Assessment of tensile strength between base-repair materials and porcelain teeth subjected to different surface treatment

Farklı yüzey işlemi uygulanan porselen dişler ve kaide-tamir materyalleri arasındaki gerilme kuvvetinin değerlendirilmesi

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SUMMARY
Aim: The purpose of study is to assess the tensile strength between porcelain teeth and two different denture base (polymamide and heat-polymerized acrylic), a repair material (auto-polymerizing acrylic) after different types of surface treatment.

Materials and Methods: Total of 63 same form and color mandibular right first molar porcelain denture teeth were used. The first molar porcelain denture teeth were separated into 3 material groups; Group 1: Heat-polymerized (HP), Group 2: Autopolymerizing (AP), and Group 3: Polyamide (PA) (n=21). Then, all material groups were divided into 3 subgroups (n=7) representing different surface treatment method; Control, Airborne abrasion, Er: YAG laser. A universal testing machine was used for determining the tensile bond strength (MPa) of the porcelain denture teeth to surface treated denture base and repair materials. The crosshead speed was set of 0.5 mm/min. Two-way ANOVA and post-hoc Tukey’s HSD was used for statically analyses (α=0.05). The effects of the surface treatment were observed by scanning electron microscopy (SEM).

Results: The polyamide (PA) has significantly higher (p< 0.05) tensile bond strength than the Heat-polymerized (HP) and Auto-polymerizing acrylic (AP). Polyamide (PA) with laser surface treatment (9.89 MPa) showed highest tensile bond strength. The lowest tensile bond strength was determined control group (6.38 MPa) of auto-polymerizing (AP). Surface treatments showed no significant difference.

Conclusion: Superior tensile strength was found polyamide denture base and different surface treatments not affect the tensile strength of porcelain teeth.

Keywords: Artificial porcelain teeth, acrylic resins, polyamide, tensile strength

ÖZET
Amaç: Bu çalışmanın amacı, porselen protez dişelere uygulanan farklı yüzey işlemlerinden sonra iki farklı protez kaide (poliamid ve ısı ile polimerize akrilik) ve tamir materyali (otopolimerize akrilik) ile arasındaki gerilme kuvvetinin değerlendirilmesidir.

Gereç ve Yöntem: Bu çalışmada 63 adet aynı şekil ve renk mandibular sağ birinci molar porselen protez dişleri kullanıldı. Birinci molar porselen protez dişler 3 materyal grubuna ayrıldı; Grup 1: Isı polimerizasyonu (HP), Grup 2: Otopolimerize akrilik (AP) ve Grup 3: Poliamid (PA) (n=21). Daha sonra, tüm poselen dişler yüzey işleme yöntemine göre 3 alt gruba ayrıldı; Kontrol, Kumlama, Er: YAG lazer. Gerilme kuvveti (MPa)universal test makinesi kullanılarak (0.5 mm/dak) tespit edildi. Gerilme değerlerinin ortalama ve standart sapması hesaplandı ve tüm veriler two-way ANOVA ve post-hoc Tukey HSD ile analiz edildi. Güven aralığı α=0.05 olarak belirlendi. Yüzey işlemlerinin etkileri taramalı elektron mikroskobu (SEM) ile incelendi.

Bulgular: Poliamid kaide materyali diğer materyallerle göre
CURRENTLY, THERMO-INJECTABLE POLYAMIDES ARE ALTER-1-3 CLINICALLY THE MOST COMMON FAILURE OF DENTURE-13-16 However, porcelain-4-8 Diatoric undercuts of sample-O In addition using injection moulding technique, 10 seconds at 0.2 MPa material. treatment and newly developed polyamide denture base. The aim of this study is to assess the tensile strength-11-12-14-15-16-11-13-15-16-11-13-16 material. The polished porcelain teeth were randomly divided into 3 material groups; Group 1 heat-polymerized (HP), Group 2 auto-polymerizing (AP), and Group 3 Polyamide (PA) (n=21). Then, all material groups were separated into 3 subgroups (n=7) representing surface treatment methods; Control group untreated, Abrasion group (airborne-particle abrasion with 250-mm Al₂O₃, 10 seconds at 0.2 MPa pressure, 10 mm distance); Er:YAG laser group [2940 nm wavelength, 0.8 mm spot size, 10 Hz pulse frequency, 150 mJ pulse energy, 100ms pulse duration, 60 seconds application time, 10mm distance (Doctor Smile; Lambda SpA, Vicenza, Italy)]. After surface treatment; a mold (3-mm diameter, 4 mm high) was prepared from silicone to standardize the size of specimen. With the help of silicone mold, pink wax-porcelain teeth combination was produced. Then, the combinations were invested in dental stone. The specimen of HP group was polymerized in water 9 hours and 74 °C in a thermal chamber (Termotron P-100, 7tepeklinik
Brazil). The specimens of AP group were polymerized under pressure (55 °C, 15 minutes). The specimen of polyanide group (PA) was prepared according to manufacturer’s instructions using injection molding technique under 5 bars for 1 minute. After polymerization of specimen, all samples were stored then stored. They were stored in distilled water (37±1°C, 24 hours).

**Experimental method**

The testing diagram is shown in Figure 2A.

![Fig. 2A. Testing diagram](image)

The tensile load was applied perpendicular to the ridge-lap porcelain tooth surface (Fig. 2B).

![Fig. 2B. A sample of PA group](image)

by using, crosshead speed 5 mm/min, universal testing machine (8501, Instron Corp). The tensile strength was recorded when failure occurred in the bonding area of porcelain tooth. The values of tensile bond strength (α) were calculated through the formula: α=L/A, where α is tensile strength (MPa), L is the load at failure (N) and A is the adhesive area (mm²).

**Scanning electron microscopy (SEM) analyses**

To evaluate change in porcelain denture teeth, ridge-lap surface was studied by selecting examples in each experimental group. The samples were evaluated under SEM (Zeiss EVO LS 10; Carl Zeiss, Nanterre, France) with 15kv at magnification 2000x. The surface image of samples, coated with 80% gold and 20% palladium at the 3μm thickness, was taken.

**Statistical analyses**

All data were statically analyzed by using two-way ANOVA, comparing surface treatment and material as independent factors. The post-hoc Tukey HSD multiple comparisons test was used to determine the mean differences (SPSS statistical software v16.0, SPSS, Chicago, IL, USA). The confidence level was set at α=0.05.

**RESULTS**

Result of tensile bond strength of specimens are listed in (Table 1). A two-way ANOVA (Table 2) and Tukey HDS (Table 3) are shown for comparisons among surface treatment and between materials (α=0.05). Significant differences were found for materials (p<0.05); however, no significant differences were observed for surface treatment and interaction between the factors (p>0.05).

The tensile strength of the PA was significantly higher (p<0.05) than with AP and HP. However, no significant difference was found between AP and HP materials (p>0.05). The highest tensile bond strength was found with PA with laser porcelain surface (9.89 MPa). The lowest tensile bond strengths were determined in AP resin control.
group (6.38 MPa). The laser and airborne particle surface treatment showed a decrease in tensile strength of HP group, while it showed an increase in tensile strength of AP group. For PA specimens, laser surface treatment was found to increase the bonding strengths, while airborne particle surface treatment was found to decrease. However, all surface treatments showed no significant differences (p>0.05).

The microstructure of the porcelain denture teeth surface was examined by SEM (X2000). Each group was tagged between Figure 3A-C.

The Control group mentioned above showed many uniform parallel scratches formed by abrasive papers during the abrasion (Fig. 3A). The Laser and Airborne abrasion surface treatment resulted in various deep irregularities on the ridge-lap surface of porcelain denture teeth. In Airborne abrasion group showed irregular shape less than 10 µm in size, while Er:YAG laser group had irregular shape size larger than 10 µm. (Fig. 3B and 3C).

DISCUSSION

Based on this study; the first hypothesis, stating that different denture base and repair material have no effect on the bond strength of porcelain teeth, was rejected. However; the second hypothesis, porcelain teeth subjected to different surface treatment have no difference on bond strength, was accepted.

Previous studies attempt to improve the bond strength of denture teeth to the acrylic resin denture base via ridge-lap surface modification such as chemical treatment or mechanical modification. Chemical etch applications (methyl methacrylate monomer, chloroform, acetone, ethylene chloride, ethyl acetate, dichloromethane) may change the morphology and chemical properties of the materials. Commonly methyl methacrylate monomer chemical agent is used to increase bond strength of denture tooth retention. Some authors obtained that wetting the ridge-lap surface with methyl methacrylate monomer increased bond strength between denture tooth and acrylic resin. However, Spratley found that wetting the ridge-lap surface with methyl methacrylate monomer did not significantly change bond strength. In addition, Morrow concluded that using methyl methacrylate monomer for wetting the ridge-lap surface of plastic teeth significantly decreased bond strength.

Other way to increase bond strength between denture tooth and acrylic resin is mechanical retention (metal pins or diatoric undercuts, grinding or grooving, roughening with sandblasting and burs, laser treatment) on ridge lap surface of denture tooth. Meng evaluated the effect of surface treatment on bond strength between the denture teeth and the auto-polymerized acrylic resin. Result of the study, diatoric macro retention systems showed higher bond strengths compared to control group. Effect of retention grooves size and shape on ridge lap surface were discussed by previous studies. Can and Kansu concluded that increase of retention grooves size on ridge lap enhanced bond strength between denture tooth and acrylic. Cardash compared the vertical and horizontal retention grooves shape on ridge lap of denture tooth and observed that vertical retention shape has a significant advantage on bond strength. However, Cunningham and Benington found that vertical grooves and surface modification with burs have no significant difference in the...
Effect of surface treatments on tensile strength

bond strength of denture tooth. Chung,22 assessed the effect of sandblasting and surface modification with burs on ridge lap surface and concluded that both surface treatments increased bond strength between denture teeth and acrylic base material. However, in the current study we found that the air bone sandblasting does not significantly change in bond strength between material and porcelain denture teeth. This might be the process of air bone sandblasting. It did not affect surface morphology for ceramic surface area. The polyamide denture base obtained higher tensile bond strength than the other materials. These results may be connected to the fact that polyamide polymer melted at a high preheated degree and it was injected with pressure, thus it penetrated into proximal retention hole undercut. In this study, Er:YAG laser-treated specimens had higher bond strength values, although the difference was not statistically significant. This is in agreement with Akin,33 and Alkurt,34 finding that laser surface treatment increased bond strength compared to the control group specimens. However, Gundogdu,35 reported that altering the PMMA surface with an Er:YAG laser was ineffective. The limitation of this study is that the tensile bond strength of porcelain denture was evaluated only two types of surface treatment. Further study is needed to evaluate effect of other surface treatment on tensile bond strength between porcelain denture teeth and denture materials.

CONCLUSIONS
Clinical significance
In the comparison of tensile bond strength between porcelain denture teeth and two different denture bases (polyamide and heat-polymerized acrylic) and a repair material (auto-polymerizing acrylic), significant differences were found among the materials. Using two different surface treatments (Airborne abrasion, Er:YAG laser) showed no significant change in tensile bond strength. Based on the present in vitro study, we can conclude that;
- The Polyamide (PA) has higher tensile bond strength than the Heat-polymerized (HP) and Auto-polymerizing acrylic (AP).
- Laser and air bone sandblasted surface treatment did not significantly affect tensile bond strength.

REFERENCES