Tikrit Journal for Dental Sciences 11(2) (2023) 331-338
https://doi.org/10.25130/tjds.11.2.19

Tikrit Journal
for
Dental Sciences
https://tjds.tu.edu.iq
ISSN:2073-1213

Teeth Bracket Adhesives: Clinical Considerations: A Review Article

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Keywords:
Teeth Bracket, Clinical Considerations.

Article Info.:

Article History:
Received: 14/12/2022
Received in revised form: 7/1/2023.
Accepted: 12/1/2023
Final Proofreading: 12/1/2023
Available Online: 1/12/2023

Citation: Al Qassar SS, Al-Mallah MR, Ahmed MK. Teeth Bracket Adhesives: Clinical Considerations: A Review Article. Tikrit Journal for Dental Sciences 2023; 11(2): 331-338
https://doi.org/10.25130/tjds.11.2.19

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At the beginning of orthodontic practice, with fixed appliances, the multi-banding technique of the teeth was used, which had aesthetic disadvantages and often provoked aggression to the gingival tissues. To overcome these unfavorable characteristics, developing the technique of direct bonding of brackets brings the advantages of reducing the cost and time during the treatment and make easier cleaning. The advent of using acid etching in a dental practice which was introduced by Buonocore **(Error! Reference source not found.)** in 1955, enabling bonding between bracket base and enamel of the teeth. This adhesion had a high impact on esthetic and conservative orthodontics. The advantages of such a direct bonding technique to the tooth surface are reduced the cost and time of overall orthodontic treatment. Additionally, it makes the oral hygiene for the patients more simple and easy. The aims of this paper is to conduct a review of formerly published articles that are dealing with the orthodontic bonding to teeth enamel. It was confirmed that composites resin (CR) beside glass ionomer cement (GIC) are suitable material for such bonding. This could be because of its GIC biocompatibility, fluoride-releasing capacity, as well as lack of acid etching on the tooth surface. In another hand, resin-modified glass ionomer (RMGI) has grown in acceptance among orthodontists. Light polymerized orthodontic adhesives, on the other hand, remain the best adhesives for bracket bonding due to their esthetic and mechanical features, and their use is widespread **(Error! Reference source not found., Error! Reference source not found.)**. In 1958, Sadler [(2)] recorded the first attempt at direct bonding of orthodontic accessories to the tooth surface. Since the 1960s, studies have been made for improving the procedure in such a way that success in this practice is guaranteed and the use of metallic brackets, directly bonded to enamel. The introduction of acid etching that was presented by Buonocore **(Error! Reference source not found.)** in 1955 carried out the opportunity of bonding the base of the bracket with the enamel surfaces and create mechanical retentions in the teeth. Thus, from the 1970s onwards, composite resin for bonding orthodontic brackets have been used.

However, this practice leads to the loss of structure of the enamel, to a greater or lesser extent, depending on the time of application and concentration of the conditioning acid solution. Recently, new materials are being developed for specific use in orthodontics. RMGI that have a composition similar to restorative CR and GIC with strong adhesion and capable of releasing fluoride are some of the main materials studied and used in this practice. Due to the large amount of materials that offered on the marketplace for bonding orthodontic accessories to teeth enamel, it is of vital importance to carry out studies that aim to evaluate the properties of these different types of materials, so that there can be a safer indication in daily practice. Based on this, this work aims to update professionals in the orthodontic field regarding the materials used for bonding orthodontic brackets, highlighting their advantages and disadvantages.

A. Adhesion between Orthodontic Accessories and Tooth Surface

Using RMGI and different adhesives options for brackets bonding composite resin, as it has an aesthetic and mechanical property, is one of the adhesives of excellent in the gluing technique. However, the quality of the final retention depends on the adhesion achieved by the adhesive at the interface with the tooth and the type of adhesive used. Tags are considered fundamental for material retention and are responsible for waterproofing surfaces, with consequent reduction of marginal infiltration. Based on this, Galassi et al.(**Error! Reference source not found.**) conducted research evaluating the penetration depth of orthodontic resins on the surface of the enamel in the occlusal, middle and cervical regions. It was observed that Concise resin presented a higher average length of tags in relation to Superbond resin. In Concise resin the occlusal region formed tags with longer length than the middle and cervical, and the latter showed equality statistics; in Super bond resin, the tags presented values statistically equal for the three regions analyzed.

Cal-Neto and Miguel have (**Error! Reference source not found.**) compared resin penetration in enamels prepared with phosphoric acid and with self-etching found that being the self-etching primer adhesive is more conservative and produces less demineralization and diffusion of the adhesive into the teeth enamel surfaces when likened with phosphoric acid. Kumar et al. (**Error! Reference source not found.**) showed that enamel conditioning with 37% phosphoric acid produced greater depths of resin penetration than self-etching primer or air abrasion. In Vilchis et al. investigation (**Error! Reference source not found.**), enamel etched with phosphoric acid was compared with enamel conditioned with self-etching primer. The scanning electron micrographs showed that 37% phosphoric acid seemed to produce more enamel loss than the self-etching primer. Moreover, the enamel-adhesive interface was more irregular when the enamel was etched with 37% phosphoric acid. Dominguez-Rodriguez et al. (**Error! Reference source not found.**) performed research that evaluated the tensile strength when using a self-etching adhesive. The results indicated an average tensile strength of 6.25 Mega-pascal (MPa), practically matching the optimal values mentioned in the literature (**Error! Reference source not found.**, **Error! Reference source not found.**) (6 MPa). Their next in vitro study of bonding to extracted human premolars compared self-etching adhesive resistance to traction with that of a conventional system (**Error! Reference source not found.**). Mean values were 8.1 MPa in the self-etching group, and 10.3 MPa for the conventional system, similar to those found by Grubisa et al (**Error! Reference source not found.**) in another comparative study: 7.7 MPa for self-etching adhesive and 9.8 MPa for the conventional system. Affirm that this adhesive can be used safely, whose advantage is the simplification of the gluing procedure and a significant decrease in clinical time. Lopes et al. (**Error! Reference source not found.**) evaluated the adhesion strength of orthodontic brackets to enamel surfaces treated with two systems conditioners. The enamel was treated with an adhesive system self-etching, or using 35%

phosphoric acid over the enamel surface of the teeth for 15 seconds. In both groups the CR activated by light-curing, light curing glass resin (LCGR) was used for bonding the orthodontic brackets. The high capacity demineralization of the self-etching system tested provided adequate bond strength for bonding orthodontic brackets, presenting resistance comparable to phosphoric acid conditioner. Sponchiado et al. (**Error! Reference source not found.**) studied the resistance of stainless-steel brackets that were bonded to enamel bovine dental care, performing a conventional adhesive protocol and a self-etching followed by a LCGR, evaluated in dry and wet conditions. There was no statistical difference between the two groups in a dry environment or wet. There was a significant reduction in resistance for the self-etching primer in a humid environment when compared to the dry environment. Vasques et al. (**Error! Reference source not found.**), assessed the resistance to shear force using LCGR for the fixation of different types of metal brackets which were glued using the conditioning of the enamel with phosphoric acid. The results showed that the resistance to shear force for different groups of metal brackets was range from 10.72 to 17.65 MPa, which demonstrated that the technique used for bonding brackets with LCGR is within established standards by Reynolds and Von Fraunhofer (**Error! Reference source not found.**) stated in 1976, that the mechanical strength necessary for clinical use to tooth movement of 5.9 to 7.9 MPa in the oral cavity. Pithon et al. (**Error! Reference source not found.**) compared resistance to the sheer force of metallic brackets bonded with the Eagle Bond composite and with the Transbond XT that is manufactured by (American Orthodontic, Sheboygon, USA) and (3M ESPE, St. Paul, Mn, USA) respectively. The bracket/composite contact was shown to have a higher number of fractures in this investigation. It follows, then, that how much shear force, the two materials tested showed similar results, with no differences in significant statistics. Today, fluoride- releasing resins for orthodontic bonding was introduced in the market due to the anti-cariogenic activity and karyo-statics of this ion. Thus, Marra (**Error! Reference source not found.**) verified that the shear strength of the bonding interfaces for conventional and fluoridated orthodontic resins to enamel, depends on the storage condition time. It was observed that neither the times nor the resins used caused a statistical difference in the resistance to shear force. On the other hand, the storage condition for 30 days determined a significant difference in the shear force, compared to 24 hours and 24 hours with thermal cycling.Use of RMGI in bracket bonding in orthodontics for reducing white spot lesions and marginal gingivitis has been of great concern to professionals who, aware of this problem, are alert to new materials that mitigate and prevent such damage to oral hard tissue. Among these materials, the most prominent is GIC. The cement of glass ionomer was initially developed by Wilson and Kent, in 1972 (**Error! Reference source not found.**). Its retentive capacity was limited, which reduces its holding capacity. With the advent of RMGI better results in the direct bonding of brackets have been reached, which increases the horizons for its application.

From this, Bertoz et al. (**Error! Reference source not found.**) analyzed the clinical behavior of cemented brackets with GIC. The work aimed to verify the efficiency of gluing of this material, as well as analyze its ability to avoid the appearance of enamel decalcification stains, commonly observed around the cementation area of the composite resin brackets. It concluded that GIC is as efficient in bonding brackets as CR, in addition to being highly reliable in prevention against the appearance of white spots of descaling.

Freitas (**Error! Reference source not found.**) presented a survey of works on bonding orthodontic accessories to dental enamel, using RMGI, It has been verified that:

1. ***The material is an efficient substitute and less iatrogenic than composite resins, in bonding, re-attachment and***

removal of the orthodontic appliance.

2. ***Furthermore, the gluing is carried out in a damp field***
3. ***Without the need for acid etching on enamel.***
4. ***Also adheres to metal and porcelain;***
5. ***Has the ability to absorb fluorine present in the oral cavity and release it gradually.***
6. ***Can be removed more easily than composite resins.***
7. ***It is biocompatible.***
8. ***Requires less clinical time.***
9. ***Applications are simpler and easier.***
10. ***Improves patient and operator comfort.***

In a saliva-contaminated environment, Godoy-Bezerra J et al. (**Error! Reference source not found.**) tested the adhesive strength of RMGI, using different pre-treatments in enamel. The sample that received 37% phosphoric acid, dry, produced the highest value of resistance (4.09 Mpa), but did not differ statistically from the sample that received 37% phosphoric acid moistened with saliva; (3.88 Mpa). There was no statistical difference between samples that treated with poly-acrylic acid whether moistened with saliva or in a dry field and samples without acid conditioning in moistened saliva. When the enamel was conditioned, In samples that were treated with 37% phosphoric acid and 10% poly-acrylic acid whether the field was dried or moistened, more than 50% of the samples showed that all the material adhered to the tooth surfaces, which did not happen in the sample that moistened with saliva without acid conditioning, in which the adhesive failure occurred mainly between the enamel interface and the adhesive material. Their results indicated that in an environment moistened with saliva, the ionomer reached better resistance values when 37% acid was used, without statistically differing from the light-curing resin Transbond XT (**Error! Reference source not found.**, **Error! Reference source not found.**). Melo et al. (**Error! Reference source not found.**) evaluated two ionomer cements, RMGI and compared them with orthodontic adhesive in terms of shear strength and release of fluoride. The results confirmed that for the shear strength and fluoride release, there were statistical differences between the groups Transbond XT CR and Fuji Ortho Band. The authors concluded that the materials Transbond XT (3M ESPE, St. Paul, Mn, USA) and Fuji Ortho have better shear strength, but less release of fluoride when compared to the Fuji Ortho Band. Tortamano et al. (**Error! Reference source not found.**) study was aimed to evaluate the bond strength of different metal brackets cementing agents, a RMGI and different CR. Concluded that the CR tested with their respective adhesive systems present adhesiveness sufficient to withstand orthodontic movement forces, constituting a viable alternative for cementation of metal brackets, and that GIC showed strength of inferior adhesion to other materials, in addition to difficulties in handling, being very sensitive to small variations in powder-liquid ratio, causing material waste. Souza et al. (**Error! Reference source not found.**) tested the strength of five types cements available in the market used in the fixation of brackets. It was concluded that all types of cements reached acceptable values for orthodontic practice and the failures of adhesives occurred, most of the time (66%), at the interface cement bracket.

Silva et al. (**Error! Reference source not found.**) conducted a study having an objective to search in the literature for the characteristics of the adhesives currently employed in orthodontics, more specifically CR and RMGI. They showed that the use of GIC in orthodontics is possible due to the polymerization reaction, giving it strength sufficient initial adhesive to withstand orthodontic forces light. After 24 hours, with its Compomers reaction complete, can be used as composite resins because have similar physicochemical properties. These

cements are biocompatible, their ability to recharge and release fluoride makes them anti-cariogenic, can be applied on damp surfaces with enamel conditioning or not, but they cannot be contaminated during their reaction of hardening. They are easily removed from enamel, resulting in an advantage of less damaging the enamel regarding Compomers, have a higher adhesiveness than resin-modified glass ionomer and smaller than composite resins. Despite being considered suitable for orthodontic use, its high viscosity causes their indication to be discussed. CR dose not allow the presence of moisture at any time of bonding and polymerization. Concluded that one should consider the best material that which meet the needs of the treatment and the professional, who will make his choice based on his knowledge of the properties and limitations of use of the materials and domain of application technique.

Grando et al. (**Error! Reference source not found.**) presented a review on the bonding orthodontic accessories to tooth enamel using CR and GIC. it was possible to conclude that: LCCR products offer the professionals a great working time margin during the gluing of the brackets on the enamel surface; the great advantage of GIC is anti-cariogenic action, due to the release of fluorides to the enamel; the elapsed time after bonding procedure shows direct correlation with the strength of GIC. The composite resins showed behavior similar to GIC in the shear strength test.

B. Adhesion between Orthodontic Accessories and Artificial Surfaces

Recently, efficient bonding in restorations like amalgam surfaces was considered unfeasible. With the development of new techniques and materials has become such procedures possible.

Vieira et al. (**Error! Reference source not found.**) performed a review of the latest materials and techniques for the collage of orthodontic accessories, bringing to the orthodontist conditions for performing efficient bonding on artificial surfaces such as amalgam, gold and porcelain. Based on reviews, it is possible to perform efficient orthodontic bonding in amalgam restorations and porcelain surface; there is a need for further studies to obtain collage in gold restorations; preparation of metal surface or porcelain by sandblasting has retentive characteristics superior to those made with a diamond tip; the material that showed higher tensile strength (Mpa), for bonding orthodontic treatment in amalgam restorations, was the Superbond C and B (Parkell Inc., Edgewood, NY, USA); the resin Concise (3M ESPE, St. Paul, Mn, USA) with intermediate application from All-Bond two Primers (Bisco Inc., Schaumburg, IL, USA) A with B was also effective for bonding restorations of amalgam; regardless of surface preparation. For porcelain, silane increased bond strength; the hydrofluoric acid is more active than vilifying for the coarsening of the porcelain surface, but it presents risks regarding its use due to its great potential corrosive; the use of hydrofluoric acid and the removal of glaze increased the fracture rate of the surface of porcelain.

Discussion

There is a large number of articles that point to the different materials used in the bonding of brackets in Orthodontics. There are studies available in the literature that highlight its advantages and disadvantages, tensile strength and to shear force; involvement of tooth structures and disease prevention, among other properties that justify its use in daily clinical practice.

In 1965, Newman (**Error! Reference source not found.**) introduced in orthodontics the bonding of orthodontic accessories, thus eliminating problems related to tooth separation and cementation of bands. There is an agreement among several authors that brackets make the appliance more aesthetic when compared to bands, offer better access to cleaning, reducing the accumulation of plaque and, consequently, the incidence of caries lesions, in addition to reducing the number of consultations and the duration of the

service in the assembly phase of the device.

Floriano et al. (**Error! Reference source not found.**), Freitas (**Error! Reference source not found.**) agree that the advantages provided by the direct bonding technique, cease to be significant when there are problems in efficiency of bonding and failure to achieve adequate retention, represented by the detachment of orthodontic brackets, causing inconvenience to the patient and the professional. quote, also, as a disadvantage the possible descaling and enamel weakening, checked around the brackets, attributed to the acid attack carried out beyond the area necessary for fixing, associated with poor hygiene of the patient. Improvements in materials and bonding techniques of orthodontic accessories together with the growing demand for aesthetic treatment have led to increasing use of corrective orthodontic appliances, consequently to the use of adhesives for bonding brackets. For this reason the importance of studying the main characteristics of the most used products in order to guide the professional to indicate the best type for each case, as the success of gluing in orthodontics involves a combination of basic factors such as adequate prophylaxis, satisfactory isolation, conditioning appropriate mechanical and/or chemical surface and correct choice of handling the adhesive system.

According to Tortamano et al. (**Error! Reference source not found.**), the ideal properties of cement for orthodontic brackets are:

1. bond strength sufficient to withstand orthodontic forces throughout the entire treatment;
2. fluidity, necessary for the penetration of the material in the bonding orthodontic brackets bracket retentions;
3. viscosity, to keep the bracket in place desired position before cement polymerization;
4. time to adequate work to allow the correct positioning of the bracket and removal of excess material;
5. Allow work in a humid environment, reducing the detachment rate in posterior teeth;
6. Fluoride release, reducing the risk of caries and white spots around the bracket;
7. Removal without damaging to the enamel surface.

Thus, professionals attentive to these issues have looking for new materials that mitigate and prevent damage to oral health. Among these materials, the ones that stand out most are glass ionomer cements. However, despite of the favorable characteristics of these materials, the retention from brackets to tooth enamel is not yet considered adequate, often not being insufficient to resist masticatory efforts and orthodontic mechano-therapy.

Souza et al. (**Error! Reference source not found.**), in their studies, justify the low resistance of GIC, probably because there no is acid etching of the enamel surface indicated by the manufacturer.

However, Bertoz et al. (**Error! Reference source not found.**), Freitas (**Error! Reference source not found.**), and Silva et al. (**Error! Reference source not found.**) do not support the ideas of these authors, stating that GIC is as efficient for gluing accessories as resins, especially with the introduction of resinous particles to its composition and have advantages such as being less iatrogenic that CR in bonding, re-bonding and removed from the orthodontic appliance. Furthermore, the collage is made in a wet field and the ionomer has the ability to adhere to enamel, dentin and cementum without the need for acid etching, and also to metals (stainless steel, tin oxide, gold and platinum) and porcelain, which is considered by Chain MC (**Error! Reference source not found.**) its most important property, in addition to its anti-cariogenic and caryo-static properties attributed to the ability to absorb fluorine present in the oral cavity and release it gradually, thus signaling a trend in contemporary orthodontics.

However, Tortamano et al. (**Error! Reference source not found.**) stresses the difficulty of handling GIC, being very sensitive to small variations in the proportion of

powder and liquid. for this reason, the working time of the material varies greatly, causing waste of material and loss of time during the attendance. Resins have become the universally used by orthodontists for bonding brackets due to their adhesion proven by several studies, capable of withstanding orthodontic movement forces, in addition to their aesthetic properties, constituting a viable alternative for cementation of metallic brackets. However, the damage is discussed not only for adhesion, when it is performed in humid environments, but also to the tooth, when acid etching issued in the bonding technique, due to the difficulty of removing the resin from the tooth structure once the device has been removed.

There is an idea that self-etching adhesives offer simplified clinical application when compared with the total acid etching technique, making it possible for the clinician and the patient to save time and increase the procedure's cost-effectiveness. Furthermore, when they were surveyed, they already pointed out an average tensile strength 6.25 MPa, which, according to the average stipulated by Reynolds and Von Fraunhofer (**Error! Reference source not found.**) ranges from 5.9 to 7.9 Mpa, is already sufficient for tooth movement in clinical use.

However, Lopes et al. (**Error! Reference source not found.**) point out that little is known about the ability to bond to enamel through these systems and that the ability of self-etch systems to produce adequate adhesion to enamel appears to be associated with the degree of selective demineralization provided in this tissue.

Thus, the results can be completely different and the ability to adhere will depend on the degree of aggressiveness of these solutions, which agrees with Cal-Neto and Miguel (**Error! Reference source not found.**) obtained in their results, in the analysis under Scan Electron microscope, that when compared to a standard phosphoric acid system, the self-conditioning system was more conservative, resulting in reduced demineralization and adhesive penetration on enamel surfaces.

Due to the concern of professionals with the preservation of dental health and the affirmations of researchers about the capacity, that the materials for bonding brackets must serve as a reservoir of fluorine, in the repeated exposures to this ion. were also fluoridated orthodontic resins are included in the market, the which become attractive since, in addition to having an action therapy, are reported in the literature as having resistance similar to conventional CR.

In recent years, the population search for orthodontic treatment has changed, with represented by a greater number of adults, which have more amalgam restorations in molars, porcelain crowns and bridges when compared to adolescents, being of paramount importance to carry out of studies regarding this type of collage.

Floriano et al. (**Error! Reference source not found.**) and Souza et al. (**Error! Reference source not found.**) agree that it is important identification of the type of substrate to be glued (porcelain, composite, amalgam or metal alloys) in the fixation of brackets, prioritizing the use of sandblasting for roughening metal surfaces or porcelain, as well as always including the use of silane in porcelain collages.

The works developed by these still show that, when the bracket is detached from enamel, most fractures occur between the base of the bracket and resin, when the bonding procedure is done correctly. It is due to the great diversity of materials, in addition to their numerous properties, that professionals are conducting new research to improve techniques and renew knowledge about their indications to get a longer lasting result. The indication of the material to be used as an orthodontic adhesive is an issue that must be analyzed carefully. Data such as oral hygiene, allergic sensitivity, amount of orthodontic force, state patient's psychological status, treatment time and habits must be considered for correct indication.

Final Considerations

In view of the above, it is concluded that the use of RMGI, due to its numerous

advantages, has been widely disseminated in the practice of bonding orthodontic brackets, however CR, due to its mechanical and aesthetics, is still one of the adhesive systems of choice in this technique. The professional should always analyze particularly each case, in order to make the correct indication and obtain treatment success.

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