REPORT

Evaluation of various concentrations of alkaline surface treatment on interfacial bond strengths of amalgam bonded to amalgam

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Abstract: This study was done to assess the influence of alkaline surface modification on interfacial bond strength of existing fractured (old) amalgam restoration bonded to fresh amalgam. Old and Fresh amalgam interfaced samples were prepared by applying a 4-methacryloyloxyethy trimellitate anhydride (4-META) containing adhesive. The adhesive used was Amalgabond (Parkell, Farmingdale, NY 11735, USA). Four concentrations of calcium hydroxide $Ca(OH)_2$ solutions were used as a surface modifiers for old amalgam to increase the pH of the amalgam surfaces. The concentrations used were 2.5, 5, 10 and 15%. Direct measurement of the interfacial bond strength was carried out using an electromechanical universal tensile testing machine at crosshead speed of 10mm per minute. Results show that all the calcium hydroxide modified samples produced the increased tensile bond strength (TBS) as compared to their control group. The highest values of bond strength were achieved using 15% $Ca(OH)_2$ solution as surface modifier. Pretreatment of fractured amalgam with calcium hydroxide improves the bond strength of 4-META adhesives. Its use in repair of amalgam may therefore be considered.

Keywords: Interfacial bond strengths, tensile bond strength, amalgam, calcium hydroxide, 4- meta adhesives.

INTRODUCTION

Managing failed restorations is a common problem encountered by dental clinicians due to creep and deformation in the set amalgam (Bayne SC, Thompson JY 2006). Ideally such restorations should be replaced entirely with fresh amalgam or with an alternate restorative material(Lacy AM, Rupprecht R, Watanabe L 1992).

Replacement of an entire amalgam has many disadvantages. It weakens the tooth each time a fractured amalgam is replaced (Baratieri LN, Monteiro Jr. S, deAndrada MA 1992). Repeated replacement converts a simple restoration into a compound/complex restoration followed by pulp necrosis.

Repair of restorations has been studied and accepted as an adequate procedure (Gordon J 2007). In another study 98% success rate in amalgam repair was reported (Van Nieuwenhuysen *et al* 2003). In year 2008, it was reported that replacement of amalgam restoration is considered an acceptable and conservative method versus entire replacement of the failed restoration. With deeper insight into cariology, minimal intervention is emphasized and repair work involves less intervention (Tyas *et al.,* 2000, Mjor, Gordan 2002). It is recommended that repair should be preferred over replacing a whole restoration (Diefenderfer and Reinhardt 1997).

Previously, amalgam repair was performed without applying adhesives on the intact surface of broken amalgam. Use of adhesives has been increasing in clinical practice (Roeder, DeSchepper and Powers 2006, Ozer *et al* 2002). A study done to enhance the bond strength of the adhesive showed that pretreatment of intact surface of old amalgam with acid reduces the bond strength of amalgambond, a 4-methacryloyloxyethy trimellitate anhydride (META) product from Parkell, Farmingdale, USA. The bond strength of the same adhesive increased when pretreatment was performed with 10% Ca $(OH)_2$ (Asaad *et al* 2011)

It was hypothesized that increased pH of existing fractured amalgam restoration enhances the tensile bond strength of the adhesives used for amalgam repair. In present study, various concentrations of an alkaline solution-Ca $(OH)_2$ have been used to observe whether increment in alkaline concentration take part in enhancing bond strength of repaired amalgam or not.

MATERIAL AND METHODS

Admixed amalgam alloy - Aristalloy (Engelhard-CLAL

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UK, Ltd. David Road, Chessington KT9, UK) was used to prepare cylindrical samples.

The amalgam included was mixed according to manufacturer's manual and was condensed with persistent force, into transparent hard plastic tubes of 4.0 mm diameter and 10.0 mm length to prepare 125 samples. The tubes were filled up to 5.0 mm (half of their lengths) with the mixed amalgam and were allowed to set hard for 21 days (Fruits, Duncanson and Coury 1981). The half filled tubes were divided into five groups of twenty five each and designated as group 'A' 'B' 'C' 'D' and 'E'. In group 'A' the flat exposed sides of the samples were treated with 2.5% $Ca(OH)_2$ for 2 minutes and then a dentine adhesive, Amalgabond (Parkell, Farmingdale, NY 11735, USA) was applied. The adhesive- coated sides, with the help of a probe were pushed inside the tubes such that uncoated sides (opposite sides of the samples) came in level with the margins of the tubes. Freshly mixed amalgam of same brand and type was filled up to full length of the transparent tubes. Similarly, group 'B' 'C' and 'D' were treated with increasing concentration of 5, 10 and 15% $Ca(OH)_2$ respectively. Rest of the procedure to prepare the samples was same as employed in Group 'A'. The samples in group 'E' were prepared without application of Ca $(OH)_2$ solution to act as control samples.

The prepared samples were left untouched at ambient temperature for three months as the most solid state changes occur within this period (Marshall, Marshall and Baloch 1997) and were subjected to electromechanical universal testing machine (SATEC USA) at the crosshead speed of 10 mm per minute to collect the data (Kanko *et al* 2006). The data was analyzed by calculating mean, SD and 2-way ANOVA using SPSS version 17, and Microsoft Excel 2003.

RESULTS

Admixed amalgam alloy was used to prepare cylindrical samples. Test groups were divided from group A-D and Ca $(OH)_2$ was applied from 2.5% - 15 % respectively (fig. 1). The mean of control was 2.95± 0.01. The test group A-D showed mean of 4.04±0.01, 4.5±0.01, 4.6±0.01 and 4.7 ±0.01 respectively. The overall variance of the data was minimal as it is indicated by minimal SD as well as calculated by overall variance. Data results show that as the concentration of the calcium hydroxide was increased there was increase bond strength noted. Although mean of group A showed 1.09 increase in MPa. The trend line in fig. 1 shows that subsequent increase in concentration of $Ca(OH)_2$ did not reveal any significant change around the mean of control. To test the difference between control and other groups, Mann-Whitney concentration shows significant difference from controls (tables 1 and 2)

Table 1: Comparison of means of control and test groups

Descriptive Statistics	
Test Groups (%)	Mean Tensile Bond Strength (Mpa)
Control Group	2.94
Group A Conc. 2.5	4.04
Group B Conc. 5	4.54
Group C Conc. 10	4.64
Group D Conc. 15	5.74

Table 2: Statistical difference measured by Mann-Whitney test

Group	P-Value
Control Vs 2.5 % Ca (OH)	0.0000
Control Vs 5 % Ca (OH)	0.0000
Control Vs 10 % Ca (OH)	0.0000
Control Vs 15 % Ca (OH)	0.0000

DISCUSSION

Variation in pH plays a pivotal role in adhesion. High acidic or alkaline pH adversely affects the bonding strength (Mukhopadhyay and Datta 2007). Kurashige *et al* (2002) used an adhesive 4-Meta bond to bond Co-Cr and Ni-Cr plates in various concentrations of acidic and alkaline solutions and reported that at pH 2.3, the samples exhibited lowest bond strength while the highest bond values were achieved at pH 8. Findings of another study concluded that alkaline treatment is effective surface modification of titanium that improves bonding (Seiji 2003). Furthermore, it is also reported that alkaline/heat treatments of commercially pure titanium surface have beneficial effect in enhancing bond strength (Fawzy and El-Askary 2009). The present study was designed to examine the various concentrations - dependant effects of alkalization of intact amalgam and part of broken restoration. During the statistical analysis the mean of control group was 2.9 as compared to mean of 15% $Ca(OH)_2$ i.e., 4.74 that indicates significant difference of data around control mean. Interestingly that variation among various group studied showed minimal variation in the group means (fig. 1).

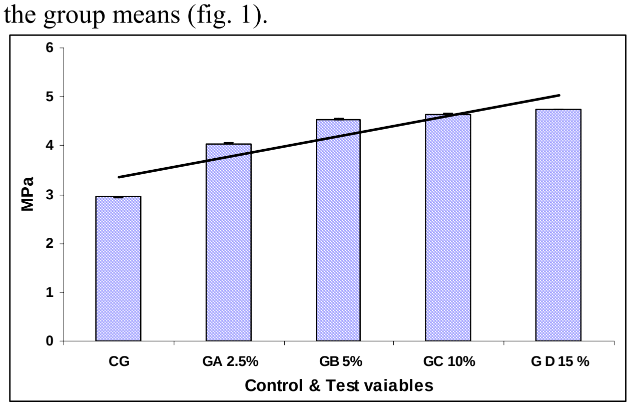

Fig. 1: Effect of various concentrations of Calcium Hydroxide on bond strength.

Hence on the basis of above mentioned data and analysis it can be assumed that alkaline pH of intact fractured amalgam restoration enhances the bond strength of the adhesives used for amalgam repair work. With the postulation that solutions of higher solute content have higher pH (final pH of the samples was not determined) the amalgam samples were treated with increasing concentration of $Ca(OH)_2$ solution.

The reason for enhanced bond strength due to alkalinization is unclear and beyond the scope of this article. A scanning microscopic study reveals that alkalinization increases contact area of the adherent surfaces (Jiang *et al* 2010). Moreover, it has been found in a study that treating a metal surface with an alkaline solution hardens the metal surface (Asaad 2006). Hardness is directly related to hardness of the bonds (KeyYan and Dong 2009). A harder surface adheres to other harder surface intimately with the help of an adhesive. The adhesives are supplied normally in liquid form which wet the surface of a solid well and fills up irregularities of the two adhering solid surfaces producing strong bond (McCabe and Walls 1998).

However similar work conducted in another study showed alkaline pH decreased the bond strength (Elkhatib *et al* 2003) The hypothetical reason might be reduction of bond strength due to the nature of dentine that contains amino acids. These amino acids perhaps do not make perfect bond with bleaching agent. Pretreatment of fractured amalgam with calcium hydroxide improves the bond strength of 4-META adhesives. On the basis of this analysis the increased bond strength was observed from 2.5 to 15%. Additionally it is evident that no major incremental response was observed between 5-15%. It can be assumed that use of $\leq$10% of $Ca(OH)_2$ would be better. Therefore, the clinical utility of calcium hydroxide in enhacing bond strength of repaired amalgam may be considered.

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