Partial Pulpotomy in Crown – Fractured Incisors – Results 3 to 15 Years After Treatment

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Djelomična pulpotomija kod sjekutića sa slomljenim krunama – rezultati 3–15 godina nakon tretmana

Summary

The pulp exposed by a crown fracture in 178 incisors was treated with partial pulpotomy and dressing with calcium hydroxide, 1 to 984 hours after the accident. Three years after treatment, healing had taken place in 169 teeth (95%). All teeth that could be followed for a longer time, up to 15 years, showed no clinical symptoms or radiographic changes. There was a numerical but not a statistically significant difference in the frequency of healing between teeth treated within 72 hours after the accident and those treated after a longer interval (96 and 87,5%, respectively).

Neither was there any significant difference between immature and mature teeth. It was concluded that crown-fractured teeth, partial pulpotomy and dressing of the exposed pulp with calcium hydroxide, is a safe and permanent treatment.

Key words: *calcium hydroxide, partial pulpotomy, pulp exposure*

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Introduction

A high frequency of healing has been reported after partial pulpotomy in crown-fractured incisors, irrespective of the size of exposure, the maturity of the root or the interval between accident and treatment (1). Treatment was based on the assumption that in pulps showing vital and/or hyperplastic tissue in the exposure, irreversible changes are limited and that if the superficial layers are removed, calcium hydroxide can be placed against healthy pulp tissue; furthermore, that any inflammatory reactions in the remaining pulp will cease once the cause of the irritation has been removed. These assumptions have been confirmed in human and animal studies (2–10), although opinions have differed about the significance of interval between the accident and treatment for healing of the pulp (9, 10).

In addition to a number of case reports (11–14), only two clinical studies, with relatively short mean observation times, have been published (1, 15). In order to form a final opinion on treatment, long-term clinical studies have been requested (16). The purpose of the present investigation was, therefore, in a more comprehensive material, to study the results of partial pulpotomy in crown-fractured incisors, 3 to 15 years after treatment.

Material and methods

The original material comprised records and radiographs of 213 crown-fractured incisors treated with partial pulpotomy at the Department of Pedodontics, Eastman Dental Institute in Stockholm, between 1973 and 1988 and, thus, included the teeth reported in 1978 (1). In 1991–92, all patients were called for a new clinical and radiographic control. For 32 teeth in patients not living in the Stockholm area, this control was performed by a local dentist, who forwarded clinical observations and radiographs, obtained at various angles. Three years was chosen as the minimum control period and 31 teeth did not meet this requirement. Furthermore, 3 dislocated teeth with uncertain pulp diagnosis and one tooth with a concomitant intra-alveolar root fracture were excluded. This left 178 teeth for evaluation, 152 maxillary and 26 mandibular incisors, in 162 patients aged 6 to 17 years at the time of treatment. The treatments had been performed by 32 dentists.

At the time of treatment, all teeth showed vital and/or proliferated pulp tissue in the exposure and were sensible to electric stimulation. A crown – root fracture with approximal exposure of the pulp was present in 21 teeth. Among the teeth treated within 48 hours after the accident, 72 were sensible to percussion and 23 were slightly mobile. Maturity of a root was judged according to Moorrees, Fanning and Hunt 1963 (17), i.e. teeth with a root development corresponding to stages R1/2 to RC were considered immature and those corresponding to A1/2 and AC mature. The distribution of the teeth with respect to the interval between the accident and treatment, root maturity and the number of teeth available at various follow-up periods, is shown in Table 1.

Partial pulpotomy was performed as described by Cvek 1978 (1). In short, the exposed pulp was removed, together with surrounding dentin, to a depth of about 1.5–2 mm below the exposure, using a diamond instrument in a high-speed contra-angle turbine. Cutting was performed intermittently, during brief periods, accompanied by continuous flushing of the area with a water spray from the turbine. The pulpal wound was then rinsed with sterile saline from a syringe until physiologic haemostasis had taken place, without formation of an extra-pulpal blood clot. Thereafter, the pulpal wound was dressed with calcium hydroxide (Calasept®, Scania Dental, Knivsta, Sweden). When the calcium hydroxide has been dried with cotton pellets and the excess removed, the amputation cavity was sealed with zinc oxide-eugenol cement. The crown was restored, usually with a composite material, at a subsequent sitting. Three to 6 months after treatment, the cavity seal and calcium hydroxide were removed under aseptic conditions in 129 teeth and the continuity of the barrier was checked clinically with a sharp explorer. In 2 of 21 crown-root fractured teeth with a proximal pulp exposure, the entire pulp tissue coronal to the lesion was removed to avoid its constriction by hard tissue formation and subsequent necrosis (18, 19); in the remaining 19 teeth, only partial pulpotomy as described above was performed.

The teeth were controlled 3 and 6 months after treatment and then annually until the age of 19, at the Department of Pedodontics, Eastman Dental Institute or at Public Dental Service clinics in the County of Stockholm, from which files and radiographs were available for the present evaluation. In the cases where the con-

Table 1. *Distribution of 178 crown-fractured incisors treated with partial pulpotomy, according to the interval between accident and treatment (hours), maturity of the roots, number of teeth available at various control periods (months) and incidence of failure: »p« denotes a case of periapical osteitis or pulpitis and »o« a case of root canal obliteration, within a group of teeth*

Tablica 1. Raspodjela 178 sjekutića s lomom krune liječenih djelomičnom pulpotomijom, prema vremenskom razmaku između nezgode i liječenja (sati), zrelosti korijena, broju zuba dostupnih u različitim kontrolnim razdobljima (mjeseci) i učestalosti neuspjeha liječenja: »p« označava slučaj periapikalnoga osteitisa ili pulpitisa, a »o« slučaj uništenja korijenskoga kanala, unutar skupine zuba.

Interval accident-treatment (h)	Observation time (m)				
	36	37–72	73–108	109–114	145–180
1– 24	138 ppppoo	128	70	45	25
25– 48	17 p	13	4	3	2
49– 72	7	7	4	1	1
73–168	8 o	8	5	2	
169–984	8 p	6	3	1	1
Total	178	162	85	52	29
Immature	90 pppooo	78	42	25	17
Mature	88 ppp	84	43	27	12

tinuity of subsequent controls was uncertain or the files were difficult to obtain, the long-term results were evaluated from final controls, obtained in the present study.

Healing was considered to have occurred if there were no clinical symptoms and no radiographically demonstrable intraradicular or periradicular pathological changes along with radiographic and when available, clinical evidence of a continuous hard tissue barrier at the site of the surgical incision, continued root development of immature teeth, and maintained sensitivity to electrical stimulation.

Statistical evaluation of the material was performed with the Chisquare test; the probability level was set at $P = 0.5$.

Results

The results are presented in Table 1, from which it may be seen that all failures occurred or could be diagnosed not more than 36 months after treatment. None of the teeth that could be followed showed any clinical symptoms or radiographic changes at later controls, up to 15 years after treatment. Evaluation of healing was, therefore, based on the results at the 36-month control.

Healing had occurred in 169 out of 178 teeth or in 95%, including 19 crown-root fractured incisors with an approximal pulp exposure (Figs. 1 and 2). All hard-tissue barriers, explored clinically in 126 of these teeth, were

Figure 1. *A and B: before and 6 years after partial pulpotomy; C and D: before and 8 years after partial pulpotomy; E: formation of hard-tissue barrier 3 months after partial pulpotomy treatment and F: 1 year later; G and H: before and 15 years after partial pulpotomy treatment.*

Slika 1. *A i B: prije i 6 godina nakon djelomične pulpotomije; C i D: prije i 8 godina nakon djelomične pulpotomije; E: stvaranje barijere od čvrstoga tkiva 3 mjeseca nakon liječenja djelomičnom pulpotomijom; F: 1 godinu kasnije; G i H: prije i 15 godina nakon liječenja djelomičnom pulpotomijom.*

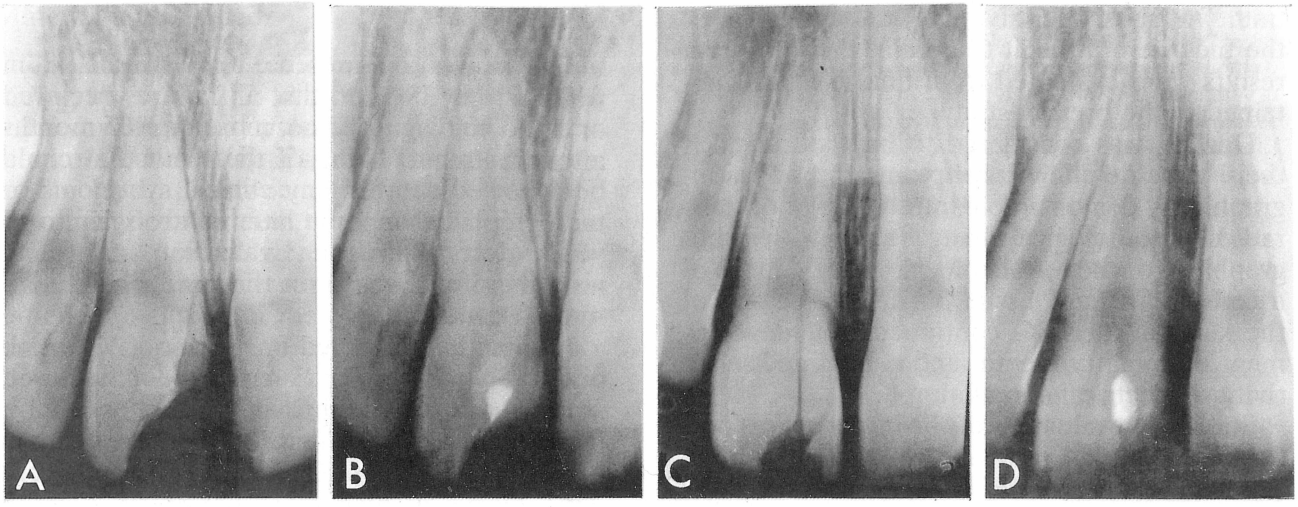

Figure 2. *A to C. Two central incisors with a crown-root fracture before and 4 years after a proximal partial pulpotomy. There are no adverse changes in the coronal part of the pulp.*

Slika 2. *Dva središnja sjekutića s lomom krune i korijena prije i 4 godine nakon proksimalne djelomične pulpotomije. Nema nikakvih štetnih promjena u koronalnomu dijelu pulpe.*

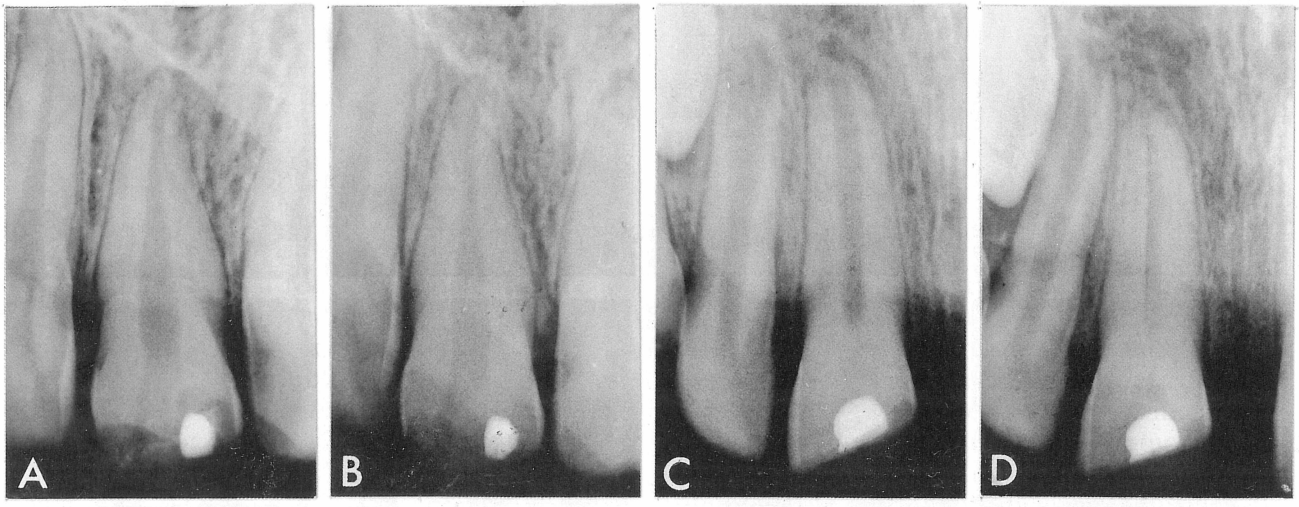

Figure 3. *A and B: Three and 40 months after partial pulpotomy, the patient complained of transient but recurrent pain in the treated tooth and a pulpectomy was performed on the request. C: The coronal pulpal lumen filled with hard tissue 6 months after partial pulpotomy treatment and D: eight months later, diminution of the root canal by apposition of hard tissue on the dentinal walls.*

Slika 3. *A i B: tri i 40 mjeseci nakon djelomične pulpotomije, bolesnik se žalio na prolaznu ali opetovanu bol u liječenomu zubu te je na njegov zahtjev učinjena pulpektomija. C: lumen koronalne pulpe ispunjen čvrstim tkivom 6 mjeseci nakon djelomične pulpotomije; D: osam mjeseci kasnije, smanjenje korijenskoga kanala uslijed prianjanja čvrstoga tkiva uz dentinsku stijenku.*

found to be continuous. The frequency of healing did not differ between the teeth in which a barrier was clinically controlled and those in which it was not.

Failures occurred in 9 teeth. In 5, a periapical radiolucency appeared 1 to 10 months after treatment. In these teeth, no formation of a hard-tissue barrier could be seen in the radio-

graphs. Another patient complained of transient but recurrent pain in the treated tooth, which at the controls was sensible to electrical stimulation, with a hard-tissue barrier visible in the radiographs and no periapical changes. At the patients request, pulpectomy was performed 40 months after treatment (Fig. 3, A and B). In the remaining 3 teeth, instead of the usual hard-tissue barrier, in the radiographs 6 to 9 months after treatment, the whole coronal pulpal lumen seem to be filled with hard tissue (Fig. 3. C and D). This was followed by a successive diminution of the root canal due to deposition of hard tissue along the dentinal walls. A thin canal in the middle of the root was still visible in the radiographs of 2 teeth 6 years after treatment, while in one tooth the root canal appeared to be completely obliterated after 9 years. There were no periradicular changes in these teeth.

As regards the interval between the accident and treatment, the largest numerical difference in the frequency of healing was found between teeth treated up to 72 hours after the accident and those treated after a longer interval, i.e. 96 and 87.5%. However, this difference is not statistically significant. Neither was there any significant difference in the frequency of healing between immature and mature teeth at the time of treatment.

Discussion

The high frequency of healing in the present material corresponds to the results from previous studies of partial pulpotomy in crown-fractured teeth (1, 15). All failures could be diagnosed within 26 months after treatment, which may indicate that a 3-year observation time is adequate after partial pulpotomy treatment, particularly if a clinical control shows a continuous hard-tissue barrier.

Clinical control of a hard-tissue barrier formed after partial pulpotomy was primarily introduced in a previous study as one of the criteria for pulp healing in a previous study (1). In the present material, however, no difference in healing frequency was found between controlled and uncontrolled teeth, which suggests that such control is not essential in clinical practice. At the same time, the clinical control also involves removal of the soft-tissue remnants always present above a barrier and visible in the radiographs as an »empty« space between the barrier and sealing material. Removal of this remnants, which are a potential substrate for bacterial growth, along with a new seal of the amputation cavity, may enhance protection of the pulp in the event of microleakage, which probably is the main reason for late failures.

It has been observed that capping in the cervical area may cause degeneration of the coronal pulp due to constriction of the blood supply by the formation of hard tissue (19). However, no such adverse effects were seen after partial pulpotomy in 19 crown-root fractured teeth with approximal exposure of the pulp, which may confirm the opinion of Pereira and Stanley (20) that this appears to be a rare phenomenon.

Two types of complication were observed: periapical radiolucency and obliteration of the pulpal lumen by formation of hard tissue. The occurrence of a periapical radiolucency, along with the absence of hard-tissue barrier formation, can be explained by the contamination of damaged and probably necrotic pulp tissue with microorganisms, either before treatment or later, for example through microleakage of an inadequate restoration. An incorrect diagnosis of pulp vitality at the time of treatment may have been an additional factor. Any explanation for the transient but recurrent pain in one tooth with no other clinical or radiographic symptoms during a 3-year observation, can only be speculative.

It has been suggested that calcium hydroxide and/or pulpotomy treatment procedures may induce formation of hard tissue in the remaining pulp, which may render a later root canal treatment difficult or impossible (21, 22). As only 3 out of 178 teeth in the present material become obliterated, such an effect of calcium hydroxide appears unlikely. On the other hand, it is conceivable that insufficient cooling and the resultant overheating may have caused coagulation and later calcification of the coronal pulp in the obliterated teeth in the present material. At a distance the effect may have been less but sufficient to damage odontoblasts, with obliteration of the root canal as a result. However, the morphologic pattern of the root canal obliteration was similar to that seen in luxated teeth (23, 24) and a luxation injury before pulp treatment could be another explanation for the pulp canal obliteration. Whether obliteration of the pulp should be seen as a failure, a complication or a

type of pulp healing is debatable but it does not meet the criteria for pulp healing in the present study.

Regarding the interval between the accident and treatment, a numerically higher frequency of healing was found in teeth treated up to 72 hours after the accident, compared with teeth treated after longer intervals. However, considering the high overall frequency of healing and the small numbers of teeth in the longer intervals, the difference can be of only limited clinical significance.

The results of the present study constitute evidence of a high ability of the exposed pulp to heal, demarcate itself with a hardtissue barrier and then remain healthy, provided favourable conditions are created by an adequate treatment. The explanation for the high frequency of healing in the present material should, therefore, be sought in the procedures and materials, or a combination of these, used for treatment. Cutting of the pulp with a gentle method, for example, inflicts only an insignificant injury to the remaining pulp, while the absence of an intermediate blood clot improves the chances of healing (25, 26). Calcium hydroxide, through formation of coagulation necrosis, seems to exert a low-grade irritation on the pulp, necessary to elicit reactions leading to the formation of a hard-tissue barrier (27–29). The compound also has a strong antibacterial effect, though it fades in the biological environment (30). The creation of the amputation cavity makes it possible to seal the operational area with zinc oxide-eugenol cement, a material that prevents microleakage and access of microorganisms to the pulp (31). Together, these procedures seem to have provided conditions for sustained healing of the exposed pulps in teeth in the present material.

Conclusions

The long-term results of the present study confirm the earlier reports of a high frequency of healing after partial pulpotomy treatment in crown-fractured incisors. In these teeth, partial pulpotomy appears to be a safe and permanent treatment, while a following pulpectomy can be restricted to teeth in which abutment in the root canal is necessary for tooth restoration.

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DJELOMIČNA PULPOTOMIJA KOD SJEKUTIĆA SA SLOMLJENIM KRUNAMA

Sažetak

Pulpa izložena lomu krune u 178 sjekutića liječena je djelomičnom pulpotomijom i oblaganjem kalcijevim hidroksidom, 1 – 984 sati nakon nezgode. Tri godine nakon liječenja, izlječenje je zabilježeno u 169 zuba (95%). Svi zubi koje je bilo moguće pratiti kroz duže razdoblje, do 15 godina, nisu pokazivali nikakve kliničke simptome niti radiografske promjene. Utvrđena je brojčana ali ne i statistički značajna razlika u učestalosti izlječenja između zuba liječenih unutar 72 sata nakon nezgode i onih liječenih nakon dužega vremenskog razdoblja (96%, odnosno 87,5%). Također nije bilo nikakve značajne razlike između nezrelih i zrelih zuba. Zaključeno je kako kod zuba s lomom krune, djelomična pulpotomija i oblaganje izložene pulpe kalcijevim hidroksidom predstavljaju sigurno i trajno liječenje.

Ključne riječi: *kalcijev hidroksid, djelomična pulpotomija, izloženost pulpe*

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