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ABSTRACT

'Press finger' in atraumatic restorative treatment (ART) is used to spread a glass ionomer cement (GIC) to seal the restoration margin and adjacent pits and fissures. This study compared the spreadability of Fuji IX® and Ketac®-Molar to establish which was best suited for this purpose. Twenty equally spaced cavities (35 mm apart) were machine-cut in each of two Perspex slabs 200 x 100 x 20 mm. Each cavity was 3 mm deep with a 4 mm diameter. Two V-shaped grooves 1 mm deep were cut to traverse the cavities: one 0,5 mm wide, the other 0,25 mm wide. Equal amounts (0,25 ml) of GIC were dispensed, 20 cavities for Fuji IX® and 20 for Ketac®-Molar and condensed under light finger pressure using a 20 mm diameter cork thinly coated with petroleum jelly. This allowed the GIC to be condensed into the cavity and spread into the differently sized grooves. The samples were stored in deionised water for 24 hours whereafter the length to which the GIC had spread along each groove from the cavity edge was measured to the closest 0,01 mm. The data were analysed using ANOVA and the unpaired Student's t-test ($P<0.05$). There was a statistically significant difference between the length of spread of the two GICs ($t=2.534$; $P=0.013$) which was confined to the 0,25 mm width groove ($t=2.83$; $P=0.007$) with Fuji IX® spreading much further along the groove (10,25 ± 1.17 mm) than Ketac®-Molar (7,66 ± 4,21 mm). Fuji IX® appears to be the better sealant material when selecting for spreadability in ART.

INTRODUCTION

Glass ionomer cement (GIC) has been used as the restorative material in atraumatic Restorative Treatment (ART) for reasons of adhesion and bonding, fluoride release, control of remaining caries at the tooth tissue interface, remineralisation potential and biocompatibility.[1] Conventional GICs used initially had some unfavorable mechanical properties with respect to strength, wear resistance and shrinkage during setting which led to premature failure rates.[2] This has led to the development of new GICs specifically for the ART technique with improved physical properties. Fuji IX? (G C Corporation) was introduced in 1993, followed a few years later by Ketac-Molar?, an ESPE product. Both manufacturers claim superior features with respect to bonding, expansion, fluoride release, strength, viscosity and ease of use, which they imply makes their product a superior restorative material for ART. Available literature, however, does not show any evidence to substantiate these claims in a purely experimental setting although comparisons have been done in clinical trials.[3-5] In particular, the benefits of improved condensability, viscosity and flow are pivotal to the success of the restorative-sealant role of the GIC when it is spread across the margins of the cavity and into adjacent pits and fissures during 'press finger'. In this way, vulnerable tooth surfaces are protected from primary and secondary decay.

Conventionally, flow characteristics of materials have been tested by means of a cone and plate viscometer,[6] but this instrument is hard to come by and the data it generates may not answer the specific research question sought. Thus, dental materials researchers investigating aspects of flow are required to devise experimental techniques to obtain data which will suit the particular aims of their investigation. Consequently, flow of dental materials has been variously tested by means of glass slabs,[7] short pipettes,[8] or an ingeniously modified crown and die apparatus.[9] In the present study a test system had to be devised which incorporated a set test method and reduced operator variables, yet had some clinical basis.

Available literature shows that the initial depth of an occlusal cavity, for reasons of both pulpal integrity and maximum preservation of sound tooth tissue should be no more than 3 mm.10 The floor of the cavity should be 1mm beyond the amelodentinal junction in a molar tooth.[11] To place fissure depth and cavity depth in some realistic relationship, the study of Gwinnett and Buonocore indicated that the fissures should extend from half to two thirds of the enamel thickness.[12] As regards the widths of these structures, a pit is defined as having a width below 675 µm while any feature with a width greater than this constituted a fissure.[13] Galil and Gwinnett indicate that pit and fissure widths at the base can be between 0,05 and 0,08 mm.[14] A more recent study has shown that the tapered shape of pits and fissures result in the width of these structures varying enormously.[15]

'Sticky' materials are difficult to manipulate and materials purported to flow require some push (shear stress) to start flow, rather than to be expected to flow under their own weight.[7] The 'press finger' technique used conventionally in ART fulfils the 'push' requirement but needed to be normalised to eliminate any error arising from the irregular surface of the operator's finger as well as uneven pressure resulting from the shape of the finger relative to the grooves of the test system. This practical and clinical reality was overcome by using a flat plastic cork, the approximate diameter of an index finger to condense the GIC into each cavity. Perspex was selected to manufacture the testing system, as it is available, cheap and easy to machine cut cavities and grooves to simulate the excavated ART cavity and fissures.

The aim of this study was to compare the spreadability of Fuji IX® and Ketac®-Molar using a test system with dimensions which correctly indicate clinical relationships.

MATERIAL AND METHODS

The test system consisted of two Perspex slabs 200 x 100 x 20 mm. For reasons of economy, both upper and lower surfaces were used. Ten equally spaced cavities were machine-cut in each surface of the Perspex slabs, two cavities in each row, 35 mm apart. Each cavity was 3 mm deep with a diameter of 4 mm. The slab was suf-

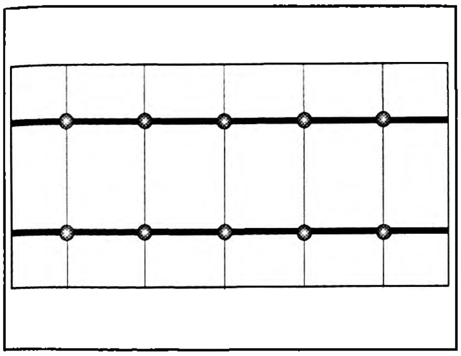

Figure 1: Dimensions of the perspex test mould with grooves and cavities. The heavy line indicates the 0,5 mm groove, the light line the 0,25 mm groove. Cavities are indicated by circles.

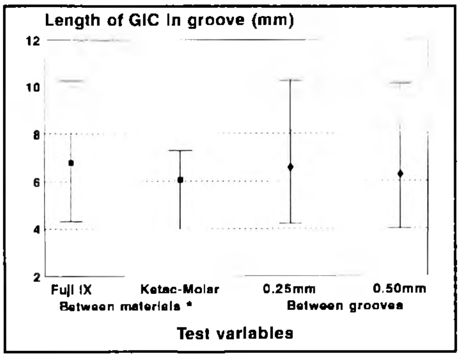

Figure 2: Maximum, minimum and mean values of the length of GIC spread within the grooves. On the left is a comparison between the two materials, which proved to be statistically significant (P<0.05) as shown by the asterisk. On the right a comparison between the GIC spread in the two grooves which showed no significance.

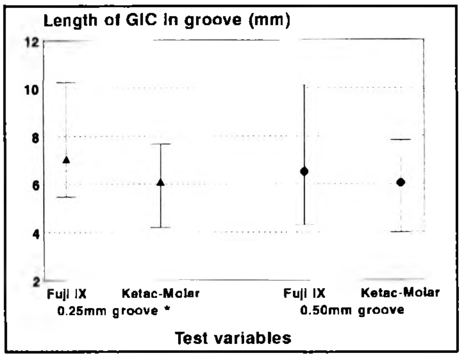

Figure 3: Maximum, minimum and mean values of the length of Fuji IX® and Ketac®-Molar spread within the two groove widths. The comparison within the 0,25 mm groove was significant (P<0.05) as indicated by the asterisk, but not the 0,5 mm groove.

ficiently thick to prevent the cavities connecting, with 14 mm of Perspex between the bases of the cavities. Two V-shaped grooves at right angles to each other were cut to traverse each cavity: both were 1 mm deep but one was 0,5 mm wide, the other 0,25 mm wide at the surface (Figure 1). One slab was used to test Fuji IX® (Batch-161071 ISO9917:1991, GC Corporation, Tokyo JAPAN) and the other for Ketac®-Molar

Table I. Length of GIC spread in mm when statistically tested against GIC and groove width.

Comparison	Mean	Standard deviation	Minimum	Maximum	t value	P value
Glass ionomer cement						
Fuji IX®	6.78	1.49	4.31	10.25	2.534	
Ketac®-Molar	6.06	1.02	4.00	7.82		0.013*
Groove width						
0,5mm	6.27	1.45	4.00	10.12	1.006	
0,25mm	6.57	1.17	4.21	10.25		0.317
Fuji IX® vs groove width						
0,5mm	6.51	1.74	4.31	10.12	1.157	
0,25mm	7.05	1.17	5.48	10.25		0.254
Ketac®-Molar vs groove width						
0,5mm	6.03	1.08	4.00	7.82	0.155	
0,25mm	6.08	0.98	4.21	7.66		0.877
0,5mm groove vs glass ionomer cement						
Fuji IX®	6.51	1.74	4.31	10.12	1.042	
Ketac®-Molar	6.03	1.08	4.00	7.82		0.304
0,25mm groove vs glass ionomer cement						
Fuji IX®	7.05	1.17	5.48	10.25	2.837	
Ketac®-Molar	6.08	0.98	4.21	7.66		0.007*

Key: * indicates that the comparison is statistically significant

(Batch-002 ESPE D-82229, Seefeld, GERMANY). Each restorative material was dispensed and mixed as per the manufacturer's instructions. Equal amounts (0,25 ml) of each material were dispensed in each cavity using a calibrated syringe (Ultradent Product Inc., South Jordan, Utah,USA), this was sufficient GIC to fill the cavity to excess as required for ART.

The restorative materials were condensed into each cavity under light finger pressure using a cork of 20 mm diameter, which was lightly coated with petroleum jelly. This allowed the GIC to be condensed into the cavity and extruded the material into the differently sized grooves in one step. The samples were stored in deionised water for 24 hours to allow the material to stabilise. Thereafter the measurements were made using vernier calipers and a dissecting microscope at magnifications between 8 and 40 magnification. The length to which the GIC had spread in each groove from the cavity edge was measured to the closest 0,01 mm. In total, there were 40 measurements each for the 0,5 mm and 0,25 mm groove. As a control two different operators prepared the specimens and did the measurements, the final value obtained was the average of the two measures.

The data were entered into a computer and analysed using Prism software version 3.0 (GraphPad Software Inc. San Diego, California, USA 1990) and SAS (Statistical Analysis Systems, SAS Institute Inc, Procedures Guide Version 6, 3rd Edition Cary, NC USA) with indpendent variables being the materials (Fuji IX®; Ketac®-Molar) and groove width (0,5 mm and 0, 25 mm). The dependant variable was the length of GIC spread. The data were sequentially reduced to four subsets, which analysed combinations of grooves and materials with ANOVA and the unpaired Student's t test. Statistical significance was set at $P<0.05$.

RESULTS

The Perspex block with precut cavities and grooves proved a simple and effective testing model. The use of the cork to spread the GIC into the grooves seemed to adequately simulate the 'press finger' technique in ART. The extent of GIC spread was easily and accurately measured with the vernier calipers. The Student's t-test showed there was a statistically significant difference in spreadability between the two GICs ($t=2.53$; $P=0.013$) although not between the extent of spread between the grooves (Figure 2). On further analysis of subsets the significance was confined to the 0,25 mm width groove ($t=2.83$; $P=0.007$) with Fuji IX® spreading much further along the narrower groove (10,25 ± 1,17 mm) than Ketac®-Molar (7,66 ± 4,21 mm). Figure 3 shows the mean, minimum and maximum spread of GICs within the different width grooves. The maximum range of spread for Fuji IX ® is considerably higher than Ketac®-Molar for both groove widths. Minimum length of spread for Fuji IX® in the 0,25 mm groove is at 5,48 mm while in all other comparisons this length varies between 4,0 and 4,31 mm. Table 1 shows the complete series of tested subsets.

DISCUSSION

The longer term (3 to 5 year) published studies of the ART approach have been from uncontrolled field trials using subjective clinical observation methods to report the behaviour of restorations.[16-18] The criteria used to assess the quality of ART restorations have been designed around secondary caries development and the reported poor strength of the filling materials.[17] Evaluation criteria have therefore been designed to measure and track the frequency and gradation of these two characteristics. While there has been a definite increase in the survival percentage of ART restorations, clinical experience gained over the years could have contributed towards the upward trend as well as the use of newer GICs with improved physical characteristics.[17,19]

Unfortunately, the evaluation criteria have been unable to distinguish between the contribution made by the 'sealant' and 'restorative' component of the approach.

The spread of Fuji IX® along the length of the grooves was greater than Ketac®-Molar in both 0,5 mm and 0,25 mm grooves. This difference in the spreadability was more pronounced and statistically significant in the 0,25 mm width grooves further reinforcing the superior spreading properties of Fuji IX® over Ketac®-Molar. Detailed analysis and interpretation of the experimental data have been hampered by dental material manufacturers' reluctance to divulge pertinent details of the composition and physical properties of Fuji IX® and Ketac®-Molar which could affect spreadability. Thus much of the conclusions are based on extrapolation of broad physical principles and the promotional material supplied by the two manufacturers.

When using a constant test method, differences in spreadability may be attributed to a number of factors which in turn, directly affect the adapting properties of the restorative material. By increasing the powder liquid ratio,[20] the poly acid concentration,[21] or the molecular weight of the polyacid,[22] the physical properties of the GIC can be improved. However in practice, the molecular weight is limited by viscosity and some balance has to be made between concentration, molecular weight and viscosity in order to achieve optimum properties from the GIC.[23] Improved physical properties in Ketac®-Molar based on its enhanced molecular composition and high cross linkage in the GIC matrix could have impacted on its flow properties due to the limitation of viscosity when molecular weight of polyacid in GIC is increased. This could have played a role in making Ketac®-Molar less spreadable when compared with Fuji IX® along the standardised grooves.

Salama *et al.* imply that the more spreadable the GIC, the better are its fissure and marginal sealing abilities.[24] Clearly such an assumption does not always hold true. The sealing ability of a GIC will also depend on factors such as the chemical composition of the material and placement procedures among others. The enhanced properties of Ketac®-Molar with respect to compressive and flexural strength, solubility and flow properties was supposed to render superior clinical performance as compared to Fuji IX®. This proved to be the converse when the sealant aspect was investigated. The superior spreadability of Fuji IX® over Ketac®-Molar in the narrower of the two grooves imply its better fissure sealing abilities, which is a pertinent factor in determining the success of ART restorations.

Manufacturers of dental materials test for safety and efficacy.[7] Few, if any physical or mechanical properties are tested to correlate with clinical success in specific applications. In the absence of specific clinical trials, the clinical success of a material is discovered by general practitioners experimenting with materials in a range of applications.[7] It is the inconsistency of this trial-and-error experience, which has made the contribution of the independent dental materials researcher essential to verify the manufacturer-proposed clinical applications of materials. The major advantages of laboratory-based studies are that they provide rapid, reproducible and sensitive means for comparing key performance characteristics of restorative materials independent from other attributes. In order to make the test system relevant to clinical procedure, the test model used in the present study was designed according to dimensions encountered of the cavity and adjacent fissures in natural teeth. Coincidently, a system using similar dimensions has been used to examine toothbrush cleaning of occlusal fissures.[25]

In view of the findings of this study it appears that FujiIX® has better flow characteristics and therefore better spreadability than Ketac-Molar. By implication, FujiIX® has the potential to be the better sealant material when selecting for this aspect of the sealant-restorative role of the ART approach, but further marginal leakage testing will need to be done to substantiate this claim. It is recommended that the manufacturers pay more attention to the sealant role of GIC in ART, since it plays a significant role in the long-term success of ART restorations. This set testing technique for restoring and spreading the GIC, into the cavities and grooves can be used to serve as a reliable method for future laboratory studies.

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