©Operative Dentistry, 2006, **31-2,** 165-170

Clinical Research

Effect of Cavity Disinfection on Postoperative Sensitivity Associated with Amalgam Restorations

WM Al-Omari • QD Al-Omari • R Omar

Clinical Relevance

Using a cavity disinfectant such as chlorhexidine before placing an amalgam restoration decreases postoperative sensitivity to cold stimulus.

SUMMARY

This clinical study assessed the postoperative cold sensitivity reported by patients following the Class I and Class II amalgam restoration of primary carious lesions after different cavity treatments. One hundred and twenty patients, each with a previously untreated tooth requiring an amalgam restoration due to the presence of a carious lesion, were included. Sixty teeth had lesions that were radiographically judged to be located in the middle third of dentin, and another 60 were located in the inner third of dentin. Six different cavity treatment regimens were used: Group 1—no treatment; Group 2—calcium hydroxide liner (Life); Group 3—cavity varnish (Copalite); Group 4—resin modified glass ionomer liner (Vitrebond); Group 5—dentin adhesive resin liner (Single Bond); Group 6—chlorhexidine disinfectant (Consepsis). Patients were telephoned on days 2 and 7 postoperatively and asked whether they experienced sensitivity to cold, and if so, its duration and intensity. If sensitivity remained up to day 7, patients were also contacted on days 30 and 90. The Kruskal-Wallis test showed postoperative sensitivity to be significantly different among cavity treatments at days 2, 7 and 30 (*p*=0.026, 0.044, 0.015, respectively). Lesion depth also affected postoperative sensitivity at day 2, with 27% of teeth with middle-third lesions producing pain, and 58% of those with lesions extending to the inner third producing pain (*p*=0.000). This difference showed up at 7 and 30 days (*p*=0.001, 0.015, respectively). Of the 51 teeth with sensitivity at day 2, 17 had mild pain, 26 were moderately painful and 8 had severe pain; each category reduced in degree of sensitivity and number with time. It would seem that medium-term (beyond 30 days) postoperative sensitivity is affected neither by the method of cavity treatment nor the depth of lesion,

Wael M Al-Omari, BDS, MDSc, PhD, assistant professor, Department of Restorative Dentistry, Faculty of Dentistry, Jordan University of Science and Technology, Irbid, Jordan

*Qasem D Al-Omari, BDS, MS, FDSRCSI, assistant professor, Department of Restorative Sciences, Faculty of Dentistry, Kuwait University, Safat, Kuwait

Ridwaan Omar, BSc, BDS, LDSRCS, MSc, FRACDS, FDSRCSEd, professor, Department of Restorative Sciences, Faculty of Dentistry, Kuwait University, Safat, Kuwait

*Reprint request: PO Box 24923, Safat, 13110 Kuwait; e-mail: qalomari@hsc.edu.kw

DOI: 10.2341/05-8

although, in the shorter term, these factors do influence the postoperative sensitivity reported.

INTRODUCTION

Even with the numerous improvements that have been reported for resin composite materials, dental amalgam remains the most widely used restorative material in most parts of the world (Leinfelder, 1991; Gwinnett & others, 1994; Burke, 2004). Postoperative sensitivity after an amalgam restoration is not uncommon, even at the hands of experts (Grover, Hollinger & Lorton, 1984; Johnson, Gordon & Bales, 1988). Gordan and others (1999b) reported that about one-quarter of patients with new amalgam restorations experienced postoperative pain on the second day following restoration placement, while Grover and others (1984) reported sensitivity in about one-half of their study subjects.

Postoperative sensitivity is believed to result from microleakage around restorations. The small, fluid-filled dentinal tubules that are exposed during the process of tooth preparation allow fluid movement from the pulp towards the cut surface. When an appropriate stimulus is applied to the dentin surface, the rate of fluid flow within the tubules changes, which, in turn, is detected by mechanoreceptors within the tubules and is interpreted as pain. This explanation for tooth sensitivity is known as the hydrodynamic theory (Brännström, Linden & Aström, 1967). Corrosion products from dental amalgam are believed to produce a gradual reduction in postoperative sensitivity (Ben-Amer, Cardash & Judes, 1995) and might take several months.

Various cavity treatments aimed at overcoming the postoperative sensitivity problem have been reported (Lyon & Michell, 1983). While cavity varnishes have been routinely used under amalgam restorations, serving as interim sealers while corrosion products form (Andrews & Hembree, 1980), they have been reported to disintegrate shortly after restoration placement (Going, 1972). Traditionally, calcium hydroxide has been used as a cavity liner and, while many practitioners recognize its potential for stimulating reparative dentin formation, the concept is neither universally accepted nor is the evidence for it compelling. Calcium hydroxide materials must be in direct contact with pulp tissue to cause reparative dentin formation (Swift & Trope, 1999).

More recently, dentin bonding agents have gained popularity as cavity liners (Chohayeb, Bowen & Adrian, 1988). Although their efficacy in reducing postoperative pain after amalgam restorations has not been shown, compared to conventional liners and bases (Browning, Johnson & Gregory, 1997), bonding agents have been known to be more effective in reducing microleakage, compared to other cavity treatments (de Morais, Rodrigues & Pimenta, 1999).

Scherer and others (1990) found that the use of glass ionomer as a cavity base under amalgam restorations reduced sensitivity to cold. The advantages of glass ionomer include its chemical bonding to tooth structure (Causton, Sefton & Williams, 1987; Aboush & Jenkins, 1986; van Dijken & Horsdt, 1986), release of fluoride (Swift, 1989; McCourt, Cooley & Huddleston, 1990), radiopacity (Maldonado, Swartz & Phillips, 1978) and low thermal conductivity (Soderholm, 1991). Additionally, Marchiori and others (1998) have found that use of a glass ionomer liner could reduce microleakage.

Brännström (1984) reported that the cause of pulpal damage is infection rather than operative procedures or the materials used in restorative dentistry. He reported two sources of bacterial contamination as being responsible for this infection: bacteria in the smear layer and the ingress of bacteria by microleakage. Thus, removal of the remaining bacteria in the cavity by using a disinfectant should reduce or eliminate postoperative sensitivity and has resulted in a disinfecting step in cavity preparation and tooth restoration, gaining wider clinical acceptance (Gwinnett, 1992). Vahdaty, Pitt Ford and Wilson (1993) found chlorhexidine and sodium hypochlorite to be effective antibacterial agents in disinfecting dentinal tubules, while Zamany, Safavi and Spangberg (2003) recommend the use of chlorhexidine as an endodontic disinfectant.

This study determined whether patients whose amalgam restorations were placed after using a disinfectant solution to clean the cavity had less postoperative sensitivity to cold than patients who had restorations placed after various other cavity treatments/liners or no liner being used.

METHODS AND MATERIALS

Patients attending for routine restorative care at the Faculty of Dentistry, Jordan University of Science and Technology, were consecutively screened for inclusion in this study on the basis of the following criteria: each patient had to have a diagnosis of a primary carious lesion that required either Class I or Class II amalgam restorations, with the diagnosis having been established by clinical examination and verified by standard bitewing radiographs; and, on the basis of the radiographs, the lesions needed to be categorized according to their depth as being in the outer, middle or inner one-third of the dentin. Patients having old amalgam restorations were excluded from the study, as were those reporting any prevailing oral and/or dental sensitivity or a recent history thereof and those who were taking medications that could interfere with pain perception. Fully informed consent was obtained from patients for their participation in the study. The research was approved by the Deanship of Research,

Table 1: *Patient Allocation Between Depth of Lesion Categories (middle third, n=60; inner third, n=60) and Among Cavity Treatment Groups*

Group	Treatment	Cavity Depth	Manufacturer	Clinical Procedure
1	No liner (CL)	Middle 1/3 (n=10)		Rinse with water; Dry without desiccating; Amalgam restoration placed
		Inner 1/3 (n=10)		
2	Calcium hydroxide (CH)	Middle 1/3 (n=10)	Life Regular Set, Kerr, Salerno, Italy	Rinse with water; Dry without desiccating; One layer Life applied; Amalgam restoration placed
		Inner 1/3 (n=10)		
3	Copalite varnish (CV)	Middle 1/3 (n=10)	Copalite Varnish, Cooley & Cooley Ltd, Houston, TX, USA	Rinse with water; Dry without desiccating; Two separate coats applied; First layer dried with air syringe, second layer air dried; Amalgam restoration placed
		Inner 1/3 (n=10)		
4	Vitrebond (VB)	Middle 1/3 (n=10)	Vitrebond,A 3M ESPE, St Paul, MN, USA	Rinse with water; Dry gently; Vitrebond applied, light cured for 40 seconds; Amalgam restoration placed
		Inner 1/3 (n=10)		
5	Single Bond (SB)	Middle 1/3 (n=10)	Single Bond, 3M ESPE, St Paul, MN, USA	Etch for 15 seconds; Rinse for 10 seconds; Moisten; Single Bond applied, and light cured for 20 seconds; Amalgam restoration placed
	Inner 1/3 (n=10)			
6	Chlorhexidine (CX)	Middle 1/3 (n=10)	Consepsis, Ultradent Products Inc, UT, USA	Two separate coats applied; Each layer air dried for 40 seconds; Amalgam restoration placed
		Inner 1/3 (n=10)		

Table 2: *Frequency of Positive Responses to Postoperative Sensitivity According to Cavity Depth and Type of Treatment/Liner at Day 2*

Cavity Depth	Treatment/Liner						
	CL	**CH**	**CV**	**VB**	**SB**	**CX**	**N**
Middle 1/3	6	7	0	1	2	0	60
Inner 1/3	6	5	6	7	9	2	60
Total	**12**	**12**	**6**	**8**	**11**	**2**	**120**

(CL=no treatment control; CH=calcium hydroxide liner [Life]; CV=cavity varnish [Copalite]; VB=resin modified glass ionomer liner, Vitrebond; SB=dentin adhesive resin liner, Single Bond; CX=chlorhexidine, Consepsis)

Jordan University of Science and Technology and the Human Rights Committee of the University.

Lesions limited to the outer one-third of dentin were excluded from the study, leaving 120 patients who were equally divided between two groups: middle third lesions (n=60) and inner third lesions (n=60). For each group, the patients were randomly and evenly allocated among one of six subgroups based on the type of treatment of dentin after cavity preparation, including a control subgroup that received no cavity treatment prior to amalgam placement (Table 1).

All amalgam restorations were provided for the selected patients by dental students working under close supervision of staff members of the Department of Restorative Dentistry, who, in turn, had been fully apprised of the purpose of the study by the investigators. Manufacturers' instructions were followed for each pre-treatment material. After pre-treatment, the teeth were restored with a dispersed–phase amalgam (Amalgam 48, TNMC Medical Devices Ltd, Guildford, UK), carved and burnished. The restorations were carefully checked for appropriate occlusion.

All patients were then contacted postoperatively on days 2 and 7. They were systematically questioned about the presence or absence of postoperative sensitivity to cold. If sensitivity was reported, they were asked to specify the intensity according to an ordinal rating scale from 0-3: 0, no sensitivity; 1, slight sensitivity; 2, moderate sensitivity and 3, severe sensitivity. Any patient who experienced sensitivity or discomfort 7 days after placement of the restoration was contacted again at days 30 and 90 to assess the degree of sensitivity at that time.

After data collection, the results were entered into a personal computer, and differences in reported postoperative sensitivity with respect to cavity treatment/liner and cavity depth were analyzed using the Mann-Whitney rank sum Test and Kruskal-Wallis test at a significance level of $p<0.05$ using SPSS Software, version 11 (SPSS, Chicago, IL, USA).

RESULTS

The mean age of the patients was 28 years (SD 9.8, range 16 to 65).

Table 2 shows the frequency of positive reports of postoperative sensitivity according to cavity depth and type of liner at day 2 after restoration. Significant differences among the different types of treatment/liners were evident ($p=0.026$), with dentin treatment with chlorehexidine producing the fewest sensitive teeth, followed by the cavity varnish group. There were also significantly more teeth with postoperative sensitivity at

Table 3: *Frequency (and percentages) of Different Degrees of Severity of Postoperative Sensitivity According to Type of Treatment/Liner at Day 2*

Treatment/Liner	Degree of Postoperative Sensitivity			Total (%)
	Mild	Moderate	Severe	
CL	3	8	1	12 (60)
CH	3	8	1	12 (60)
CV	3	1	2	6 (30)
VB	2	5	1	8 (40)
SB	6	4	1	11 (55)
CX	0	0	2	2 (10)
Total	17	26	8	51 (43)

Kruskal-Wallis test, p*=0.026*

(CL=no treatment control; CH=calcium hydroxide liner [Life]; CV=cavity varnish [Copalite]; VB=resin modified glass ionomer liner, Vitrebond; SB=dentin adhesive resin liner, Single Bond; CX=chlorhexidine, Consepsis)

Table 4: *Frequency of Different Degrees of Severity of Postoperative Sensitivity According to Cavity Depth at Day 2*

Cavity Depth	Degree of Postoperative Sensitivity			Total
	Mild	Moderate	Severe	
Middle 1/3	7	9	0	16
Inner 1/3	10	17	8	35
Total	17	26	8	51

Wilcoxon rank-sum (Mann-Whitney), p*=0.000*

Table 5: *Frequency (and percentages) of Positive Responses to Postoperative Sensitivity According to Cavity Depth at Days 2, 7, 30 and 90*

Cavity Depth	Number of Days Postoperatively				N (%)
	2%	7%	30%	90%	
Middle 1/3	16(27)	8(13)	1(.02)	0(0)	16 (27)
Inner 1/3	35(58)	23(38)	8(.13)	0(0)	35 (58)
Total	51(43)	31(26)	9(.08)	0(0)	51 (43)

Wilcoxon rank-sum (Mann-Whitney), p*=0.000, 0.001, 0.015 at days 2, 7 and 30, respectively*

day 2 with lesions in the inner third (n=35, 58%) compared to those whose lesions were limited to the middle third (n=16, 27%) (p=0.000). No differences in postoperative sensitivity were noted between Class I and Class II restorations (p=0.322, 0.769, 0.257 at days 2, 7 and 30, respectively).

Table 3 shows the degree of sensitivity at day 2 in relation to the type of liner. The range and degree of sensitivity at day 2 in relation to cavity depth revealed that middle third cavities had significantly fewer sensitive teeth, with less severe sensitivity, than inner third cavities (p=0.000) (Table 4). This pattern continued at 7 and 30 days (p=0.001, 0.015, respectively), but no difference was noted at 90 days (p=1.00) (Table 5).

The change in sensitivity levels over time in relation to the type of treatment/liner showed that there were significant differences among the types of treatment/liner at days 2, 7 and 30 (p=0.026, 0.044, 0.015, respectively) but not at 90 days (p=1.00) (Table 6).

DISCUSSION

All patients in this study received one restoration each, in order to limit the potential cause of perceived pain to one source—the study tooth—and not to risk confounding the outcome with any other newly restored teeth that were not part of the study. For the same reason, the restoration of cavities treated differently in the same patient would have been an obvious source of error. Although the determination of cavity depths for the purpose of allocating patients to groups was performed radiographically, if a case could not be clinically confirmed, that patient was excluded from the study. Lesions in the outer third of dentin were excluded from the study, because previous research (Gordan, Mjör & Moorhead, 1999a) found that such lesions had less postoperative sensitivity than others.

The hydrodynamic theory (Brännström & Aström, 1972) is most widely accepted for the explanation of tooth sensitivity. According to this theory, dentin sensitivity is mediated by fluid movements within the dentinal tubules. Factors that can cause this fluid movement include dentin drying (Matthews, Showman & Pashley, 1993), heat resulting from cavity preparation (Stanley & Swerdlow, 1959), chemical agents and bacterial penetration (Brännström & Johnson, 1978). The results of this study appear in line with this theory in that disinfection of the cavity will likely remove bacteria from the smear layer, thus eliminating one of the possible causes of pulpal sensitivity.

The surface area of dentin is much greater at the dentinoenamel junction (DEJ) than at the pulpal aspect of the cavity. The number of dentinal tubules increases from 15,000 to 20,000/mm^2 at the DEJ to 45,000 to 65,000/mm^2 at the pulpal wall. The lumen of the tubules also varies in size from the DEJ to the pulpal wall. In coronal dentin, the average diameter of tubules at the DEJ is 0.5 to 0.9 µm, but this increases to 2 to 3 µm pulpally (Garberoglio & Brännström, 1976). This means that the larger the cavity preparation, the greater the area of dentinal tubules exposed. Likewise, the deeper the cavity, the wider the dentinal tubules.

These morphological factors could explain why deeper cavities had more reports of postoperative sensitivity and pain of greater severity. While this might also help explain the authors' observation that Class II cavities had more postoperative sensitivity than Class I cavities (49% vs 39%), it should be noted that the difference was not statistically significant.

Previous research has shown that use of an adhesive liner did not reduce sensitivity to cold, compared with conventional liners and bases (Browning & others, 1997), with which the results of this study concur. However, it should be noted that most reports of postoperative sensitivity associated with the dentin bonding agent group occurred in inner third cavities. Adhesion can be affected by the remaining dentin thickness after cavity preparation, with reduced bonding strengths occurring in deep dentin than in superficial dentin (Suzuki & Finger, 1988).

Overall, about 43% of the patients in this study reported some postoperative sensitivity at day 2, which is in general agreement with the results of Silvestri, Cohen and Wetz (1977). On the basis of cavity depths, however, Gordan and others (1999a) reported 27% of their sample as having postoperative sensitivity for middle third lesions and 29% having postoperative sensitivity when lesions were located in the inner third of dentin. In this study, the corresponding figures were 27% and 58%, respectively. This difference for deep cavities may be due to differences in the materials and/or techniques used in the two studies.

The results of this study also agree with previous findings, inasmuch as the degree of postoperative pain decreasing with time (Gordan & others, 1999b; Browning & others, 1997; Schwartz, Conn & Haveman, 1998). The proportion of those reporting postoperative sensitivity reduced steadily from 43% at 2 days, to 26% at 7 days, to 8% at 30 days and none at 90 days.

In interpreting the results of this study, it should be remembered that the results obtained apply to the materials used and the prevailing clinical conditions. Because this study occurred in a teaching setting, it cannot be considered representative and, thus, not fully applicable in routine dental practice. A further limitation of this study was contacting patients on the phone postoperatively rather than by clinical examination, which may have detracted from its accuracy. For greater clarification of the outcomes in general practice, a similar practice-based study seems warranted.

Table 6: *Frequency of Positive Responses to Postoperative Sensitivity According to Type of Treatment/Liner at Days 2, 7, 30 and 90*

Treatment/Liner	Number of Days Postoperatively			
	2	**7**	**30**	**90**
CL	12	9	5	0
CH	12	9	2	0
CV	6	4	0	0
VB	8	5	2	0
SB	11	2	0	0
CX	2	2	0	0
Total	51	31	9	0

Kruskal-Wallis test, p=0.026, 0.044, 0.015 at days 2, 7 and 30, respectively.

(CL=no treatment control; CH=calcium hydroxide liner [Life]; CV=cavity varnish [Copalite]; VB=resin modified glass ionomer liner, Vitrebond; SB=dentin adhesive resin liner, Single Bond; CX=chlorhexidine, Consepsis)

CONCLUSIONS

There were significant differences in reported postoperative sensitivity among the cavity treatments and/or lining materials used in this study. Treatment with chlorhexidine disinfectant produced the least pain experience, while cavities of greater depth produced not only more postoperative pain but also pain of greater severity. No differences were apparent in relation to cavity design. From a time perspective, 43% of teeth were sensitive on the second day postoperatively, and this figure decreased to zero at three months.

(Received 12 January 2005)

References

Aboush YE & Jenkins CB (1986) An evaluation of the bonding of a glass-ionomer restoratives to dentin and enamel *British Dental Journal* **161(5)** 179-184.

Andrews JT & Hembree JH Jr (1980) Marginal leakage of amalgam alloys with high content of copper: A laboratory study *Operative Dentistry* **5(1)** 7-10.

Ben-Amer A, Cardash HS & Judes H (1995) The sealing of the tooth/amalgam interface by corrosion products *Journal of Oral Rehabilitation* **22(2)** 101-104.

Brännström M, Linden LA & Aström A (1967) The hydrodynamics of the dental tubule and of pulp fluid: Its significance in relation to dentinal sensitivity *Caries Research* **1(4)** 310-317.

Brännström M & Aström A (1972) The hydrodynamics of the dentine: Its possible relationship to dentinal pain *International Dental Journal* **22(2)** 219-227.

Brännström M & Johnson G (1978) The sensory mechanism in human dentin as revealed by evaporation and mechanical removal of dentin *Journal of Dental Research* **57(1)** 49-53.

Brännström M (1984) Communication between the oral cavity and the dental pulp associated with restorative treatment *Operative Dentistry* **9(2)** 57-68.

Browning WD, Johnson WW & Gregory PN (1997) Postoperative pain following bonded amalgam restorations *Operative Dentistry* **22(2)** 66-71.

Burke FJ (2004) Amalgam to tooth-coloured materials—implications for clinical practice and dental education: Governmental restrictions and amalgam-usage survey results *Operative Dentistry* **32(5)** 343-350.

Causton B, Sefton J & Williams A (1987) Bonding Class II composite to etched glass ionomer cement *British Dental Journal* **163(10)** 321-324.

Chohayeb AA, Bowen RL & Adrian J (1988) Pulpal response to a dentin and enamel bonding system *Dental Materials* **4(3)** 144-146.

de Morais PM, Rodrigues AL Jr & Pimenta LA (1999) Quantitative microleakage evaluation around amalgam restorations with different treatments on cavity walls *Operative Dentistry* **24(4)** 217-222.

Garberoglio R & Brännström M (1976) Scanning electron microscopic investigation of human dentinal tubules *Archives of Oral Biology* **21(6)** 355-362.

Going RE (1972) Microleakage around dental restorations: A summarizing review *Journal of the American Dental Association* **84(6)** 1349-1357.

Gordan VV, Mjör IA & Moorhead JE (1999a) Amalgam restorations: Postoperative sensitivity as a function of liner treatment and cavity depth *Operative Dentistry* **24(6)** 377-383.

Gordan VV, Mjör IA, Hucke RD & Smith GE (1999b) Effect of different liner treatments on postoperative sensitivity of amalgam restorations *Quintessence International* **30(1)** 55-59.

Grover PS, Hollinger J & Lorton L (1984) A review of the incidence of pain after an operative treatment visit: Part I *Journal of Prosthetic Dentistry* **51(2)** 224-225.

Gwinnett AJ (1992) Effect of cavity disinfection on bond strength to dentin *Journal of Esthetic Dentistry* **4(Supplement)** 11-13.

Gwinnett AJ, Baratieri LN, Monteiro SJ & Ritter AV (1994) Adhesive restorations with amalgam: Guidelines for the clinician *Quintessence International* **25(10)** 687-695.

Johnson GH, Gordon GE & Bales DJ (1988) Postoperative sensitivity associated with posterior composite and amalgam restorations *Operative Dentistry* **13(2)** 66-73.

Leinfelder KF (1991) Dental amalgam alloys *Current Opinions in Dentistry* **1(2)** 214-217.

Lyon HE & Michell RJ (1983) Pulp protection and basing procedures: A survey of dental schools *Operative Dentistry* **8(3)** 106-111.

Maldonado A, Swartz ML & Phillips RW (1978) An *in vitro* study of certain properties of a glass ionomer cement *Journal of the American Dental Association* **96(5)** 785-791.

Marchiori S, Baratieri LN, de Andrada MA, Monteiro S Jr & Ritter AV (1998) The use of liners under amalgam restorations: An *in vitro* study on marginal leakage *Quintessence International* **29(10)** 637-642.

Matthews WG, Showman CD & Pashley DH (1993) Air blast-induced evaporative water loss from human dentine, *in vitro Archives of Oral Biology* **38(6)** 517-523.

McCourt JW, Cooley RL & Huddleston AM (1990) Fluoride release from fluoride-containing liners/bases *Quintessence International* **21(1)** 41-45.

Scherer W, Cooper H, Kaim J, Hittleman E & Staffa J (1990) Sensitivity study *in vivo*: Glass-ionomer versus zinc-phosphate bases beneath amalgam restorations *Operative Dentistry* **15(5)** 193-196.

Schwartz RS, Conn LJ Jr & Haveman CW (1998) Clinical evaluation of two desensitizing agents for use under Class V silver amalgam restorations *Journal of Prosthetic Dentistry* **80(3)** 269-273.

Silvestri AR Jr, Cohen SH & Wetz JH (1977) Character and frequency of discomfort immediately following restorative procedures *Journal of the American Dental Association* **95(1)** 85-89.

Soderholm KJ (1991) Correlation of *in vivo* and *in vitro* performance of adhesive restorative materials: A report of the ASCMD 156 Task Group on test methods for the adhesion of the restorative materials *Dental Materials* **7(2)** 74-83.

Stanley HR Jr & Swerdlow H (1959) Reaction of the human pulp to cavity preparation: Results produced by eight different operative grinding technics *Journal of the American Dental Association* **58(5)** 49-59.

Suzuki T & Finger WJ (1988) Dentin adhesives: Site of dentin vs bonding of composite resins *Dental Materials* **4(6)** 379-383.

Swift EJ Jr (1989) Effects of glass ionomers on recurrent caries *Operative Dentistry* **14(1)** 40-43.

Swift EJ Jr & Trope M (1999) Treatment options for the exposed vital pulp *Practical Periodontics & Aesthetic Dentistry* **11(6)** 735-739.

Vahdaty A, Pitt Ford TR & Wilson RF (1993) Efficacy of chlorhexidine in disinfecting dentinal tubules *in vitro Endodontic and Dental Traumatology* **9(6)** 243-248.

Van Dijken JWV & Horstedt PMA (1986) *In vivo* adaptation of restorative materials to dentin *Journal of Prosthetic Dentistry* **56(6)** 677-681.

Zamany A, Safavi K & Spangberg LS (2003) The effect of chlorhexidine as an endodontic disinfectant *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology & Endodontology* **96(5)** 578-581.