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Impact of Different Surface Treatments on Marginal Adaptation of Vonlay Zirconia Restorations (In Vitro Study).

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ABSTRACT: This study aimed to evaluate the effect of different surface treatment protocols on marginal adaptation of zirconia vonlay restorations.
Materials and methods: Twenty-one intact human maxillary premolars were prepared to receive vonlay restorations made from kATANAYML zirconia. The specimens were randomly allocated into three groups (n=7) according to surface treatment protocol. The surface treatments applied to the samples were as follows: (1) air abrasion with 50 µm Al_2O_3 particles (AK), (2) Er: YAG laser (LK), and (3) Hot etching (EK). After thermo cycling, assessment of marginal adaptation was done utilizing a stereomicroscope and image processing software. The marginal gap was assessed under a magnification of 40x.Data were statistically analyzed by one-way ANOVA at a significance level ($p< 0.05$).
Results: Considering the total measurements, it was found that LK subgroup recorded the lowest marginal gap (64.23±9.17), followed by AK (65.69±9.38), with the highest marginal gap in subgroup EK (69.84±9.97). One-Way ANOVA test analysis showed no significant statistical difference between AK, LK and EK.
Conclusion: Under the present study conditions, marginal adaption of the tested zirconia is within the accepted range of clinical application. EK group showed the largest marginal gap of all tested groups.
.**Keywords:** zirconia, vonlay, laser, hot etching, marginal adaptation.

I. INTRODUCTION:

In restorative dentistry, minimally invasive dentistry is becoming more popular. Maintaining the integrity of tooth structure is essential to the durability of teeth and dental restorations.**(1)** Vonlay is a type of partial coverage restoration that can be used as a conservative esthetic alternative to complete coverage restorations. This restorative option requires a much less invasive preparation than a full coverage crown.**(2)**The clinical success of ceramic restorations depends on the cementation process, as it improves retention, marginal adaptation, and fracture resistance and enables more conservative cavity preparations.**(3)**Etchable glass ceramics have demonstrated success in the treatment of anterior teeth.**(4)**Fracture of etchable ceramic material is the most common complication in the posterior region, especially when covering one or more cusps or the complete occlusal surface.**(5)**However, when designed properly, these materials can provide durable clinical performance. Limited material flexural strength and resultant fracture require etchable ceramic restorations to be 1.5–2 mm thick. With the development of stronger ceramics, it is possible to make thinner, more conservative restorations.**(6)**Zirconia has excellent mechanical properties with a flexural strength of 800-1200 MPa.**(7)** It also has a phase transformation property, which is an increase in material volume immediately in front of a propagating fracture. This limits further fracture propagation and results in superior performance during occlusal function.**(8)**

Success of zirconia partial coverage restorations necessitates good adhesion between zirconia and luting cement. However, a major impairment to its adhesion is related to its nearly inert status, as it has a very dense and homogeneous structure after sintering and there is no intrinsic glass content in the matrix of zirconia. As a result, several pre-treatment methods have been suggested to increase the adhesion of cement to zirconia ceramics, such as, airborne particle abrasion, tribochemical coating, and taking laser irradiation or etching into consideration.[9]

Longevity of fixed restorations relays on the state of the marginal adaptation to the teeth. Marginal spaces may create an ideal environment for the deposition of biofilm, which can lead to the development of periodontal and dental cavities. [10].

Lack of adaptation is strongly related to gingival inflammation, secondary caries, and prosthesis failure; thus, proper marginal fit is essential to guarantee minimal cement film thickness.[11]

II. MATERIALS AND METHOD

Tooth selection and mold construction:

Twenty-one intact human maxillary premolars with homogenous dimensions and morphology. A digital calliper was used to measure the dimensions of each tooth. In order to facilitate the manipulation of the teeth, the roots of each tooth were inserted vertically in epoxy resin using a centralizing device. The selected teeth were marked 2mm apart from the cemento-enamel junction.The root of each tooth was inserted in epoxy resin 2 mm below the cement enamel junction, covering the furcation area to mimic the position of the root in the bone.

Tooth Preparation to Receive zirconia Restorations:

Before beginning tooth preparation, a silicon index was made to evaluate the amount of reduction in each tooth. The index was then split in a buccolingual direction into two halves to control tooth structure removal during preparation. The occlusal preparation was started with occlusal guiding grooves by tapered diamond stone using a high-speed headpiece (NSK-Nakanishi International, Japan). The amount of preparation was verified by the preparation putty index and calibrated periodontal probe**.** The pulpal floor cavity's depth was 1 mm at the central groove, the occlusal cavity width was maintained at one-third the intercuspal distance, and each wall had a 3° taper.[12] The mesio-distal width of the proximal box is 1 mm, and its gingival seat was placed 1 mm above the cemento-enamel junction.[12, 13] The preparation design was additionally extended to the buccal surface with a0.5- mm chamfer reduction.[13,14] Finishing of the teeth included removal of any surface irregularities, all sharp line angels, defining the margins of preparation, and removal of all unsupported enamel. **Figure (1)**

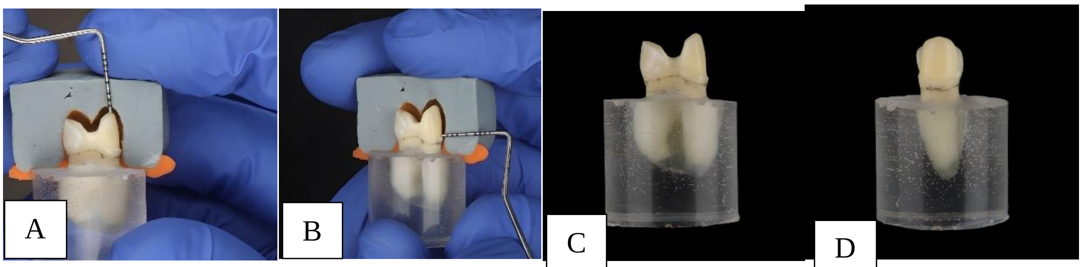

Figure 1: (A and B) Checking amount of tooth reduction, (C and D) Tooth after preparation and finishing, proximal, and buccal aspects.

Fabrication of the definitive restorations:

Each tooth is fixed to the scanner holder. Anti-reflection 3D scanning spray (BiLKiM, Izmir, Turkey) was sprayed over each tooth. Following that, the tooth is placed inside the optical scanner for scanning (DOF 3D Edge scanner, Korea)**.** To obtain the best image of the tooth, a large number of scans were collected at different angles around the tooth, and then the images were merged to obtain the best image of the scaned tooth. A three-dimensional model of the prepered tooth was created using a digital image. Each design file was transmitted to the milling machine after it was finished. The milling procedure was started using special burs (Ceramill Roto, Amann Girbach GmbH1, Germany). The blank (A2/D98.5mm/T14mm) was fixed in the milling machine chamber (CORiTEC 250i ouch, imes-icore, Germany) using a special holder. After the milling of the restorations was done, vonlays were cut and finished at the sites where the sprues were attached. Then, they were placed in a tray with zirconium dioxide beads to be sintered. Milled vonlays were loaded into the firing tray, which was then put inside the sintering furnace (Tabeo-1/M/Zirkon-100, Germany) The sintering program was started at room temperature and increased by 10 °C every minute until it reached 1500 °C, according to the manufacturer's instructions. Following that, it was maintained at 1500 °C for two hours before being cooled at a rate of 10 °C per minute to room temperature.

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Surface treatment of zirconia restorations:

The teeth were divided into three groups (n= 7) according to the method of surface treatment used. Three different surface treatment protocols were used in this study:

Air-born particle abrasion:

Air-particle abrasion using 50 µm-sized aluminum oxide particles, 2 bar of pressure, and 15 seconds at a distance of 10 mm between the sandblaster tip and the restorations.[15]

Hydrofluoric Acid Etching using Zir Cloud etching system:

Samples were etched using the Zirconia Etchant Cloud System (Ceramic Etchant, Medifive Co., Ltd., Korea). The samples were kept for ten minutes in a closed container and a heat-generating pack was placed. HF neutralizing agent (Neutralizer, Medifive Co., Ltd., Korea) was used.[16]

Laser surface treatment:

The surface of zirconia restorations was exposed to radiation using an Er:YAG laser (Fidelis Plus III, Fotona, Ljubljana, Slovenia). Parameter settings of the device were wavelength: 2940nm; frequency: 10 Hz; energy: 200 mJ; output power: 2 W for a duration of 10 seconds.[17--19]

After surface treatment, all zirconia restorations and all prepared teeth were cleaned in an ultrasonic path with distilled water, and then meticulously cleaned with water spray, followed by a gentle drying with oil-free air. After applying of Zirconia primer to the entire fitting surface, a suitable amount of cement was injected on the fitting surface of zirconia**.** The cemented restorations were subjected to thermocycling using a thermal aging device to simulate the intraoral conditions. 10,000 cycles.

Marginal adaptation test:

The assessment of marginal adaptation involved utilizing a stereomicroscope (Nikon SMZ745T) and image processing software (OmniMet image analysis software, USA) to measure the vertical gap between the prepared tooth margin and the cemented restorations. The marginal gap was assessed under a magnification of 40x.

III. RESULTS

The marginal gap was assessed by capturing all the samples from buccal, mesial, distal, and palatal margins; three readings were recorded for each surface, under a magnification of 40x, taking 12 readings for each tooth. **(Figure 2)**

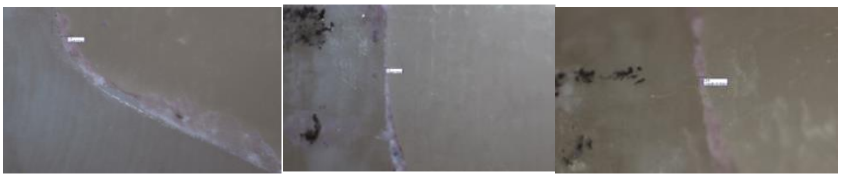

Figure 2: **Three readings were recorded for each surface, under magnification of 40x.**

Considering the total measurements, it was found that subgroup LK recorded the lowest marginal gap (64.23±9.17) followed by subgroup AK (65.69±9.38) with the highest marginal gap in subgroup EK (69.84±9.97). One-Way ANOVA test analysis showed no significant statistical difference between AK, LK and EK.

Comparison of marginal gap measurements between the three groups (AK, LK, and EK). **Table (1) and Figure (3) illustrate the results**.

Table (1): Comparison of marginal adaptation between AK, LK& EK groups.

	AK subgroup	LK subgroup	EK subgroup	P value
Average	65.69±9.38 [a]	64.23±9.17 [a]	69.84±9.97 [a]	0.44

Data expressed as mean & SD
P: Probability *: significance ≤0.05

Test used: One-Way ANOVA
Different superscript alphabetical letters

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indicate significance between different groups in the same raw.

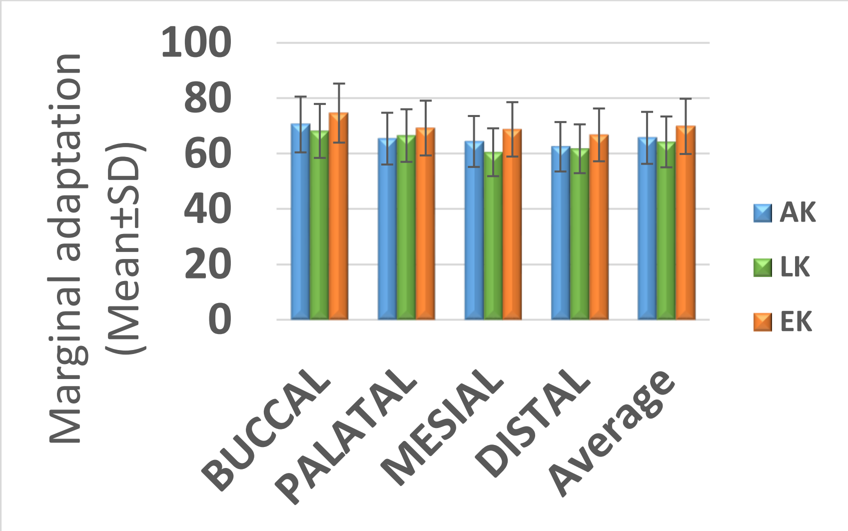

Fig.(3): Mean±SD of marginal adaptation between AK, LK & EK groups within buccal, palatal, mesial, Distal & Average of surfaces.

IV. DISCUSSION

KATANAYML zirconia was used in this study. Itis an extra translucent zirconia. The blank is composed of 3% (cervical) and 5% (incisal) yttria content).[20]

In order to replicate the location of the tooth root in the bone, the root of each tooth was placed in epoxy resin 2 mm below the cement enamel junction, covering the furcation region. The modulus of elasticity of epoxy resin (12 GPa) was selected to be near that of human bone (18 GPa).[21]

Air-abrasion should be performed with proper parameters to obtain the necessary bond strength with the lowest adverse effects.[22]**Zhang et al.** [23] stated that excellent strength for transparent zirconia ceramics may be achieved by air-abrasion with 50 µm abrasive alumina particles at 0.2 MPa while preserving sufficient and long-lasting bonding with resin cement. These parameters were used in this study.

Hot etching is considered an available method for surface treatment of zirconia, as mentioned by **Kim et al.** [24], who found that sandblasted samples displayed an irregular, uneven surface, while hot etched samples showed sharply defined, small, homogenous holes. Hot-etched samples had noticeably higher shear bond strength values.

This study employed Er- YAG laser since it has been demonstrated in other investigations that Er:YAG laser can improve the micromechanical retention and roughen the surface of Y-TZP when used under the right conditions. Zhu et al, concluded that, in order to modify the surface of Y-TZP and strengthen the bond to resin adhesive, Er:YAG laser at 10 Hz can be utilized instead of sandblasting with Al_2O_3 at a diameter of 110 µm.[25]

Different techniques, such as the replica technique described by**Ghaffari et al.** [26], SEM[27], or stereomicroscope[28], can be used to evaluate marginal adaptation. In order to measure the marginal adaptation in this study, a stereomicroscope and a coupled digital camera were utilized. Marginal discrepancy is defined as the separation between the finish line and the restoration margin.

There are many variables affecting the marginal fit of the restoration such as, manufacturing systems, restorative materials, span length, veneering of the restoration, artificial aging, cementation process, impression accuracy, and sintering protocol.[29] It is possible to assess the marginal gap both before and after cementation. Because the marginal gap changes after cementation, measuring the marginal gap prior to cementation does not accurately reflect the effects of marginal adaptation in the clinical environment. The benefit of measuring after cementation is that it preserves the samples for use in future investigations. However, the disadvantage of this approach is that extra cement overlaps the margins.[30]

Antunes et al.[31] and **Liang et al**.[32]compared the effect of different surface treatments of zirconia on its marginal adaptation. To our knowledge, no previous studies compared the effect of air abrasion, laser, and hot etching on themarginal adaptation of zirconia.

The null hypnosis was rejected, as there is a difference between groups. Considering the total measurements, it was found that subgroup LK recorded the lowest marginal gap (64.23±9.17) followed by subgroup AK (65.69±9.38) with the highest marginal gap in subgroup EK (69.84±9.97). One-Way ANOVA test analysis showed no significant statistical difference between AK, LK and EK.

The slight variation between the results may be due tothe fact that the aluminum oxide abrasive may lead to in advertent abrasion of the delicate inner surface and cause larger marginal discrepancy.[33]

It also may attributed to different martial response to different surface treatment protocols; also, the blank consists of different yttria content depending on the vertical milling position of the disk. Surface treatments may affect weaker and thinner zirconia restorations.

According to studies, maximum marginal gaps should be between 50 and 75 µm; however, marginal gaps smaller than 120 µm are typically regarded as clinically appropriate. [29]

V. CONCLUSION

1- Marginal adaption of the tested zirconia is within accepted range of clinical application and it can be used as a partial coverage restoration.

2-Different surface treatments had slight effect marginal adaptation of the tested zirconia material.

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