Direct Pulp Capping of Carious Primary Molars. A Specialty Practice Based Study

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Objective: *Recommendations against direct pulp capping (DPC) for carious primary teeth are based on old, low level evidence. This study investigates the medium to long term clinical and radiographic outcomes of such treatment.* ***Study design***: *Each of 62 3-9 year old children with any deep, primary molar cavity was included if a pulp exposure occurred during caries excavation. Exclusion criteria were irreversible pulp damage / uncontrolled hemorrhage. Using rubber-dam, fast setting calcium hydroxide (CH) and tooth restoration were placed. Patients were followed up for signs/symptoms. Survival analysis, the Kaplan-Meier method and the Mantel-Cox test were used for statistically analyzing the data.* ***Results***: *Seven patients (11.3%) dropped out. Controlled hemorrhage occurred in 25 exposures. Fourteen exposures were large and 46 were pin point. Out of 60 primary molars with DPC (in 55 patients), 7 failed by clinical and/or radiographic criteria. The remaining 53/60 (88.3%) teeth survived for 21.0 (±9.0) months. The 4 year cumulative survival rate by Kaplan-Meier analysis was 80%. All restorations remained in place with 3 needing replacement without affecting pulp survival.* ***Conclusion***: *The CH success rate of carious primary molar DPC justifies further research based on careful initial diagnosis of pulp inflammation reversibility.*

Key words: *Direct pulp capping, primary teeth, pulp survival, calcium hydroxide, children*

INTRODUCTION

In the permanent teeth, direct pulp capping (DPC) and partial pulpotomy are techniques used routinely for carious exposures. Preferable materials have been calcium hydroxide (CH) and mineral trioxide aggregate (MTA),[1-4] while other experimental materials are being tested.[5,6] Factors like material choice and possibly performer's training may influence success rates. For example, in a University clinic DPC of carious permanent teeth performed mainly by undergraduate students resulted in 78% successful outcome in the MTA treated group and 60% in the CH treated group for a mean of 2 years observation time.[7] When DPC was conducted by an experienced specialist, the successful outcome with MTA was 98% for a mean of 4 years.[4] A recent systematic review reveals an overall success rate of DPC for cariously exposed permanent teeth in the range of 72.9%-95.4%,[8] while a previous review had advised against the use of adhesive resin agents directly over exposed pulp.[9] DPC in the preferred form of partial pulpotomy is recommended for young permanent teeth by covering the exposed pulp with CH or even better with MTA after haemorrhage control.[10]

DPC of carious exposures in primary teeth however, is not recommended by the American and the British Academies of Pediatric Dentistry clinical guidelines.[10,11] Vital pulpotomy and indirect pulp treatment (IPT) are both the recommended strategies for deep carious primary teeth with a healthy pulp or one with reversible pulpitis and, in the case of a carious exposure, the recommended choice is that of vital pulpotomy. DPC may be used only in the case of an asymptomatic tooth with a small traumatic (non-carious) pulpal exposure; even then, 'prognosis is reported to be generally poor'.[11] DPC with CH or MTA is characteristically offered as an option for a pulp exposure, not excluding a carious one, only in an older child 1 or 2 years prior to normal exfoliation of the tooth.[11,12] It is explained that this is because in such a case 'treatment failure would not imply the need for a space maintainer following extraction, as it would in younger children'.

The unfavorable and/or unpredictable outcomes of carious primary teeth DPC come from early observational reports[13] as well as from congress presentations about the use of resin bonding agents listed in a textbook citation.[12] It is therefore conceded that only low level evidence (Grade C) exists for the British guideline: 'No studies of good quality are available thus recommendations are based on clinical experience and expert opinion'.[11] The negative recommendation of DPC for carious primary molars in the AAPD guideline[10]

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is similarly based in the previously mentioned textbook citation[12]. AAPD further 'encourages additional research for consistently successful and predictable techniques using biologically-compatible medicaments for vital primary teeth'.[10]

More recent clinical studies have shown some interesting DPC results for primary teeth. In addition to well accepted materials like CH and MTA, other materials, e.g. Portland cement, enamel matrix derivative, a calcium enriched mixture, and hydroxyapatite or its chemically similar tricalcium phosphate, have been used in these studies. Studies have been performed either experimentally, in non-carious primary pig teeth,[14] or mainly in cariously exposed human primary molar pulps in the clinic under various follow up times and with success rates ranging from 61% up to 100%.[15-19]

These later findings indicate that the carious primary teeth DPC warrants further research. The aim of the present study was to observe the medium to long term clinical and radiographic outcome of DPC with CH in carious pulp exposures of primary molar teeth.

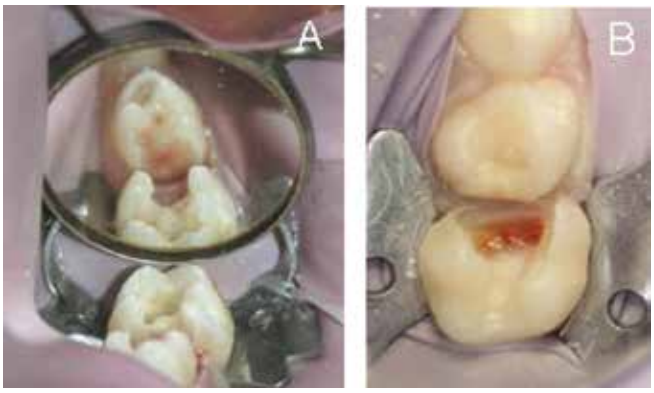
MATERIALS AND METHOD

The present study was initiated on February 2007. Its clinical part was conducted prospectively in the setting of a part time privately operated specialty clinic and was institutionally approved by Aristotle University Dental Faculty Ethics Committee (186/2010). All attending healthy cooperative dental patients aged 3-9 years old were eligible to enter the study, provided they fulfilled the following inclusion criteria, characteristic of a healthy pulp or those of one with reversible pulpitis:[11]

1. They had a deep primary molar cavity without history of pain, or with a stimulus-provoked pain which fully subsided soon without/after the administration of analgesics.
2. Clinically, there were neither symptoms present at examination nor any signs of pathological mobility, edema or fistula.
3. Radiographically, carious dentin was seen to contact the pulp, with no evidence of internal root resorption or furcation/apical pathology.

These clinical and radiographic diagnostic criteria were reviewed and dental treatment was performed by the prime author (NK). Local analgesia and rubber dam isolation was used as part of quadrant dentistry delivered on prescheduled appointments. Cavity preparation and deep caries excavation, in this order, involved high and low speed and usually hand instruments. Low speed was delivered last, caring to remove all carious peripheral dentine and as much near the pulp as it was necessary for a long lasting restoration without exposing the pulp. In case that exposure of any size occurred, it was covered with a minute amount of fast setting CH (Renew; SS White, Philadelphia, USA), following hemostasis in case of bleeding. Pulp exposure during deep caries excavation was diagnosed either by the mere presence of red pinpoint or spot or by pulp hemorrhage (figure 1). Hemorrhage had to be self resolved and hemostasis was not assisted by any medication or disinfectant. Any blood or exudate was gently wiped with a cotton pellet moistened with saline and followed by a dry one. Uncontrolled bleeding for more than 5 min, denoting 'irreversible' pulp damage, was criterion for exclusion. The parent or legal guardian had been informed during treatment planning for the treatment alternatives, possible discomfort and risks. If he/she consented for the DPC procedure, the patient was eligible to enter the study. Appropriate matching controls with parental approval for an alternative to DPC standardized procedure were difficult to find in this specialized practice based study and, therefore, there was no control group. The aim was to monitor pulpal survival time and relate it to other DPC studies or the alternative treatment of vital pulpotomy.

Figure 1: A. primary molar pulp considered exposed by the red spot appearing at axial wall; no hemorrhage. B. A primary molar pulp after hemorrhage control in 3 sites (including 2 pulp horns).



Evidently, during operative procedures, 62 child patients entered the study with 67 primary molar teeth. Following the DPC procedure, depending on the form of the cavity, each molar tooth was restored with an adhesive restoration or, in the case of a multi-surface cavity, with a primary molar crown (PMC). The former was either resin modified glass ionomer cement (RMGIC: Ketac N100 – while still on the market – or Vitremer) for extended class II cavities (often slightly exceeding the proximo-lingual or proximo-buccal corner, as in figure 2), or composite resin (Z250) for class I cavities (possibly entering buccal or lingual surface to some extend) after being based with Vitrebond. All plastic restorative and base materials as well as the PMCs were of 3M-ESPE (St Paul, MN, USA).

Figure 2: Periapical/bitewing radiographs of a lower first primary molar before (A) and 17 months after (B) successful DPC. Extended class II RMGIC restoration at the same recall (C).

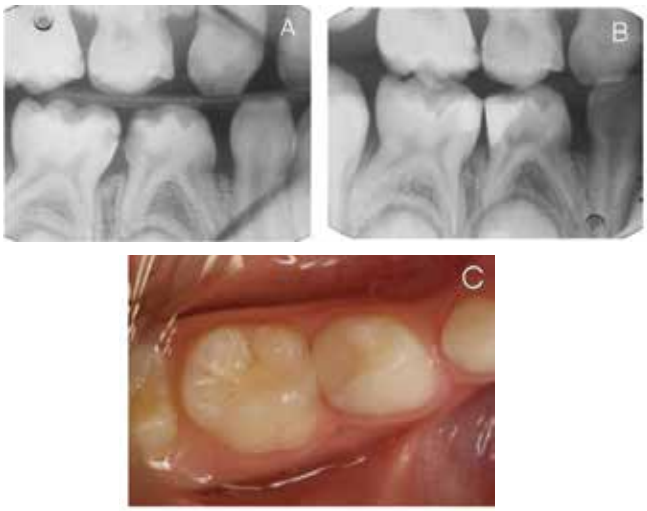


Table 1. Descriptive statistical presentation of the carious primary molar DPC data.

Examination criteria	Number of examined teeth	Number of successful treatments	Successful treatments (%)	Mean follow-up of successful cases (mo)	Follow-up range of successful cases (mo)
Clinical	60	55	91.7	25.7±12.8	10-52
Clinical plus radiographic	60	53	88.3	21.0± 9.0	10-44

Table 2. Life table analysis of survival primary molar DPC data based on clinical plus radiographic evaluation.

Interval (months)	No of teeth at beginning of interval	Probability of failure (%)	Probability of surviving (%)	Cumulative success rate %
0-12	60	5	95	95
12-24	52	8	92	87
24-36	19	8	92	80
36-48	5	0	100	80

Mean (±SE) survival time: 38.7±2.0 months

Oral hygiene instructions had been given prior to the restoration. The teeth followed up for signs/symptoms. In order to minimize drop outs, the patients' parents were sent notices and/or conducted by phone and many of them were given compliance motives like free check-ups. The protocol was such that all children were to be seen twice annually for check-ups and fluoride varnish treatment, as these were caries risk patients. Pulp and restoration survival were clinically evaluated by NK, observing the aforementioned criterion No. 2 set for inclusion (i.e. absence of signs and symptoms). New radiographs adequately revealing the molar furcation area were taken at the, approximately annual, check-ups. All final follow up radiographs were for the purpose of the study evaluated for DPC success (absence of internal or pathological external resorption, furcation or periapical bone pathology) independently, by the second and third authors (KNA, AA), at an Aristotle University Dental School darkroom. Possible differences were resolved by consensus between them, following the recording of inter-examiner accord.

Descriptive statistical analysis was used after summarizing the available data. Survival analysis and the Kaplan-Meier method were used to estimate the probability of DPC failure. Mean time failure between various groupings of teeth was compared by applying the Mantel-Cox test. All the statistical analyses were performed with the SPSS v.15.0 statistical software.

RESULTS

Seven patients (11.3%) dropped out as they did not return for any recall. It was possible for only 4 of those to be reached during the 1st year on their parent mobile phone; none included dental symptoms among reasons for non-attending recalls. Out of the 60 teeth in 55 patients finally answering to recalls, 5 had received class I composite restorations, 51 class II RMGIC restorations and 4 PMC restorations. Distribution of teeth were 21 upper first, 10 lower first, 14 upper second and 15 lower second primary molars. Mean age (±SD) of the 55 patients at DPC treatment was 6.0±1.7 years and female/male ratio was 31/24.

Five teeth failed as a result of pulp necrosis diagnosed clinically by excess mobility or fistula at follow-up times between 1 and 14 months while 2 further teeth presented each with radiographic evidence of treatment failure at 12 and 28 months, i.e. furcation pathology or internal resorption leading to root perforation (figure 3). The remaining 53/60 (88.3%) teeth were asymptomatic for a mean (±SD) clinical and radiographic observation time of 21.0 (±9.0) months (table 1). Inter-examiner accord for radiographic evaluation was high (κ=0.96).

Table 2 presents the life table analysis of survival data based on the clinical plus radiographic evaluation and the data are graphically presented in figure 4. Probability of the primary pulp surviving a carious DPC was 95% for 12 months and the cumulative success rate for a period of 48 months was 80% with mean (±SE) survival time 38.7±2.0 months.

All but 2 of 25 exposure cases with controlled pulp hemorrhage (92.0%) and all but 5 without evident hemorrhage (85.7%) were successful cases, the difference of frequencies between them by the Mantel-Cox test being not statistically significant ($\chi^2(1)=0.325$, p=0.568). From 46 small or pin point exposure sites, 42 (91.3%) were successful cases and so were 11 (78.6%) out of 14 large, 0.5-1.5mm or pin head, exposure sites. Similarly, this difference between small or large exposure sites was not statistically significant ($\chi^2(1)=1.812$, p=0.178).

Figure 3: A. Bitewing radiograph of an upper second primary molar 28 months after unsuccessful DPC leading to generalized internal resorption. B. A wide root perforation is evident after tooth extraction.

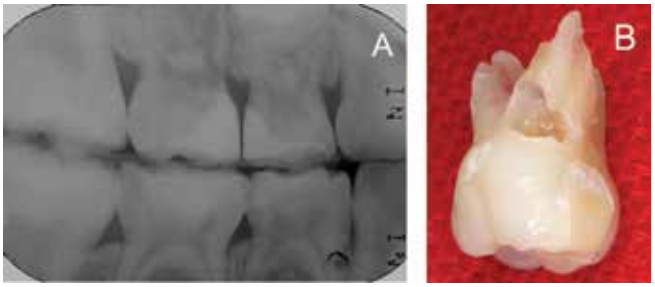
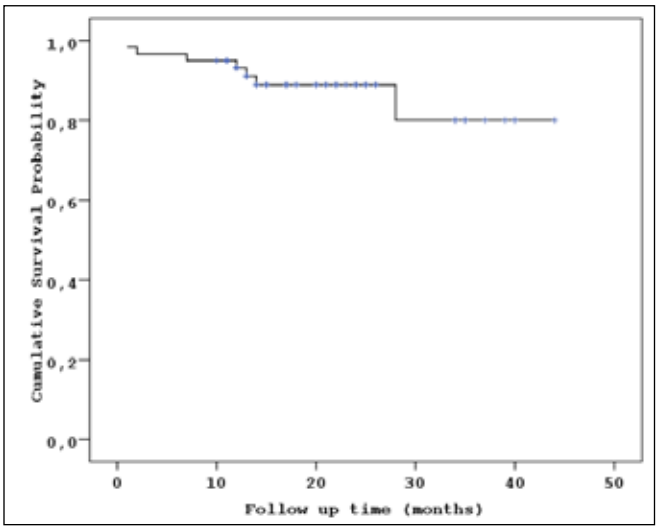


Figure 4: Kaplan-Meier probability estimate of pulp survival for carious primary molar DPC based on clinical plus radiographic criteria.



All restorations remained in place with two needing repair because of marginal defect seen at 14 and 16 months and one needing replacement with a PMC after 25 months because of new undermining caries in neighboring proximal surface, i.e. not secondary caries. All 3 were in successful DPC cases and needs were met with no effect on pulp survival.

DISCUSSION

The pulp survival after primary molar DPC of the present study is lower than the other recommended treatment choice for such teeth with a healthy pulp or one with reversible pulpitis, i.e. vital pulpotomy with MTA or CH.[10,11] MTA pulpotomies have given the highest clinical 98.5% and 98% radiographic success, averaged from 8 available studies with a success range of 94-100%.[20] Regarding the other recommended treatment choice for similar primary pulp condition without exposure, that of IPT, the present DPC success rate is somewhat lower than the 93% success of five dental school studies reviewed by Coll.[21] It is also lower than the 96.5% IPT success found at the same specialty practice – and operator – with the present DPC study.[22]

DPC cases in the present study occurred mainly in extended class II or multi-surface cavities. According to a histologic study,[23] this implies that they all had partially inflamed pulps, yet reversibly so for most of them as judged by their survival on follow ups. The reason 7 cases failed is not known. It is possible that technical inadequacies of performing the DPC are to blame. It is however possible that misjudgment and overoptimistic diagnosis of pulp condition led to inclusion of symptomatic teeth, with a pulp inflammation that could not be reversed with present treatment modalities. The primary tooth pulp maintains structures necessary for its healing and repair until advanced stages of root resorption.[24] Its histological similarity with the permanent tooth pulp suggests comparable healing capacity to withstand inflammation and means that the management of the compromised primary tooth pulp needs to be reappraised.[25] Restorative procedures with hermetic adhesion of dental materials to the sound peripheral dental tissues are now more feasible than in the past, further aided with materials like e.g. glass ionomers, which are recommended for covering MTA pulp capping or partial pulpotomies.[10] Following any vital pulp treatment, the objective is that 'the restorative material should seal completely the involved dentin from the oral environment'[10,11] and this was followed in the present study.

In the current teaching of methods of primary pulp therapy in UK and Ireland dental schools, DPC is the least frequently taught one.[26] Half of the respondents stated that they taught it, with hard-setting CH being the most popular DPC lining material. In the US, between 52% and 69% of under- or post-graduate pediatric dentistry departments or diplomates do direct primary tooth pulp caps using predominantly (60%) CH.[27] It was however inferred from both of those studies that DPC probably involved traumatic and generally non-carious exposures. In a similar survey in Brazil with a nearly 50% response rate, DPC was taught by 69% of dental schools with CH preferred by 97% of them. From their answers to case scenarios it was clear that this concerned DPC following complete caries removal and only 10% of the answers concerned carious DPC.[28]

In the present study, all cavities to be restored were radiographically highly suspected for pulp exposure. There was no intention to expose the pulp and, in all cases included in the study, a carious exposure occurred before complete caries removal. Deep caries removal was carefully attempted with low speed burs and thus it was possible to stop in 35/60 cases just at the moment a red spot or exposure point appeared, just before the event of any hemorrhage. In the literature there is a characteristic absence of views on the cut point that defines a pulp exposure, i.e. whether there should necessarily be flow of hemorrhagic fluids or just the red spot of pulp wall or the red point of a pulp horn. For the purpose of this study, there was no discrimination between those and were all considered as pulp exposures. Despite the limited number of the two kinds of exposure with or without hemorrhage, no statistically significant difference was evident between them.

Another interesting association was that of the size of exposure with pulp survival. Although the low number of 14 large exposures as opposed to 46 small or pin point ones does not allow for convincing statistics, exposure size did not seem to significantly increase the failure of DPC. A similar conclusion has been reached for permanent teeth.[29]

Fast setting CH was chosen in the present study because, at its initiation in 2007, it was still considered the standard material for DPC in permanent teeth.[30] Another advantage is that the material is easy to handle and can quickly be placed only at the exposure site of the small sized primary molars, the first ones in particular. It does promote reparative dentin formation, but this has been shown to be less predictable on the long term with the appearance of channel defects.[31] In view of the more bioactive and predictable materials like MTA used nowadays,[3,4] CH might not be the first choice any more for the primary teeth either.

Since coronal pulp inflammation has histologically been found to be significantly more extended as a result of proximal than of occlusal primary molar caries,[32] future randomized clinical trials among any pulp treatments should take into account the location of pulp exposure – proximal or occlusal – as well as the matching of the restoration type and material. So far such comparative studies are lacking even between the two recommended choices mentioned for deep caries pulp treatment, those of vital pulpotomy and IPT.

One limitation of this study is the non-blind design for the clinical evaluation. This, however, was overcome by performing the radiographic evaluation blindly to the clinical evaluation by two independent assessors and working on those data for pulp survival outcomes. Another limitation is the lack of a suitable control, but that was the case in another similar specialty practice based study on permanent molar DPC,[4] as consent cannot always easily be granted in such environments for matching controls. Finally, it should not be implied that conclusions of these results from a specialty practice can be readily applied in the general dental practice.

CONCLUSION

The success rate of carious primary molar DPC with CH found in this study was moderately high. This calls for controlled clinical studies with newer, alternative pulp capping agents against other recommended treatments.

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