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Comparative evaluation of fracture resistance of teeth restored with different types of restorative material- An in vitro study

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Abstract

The development of adhesive dental materials resulted in good chemical bonding to tooth structure. However, they are still lacking in color s stability and strength in oral environment over a long period of time. Duo to these disadvantages of dental materials, amalgam restoration is still preferable as the restorations of choice for posterior region. The use of adhesive resins to increase the retention, resistance and marginal seal of amalgam restoration has gained a strong foothold in restorative dentistry. The advantage of bonded restoration is the conservation of tooth structure as well as tooth reinforcement. The aim of the study was to investigate and compare the fracture resistance of conventional amalgam restoration with bonded amalgam, pin retained amalgam restoration and composite restoration and influence of bonded amalgam restoration on the fracture resistance of mandibular molars and to determine whether bonding amalgam are suitable alternative to the pin retained amalgam restoration system. Seventy five extracted mandibular molars were randomly divided in to five groups including one control group. A mesio-occlusal preparation including lingual cusp was performed on all the teeth. Group 1 serves as negative control group with no tooth preparation. Group 2 were restored with conventional restoration. Group 3 were restored with bonded amalgam restoration. Group 4 were restored with pin retained amalgam restoration. Group 5 were restored with posterior composite (Micro hybrid) restoration. All the specimens were mounted in acrylic block and thermocycled. Each specimen was loaded in compression at 90 degree angle in an Instron testing machine with cross head speed of 5mm/min. The load required to fracture the teeth were graphically recorded in Newton and data obtained were subjected to statistical analysis.

Keywords: Silver Amalgam, Composite, Instron Testing Machine and Bonding

Introduction

Amalgam has been used to restore posterior teeth since 1826 because of its ease of handling, physical properties, cost, life expectancy, and biocompatibility. Though amalgam possesses adequate mechanical properties, it does not bond to tooth structure.[1] The remaining tooth structure is weakened rather than strengthened The bond of a restorative material to tooth structure has 3 advantages: first, it can reduce or even eliminate microleakage, a major dental problem implicated in secondary caries; second, a chemical bond between the restorative material and dentin enhances retention; and third, this bond preserves tooth structure.[2] The short coming of amalgam restorations, including poor appearance, lack of adhesion to tooth structure and microleakage are widely recognized. When a badly broken down tooth is restored, mechanical retention forms may include additional grooves, slots, and retention pins. These retentive means generally provide the support once furnished by walls. In this context, pins allow the operator to gain axial wall height, which improves the chance of keeping the margin of the restoration coronal to the gingival margin. Pins also act as a binding device between the tooth and restorative material.[3] Properly placed pins will resist dislodgment of the restorative material caused by forces of mastication. However, pins will not eliminate microleakage. In fact, it has been shown that the use of pins can weaken restorations. Because several problems have been associated with self-threading pins, the advent of adhesives has diminished the use of pins to increase the retention.[4]

Studies have demonstrated high-stress concentrations in dentin, dentinal cracks and amalgam voids surrounding the self-threading pins (Khera, Chan & Rittman, 1978). Ianzano, Mastrodomenico & Gwinnett (1993) studied the bond strength of adhesives and self-threading pins with amalgam restorations. They compared the use of amalgam with an adhesive, amalgam alone, amalgam with a pin, and amalgam with a pin in conjunction with an adhesive. They concluded that the strength of amalgam restorations benefited more from the use of a 4-meta adhesive. Composite resin; posses such positive features as a bonding capacity to enamel and dentin, in fact that the timing of their hardening can be controlled, low thermal conductivity, a pleasant aesthetic appearance, ease of application, resistance and low solubility in oral environment.[5] Posterior composite resins are now frequently used as restorative materials by many clinicians. The material is highly aesthetic and the introduction of different filler particles has improved the physical properties. The newer bonding adhesive systems have improved the marginal adaptation of composite resins.[6]

Materials and Methods

A comparative in vitro study to evaluate the fracture resistance of mandibular molars was undertaken at the Department of Conservative Dentistry and Endodontics, K.M.Shah Dental College and Hospital, Vadodara.

Seventy five extracted, intact, non-carious and unrestored human mandibular molars collected from the Department of Oral and Maxillofacial Surgery, K.M.Shah Dental College and Hospital, Vadodara were stored, disinfected and handled as per the recommendations and guidelines laid down by Occupational Safety and Healthy Administration (OSHA) and Center for Disease Control and Prevention (CDC). All the collected teeth were cleared of blood, calculus and surface deposits and stored in isotonic saline. All the teeth were inspected under transillumination fiber-optic light to detect the presence of cracks. Those with apparent cracks were excluded from the study.

Preparation and Grouping of the Specimen

The specimen teeth were embedded 2mm apical to the cemento enamel junction in autopolymerising acrylic resin held in a hollow cylindrical metallic mold of height, 3 inch and diameter2 inch. Except for fifteen intact molars which comprised one of the control groups, standardized class II complex cavity preparations, including lingual cusp was performed on all the teeth using a No. 245 tungsten carbide bur with a high speed airotor hand piece under air/water spray. The size of the preparation was made proportional to the dimensions of the tooth to minimize variations resulting from tooth size. The specimens were randomly divided into groups with specimens in each group and labeled Specimens with color coding (fig-1) with colored coding tape for identification. One group was coded as the control groups and the other four as experimental groups

Fig.1: (All five groups with their respective colour coding)

Groups

Group-1: Intact teeth (as a control group).

Group-2: Conventional amalgam restoration with a varnish.

Group-3: Bonded amalgam restorations.

Group-4: Conventional amalgam restoration with a varnish and pin-retention.

Group-5: Teeth restored with Composite resin restoration

Fig. 2: Instron Testing Machine

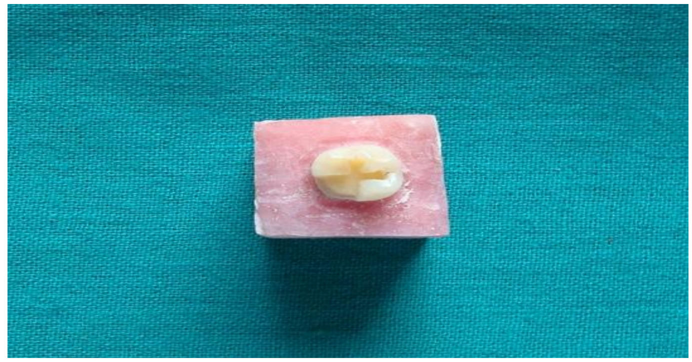

Fig. 3: Specimen Mounted With Acrylic Block

Before being tested, all specimens were thermocycled 6 C to 57 C for 1,000 cycles with a dwell time of 30 seconds. The experimental specimens were mounted on the lower cross member of Instron testing machine (fig-2) using a steel mold which have a inclination of 13.5^o angle to the vertical plane. This mold had a socket of (16,16,14) suitable for the dimensions of the acrylic specimens. A steel sphere 6.5 mm in diameter and 7 cm in length was attached to the upper cross member of the machine. The occlusal cuspal planes were adjusted so that the steel sphere contacted the tooth far enough up the cuspal inclines without engaging the restoration (except for the control group). The force was applied to the right angle to the inclined plane (mesio-lingual). The testing machine was programmed to deliver an axial force to the occlusal surface of the specimens increasing from zero up to the maximum of 1000 kegs at a crosshead (Strain Rate) speed of 5mm/min. In entire testing procedure the specimens were irrigated with syringe to avoid the dehydration of the tooth. As the force increases, which were monitored on the display, at the stage when the tooth were fractured the readings, were start reversing. The loads required to fracture the teeth were graphically recorded (table-2) in newton and the data obtained were subjected to statistical analysis.

Result and Statistical analysis

Groups	Mean	Standard deviation
Group 1	1602	312
Group 2	1084	299
Group 3	1282	325
Group 4	1196	340
Group 5	1516	342

Table-1 Mean and Standard deviation of compressive load to fracture

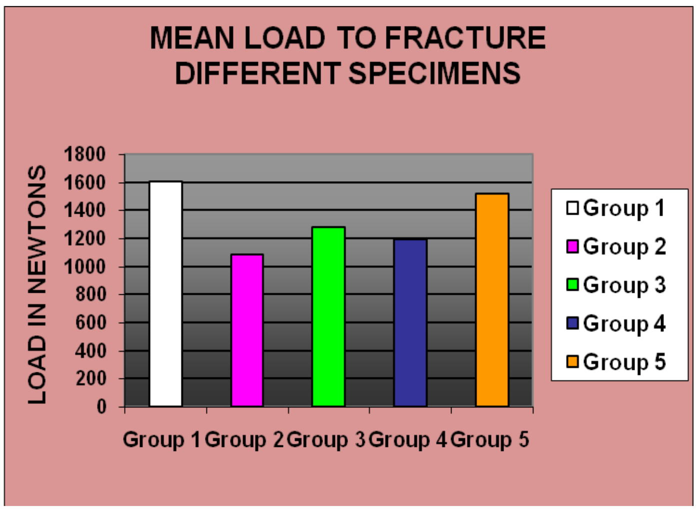

Table-2

Discussion

The anatomic forms of posterior teeth with cusps and fosse present a design possessing a tendency to deflect the cusps under stress. While sound teeth rarely fracture from the stresses of mastication, fracture of a cusp may occur in teeth that have been weakened by carious lesion and cavity preparation. One experimental approach to study the effect of cavity preparations and restorative procedures is to apply loads to fracture teeth. Crushing teeth with compressive forces is a testing model that is clinically unrealistic. The breaking forces are much greater than those generally encountered in the mouth. In addition, statistical differences between restorative procedures are difficult to depict, as they become masked by the destructive nature of the test.[7] Cavity preparation reduced the stiffness and weakened the tooth. Restoring the prepared tooth with unbonded amalgam did not restore the lost tooth stiffness. Restoring the prepared tooth with bonded amalgam or with bonded composite recovered a significant portion of the lost tooth stiffness.[8] A restored tooth tends to transfer stress differently than an intact tooth. Any force on the restoration produces compression, tension or shear along the tooth/restoration interface. Since enamel is no longer continuous its resistance is much lower. Therefore, most restorations are designed to distribute stresses onto dentin, rather than to enamel. Once in dentin, the stresses are resolved in a manner similar to normal tooth. Even though there is an increase in awareness of preventive dentistry, dental amalgam remains the most widely used posterior restorative material providing longevity, ease of use and effectiveness.[11]One of the primary shortcomings of amalgam is its inability to bond to tooth structure. To retain the restoration and wear occlusal load, healthy tooth structure sacrificed in the form of dove tail, grooves, and slots thus weakening the tooth structure. In addition to providing adequate retention, bonded amalgam restorations may provide distinct advantages over non-bonded amalgam restorations by added tooth reinforcement, decreased postoperative sensitivity, better marginal adaptation, reduced secondary caries, and more conservative preparation. There is a substantial body of supportive evidence for the advantages of bonding amalgams, a great deal of which is derived from *in vitro* investigations.[9] Randall et al. suggested that the non-invasive methods that general practitioners can use when restoring complex restorations without all the risks involved with the placement of dentinal pins and pots and slots. These data suggest that adhesive resin liners may be used as an alternative or adjunct to mechanical retention.

Even though the laboratory and clinical studies reviewed did not demonstrate a statistical significance between adhesive resin liners and placement of dentinal pins and pots and slots, investigators still found an overall increase in the bond strength of amalgam and composite resin to tooth structure when an adhesive/bonding agent was used. When comparing the restorations that were bonded versus the ones that used dentinal pins alone, the resistance to fracture was slightly higher.[10] The degree to which these advantages are realized is proportional to the strength and longevity of the adhesive bond. The few *in vivo* studies available to date show little advantage for bonding in traditional preparations with mechanical undercuts. However, there is evidence accruing that bonded amalgam can be favorably used in other situations, such as large compound restorations, preparations without retention, or as sealants in pits and fissures, notably adjacent to bonded amalgam restorations. Sealing pits and fissures close to a bonded amalgam restoration may be conveniently performed at the same time as the restoration placement.[3]Despite the apparent advantages of bonding amalgam restorations, for small restorations it is unlikely that bonding will be routinely employed in preference to traditional non-bonded amalgam restorations, nor challenges the ever-increasing use of bonded resin composite. But there seems to be an apparent increased confidence of clinicians in using bonding in the placement of large compound amalgam restorations. Prospective randomized controlled clinical studies over longer periods of time are required to determine the longevity of the bonded amalgam restoration in clinical service. These studies should also cover extended uses for the resin bonding of amalgam, such as for prolonging the life of existing restorations by repairs and additions. Notwithstanding the advantages of the technique, there is an added cost associated with bonding, which should be subjected to cost benefit analysis. Furthermore, given the increasing applications and use of amalgam bonding, it is suggested that this procedure should be widely included in the pre-doctoral dental curriculum.[11] Application of adhesive resins between dental surfaces and amalgam restorations in place of copal varnish has become a common procedure. There are two main reasons for using adhesives in restorative dentistry: to improve both the marginal seal and retention.The use of any retentive features incorporated into the cavity preparation involves the removal of additional tooth structure. The use of a bonding system has proven to have adequate bond strengths to amalgam. Hadavi *et al*. (1994) compared several adhesives systems.[12]

The advent of adhesive dentistry has increased the bond strengths of amalgam and composite resins. The other advantages of a bonded restoration include the conservation of tooth structure, reduction in microleakage and reduction in post-operative sensitivity.[13]The adhesive adheres to the tooth structure through the formation of a hybrid layer, which is formed through the infiltration of the monomers into the pre-treated dentin.[14,15] The bond to amalgam then becomes a mechanical retention, with the resins being incorporated into the amalgam. The development of the newer adhesives currently, creates dentin bond strengths similar to those of the enamel bond to composite resins.[16]

In the resin bonded amalgam the weakest link is the amalgam/resin interface due to the inherent stiffness of amalgam.[18,19] The fracture site results of this study suggest the highest bond strengths occurred when a majority of failures were cohesive in nature and the weakest bonds were associated with a high percentage of adhesive failures. It is generally accepted the attachment mechanism is achieved largely by the intermingling of adhesive resin and unset amalgam at the time of amalgam insertion.

Conclusion

The present study concluded that the pin retained restoration showing the higher fracture resistance then conventional amalgam restoration, but the use of adhesive resin relatively increases the fracture resistance of tooth, when compared with the non adhesive group. The values for composite resin were higher than other restorative groups except for the intact group.

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