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EPITHELIAL REMNANTS AND DENTICLE FORMATION IN THE HUMAN DENTAL PULP

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INTRODUCTION

Various types of mineralized deposits in the dental pulp have been reported, and they are usually referred to as pulp stones or denticles. They have been classified according to their location (free, attached and embedded) or according to their structure (true, false and diffuse or amorphous (*Orban*, 1957)). The variation in location and structure may indicate differences in the histogenesis of pulp stones. True denticles, which exhibit typical dentine structure, are usually found in the radicular pulp (*Orban*, 1957; *Sundell et al.*, 1968).

A number of conditions have been claimed to initiate or predispose to denticle formation, such as ageing (*Hill*, 1934; *Sayegh & Reed*, 1968), circulatory disturbances (*Reichborn-Kjennerud*, 1967; *Sundell et al.*, 1968), caries and pulp pathosis (*Sayegh & Reed*, 1968; *Hall*, 1968), arteriosclerosis (*Stafne & Szabo*, 1933), and epithelial rests in the pulp tissue (*Orban*, 1928; *Jarmer*, 1951; *Hoffer*, 1966).

Epithelial remnants or rests, believed to originate from Hertwig's sheath, are frequently found in the periodontal membrane (MALASSEZ's epithelial rests), but such rests have only occasionally been observed in the pulp (*Wentz et al.*, 1950; *Russel*, 1967).

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A high frequency of pulp stones and epithelial remnants was observed in the apical region of young premolars which had been subjected to experimental intrusion (*Stenvik & Mjör*, 1970; *Stenvik*, 1970). The material from these investigations was, therefore, re-examined in order to study the histogenesis of pulp stones under these experimental conditions.

MATERIALS AND METHODS

All the teeth were premolars which were scheduled for extraction in connection with orthodontic treatment. Thirty-five of the teeth were extracted without previous treatment (control material), and another group of 35 teeth (experimental material I) was subjected to intrusive forces (35—250 g) from 4—35 days using fixed orthodontic appliances (*Stenvik & Mjör*, 1970). The teeth in this experimental group were extracted immediately after the intrusive force had been removed. In a third group (experimental material II), comprising 25 teeth, the intrusive force (50—200 g) acting from 5—28 days, was removed 4—104 days prior to the extraction of the teeth (*Stenvik*, 1970).

Hematoxylin and eosin stained, decalcified sections were prepared from all the teeth using a conventional histologic technique. The teeth were examined in order to study the frequency, development and structure of pulp stones and the presence of epithelial remnants in the pulp tissue. The terms pulp stones and denticles will be used synonymously in the present report. Amorphous deposits were identified as acellular, strongly hematoxyphilic areas in the pulp tissues.

OBSERVATIONS

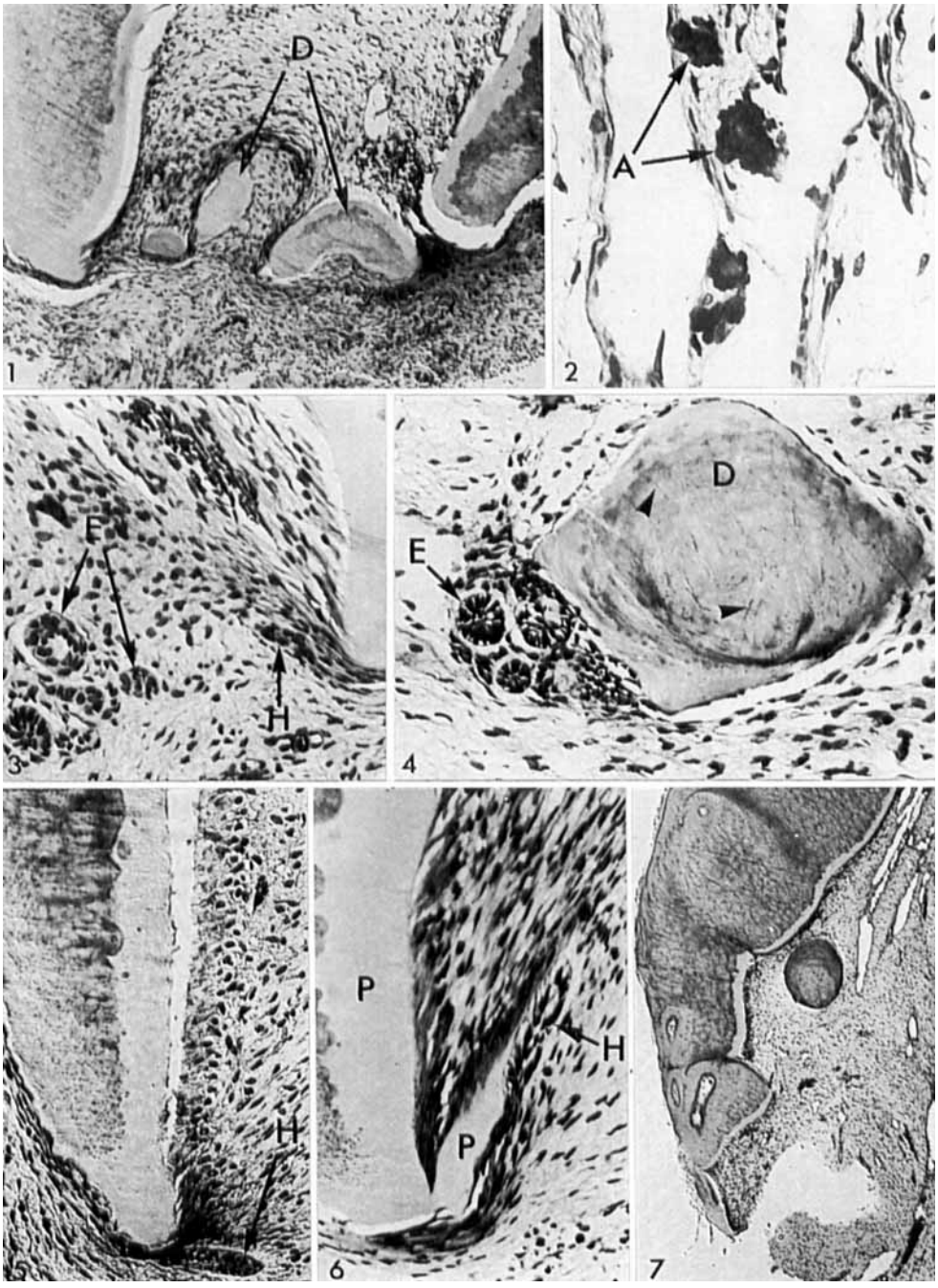
The distribution of pulp calcifications in the different series of the present material is shown in Table I.

Table I.

Distribution of material and incidence of pulp calcification

Material	Total number of teeth	Teeth with denticles	Teeth with amorphous deposits
Control	35	9 (25 %)	7 (20 %)
Exp. I	35	11 (30 %)	11 (30 %)
Exp. II	25	12 (50 %)	6 (25 %)

PLATE I



All illustrations in Plates 1 and 2 are from hematoxylin and eosin stained sections of decalcified, young human premolars.

PLATE 1.

Fig. 1. Apical area of premolar which had been intruded for 4 days with 150 g and then extracted 37 days later. D: denticle. X = 155.

Fig. 2. Amorphous deposits (A) along pulpal vessels. X = 610.

Fig. 3. Apical area of experimental tooth. Note the appearance of Hertwig's sheath (H) and epithelioid cell islands (E). X = 418.

Fig. 4. Denticle (D) and epithelioid cells (E) in the apical part of the pulp from a tooth in the experimental series. Note the irregular distribution of dentinal tubules (arrows). X = 418.

Fig. 5. Apical area of control tooth. H: Hertwig's sheath. X = 418.

Fig. 6. Apical area of tooth intruded for 14 days with 87 g and then extracted 6 days later. Note the abnormal root formation. H: Hertwig's sheath. P: predentine. X = 418.

Fig. 7. Illustration taken from tooth intruded for 14 days with 120 g and then extracted 97 days later. Note the irregular structure in the apical part of the root. X = 61.

PLATE 2.

Fig. 8. Epithelioid cell island in apical part of pulp of experimental tooth. Note arrangement of cells peripheral to island. X = 660.

Fig. 9. Core of cells partly surrounded by matrix (M) in the apical part of the pulp from a tooth in the experimental series. Note the cell layer at the periphery of the matrix. X = 660.

Fig. 10. Illustration taken from apical part of experimental tooth. Matrix (M) partly surrounds a nidus of cells X = 610.

Fig. 11. Denticle in apical part of experimental tooth. Radially arranged tubules and an eosinophilic peripheral zone (light) can be seen. Note cell remnants in centre of denticle. X = 610.

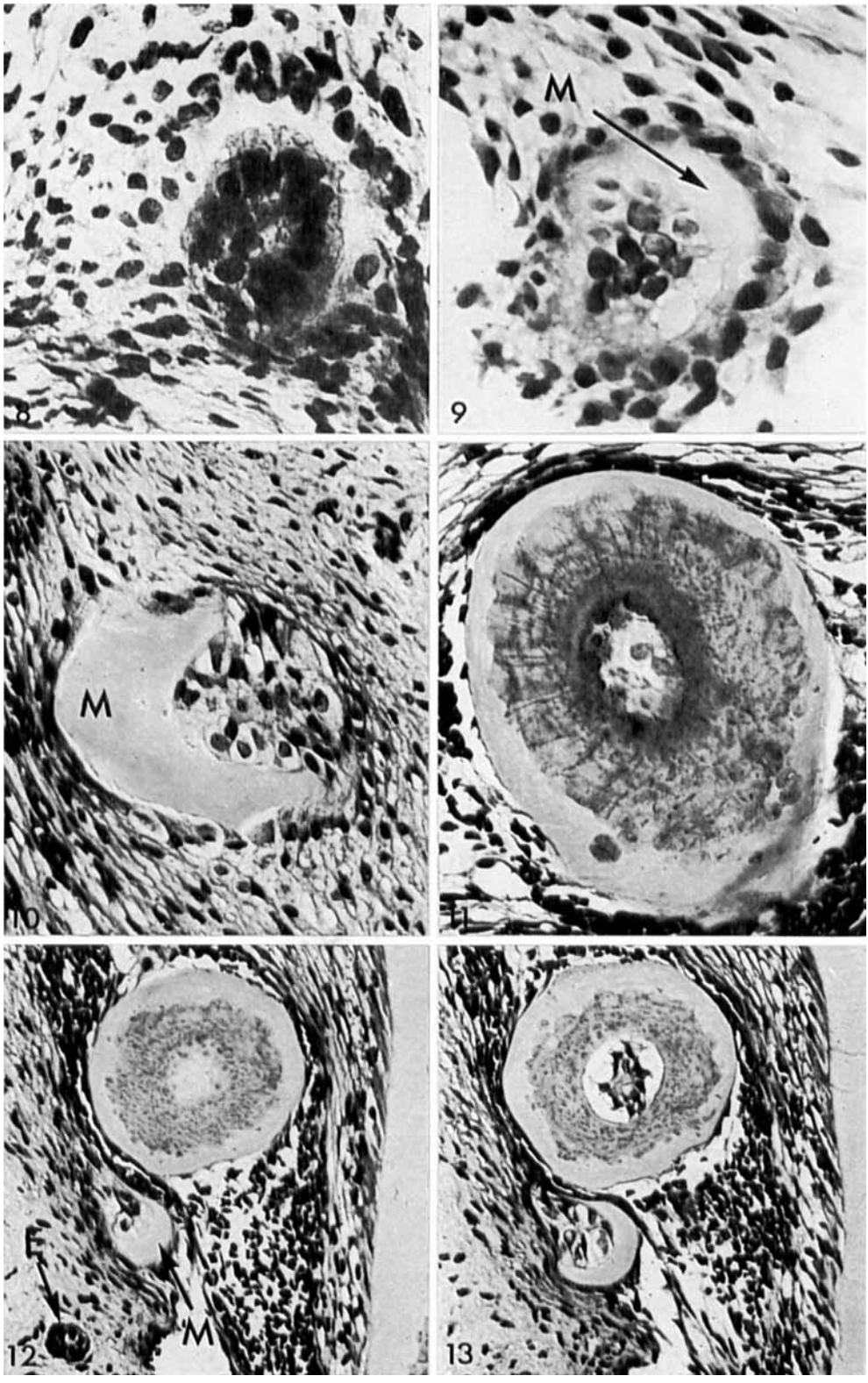
Fig. 12. Epithelioid cell island (E), matrix (M) formation around nidus of cells, and pulp stone in apical area of an experimental tooth. X = 418.

Fig. 13. Adjacent section to that in fig. 12. Note the disappearance of epithelioid cell island and that cellular elements have become apparent in center of pulp stone. X = 418.

It was apparent that the number of teeth with denticles was increased in experimental material II, where approximately half of the teeth exhibited such structures (Fig. 1). In the control material only every fourth tooth had pulp stones and approximately the same frequency was found in experimental material I. No marked differences in the frequency of amorphous deposits (Fig. 2) were observed in the three series.

Cell islands, considered to be of epithelial origin, were observed in association with denticle formation, and, when present, usually more than one island was found in each of the teeth. The cells in these islands (Figs. 3, 4)

PLATE II



were similar in appearance to those in Hertwig's epithelial sheath (Figs. 3, 5, 6). They were all located in the apical area of the pulp. The normal root development (Fig. 5) was markedly affected by the experimental intrusion (Figs. 6, 7). This was associated with alterations in the normal location of Hertwig's sheath (Fig. 6).

Radially arranged cells were found in the cell islands (Figs. 3, 4, 8). Matrix formation sometimes occurred adjacent to these islands (Figs. 9, 10, 12, 13), and some cell remnants were surrounded by matrix typical of pulp stones (Figs. 11—13). In certain sections, the stones did not show such a central core of cells (Fig. 12), but by studying serial sections, it became apparent that all of the pulp stones in this material had cells entrapped centrally (Fig. 13).

The structure of the pulp stones was usually of an irregular and globular type of dentine with tubules (Figs. 4, 11). Their stainability indicated a peripheral zone of unmineralized (eosinophilic) matrix. A distinct layer of cells, considered to be the formative elements, often bordered the eosinophilic, peripheral zone (Fig. 9).

DISCUSSION

The increased frequency of pulp stones in the present experimental material as compared to the normal material, indicates that pulp stone formation may be initiated by orthodontic treatment. However, the increased frequency was only manifested in experimental material II where the observation periods were longer than in experimental material I. It appears likely that other types of continuously acting mild »traumas» may affect the pulp similarly. More intermittently acting forces, as found in connection with hyperfunction, have also been reported to result in pulp stone formation (*Reichborn-Kjennerud*, 1967).

The experimental treatment is considered to result in an altered location and an interruption of the epithelial sheath in those teeth where root formation was incomplete. Because of interruptions, epithelial islands may appear in the pulp tissue. The cells in these islands, believed to originate from Hertwig's sheath, in some cases apparently maintain their normal properties as far as induction of odontoblast differentiation from the cells in the dental papilla is concerned. However, cell remnants with no adjacent matrix formation were also observed in some teeth, including the tooth with 104 days observation period after the intrusive force was removed. The explanation for this phenomenon can only be conjunctional. It may be that the cells in these particular islands had not reached full differentiation before they became detached from the epithelial sheath or that they had lost their inductive properties.

Epithelial remnants in the pulp have only rarely been reported; *Wentz et al.* (1950) in rat pulp and *Russel* (1967) in bovine pulp. Their low frequency in a normal material may, however, be because the remnants have induced pulp stone formation, which may mask the epithelial cells. It has also been claimed that such epithelial remnants may result in cyst formation in the dental pulp (*Manley*, 1945; *Stanley*, 1965).

The present studies support the hypothesis that epithelial rests may initiate pulp stone formation (*Orban*, 1928; *Jarmer*, 1951; *Hoffer*, 1966), and that these pulp stones may contain dentinal tubules. It is considered likely that the mechanism of odontoblast induction from epithelial cell rests is usually found in connection with histogenesis of true denticles. These findings disagree with observations made by *Johnson* and *Bevelander* (1956) who maintain that all denticles are false in origin and do not contain dentinal tubules. However, the present studies do not indicate whether other mechanisms may act under other conditions.

SUMMARY

A higher frequency of pulp stones and epithelial cell rests than that found normally, was observed in the apical region of teeth which had been subjected to experimental intrusion. The pulp stones exhibited an irregular, globular type of dentine with tubules. The present study indicates that epithelial remnants in the pulp may induce odontoblast differentiation from the cells in the dental papilla.

RÉSUMÉ

DÉBRIS ÉPITHÉLIAUX ET FORMATION DE DENTICULES DANS LA PULPE DENTAIRE HUMAINE

La fréquence des pulpolithes et des reliquats de cellules épithéliales observée dans la région apicale de dents ayant subi une intrusion expérimentale était plus élevée que celle que l'on rencontre normalement. On trouvait dans les pulpolithes un type irrégulier et globulaire de dentine contenant des canalicules. La présente étude indique que des restes épithéliaux dans la pulpe pourraient induire la différenciation d'odontoblastes à partir des cellules de la papille dentaire.

ZUSAMMENFASSUNG

EPITHELIALE ZELLRESTE UND DENTIKEL-BILDUNG IN MENSCHLICHER ZAHNPULPA

Eine grössere Häufigkeit von Dentikeln und epithelialen Zellresten als normal wurde in der apikalen Pulpa der Zähne gefunden die einer Intrusion aus-

gesetzt worden waren. Die Dentikel wiesen einen irregulären, globulären Typus von Dentin mit Kanälchen auf. Die vorliegende Untersuchung scheint zu zeigen, dass epitheliale Zellreste eine Ausdifferenzierung von Odontoblasten bewirken können.

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