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REVIEW

The role of intraoral abrasion pressure with alumunium oxide on the bond strength of resin cement in adhesive bridge restorations

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Keywords: Adhesive bridge, Adhesive resin cement, Intraoral abrasion, Alumunium oxide, Water airborne abrasion.

ABSTRACT

Adhesive bridge is a fixed denture with minimal abutment preparation attached with resin cement. Exposure of the dentin during preparation in the posterior region causes frequent detachment of the adhesive bridge. This is due to the presence of fluid and changes in the smear layer on the dentinal tubules, to increase bond strength, the intraoral abrasion method was developed. Intraoral abrasion is a mechanical technique using air and water sprays to produce tooth surface roughness while increasing bond strength without damaging the tooth structure. One of the intraoral abrasion materials used is aluminum oxide (Al2O3). One of the operating parameters of intraoral abrasion that can affect bond strength between resin cement and the tooth surface is pressure. Optimal intraoral abrasion pressure with Al2O3 and the right type of resin cement aims to create tooth surface roughness while increasing the bond strength of resin cement in adhesive bridge restorations. The success of adhesive bridges, especially in the posterior area, cannot be separated from the role of optimum intraoral abrasion pressure on the tooth surface. The correct use of intraoral abrasion pressure can increase the bond strength of resin cement on the tooth surface while reducing tooth structure damage. (IJP 2024;5(1):24-28)

INTRODUCTION

An adhesive bridge is a fixed denture with minimal preparation of the enamel of the abutment teeth attached with adhesive resin cement.[1] The success of an adhesive bridge restoration is influenced by several factors. The condition of the abutment teeth and the cementation procedure are factors that often lead to the failure of restoration attachment to adhesive bridges. Restoration attachment failure occurred due to exposure of dentin during the preparation of posterior abutments. Exposure to dentin causes a reduction in the adhesive strength of resin cement on the tooth surface. This is due to the presence of dentin composition that can affect the bond between the resin cement and the tooth surface.[2-4]

The cementation procedure for adhesive bridge restorations uses conventional and latest-generation resin cement. Conventional resin cement is divided into two which are total etch and self etch. The total-etch system can cause discoloration of the marginal tooth structure and post cementation procedure sensitivity.[5] So that a one-step system cement was developed, known as self-adhesive resin cement. However, self-adhesive resin cement has lower adhesive strength to enamel and dentin than conventional resin cement.[6] Currently, a pre-treatment procedure on the tooth surface is being developed before the cementation procedure known as the intraoral abrasion technique.[6-9]

Intraoral abrasion is a procedure that sprays abrasive particles at high speed to form roughness and lift debris on the tooth surface with the spray of water and air. Some of the operational parameters are nozzle size, pressure, time, distance, flow, and contact angle. One of the important parameters in this technique is pressure. This is supported with a study by Chan Te Huang et al; 2019, where intraoral abrasion with a pressure of 60 psi or ± 4 bar can increase the adhesive strength of conventional and self-adhesive resin cement on enamel or dentin.[9] However, there is no study to determine the optimal parameter values in the restoration procedure of adhesive bridges.

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LITERATURE STUDIES

Adhesive Bridge

An adhesive bridge is a fixed denture that is attached to the enamel after an etching procedure with the aim of increasing the bond strength of the resin cement by a micromechanical method.[1-2]

Factors affecting the success of an adhesive bridge

Some of the success factors for restoration are case selection, adhesive bridge design, and clinical expertise.[3-7]

Selection of patient cases; Some factors in terms of patient case selection that must be considered.

General factors of the patient; Common factors for the patient are age, systemic history, patient preference, oral hygiene, and the number of teeth to be replaced. This is related to the indication of an adhesive bridge to replace a missing tooth and a young patient with a large pulp chamber.

Selection of abutment teeth; One of the factors in the selection of abutment teeth should consider the endodontic treatment history, the condition of the periodontal tissues, and the enamel structure present in the abutment crowns as retainer support and guiding plane.

Occlusal factors; The pontic must not be forced during excursive movements of the mandible is a concern in relation to occlusal and occlusal guidance. The existence of guidance from natural teeth can reduce damage to the abutment teeth.[8]

Aesthetic; The aesthetics of an adhesive bridge is determined by the metal retainer, porcelain coating, and also soft tissue. Metal connectors can be seen on the incisors which are slightly translucent giving them a grayish appearance. This problem can be overcome by using a block of opaque resin cement.

Pontic design; The most commonly used pontic design is the modified ridge lap. This design provides a great aesthetic result and oral hygiene.

Adhesive bridge design; The design factor of adhesive bridges with cantilevers has a higher success than fixedfixed bridges. Clinically, the fixed-fixed design in cases with large edentulous spaces is of great interest to clinicians because of limited contact during excursive movement and intercuspation only on retainers. A review study in which 11 cases of an adhesive bridge with a cantilever design that used a conventional design using two abutments had advantages in terms of strength, better aesthetics, reduced gingival tissue damage, easy cleaning, and more economical cost, and less attachment failure.[3,6,9,10]

Table 1. Shear bond strength values using 50 µm Al2O3 after pre-treatment using intraoral abrasion technique and without intraoral abrasion technique.

	Adhesive System	Without intraoral abrasion (MPa)	With intraoral abrasion (MPa)
Enamel	Etch-and-rinse	28.4 ± 6.7	30.4 ± 4.5
Dentin	Etch-and-rinse	27.3 ± 5.2	24.9 ± 9.8
	Self-etch	22.8 ± 7.2	23.9 ± 3.6

Clinical expertise; In terms of expertise, the clinician should consider the limitations of abutment preparations that are limited to enamel or minimal preparation, or no preparation at all. In an in vitro study, the preparation of 20 premolars resulted in 11.06 mm^2 of dentin exposure, or about 16.15%. Meanwhile, the preparation of the groove in the proximal area of up to 1 mm caused the dentin to be exposed at the gingival margin. This causes adhesive bridge restorations to often fall off, especially in the posterior area. The detachment of the adhesive bridge in the posterior area because the cement attachment to the dentin is lower than the enamel.[9,11]

Retention of abutment teeth in the posterior region through 0.5 mm axial preparation, formation of grooves, boxes, and rest seats will cause the dentin to be exposed. Exposure to dentin will cause dentin sensitivity and caries to cause attachment failure.[13] This is due to the low content of inorganic elements and the homogeneity of the dentin structure. The high fluid content in the dentinal tubules and changes in the smear layer cause the adhesive strength of dentin to be not as good as enamel. In terms of clinical expertise as a prosthodontist, errors in cementation procedures can lead to attachment failure. Therefore, it is important for clinicians to know the contents and techniques of cementation procedures with resin cement.

Cementation of adhesive bridge restoration; The success of an adhesive bridge restoration cannot be separated from the type of resin cement that will be used in the cementation procedure. The main ingredients are bisphenol-a-glycidyl methacrylate (Bis-GMA) resin and other methacrylate modified from composite resins.[16-18]

Advantages and disadvantages of resin cement; The disadvantages of previous resin cement are that they are easy to degrade and lack adhesion when used for a long time. Panavia resin cement (Kuraray Co. Ltd, Osaka, Japan) showed high adhesive strength. This is due to the formation of chemical bonds between the phosphate group of the cement monomer and the oxidant layer on the metal retainer. The advantages of resin cement compared to other types of cement are higher compressive/ tensile/ bonding strength, low solubility, and better aesthetics.[15] Disadvantages are the inability to release fluoride, relatively high film thickness, high sensitivity of dentin, high cost, and particle residue left during the cementation procedure.[19]

Resin Cement Classification; Resin cement is divided into conventional cement and the latest generation figure 1.[17,20,21] Conventional cement is total etch and self etch, while the latest generation cement is self-adhesive.

Polymerization; Based on the polymerization, resin cement is divided into light cured, self cured, dual-cured. Self-cured and dual-cured resin cement can be used in all types of cementation procedures. Meanwhile, light-cured resin cement is only limited to porcelain veneers and glass-ceramic restorations, which allow light to penetrate through porcelain. Several studies reported that dual-cured resin cement without light activation reduced adhesive strength and microhardness. It is advisable to carry out light polymerization on the entire restoration margin.[17]

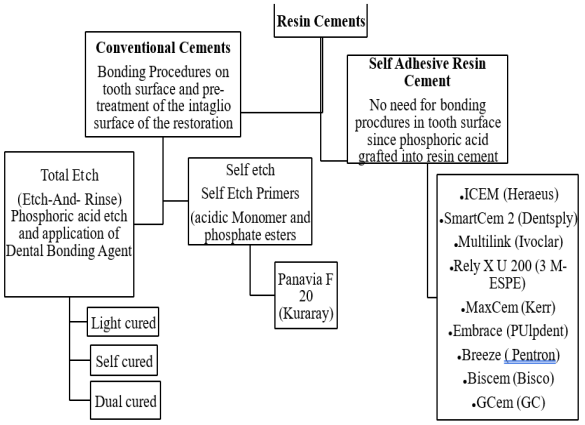

Figure 1. Classification of resin cement.

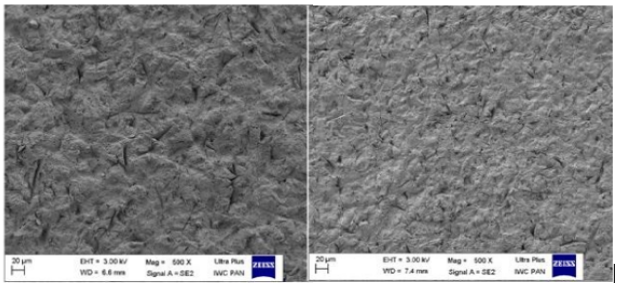

Figure 2. Effect of intraoral abrasion with A2O3 on the enamel surface, A. 50 µm, B. 29 µm with parameter distance: 4-5 mm, contact angle: 60^0, and pressure: 70 ±2 psi using SEM.

Attachment mechanism; Based on the attachment mechanism, resin cement is divided into total-etch, self-etch, and self-adhesive. [17] The 3 steps in total-etch are: acid etching, irrigation, and drying; bonding agent application, cured; resin cement application, cured. Meanwhile, in selfetching resin cement, the first step is a combination of acid etching and bonding agent application in one stage, followed by the application of resin cement. Total etch and self-etch resin cement is known as conventional resin cement. Self-adhesive cement is cement using universal bonding which can be used in total-etch and self-etch systems.

Surface treatment; Attachment to dentin is very challenging because it contains 50% minerals, 30% collagen, and 20% water. Adhesion to dentin must maintain moisture in the mineral and organic structures (especially collagen). Most of the dentin layer is protected by a "smear layer" which can prevent adhesives from entering the dentinal structure. Therefore, a mechanical modification technique of smear layer on dentin is currently being developed to form a hybrid layer so that maximum adhesion occurs between resin cement and dentin. [2,20] One technique that has developed a lot is intraoral abrasion. Pre-treatment on the tooth surface consists of chemical and mechanical. Chemically is the use of acidic materials such as polyacrylic acid or phosphoric acid. The application of 37% phosphoric acid can cause the opening of dentinal tubules and the lifting of some of the hydroxyapatite layer on the enamel surface by 80 µm. A study suggests using polyacrylic acid is better than phosphoric acid.[2] The pre-treatment procedure is mechanically known as air abrasion or water air abrasion or intraoral abrasion.

Intraoral abrasion; Intraoral abrasion is a mechanical technique using a spray of abrasive particles at the speed of an air or water thrust known as intraoral abrasion. This technique aims to form a surface roughness while removing debris on the tooth surface while increasing the adhesive strength of the restoration.[7,23-25] Intraoral abrasion uses several types and sizes of particles of different materials. In adhesive bridge restorations, this technique aims to maintain the enamel or dentin surface free from contamination prior to etching and primer application prior to cementation procedures to increase bond strength. This technique uses materials such as bioglass, aluminum oxide, and sodium bicarbonate or baking soda.[22,26] One material that is often used is aluminum oxide (Al2O3), available in sizes 29 µm, 50 µm, and 90 µm.

According to Rafael et al., Al2O3 has advantages because it produces surface roughness while increasing the adhesive strength. This is because Al2O3 does not affect the diameter of the dentinal tubules so the sensitivity of the dentin is reduced. [23] An intraoral abrasion study with Al2O3 resulted in higher adhesion strength than the use of a pumice or hand instrument prior to cementation with a self-adhesive resin material.[19]

The air abrasion technique with Al2O3 measuring 27 and 50 µm forms an irregular and amorphous dentin surface on the smear layer.[29]

Operating parameters

In the intraoral abrasion procedure there are several operational parameters:

Nozzle; The nozzle size consists of 0.4, 0.6, and 0.8 mm. The smaller the nozzle size, the greater the flow velocity. On the other hand, the larger the nozzle size, the greater the effect of strength and accuracy on surface roughness. Therefore, it is recommended to use clinical nozzles with a size of 0.8 mm, as the best surface treatment measure because the results of the spray material will be scattered and not concentrated at one point.

Time; Time as a parameter in the intraoral abrasion procedure shows that increasing can result in increased damage to the enamel crystal layer. It is therefore recommended that the intraoral abrasion procedure be limited to 3 seconds per tooth. This is supported by a study by Garcia LR et al; 2014 where sandblasting with low pressure in a short time will reduce enamel damage compared to the use of 37% phosphoric acid.[6]

Distance; Different spacing settings will affect the amount of damage to the enamel. In the sandblasting technique with Al2O3, the amount of enamel damage with its effect on the bond strength can be controlled by the operator. Olsen et al said that the adhesive strength of the adhesive material will be significantly reduced if sandblasting is carried out at a distance of 5 mm from the enamel.[25,27] Meanwhile, according to D'amario et al, intraoral abrasion Al2O3. 50 µm, with a pressure of 2 bar for 10 seconds and a distance of 5 cm can increase the adhesive strength of total-etch resin cement on the tooth surface after a tensile test.[26] So it is not known exactly how much distance is right to increase the adhesive strength of a restoration.

Flow; Tepedino M et al said that the use of aluminum oxide as pretreatment with a pressure of 3 bar with the minimum flow, 5 bar with the medium flow, and 7 bar with maximum flow had no significant effect on the bond strength between adhesive resin cement and dentin surface after tensile test.[28]

Contact angle; In a recent study by Szersze´n M, spraying air particles as a pre-treatment with a contact angle of 60° and a pressure of 70 ± 2 psi or 5 bar in a cementation procedure using adhesive resin cement materials will increase the adhesive strength of fixed restorations. This is because the effect of microparticle jets will cause changes in topography, structure shape, and bond strength between dentin and prostheses using self-adhesive resin cement figure 2.[27]

Pressure; The magnitude of the pressure as a parameter of intraoral abrasion will increase the surface roughness of the teeth. In a study by Chan Te Huang et al; 2019, where intraoral abrasion using 50 μm Al2O3 with a pressure of 60 psi or ±4 bar can increase the adhesive strength of conventional and self-adhesive resin cement on enamel or dentin table 1.[9]

DISCUSSION

Based on a systematic review, the success rate of adhesive bridge restoration for 5 years was 87.7% lower than that of conventional fixed dentures which reached 90%. Meanwhile, according to Balasubramaniam; 2017, the success rate of this restoration with 5year durability reached 83.6% and 10 years reached 64.9%. The failure that often occurs in adhesive bridges is the occurrence of debonding or loss of fixed dentures by 77%. Another failure is the occurrence of fractures or broken porcelain by 13%.[13] This is due to the lower bond strength of dentin compared to enamel. Therefore, a pre-treatment of the tooth surface with intraoral abrasion was developed to reduce the failure rate of attachment to restorations with adhesive bridges.

A study by H. Milly et al, 2014; air abrasion with bioglass and 29 μm aluminum oxide on enamel surface damage with a pressure of 1 to 4 bar produced a non-significant difference.[29,30] Baraba et al., said that sandblasting with air-driven and low speed produces kinetic energy that creates microscopic dentin surface roughness to increase the bond strength.[31] Meanwhile, according to Rafael et al., 2016, intraoral abrasion aims to maintain the diameter of the tubular orifice and intertubular dentin so that it can affect the increase in adhesive strength. Intraoral abrasion Al2O3.50 μm, with a pressure of 2 bar for 10 seconds and a distance of 5 cm can increase the adhesive strength of the total etch resin cement on the tooth surface after the tensile test.[23] Tepedino M et al, 2021 using pressures of 3, 5 and 7 bar of intraoral abrasion Al2O3, 50 m with different flow velocities where there are differences in the adhesive strength of the total etch resin cement.[28] Then a study by Chan-Te Huang et al., 2019, intraoral abrasion Al2O3, 50 m with a pressure of 60 psi or 4 bar on total resin cement etch can increase the adhesive strength of the enamel to reach 30.4 ± 4.5 Mpa; and in dentin which it reaches 24.9 ± 9.8 MPa; while the self-etch resin cement reached 23.9 ± 3.6 Mpa. This supports the previous study conducted by De Souza-Zaroni et al of 4 bar can increase the adhesive strength of cement to 31.82 MPa of self-etch resin on enamel compared to conventional resin cement.[7] In a recent study by Szersze n, M, particle blast with a contact angle of 60° and a pressure of 70 ± 2 psi or 5 bar before cementation procedure using aluminum oxide with adhesive resin cement will increase the adhesive strength of the fixed restoration. Therefore, spraying of particles with air as a pre-treatment is the recommended procedure for cementation of fixed restorations using adhesive resin cement.[27]

CONCLUSION

The success of the adhesive bridge, especially in the posterior area, cannot be separated from the role of intraoral abrasion pressure on the tooth surface. The intraoral abrasion procedure has several operating parameters, namely nozzles, pressure, time, distance, flow, and contact angle. One of the operating parameters in the Al2O3 intraoral abrasion technique that plays an important role is pressure. The use of optimal intraoral abrasion pressure from Al2O3 can increase the bond strength between resin cement and the tooth surface while reducing tooth structure damage. Several previous studies have identified the role of intraoral abrasion on surface roughness and its effect on the adhesive strength of resin adhesive cement. However, its role in the restoration of adhesive bridges is not yet clear.

SUGGESTION

The intraoral abrasion technique is currently very developed in the field of dentistry. This intraoral abrasion technique on the tooth surface has previously been developed in the field of orthodontics and conservation. In the field of prosthodontics, this technique is generally limited to metal surfaces which is known as sandblasting. As a clinician, it is necessary to know the exact operational parameters of the restoration to be performed. Errors in determining operational parameters in the intraoral abrasion technique will affect the success of an adhesive bridge restoration. This cannot be proven because there are no studies conducted. Therefore, it is necessary to study the role of pressure as one of the operating parameters in the intraoral abrasion technique with Al2O3 material and how it affects the adhesive strength of resin cement in adhesive bridge restorations.

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