*eVitroKhem*. 2023; 2:46
doi: 10.56294/evk202246

REVIEW

# Evaluation of adhesive strength in bracket cementation

## Evaluación de la resistencia adhesiva en la cementación de brackets

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**Cite as:** Yanac Calero DN, Chanamé Marín AR. Evaluation of adhesive strength in bracket cementation. eVitroKhem. 2023; 2:46. https://doi.org/10.56294/evk202246

**Submitted:** 04-09-2022 **Revised:** 22-12-2022 **Accepted:** 12-06-2023 **Published:** 13-06-2023

**Editor:** Prof. Dr. Javier Gonzalez-Argote

**ABSTRACT**

The cementation of metal *brackets* was an essential aspect of successful orthodontic treatment, as the adhesive strength against shear forces determined their stability during treatment. Various national and international studies analysed the effectiveness of different cements, such as orthodontic resins and glass ionomers, showing variations in the adhesive strength achieved. Research such as that conducted by Chumacero, Huaita and Aguilar showed that, although some cements offered higher resistance values, the differences were not always statistically significant. Furthermore, multiple factors were identified that influenced adhesion, such as the type of bracket base, enamel preparation, the pressure exerted during cementation, and the patient's clinical condition. Likewise, the need to achieve adhesion that is strong enough to maintain the *brackets* during treatment, but also safe enough to allow removal without damaging the enamel, was highlighted. Studies such as those by García and Herrera emphasised the importance of the bracket base and the type of resin used, while Fraga and Spaccesi evaluated the effects of pre-conditioning and concluded that there were no significant differences between techniques or concentrations applied. Overall, the evidence supported the importance of selecting an adhesive system that is balanced in strength, safety and practicality, highlighting the need for further standardised research to improve clinical efficacy.

**Keywords:** *Brackets*; Adhesion; Cements; Orthodontics; Shear.

**RESUMEN**

La cementación de *brackets* metálicos constituyó un aspecto esencial en el éxito de los tratamientos ortodónticos, debido a que la fuerza adhesiva frente a fuerzas de cizallamiento determinó su estabilidad durante el tratamiento. Diversos estudios nacionales e internacionales analizaron la eficacia de diferentes cementos, como las resinas ortodónticas y los ionómeros de vidrio, evidenciando variaciones en la resistencia adhesiva alcanzada. Investigaciones como las de Chumacero, Huaita y Aguilar demostraron que, aunque algunos cementos ofrecieron valores más altos de resistencia, las diferencias no siempre fueron estadísticamente significativas. Por otra parte, se identificaron múltiples factores que condicionaron la adhesión, tales como el tipo de base del bracket, la preparación del esmalte, la presión ejercida al cementar, y las condiciones clínicas del paciente. Asimismo, se destacó la necesidad de lograr una adhesión suficientemente fuerte para mantener los *brackets* durante el tratamiento, pero también segura para permitir su remoción sin dañar el esmalte. Estudios como los de García y Herrera resaltaron la importancia de la base del bracket y del tipo de resina empleada, mientras que Fraga y Spaccesi evaluaron los efectos del acondicionamiento previo y concluyeron que no hubo diferencias significativas entre técnicas o concentraciones aplicadas. En conjunto, la evidencia respaldó la importancia de seleccionar un sistema adhesivo equilibrado en fuerza, seguridad y practicidad, subrayando la necesidad de continuar con investigaciones estandarizadas para mejorar la eficacia clínica.

**Palabras clave:** *Brackets*; Adhesión; Cementos; Ortodoncia; Cizallamiento.

## INTRODUCTION

The cementation of brackets symbolizes a major challenge in the installation of orthodontic appliances. Reliable bonding between fixed appliances and tooth surfaces is paramount to the clinical success of any orthodontic treatment. Detachment of brackets is closely related to longer treatment duration. If shear forces are too high, they will compromise the bonding of the two surfaces, this weakness occurs close to the bracket-tooth interface, resulting in loss of adhesion of these two structures.[1,2,3,4]

Resins have become the material most commonly used by orthodontists for bracket cementation. The main difference with traditional resins is the percentage of filler and particle size. Orthodontic resins have a smaller amount of filler particles, which allows a greater bonding strength of the brackets on the dental enamel. Currently there are several materials for the cementation of brackets, such as glass ionomers and orthodontic resins, very similar to the resins used for dental restorations, both materials have a satisfactory bond strength on dental enamel.[1,3,4,5,6,7]

The literature is unanimous in stating that the detachment of orthodontic brackets is due to failures in the cementation method, due to poor retention of certain bracket bases or due to the action of masticatory forces. These failures can undermine treatment, delay expected results and reduce patient satisfaction. Therefore, the state of the enamel, the cleanliness of the surface where the device will be cemented, the quality of the cementing agent and the selection of the agent are points to consider in order to achieve optimal efficiency in orthodontic bracket treatment.[3,4,5,7,8,9,10]

Therefore, this study aims to determine the adhesive strength against shear forces of metal brackets using different adhesive cements. In vitro study. Lima - Peru. 2021.

## DEVELOPMENT

### Background of the research

*National background*

Chumacero M. carried out an investigation at the Dental Center of the San Martin de Porres University in Lima, Peru to "determine the shear strength of brackets using two adhesive systems". For which he used 64 premolars, collected in the mentioned dental center for orthodontic reasons. Dividing into two groups A: adhesives transnbond XT and B: Brace Paste TM. The results: the Brace Paste MT adhesive had a resistance to brackets shearing of 8,1291 M Pa, and for the transbond XT obtained a mean of 8,7906 M Pa. The parametric T Student test showed that there was no significant difference (p= 0,262) between the two adhesive systems in relation to the shear force, as well as the normality test and Boxplot graph. Corroborating that both systems present a low bond that would not cause enamel fracture during the shearing of the brackets and reaching the conclusion that both are safe adhesives for dental enamel.[11]

Cruz M.[6] conducted an investigation in Lima, Peru to "determine the shear strength of two types of brackets". For this, he used metallic and ceramic type brackets on 15 premolars per group. These brackets were bonded using Transbond XT orthodontic resin cement. Once the brackets were bonded to the teeth, an acrylic base was made so that they could be taken to the universal testing machine. The teeth were placed in such a position that the shear blade had a direction of advance tangential to the axis of the tooth, having contact with the brackets until their detachment. The results showed that the bond strength of metal brackets was 22,77 ± 2,90 Mpa, while the bond strength of ceramic brackets was 18,48 ± 5,77 Mpa. Therefore, it was concluded that the bond strength was higher for metal brackets.

Huaita J.[7] executed a study in Lima, Peru to "compare the bond strength of three orthodontic cements (Orthocem, Heliosit or Transbond XT) on human teeth". For this used 45 premolars divided into 3 study groups, the brackets used were of the Azdent brand. Once the brackets were placed on the teeth, they were light cured for 20 seconds for occlusal and 20 seconds for cervical, then the teeth were placed on an acrylic base and taken to a universal testing machine that had an angled metal rod that contacted the tooth-cement-brackets junction and presented an advance speed of 0,75 mm/min until the brackets were detached from the tooth surface. The results showed that the brackets that were cemented using Orthocem cement generated a bond strength of 5,074 ± 1,549 Mpa, while the Heliosit cement presented a bond strength of 6,254 ± 1,619 Mpa and finally the Transbond XT cement presented a bond strength of 6,876 ± 2,241 Mpa. Concluding that the bond strength is higher in Transbond XT followed by Heliosit-Orthodontic and finally Orthocem.

Aguilar V.[8] conducted a study in Arequipa, Peru to "determine the shear strength of non-traditional bonding systems used for the cementation of orthodontic brackets". Three types of resins were used, including two types of conventional restorative resins (Z-100 and alpha-dent) and an orthodontic resin (Orthocem). Thirty premolar teeth divided into three groups were used for the study. The brackets used for bonding were of the Morelli brand, Edgewise Slot 0,022 type. Once the brackets were bonded, a base was made for the teeth to be placed in the testing machine. Once they were in the testing machine, the dental pieces were placed just below a metallic rod that would have an advance of 1 mm/min in vertical direction, being its path from top to bottom, and where it would contact with the upper vertical slot of the brackets to generate a shearing force

https://doi.org/10.56294/evk202246 ISSN: 3072-7944

until the brackets were detached from the dental pieces. The results showed that the brackets bonded using the conventional Z-100 resin generated an adhesion resistance of 14,84 ± 9,17 Mpa, while the conventional Alpha Dent resin generated a resistance of 24,02 ± 9,01 Mpa and finally the orthodontic resin (Orthocem) generated a resistance of 17,42 ± 10,67 Mpa. It is concluded that there is no statistically significant difference between the values of adhesion resistance between the resins used.

**International background**

Fraga E.[12] conducted an investigation in Querétaro, Mexico to "determine the shear strength in orthodontics using 2,5 % and 5,25 % sodium hypochlorite prior to bonding". For this, 32 premolars were randomly divided into 2 groups of 16 teeth. Group A was deproteinized with 5,25 % NaOCl prior to etching. Group B was deproteinized with 2,5 % NaOCl. After deproteinization, acid etching at 37 % for 15 seconds, washing and drying, the brackets were cemented in the center of the clinical crown to be subjected to the shear strength test using a universal testing machine. A shear blade was lowered parallel to the base of the brackets at a constant speed until adhesion failure between the brackets and the dental piece was achieved. These data were processed, showing that the adhesive strength of the pieces deproteinized with 5,25 % sodium hypochlorite was 11,73 Mpa. And the adhesive strength of the parts deproteinized with 2,5 % sodium hypochlorite was 11,92 Mpa. Concluding that there is no statistically significant difference between the use of 5,25 % and 2,5 % sodium hypochlorite.

Spaccesi M.[9] conducted a study in Cordova, Argentina to "analyze the adhesion to enamel of metal brackets cemented with light-curing resins using different conditioning techniques". For this, he used 75 premolars divided into 3 groups of 25 teeth, in which the acid conditioning would be by group of 15 seconds, 30 seconds and the last group using self-etching agents, to subsequently cement the metal brackets using Transbond XT light-cured resin. Once the brackets were placed in their location, the teeth were taken to a universal testing machine where a vertical force was applied using a blade with a 22° bevel angle and 1 mm thick at the end, which contacted the cement-tooth-bracket interface until separation was achieved. As a result, the group of teeth with a 15-second acid conditioning achieved a pull-out resistance of 18,51 ± 4,07 Mpa, the group with 30-second acid conditioning achieved a resistance of 18,26 ± 4,88 Mpa and the self-conditioning group achieved a pull-out resistance of 18,71 ± 4,55 Mpa. Concluding that there are no statistically significant differences between the three study groups.

Calvo F et al.[10] concluded a study in Mexico City, Mexico to "compare the resistance to detachment of tubes adhered to a sealed surface". For this purpose, they used 40 extracted third molars previously divided into two groups, to these dental pieces a restoration (Empress Direct resin) was made on the vestibular side of the dental piece, exactly in the area where the metal tube would be adhered. In the first group the metal tube was bonded using the same resin used for the restoration, while in the second group the tube was bonded with an orthodontic resin "Transbond XT". These teeth were taken to a universal testing machine that contained a shear in its structure which generated an advance speed of 1mm/min directly to the longitudinal axis of the tube until it was detached. The results showed that group I presented a resistance to detachment of 39,26 Megapascals, while in group II the resistance to detachment was 31,97 Megapascals. It was concluded that the resistance was greater in the teeth that had a previous restoration.

García M et al.[13] they conducted a study in Murcio, Spain to "evaluate the adhesive strength of metal brackets with different types of base". For this, two types of brackets were used one of them with traditional mesh base and the other type with micro column base. The brackets were bonded to 50 bovine incisors divided into two groups and cemented with transbond plus resin cement. Once the brackets were bonded, they were placed in a universal testing machine to generate a shearing force with the help of a metal rod with a 30º bevel termination and thus achieve the detachment of the brackets, the testing machine had an advance force of 1 mm/min and went vertically until separation was achieved. The results showed that the metal brackets with traditional mesh base achieved a bond strength of 13,19 ± 5,87 Mpa, while the metal brackets with micro column base showed a bond strength of 18,14 ± 6,28 Mpa. Concluding that the micro-column base supposes an alternative to mesh, since brackets with this type of base presented a significantly higher adhesive strength.

Herrera R.[14] conducted a study in Quito, Ecuador to "evaluate the tensile strength between a light-curing resin and a self-curing resin in adhesion of metal brackets". For this purpose, 80 premolar teeth were divided into two groups of 40 dental pieces, to these pieces were added metallic brackets of the Morelli brand, prescription Roth - Max Monobloc 0,022 being adhered to the vestibular side of the premolars, one group adhered with a light-curing resin and the other group with a self-curing resin. After bonding the brackets, the teeth were placed on an acrylic base, while each bracket was tied with ligature wire and attached to the universal testing machine that generated a traction force with an advance of 50mm/min until bracket detachment was achieved. The data obtained after the procedure were that the metal brackets cemented with a light-curing resin generated a tensile bond strength of 2,46 ± 1,33 Mpa, while the self-curing resin generated a tensile bond strength of 4,86 ± 2,76 Mpa. Concluding that the self-curing resin generated higher tensile bond strength.

**Theoretical basis**

In orthodontic treatment, adequate adhesion between the brackets and the tooth is important. We should consider that the adhesive system that joins the brackets to the enamel should be strong enough so that it does not accidentally come off, and at the same time it should allow the brackets to be removed at the end of the treatment without producing lesions in the enamel.(13)

*Orthodontic treatment*

Orthodontics is concerned with diagnosing, correcting and even preventing anomalies (malocclusions) in the form, position, relation and function of the teeth and jaws, the face and functional disorders of mastication.(5,15,16)

Orthodontics "like other areas of stomatology also presents challenges, one of these is the search for systems that guarantee the permanence of the brackets on the teeth, so that the forces applied remain constant and are not interrupted" by decementation.(15,16)

*The brackets*

Brackets can be metallic, ceramic, plastic or made of different materials which are part of the appliances used in fixed orthodontics. They are devices that serve to guide the movement of the tooth and support the active elements of the orthodontic appliances, which are the archwires.(17,18)

Brackets are metallic or ceramic devices whose function is to guide orthodontic movements produced through forces. They support active elements such as the main arch, elastics, springs, etc. There are three types of fixations available in the market for the adhesion of brackets in orthodontics: brackets with plastic base, brackets with ceramic base or metal base (stainless steel, gold plated or titanium).(18)

*Installation of brackets*

Proper placement of brackets is crucial in orthodontic treatment and proper archwire provides the desired mechanical effect.(1,19)

The conventional bracket bonding method employs three different agents: conditioner, adhesive and resin composite.(20)

This procedure has advantages in comparison with conventional bands, presenting more esthetics, less discomfort, more precise positioning, simplicity, speed and ease of cleaning.(1)

*Direct bracket installation*

This involves placing the brackets one by one directly on the teeth. This type of placement is slower, less precise, more uncomfortable for the patient and will force the orthodontist to change many brackets during treatment.(5)

*Indirect bracket installation*

This method consists of the positioning of brackets on a working model and the subsequent fabrication of a transfer splint that ensures the correct placement of the brackets on the patient's teeth.(5,7)

*Adhesion to enamel*

The adhesion established on the dental tissue (enamel) is due to the action of orthophosphoric acid, which produces an alteration of the surface, making it rougher and rougher.(21,22)

This process consists of "placing 30 - 37 % phosphoric acid on the enamel for 15 to 30 seconds, then washing with a jet of water and drying with a jet of air, leaving the surface of the enamel with a rough appearance, then proceed to the placement of the adhesive agent and composite resin".(8,18,23)

In orthodontics, adhesion to tooth enamel is a vitally important issue as it is a constant concern for orthodontists. The main reason why adhesion is needed is to ensure that the brackets remain adhered to the teeth, supporting the forces necessary for orthodontic movements, chewing, food-induced forces and any other force that the orthodontic appliance has to withstand.(22,24,25)

Some so-called self-adhesive resin cements do not require etchants, primers, or adhesives to bond to the tooth surface. Therefore, they are more likely to reduce the time required for bonding.(22)

*Bond strength*

Adequate bond strength in orthodontic fixed appliances allows an anchorage of the brackets for the entire treatment, the same that is achieved by using an appropriate adhesive system, this well selected system can mitigate the working time and prevent possible undesirable effects that can structurally affect part of the enamel surface.(4,17)

According to Adrianzen B refers that "adhesive strength is an important factor to take into account during treatment with brackets, due to the fact that these must be able to withstand, both masticatory forces, as well as those necessary for the treatment. Adhesion is based on the development of materials that establish an effective bond with the dental tissues".[3,26]

*Factors determining the quality of adhesion*

Serrano P. describes that there are several factors that could alter the adhesion achieved, such as: "Composition, elastic modulus and viscosity of the adhesive, design of the bracket base, characteristic of the surface on which it will be fixed, pressure applied during bracket adaptation, location of the tooth in the dental arch, possibilities of oral humidity control, clinical conditions of the patient as a mouth breather".[15]

*Adhesive systems in orthodontics*

Nowadays, in the market of dental materials a diversity of cements can be found for the adhesion of orthodontic brackets on the dental pieces; among these are the cements that are similar to the resins that are commonly used in restorative dentistry; as well as the glass ionomers, both presenting a very good adhesion strength.[3]

Conventional orthodontic resins, flowable resins, glass ionomer cements and, more recently, resin cements have been used to bond orthodontic attachments.[22]

Orthodontic cements have been widely used in orthodontics for the attachment of brackets to the enamel surface. The most commonly used materials consist of composite resins similar to those used for restoration, but with a very different proportion of their components in order to obtain ideal characteristics for their use. Studies related to these cements in the literature consist mainly of tests of resistance to decementation.[4]

The material of choice should have an "adhesive strength capable of withstanding both masticatory forces and those generated by orthodontic mechanics and, at the same time, provide the operator with sufficient clinical working time to allow adequate positioning of the brackets and not damage the enamel when removed".[3]

*Properties of adhesive materials in orthodontics*

The different cements or bonding materials should present some properties such as:[15]

- Adhesion "sufficient to prevent debonding of brackets".
- Impermeability "immediate and long lasting to avoid problems of demineralization stains or carious lesions under the cement".
- Adequate working time
- Easy "removal of excess".
- Tolerance "to handling in an environment of possible contamination with moisture or accidental saliva"
- Easy removal of the brackets without damaging the enamel

*Failure of bracket adhesion*

The literature is unanimous in stating that loosening or detachment of orthodontic brackets is due to failures in the cementation method, due to poor retention of certain bracket bases or due to the action of masticatory forces. These failures can undermine treatment, delay expected results and reduce patient satisfaction. Therefore, the state of the enamel, the cleanliness of the surface where the device will be cemented, the quality of the cementing agent and the way in which this agent is selected are points to consider to achieve optimal efficiency in the treatment with orthodontic brackets.[5,27]

It is also important to know that a critical point to take into account is the union of the tooth surface with the restorative material. For this, a correct conditioning of the substrate must be carried out" to achieve a correct adhesion.[27,28]

*Removal of brackets*

Once orthodontic treatment is completed, the brackets are removed from the teeth. When a bracket is debonded, bond failure can occur at any of three sites: at the bracket-adhesive interface, within the adhesive, or at the enamel-adhesive interface. If a strong bond has been achieved, failure at the enamel-adhesive interface is undesirable because the adhesive can cause enamel tearing defects as it detaches from the enamel. For this reason, the bracket-adhesive interface is the preferred failure site for most orthodontists, and is considered ideal if the adhesive remains on the tooth surface. Obviously, the remaining adhesive must be removed from the teeth.[28,29,30]

*Bracket removal*

Among the techniques "to remove metal brackets with pliers, the best known method is to place the tips of the double-nosed pliers on the distal and mesial edge of the bracket base in order to isolate the bracket from the tooth. A technique also known consists of squeezing the bracket fins mesiodistally" with pliers such as the

https://doi.org/10.56294/evk202246 ISSN: 3072-7944

Weingart or the Howe and detach it by exerting a separating force.[6]

*Removal of brackets by mechanically induced forces*

In orthodontics, it has been stipulated that the values necessary to withstand biomechanical forces range between 6 and 8MPa. However, it is important to remember that high values of resistance to decementation can be dangerous. It has been shown that when the de-cementing strength exceeds 14 MPa, the enamel may fracture and/or detach.[4] Generally, the debonding strength of orthodontic brackets is measured using a universal testing machine and results are given in kilograms (kg) or Newtons (N), to be converted into Mega Pascals (MPa).[4]

*Shear strength*

Resistance to shear forces is generally defined as the property of an area to resist the displacement between the particles that form it, when exposed or subjected to an external force:[6,8]

The evaluation of adhesion in cementitious agents used in orthodontics is based on the measurement of adhesive strength. There are two ways to measure it, a test for shear strength and another for microtensile strength of a sample of orthodontic adhesive until it fractures.[8]

General hypothesis

- Hi: There is a difference in the adhesive strength against shear forces of metal brackets using different adhesive cements.
- Ho: There is no difference in the adhesive strength against shear forces of metal brackets using different adhesive cements.

## CONCLUSIONS

The cementation of metal brackets represents a critical aspect in the success of orthodontic treatments, being the adhesive strength against shear forces one of the determining factors. Through the analysis of various national and international studies, it has been shown that there are multiple adhesive materials available, each with particular properties that influence their clinical behavior. Most of the studies reviewed agree that, although some cements show numerical differences in their adhesive strength, these are not always statistically significant, which underlines the importance of other clinical factors such as the state of the enamel, the conditioning of the tooth surface and the cementation technique used.

Furthermore, it is emphasized that adequate adhesive strength should not only guarantee the permanence of the bracket during treatment, but also allow its removal without compromising the integrity of the enamel. In this sense, the choice of adhesive system should be based on a balance between bond strength, safety for the enamel and ease of clinical use. Finally, the findings support the need for further research under standardized conditions to optimize the performance of adhesive cements in orthodontics and ensure more efficient and safer treatments for patients.

## BIBLIOGRAPHIC REFERENCES

1. Cruz A, Delgado E. Experimental study of *brackets* adhesion with a novel enamel-protective material compared with conventional etching. Saudi Dental Journal. 2019; 10(1):1-7.

2. Carrillo I. Comparación de la resistencia al descementado de *brackets* metálicos adheridos con una resina fluida, una bioresina y una resina convencional. [Tesis para optar el título de especialista en Ortodoncia]. Toluca: Universidad Autónoma del Estado de México; 2017.

3. Robaski A, Pamato S, De Oliveira M, Pereira J. Effect of saliva contamination on cementation of orthodontic *brackets* using different adhesive systems. J Clin Exp Dent. 2017;9(7):919-924.

4. Cruz M. Resistencia al cizallamiento in vitro de dos tipos de *brackets* y su efecto sobre el esmalte dental. Lima- Perú. 2014-2015. [Tesis para optar el Grado Académico de Magister en Docencia e Investigación en Salud]. Lima: Universidad Nacional Mayor de San Marcos; 2019.

5. Huaita J. Comparación de la fuerza de adhesión de tres cementos para ortodoncia en esmalte humano. [Tesis para optar el título de Cirujano Dentista]. Lima: Universidad Nacional Federico Villarreal; 2018.

6. Aguilar V. Estudio in vitro de la resistencia al cizallamiento de sistemas de adhesión no tradicionales usados en el cementado de *brackets* ortodóncicos, Arequipa. [Tesis para optar el título de Doctor en Ciencias de la Salud]. Arequipa: Universidad Nacional de San Agustín; 2017.

https://doi.org/10.56294/evk202246 ISSN: 3072-7944

7. Spaccesi M. Análisis de la adhesión a esmalte de *brackets* metálicos cementados con resina de fotocurado, utilizando diferentes técnicas de acondicionamiento e imprimación. [Tesis para optar el título de Doctor en Odontología]. Córdoba: Universidad Nacional de Córdoba; 2017.

8. Calvo F, Murayama N, Justus R, Ondarza R, Garcia S. Estudio comparativo de la resistencia al desprendimiento de tubos adheridos a una superficie de resina obturada sobre la superficie bucal de los molares con la resina Empress Direct y con la resina Transbond XT: un estudio ex vivo. Revista Mexicana de Ortodoncia. 2017; 5(3):140-147.

9. Chumacero M. Resistencia al cizallamiento de *brackets* utilizando dos sistemas adhesivos. Lima- Perú 2021. [Tesis para optar segunda especialidad en Ortodoncia y ortopedia maxilofacial]. Lima: Centro Odontológico de la Universidad Privada San Martin de Porres; 2021.

10. Fraga E. Incremento de la resistencia al cizallamiento en ortodoncia utilizando hipoclorito de sodio al 2.5 % y al 5.25 % previo a la adhesión. [Tesis para optar el título de especialista en ortodoncia]. Querétaro: Universidad Autónoma de Querétaro; 2018.

11. García M, Vicente A, Bravo L. Evaluación de la fuerza adhesiva de *brackets* con bases de diferentes diseños. Ortod. Esp. 2016; 54 (2):27-32.

12. Herrera R. Estudio comparativo in vitro de resistencia a la tracción entre una resina fotopolimerizable y una autopolimerizable en adhesión de *brackets* metálicos. [Tesis para optar el título de Odontólogo]. Quito: Universidad de las Américas; 2016.

13. Serrano P. Estudio in vitro con microscopio electrónico de la interfase esmalte dental - adhesivo utilizando resina transbond xt combinado con hipoclorito de sodio y clorhexidina como agentes eliminadores de placa bacteriana previo al protocolo de cementación de *brackets*. [Tesis para optar el título de especialista en Ortodoncia]. Quito: Universidad San Francisco de Quito; 2015.

14. Mandril M, Lezcano M, Navarro J, Zamudio M. Estudio comparativo in vitro de la fuerza de adhesión a la superficie dental de *brackets* metálicos y cerámicos utilizando un cemento a base de resina, con diferentes sistemas de fotopolimerización y espesores de material. Acta odontológica venezolana. 2018; 56(2):11-12.

15. Turpo F. Retiro de *brackets*. [Tesis para optar el título de especialista en Ortodoncia]. Tacna: Universidad Privada de Tacna; 2016.

16. Viteri D. Comparación in vitro de la fuerza de adhesión de *brackets* de porcelana reacondicionados vs *brackets* nuevos. [Tesis para optar el título de Cirujano Dentista]. Quito: Universidad Central del Ecuador; 2017.

17. Nawrocka A, Lukomska M. The Indirect Bonding Technique in Orthodontics. A Narrative Literature Review. Materials. 2020;13(1):1-8.

18. Camargo Y, Oliveros J. Comparación de la resistencia a la descementación de *brackets* mediante el acondicionamiento de la superficie del esmalte dental con hipoclorito de sodio. [Tesis para optar el título de especialista en Ortodoncia]. Cartagena: Universidad de Cartagena; 2018.

19. Vargas H, Miranda E, Lazo L, Cosio H. Comparación in vitro de la Resistencia adhesiva de los sistemas adhesivos grabado y enjuague y autograbado. Odontología Vital. 2019; 30(1):45-50.

20. Carrillo M. Michael G. Buonocore, padre de la odontología adhesiva moderna, 63 años del desarrollo de la técnica del grabado del esmalte (1955-2018). Revista ADM. 2018; 75(3):135-142.

21. Chacón J, Del Rosario N, Zamudio M. Adhesión posclareamiento y el efecto de la aplicación de antioxidantes. RAAO. 2018; 59(2):21-25.

22. Gutiérrez M, Sánchez T, López A. Frecuencia de aparatos utilizados en tratamientos de ortodoncia interceptiva. Rev. Cient. Odontol. 2016; 12(2):8-14.

23. Martínez Z, Quintero L, Flores A, Ortiz J, Sandoval Z, Torres P. Comparación de resistencia al cizallamiento

y carga máxima en tres sistemas adhesivos adheridos al esmalte. RODYB. 2017; 5(1):25-25.

24. Rodríguez A, Pereyra A, Zamudio M, Álvarez M, Christiani J. Estudio In Vitro de la resistencia al cizallamiento de una resina reforzada según el tratamiento del sustrato. Revista facultad de odontología. 2016; 9(1):7-12.

25. García V. Estudio de la fuerza de adhesión de *brackets* metálicos y cerámicos sobre superficies de zircona tratadas con láser de femtosegundos. [Tesis para optar el grado de Doctor en odontología]. Valencia: Universidad de Valencia; 2018.

26. Erazo M. Resistencia al desprendimiento de *brackets* mediante fuerzas de cizallamiento, en el esmalte dental previamente desproteinizado. estudio in vitro en la facultad de odontología de la universidad central del ecuador. [Tesis para optar el título de odontología]. Quito: Universidad Central del Ecuador; 2017.

27. Aguilar R. Efecto de la desproteinización adamantina con hipoclorito de sodio al 5 % en la calidad de la adhesión de los *brackets* ortodónticos evaluados mediante un sistema de fuerza de cizallamiento. [Tesis para optar el título de especialista en ortodoncia y ortopedia maxilar]. Lima: Universidad Inca Garcilaso de la Vega; 2017.

28. Macedo N, Melo J, Cabral V, Bottino M, Villaca L. Evaluación de la resistencia de unión de *brackets* ortodónticos fijados a cerámica de disilicato de litio. Int. J. Odontostomat. 2019;13(2):207-218.

29. Bendezu B. Resistencia de adhesión al desprendimiento de *brackets* ortodónticos de la superficie del esmalte por tiempos de polimerización. [Tesis para optar el título de especialista en ortodoncia y ortopedia maxilar]. Huancayo: Universidad Continental; 2020.

30. Sabando N. Técnicas de adhesión en ortodoncia convencional y lingual. [Tesis para optar el título de cirujano dentista]. Guayaquil: Universidad de Guayaquil; 2021.

**FUNDING**

None.

**CONFLICT OF INTEREST**

None.

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