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Article *in* Australian Dental Journal · April 2006

DOI: 10.1111/j.1834-7819.2006.tb00399.x · Source: PubMed

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Australian Dental Journal 2006;51:(1):42-45

The effect of silver fluoride and potassium iodide on the bond strength of auto cure glass ionomer cement to dentine

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Abstract

Background: Diamine silver fluoride ($Ag(NH_3)_2F$), referred to as AgF, has been shown to reduce the incidence of caries in primary dentitions. The clinical application of this material has been limited by staining associated with both teeth and restorative materials. The application of potassium iodide (KI) after AgF eliminates stain formation. There is a lack of information as to how the addition of AgF followed by KI may affect the bond strength to dentine. The purpose of this study was to compare the bond strengths of auto cure glass ionomer cement to dentine surfaces that had been treated with AgF and KI and without treatment.

Methods: Ten recently extracted human third molars were embedded into methyl methacrylate resin and sliced to form a square block of exposed dentine surfaces. Each of the four surfaces were treated by one of the following procedures: (a) etching with 37 per cent phosphoric acid; (b) applying GC dentine conditioner; (c) etching, followed by application of AgF/KI then washing off the precipitate and air drying; and (d) etching, applying AgF/KI and air drying the reaction products on the surface. Fuji VII auto cure glass ionomer cement was bonded onto each sample and fracture tested.

Results: The dentine samples treated with AgF/KI followed by washing away the precipitate and air drying had bond strengths (2.83MPa) not significantly different from samples that had been conditioned (2.40MPa). Samples where the AgF/KI precipitate had been air dried onto the dentine surface had significantly lower bond strengths (1.49MPa) than the washed samples. Samples that were etched had significantly lower bond strengths (1.91MPa) than the conditioned samples.

Conclusions: This study found that the application of AgF/KI to etched dentine samples followed by washing off the precipitate, created bond strengths that were not significantly different to conditioned samples. Leaving the AgF/KI precipitate on the dentine surface significantly reduced the bond strength of auto cured glass ionomer cement to dentine. Washing away the reaction products and air drying is recommended as the clinical protocol for using AgF and KI on dentine surfaces prior to application of an auto cure glass ionomer cement.

Key words: Dentine, bond strength, auto cure glass ionomer cement, silver fluoride, potassium iodide.

Abbreviations and acronyms: AgF = diamine silver fluoride; ART = atraumatic restorative technique; GIC = glass ionomer cement; KI = potassium iodide.

(Accepted for publication 2 May 2005.)

INTRODUCTION

Diamine silver fluoride ($Ag(NH_3)_2F$), referred to as AgF, has been used in an attempt to prevent or arrest open carious lesions.[1-5] The application of AgF under auto cure glass ionomer cement (GIC) restorations in primary teeth has been shown to produce a favourable pulpal response and to be effective in promoting reparative dentine formation.[6]

The adhesiveness of restorative materials to tooth structure is an important factor in current restorative techniques. Early studies showed that application of AgF significantly improved the bond strength of zinc phosphate cement to ivory.[7] Prior application of AgF has been shown to reduce the bond strengths of resin luting cements to dentine[8] yet increase the bond strengths of GICs.[9] For AgF to be acceptable on a wider scale as a dentine treatment agent, the untoward side effects of staining tooth structure and adjacent tooth-coloured restorations should be eliminated.[10]

A way of managing this problem is to use a follow-up treatment with a salt that reacts with free silver ions (remaining after the application of AgF) to produce a white, as distinct from a black, reaction product. One of the salts to do this is potassium iodide (KI). It produces silver iodide, a creamy white reaction product, that has been used previously in dentistry.[11] There is a lack of information to show what effect the application of KI after AgF treatment will have on the bond strength of GIC to dentine. The purpose of this study was to compare the bond strengths of GIC to dentine surfaces that had been treated with and without AgF and KI.

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MATERIALS AND METHODS

Sample preparation

Ten recently extracted human third molars were stored in 5 per cent chloramine prior to preparation. Teeth were collected within the guidelines set by the Committee for the Ethics of Human Experimentation at The University of Adelaide.

The teeth were embedded into a square mould 30mm x 30mm x 10mm using fast set methyl methacrylate resin so that the crowns were free of the mould material. The teeth were aligned so that their long axes were perpendicular to the base of the moulds and the line angles coincided with the corners of the square mould.

The moulds were glued with sticky wax onto the cutting platform of a diamond cutting wheel (Van Moppes Electrometallic, Wellingborough, UK) and four slices of tooth were removed, perpendicular to the base of the mould to create a square block with four exposed dentine surfaces. The samples were again stored in 5 per cent chloramine solution.

Dentine preparation prior to experimentation

The teeth were removed from the chloramine solution, washed and dried with oil-free air. Each of the four sections of dentine was treated using one of the following: (1) conditioned for 10 seconds with 35 per cent polyacrylic conditioner (GC Corp, Tokyo, Japan), washed and dried with oil-free air; (2) etched for five seconds with 37 per cent phosphoric acid gel (SDI Pty Ltd, Melbourne, Australia), washed and dried with oil-free air; (3) etched for five seconds with 37 per cent phosphoric acid, washed and dried with oil-free air. A solution of 1.8M AgF was applied followed by a saturated solution of KI leaving the reaction products to dry on the dentine surface; (4) etched for five seconds with 37 per cent phosphoric acid, washed and dried with oil-free air. A solution of 1.8M AgF was applied followed by a saturated solution of KI. The reaction products were washed away with water and the dentine surfaces were dried with oil-free air.

A 30mm length of a 4.5mm diameter plastic drinking straw was used as a mould to place a sample of Fuji VII (GC Corp) on each of the prepared surfaces. The capsulated GIC was mechanically mixed for 10 seconds using a RotaMix (3M ESPE, St Paul, Minnesota, USA), inserted into the moulds and allowed to self cure for four minutes after which the moulds were removed and the samples placed into a solution of distilled water for two weeks prior to testing.

Experimental method

Samples were kept moist prior to testing to avoid any dehydration changes in the dentine or GIC that may have affected bond strengths. Shear testing of each of the samples was carried out using a Houndsfield Universal Testing Machine H50KM (Surrey, UK), moving at 1mm per minute with a maximum loading of 500N.

Table 1. Shear bond strength in megapascals of Fuji VII to dentine

Sample	Conditioner	Etch	AgF/KI, wash	AgF/KI, air dried
1	2.45	1.54	3.30	1.61
2	0.85	1.89	1.38	0.25
3	3.33	1.95	4.27	0.82
4	1.29	2.73	2.64	1.70
5	2.48	1.48	2.01	1.57
6	3.27	0.79	2.17	1.26
7	1.73	2.17	2.07	1.57
8	2.77	2.23	1.89	1.38
9	2.36	2.61	#	3.08
10	3.49	1.73	5.72	2.07
Median	2.47	1.92	2.17	1.48
Range	0.84-3.38	78-2.73	1.38-5.72	0.25-3.07

#Sample failed prior to testing.

Data analysis

Since the data were not normally distributed, the Kruskall-Wallis test was used to determine if there was a difference amongst the groups. *Post hoc* testing was used to look at pairwise comparisons with no adjustment made for multiple comparisons.

RESULTS

The surface area of the samples were each 15.91mm^2. Failure loads were recorded in newtons, converted to megapascals and expressed as shear bond strengths. The recorded results are presented in Table 1 and shown graphically in Fig 1. There were significantly lower bond strengths ($P<0.05$) amongst samples where the reaction products had air dried on the dentine surface (1.48MPa) compared to the samples where the precipitate had been washed away (2.83MPa).
Washing away the precipitate resulted in adhesion levels not significantly different ($P>0.05$) to the conditioned samples (2.40MPa). Samples treated with AgF/KI and air dried on the dentine had adhesion levels that were not significantly different ($P<0.05$) to the etched samples (1.91MPa) (Table 2).

There were significantly lower bond strengths ($P<0.05$) between samples treated with phosphoric acid

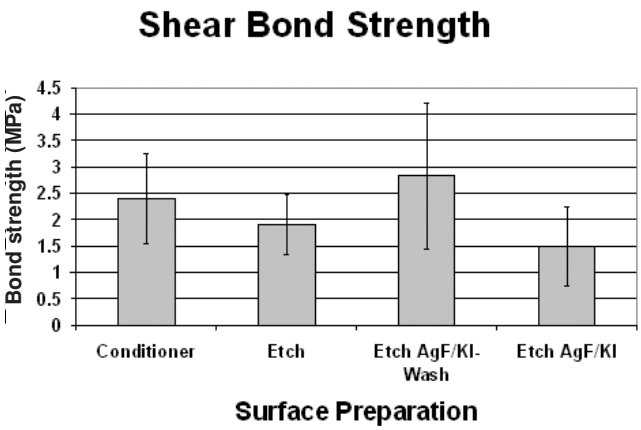

Fig 1. Mean shear bond strengths of Fuji VII to treated dentine samples.

Table 2. Statistical significance (P<0.05) amongst the samples applying Kruskall-Wallis regression analysis

	Conditioner	Etch	AgF/KI washed	AgFKI air dried
Conditioner		0.0495 Significant	0.8793 Not Sig	0.0009 Significant
Etch	0.0495 Significant		0.0471 Significant	0.1169 Not Sig
AgF/KI washed	0.8793 Not Sig	0.0471 Significant		0.0011 Significant
AgF/KI air dried	0.0009 Significant	0.1169 Not Sig	0.0011 Significant	

alone compared to samples conditioned with polyacrylic acid (Table 2).

DISCUSSION

The use of AgF has been generally limited to deciduous teeth due to the staining associated with its application. Notwithstanding this there are indications that AgF has the capacity to form a biological seal at the restorative interface, significantly improving the prognosis of a tooth restored using the atraumatic restorative technique (ART).[10] AgF has also been shown to assist with the disinfection and remineralization of carious deciduous dentine enabling restorative dentists to incorporate demineralized infected dentine as part of the base of a restoration, reducing the chance of a mechanical pulpal exposure in teeth severely affected by caries.[6]

After restoration of permanent teeth, viable bacteria in the remaining carious dentine gradually lose their viability if the cavity margins are completely sealed.[12] However, it would be an added benefit if the remaining organisms were rendered non-viable at the time of restoration placement, especially if no residual staining occurred.

The application of KI to AgF, or the AgF/KI precipitate on the dentine surface, may have reduced the bond strength of dentine to GIC and limited the clinical applications of this procedure. While the bond strengths recorded for the conditioned and AgF/KI washed samples were similar to those found in other studies,[13] it was evident that the reaction products of AgF and KI left to air dry on the dentine surface interfere with bond formation between GIC and dentine.

The standard protocol of conditioning dentine surfaces prior to bonding is to apply a 10 per cent solution of polyacrylic acid.[14] Tay *et al.* have shown there is no significant difference in bond strengths between dentine that has been conditioned or etched for up to 15 seconds.[15] Unlike conditioning, phosphoric acid removes the surface bioload as well as the smear layer and smear plugs and may facilitate the permeation of AgF and KI into the dentine.

Fuji VII is a high fluoride releasing GIC that was specifically designed as an interim restorative to facilitate remineralization of carious dentine and an appropriate material to use in conjunction with AgF application.

CONCLUSIONS

GICs have been shown to have a relatively low yet effective chemical bond to dentine. The long-term maintenance of this bond is an integral part of the clinical application of GICs. This study has shown that dentine samples that had been etched with 37 per cent phosphoric acid for five seconds prior to the application of AgF and KI, followed by washing away the precipitate and air drying the tooth, produced bond strengths not significantly different to samples that had been treated with 10 per cent polyacrylic acid conditioner for 10 seconds. Washing away the reaction products and air drying is recommended as the clinical protocol for using AgF and KI on dentine surfaces prior to application of a GIC.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the assistance of Mr Victor Marino with data collection and statistical support from Ms Emmae Ramsay, Statistician, Department of Public Health at The University of Adelaide.

DISCLOSURE

The corresponding author was associated with the development of Fuji VII and has a financial interest in this product. His name is also on a process patent associated with the use of silver fluoride and potassium iodide.

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