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Histological and chemical analyses of mesiodens development and mineralization

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ABSTRACT

Objective: This study aimed to compare the developmental timing and mineralization quality of mesiodentes, i.e., supernumerary teeth located mainly in the midline of the maxilla between the central incisors, with the developmental timing and mineralization quality of permanent and primary central incisors.
Design: Sixteen mesiodentes, nine permanent and seven primary central incisors were collected. The location of the neonatal line was determined using a light microscope at 10× or 20× enlargements. Chemical composition of the enamel at two locations was analyzed using energy dispersive X-ray spectrometer.
Results: Neonatal lines were observed in eight out of 16 mesiodentes, in all primary central incisors and in none of the permanent central incisors. Chemical analyses showed that mesiodentes mineralization was impaired, resulting in higher amount of organic ions and reduced inorganic ions. Discriminant analysis showed minimal overlap of mesiodentes with either primary or permanent centrals.
Conclusions: Mesiodentes development begins before birth in 50% of the cases but later than the primary centrals. Mineralization of mesiodens is impaired with less mineral content and higher organic content. The results showed that mesiodentes are a special group of teeth with defective morpho-differentiation and mineralization, with little similarity to primary or permanent central incisors.

1. Introduction

Supernumerary teeth are extra teeth added to normal dentition. They can be single or multiple, unilateral or bilateral, erupted or impacted and located in the maxilla and/or in the mandible. These teeth are more common in the anterior region and mostly in the maxilla. The most common type of supernumerary teeth is the mesiodens, which is a supernumerary tooth located in the midline of the anterior maxilla between the maxillary central incisor teeth (Alberti, Mondani, & Parodi, 2006). The phenomenon of multiple supernumerary teeth in the midline is termed mesiodentes (Gallas & Garcia, 2000). In some syndromes, e.g. cleidocranial dysostosis, Gardner syndrome, Nance–Horan syndrome, Trichorhinophalangeal syndrome, Down syndrome and Ehlersedanlos syndrome, mesiodentes may be part of the oral signs (Van Buggenhout & Bailleul-Forestier, 2008). However, mesiodentes may also be found in normal individuals and a positive family history being one of the predisposing factors (Fernandez Montenegro, Valmaseda Castellon, Berini Aytes, & Gay Escoda, 2006).

The reported prevalence in the general population ranges between 0.15–3.8%, and the phenomenon is more common in males with a 2:1 ratio (Van Buggenhout & Bailleul-Forestier, 2008; Ray, Bhattacharya, Sarkar, & Das, 2005). Variations due to differences in demographic and environmental susceptibilities may impact the reported prevalence. While the occurrence of mesiodens in primary dentition is quite rare, in permanent dentition it is considered to be the most common dental abnormality (Ferres-Padro, Prats-Armengol, & Ferres-Amat, 2009). In 82% of the cases it occurs in the maxilla (Ferres-Padro et al., 2009). Three common types of mesiodentes have been described: conical or peg-shaped, tuberculate and supplemental (Gallas & Garcia, 2000; Fernandez Montenegro et al., 2006; Prabhu, Rebecca, & Munshi, 1998).

The main morphology pattern of mesiodentes is conical (Gallas & Garcia, 2000; Fernandez Montenegro et al., 2006; Prabhu et al., 1998). Conical teeth are the very primitive teeth during mammalian evolution. In humans, by 12 weeks *in utero* (stage II) the primary incisors crowns consist entirely of a single conical cusp, clearly delineated and occupying the incisal edge. One week later the mesial and distal portions of the incisal edge become elevated to such extent that the apex of the original cusp appears much reduced in size. Calcification of the central incisor begins at 14 weeks from only one center of calcification, and the calcification rate is faster than all other primary teeth (Kraus & Jordan,

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1865). In comparison with permanent peg shaped laterals, where morpho-differentiation of the crown had stopped at stage II, similar to most of the mesiodentes, the mesiodentes have shorter roots and crowns, similar to primary centrals.

Mesiodentes may erupt normally but in some cases they remain impacted or erupt in an inverted position. Most are located palatal to the central incisors, and it is probable that these teeth follow an abnormal path of eruption or take an ectopic position. Unerupted mesiodentes can induce complications such as eruption path alteration of permanent teeth causing malocclusion, root resorption and cystic lesion formation (Meighani & Pakdaman, 2010). Recently it has been reported that 41% of non-extracted mesiodentes undergo a resorption of some degree, from limited to nearly complete without any pathologies involving adjacent permanent teeth (Mensah et al., 2015).

The etiology of mesiodens remains unclear; but a few theories have been suggested. The genetic theory, based on the observations of familial high rate of hyperdontia (Stellzig, Basdra, & Komposch, 1997) is supported by current research that revealed that some genes may enhance the risk for dental anomalies. In syndromes where mesiodentes occur as part of the symptoms, the genetic basis might play an important role (Townsend, Richards, Hughes, Pinkerton, & Schwerdt, 2005). X-linked inheritance has been documented that may explain sex dominance in the supernumerary anomaly (Sedano & Gorlin, 1969). While according to the dichotomy theory splitting of the tooth bud into two equal or unequal sections may either form two equal sized teeth or one normal and one dysmorphic tooth (Rajab & Hamdan, 2002). The hyperactivity theory, that postulates the restricted increase in the activity of dental lamina, is considered the most etiologically acceptable (Rajab & Hamdan, 2002). It has been reported that the chronology of mesiodentes development differs from teeth of the other dentitions and their development was faster than ordinary teeth (Tyrologou, Koch, & Kurol, 2005).

This study aimed to analyze the developmental chronology and mineralization quality of mesiodentes and compare these factors with the timing of development and mineralization quality of permanent and primary central incisors.

2. Materials and methods

This retrospective study included three groups of teeth – 16 mesiodentes, nine permanent central incisors and seven primary central incisors. The teeth were extracted during routine dental procedures or collected after normal exfoliation. The parents gave their approval for leaving the teeth at the clinic. The research was exempt from ethical committee approval since no personal data of the patients was used.

2.1. Scanning electron microscopy

The teeth were embedded in epoxy (Epofix kit, Struers) and sliced bucco-lingually parallel to their sagittal axes, using a wafer blade (Isomet 1000, Buehler). A slice of approximately 150 μm was polished and photographed using a microscope (BestScope T3040) at ×10 and ×20 enlargements in order to detect the neonatal line.

By using scanning electron microscopy (SEM; Quanta 200, Oregon, USA) under high vacuum mode in conjugation with an energy dispersive X-ray spectrometer (EDS), the ion content of two regions, squares of 0.2 × 0.2 mm, was determined in the three groups (Fig. 1). The two regions were: 1) The upper region of the crown close to the dentino-enamel junction (DEJ) representing pre-natal enamel formation in the primary centrals, 2) The cervical region of the crown close to the outer surface of enamel representing the post-natal enamel in primary centrals.

On each square more than 5000 readings were performed by the EDS, and the results were given by mean and standard deviation (SD). The main ion content of each region was calculated, and the results were recorded in mol. wt% (molecular weight) units.

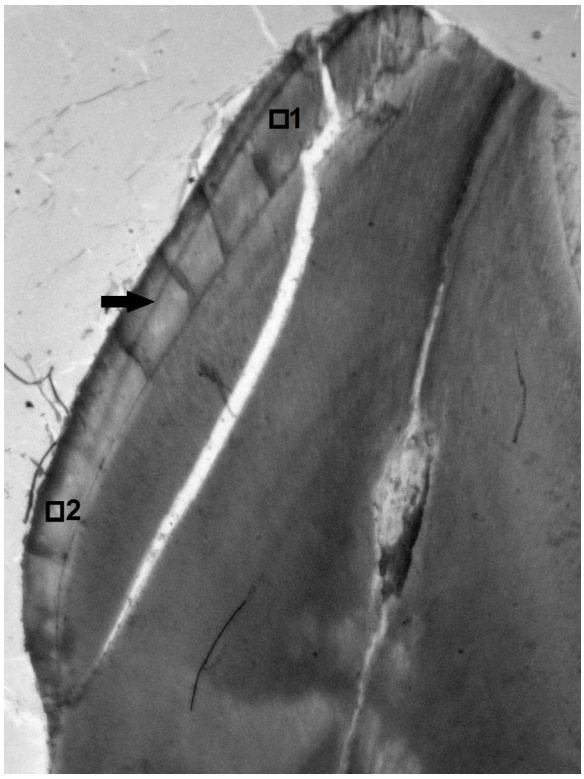

Fig 1. The location of ion content measurements at pre-natal and post-natal enamel.

2.2. Statistical analysis

Using IBM SPSS software, statistical analyses (two-tailed student's *t*-test) were performed to compare the ion content of mesiodens and permanent or primary central incisors and also between the primary and permanent centrals, and P values were calculated. The level of statistical significance was set at $P < 0.05$.

As a follow-up procedure for ascertaining how the groups of teeth (mesiodentes, primary and permanent incisors) differ on the composition of dependent variables, canonical discriminant functions were performed using the predictor variables, i.e., the ion contents of each tooth. Discriminant function analysis is a statistical analysis to predict a categorical dependent variable (grouping variable) by one or more continuous or binary independent variables (predictor variables). It is useful in determining whether a set of variables is effective in predicting category membership. It is used when groups are used apriori. In simple terms, discriminant function analysis is classification- the act of distributing things into groups of the same type. Discriminant analysis works by creating one or more linear combinations of predictors, creating a new latent variable for each function. The first function created maximizes the differences between groups on that function. The second function maximizes differences on that function, but also must not be correlated with the previous function. Each function is given a discriminant score to determine how well it predicts group placement.

3. Results

Table 1 shows the distribution of the mesiodentes by age and gender, Male to female ratio was 12/4. All mesiodentes were dysmorphic/conical. Neonatal lines were observed in all primary central incisors (Fig. 1) and in eight (7 males and 1 female) out of 16 mesiodentes (Fig. 2). The amount of pre-natal enamel in the mesiodentes was significantly lower than that of pre-natal enamel in the primary central incisors (Figs. 1 and 2). No neonatal line was observed in the permanent central incisors.