International Journal of Applied Dental Sciences 2016; 2(2): 77-80

ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2016; 2(2): 77-80

www.oraljournal.com
Received: 10-02-2016
Accepted: 11-03-2016

Dr. Uday Kamath
Professor and Head of the Department, Department of Conservative Dentistry and Endodontics, Dr. Syamala Reddy Dental College Hospital and Research Centre, Bangalore.

Dr. Afna Salam
Post Graduate Student, Department of Conservative dentistry and Endodontics, Dr. Syamala Reddy Dental College Hospital and Research Centre, Bangalore.

Correspondence
Dr. Uday Kamath
Professor and Head of the Department, Department of Conservative Dentistry and Endodontics, Dr. Syamala Reddy Dental College Hospital and Research Centre, Bangalore.

Fracture resistance of maxillary premolars with mod cavities restored with Zirconomer: An *in vitro* comparative study

Dr. Uday Kamath, Dr. Afna Salam

Abstract
Aim: To test the fracture resistance of maxillary premolars with MOD cavities restored with a new Zirconia reinforced Glass Ionomer Cement (Zirconomer) and to compare it with other conventional posterior restorative materials like GIC and Amalgam.
Materials and Methodology: Freshly extracted forty intact, non-carious human maxillary premolars were collected and stored in distilled water. The teeth were randomly divided into 2 Control groups with 5 teeth each (n=5) and 3 experimental groups with 10 teeth each (n=10).
Group I: No cavities were prepared (Positive control).
Group II: Class II MOD cavities were prepared but not restored (Negative control).
Group III: Cavities were restored with Amalgam (DPI).
Group IV: Cavities were restored with Glass Ionomer Cement (GC).
Group V: Cavities were restored with Zirconomer (Shofu). Fracture resistance was tested with a steel ball of 4mm diameter with a cross head speed of 1mm/min in Universal Testing Machine. Statistical analysis was done using One-Way Analysis Of Variance (ANOVA) and Tukey test

Results: Teeth restored with Zirconomer were most resistant to fracture load followed by Amalgam ($p>0.05$) and Glass Ionomer Cement ($p<0.05$), suggesting Zirconomer can be used as a potential substitute for amalgam in posterior teeth.

Keywords: Fracture resistance, Zirconomer, Glass Ionomer Cement, Amalgam

Introduction
Removal of tooth structure via cavity preparation has been shown to weaken teeth and increase their susceptibility to fracture [1, 2]. Studies on the weakening of teeth by mesio-occlusal-distal (MOD) cavity preparations and the effect of restorations in strengthening the remnant tissue have been conducted experimentally. Depending on the extent of the cavity, restorative treatment is a predisposing factor for an incomplete or complete tooth fracture [3]. According to a study conducted by Joynt *et al*, in 1987 [4], preparation of an occlusal cavity reduces the tooth stiffness by 20%. If a marginal ridge is also involved and removed during this preparation the occlusal cavity transforms into a proximal cavity and the tooth stiffness further reduces by 2.5 folds resulting in an overall 46% reduction in tooth stiffness. If both marginal ridges are included in the cavity preparation design, the stiffness decreases by 63% [4, 5]. Posterior teeth, particularly maxillary premolars, have an anatomic shape that makes them more likely to fracture the cusps under occlusal load [6, 7].
Amalgam has traditionally been used as the best build-up material [8, 9]. As amalgam is strong in bulk section, but its slow setting process, mercury content and unpleasant colour, were some of the reasons why alternative core build-up materials have been developed [10]. The major disadvantage of amalgam, however, is its inability to bond to dental hard tissues which necessitates the use of macro mechanical retentive features which cause further weakening of the remaining tooth structure [11, 12]. Several properties of glass-ionomer cements such as fluoride release, adhesion to tooth structure, ease of placement and biocompatibility make these materials attractive for their use in practice, but they have inferior compressive and tensile strengths [10, 13].
With the decline in popularity of amalgam in recent years, there is a need for an equally strong yet safer replacement. Zirconomer defines a new class of restorative glass ionomer that

Promises the strength and durability of amalgam with the protective benefits of glass ionomer while completely eliminating the hazard of mercury. According to the manufacturer, Zirconomer has been reinforced with special zirconia fillers to match the strength and durability of amalgam; sustained high fluoride release; packable and condensable like amalgam without the hazard of mercury, risk of corrosion, expansion and thermal conductivity. The high flexural modulus and compressive strength of Zirconomer ensures longevity in stress bearing areas; it chemically bonds to enamel/dentin and has tooth-like co-efficient of thermal expansion resulting in low interfacial stresses and long-lasting restorations; has adequate working time with snap-set reaction; easy mixing and handling characteristics minimize chair time and enables ease of bulk placement and excellent resistance to abrasion and erosion.

Materials and Methods

A total of 40 extracted human maxillary premolars extracted for orthodontic purposes, were selected. Ten intact premolars served as the control group and 40 premolars received MOD cavity preparation and were divided into four groups (n = 10). Any calculus deposits and soft tissue were removed from the selected teeth using a hand scaler. The teeth were cleaned with pumice and examined under ×10 magnification to detect any pre-existing defects. Following post-extraction storage in 10% neutral buffered formalin for at least four days, the teeth were stored in tap water at room temperature until used.

Each tooth was fixed, with the crown uppermost and long axis vertical in polyvinyl chloride (PVC) rings with a length of 25mm and a diameter of 10mm, using auto-cured acrylic resin. The level of the resin was limited to 1.0 mm below the cemento - enamel junction. The teeth were divided into 5 groups which were color coded for easy identification and scoring: 2 control groups (n=5) and 3 experimental groups (n=10). Standardized class II MOD cavities were prepared in all teeth except the positive controls with the dimensions : 2 ± 0.2 mm pulpal width, 2 ± 0.2 mm gingival width, 3 ± 0.2 mm buccolingual width and are verified using a periodontal probe. The facial and lingual walls of the occlusal segment were prepared parallel to each other with the cavosurface angle at 90^0

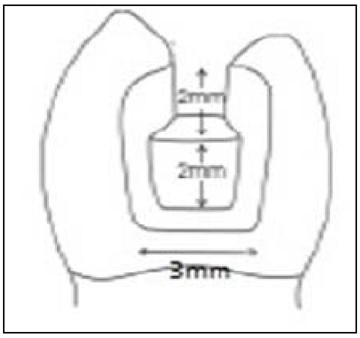


Fig 1: Schematic representation of the standardized cavity preparation

Group I: Blue color coded group which serves as the positive control with unprepared teeth.

Group II: Pink color coded group which serves as the negative control. This consisted of teeth in which cavity preparations have been done but were left unrestored.

Group III: Grey color coded. Here, Class II MOD cavities were prepared, matrix band & retainer were adapted and were restored with Amalgam (DPI).

Group IV: Green color coded group. Here, Class II MOD cavities were prepared, matrix band & retainer were adapted and were restored with GIC (Fuji Type IX, GC).

Group V: Violet color coded group. Here, Class II MOD cavities were prepared, matrix band & retainer were adapted and were restored with Zirconomer (Shofu)

The specimens were stored in distilled water and thermocycler for 5,000 cycles at 5 °C and 55 °C with each cycle corresponding to a 15 sec bath at each temperature. The specimens were tested individually in a universal testing machine (Instron, ARML, Bangalore). Each specimen was subjected to compressive loading using a rounded stainless steel testing probe, 5mm in cross section, at a cross head speed of 1mm/min until the cusp is fractured.

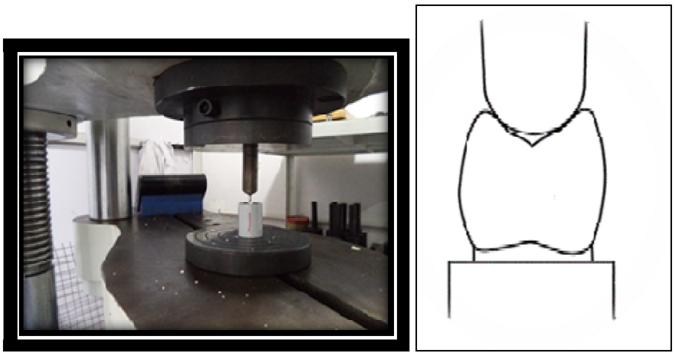


Fig 2: Load applied on the buccal and lingual slopes of the teeth

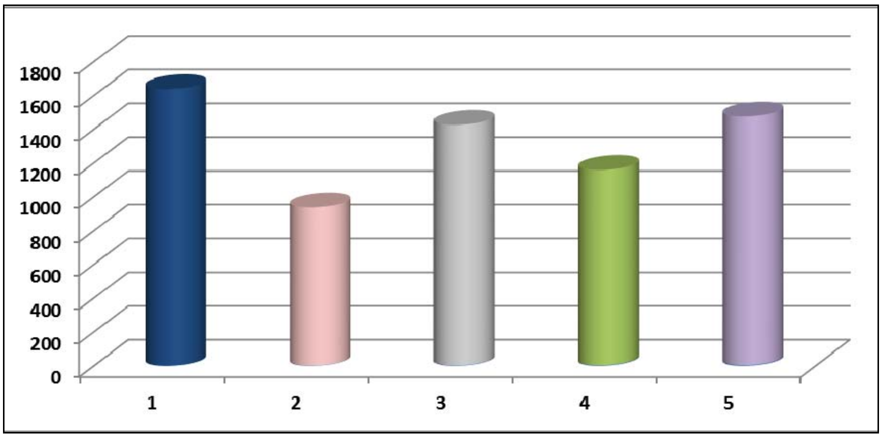
The probe should contact the inclined planes of the facial and palatal cups beyond the margins of the restorations. Peak load to fracture was recorded in Newtons (N) for each specimen and the mean was calculated for each group. Statistical analysis was done using One Way Analysis of Variance and Tukey test. A p – value less than 0.05 is considered significant.

Results

All samples failed with a buccal or lingual cuspal fracture after compression. Mean values of the compression force required for cuspal fracture (N) and standard deviations for each experimental group are shown in Table 1. Statistical analysis revealed that the mean fracture load for group 1 (intact teeth) was significantly higher than that of the other groups ($p <$ 0.05). Among the experimental groups, Group 5 (Zirconomer) had highest fracture loads, followed by Groups 3 (Amalgam) and among the experimental groups. The fracture load values for Zirconomer and Amalgam didn't show statistically significant difference among them but were significantly higher than that of Group 4 (GIC).

Table 1.

Groups	N	Mean	Standard deviation
Positive controls	5	1701.0000	19.4936
Negative controls	5	935.0000	42.7668
Amalgam	10	1439.2000	137.5111
GIC	10	1155.6000	76.0690
Zirconomer	10	1493.8000	123.7756



Discussion

A fracture is a complete or incomplete break in a material resulting from the application of excessive force. Fracture resistance is an important property directly related to cracking [3, 14]. Masticatory forces on restored or unrestored teeth have a tendency to deflect the cusps under stress [15]. Even though *in vitro* studies are not an actual reproduction of a typical chewing stroke, in that they apply a continuously increasing force until the tooth fractures, they represent an important source of information on the structural integrity of the tooth.

Ideally any material that is used to restore missing tooth structure should reinforce the tooth and minimize risk of cuspal fracture. In this study, the difference in resistance to catastrophic fracture between the sound (unprepared) teeth and restored teeth was highly significant. This supports previous findings that demonstrate the deleterious effect that cavity preparation has on the fracture resistance of posterior teeth [16]. Hood analysed the biomechanics of the intact, prepared and restored tooth and considered that the degree of cuspal deflection increases with the depth of the preparation [17]. According to Mondelli and others, teeth with large MOD cavities are severely weakened due to the loss of reinforcing structures and become more susceptible to fractures [18].

In the present study, teeth restored with Zirconomer showed highest fracture resistance because of yttrium stabilized zirconia (YSZ) particles in Zirconomer which provide high strength and high elastic modulus [19]. Zirconomer showed statistically significant increase in fracture resistance over GIC as Zirconia particles are significantly harder than glass particles that is present in conventional GIC [20]. The mechanical properties of YSZ-GIC may be high because of continuous formation of Aluminium salt bridges, which improved the strength of the cement. The micro-sized YSZ - GIC powders revealed a bimodal particle distribution and this ensured a high packing density of glass ionomer cements giving high mechanical properties for Zirconomer [20]. The bonding capability of GICs to dentin were assessed by many authors [21-23]. Almost all of these studies were carried out on extracted teeth. All these *in vitro* studies proved the fact that the bonding of GICs to dentin is poor (weak) or non-existent. The results of this study are in agreement with the above studies [10].

The results of this study have shown that the material of choice for premolars with MOD cavities include dental amalgams and the newly introduced Zirconomer, as they are as strong as the control group. These results are in agreement with the results of Burke *et al* [24]. Who have concluded that the teeth restored with amalgam were most fracture resistant. Zirconomer showed slightly better fracture resistance than amalgam. This is because of the presence of Yttria stabilized Zirconia particles in the material that increased the compressive strength [19]. Combination of outstanding strength, durability and sustained fluoride protection deems it ideal for permanent posterior restoration in patients with high caries incidence as well as in cases where strong structural cores and bases are required. Y.W Gu. *et al.* have done a study in which Yttria stabilized zirconia (YSZ) particles were used for the replacement of amalgam alloy in Miracle Mix. Their results also showed that the YSZ–glass ionomer cements have improved mechanical properties when compared with the conventional glass ionomer cements [25].

Conclusion

Zirconomer is found to have better strength than the conventional posterior restorative materials. Within the limits of this study it can be concluded that Zirconomer can be used as a replacement for amalgam as posterior direct tooth coloured restoration. Further research has to be carried out to determine the clinical efficiency and longevity of Zirconomer to use it as an alternative for amalgam.

References

1. Joynt RB, Davis EL. Fracture resistance of posterior teeth restored with glass-ionomer-composite resin system, J Prosthet Dent. 1989; 62:28-31.
2. Stephan EW, Staninec M, Lacy AM. Effect of bonded amalgam on the fracture resistance of teeth, J Prosthet Dent. 1992; 68:257-260.
3. Hamouda IM. Fracture resistance of posterior teeth restored with modern restorative materials, J of Biomed Res. 2011; 25(6):418-424.
4. Joynt RB, Wieczkowski G Jr, Klockowski R, Davis EL. Effects of composite restoration on resistance to cuspal fracture in posterior teeth, J Prosthet Dent. 1987; 57:431-435.
5. Rezvani MB, Mohammadi Basir M, Mollaverdi F, Moradi Z, Sobout A. Comparison of the Effect of Direct and Indirect Composite Resin Restorations on the Fracture Resistance of Maxillary Premolars: An *In Vitro* Study J Dent Sch. 2012; 29(5):299-305.
6. Mondelli RFL, Ishikiriama SK, Oliveira Filho O, De, Mondelli J. Fracture resistance of weakened teeth restored with condensable resin with and without cusp coverage, J Appl Oral Sci. 2009; 17(3):161-165
7. Mondelli RFL, Barbosa W, Mondelli J, Franco E, Carvalho R. Fracture strength of weakened human premolars restored with amalgam with and without cusp coverage, Am J Dent. 1998; 11:181-184.
8. Van Nieuwenhuysen JP, D'Hoore W, Carvalho J, Qvist V. Long-term evaluation of extensive restorations in

permanent teeth, Journal of Dentistry. 2003; 31(6):395-405.
9. Wassell RW, Smart ER. Cores for teeth with vital pulps, British Dental Journal. 2002; 192:499-502, 505-509.
10. Petronijević B. Fracture resistance of restored maxillary premolars Contemporary Materials 2012; 3(2):219-225.
11. Staninec M. Retention of amalgam restorations: undercuts versus bonding, Quintessence International 1989; 20(5):347-351.
12. Shivaughn M. Cusp Fracture Resistance of Maxillary Premolars Restored with the Bonded Amalgam Technique Using Various Luting Agents. International Journal of Dentistry. 2009, 946-830, 4.
13. Tirado JIM, Nagy WW, Dhuru VB, Ziebert AJ. The effect of thermo cycling on the fracture toughness and hardness of core build up material, Journal of Prosthetic Dentistry. 2001; 86:474-480.
14. Schultrich B. Strength of cemented carbides, in: Mechanical properties of brittle materials, in: Modern theories and experimental evidence (Wiss. Acad. Tier Wissenschaften der DDR. Zentralinstitut fur Festkorperphysik und Werkstofforschung N32, 1986, 229-66.
15. Jagadish S, Yogesh BG. Fracture resistance with class II silver amalgam, posterior composite and glass–ionomer cement restorations Opera Dent 1990; 15:42-47.
16. C¨otert HS, Sen BH, Balkan M. *In vitro* comparison of cuspal fracture resistances of posterior teeth restored with various adhesive restorations, The International Journal of Prosthodontics. 2001; 14(4):374-378.
17. Hood JA. Biomechanics of the intact, prepared and restored tooth: some clinical implications, Int Dent J. 1991; 41(1):25-32.
18. Santos MC, Bezerra RB. Fracture Resistance of Maxillary Premolars Restored with Direct and Indirect Adhesive Techniques, J Can Dent Assoc. 2005; 71(8):585.
19. YW Gu. Effects of Incorporation of HA/ZrO2 glass ionomer cement, Biomaterials 2005; 26:713-720.
20. Gu YW. Journal of non-crystalline solids. 2005; 351(6):508-514.
21. Mason PN, Ferrari M. *In vivo* evaluation of glass-ionomer cement adhesion to dentin. Quintessence International 1994; 25:499-504.
22. Cunningham MP, Meiers JC. The effect of dentin disinfectants on shear bond strength of resin-modified glass-ionomer materials, Quintessence International 1997; 28:545-551.
23. Croll TP, Phillips RW. Six years, experience with glass-ionomer-silver cermet cement. Quintessence International 1996; 22:783-793.
24. Burke FJT, Shaglouf AG, Combe EC, Wilson NHF. Fracture resistance of five pin-retained core build-up materials on teeth with and without extra coronal preparation, Operative Dentistry 2000; 25:388-394.
25. Gu YW. Zirconia Glass Ionomer Cement– A Potential Substitute for Miracle Mix, Scripta Materialia 2005; 2(2):113-116.