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Long-term follow up of root canal treated primary molars

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Background. Root canal treatment (RCT) is commonly performed to preserve primary molars with an infected or necrotic pulp.

Aim. This study evaluates the long-term effects of RCT in primary molars on the development and eruption of their permanent successors.

Methods. This is a retrospective study of treatment of pulpectomised primary molars in a public dental clinic. All teeth were treated by the same operator using the same material (Endoflas F.S.) and the same method. Records of 194 patients with 242 pulpectomised primary molars (124 in 97 boys and 118 in 97 girls) met the inclusion criteria. The children's age at the time of treatment ranged from 5 to 11 years (mean 6.72). Follow-up time ranged from 6 to 113 months (mean 33.5).

Results. Eight (3.3%) of the 242 primary molars presented a new radiolucent defect or enlargement of existing periapical radiolucency. Of the 106 molars followed until eruption of the permanent successor, none had radiographic pathological signs. Of 17 permanent teeth evaluated clinically, three were erupted into a rotated alignment, and one premolar presented hypocalcified defect in the enamel.

Conclusions. Failure of root canal treatment in primary molars may be evident from development of new radiolucent defects or enlargement of existing defects. No relationship was found between RCT in the primary molars and the appearance of enamel defects or the ectopic eruption of following permanent teeth.

Introduction

Endodontic treatment (e.g., root canal treatment, RCT) is a preferred procedure for preserving a restorable primary molar with an infected and/or necrotic pulp. The advantages include preserving masticatory functions, maintenance of space for the succedaneous permanent tooth, and avoidance of untimely eruption[1–4].

According to the Guidelines of the American Academy of Pediatric Dentistry, RCT is indicated in primary teeth with carious pulp exposures in which, following coronal pulp amputation, the radicular pulp exhibits clinical signs of hyperaemia, or evidence of necrosis of the radicular pulp, with or without caries involvement[5]. Treatment is considered successful if after a follow-up period the tooth (i) is not mobile, (ii) remains functioning without pain, discomfort or infection until the permanent successor is ready to erupt (iii) undergoes physiologic resorption[3]. Radiography of the tooth should show absence or reduction in size of pathologic radiolucent defects. Indications and contraindications for RCT in primary teeth are discussed lengthily in the literature[3,4].

Although its success rates have been studied[6–9], the influence of RCT on the resorption of the roots, the development of the permanent tooth bud, and the eruption of the permanent tooth have rarely been evaluated.

Coll *et al.*[10,11] found a higher than expected rate of ectopic eruption following RCT in primary teeth using zinc oxide eugenol as a dressing material. They suggested that there might be a correlation between the endodontic treatment and the ectopic eruption of the permanent teeth, yet such a relationship has not been confirmed.

The purpose of this study was to explore the long-term effects of RCT in primary molars on the development and eruption of the succedaneous teeth.

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Materials and methods

Study material

A review of all active dental records (4363 patients) of a public dental practice, the DVI clinic, which treats cost-free underprivileged children aged 5–18, yielded 370 teeth of 289 patients who had one or more primary molars with RCT. Of these, 242 teeth of 194 patients fulfilled the following inclusion criteria: (i) treatment by the same operator (MM), using the same protocol[12], and the same root canal filling material; (ii) availability of at least 6 months post-operative follow up, including radiographs; (iii) clear demonstration of inter-radicular and periapical areas on the immediate post-operative and follow-up radiographs.

Root canal treatment was performed in primary molars with irreversible pulpitis determined as continuous bleeding exceeding 5 min, with dark to purple blood colour, or pulp necrosis. In vital teeth a pulpotomy was performed in cases where bleeding of pink colour ceased within 5 min. These teeth were not included in this study. Teeth were extracted if presented with one or more of the clinical or radiographic signs listed as contraindication to RCT, such as involvement of the follicle of the permanent tooth, extensive root resorption, perforating internal resorption, and nonrestorable teeth.

Each treatment was completed in one visit and the root canals were filled with Endoflas (Endoflas F.S. Sanlor & cfa. S. en C.S. Columbia, South America), which is FDA approved. Endoflas F.S. contains a powder of tri-iodmethane and iodine dibutilorthocresol (40.6%), zinc oxide (56.5%), calcium hydroxide (1.07%), and barium sulphate (1.63%) with a liquid consisting of eugenol and paramonochlorophenol. The teeth were restored with Intermediate Restorative Material (IRM – Dentsply International Inc. Milford, DE, USA). The patients were asked to return 1 month later for coronal restoration. In the absence of clinical pathological signs of inflammation, the root-canal treated primary molars were restored with an amalgam restoration if sufficient crown structure was left to allow retention of the restoration; otherwise, a stainless-steel crown was adapted.

Data collected from the patients' records

1. Gender.
2. Age at the time of the treatment.
3. Type of tooth/teeth treated.
4. Type of coronal restoration after treatment.
5. Time interval between treatment and the last follow-up appointment.
6. Presence/absence of radiolucent lesions around the roots or in the inter-radicular area before treatment was performed.
7. Presence/absence of a new radiolucent lesion or enlargement of an existing lesion around the roots of the endodontically treated tooth.
8. The following data were collected when a new radiolucent lesion or enlargement of an exiting lesion was detected:

   Size of the radiolucent lesion.

   Effect of the lesion on adjacent teeth.

   Treatment performed following detection of the radiographic radiolucent area.

   Time elapsed between RCT and detection of the pathology.

All data were collected using a Microsoft Excel program Redmond, WA, USA for basic analysis.

For 106 (43.8%) of the 242 primary molars follow-up evaluations continued until eruption of permanent successors. Eighty-nine of these had radiographic follow up only. The 17 other permanent teeth were evaluated clinically for the presence of malformations, for example, hypoplasia, hypocalcification, and ectopic eruption or rotation.

Results

Of the 242 teeth with RCT that met the inclusion criteria, 121 were first primary molars and 121 were second primary molars. One hundred and eighteen RCT were performed in 97 girls and 124 in 97 boys. Table 1 shows the distribution of teeth with RCT according to type and arch. The mean age of the patients was 6.72 years, the range 5–11 years, and the median age 7 years. Follow-up time was between 6 and

Table 1. Distribution of RCT teeth according to type and arch.

Primary molar	Mandible**	Maxilla**	Total
First*	70 (46%)	51 (57%)	121 (50%)
Second*	83 (54%)	38 (43%)	121 (50%)
Total	153 (100%)	89 (100%)	242 (100%)

*The difference in distribution of teeth between the first and second molars is not statistically significant (χ^2 $P > 0.05$).
**The difference in distribution of teeth between the maxilla and mandible is statistically significant (χ^2 $P < 0.005$).

Table 2. Distribution of teeth according to change in the nature of periradicular radiolucent defect before and after the root canal treatment (RCT).

Periradicular radiolucent defect	Before RCT	After RCT (new or enlarged defect)	Total
Present	40 (90.1%)	4* (9.9%)	44 (100%)
Absent	194 (98%)	4* (2%)	198 (100%)
Total	234 (96.7%)	8* (3.3%)	242 (100%)

*The data refers only to periradicular radiolucent defects that appeared or increased in size after the RCT.
χ^2 $P < 0.05$

113 months, with a mean of 33.5 months, and a median of 28.5 months.

In the 89 that had radiographic follow up only, misalignment or coronal deformations were not detected in the follow-up radiographs. Of the 17 permanent teeth that were evaluated both clinically and radiographically, three were found to erupt in a rotated alignment. One of the homologous teeth presented rotation even though its predecessor had no RCT. One tooth presented a hypocalcified defect in the enamel.

A stainless-steel crown was performed in 221 of the 242 root treated teeth, five had an amalgam restoration and 16 teeth remained with a temporary filing until the patients returned for delayed follow-up examinations. Failure to return on time for crown restoration resulted in seven teeth requiring extraction. These nonrestorable teeth did not present any pathologic lesion related to the RCT.

A total of 3.3% (8/242) of the primary molars presented a new radiolucent periradiclular defect or enlargement of an existing defect in the last follow-up radiograph. Preoperative radiographs demonstrated a periapical or interradicular radiolucent area in 44 teeth. In 40 (90.9%) the radiolucent defect disappeared or decreased in size. In the other four there was an enlargement of the radiolucent area. In four other teeth the radiolucent area was detected after performance of the RCT. Table 2 shows that only 3.3% of teeth with no periradicular radiolucent defect developed such defect after the performance of the RCT, whereas almost 10% of the pre-existing radiolucent defects were found to increase in size.

In four teeth the pathologic defects were detected within the first year and were diagnosed as the enlargement of an existing radiolucent defect or development of a new periradicular radiolucent defect. In the other four the defects were detected after a follow-up period of several years. The defects in these teeth resembled cysts surrounding the crown of the permanent successor. None of the pathologic radiolucent defects was accompanied by swelling or a sinus tract. All eight pathologic defects were in the mandible. Two were detected in first primary molars and six in second primary molars. Time between the RCT and detection of the pathology ranged between 11 and 49 months, with an average of 22.3 months and a median of 15.5 months. Of the eight pathologic defects six were in teeth restored with a stainless-steel crown and two in teeth with IRM. Six of these eight cases were followed radiographically until complete eruption. Table 3 describes the fate of the primary molars and their permanent successors.

Four teeth with a pathologic defect were left untreated with follow up only. Two of them exfoliated naturally. The other two were still under follow up when the data for this study were concluded. Three teeth were extracted due to a significant size of the lesion. In these cases the lesion disappeared spontaneously following removal of the primary tooth. One tooth was removed with surgical excision of the cyst that was diagnosed as a radicular cyst by histological examination (Fig. 1a–e). The six permanent successors that already erupted were found in a normal alignment.

Table 3. The fate of root canal treated primary teeth with pathological radiographic findings and their permanent successors.

Tooth Number	Tooth type	Coronal restoration	Primary tooth	Permanent successor
1	#75	Stainless-steel crown	Extracted	Erupted into normal alignment
2	#75	Stainless-Steel crown	Extracted	Erupted into normal alignment
3*	#85	Stainless-steel crown	Extracted + enucleation of the cyst	Erupted into normal alignment
4	#84	Temporary filling	Extracted	Erupted into normal alignment
5	#85	Stainless-steel crown	No treatment	Erupted into normal alignment
6	#75	Stainless-steel crown	No treatment	Erupted into normal alignment
7	#85	Temporary filling	No treatment	Not erupted** – Normal alignment
8	#85	Stainless-steel crown	No treatment	Not erupted – normal alignment**

*See Fig. 1–e.
**Last follow up was prior to exfoliation of the primary molar.

Discussion

According to the literature the average age at which RCT in primary molars is performed is between 4 and 6 years[7,10]. In this study age range was 5–11 years with a mean of 6 years and 9 months. Children under the age of 5 are not accepted for treatments in the DVI public clinic, which may explain the older age range for RCT in this study. In this study, however, there was no correlation between the child's age at which the RCT was carried out and the child's age when the pathologic defect was detected.

One of the purposes of the study was to evaluate radiographic changes in teeth undergoing RCT. Table 2 shows that if a tooth had a periradicular radiolucent defect before the RCT the chances of failure (increase in size of the defect) are higher than if such a defect was absent before the treatment. The extent of filling material may be due to extension of the Endoflas F.S. beyond the apex in teeth in which a periapical lesion allowed flow of the material into the lesion. In those cases, however, the prognosis of the treatment was poor a priori due to the pre-existing pathologic changes[12]. Effects the filling material components may have on the outcomes of root canal treatment should be investigated.

The 6- to 113-month follow up of root canal treated primary molars is the longest documented[7–10,13]. In some cases observation of the primary teeth until the age of natural exfoliation and eruption of the permanent successor was possible. This enabled the detection of four teeth with pathologic defects during the first year and another four several years after the root canal treatment (Fig. 1). We believe that the defects detected within the first year were due to failure of the RCT to overcome the inter-radicular infection, and the four late-detected cases resulted from exposure of the follicle of the permanent successor to the root-filling material[14].

Though a radicular cyst was diagnosed in only one tooth that underwent histological examination, based on the similarity in the other three teeth, we assume that the radiolucent defects were also radicular cysts. Radicular cysts have been considered rare in the primary dentition, reported to appear in 0.44–0.8% of the population between the ages 4–16[15,16]. Radicular cysts in the primary dentition encompass the roots and the inter-radicular area of the primary molars. Their size is 4–30 mm in diameter, with an average of 13 mm. As in the permanent dentition, most radicular cysts in the primary dentition do not demonstrate clinical signs, but if the cyst attains a certain size, displacement of the developing tooth bud might occur[4,11,17,18], accompanied by expansion of the buccal cortical plate[17,18].

Coll *et al.*[10] found RCT in primary teeth to relate to ectopic eruption of the permanent successors. In this study, 17 root treated primary teeth were followed until the eruption of the permanent successors. Although no early radiographic signs presented, only three of these permanent teeth erupted into a rotated alignment. In one of these cases, the permanent successor of the homologous

none-root-treated primary tooth was found rotated. Therefore, it seems that eruption into a rotated alignment does not associate with RCT.

Coll *et al.*[10] found no relationship between RCT and the appearance of enamel hypoplasia. With only one of 17 erupted permanent successors presenting enamel hypoplasia in this study, correlation between enamel hypoplasia and RCT is not demonstrated.

The performance of twice as many mandibular as maxillary primary molars (153 and 89, respectively) performed at the clinic concurs with the higher number of primary molar RCTs performed in the mandible documented in the literature[7,17]. The present finding that all eight teeth with pathologic defects were located in the mandible is also in agreement with reports that periapical radiolucencies after the performance of RCT in primary molars were located mainly in the mandible[14,17]. Lustman and Shear[19] detected 16 cysts associated with untreated primary molars, 10 of which were in the mandible. The higher number of mandibular teeth with pathological radiolucent defects may be attributed to the difference in the anatomy of the roots that makes it easier to detect such defects in the mandible.

Root canal treatment can be considered to have succeeded in the 40 (90.9%) of 44 primary molars in which the size of periradicular defects decreased, and a failure in the four (9.1%) in which the size increased[5,10]. The late development of new radiolucent defects in endodontically treated primary molars challenges the definition of success of RCT, as infection did not present in any of the four teeth considered failures. Only one of the four teeth extracted showed a cystic radiolucent lesion that deflects the permanent successor from its normal location. The definition of success depends on the purpose of the treatment. The purpose of the RCT in the population described in this study was to

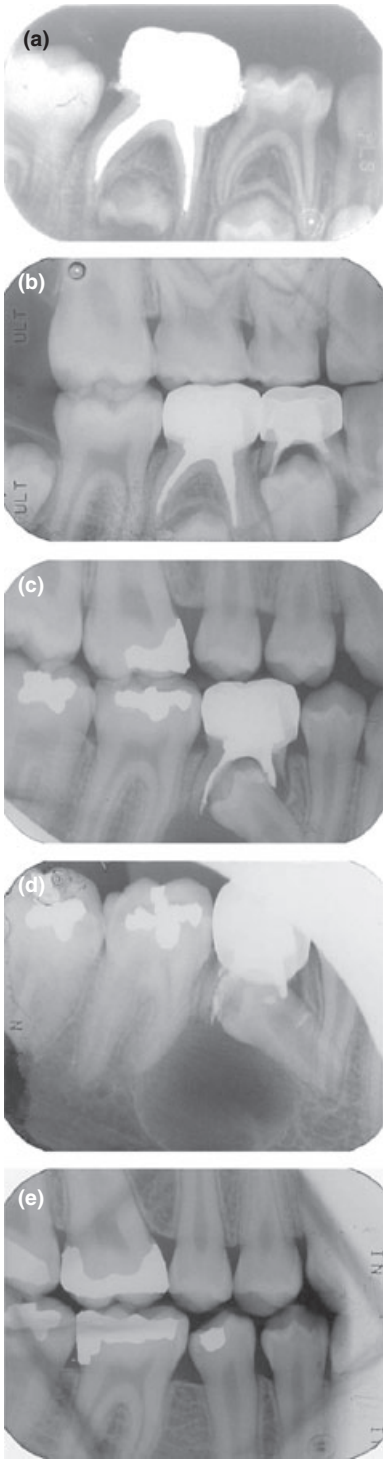

Fig. 1. (a) Periapical radiograph of lower right second primary molar immediately after root canal treatment. Patient's age at time of treatment was 5 years. (b) Right bitewing radiograph of the same patient 5 years and 3 month after the root canal treatment in the second primary molar. (c) Right bitewing of the same patient 6 years and 11 month after the root canal treatment. (d) Radiograph of the lower right second primary molar with periapical radiolucency, later diagnosed as a radicular cyst, displacing the permanent second premolar 6 years and 11 month after RCT. (e) Right bitewing of the same patient 10 years after RCT. The primary molar was extracted and marsupialisation of the cyst carried out. The permanent premolar erupted into a normal alignment.

keep the primary molars until natural exfoliation and eruption of their permanent successors clear of infection and with no development of new periradicular radiolucent defects. Here, RCT in teeth with the enlargement of a radiolucent defect or a newly developed periradicular radiolucent defect can be defined as failure. We believe that the development of a cyst-like radiolucent defect in four teeth was the result of irritation to the follicle of the permanent successor by one of the components of the root-filling material. The relationship between RCT in primary molars and the appearance of cysts in the primary dentition has not been studied. From the few case reports published it seems probable that there is an association between RCT and the appearance of periapical lesions in the primary dentition[14,20–24]. Grundy *et al.*[14] reported 17 cases of radiolucent lesions following endodontic treatment of primary teeth that were treated by three different materials (Formacresol, Caustinerf, Kri) that all contain phenol. The histological characteristics of the lesions were similar. The late detection of cyst-like radiolucent defects in four primary molars, one of which was a proved radicular cyst, should alert the dentist to careful evaluation of the periodically taken bitewing radiograph of children with RCT in primary molars, even if the child has no complaints or clinical pathologic signs. Eruption of the permanent successor into contact with roots of the primary tooth and the root-filling material should be given particular attention.

The teeth evaluated in this study were filled with Endoflas that contained chlorphenol. Lately, the manufacturer removed the chlorophenol from the composition of Endoflas F.S.

Conclusion

Failure of root canal treatment in primary molars may be evident from development of new radiolucent defects or enlargement of existing defects. Periodic radiographs taken during recall appointments should show the bifurcation and periapical areas of RCT teeth even if the child has no complaints or clinical pathologic signs.

No relationship was found in this survey between RCT in the primary molars and the appearance of enamel defects or the ectopic eruption of following permanent teeth.

What this paper adds

- This is the largest study of RCT in primary molars with the longest follow up, continuing for some cases until natural exfoliation and eruption of the permanent successor. No association was found between RCT in the primary molars and the appearance of enamel defects and the ectopic eruption of following permanent teeth.

Why this paper is important to paediatric dentists

- Even in light of the high rate of success of RCT in primary molars, periodic radiographs taken during recall appointments should show the bifurcation and periapical areas of RCT teeth even if the child has no complaints or clinical pathologic signs until the age of natural exfoliation.

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