Caries Control and Other Variables Associated With Success of Primary Molar Vital Pulp Therapy

Raj Vij, BDS, DDS James A. Coll, DMD, MS Preston Shelton, DDS, MS Naila S. Farooq, BDS, MSc, DDPH

Dr. Vij is a former pediatric dental resident at the University of Maryland Dental School, and is now in private practice in Akron, Ohio; Dr. Coll is in private practice in York, Penn and is clinical professor, Department of Health Promotion and Policy, University of Maryland Dental School; Dr. Shelton is associate professor and program director of the Post Graduate Pediatric Dental Residency, Department of Health Promotion and Policy, University of Maryland Dental School; Dr. Farooq is a former pediatric dental resident at the University of Maryland Dental School, Baltimore, Md, and is now in private practice in Commerce, Mich.

Correspond with Dr. Coll at dmd@suscom.net

Abstract

Purpose: This research evaluated initial treatment of deep dental caries with caries control (CC) procedure and the effect of other factors on the success of indirect pulp therapy (IPT) and formocresol pulpotomy (FP).

Methods: Retrospective chart audits were performed on 226 primary molars with deep caries approaching the pulp that were treated using IPT and FP. Mean follow-up was 3.4 years. CC with glass ionomer cement (GIC) was performed on 50 of the 226 teeth 1 to 3 months before pulp therapy.

Results: IPT therapy was successful 94% of the time, whereas FP was successful 70% of the time. The initial use of CC increased the IPT/FP success rate to 92% vs a 79% success rate in teeth without CC. Primary molar FP success on primary first molars was 61% vs 83% in second molars. IPT therapy was successful 92% of the time for first molars vs 98% of the time for second molars. Thirty-six percent of the FP-treated teeth exfoliated early vs 2% of the IPT-treated teeth. Primary first molars with reversible pulpitis had a higher success with IPT (85%) vs FP (53%). The type of final restoration did not affect IPT or FP success, except that FPs restored with an immediate IRM (Dentsply/Caulk, Milford, Del) restoration decreased success to 39%.

Conclusions: IPT for the treatment of deep dental caries lesions produced greater long-term success than FP. FP success in primary first molars was lower compared to IPT success, especially in teeth with reversible pulpitis. Also FP-treated teeth showed significantly earlier exfoliation patterns. The prior treatment of deep dental caries lesions with CC procedures improved the subsequent IPT or FP success. (*Pediatr Dent.* 2004;26:214-220)

KEYWORDS: CARIES CONTROL, INDIRECT PULP THERAPY, PULPOTOMY

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A 1997 survey of predoctoral pediatric dental program directors clearly shows that there is a lack of consensus in vital pulp therapy in primary teeth.[1] The survey found that 26% preferred indirect pulp therapy (IPT), 70% preferred pulpotomy, and 2% advocated direct pulp capping for the treatment of deep dentinal caries. Similar disparities in treatment are obvious in pediatric dentistry text books.[2-5]

The formocresol pulpotomy (FP) remains the most widely studied pulpotomy procedure for vital pulp therapy in primary teeth. One long-term study found success rates of 70% after 3 years using full-strength formocresol[6]; another using formocresol diluted 1:5 found a 98% pulpotomy success with a 36 to 60 month follow-up.[7] For both of these studies, the pulpotomy procedure was based on the tooth having a carious exposure.

Because a 1978 study[8] showed that formocresol became distributed systemically when a pulpotomy was done, efforts were begun to find an acceptable substitute for formocresol. Glutaraldehyde,[9,10] ferric sulfate,[11,12] and electrosurgery[13-15] have all been tested as pulpotomy replacements for FP in teeth with a diagnosis carious exposure. Success rates for these different pulpotomy treatments have varied (77%-100%), depending on the

study and time of follow-up. Calcium hydroxide used as a pulpotomy medicament for teeth with pulpitis have reported success rates of 59% and 88%.[16,17] One comparative study of IPT to FP using 133 teeth reported a 93% vs 74% success rate, respectively.[18]

Caries control (CC) procedures with glass ionomer cement have been advocated as a pretreatment before definite pulp therapy in primary teeth.[5] Glass ionomer cements are known to have an antimicrobial and remineralization effect on caries.[19] However, there have been no studies to assess if CC influences the success of the subsequent pulpal therapy in primary teeth being treated for deep dentinal caries.

The purpose of this retrospective study was to study the effects of CC procedures on subsequent IPT or FP success in a private practice setting. Additionally, the study aimed to examine other factors such as molar type, final restoration, and time on success of vital pulp therapy in primary molars.

Methods

This was a retrospective study of 2 groups of patients that had treatment for deep caries approaching the pulp. The study was reviewed by the University of Maryland at Baltimore's Institutional Review Board and was classified as "exempt" because the study was a retrospective chart review in which all the patient identifiers were eliminated. The first group (group I) of patients was from the previously published Farooq et al study[18] that consisted of 133 molar teeth in 88 children, of which 78 teeth received FP and 55 received IPT between 1975 and March 1996. The second group (group II) consisted of 93 teeth, of which 53 were treated with IPT and 40 were treated with FP. Group II was derived from 53 children treated between November 1996 and January 1999. Six pediatric dentists treated these 141 patients in 3 private dental offices. The data from group I was combined with group II due to the similar criteria used for treatment.

CC which is similar to atraumatic restorative treatment (ART),[20,21] was performed on 78 of the 226 teeth 1 to 3 months prior to IPT or FP. CC was done at the initial visit on large carious lesions without local anesthetic. CC consisted of removing superficial caries using a spoon excavator or slow-speed bur to create retention for the temporary filling of either reinforced zinc oxide eugenol (N=20; IRM, Dentsply/Caulk, Milford, Del) or glass ionomer cement (GIC; N=58; Ketac Silver, Espe Dental, Seefeld, Germany). Teeth treated by CC were primarily those that exhibited signs and symptoms compatible with reversible pulpitis. In this study, reversible pulpitis pain was defined as provoked pain caused by chewing food in which the pain dissipated in 20 minutes or less, and there was no soft tissue pathology, radiographic furcation radiolucency, or spontaneous pain.

Teeth that were treated with FP had radiographic deep caries approaching the pulp in which complete caries removal resulted in a mechanical pulp exposure. In this procedure, vital appearing pulp tissue was amputated with slow-speed round burs or spoon excavators, bleeding was controlled with dry cotton pellets, and full-strength formocresol was applied for 5 minutes. The pulp chamber was then filled with IRM. All but 13 of the FPs were immediately restored at the same visit with stainless steel crowns, amalgam, GIC, or composite. The immediate restoration in 13 of the 78 FPs from group I was with IRM only.

Teeth treated with IPT had radiographic deep caries approaching the pulp which were the same as FP-treated teeth except all the caries were not removed to avoid a pulp exposure. (Figure 1) In this procedure, dentin with caries approaching the pulp was removed with a slow-speed round bur. However, the deepest layer of decayed dentin was left in place to avoid a pulp exposure. In 80% of these cases, GIC liner/base (Vitrabond, 3M, Minneapolis, Minn) was used to cover the dentin. The remaining teeth had the GIC used as the final filling or as the cement inside the steel crown, which covered the dentin. All teeth treated with IPT were restored immediately with steel crowns, amalgam, glass ionomer, or composite.

Both the teeth treated with both FP or IPT met the same pretreatment criteria, including:

1. caries lesions close to the pulp;
2. no clinical signs of gingival swelling or tooth mobility;
3. no radiolucency;
4. no internal resorption;
5. no pain or pain compatible with reversible pulpitis that could be relieved by analgesics or brushing after 20 minutes; in addition,
6. adequate pre-operative and postoperative radiographs of at least 1 year recall; and
7. adequate treatment documentation was available.

Two pediatric dentists assessed all the teeth, and one of these 2 dentists was not one of the 6 dentists who performed the treatment. The radiographs and chart notes for each tooth were independently reviewed, and there was a 97% agreement in their ratings of success. In cases of disagreement, after conferring with a third pediatric dentist, a mutual consensus was reached. The pulp therapy was considered successful if all of the following were noted postoperatively:

1. no fistula or gingival swelling associated with the treated tooth;
2. no abnormal mobility;
3. no pain to percussion or history of pain in the tooth;
4. no radiographic signs of internal or external pathologic root resorption, widened PDL, or pathologic radiolucency.

Success rates for IPT and FP were computed for the time intervals of 1, 2, 3, and more than 3 years. Not all teeth were evaluated in each time frame, but a failure in one time interval was counted as a failure in all subsequent intervals. An assessment from treatment notes and postoperative radiographs also was made as to whether the tooth exfoliated early, normally, or later than expected as compared to the adjacent and contralateral teeth. Although this study is a retrospective chart audit in which there are not true control and treatment groups, the data was still statistically evaluated using chi-square analysis.

Table 1. Effect of Time on Indirect Pulp Therapy (IPT) and Formocresol Pulpotomy (FP) Success

	0-1 year	1-2 years	2-3 years	>3 years
FP success	95%	84%*	76%*	70%*
IPT success	98%	96%*	94%*	94%*

*Percentages are significantly different for each time category by chi-square (P=.004).

Results

There were a total of 108 IPTs and 118 FPs treated by a total of 6 pediatric dentists to give a total of 226 teeth available for study. In group I, the minimum follow-up time was 1.9 years (±4 years), while in group II it was 1 year (±2.5 years). For both groups, there was an overall mean follow-up of 3 years, 4 months. The success rates for IPT and FP from groups I and II were not statistically different (P=.4), allowing the groups to be combined.

Indirect pulp therapy vs formocresol pulpotomy success and effect on exfoliation

The success for IPT after more than 3 years was 94%, while FP success was 70% (P=<.001) based on clinical and radiographic findings. Thirteen FPs having IRM as their final restoration had a low success rate of 39%. Excluding these 13 FPs left 105 FPs all with immediate restorations like the IPT group. The 74% FP success rate in these 105 FPs was still significantly lower than the 94% IPT rate.

When the success rates of IPT and FP were analyzed over time, it was found that in year 1 the IPT success of 98% was not different from the FP success of 95%. In year 2 and in all subsequent years, IPT success was better than FP success (Table 1).

An assessment was made of the IPT or FP tooth's exfoliation. One hundred and one of the IPT teeth and 74 of the FP teeth could be assessed for exfoliation; 2% of the IPT teeth were categorized as having early exfoliation, compared to 36% of the FPs. These exfoliations were significantly different. All of the remaining teeth were categorized as having normal exfoliation.

Caries control

The effect of performing a CC procedure 1 to 3 months prior to IPT or FP was tested in the 226 teeth. There were 50 of 58 glass ionomer CC restorations that remained in place prior to IPT or FP. These 50 were termed as successful GIC CC restorations. This grouping was compared to 148 teeth that never had a CC restoration, together with 13 that lost their CC restoration plus 15 that had intact IRM CC restorations prior to pulp therapy. This resulted in a sample of 176 teeth categorized as not having successful GIC caries lesion control.

A comparison was made between the success of IPT or FP in the 50 teeth having had successful GIC CC restorations vs the success of 176 teeth categorized as not having successful GIC CC restorations. Teeth having an initial GIC CC restoration had a 92% success rate vs a 79% IPT/FP success rate in teeth not having a GIC CC restoration. There was a much lower success rate (67%) for IPT/FP following the intact IRM CC restorations. Treating first primary molars with GIC CC restorations before pulpal therapy resulted in a 90% IPT/FP success rate vs 71% success when no GIC CC restoration was used (Table 2).

Primary first molar vs primary second molar

The effect of the type of molar, whether first or second, and the type of pulp therapy rendered was evaluated (Table 3). Primary first molars had a combined IPT/FP success rate of 76%, which was lower than the IPT/FP success rate of 91% in the primary second molars. The IPT success in primary first molars was 92% compared to 61% for FP. The FP success in first molars was 61% vs 83% for second molars, and the IPT success was 92% for first molars vs 98% for second primary molars.

The treatment of primary molars with a history of pain compatible with reversible pulpitis was tested to determine if IPT was more effective than FP in these teeth. There was a total of 39 out of the 131 primary first molars treated for reversible pulpitis, with 20 having IPT and 19 FP. The success rate in these 39 teeth treated with IPT was 85%, which was statistically better than the 53% success following FP. In the 30 primary second molars with a history of pain compatible with reversible pulpitis, the IPT success of 93% was not statistically different from the FP success of 75% (Table 3).

The percentage of FPs in the maxillary and mandibular primary first molars was compared to the percentage of FPs in the second molars. Fifty-three percent of the 131 primary

Table 2. Effect of Glass Ionomer Cement (GIC) or Intermediate Restorative Material (IRM) Caries Control (CC) on the Combined Subsequent Indirect Pulp Therapy (IPT) and Formocresol Pulpotomy (FP) Success

	Subsequent IPT/FP success		
			Significance
All primary molars (N=226)	No GIC CC 139/176 (79%)	GIC CC 46/50 (92%)	P=.06NS*
Molars with IRM or GIC CC(N=65)	IRM CC 10/15 (67%)	GIC CC 46/50 (92%)	P=.04
Primary first molars success(N=131)	No GIC CC 71/100 (71%)	GIC CC 28/31 (90%)	P=.05

*NS=not significantly different by chi-square analysis.

first molars were treated with FP, which was not statistically different than the 51% FP rate in the second molars.

Effect of restoration type on pulp therapy success

The effect of the restoration placed at the time of pulp therapy was tested to see if the type of restoration affected success. Of the 213 that had permanent restorations placed at the time of treatment, 198 were restored with stainless steel crowns and 15 with amalgam, composite, or glass ionomer restorations. The 83% success rate for the IPT/FPs restored with stainless steel crowns was not statistically different from the 87% success in teeth restored with intracoronal restorations.

Table 3. Effect of Type of Molar on Indirect Pulp Therapy (IPT) or Formocresol Pulpotomy (FP) Success

	Primary first molar	Primary second molar	Significance
Combined IPT/ FP success	99/131 (76%)	86/95 (91%)	*P*=.007
Success first molars	IPT 56/61(92%) FP 43/70 (61%)		*P*=.04
FP vs IPT	FP 43/70 (61%)	IPT46/47 (98%)	*P*=<.001
FP success	FP 43/70 (61%)	FP40/48 (83%)	*P*=.02
IPT success	IPT 56/61(92%)	IPT46/47 (98%)	NS**P*=.4
Molars with	IPT success	FP success	Significance
Reversible pulpitis first molar	17/20 (85%)	10/19 (53%)	*P*=.04 Chi-square using Fisher exact test
Reversible pulpitis second molar	13/14 (93%)	12/16 (75%)	NS* *P*=.31

*NS=not significantly different by chi-square analysis.

Discussion

Comparison of the present study's FP success to other pulpotomy research showed similar results when time is considered. In the present study, the 0- to 1-year time interval for FP success was 95% compared to the 96% success rate reported by Fei et al[11] for 1:5 diluted FP after 12 months. Longer time intervals have shown poorer success for FP. Redig[22] reported an 85% success rate for a single-visit FP for deep caries after 18 months, which compares to the 84% success in the 1- to 2-year interval for the present study. Fuks et al[9] had an 83% success rate in treating carious exposures after 25 months using glutaraldehyde, while Tsai et al[10] had a 79 % success rate after 36 months.

Only a few pulpotomy studies show comparable success to the present IPT findings, and those studies have certain limitations. This study's IPT success of 94% in teeth followed for greater than 3 years is not matched in any pulpotomy study other than the one study by Morowa et al[7] in which they demonstrated 98% success using 1:5 diluted formocresol. The diluted formocresol does not avoid the systemic distribution described by Myers[8] and is not sold commercially, making its widespread use limited.[23]

Also of interest in the present study is that FPs show significantly more failures than IPTs over time. IPT, therefore, appears to be a better alternative to pulpotomy procedures to treat caries close to the pulp. Other studies have found similar success for IPT. Aponte[24] (100% IPT success) as well as Nirschl and Avery[25] (94% IPT success) have comparable IPT results to the present study, but with shorter follow-up. Kerkhove et al[26] found a slightly lower IPT success of 89% after 12-month follow-up. Falster et al[27] also reported a 96% IPT success after 2 years using an adhesive resin without a liner in 25 teeth, which is comparable to the present study where glass ionomer was used over the deep decay. This same study also reported a success rate of 83% after 2 years with calcium hydroxide in 23 other teeth treated with IPTs. A recent study by Al-Zayer et al[28] showed a 95% success with IPT in 187 teeth, some of which were followed up to 73 months using calcium hydroxide liner.

CC was done with 2 different materials in this study. Comparison to other studies is not possible, since this is the first study conducted on the subject. This study showed that successful GIC CC restorations did improve the success of the subsequent IPT/FP. Perhaps the reason for the improved success following CC restorations with GIC may be due to the antimicrobial effect on *mutans streptococci*[19] or the "drying out" of the moist soft leathery decay that was observed by the treating dentist after 1 to 3 months. This drying-out effect on the dentin seemed to help avoid pulp exposures when doing IPT.

In addition, GIC CC restorations allow the tooth to develop signs or symptoms of irreversible pulpitis if the pulp is irreversibly involved. Conversely, not using GIC CC restorations may result in treating some primary molars with vital pulp therapy that had irreversible pulpitis that was not clinically evident to the treating dentist, which, consequently, results in lower pulp therapy success. There are newer glass ionomer materials and it appears they are retained better than Ketac Silver as a CC restoration. The greater success after GIC CC restorations in subsequent pulp therapy suggests that it is better than IRM CC, but further research with larger sample sizes using different glass ionomer materials is needed.

These lower success rates found by the authors in this study with first molars does not agree with some reports.

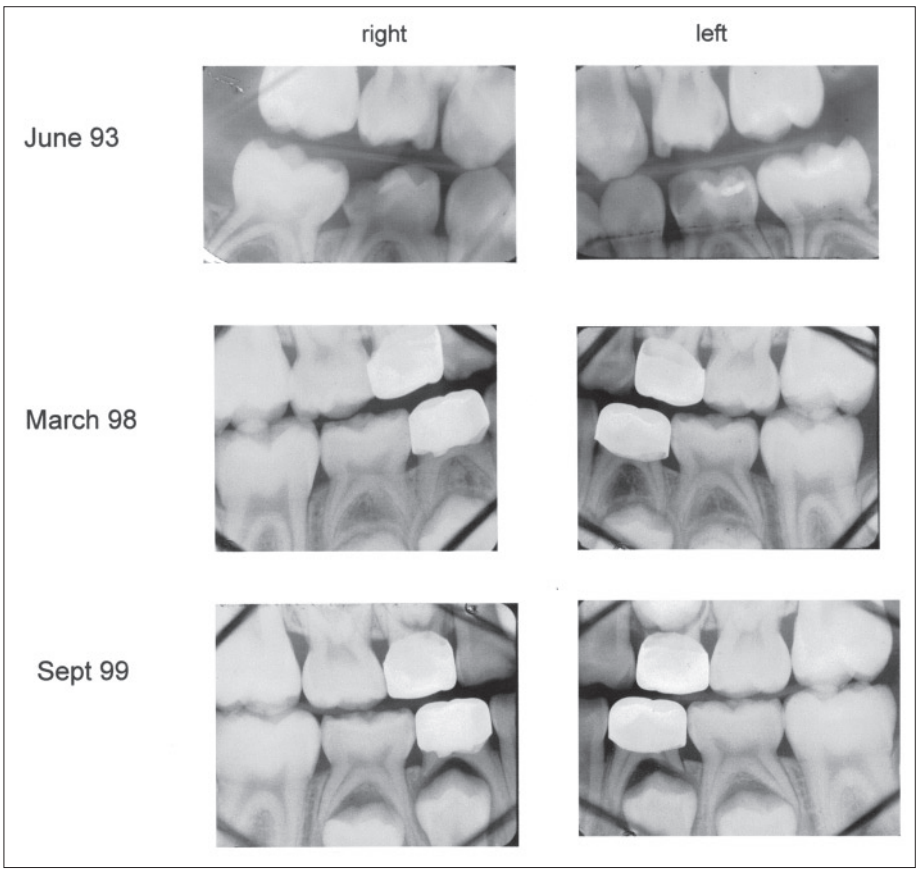

Figure 1. This is an example of treating bilaterally similar deep caries approaching the pulp in 2 different ways. The right molar received a formocresol pulpotomy while the left received an indirect pulp therapy after 1 month of glass ionomer caries lesion control. Postoperative radiographs at 5 and 6 years later show good success in both molars with normal exfoliation.

Strange et al[29] found no difference in radiographic success for primary first and second molars treated with formocresol/ZOE sub-base pulpotomies but did find a difference between maxillary and mandibular molars. Smith et al[12] found no difference between first and second molars or maxillary vs mandibular molars treated with ferric sulfate pulpotomies. It must be noted that the latter 2 studies categorized success and failure so that a tooth rated as a failure in one time frame could be rated a success in the next time frame. In the present study, a tooth categorized as a failure was always counted as a failure in all future time frames. This may account for the difference in findings or the fact different pulpotomy agents were used.

A more recent study showed significantly lower FP success in the primary first molar as in the present study. Holan et al[30] investigated 341 primary molars receiving FPs followed for a mean of 27 to 29 months. When their data is reanalyzed using a chi-square analysis, the 173 primary first molars had a statistically lower success rate of 82% vs the second molar's success of 91%. The Holan et al study suggests that the first molar's FP success would even be lower than the second molar's if the follow-up was of similar duration to the present study.

It was also interesting to note the difference in the results of treating primary first and second molars when these teeth are diagnosed with reversible pulpitis. The primary first molar with reversible pulpitis pain exhibited a significant improvement in their success rate when treated with IPT compared to FP, while the primary second molars did not. Farooq et al[18] found no significant difference between IPT and FP success treating teeth with reversible pulpitis. Since this study had those same 133 teeth plus 93 more, the larger sample size allowed the statistical difference in primary first molars to be evident. A larger sample may reveal a statistical difference in primary second molar IPT and FP success in treating reversible pulpitis.

The current study found the type of restoration had no significant effect on IPT/FP success whether a stainless steel crown, or permanent restoration of amalgam, composite, or glass ionomer was placed. However, only 15 intracoronal restorations were evaluated and most were occlusal restorations. Holan et al[30] published similar results showing FPs restored with stainless steel crowns and amalgam succeeded equally, but 1 surface amalgam was significantly better than 2 surface amalgam fillings. Farooq et al[18] whose data is included in the present study, found that an IRM immediate restoration following FP resulted in a significantly lower success rate of 39%. Guelmann et al[31] had a 31% success for emergency FPs immediately restored with IRM and followed for 1 year. The high chance of failure following emergency FP restored with IRM without a final permanent restoration is likely a result of a poor marginal seal and should be avoided. Therefore, it seems likely that successful IPT or FP therapy is enhanced by a restoration that prevents microleakage.

The early exfoliation of primary molars treated with FP was expected and concurs with others research.[7] This early exfoliation following FP is likely a result of a chronic infection that is not clinically or radiographically evident in many FP-treated teeth in the furcation area. Additionally, there has been a report of delayed eruption following FP[5]; however, delayed eruption was not seen in any of the FP teeth analyzed in this study. The fact that almost all IPT-treated teeth had normal exfoliation is just another reason justifying its use.

The results of the present study should be considered with regard to its limitations. Readers should be aware that this is a retrospective review of dental treatment performed by

several different operators over a period of several years. Certainly a better research design would be a prospective, randomly-assigned, double-blind study, provided that institutional Review Board approval could be obtained for such a proposal. Additionally, since this is a retrospective study with several operators, one cannot rule out biases in the selection of treatment of a particular tooth and operator preferences. Nevertheless, this report may represent the findings and successes that might be expected in clinical practices.

Conclusions

1. Long-term vital pulp therapy was more successful using IPT compared to FP.
2 Glass ionomer CC for 1 to 3 months, before vital pulp therapy, improved the vital pulp therapy success, especially in primary first molars.
3. Primary molars having reversible pulpitis were successfully treated with IPT, with primary first molars having a much higher success rate with IPT compared to FP.
4. Vital pulp therapy success in the primary first molar was significantly lower than the primary second molar, mostly due to the lower pulpotomy success in the primary first molar.
5. Teeth treated with FP had a significantly earlier exfoliation than those with IPT.

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References

1. Primosch RE, Glomb TA, Jerrell RG. Primary tooth pulp therapy as taught in predoctoral pediatric dental programs in the United States. *Pediatr Dent*. 1997;19:118-122.
2. Fuks AB. Pulp therapy in the primary dentition. In: Pinkam JP et al, eds. *Pediatric Dentistry: Infancy through Adolescence*. 2nd ed. Philadelphia: WB Saunders Co; 1994.
3. Fuks AB. Pulp therapy for the primary and young permanent dentitions. *Dent Clin N Am*. 2000;44:571-596.
4. Mathewson RJ, Primosch RE. Pulp treatment. In: Mathewson RJ, Primosch RE, eds. *Fundamentals of Pediatric Dentistry*. 3rd ed. Chicago: Quintessence; 1995.
5. McDonald RE, Avery DR. Treatment of deep caries, vital pulp exposure, and pulpless teeth. In: McDonald RE, Avery DR, eds. *Dentistry for the Child and Adolescent.* 6th ed. St Louis: CV Mosby Co; 1994.
6. Rolling I, Thylstrup A. A 3-year clinical follow-up study of pulpotomized primary molars treated with formocresol technique. *Scand J Dent Res*. 1975;83:47-53.
7. Morawa AP, Straffon LH, Han SS, Corpron. Clinical evaluation of pulpotomies using dilute formocresol. *J Dent Child*. 1978;42:360-363.
8. Myers D, Shoaf HK, Dirksen TR, Pashley DH, Whitford GM, Reynolds KE. Distribution of 14C-formaldehyde after pulpotomy with formocresol. *J Am Dent Assoc*. 1978;96:905-913.
9. Fuks AB, Bimstein E, Guelman M, Klein. Assessment of a 2 percent buffered glutaraldehyde solution in pulpotomized primary teeth of schoolchildren. *J Dent Child*. 1990;57:371-375.
10. Tsai TP, Su HL, Tseng LH. Glutaraldehyde preparations and pulpotomy in primary molars. *Oral Surg Oral Med Oral Pathol.* 1993;76:346-350.
11. Fei AL, Udin RD, Johnson R. A clinical study of ferric sulfate as a pulpotomy agent in primary teeth. *Pediatr Dent*. 1991;13:327-332.
12. Smith NL, Seale NS, Nunn ME. Ferric sulfate pulpotomy in primary molars: A retrospective study. *Pediatr Dent*. 2000;22:192-199.
13. Mack RB, Dean JA. Electrosurgical pulpotomy: A retrospective human study. *J Dent Child.* 1993;60:107-114.
14. Dean JA, Mack, RB, Fulkerson BT, Sanders BJ. Comparison of electrosurgical and formocresol pulpotomy procedures in children. *Int J Paediatr Dent*. 2002;12:177-182.
15. Fishman SA, Udin RD, Good DL, Rodef F. Success of electrofulguration pulpotomies covered by zinc oxide and eugenol or calcium hydroxide: A clinical study. *Pediatr Dent.* 1996;18:385-390.
16. Schroder U. A 2-year follow-up of primary molars pulpotomized with a gentle technique and capped with calcium hydroxide. *Scand J Dent Res.* 1978;86:273-278.
17. Helig J, Yates J, Siskin M, McKnight J. Calcium hydroxide pulpotomy for primary teeth: A clinical study. *J Am Dent Assoc*. 1984;108:775-778.
18. Farooq NS, Coll JA, Kuwabara A, Shelton P. Success rates of formocresol pulpotomy and indirect pulp therapy in the treatment of deep dentinal caries in primary teeth. *Pediatr Dent*. 2000;22:278-286.
19. Loyola-Rodriguez JP, García-Godoy F, Lindquist, R. Growth inhibition of glass ionomer cements on mutans streptococci. *Pediatr Dent*. 1994;16:346-349.
20. WHO. Revolutionary new procedure for treating dental caries. Press release: WHO/28. April 7, 1994.
21. American Academy of Pediatric Dentistry. Reference Manual 2001-2002. Policy statement on alternative restorative treatment. *Pediatr Dent*. 2001;23:13.
22. Redig DF. A comparison and evaluation of two formocresol pulpotomy techniques utilizing "Buckley's" formocresol. *J Dent Child.* 1968;35:22-30.
23. King SRA, McWorter AG, Seale NS. Concentrations of formocresol used by pediatric dentists in primary tooth pulpotomy. *Pediatr Dent*. 2002;24:157-159.

24. Aponte AJ, Hartsook, JT, Crowley MC. Indirect pulcapping success verified. *J Dent Child*. 1966;33:164-166.
25. Nirschl RF, Avery DR. Evaluation of a new pulp capping agent in indirect pulp therapy. *J Dent Child*. 1983;50:25-30.
26. Kerkhove BC Jr, Herman SC, Klein AI, McDonald RE. A clinical and television densitometric evaluation of the indirect pulp capping technique. *J Dent Child*. 1967;34:192-201.
27. Falster CA, Araujo FB, Staffon LH, Nor JE. Indirect pulp treatment: in vivo outcomes of an adhesive resin system vs calcium hydroxide for protection of the dentin-pulp complex. *Pediatr Dent*. 2002;24:241-248.
28. Al-Zayer MA, Straffon LH, Feigal RJ, Welch KB. Indirect pulp treatment of primary posterior teeth: A retrospective study. *Pediatr Dent*. 2003;25:29-36.
29. Strange DM, Seale NS, Nunn ME. Outcome of formocresol/ZOE sub-base pulpotomies utilizing alternative radiographic success criteria. *Pediatr Dent*. 2001;23:331-336.
30. Holan G, Fuks AB, Keltz N. Success of formocresol pulpotomy in primary molars restored with crowns vs amalgam. *Pediatr Dent*. 2002;24:212-216.
31. Guelmann M, Fair J, Turner C, Courts F. The success of emergency pulpotomies in primary molars. *Pediatr Dent*. 2002;24:217-220.

Abstract of the Scientific Literature

Occurrence of Periodontal Bacteria in Healthy Children

The pathogenesis of periodontitis in children is not completely understood. Much of the literature, however, suggests that it is an infectious process, probably caused by specific bacteria. The purpose of this investigation was to examine the occurrence of 10 types of bacteria in plaque and saliva samples obtained from periodontally healthy children. Saliva and plaques samples from 119 systemically healthy children ages 2 to 13 were used in this study. Bacterial genomic DNA was isolated from the samples, and 10 species of gram-negative anaerobic bacteria were identified. The results indicated that *Capnocytophaga ochracea*, *Capnocytophaga sputigena,* and *Actinobacillus actinomycetemcomitans* were frequently found in saliva and tended to persist for the duration of the study. *Porphyromonas gingivalis, Treponema denticola,* and *Prevotella intermedia* were rarely detected. *Prevotella nigrescens* was more frequently detected in plaque and its prevalence increased with age. *Eikenella corrodens* and *Campylobacter rectus* were sometimes present in both plaque and saliva, but *Tannerella forsythensis* was infrequently found in saliva only. In conclusion, the study demonstrated that *A actinomycetemcomitans*, *C ochracea, C sputigena, P nigrescens, C rectus, and E corrodens* are commonly found in the oral flora of healthy children, while *P gingivalis, P intermedia, and T denticola* appeared to be transient organisms.

Comments: This paper provides an interesting look at the normal microbiological flora found in healthy children who were followed over time. **BB**

Address correspondence to Dr. Takashi Ooshima, Department of Pediatric Dentistry, Osaka University Graduate School of Dentistry, 1-8 Yamada-Oka, Suita, Osaka 565-0871, Japan. ooshima@dent.osaka-u.ac.jp

Ooshima T, Nishiyama N, Hou B, Tamura K, Amano A, Kusumoto A, Kimura S. Occurrence of periodontal bacteria in healthy children: A 2-year longitudinal study. *Community Dent Oral Epidemiol.* 2003;31:417-425.

25 references