۳۰ درصد تخفیف نوروزی ویژه کارگاه‌ها و فیلم‌های آموزشی

اصول تنظیم قراردادها

پریپوزال نویسی

آموزش مهارت‌های کاربردی در تدوین و چاپ مقاله
Reinforcement of Unsupported Enamel by Restorative Materials and Dentin Bonding Agents: An In Vitro Study

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Abstract:
Objective: Preservation of unsupported occlusal enamel after removal of underlying carious dentin may result in maintenance of aesthetics as well as wear resistance against the opposing enamel. This study investigates the influence of different restorative materials and bonding agents on reinforcement of unsupported enamel in molars and compares it with sound dentin.

Materials and Methods: In this in vitro study, forty-five extracted human molars were selected and randomly divided into five groups of nine. All lingual cusps were cut off. The dentin underlying the buccal cusps was removed in all groups except the positive control. The negative control group received no restorations. After application of varnish and Panavia F, spherical amalgam (Sina) and after application of Single-Bond (3M), composite resin (Tetric Ceram) was used to replace missing dentin. All specimens were thermocycled, then mounted in acrylic resin using a surveyor. Lingual inclination of facial cusps was positioned horizontally. Load was applied by an Instron machine at a crosshead speed of 10 mm/min until fracture. Data were subjected to ANOVA (one way) and Post hoc Test (Duncan).

Results: Statistically significant differences were found between the five groups (P<0.001); however, no significant difference was revealed between bonded amalgam and the positive control groups (P=0.762). Composite and amalgam had the same effect (P=0.642), while the composite and negative group had no significant difference (P=0.056).

Conclusion: Bonded amalgam systems (Panavia F) could reinforce the undermined occlusal enamel effectively.

Key Words: Dentin-Bonding Agents; Dental Amalgam; Dental Enamel; Dental Restoration, Permanent

INTRODUCTION
Teeth are exposed to a great variety of damages, which may weaken their structure. Caries, fractures, attrition, and endodontic access cavities are the most common reasons of tooth structure loss rendering them susceptible to fracture [1]. According to cavity preparation principles [2], it is recommended to remove all the undermined enamel to prevent functional fracture. When restoring teeth with large cavities, choosing the most ideal method and material to restore strength and esthetics is a real challenge. Often it is necessary to use full or partial coverage instead of a simple intracoronal restoration. This fact has been based on clinical studies and indicates the need for spe-
cial restorative considerations for teeth susceptible to fracture. The recommended restoration has long been cuspal protection with a cast restoration [3]. Effects of amalgam, gold and a variety of composite systems have been evaluated on the resistance of teeth to fracture [4-6]. Wendt et al [5] have shown that cast gold restorations providing cuspal protection could result in a significant increase in the resistance of teeth to fracture, compared to unaltered teeth. Salis et al [6] showed that gold onlays provided good support for the remaining tooth structure. In addition, it has been revealed that in case of high stress, such teeth suffered only superficial cuspal fractures [5]. Some researchers have claimed that if the teeth are over loaded, composite restorations make the tooth fracture more promising at the tooth-resin interface [5-7]. In recent years, there has been an increased acceptance and use of bonding techniques in strengthening tooth structure [8-10]. Due to the success of bonding techniques, there is an increasing interest in determining how a restoration bonded to the tooth by different methods can affect its conservation and longevity. It has been shown that the acid-etch technique might influence the deformation of a cusp under occlusal forces [11-13]. Bonded restorations are applied to reinforce the enamel in non-stressed areas. Latino et al [14] found no difference between restorative materials (amalgam, bonded amalgam, and composite) regarding the ability to reinforce unsupported enamel; however, sound dentin was the most reinforcing factor.

Enamel has been proved to be the most appropriate tissue against the opposing tooth enamel, both esthetically and mechanically [15]. As the major role of the enamel is to preserve function and the natural contact points of the teeth, reinforcement of the unsupported enamel has gained significant attention in operative dentistry. This approach can also help maintain appropriate color and contour. Apparently, two major factors may provide the dentinal support of the enamel; namely, strong connection at the dentino-enamel junction (DEJ) and appropriate dentin elasticity [16]. Inherent dentin elasticity enables it to absorb the mechanical energy applied to the tooth; consequently, leading to resistance against masticatory forces, whereas the enamel does not possess such characteristics [16]. Needless to say that the dentino-enamel junction may serve the tooth strength by its unique characteristics [17].

The purpose of the present study was to investigate the effect of various restorative materials and bonding agents on the unsupported enamel reinforcement and to compare it with sound dentin.

**MATERIALS AND METHODS**

In this *in vitro* study, forty-five extracted human molar teeth were selected, washed thoroughly, and stored in Chloramine T for one week. After cleansing with rubber cup and pumice, the teeth were randomly divided into five groups of nine. High-speed hand piece and a diamond fissure bur (No=837 L 0.012, Teeskavan) was used to remove the lingual cusp of each tooth. As proposed by Probhakar et al [18], two cuts were used in each tooth; the first cut was vertical, parallel to the long axis and 1 mm facial to the central groove extending mesially and distally through the marginal ridges. The second cut was horizontal, perpendicular to the long axis of the tooth on the lingual surface and approximately 2 mm coronal to the cemento-enamel junction (CEJ), extending to join the first cut. Then the teeth were randomly divided into five groups of nine. The group with sound dentin was considered as the positive control. In groups 2 to 5, the dentin supporting the buccal cusps was removed at approximately 3 mm gingival to the occlusal enamel of the buccal cusps using a No. 801.018 (Teeskavan) round diamond bur. All steps were carried out under sufficient light, taking care to reduce the risk of enamel
crack or wall crazing, while undermining the enamel. After this step, these groups received different treatments as mentioned below:
- **PC**, the dentin of facial cusps was left intact (Positive Control Group).
- **NC**, the prepared cavities were not restored (Negative Control Group).
- **A**, the prepared cavities were filled using two layers of varnish (Kimia) and spherical amalgam (Sina) inserted in 0.5-1 mm thick increments and thoroughly condensed. Preparation and manipulation of the amalgam was performed according to manufacturer’s instructions.
- **BA**, the teeth were restored with an amalgam bonded system, (Panavia, Kuraray Company) and spherical amalgam (Sina). The manufacturer’s instructions were followed.
- **C**, the cavities were filled using resin composite and a fifth generation dentin-bonding agent, Single Bond (3M). The composite resin (Tetric Ceram Viva Dent) was inserted incrementally, each layer light cured for 10 seconds using Colten light cure unit (Coltolux 2.5) with light intensity of 300 mW/cm².

All specimens were thermocycled for 1500 cycles at 3°C and 45°C with a dwell time of 20 seconds, and then kept at room temperature in distilled water before mounting them in self-cure acrylic resin. A surveyor was used to position the lingual inclines of the facial cusps horizontally. Then a flat horizontal surface of approximately 1.5×2.5 mm was cut at the tips of the remaining enamel cusps using a diamond disk. All the specimens were then loaded compressively to fracture using an Instron testing machine (model, 1195). The load-applying rod was rectangular in shape with a flat end. The end of the rod was placed against the flattened area of the enamel (Fig 1). Fracture loads were recorded by Instron machine. The data were subjected to one way analysis of variance (ANOVA) and Duncan Post hoc tests. P value smaller than 0.05 was the level of significance.

**RESULTS**

The data are described in Table 1. Table 2 shows the comparison of fracturing loads in different groups. The results showed that the negative control group with not restored undermined enamel was significantly weaker than all the other groups, except the composite group. The resin composite group was not significantly different from either the negative or the amalgam restored groups (P=0.056, [Table 1](#table1).

![Fig 1](http://example.com) The occlusal enamel to the facial cusps was loaded to failure with an Instron testing machine, using a rectangular loading rod.

### Table 1. Descriptive analysis of the data.

| Groups               | N  | Mean (Newton) | SD (Newton) | SE (Newton) | 95% CI for Mean | Min (Newton) |
|----------------------|----|---------------|-------------|-------------|-----------------|--------------|
| Positive Control     | 9  | 3286.1111     | 972.8430    | 324.28102   | 2583.3177       | 2125.00      |
| Negative Control     | 9  | 1450.0000     | 414.3896    | 138.12987   | 1131.4719       | 925.00       |
| Composite            | 9  | 2041.6667     | 366.5719    | 122.19065   | 1759.8945       | 1500.00      |
| Amalgam and Amalgam Bond | 9 | 3194.4444 | 720.97783   | 240.32594   | 2640.2518       | 2300.00      |
| Amalgam              | 9  | 2182.2222     | 507.5992    | 169.19973   | 1792.0469       | 1500.00      |
| Total                | 45 | 2430.8889     | 937.2216    | 139.71275   | 2149.3163       | 925.00       |

SD=Standard Deviation, SE=Standard Error, CI=Confidence Interval, Min=Minimum
Table 2. Comparison of the reinforcing effect of different treatment groups.

| Group | NC | C | A | BA | PC |
|-------|----|---|---|----|----|
| NC    | NS | S | S | S  | S  |
| C     | NS | NS| S | S  | S  |
| A     | S  | NS| S | S  | S  |
| BA    | S  | S | S | NS | S  |
| PC    | S  | S | S | NS |     |

NS=Not Significant, S=Significant

P=0.642, respectively). Bonded amalgam restorations were not significantly different from the positive group (P=0.762). Both amalgam and bonded amalgam groups were significantly different from the negative control (P=0.00). In addition, the amalgam group revealed a significantly less reinforcing effect than the amalgam bonded restorations and the positive group (P=0.00).

DISCUSSION

Nowadays, bonding technology is believed to possess the capability to strengthen tooth structure [8-10]. In the present study, there was no significant difference in the amount of support provided by bonded amalgam (Panavia F) and sound dentin (P=0.762), showing the ability of this method of restoration in maintenance and reinforcement of the undermined enamel.

Latino et al [14] showed no significant difference among different restorative materials in their ability to support undermined enamel. Grisanti et al [19] showed no significant difference in enamel support between tooth colored restorative materials (composite resin, resin-modified glass ionomer and conventional glass-ionomer). In both the above-mentioned studies, the applied restorative materials could provide less enamel support compared with sound dentin. This conclusion partly supports the results of the present study. Mc Cullock et al [13] revealed that adhesive materials increased tooth resistance to fracture as much as two to six times, depending on the applied technique. Pilo et al [11] proved that adhesives enhanced the reinforcing effects of bonded amalgam up to 39%-61%, resulting in a recovery in amalgam stiffness. Eakle [8] also attributed fruitful results to the application of dentinal adhesive in the promotion of tooth resistance to fracture. These results support our study, which shows that amalgam bond restoration causes the same strength as sound dentin and significantly more than unrestored cusp. It should be mentioned that Dias de Souza et al [20] reported no significant differences in fracture resistance of non-bonded amalgam combined with varnish restorations as compared with those restored with bonded amalgam plus Panavia F, which is not supported by the results of the present study.

Molinaro et al [21] showed that both packable and conventional composite resins could not provide much cuspal stiffness compared to bonded amalgam. This confirms the results of the present study, which surprisingly showed no statistically significant difference between resin composite and undermined enamel groups (P=0.056), meaning that resin composite is not able to provide satisfactory support for the undermined enamel. This does not agree with Mckenzie [22] who showed that composite restored teeth were found to be significantly stronger than those unrestored; however, in their study, resin composite was not compared with bonded and non-bonded amalgam. Other than the type of material, the method of insertion with care to prevent voids is important. More studies using different types of bonding materials and composites are recommended.

CONCLUSION

Bonded amalgam (Panavia F) could support undermined enamel as well as sound dentin.

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