The effect of thermocycling on the determination of microleakage in permite amalgam restorations

SADJ October 2009, Vol 64 no 9 p394 - p396

S Rajbaran: *BChD, PDD, MSc (Odont)*, Lecturer, Department of Odontology, University of Pretoria, P.O Box 1266, Pretoria, Gauteng, South Africa 0001. Tel: 012 319 2277. E-mail: sandeepa.rajbaran@up.ac.za

M Dannheimer: *BChD, BChD (Hons), M.Dent, Ther.Dip,* Associate Professor, Division Head: Basic Restorative Dentistry, Department of Odontology, University of Pretoria, P.O Box 1266, Pretoria, Gauteng, South Africa 0001. Tel: 012 319 2440. E-Mail: manfred.dannheimer@up.ac.za

F De Wet: *BChD, BChD (Hons), M.Dent, DSc (Odont),* Professor and Head, Department of Odontology, University of Pretoria, P.O Box 1266, Pretoria, Gauteng, South Africa 0001. Tel: 012 319 2443. Fax: 012 326 2754. E-Mail: fadewet@medic.up.ac.za

Corresponding Author:

Sandeepa Rajbaran: *BChD, PDD, MSc (Odont)*. Lecturer, Department of Odontology, University of Pretoria, P.O Box 1266, Pretoria, Gauteng, South Africa 0001. Tel: 012 319 2277. E-mail: sandeepa.rajbaran@up.ac.za

ABSTRACT

The effect of thermocycling on the determination of microleakage in Permite amalgam restorations

Introduction

Microleakage is an important clinical performance parameter of restorative materials. A literature review of the effect of thermocycling on microleakage revealed an incongruity of results.

Aims and objectives

The aim of this study was to describe the effect of thermocycling on microleakage in Class V Permite amalgam restorations. Methods: Class V cavities were prepared at the mesial and distal cemento-enamel junctions of 20 extracted, sound, human molar teeth. Cavities were treated with Polyvar cavity varnish and restored with Permite amalgam as per manufacturer's directions. Teeth were randomly divided into two groups of 10 teeth each. After one day only one group was thermocycled for 500 hundred cycles (5 - 55°C; dwell time of 30 seconds: transfer time of 10 seconds). Teeth were subsequently submersed in 0.5% Basic Fuchsin solution (24 hours: room temperature), then cleaned and embedded in polyester potting resin. Teeth were sectioned longitudinally along the long axis of the tooth into three slices using the Isomet low speed saw. Microleakage was scored under a light microscope at 10 times magnification.

Results

While microleakage at cementum margins was significantly and negatively influenced by thermocycling, enamel margins appeared to be significantly unaffected.

Conclusion

The effect of thermocycling on the determination of microleakage was only significant at the cementum margins of Permite restorations.

INTRODUCTION

Dental restorative materials have improved significantly in recent years, yet microleakage remains a formidable challenge. Microleakage or marginal leakage is the penetration of oral fluids and bacteria between the restorative material and tooth surface.[1] Post-operative pain, recurrent caries, marginal staining and pulpal inflammation are well-documented consequences of inadequate marginal adaptation and microleakage.[2-7] Microleakage is an important clinical performance parameter in the evaluation of restorative materials and is used in laboratory studies to indicate the clinical success of restorative systems.[8-10]

The effect of temperature changes on the marginal adaptation of restorative materials has been investigated since the early 1900s.[11] Changes in the intraoral thermal environment induced by eating, drinking and breathing have been shown to exacerbate the consequences of microleakage.[12,13,14,15] Thermocycling is the *in vitro* process of subjecting the restoration and tooth to temperature extremes that conform to those found in the oral cavity.[16] This simulates the momentary introduction of hot and cold temperatures in the oral cavity and highlights the difference in thermal expansion between the tooth and the restoration. The methodologies of contemporary in vitro microleakage studies are often characterised by the thermocycling process.[17] While thermocycling is routinely employed in microleakage studies, there exists much variation in thermocycling regimens and reports of the effect of thermocycling on microleakage remain contentious.[16-19]

Some experimental work has attempted to measure intraoral temperatures with great difficulty due to variations in subjects, occasions and locations within the mouth. With the exclusion of thermal loading and mouth breathing, the intraoral temperature has been approximated as 35°C.[20] A review of 130 thermal cycling experimental reports revealed mean low temperature points of 6.6°C (median 5.0°C) and mean high temperature points of 55.5°C (median 55°C) within ranges of 0-36°C and 40-100°C respectively.[17] The same review reported great disparity in the number of cycles employed varying from one to one million with a mean of 10 000 and a median of 500 cycles. Popular dwell times of exposure to each temperature extreme have varied between 15, 30 and 60 seconds.[21, 22]

Microleakage tests are frequently assessed in vitro due to the high cost and extended period of time required in clinical trials. It is therefore important to standardise thermocycling regimens and

Table 1: Summary of manufacturer details and chemical compositions of materials

Material	Manufacturer	Composition
Permite	SDI limited, Melbourne, Australia	Non-gamma 2 admixed, (spherical and lathe-cut) alloy; 56% Ag, 27.9% Sn, 15.4% Cu, 0.5% In, 0.2% Zn; 364 mg Mercury and 400mg Alloy
Polyvar varnish	Young Dental Manufacturing Company, Earth City, Missouri, USA	Purified Copal Varnish

to provide guidelines for the implementation of such regimens when employed with microleakage studies. This could potentially prevent the over or underestimation of the clinical performance of restorative dental materials. The purpose of this study was to evaluate the effect of thermocycling on microleakage in conventional amalgam restorations.

MATERIALS AND METHODS

The effect of thermocycling on microleakage in Permite (SDI limited, Melbourne, Australia) amalgam restorations was investigated. Polyvar cavity varnish (Young Dental Manufacturing Company, Earth City, Missouri, USA) was used as a varnish prior to amalgam placement. (Table 1)

Twenty sound, extracted, human molars were carefully debrided of tissue, cleaned with pumice, rinsed with water and stored in a 0.2% phosphate-buffered thymol solution (PBTS) until preparation. The teeth were stored for a maximum period of one month prior to cavity preparation. Class V cavities were prepared with a dome-shaped diamond bur on a high-speed handpiece on the mesial and distal surfaces of each tooth resulting in a total of 40 cavities. The cavities were prepared at the cemento-enamel junctions of teeth with margins in cementum as well as enamel. Prepared cavities were treated with two layers of Polyvar cavity varnish applied with a cotton pellet.[5,23,24] Permite amalgam was then triturated for eight seconds on a mechanical amalgamator (Linea Tac 200S) and subsequently hand-condensed into the prepared cavities. The amalgam was then carved flush with the external surface of the tooth. The teeth were then stored for one day in distilled water at room temperature before being randomly divided into two groups of 10 teeth each. Only one group was thermocycled in a six-cup thermocycler for 500 cycles between 5-55°C with a dwell time of 30 seconds and transfer time of 10 seconds.[25-29] Teeth were afterwards painted with two coats of nail varnish except for 1 mm surrounding the margins of the restoration. The apices of teeth were sealed with sticky wax.[30] Teeth were subsequently submersed in 0.5% Basic Fuchsin solution for 24 hours at room temperature.[5,31] Teeth were removed from the staining solution, cleaned and embedded in clear polyester potting resin. Each tooth was sectioned mesio-distally in three slices using the Isomet low-speed saw (Buehler, Lake Bluff, Illinois, USA). Microleakage was scored, by two completely calibrated operators, after viewing samples under a light microscope at a magnification of 10 times.

Microleakage was scored as follows (Figure 1): [32]

1 = no leakage

2 = penetration up to half the distance from the margin to the axial wall

3 = penetration further than half the distance from the margin to the axial wall but not touching the axial wall

4 = penetration along the axial wall

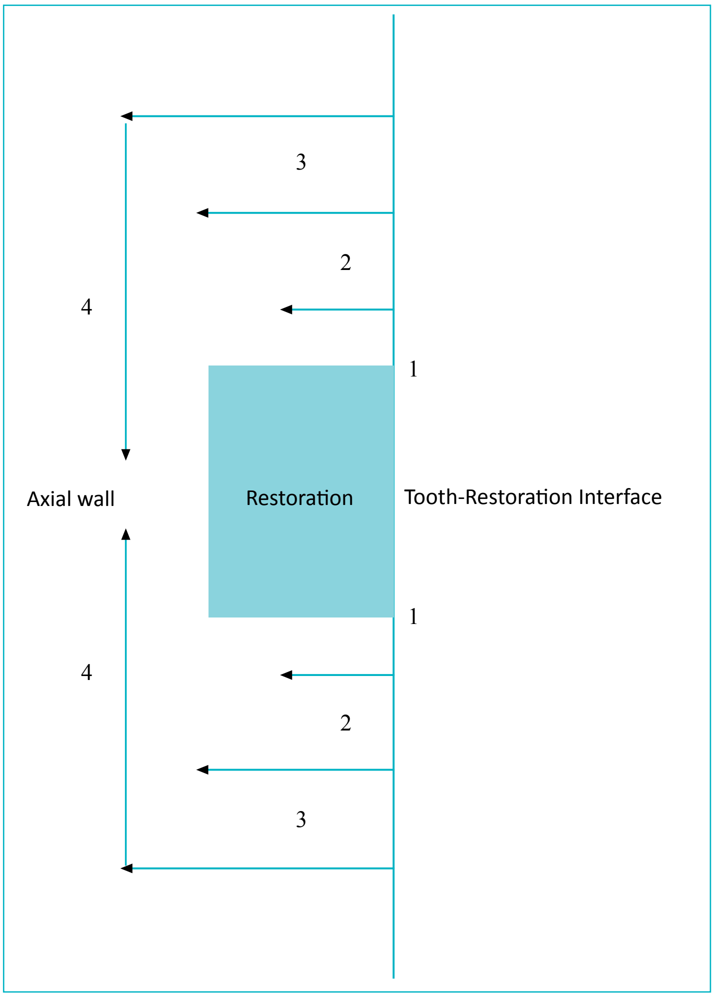

Figure 1: Sketch of scoring system for enamel and cementum microleakage

RESULTS

The data for this study was analysed using the Kruskal-Wallis and Mann-Whitney statistical tests. For the purpose of statistical interpretation, a p-value of <0.05 was considered statistically significant.

When the Kruskal-Wallis test was employed the thermocycled group showed no statistically significant difference among enamel ($p=0.986$) and cementum ($p=0.674$) readings. Similar results were found for the enamel ($p=0.885$) and cementum ($p=0.286$) readings within the non-thermocycled group. When the thermocycled group was compared to the non-thermocycled group using the Mann-Whitney test no statistically significant difference was found between enamel readings of both groups (Figure 2). Cementum readings, however, did reveal a statistically significant difference ($p=0.020$ and $p=0.040$) between thermocycled and non-thermocyled groups as illustrated in (Figure. 3). When all readings for both thermocycled and non-thermocycled groups were collectively compared, no statistically significant differences were found between the groups ($p=0.155$). This p value, however, does indicate a tendency towards a significant difference between groups if the number of teeth in the sample size were to be increased.

DISCUSSION

Over the past few decades the elimination of microleakage in restorative materials has been prioritised, yet microleakage remains an obstacle to the complete success of modern-day restorations. Contemporary dental materials such as Permite and Polyvar varnish are not exempt from microleakage.

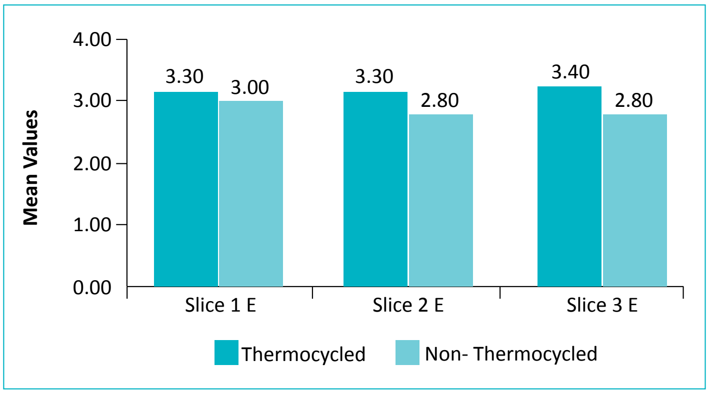

Figure 2: Comparison of mean enamel values between thermocycled and non-thermocycled groups

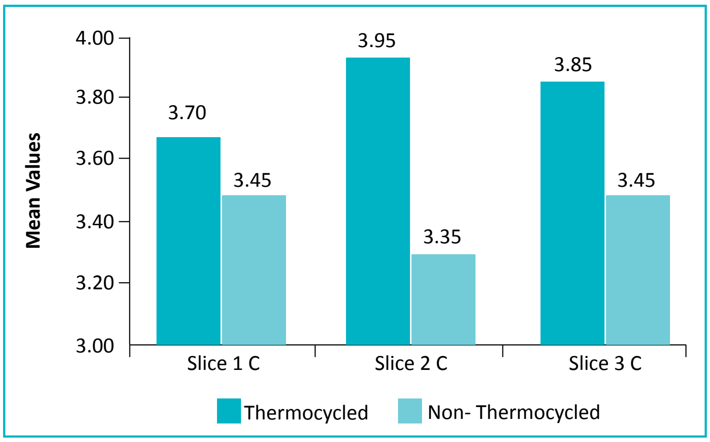

Figure 3: Comparison of mean cementum values between thermocycled and non-thermocycled groups

The long-term performance of amalgam is well documented. Amalgam offers advantages such as cost-effectiveness, ease of manipulation and placement, good wear-resistance, low technique sensitivity and satisfactory life expectancy.[33-35] The declining use of amalgam worldwide is importantly attributed to the lack of amalgam adhesion to tooth structure, resulting in microleakage and the clinical consequences thereof.[36,37] Traditionally the corrosive products of low-copper amalgams and cavity varnishes have been utilised to reduce microleakage.[5] Historically conventional low-copper amalgam alloys displayed a marked decrease in microleakage with time. The decreased microleakage in conventional amalgam alloys was attributed to the weak Gamma-2 phase, which leads to the formation of corrosion products. High-copper amalgam alloys are free of the Gamma-2 phase, therefore the corrosion process may not occur or is slower than for conventional amalgams.[38] Permite is a Non-gamma 2 admixed alloy, consisting of spherical and lathe cut alloy particles and therefore conforms to the corrosive behaviour of high-copper amalgam alloys.

The method employed for the preparation of teeth and cavities in this study was considered reliable and substantiated by similar studies.[5, 25, 31] The simulation of the introduction of hot and cold temperatures in the mouth was achieved by the thermocycling process in vivo. Regular temperature changes have been proposed to aggravate inadequate marginal adaptation in two ways. Firstly, intraoral temperature changes can cause mechanical stresses that induce crack propagation along bonded interfaces.[39] Secondly, changing gap dimensions result in gap volume variations. The gap volume differential results in the pumping of pathogenic oral fluids in and out of gaps.[12] The variation of thermocycling regimens in reviewed microleakage and material strength tests presented a challenge when deciding the regimen for this study. While the thermocycling procedure employed in this study displayed congruency with several studies[26-30] it is not a cycle uniformly employed in tests. It is argued that the variables of exposure times, number of cycles, storage media and temperature extremes make the comparison of microleakage studies difficult, if at all possible. Furthermore, this lack of standardisation contributes to the controversy of the effect of thermocycling on microleakage. While certain authors believe thermocycling to be an extremely important process in the study of microleakage because it simulates an intraoral environment, [18] others believe thermocycling to be an 'irrelevancy with spurious legitimacy', or at best premature due to the lack of standardisation.[17]

Several tests have been devised to evaluate microleakage. These tests include the use of radioisotopes, dyes, air pressure, bacteria, neutron activation analysis, caries inhibition and scanning electron microscopy.[40,41] Most microleakage tests involve the penetration of a dye on the basis that the test specimen is itself flawless. It is therefore implied that any dye must have penetrated through the interfacial gap.[42] Basic Fuchsin in a 0.5% solution is commonly used as a tracer in microleakage studies. This could be credited to the relatively low cost of this material as well as the ease of availability. Factors affecting the outcome of in vitro microleakage tests include the particular dye used, the pH of the dye and the molecular size of the dye.[43] In order to enhance microleakage tests it is suggested that these factors be standardised.

The results of the study on which this article is based, contributed to the body of contradictory findings on the effect of thermocycling on microleakage. The study showed congruence with studies that revealed no significant difference in microleakage of thermocycled specimens when compared to non-thermocycled specimens[19,44] and appeared incongruous with other studies.[45] It is suggested that the effect of thermocycling on microleakage may be of greater significance at cementum margins of amalgam restorations than enamel margins. This in vitro study once more highlighted the need to standardise thermocycling regimens in order to enhance the comparison of microleakage tests. Furthermore thermocycling regimens need to be developed in recognition of the differing thermal properties of the different classes of restorative materials.

CONCLUSION

Within the confines of the study upon which this article is based, it was concluded that the thermocycling regimen employed did not significantly affect microleakage at the enamel margins of amalgam restorations. Cementum margins demonstrated the significant and negative influence of thermocycling on microleakage of amalgam restorations.

Declaration: No conflict of interest was declared.

REFERENCES

1. Ziskind D, Venezia E, Kreisman I, Mass E. Amalgam type, adhesive system, and storage period as influencing factors on microleakage of amalgam restorations. *J Prosthet Dent* 2003; **90**: 255-260
2. Cohen S, Burns RC. Pathways of the pulp 8th ed. St.Louis. Mosby. 2002: 595-596
3. Setcos JC, Staninec M, Wilson NHF. Bonding of amalgam restorations: Existing knowledge and future prospects. *Oper Dent* 2000; **25**: 121-129
4. Smales RJ, Wetherell JD. Review of bonded amalgam restorations, and assessment in a general practice over five years. *Oper Dent* 2000; **25**: 374-381

Additional references (5-45) are available on www.sada.co.za