22 Permanent Molars: Etiological Considerations

**Inger Kjær[1*]**

[1]Department of Odontology, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark

***Correspondence author:** Inger Kjær, Department of Odontology, Faculty of Health and Medical Sciences, University of Copenhagen, Denmark; E-mail: ik@sund.ku.dk

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## Abstract

Background and objectives: The purpose is to demonstrate how histochemical analyses can contribute to the understanding of the aetiology behind arrest in the normal eruption process of permanent molars.

Methods: Histochemical analyses: 22 permanent molars diagnosed clinically or radiographically with arrested eruption and subsequently extracted or surgically removed, were analysed histochemically. After fixation in formalin followed by decalcification, paraffin embedding, sectioning and later staining with haematoxylin-eosin and alcian blue, according to the van Gieson method, the sections underwent microscopy and photography. The sectioning of each molar allowed only microscopic observations in the cutting plane.

Results: The periodontal membrane was abnormal in all cases. The dominant impression of the roots was the presence of enormous or severe layers of hard tissue (hypercementosis).

Conclusion: The layering of appositional bone on the root surfaces of the arrested molars might explain the arrest, also in cases where the space was sufficient for eruption. The arrest in eruption was associated with lack in alveolar bone apposition.

**Keywords:** Eruption; Permanent Molars; Radiography; Histochemistry; Human

## Introduction

The aetiology of arrested eruption does not have a specific explanation. Arrest can be caused by various factors. One factor is heredity, but several other factors have been mentioned, such as lack of space in the dental arch due to tipping of neighbouring teeth or growth patterns in the jaws [1-4]. Arrested eruption of permanent molars is also observed in dentitions with adequate space for eruption [2].

In the discussion of the aetiology behind this severe eruption problem, insight into the normal eruption process is of specific importance. Three factors are important in the early physiology of normal eruption: pressure from the apical root sheath, the ability of the crown follicle to resorb the overlying bone tissue and create the eruption path, and, thirdly, the ability of the periodontal membrane to adapt to the ongoing upward movement of the root [5-7, 9]. When the molar has penetrated the gingiva and is visible in the mouth, only two factors are important for continued eruption, namely the apical sheath and the periodontal membrane [6-9].

A human permanent molar arrested in the eruption process after having penetrated the gingiva is nearly always diagnosed radiographically at the time when the apical part of the root has completed its formation [7].

The purpose of the present study is to analyse the apical part of the root and the periodontal membranes in extracted arrested human permanent molars by histochemical methods and to observe radiographically the alveolar bone and the space available for eruption of the molars. A study of this kind has seemingly not been performed before and the perspective is that it may add information about the aetiology behind these mysterious arrests in permanent molars. The recent study performed on primary molars arrested in eruption has demonstrated that the periodontal membrane in the arrested primary molars can react differently during arrested eruption [10]. The reactions observed were different morphologies, of resorption defects in the root dentine, in a few cases covered by bone apposition. In one case the periodontal membrane had disappeared between the jawbone and the root dentine.

**Materials and Methods**

During 1990–2020, radiographs or extracted teeth were forwarded to the author at the University of XX from pedodontists and orthodontists working in XX municipal dental clinics for children and young adults. The purpose of forwarding this material was to clarify or verify the diagnosis and in addition to discuss the aetiology and treatment possibilities.

During these years, a large number of teeth diagnosed with arrested molar eruption were received. Among these were 22 permanent molars from children and young adults younger than 22 years of age. The teeth were received either with or without radiographic material and anamnestic information. The arrested permanent molars had been removed by extraction or surgical procedures after radiographic and clinical diagnosis.

The 22 teeth were forwarded to the author in liquid formalin fixation together with the questions raised. All teeth were analysed histochemically.

The forwarded radiographs were predominantly Orthopantomograms (OPGs) taken at different clinics of children and young adults. Sections from OPGs demonstrating the arrested molars are shown in Fig. 1-4. In two cases, only dental radiographs were available. The quality of the received radiographs varied.

*Histochemical Methods*

The teeth forwarded in neutral buffered formalin were decalcified in the laboratory in equal parts of 2% citric acid and 20% sodium citrate, pH 6. This decalcification process was very mild and lasted up to 1 year. After decalcification, paraffin embedding and sectioning were performed from each specimen. The sections were stained with haematoxylin/eosin and toluidine blue or alcian blue, according to the Van Gieson method. The plane of slicing or cutting of each molar allowed observation in the microscope only in the cutting plane.

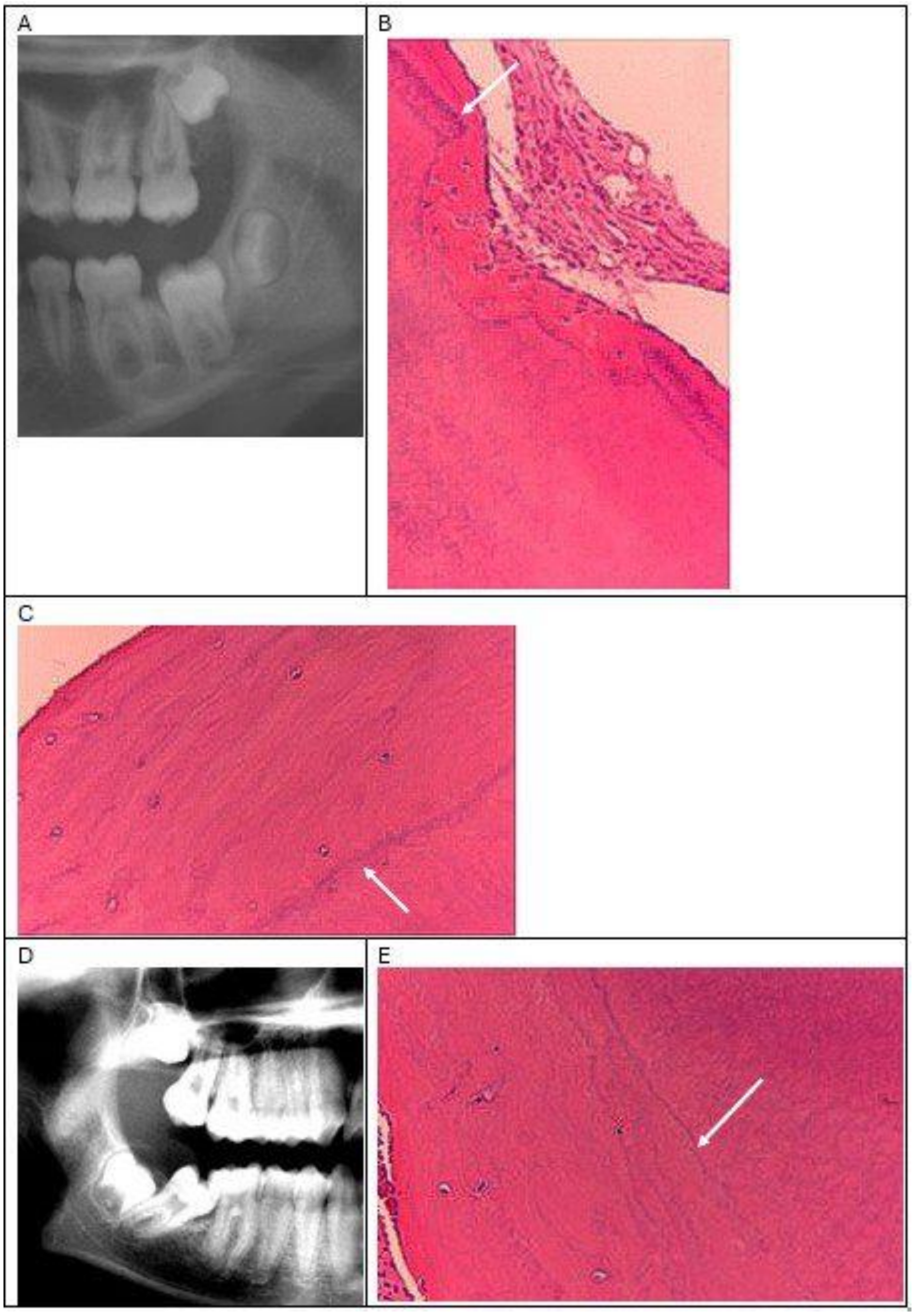


**Figure 1:** Top (A, B, C): A radiograph and two histochemical sections of a second lower molar from a girl 14 years of age. The radiograph (A) is a section from an OTP demonstrating a second mandibular molar arrested in eruption. The roots of the molar have fully developed. The occlusal plane of the arrested molar is far below the occlusal plane of the first mandibular molar. The space around the second molar would have been sufficient for eruption and therefore crowding is seemingly not the causative factor for arrestment. The two histochemical sections (B and C) are stained with Haematoxylin/Eosin. B demonstrates resorption activity in the root dentine from the periodontal membrane. The white arrow points towards the sharp borderline between resorbed root dentine and the root dentine not resorbed; Middle (C): Histochemical section demonstrating appositional layers of cementum or bone tissue (hypercementosis) covering the root dentine. The arrow points towards the borderline between dentine and cementum. This borderline is the previous location of the periodontal membrane between root cementum and the layer of cementum or bone. The hypercementosis might have prohibited eruption and caused the arrestment. Bottom (D and E) demonstrate, to the left (D), a section of an OPG demonstrating a tilted mandibular second permanent molar from a boy 16 years of age. The roots of the molar have fully developed and the tilting might have been the causative factor for molar arrestment. The histochemical section to the right (E), stained with Haematoxylin/Eosin, demonstrates severe hypercementosis covering the root dentine. The arrow points towards the former location of the periodontal membrane.

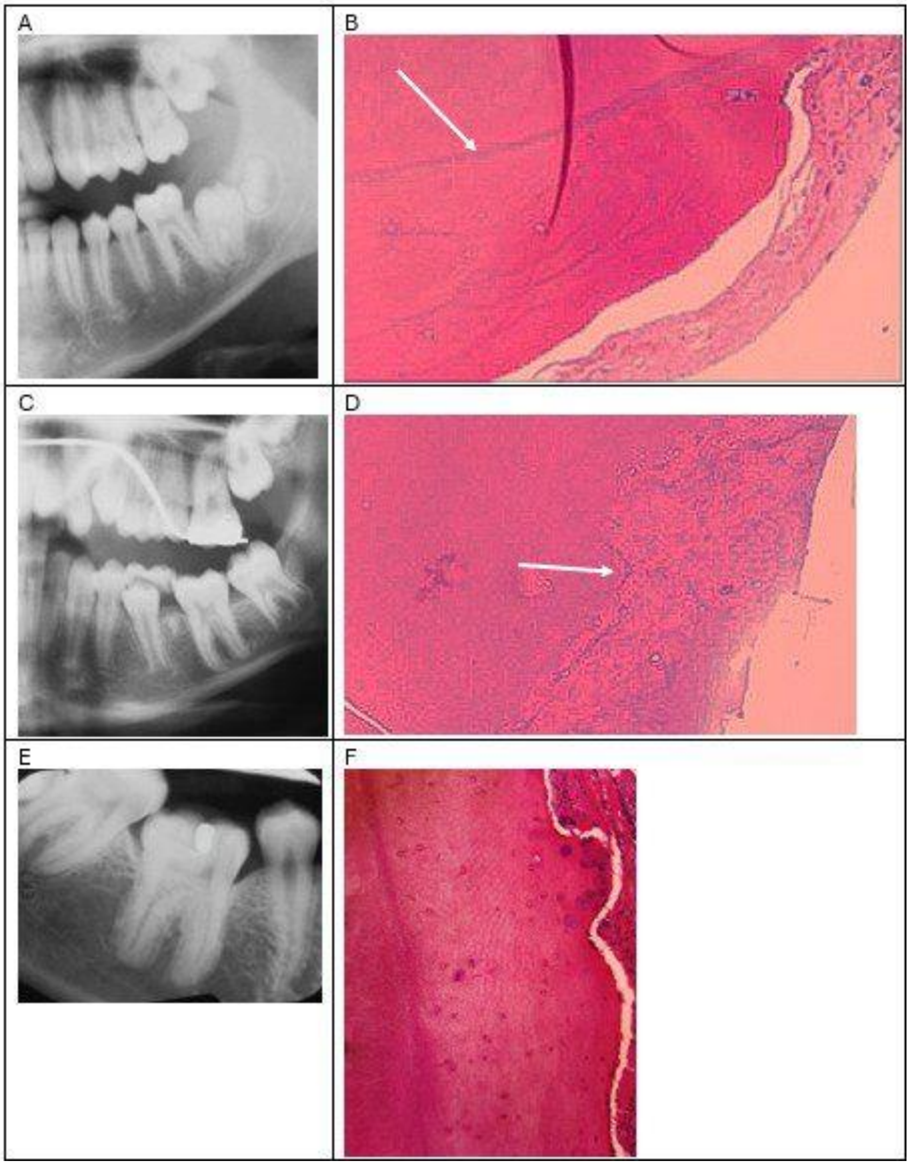


**Figure 2:** Examples of radiographs and histochemical sections from three children with arrested eruption of permanent mandibular molars. Top (A and B): Radiograph and histochemical section from a male 18 years of age. The radiograph (section of an OTP) to the left (A) demonstrates arrested eruption of a second mandibular molar. The roots are fully developed and the molar is tilted distally with narrow space for eruption. What has caused the arrest is not clear. The histochemical section to the right (B), stained with Haematoxylin/Eosin, demonstrates huge amounts of cementum and the arrow points to the region where the former periodontal ligament was located. This huge layer of hypercementotic tissue might have contributed to the eruptive arrest. Middle (C and D): Radiograph and histochemical section from a girl 12 years of age. The radiograph (section of an OTP) to the left (A) demonstrates arrest of eruption of the mandibular first molar with fully developed roots. What has caused the arrest is not clear. The histochemical section to the right (B) demonstrates an irregular borderline between dentine and cementum, which could indicate a former regional inflammation in the periodontal ligament. Bottom (E and F) demonstrate arrestment in eruption of a first permanent mandibular molar. The dental radiograph to the left (E) demonstrates slanting alveolar bone contours, marked by arrows, indicating that alveolar bone apposition has not occurred as in a normal eruption process. The roots of this molar have plump appearances. What caused the arrest, documented with a low occlusal level of the first molar compared to the occlusal levels of the neighbouring teeth, cannot be concluded from this radiograph. The histochemical section to the right (F), stained with Haematoxylin/Eosin, demonstrates a thick layer of cementum or bone. In the upper part of this thick layer appear large osteoblasts and a huge multinuclear osteoclast. The cementum tissue might have caused the arrest.

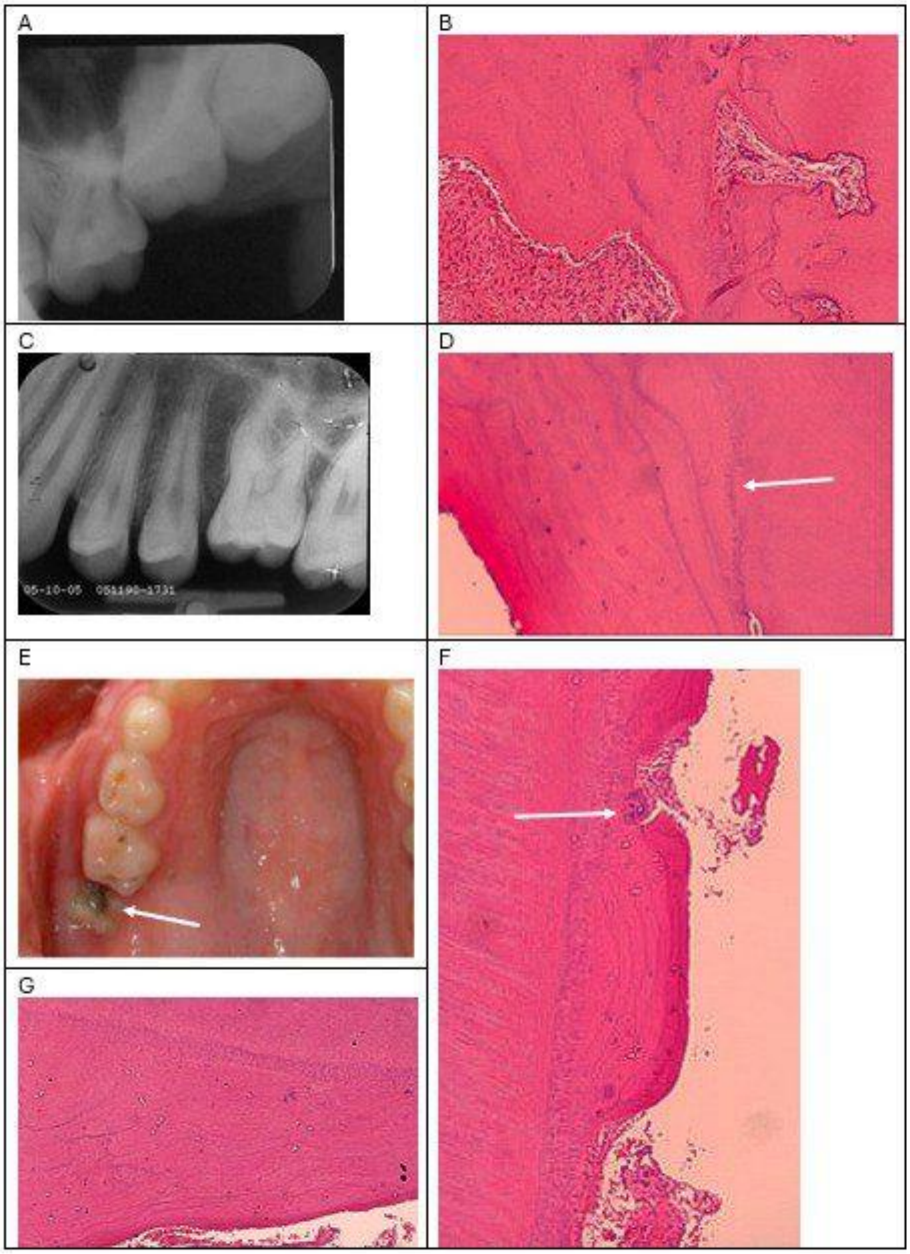


**Figure 3:** Overview of radiographs, clinical photo and histochemical sections from three children and young adults with arrested maxillary permanent molars. Top (A and B): Dental radiograph and histochemical section from a male 17 years of age with arrested second maxillary molar. The radiograph (A) is not optimal but indicates a lower occlusal level of the second molar compared to the occlusal level of the first molar. There seems to be lack of space for a normal physiological eruption path. The histochemical section to the right (B) stained with Haematoxylin/Eosin indicates severe resorption processes in the root dentin. Middle (C and D): Dental radiograph and histochemical section from a male 18 years of age. The section of an OTP radiograph (C) indicates arrest in eruption of the first maxillary permanent molar. The occlusal level is lower in the first molar compared to the occlusal levels of the neighbouring teeth. There seems to be adequate space for eruption. To the right (D) a histochemical section stained with Haematoxylin/ Eosin indicating distinct layers of cementum or bone covering the root dentin. The arrow indicates the borderline between root dentin (right) and cementum (left). Hypercementosis might have prohibited the normal eruption process and caused the arrestment. Bottom (E, F and G): Clinical photo and histochemical sections from a girl 10 years of age. The clinical photo (E) of the palate in the occlusal view indicates arrest in the first maxillary molar marked by an arrow. The two histochemical photos (F and G) indicate regional occurrence of cementum or bone deposits at the root surface. The arrow in the lower right figure (F) marks a multicellular osteoclast. This abnormal deposits of hard tissue covering the root surface might have caused the arrestment in eruption of the first maxillary molar.

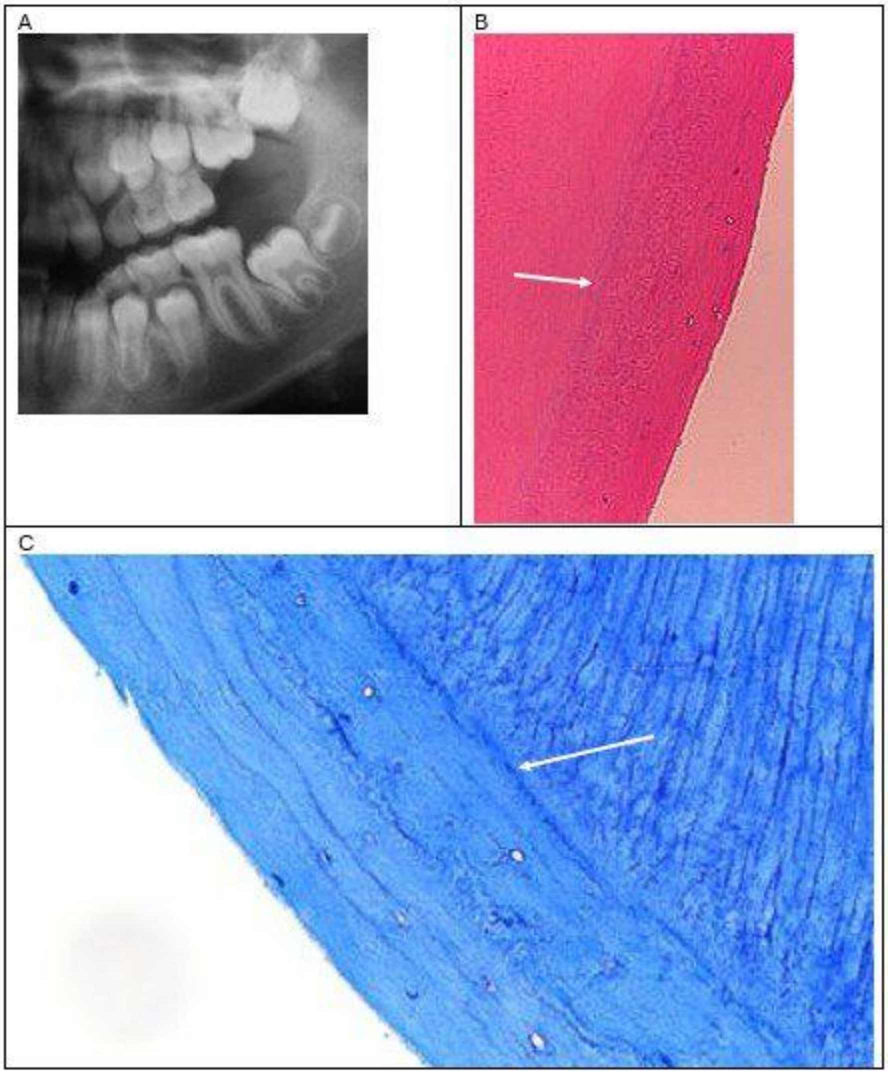


**Figure 4:** Periodontal membranes in arrested eruption in human permanent molars. Top (A and B): A radiograph and a histochemical section from a girl 11 years of age. The radiograph (A) demonstrates crowding in the upper molar region and arrested eruption of the fully developed first maxillary molar. There seems to be sufficient space for normal eruption. The histochemical section (B) demonstrates hypercementosis. The arrow points towards the area where the former periodontal membrane was located. It is suggested that the hypercementosis has prevented the first molar in normal eruption. Bottom (C): Histochemical section stained with Alcian blue/ Van Gieson method from a permanent molar arrested in eruption. Radiograph of the arrested molar was not present. The section demonstrates the root dentine (upper right part of the section) covered below by distinct layers of cement tissue. The white arrow points towards the area where the former periodontal ligament was located. The distinct layer of cementum might have prohibited normal molar eruption.

## Results

The radiographs available, all demonstrating arrest of a permanent molar, were from 8 maxillary molars (4 first molars and 4 second molars) and 11 mandibular molars (3 first molars and 8 second molars). In all cases, the arrest was diagnosed by comparing the occlusal level of the arrested molar with that of the neighbouring teeth. In 7 cases, crowding in the relevant region was reported at the time of extraction. In a few cases, radiographs obtained before extraction existed, in which crowding could not be observed. In several cases, the alveolar bone demonstrates slanting occlusal contours (Fig. 2).

The histochemical sections demonstrated in Fig. 1-4 showed the following:
Abnormal deposits of bone tissue appearing apically were observed in five cases (Fig. 1).
The periodontal membrane was abnormal in all cases. In two cases, active resorption of the root dentin was registered (Fig. 1) and in a few cases concave markings in border lines between root dentine and bone indicating previous resorption activity were

observed (Fig. 2). These markings were often covered by heavy bone appositions. The dominant impression of the roots was the presence of enormous or severe layers of hard tissue (cementum or bone?) appositions (Fig. 3-5).

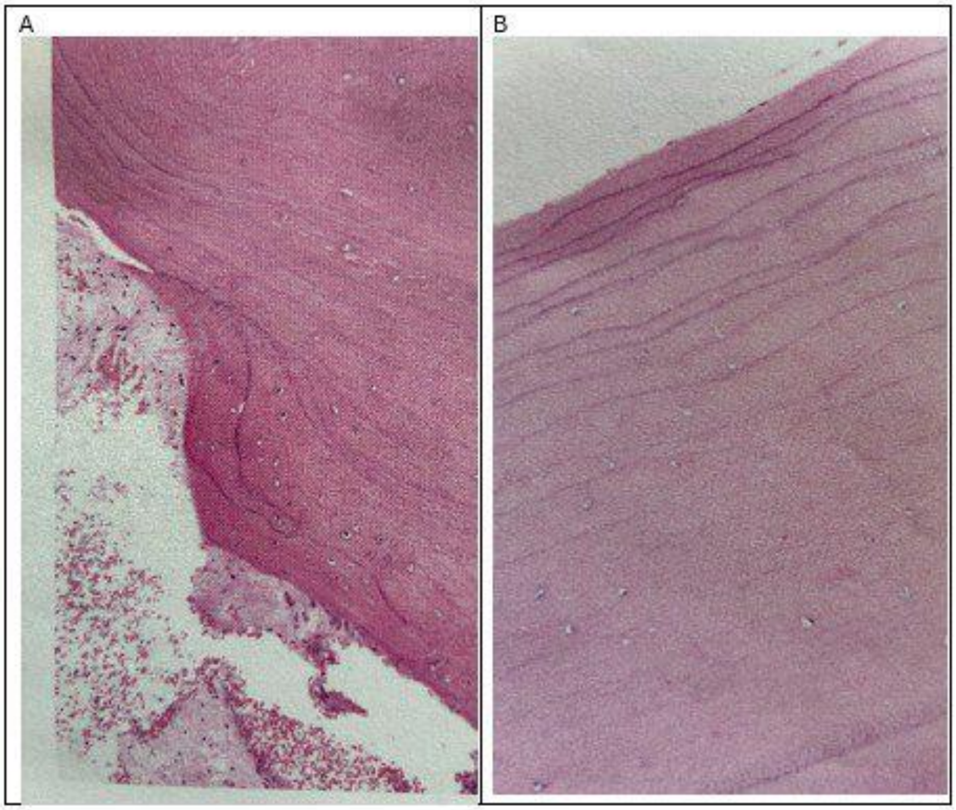


**Figure 5:** Two histochemical sections from the same young adult diagnosed with arrested permanent molar eruption. The sections have been stained with Hematoxylin/Eosin. A radiograph of this arrested molar did not exist. The histochemical sections demonstrate hypercementosis along different areas of the root. The slides demonstrate how the formation of cementum can change regionally from a thin to a thick layer (left) and in the same root also with a straight uninterrupted appearance. Note the distinct lines between the layers. This hypercementosis might have prohibited the normal eruption.

**Discussion**

The radiographic and clinical observations of arrested eruption in permanent molars have been documented by histochemical methods in the present study. The histopathological findings of extensive bone apposition in arrested permanent molars are new. The hypercementosis (layered hard tissue deposits) may explain the disturbance in the periodontal membrane, which is decisive for a normal eruption process. The resorbing process at the root surface by osteoclasts and later apposition of bone by osteoblasts may be initiated from the mesenchymal cells in the periodontal ligament [10-12]. As all investigated molars demonstrate identical histochemical reactions it is supposed that the different photographic phenotypes have the same aetiologic background. Investigations based on histochemical sections highlighted in the present study have several limitations. First, the histological 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 must be accepted, due to the tissue cutting process. It has also to be accepted that the study relies on different clinical dentists' diagnostics and also that radiographs only rarely were forwarded together with the specimen for histological investigations. Also, the use of OPGs for space analyses and alveolar bone morphology can be criticized. This study has not been planned as a scientific study for precise analyses and statistics, but as a retrospective study, where the use of material present for clinical and radiological diagnostics has been accepted.

In previous studies, the focus has been on similarities in the cell layers composing the periodontal membranes in primary and permanent teeth [10-12]. The three cell layers are, first, an inner layer of innervation close to the root; second, a median layer of ectomesenchymal cells; and third, an outer layer of ectodermal epithelium. The vascularization of the periodontal tissue layers has also been elucidated in the two dentitions [11].

Studies on arrested eruption in the permanent dentition demonstrate that the periodontal membrane has the ability to act differently. The factors responsible for these differences are not known precisely, but they might be found in the maturity of the mesenchymal cell layer in the periodontium to form both osteoblasts and osteoclasts [13,14].

The differences between osteoclasts and dentinoclasts are not clarified [13]. Multinuclear osteoclasts responsible for resorption originate from hematopoietic precursor cells, which also have the ability to differentiate into osteoblasts responsible for bone formation. This change is regulated especially by genes and hormones [14].

These hematopoietic cells might be responsible for resorption in the primary dentition as well as for apposition in the permanent dentition, but this is still an unproven hypothesis.

Insight into the aetiology behind dental or medical malformations and disruptions is a precondition for optimal treatment. There might be differences in types of arrest due to lack of space in the bone and dental arch. Adequate treatment for arrested eruption is normally extraction or surgical removal, but sometimes orthodontic treatment is recommended [1]. Success in orthodontic treatment in a region with an arrested permanent molar might depend on crowding in the relevant region, as well as rapid expansion and rapid traction in the occlusal direction [1]. However, this must be verified and followed up by clinicians.

Orthodontic treatment seems impossible in cases of arrested permanent molar eruption with enormous hypercementosis such as demonstrated in the present study.

## Conclusion

The general impression observed in the microscope was that arrest in molar eruption is caused by hypercementosis/bone apposition, which seemingly explains the arrested eruption. In some cases, this apposition could be a follow-up process after previous root resorption.

## 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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