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ORIGINAL ARTICLE

The risk of healing complications in primary teeth with root fractures: A retrospective cohort study

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Abstract

Background/Aim: Primary teeth are frequently affected by traumatic dental injuries. Root fractures are rare and have a reported incidence of 2% in the primary dentition. Hence, there is limited evidence on this topic. This study aims to evaluate the risk of healing complications in primary teeth with root fracture and to identify possible sequelae in the permanent dentition following root fracture in the primary dentition.

Materials and methods: A retrospective analysis of a cohort of 53 patients with 74 root fractured primary teeth. The standard follow-up program included clinical and radiographic examination after 4 weeks, 8 weeks, 6 months, and 1 year after the trauma and when the patient was 6 years of age. The following complications were registered: pulp necrosis (PN), pulp canal obliteration (PCO), ankylosis with replacement root resorption (ARR), infection-related root resorption (IRR), premature tooth loss (PTL), and repair-related resorption (RRR). Statistics: The Kaplan–Meier and Aalen-Johansen estimators were employed. The level of significance was 5%.

Results: A total of 74 teeth were included. 42 teeth were extracted at the initial examination. Risks estimated after 3 years: PTL 45.9% [95% CI: 28.8–63.0], PCO 12.9% [95% CI: 2.3–23.4], PN 14.9% [95% CI: 3.9–25.9], RRR 2.6% [95% CI: 0.0–7.5]. No teeth showed ARR or IRR. All complications were diagnosed within the first year. Most common sequelae in the permanent dentition was demarcated opacities, with an estimated risk of 20% [95% CI: 8.2–41.3].

Conclusions: There is a low risk of healing complications following a root fracture in the primary dentition. Root fractures often result in early extraction of the coronal fragment. The remaining apical fragment will undergo a physiological resorption. Aside from opacities, there is a low risk of sequelae in the permanent dentition.

KEYWORDS
dental trauma, primary teeth, pulp necrosis, root fracture, sequelae, tooth loss

1 | INTRODUCTION

Root fractures in the primary dentition are rare, with a reported incidence of 2% of all traumatic dental injuries (TDI) in the primary dentition.[1–4] A root fracture is defined as a radiographically visible horizontal fracture line on any level of the root.[5] A common clinical sign is a mobile coronal segment, which may be displaced.[6–8] The degree of mobility and displacement of the coronal fragment influences the choice of treatment as recommended by the International Association of Dental Traumatology (IADT). In cases of minimal displacement and mobility of the coronal fragment, it has been suggested that the fragment is left untreated.[9] However, when the coronal fragment is highly mobile, mobility grade 3, and the amount of displacement is interfering with occlusion or splinting is not possible, extraction is indicated.[10] If extraction is preferred, only the coronal fragment should be extracted, and manipulation of the apical fragment should be avoided due to the risk of injuring the permanent tooth germ. Damage of the permanent tooth germ, can result in demarcated opacities, hypoplasia, and malformation of the permanent successor.[11,12] Hence, it has been recommended that the apical fragment should be left for biological resorption.[13] In the literature, there is a lack of data on root fractures in the primary dentition. The authors have only found one case series specifically studying root fractures in primary incisors, and it indicated that some teeth may successfully heal if left in situ without treatment.[14] There is little scientific evidence regarding how to manage root fractures in primary teeth. Long-term complications, such as pulp necrosis (PN) and different types of root resorption that are seen after TDI in permanent teeth, may also affect the primary dentition[15,16] and, if left untreated, potentially cause further damage to the permanent successor. In order to choose the optimal treatment for the child (i.e., extraction or preservation of the injured primary tooth), it is necessary to gain more knowledge of the risk of such healing complications in primary teeth with root fracture. Therefore, the aims of this study were to assess the risks of complications such as PN, pulp canal obliteration (PCO), ankylosis with replacement root resorption, infection-related root resorption (IRR), and premature tooth loss (PTL) in primary teeth with root fracture and to assess the risk of other possible sequelae in the permanent dentition following root fracture in the primary dentition.

2 | MATERIALS AND METHODS

The data consist of records of patients diagnosed with root fracture injury in the primary dentition at the Department of Oral and Maxillofacial Surgery, University Hospital, Rigshospitalet, in Copenhagen, Denmark, between 1973 and 1995.

This study included patients with complete records (clinical photos, radiographs, and trauma data sheet) from the initial examination and follow-up visits. Another inclusion criterion was to have at least 1 year follow-up or until the time of tooth loss if the tooth was lost within the first year after the injury. Patients with previous trauma to the involved teeth or severe destruction of teeth caused by caries at the time of injury were excluded.

The standard follow-up program included clinical and radiographic examination after 4, 8 weeks, 6 months, and 1 year after the trauma and when the patient was 6 years of age. Table 1 shows the number of patients and teeth after 1, 2, and 3 years of observation. All follow-up visits were performed by the same dentist. All patients were invited for an additional follow up visit at 10 years of age for evaluation of sequelae in the permanent dentition. Twenty-five patients (30 teeth) attended the 10-year follow-up. Patients with signs of MIH or generalized mineralization disturbances were excluded.

At the time of the injury, the following parameters were recorded using a special standardized trauma chart: gender, age, cause of injury, date and time of injury, and number of injured teeth. For each tooth, clinical information from the time of injury and follow-up examinations was recorded using a standardized form, including tooth color, tenderness to percussion, and mobility.

Mobility was registered on a scale of 0–3, where 0 = no abnormal mobility, 1 = facio-lingual and/or mesiodistal movement of 1 mm or less, 2 = facio-lingual and/or mesio-distal movement of more than 1 mm, and 3 = more than 1 mm movement in any direction.

At the initial examination, clinical photographs were taken in two planes: horizontal and perpendicular to the tooth axis. A conventional radiograph with occlusal exposure ensuring a bisecting angle technique (Kodak Ultra-speed dental X-ray, film size 2) was taken at the initial visit and at each follow-up. All radiographs were taken using a specially designed film holder for primary teeth, with a fixed focus-object distance (33 cm) to ensure a standardized technique, with an exposure time of 0.8 s at 55 kVp and 15 mA. During occlusal exposure, the beam was oriented to the midline between the central incisors.[17] To avoid bias due to knowledge of later radiographic events, a specifically developed concealment was used. All radiographs was viewed sequentially and independently of the patients' records by two dentist with experience in dental trauma to ensure minimal bias related to prior knowledge of treatment and diagnosis. Each radiographic series was evaluated twice. In case of disagreement, agreement was reached by consensus discussion.

TABLE 1 Distribution of patients with root fractures of primary teeth according to age and gender.

	Gender		
Age (years)	Male, *n* (%)	Female, *n* (%)	Total, *n*
0–1	3 (100)	0 (0)	3
1–2	3 (60)	2 (40)	5
2–3	5 (100)	0 (0)	5
3–4	4 (57.1)	3 (42.9)	7
4–5	13 (56.5)	10 (43.5)	23
5–6	12 (57.1)	9 (42.9)	21
6–7	6 (100)	0 (0)	6
7–8	3 (75)	1 (25)	4
Total	49 (66.2)	25 (33.8)	74

The radiographs were evaluated in a dark room using magnifying glass.[18,19]

Most patients (96%) received initial treatment within the first 24 h after the injury occurred. Forty-two coronal fragments were extracted at the initial visit due to excessive mobility. The apical fragment was left in situ. The remaining 25 teeth were repositioned without splinting. The patients' parents or guardians were instructed to swab the injured area with 0.1% chlorhexidine on a cotton swab twice a day until normal tooth brushing could be performed. Soft diet and minimum use of a pacifier were recommended during the first week.

PCO was diagnosed radiographically when there was increased deposition of hard tissue along the walls of the pulp canal and the coronal pulp chamber compared with the non-injured contralateral tooth.

PN was diagnosed if clinical or radiographic signs of pulpal infection were present. These signs include IRR, radiographic radiolucency associated with the apex of the tooth in combination with tenderness to percussion, increased mobility, or gray discoloration, sinus tract in relation to the involved tooth or acute symptoms of infection, such as pain, swelling, or abscess formation in relation to the involved tooth.

IRR was diagnosed radiographically as progressing root resorption when the width of the periodontal ligament was increased in areas of tooth resorption with simultaneous bone resorption.

Ankylosis related resorption (ARR) was diagnosed if one or more of the following clinical and radiographic signs were present; a high pitch percussion tone and absence of clinical mobility, progressive infraposition of the tooth and radiographic absence of periodontal space with replacement by bone, usually in association with an uneven contour of the root.

Repair-related resorption (RRR) was diagnosed radiographically as localized areas of non-aggressive root resorption with a normal appearance of the periodontal ligament.

PTL was registered if a primary incisor was lost more than 4 months earlier than the non-injured contralateral tooth. If both incisors were lost, the expected time of eruption of the permanent tooth minus 2 SD was used as a reference point.[20,21]

The evaluation of developmental disturbances in the present study was based on the evaluation of clinical photographs and radiographs as well as results from the clinical examination when the patient was 10 years of age.

Enamel defects were classified as diffuse opacity, demarcated opacity, and hypoplasia according to the modification of the FDI-EDD Index.[22] Malformation of teeth was classified according to the Andreasen classification.[23]

The risks of PN, PCO, RRR, IRR, ARR, and PTL were analyzed using Kaplan–Meier and Aalen-Johansen estimators to account for censoring and competing risks.[4] Robust confidence limits were obtained to account for the dependencies of teeth placed in the same patients. For the Aalen-Johansen estimate, such a robust variance formula was not available; therefore, the standard Greenwood variance formula was used.[24,25] All analyses were performed with the statistical software R.[26]

All data used in the present study were obtained in a clinical context as part of a standardized treatment regime with full acceptance from the parents and are fully in line with the World Medical Association's Declaration of Helsinki from 2013. By Danish law, this study is considered a quality assurance follow-up study (all data were obtained in a clinical context and/or as part of a standardized treatment protocol), and the study does not qualify for evaluation by a research ethics committee in Denmark. The participants did not sign an informed consent guaranteeing confidentiality of the data as the data was collected between 1973 and 1995 which was not required at the time.

3 | RESULTS

A total of 53 patients aged 0–7 years with a root fracture in the primary dentition were included in this study. The distribution of patients according to age and gender at the time of injury is shown in Table 1.

The total number of primary incisors with a root fracture was 74. Forty-nine teeth were lost before the normal time of exfoliation (PTL). A total of 42 teeth were subjected to extraction of the coronal fragment at the initial examination due to excessive mobility. The apical part of the root was left in situ. All apical fragments were resorbed over time without healing complications. One tooth was lost due to increased mobility in the follow up period. Six teeth were diagnosed with PN and were later extracted. Table 2 shows the estimated risk of PTL after 3 years (45.9% [95% CI: 28.8–63.0]). Figure 1 shows that all cases of PTL occurred within the first 6 months after dental trauma. Five teeth developed PCO within the first 3 years after the injury, with an estimated risk of 12.9% [95% CI: 2.3–23.4] after 3 years. All teeth that developed PCO were detected at the earliest 6 months after trauma, as seen in Figure 1. Regarding PN, six cases was diagnosed within the first year after dental trauma, with an estimated risk of 14.9% (95% CI: 3.9–25.9) after 3 years. One tooth developed RRR, and the estimated risk after 3 years was 2.6% (95% CI: 0.0–7.5). IRR or ARR was not seen during the follow-up period.

Nine teeth displayed gray discoloration, among which three cases were reversible. Moreover, three teeth were diagnosed with a fistula. Yellow discoloration was seen in four teeth.

TABLE 2 The risk of PN, PCO, ARR, IRR, RRR, PTLOSS estimated after 3 years for teeth not extracted at the examination date.

Event	Risk (95% CI)
PN	14.9 [3.9–25.9]
PCO	12.9 [2.3–23.4]
RRR	2.6 [0.0–7.5]
IRR	0.0 [0.0–100.0]
ARR	0.0 [0.0–100.0]
PTLOSS	45.9 [28.8–63.0]

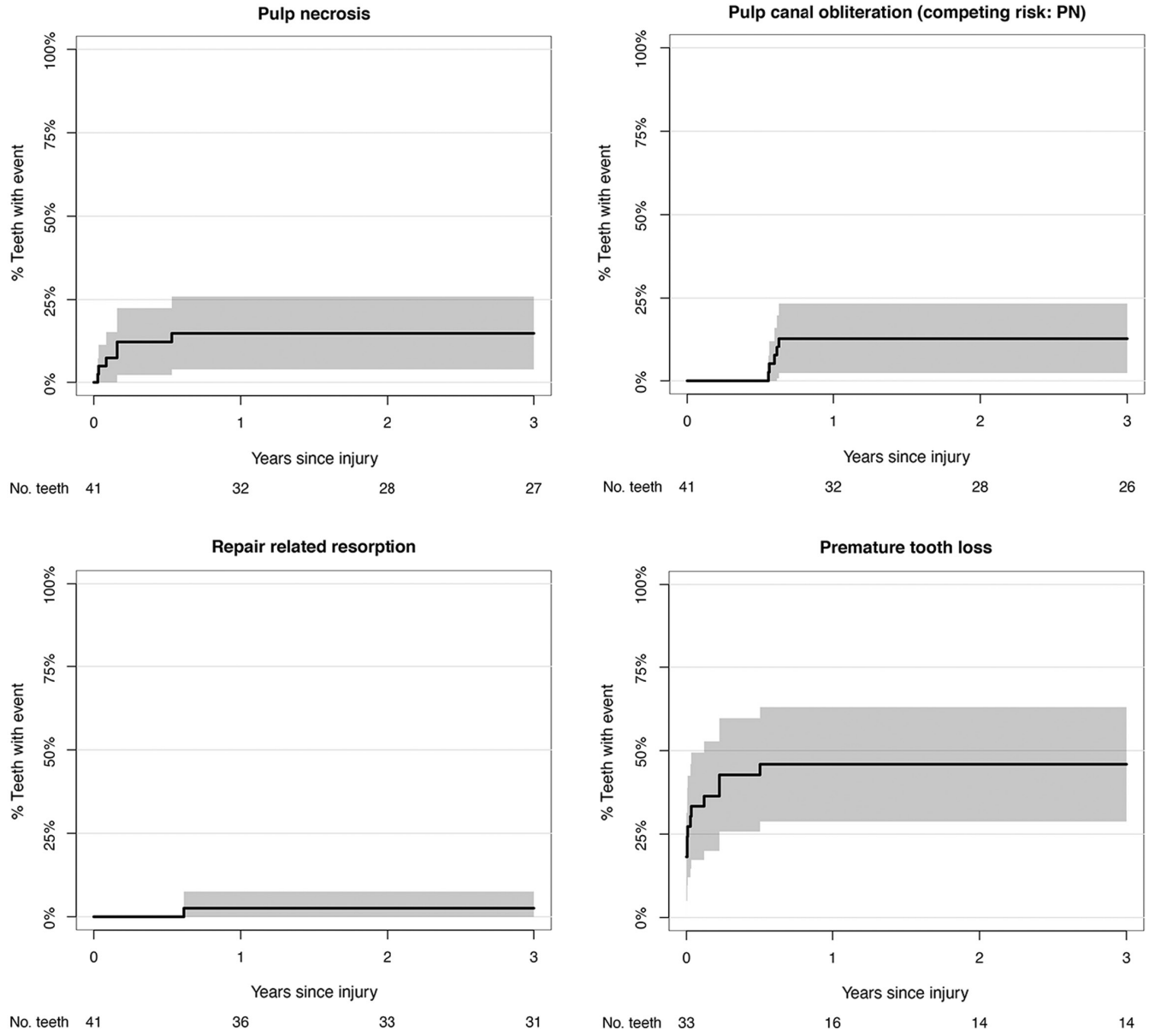

FIGURE 1 Risk of healing complications and premature tooth loss in primary teeth with root fracture. The shaded area represents 95% confidence interval.

TABLE 3 Sequelae in the permanent dentition after root fracture of a primary tooth.

Sequelae	Number of events	Risk (%)	95% confidence limits
Demarcated opacity	6	20.0	[8.2–41.3]
Hypoplasia	2	6.7	[1.6–23.4]
Malformation	1	0:5	[0.5–20.4]

Twenty-five patients (30 teeth) were followed till 10 years of age. These patients were included in the analysis of the risk of sequelae in the permanent dentition as seen in Table 3. The most common sequelae was demarcated opacities, which could be seen in six teeth, with an estimated risk of 20% [95% CI: 8.2–41.3]. Two teeth developed hypoplasia, and one tooth had a malformation. Table 4 shows the distribution of age at the time of injury for patients with sequelae and the presence of pulpal infection in relation to the type of sequelae in the permanent dentition among these patients. The primary teeth were extracted in case of pulpal infection of the coronal part of the tooth. No teeth showed signs of pulpal infection in the apical part of the fractured primary root.

4 | DISCUSSION

The main results of the present study show that the risk of most complications is low following a root fracture in the primary dentition caused by TDI. PTL is the most common complication

TABLE 4 Distribution of age at the time of injury and the presence of pulpal infection in relation to type of sequelae in the permanent dentition among these patients.

Age at time of injury	2 years		3 years		4 years		5 years	
	Pulpal infection	No pulpal infection	Pulpal infection	No pulpal infection	Pulpal infection	No pulpal infection	Pulpal infection	No pulpal infection
Demarcated opacity (no)				1	2	1	1	1
Hypoplasia (no)		1			1			
Malformation (no) (root dilaceration)					1			

occurring in almost half of the cases. Provided that the traumatically injured primary tooth is persistent, the results of our study imply that it might not be necessary to perform dental treatment during the emergency phase if there is no interference of occlusion or acute pain.

Based on our results, both PTL and PN can be expected shortly after the dental trauma. These findings are in accordance with other studies, which reported that the risk of healing complications in primary teeth is highest between 4 and 8 months after TDI.[18,19,27] In the present study, most of the healing complications were diagnosed within the first year after the dental trauma. There were no cases of IRR and ARR in our study. This might be due to the size of the study population, hence limiting the possibility of drawing a conclusion on these complications. However, the frequency of these complications can vary depending on the type of TDI. While a concussion may carry a relatively small risk for IRR and ARR, a lateral subluxation can significantly increase the likelihood of IRR.[15,17]

As seen in the results, nine teeth displayed gray discoloration. Current evidence states that gray discoloration alone cannot be seen as a sign of PN.[28–31] Some studies suggest that traumatically injured teeth can display gray discoloration without pathological changes and symptoms.[16] Therefore, gray color changes are not a reliable predictor of PN. A study reported that all traumatically injured primary teeth with PCO showed a yellow discoloration.[32] In agreement with these results, four out of five teeth with PCO showed yellow discoloration in the present study. Due to the limited amount of data, it is not possible to draw a conclusion regarding the correlation between yellow discoloration and PCO.

The results of the present study showed that the risk of PN was lower than the estimated risk of PN following lateral luxation or intrusion of primary teeth.[15] This lower risk of complication may be because teeth with severe displacement were extracted at the initial visit. The chance of revascularization is likely higher in teeth with minimal displacement of the coronal fragment.

Hence, the results support the IADT recommendation suggesting that a conservative approach with preservation of the traumatically injured tooth should be considered if the child shows no signs of acute pain, occlusal interference, or infection, and it should be considered because of aesthetics, function, and speech.[9]

In the present study, TDIs were more common among male than female patients which has also been reported in recently published studies on dental trauma in children.[18,19] Moreover, dental trauma is overrepresented among 1–3-year-olds, possibly because children at that age have not yet developed risk judgement when playing.[33,34]

Sequelae in the permanent dentition occurred in 20% of the root-fractured primary teeth. To the authors' knowledge, there are no previous studies reporting sequelae in permanent successors after root fracture in the primary dentition.[23]

There are some limitations to this study. Root fracture in the primary dentition is a rare injury, so the number of cases is limited in a study like this. Another possible limitation is that all cases were registered at the same center. The reason for this was that all TDI were referred to the main center in Copenhagen. However, only one center is also an advantage for conformity in registration. Although this study was a retrospective analysis of data collected between 1973 and 1995, the data were collected prospectively with predefined principles for diagnosis and treatment as well as clinical and radiographic documentation, which is a strength of this study. To the authors' knowledge this is the only long-term study of root fracture of primary incisors. Another strength is the meticulous registration of data along with clinical photographs and radiographs from the initial examination, making it possible to verify the original diagnoses. Furthermore, all radiographs were taken with a film holder. This ensured a uniform angle of the X-ray beam each time a radiograph was taken. Another strength of the study is that all follow-up visits were carried out by the same dentist. Owing to the abovementioned factors, the quality of the data is considered high.

The patients were followed for varying time periods. Since they would have had different probabilities of experiencing a given complication within the various observation periods, the different durations of follow-up periods introduced a bias into the calculation of risks as number of events divided by number of teeth. This fact must be considered, and survival analysis is the recommended method in such situations.[24,25] According to the protocol, the children were followed until 10 years of age. There was a high drop-out of patients for the last visit, possibly due to the long follow-up time. Consequently, the number of patients included in the analysis of sequelae in the

permanent dentition is low, which is reflected in the somewhat large confidence limits.

Within the limitations of this study, traumatically caused root fracture in the primary dentition constitutes a low risk of healing complications. Accordingly, the results support the present guidelines suggesting a conservative approach with preservation of the tooth in case of minimal displacement and minimal mobility of the coronal fragment. In cases of extraction of the coronal fragment, the remaining apical fragment will undergo a physiological resorption without causing further damage to the permanent tooth.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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