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5. Type of clearance: _x_Paper __Article __ Book ___Poster ___Presentation ___Other

6. Title: "Proximal Contact Repair of Complex Amalgam Restorations"

7. Intended publication/meeting: *Operative Dentistry*

8. "Required by" date: 30 June 2015

9. Date of submission for USU approval: 16 June 2015

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Proximal Contact Repair of Complex Amalgam Restorations

Abstract

The carving of a complex amalgam restoration may occasionally result in a light proximal contact with the adjacent tooth. The purpose of this study was to investigate the strength of complex amalgam restorations repaired with an amalgam proximal-slot preparation. Extracted human third molars of similar coronal size were sectioned at the height of contour using a saw and randomly distributed into nine groups of ten teeth each. One regular TMS pin (Coltene) was placed at each line angle of the flattened dentinal tooth surface approximately 1mm from the dentino-enamel junction. A metal matrix band was placed and an admixed alloy (Dispersalloy, Dentsply) was condensed and carved to create a full crown contour but with a flat occlusal surface. A proximal slot was prepared with or without a retention groove and repaired using a single-composition spherical amalgam (Tytin, Kerr) after 15 minutes, 24 hours,1 week, and 6 months after the initial crown condensation. The specimens were stored for 24 hours in 37ºC water before fracture at the marginal ridge using a round-ended blade in a universal testing machine (Instron). The control group was not prepared. The mean maximum force in newtons and standard deviation were determined per group. Data were analyzed with a 2-way ANOVA/Tukey's and Dunnett's tests (alpha=0.05). Significant differences were found between groups based on type of slot preparation (p=0.017) but not on time (p=0.327) with no significant interaction (p=0.152). No significant difference in the strength of the marginal ridge was found between any repair group and the unrepaired control (p>0.076). The proximal repair strength of a complex amalgam restoration was not significantly different from an unrepaired amalgam crown. Placing a retention groove in the proximal slot preparation resulted in significantly greater fracture strength than a slot with no retention grooves. Time of repair had no significant effect on the strength of the repair.

Introduction

The repair rather than replacement of defective restorations is practiced more frequently today in dental practices. Complete replacement of restorations has the disadvantages of being time consuming, with unnecessary removal of healthy tooth structure, enlargement of the preparation, the risk of converting the restoration to an indirect restoration, the possibility of major injuries to the pulp tissues, and more expense for the patient. Even though the repair of a functional, intact section of an existing amalgam restoration has been accepted as a practical alternative, it requires sound judgment.

Martin et al. (2012) supported through their five-year clinical study the concept that repair treatment is as effective as total replacement of restorations with localized defects and reduces biological costs to the patient. Minimally invasive treatments of defective amalgam restorations presented similar results to the restorations that were replaced. A clinical study by Smales et al. (2004) also indicated repair of local defects in amalgam restorations is an effective alternative to total replacement, at least over a five-year period.

Roggenkamp et al. (2010) suggested freshly mixed amalgam added to existing amalgam restorations as a means of repair, may be expected to join together at nearly the original strength with sufficient condensation time and pressure. Under the condensation pressure used in their study, the addition of new amalgam to smooth previously set amalgam surfaces (up to seven years), resulted in shear-bond forces not statistically different from the intact control. Virtually all (94%) of the bonds tested resulted in cohesive rather than adhesive failures. Condensation was done with a consistent force of 22.5 MPa, which is similar to the force the dental practitioner should apply when condensing an amalgam restoration.

The proper technique of condensing amalgam to the surface of an old amalgam is critical in establishing a bond between a new amalgam and old amalgam restoration. Shen et al. (2006) showed condensation pressure should be applied vertically to the repair surface whenever possible; or the size of the condenser should be smaller than the repair site in order to exert maximum pressure on the repair surface. Their study also concluded when repair of an amalgam restoration is carried out, an amalgam material of different composition should be used to achieve greater repair strength. Chiayl et al. (2007) also concluded reducing the dimension of the amalgam repair site improved repair strength. As the diameter of the condenser decreases along the width of the repair site, the axial condensation pressure exerted on the freshly triturated repair amalgam increases. The lateral pressure on the repair substrate also increases, resulting in greater flexural strength at the repair interface. Oggura et al. (1983) recommend spherical alloy should be selected as the repair material due to its high plasticity which could facilitate the adaptation between new and old amalgam. The modes of measurement of interfacial bond between new and existing amalgam include tensile (Hadavi et al, 2002), shear (Gordon et al, 1987; Hadavi et al, 1992; Nuckles et al, 1994; Diefenderfer et al, 1997), and flexural strength values (Jorgensen et al, 1968, Jessup et al, 1998). All of these studies, however, have reported that the bond strength of the repaired amalgam was significantly less than that of the intact specimen (less than 50%).

Fruits et al, (1992) also concluded the strength of the repaired amalgam was about only 40% of that of unrepaired amalgam. Leelawat et al, (1992) revealed similar results when testing the shear and flexural strength of the repaired amalgam. There were higher shear bond and flexural strength when Amalgambond (Parkell, Edgewood, NY) was applied to the prepared surface of the existing amalgam. Even with this treatment, however, the strength values were less than 50% of the amalgam control group.

Hadavi et al, (1992), concluded fractures in the repaired amalgam always occurred at the junction between old and new amalgam. The repaired amalgam exhibited a reduced tensile strength when compared with intact restorations. Hadavi et al. suggested when an amalgam repair is anticipated, precise mechanical retention must be prepared in the tooth and in the remaining amalgam restoration to complement the union between old and new amalgam alloys. Where the amalgam repair is in functional occlusion, the additional retention is critical to the longevity of the restoration.

All of these studies have compared old amalgam repaired with new amalgam. However, very little investigation has been done to compare the repair of the newly condensed amalgam with newly triturated amalgam. The repair of new amalgam with new amalgam can become necessary when the clinician discovers a defect after the removal of the matrix band or an open contact is discovered after condensing a full cuspal-coverage amalgam. Bagheri et al, (1993) revealed when new amalgam was repaired, the samples that were repaired five minutes after the initial condensation had 84% of the tensile strength of the controls. The 15 minutes samples had 59% of the tensile strength of the controls while the 30 minute, 60 minute, and 24 hour samples had tensile strength that was less than 50% of the controls. The study concluded the repair of the newly condensed amalgam restorations,beyond 15 minutes, precise mechanical retention must be added.

No research has evaluated the strength of a complex amalgam after repair of a proximal contact using a slot preparation in human teeth. The purpose of this study was to investigate the strength of complex amalgam restorations repaired with newly triturated amalgam and added mechanical retention. The site of repair was the proximal contact area of a full cuspal-coverage amalgam restoration and the mechanical retention was achieved through a slot preparation with or without retention grooves. The first null hypothesis to be tested was that there would be no difference in marginal ridge strength between the repaired marginal ridge and the unrepaired control group. The second and third null hypothesis was that there would be no difference in marginal ridge strength based on time of repair or type of slot preparation.

Materials and Methods

The protocol was approved by the Institutional Review Board at Wilford Hall Ambulatory Surgical Center, JBSA-Lackland, Texas. Human third molar teeth were collected, stored in 0.5% Chloramine T, and used within 6 months of extraction. Ninety caries free maxillary and mandibular third molars of similar coronal size were collected. The groups that were tested are shown in Table 1.

Group	Repair Time	Preparation Type
1	No repair (control)	None
2	15 minutes	Slot
3	15 minutes	Grooved Slot
4	24 hours	Slot
5	24 hours	Grooved Slot
6	1 week	Slot
7	1 week	Grooved Slot
8	6 months	Slot
9	6 months	Grooved Slot

Table 1: Groups based on time of repair and type of preparation.

A diamond saw (Isomet, Buhler, Lake Bluff, IL) was used to section the crowns of the teeth to a level one millimeter below the height of contour. A uniform smear layer was created on the flat dentin surfaces using ten passes on 600-grit carbide paper. One retentive regular TMS pin (Coltene, Cuyahoga Falls, OH) was placed at each line angle of the flat, sectioned dentinal tooth surface about 1.0 mm from the dentino-enamel junction (DEJ). The pin hole was prepared using a slow-speed handpiece (Midwest, Shorty, Dentsply, Milford, DE) by aligning the drill parallel to external surface of the tooth. The teeth were mounted in the posterior sextant of a ModuPRO (Acadental, Inc. Mision, KS) typodont next to a dentaform tooth that is part of the typodont using a heavy vinyl polysiloxane material (Regisil PB, Dentsply). The dentaform tooth served to provide proximal contour during the condensation of amalgam as well as a point of reference for the height of the complex amalgam restoration. A #1 adult matrix band (Henry Schein, Melville, NY) was placed and secured with a Tofflemire matrix retainer (Henry Schein). A wedge was used to separate the teeth. See Figure 1.

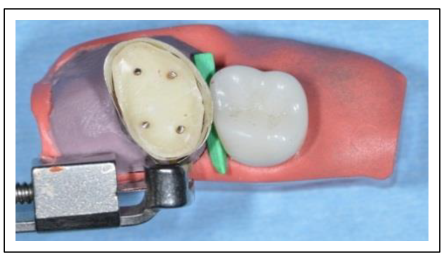

Figure 1: A flattened tooth with pin and matrix band placement is ready for amalgam placement.

An admixture amalgam (Dispersalloy, Dentsply) was triturated per manufacturer's instructions, and incrementally placed and condensed with a Densco Condensaire (WaterPik, Inc, Ft. Collins, CO). The matrix was removed and the amalgam was carved to contour with a flat occlusal surface to a height of 5 mm. The tooth specimen was removed from the ModuPRO. Each group consisted of ten specimens.

All specimens were stored in a lab oven in 100% humidity at 37°C for 15 minutes, 24 hours, 1 week, or 6 months after condensation and carving before the proximal surface was prepared with a box and repaired with new amalgam.

The slot preparation was created at the proximal contact either with or without retention grooves. The slot was prepared using a #330 bur in high-speed handpiece (Starbright, Star Dental, Lancaster, PA). The occluso-gingival height of the proximal slot was 4mm. The proximal preparation had a mesiodistal dimension of 2mm and a buccolingual dimension of 3mm at occlusal surface and 4mm at the gingival floor. The gingival floor was flat and perpendicular to the long axis of the tooth. The lingual and facial wall converged to the occlusal. The slot preparations were measured with a digital micrometer. For the grooved-slot preparations, the retention grooves were 0.5 mm in diameter and opposed each other to form a dovetail effect. The grooves were placed at the axio-pulpal line angles with a No. 169L bur using the high-speed handpiece. The grooves extended from the gingival floor to the occlusal surface and were prepared to be parallel buccolingually to each other. See Figure 2.

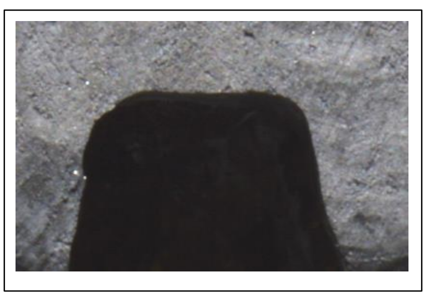

Figure 2: Occlusal view of the slot preparations with or without grooves.

After the slot preparations were created, the tooth specimens were placed back into ModuPRO. A #1 adult matrix band was placed and secured with a Tofflemire matrix retainer and a wedge. A single-composition spherical amalgam (Tytin, Sybron Kerr, Orange, CA) was triturated per manufacturer’s instructions, incrementally placed and condensed, and carved to contour in the slot preparation. The specimen was removed from the ModuPRO and mounted in PVC pipe with dental stone and bis-acryl resin (Integrity, Dentsply). The tooth specimens were stored in a lab oven in 100% humidity at 37°C. Twenty-four hours after repair, each specimen was removed from storage. A #6 round bur in a high-speed handpiece was used to produce a small flat area in the middle of the marginal ridge against which the loading force was applied. A smooth, round-ended blade was attached to the upper member of a universal testing machine (Instron #5943, Norwood, MA), and a compressive force was applied parallel to the specimens long axis using a crosshead speed of 5mm/min. See Figure 3.

Figure 3: Tooth specimen mounted in universal testing machine with round-ended blade lowered onto marginal ridge in preparation for loading force.

Failure strength of the restorations was recorded in newtons. A mean and standard deviation was determined per group. Data were analyzed with a 2-way ANOVA with Tukey's post hoc tests to evaluate the marginal ridge strength of repaired complex amalgam restorations based on time of repair (4-levels) or type of preparation (2-levels) (alpha = 0.05). Data ware also analyzed with Dunnett's test to compare differences between the control and the other eight groups (alpha = 0.05). Fracture patterns were observed under 10X magnification using a stereomicroscope.

Results

The two-way ANOVA found significant differences between the groups based on type of slot preparation ($p=0.017$) but not on time ($p=0.327$) with no significant interaction ($p=0.152$). Placing a retention groove in the proximal slot preparation resulted in significantly greater fracture strength than a slot with no retention grooves. The Dunnett's test found no significant difference between any repair group and the unrepaired control ($p>0.076$). See Table 2. Four fracture patterns were observed among groups. See Figure 4.

	Mean Fracture Strength (N, st dev)	
Time	**Slot**	**Grooved Slot**
15 minutes	1323.8 (292.8)	1805.4 (481.2)
24 hours	1278.3 (463.2)	1697.6 (273.8)
1 week	1486.1 (572.5)	1433.1 (405.0)
6 months	1646.2 (303.7)	1735.4 (520.5)
Control (unrepaired)	1324.6 (389.4)	

Table 2: Mean fracture strength in Newtons.

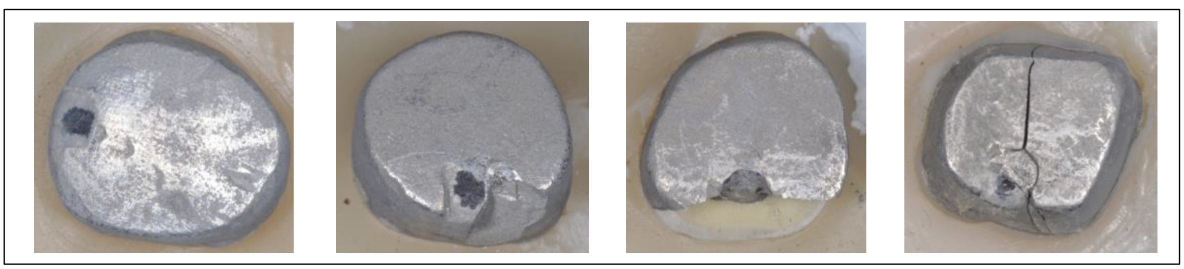

Figure 4: Fracture patterns (left to right): internal amalgam fracture; partial amalgam fracture of marginal ridge; complete amalgam fracture of marginal ridge; amalgam crown fracture.

The unprepared control group was associated with more amalgam crown fractures and the prepared groups were associated with a mix of internal, partial, and complete amalgam fractures of the marginal ridge. See Figure 5.

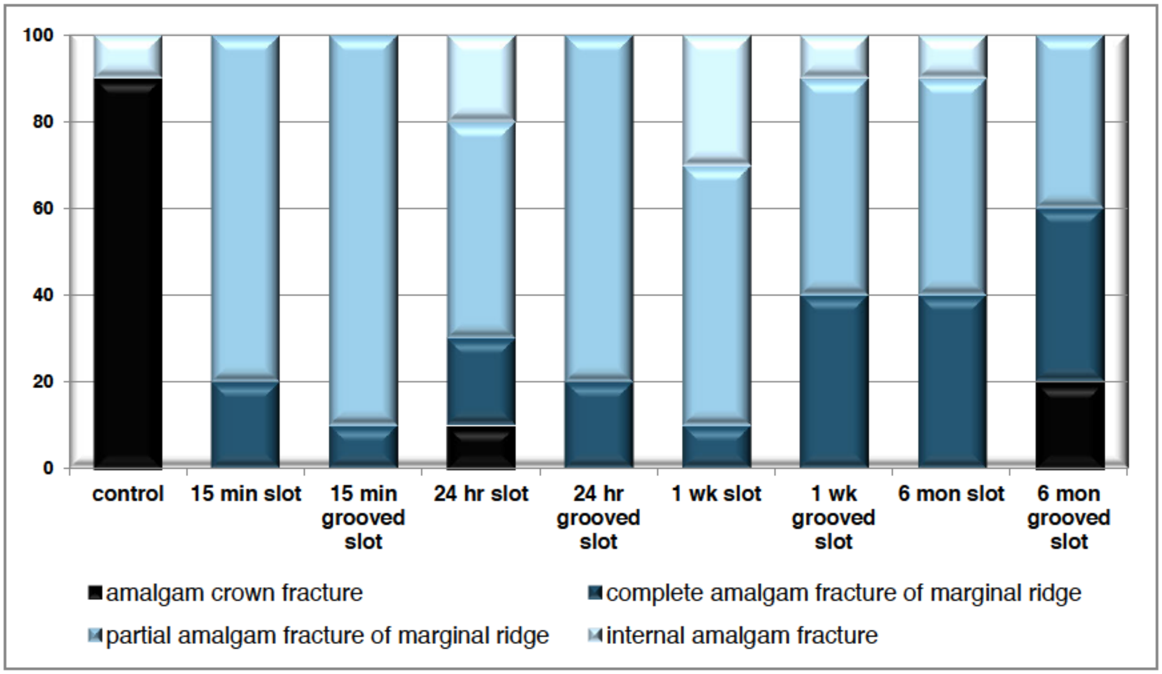

Figure 5: Fracture pattern percentage per group

Discussion

Minimal intervention dentistry, such as repair of localized defects of restorations, could increase the longevity of amalgam restorations and reduce patient stress regarding treatment time and cost. Many studies of amalgam repair have been published in the literature. Smales et al. (2004) indicated repair of local defects in amalgam restorations is an effective alternative to total replacement.

Most of the previous amalgam studies observed the repair of old amalgam with newly triturated amalgam. In some clinical situations, the repair of the newly condensed amalgam restoration may become necessary. However, a study by Bagheri et al. (1993) determined when newly condensed amalgam was repaired after 15 minutes or later, precise mechanical retention must be prepared in the newly condensed amalgam restorations to compensate for diminished tensile strength of repaired amalgam. If an open contact is discovered in full cuspal-coverage amalgam restoration, should the clinician replace the restoration or should a slot-type box be prepared and repaired with newly triturated amalgam? This study demonstrated that the marginal ridge strength of a repaired proximal contact is not significantly different from the strength of an intact complex amalgam crown. Also, time of repair did not have a significant effect on marginal ridge strength. Therefore, the first and second null hypotheses were not rejected. However, the repaired amalgam with a grooved-slot preparation had significantly higher fracture strength than the repaired amalgam with only a slot preparation. Therefore, the third null hypothesis was rejected. This study supports the concept that when an amalgam repair is planned, greater retentive features should be accomplished in the preparation to complement the union of the new and old amalgam (Hadavi et al, 1992).

The present study did not show a biological risk for the teeth: there were no catastrophic tooth fractures in any of the groups. Four fracture patterns of the amalgam restoration were observed among the groups: internal fracture; partial amalgam fracture of marginal ridge; complete amalgam fracture of marginal ridge; and amalgam crown fracture. The prepared groups were associated with a mix of internal, partial, and complete amalgam fractures of the repaired marginal ridge. However, the unprepared control group was associated with more amalgam crown fractures and no fractures of the marginal ridge. Hadavi et al. (1992) also observed that fractures in the repaired amalgam always occurred at the junction between old and new amalgam. This finding could be related to the fact that the interface between the newer and older amalgam at the marginal ridge is the weakest point of the amalgam crown.

Although not statistically different, it was observed that the repairs completed with Tytin amalgam (spherical alloy) in the grooved-slot preparation displayed higher fracture strength than the unrepaired amalgam crown control group which was completed using Dispersalloy amalgam (admixed alloy). The trend towards greater fracture strength could have been due to the higher mechanical properties of the spherical alloy compared to the admixed alloy (Malhotra and Asger, 1978). Although, Shen at al, (2004) contributed the higher repair strength of a spherical alloy to the fact that the spherical amalgam is more plastic than admixed amalgam immediately after trituration. The extra plasticity may result in better wetting of the repair surface and higher repair strength values.

The carving of a complex amalgam restoration may occasionally result in a light proximal contact with the adjacent tooth. Complete replacement of restorations has the disadvantages of being time consuming, with unnecessary removal of healthy tooth structure, enlargement of the preparation, the risk of converting the restoration to an indirect restoration, the possibility of major injuries to the pulp tissues, and more expense for the patient. This is the first study to evaluate the fracture strength of the marginal ridge of a repaired complex amalgam restoration. This investigation found no significant difference in fracture strength between repaired and unrepaired amalgam and suggests that the repair of a light proximal contact in an otherwise functional, intact existing complex amalgam restoration may be an acceptable alternative to replacement.

Conclusion

The proximal repair strength of a complex amalgam restoration was not significantly different from an unrepaired amalgam crown. Placing a retention groove in the proximal slot preparation resulted in significantly greater fracture strength than a slot with no retention grooves. Time of repair had no significant effect on the strength of the repair.

Disclaimer

The views expressed in this study are those of the authors and do not reflect the official policy of the United States Air Force, the Department of Defense, or the United States Government. The authors do not have any financial interest in the companies whose materials are discussed in this article.

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