Review Article

Complications of ceramic brackets

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ABSTRACT

An expectation of beautiful smiles at the end of orthodontic treatment is a primary concern to each patient but is also equally concerned with appearance while undergoing treatment. Many attempts have been made by manufacturers to meet this demand. It includes by making metal brackets smaller, developing lingual or "invisible" brackets, making plastic brackets, and finally, introducing translucent ceramic brackets. Ceramic brackets are now popular as esthetic appliances which could withstand orthodontic forces and resist staining better than plastic brackets. Several clinical complications may arise from the use of ceramic brackets. The effects are enamel damage during debonding, attrition of teeth occluding with ceramic brackets, and increased friction in the orthodontic appliance. Solutions to these problems are discussed which indicate the need for careful selection of the teeth to be bonded with ceramic brackets. This article will help clinicians about the potential hazards and clear contraindications to the use of ceramic brackets. Apart from offering esthetics, ceramic brackets exhibit excellent biocompatibility. There has been much concern regarding the allergic and cytotoxic effects induced by constituents and the corrosion products of the stainless steel brackets. Nickel and chromium are the most common causes of metal-induced allergic contact dermatitis in man. Nickel has recently been reported to be moderately cytotoxic. Hence, the advantages offered by the ceramic brackets, namely excellent esthetics, biocompatibility, corrosion resistance, stability in the oral environment, and non-toxic nature, have made them an integral part of the orthodontists' armamentarium. The aim of this review is to gain a clear knowledge about the potential hazards of ceramic brackets due to its properties.

KEY WORDS: Armamentarium, Biocompatibility, Corrosion, Cytotoxic, Friction, Hazards

INTRODUCTION

Orthodontic usually details with the correction of malocclusions and craniofacial abnormalities, by ensuring alignment of the teeth properly with harmonious occlusal and jaw relationship, that will eventually improve mastication, phonetics, and facial esthetics, with beneficial effects on the general and oral health, individual's comfort, and self-esteem, having a positive role in improving the quality of life. Therefore, the treatment objectives are consistent with the aims of medical interventions, namely ensuring health, the "state of complete physical, mental, and social well-being," as perceived by the World Health Organization (World Health Organization, 1946). Various types of treatment are available based on the patients' malocclusion, face form, defects, etc. Orthodontic treatment is classified into removable and fixed types. Fixed appliances such as braces are attached to the teeth by metal bands or special cement. The brackets used are classified into metal and ceramic brackets. Typically made of high-grade stainless steel, traditional metal braces remain by far the most common type of fixed orthodontic appliances.[1] In case of fixed orthodontic treatment, it consists of metal bands that wrap around the molars in the back and smaller metal brackets that are cemented to the front surfaces of the other teeth. A thin, springy metal wire, running through the brackets, gently guides the teeth into a proper position. This thin, metal wire known as archwire is going to be fastened to the brackets by versatile elastics, metal ties, or different forms of clasps. During recent times, braces are actually smaller, lighter, and more comfortable to wear when compared with older ones. Now, we have a lot of options like we can choose colorful elastics for the brackets, which are

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readily available in the market. The aim of this review is to overview the properties, clinical advantages, and disadvantages of the ceramic brackets.

Ceramic Brackets

As the number of adults seeking the orthodontic care increased, the demand for orthodontic treatment also increased, so the orthodontist felt the need to provide their patients with more esthetically appealing treatment. This motivated the manufacturers to produce more acceptable esthetic brackets, and finally, it leads to the development of ceramic brackets. Clear ceramic braces are a replacement variation on the normal system that has a way less noticeable technique of treatment. Clear ceramic brackets are made of translucent ceramic material on the front side of the brackets which will match with the natural tooth's color. This system has become a favorite for adults (including some well-known celebrities) because they are not so visible like metal brackets. Presently, several kinds of ceramic braces are available on the market, and therefore, the technology is continually up. The durability of ceramic brackets are less; plus, the elastic bands that attach the brackets to the archwire will stain (however, these are generally changed each month.) Ceramic braces also cost more than metal. The ceramic brackets are one of the popular esthetic appliances. The new ceramic brackets have excellent optical properties and it has additional esthetic appeal without significant functional compromises. Mostly, ceramic brackets are durable and allow adequate force control over long treatment periods, and their discoloration risk is minimal. The use of ceramic brackets was one of the great developments in the orthodontic treatment of adult patients. Their acceptance by the patients has been unprecedented in the practice of orthodontics. Apart from esthetics, ceramic brackets exhibit excellent biocompatibility. There are so many risk factors such as allergic and cytotoxic effects which are produced by constituents and the corrosion products of the stainless steel brackets.[2] Nickel and chromium are the most common causes of metal-induced allergic contact dermatitis in man. Nickel has recently been reported to be moderately cytotoxic. Nickel elicits contact dermatitis, which is a Type IV delayed hypersensitivity immune response. Hence, the advantages offered by the ceramic brackets, namely excellent esthetics, biocompatibility, corrosion resistance, stability in the oral environment, and non-toxic nature, have made them an integral part of the orthodontists' armamentarium.[3] The demand for orthodontic treatment in adults has greatly increased, and this presented new problems to the orthodontist. Patients demanded more esthetically pleasing appliances, and ceramic brackets were introduced to help meet this need. As the popularity of esthetic dentistry grows, orthodontists are often faced with the challenge of bonding attachments on teeth restored with resin or veneering porcelain. However, the bond strength between the brackets and the porcelain surface is still a problem in adult orthodontics.

Composition and Types of Ceramic Brackets

Ceramics consist of metal oxide elements and nonmetal elements that include precious stones, glasses, clays, and mixtures of ceramic compounds.[4,5] A ceramic is not metallic or a polymeric. New ceramic materials had been developed with numerous new applications, by taking advantage of the properties found in different atomic structures. Alumina (A12O3) is a typical member of contemporary ceramics, fashioned once metallic element is supplementary to steel to take away chemical element dissolved in the steel. Corundum might be used as a single-crystal material or as a crystalline material.[4] Monocrystalline and polycrystalline alumina are used in the manufacture of orthodontic ceramic brackets.[5] Ceramic brackets are mostly composed of aluminum oxide. Ceramic brackets are classified into two types based on their differences seen during fabrication, they are (a) polycrystalline ceramic brackets and (b) monocrystalline ceramic brackets.[6] The method of manufacturing of ceramic brackets plays an critical role in the clinical performance. The production of polycrystalline brackets is less complicated, and thus, these brackets are more readily available at present.[4] The most apparent difference between polycrystalline and monocrystal brackets is in their optical clarity. Single crystalline are noticeably clearer than polycrystalline brackets and so they are translucent. Both single crystal and polycrystalline brackets resist staining and discoloration.[7] Ceramic brackets are available in different forms including true Siamese, semi-Siamese solid, Lewis/Lang, and Begg designs. Ceramic brackets are made, especially, by expertise in the ceramic manufacturing and are sold under different names by manufacturers or distributors of orthodontic products sellers.

Hardness

Ceramic is the third hardest material known to humans because of the presence of aluminum oxide which is more stronger than stainless steel. Extreme high hardness of aluminum oxide is one of the most important physical properties of the ceramic brackets. This is the significant advantage of both monocrystalline and polycrystalline ceramic brackets over stainless steel brackets.[8] Ceramic brackets are 9 times harder than stainless steel brackets or enamel and severe enamel abrasion from ceramic brackets might occur rapidly if contacts between teeth and ceramic brackets exist.[3]

Tensile Strength

The tensile strength is higher in ceramic brackets than stainless steel, but when compared to polycrystalline

alumina, the monocrystalline alumina has much higher tensile strength than in polycrystalline alumina.[4] This is the main reason that the only true Siamese brackets have been produced from monocrystalline alumina. Tensile strength characteristics of ceramics depend on the condition of the surface of the ceramic. A shallow scratch on the ceramic bracket reduces the load required for fracture. Ceramic material is <1% at failure during elongation when compared with approximately 20% of stainless steel, thus making ceramic brackets more brittle. Deformation of ceramic brackets is 20% under stress before fracturing, but the ceramic brackets deforms <1%.[9]

Optical Properties of Ceramic Brackets

The optical properties of ceramic provide the only advantage over stainless steel brackets. The larger the ceramic grains, the greater the clarity. However, the grain size increases, the ceramic material becomes weaker.

Bonding Strength

The bond strength between mechanical and chemical bondings differs is mainly in the way stress concentration which is distributed over the bonding surfaces. Ceramic brackets that supply a mechanical bond with the adhesive have holding grooves in that edge angle square measure 90°. Bond strengths are greater with chemical bonding than with mechanical retention. There are also crosscuts to prevent the brackets from sliding along the undercut grooves that have sharp edge angles, thus leading to high localized stress concentrations around the sharp edges and resulting in brittle failure of the adhesive. Shear debonding force is applied so that part of the adhesive remained on the tooth and part on the grooved bracket. On the other hand, the shiny surfaces of ceramic brackets bonded chemically allow a much greater distribution of stress over the whole adhesive interface without the presence of any localized stress areas. Surface roughening with a diamond bur plus phosphoric acid did not produce sufficient bond strengths. Consequently, significantly greater shear bond was needed to cause debonding and pure adhesive failure.[10] A glazed porcelain surface is not responsive to adhesive penetration, and if the surface is roughened to provide mechanical retention, it may not be acceptable after debonding. Various factors that affect bond strength include type of bonding resin, etching time, condition, bracket base design, and preparation of teeth involved. Conventional acid etching (orthophosphoric acid gel 37%) is ineffective in the preparation of porcelain surfaces for the mechanical retention of orthodontic attachments. Many studies concluded that the shear bond strength of polycrystalline ceramic brackets was significantly greater than that of stainless steel brackets but lesser than that of the monocrystalline brackets.[11] High-frequency limit combined with silane produced the most retentive surface. Bond strength of recycled brackets is clinically adequate, although it is lower than that of new brackets. Unwanted enamel removal during debonding can be minimized with the recycling of weaker bond strength ceramic brackets.

Potential Clinical Problems

The major clinical problems of ceramic brackets include enamel fracture, patient discomfort during debonding, bracket fracture, increased friction and attrition of teeth occluding against the bracket. Various measures have been taken to overcome these problems, of that few are discussed below.

Enamel Fracture during Debonding

Techniques for removing metal orthodontic attachments are, for the most part, not as effective with ceramic brackets because the properties of ceramic brackets differ greatly from those of the conventional metal orthodontic brackets. At present, on the market, ceramic brackets are composed of aluminum oxide crystals in either a crystalline or monocrystalline type that includes a low fracture toughness compared thereupon of chrome steel.[12] When compared with stainless steel fracture, toughness of ceramics is 20–40 times less. Hence, it is much easy to fracture a ceramic bracket than a metallic one. Enamel fracture during debonding is related to the high bond strength of ceramic brackets and sudden impact loading.[13,14] Prevention of enamel fracture during debonding can be done by avoiding sudden force loading within the enamel , avoiding bonding of ceramic brackets on structurally damaged teeth like teeth with heavy crack lines, heavy caries, large restorations covering major portion of the tooth, hypoplasia tooth, hypo calcification, and non-vital tooth[15]. We can also reduce the bond strength of ceramic brackets by adding mechanical retention,[16,17] reducing chemical retention, adding a metal mesh at the base of the bracket, reducing the base area of the brackets, using weaker resins,[18] adding extra plasticizer to the resin, modifying the thickness of adhesive used by modifying the etching time and debonding with ultrasonic, electrothermal, and laser devices One of the disadvantages of direct bonding is that enamel demineralization can occur around orthodontic brackets. We also have report that there is no evident enamel damage during debonding of ceramic brackets with appropriate pliers, while other studies reported that there is an increase in enamel cracks and crack length during debonding The hardness and brittleness of ceramic materials have necessitated the use of special instruments to debond ceramic brackets, including wrenches, pliers with and without sharp blades, and ultrasonic and electrothermal instruments. Recently, a new instrument was introduced which was designed to grasp the tie wings of the ceramic bracket

during debonding, in an effort to hold the bracket together, thus allowing for efficient removal.

Removal of Broken Ceramic Brackets by Grinding

When a proper debonding technique fails, grinding the ceramic bracket becomes the option of choice. Grinding should be carried out with high-speed diamond burs or low-speed green stones. The procedure is time-consuming and the heat which generated by grinding might affect the dental pulp and, subsequently, the vitality of the tooth. Pulp damage during grinding can be managed and avoided by fracturing the tie wings with ligature cutting pliers and that will reduce the ceramic bracket size to be grind, which will help in avoiding the buildup of heat during grinding Air or water coolant must be used while grinding the bracket to avoid damaging the pulp.[14]

Attrition of Teeth Occluding against Ceramic Brackets

Several clinical complications may arise from the use of ceramic brackets.This includes the effects of debonding on underlying enamel, attrition of teeth occluding with ceramic brackets and increased friction in the orthodontic appliance. Attrition of teeth occluding against ceramic brackets is the most important disadvantage of the ceramic brackets. The fact is ceramics which are harder compared to enamel.[19] Such problem can be overcome by selecting the teeth to be bonded with ceramic brackets. The clinician must avoid bracket contact with opposing teeth. In deep anterior overbite cases, bonding the mandibular teeth with ceramic brackets should be avoided. Similarly, in cases where the maxillary canine is retracted past the mandibular tooth, bonding the mandibular canine should be avoided. Since ceramic bracket is harder than stainless steel, severe enamel abrasion might rapidly occur, if contacts between teeth and ceramic brackets exist.

Increased Friction with Ceramic Brackets

Orthodontic tooth movement relies on sliding mechanics. Sliding mechanics refers to the sliding between the bracket and archwire. Sufficient applied force is required for tooth movement to overcome this frictional resistance. Studies have shown that up to 60% of the applied force is lost in overcoming frictional resistance. The total force applied to orthodontic brackets has to be twice that needed to produce an effective force in the absence of friction. Binding of the archwire in the bracket slot results in a reduction or even inhibition of tooth movement. High friction is due to the roughness of the bracket interface which slows the sliding of the archwire through the bracket.[20] This clinical problem can be managed using ceramic brackets with smoother slot surfaces.

Breakage of Ceramic Brackets

This is due to the low fracture toughness of the ceramic brackets. Compared with metal brackets, ceramic brackets are more susceptible to fracture due to force applied during orthodontic treatment. It often affects bracket wings and usually occurs accidentally when cutting ligature wires or engaging a heavy archwire in the bracket. Sometimes, fracture of brackets can be due to the slight torque of such wire in the bracket interface. Such problem can be avoided by avoiding direct contact of the brackets while cutting ligature wires and forceful engagement of increasingly heavy archwires used for leveling. Successive archwires should be fully engaged in the brackets. People who are professional player or in sports activities such as football, athletes, and people who are more prone to fracture and trauma should avoid orthodontic treatment with ceramic brackets.[3]

Increased Pain or Discomfort while denouncing Ceramic Brackets

This is related to the higher bond strength and it can be managed by having patient bite with pressure on cotton roll and/or gauze during debonding. Although ceramic brackets have a definite advantage over plastic attachments, some polycrystalline brackets do stain. This is probably due to the prolonged use of caffeine (coffee, tea, and colas), certain mouthwashes, or lipstick and may also be associated with the type of bonding resins used. It is necessary to avoid the excessive use of staining substances and discoloring resins. Ceramic brackets are being used more often on account of their esthetics, greater hardness, and resistance to stains. Ceramic brackets may look discolored when the brackets themselves stain (direct discoloration) or when stains on the teeth or bonding resin show through the bracket (indirect discoloration). Discoloration of ceramic brackets tends to occur in polycrystalline brackets. Which is the most commonly manufactured and so most commonly used in the field of orthodontics. Using two-base resins, which tend to discolor less than no-mix one-step bonding resins, has been advocated by Swartz who also suggested the light-cured resins may offer "excellent color stability".[9]

Maintenance

Ceramic brackets are larger than metal brackets. Since these ceramic brackets are larger, it is harder to clean; ultimately, it will end up in hygiene problems and some loss of calcium from the teeth. Mostly, the ceramic brackets are not easily stained by food, drinks, or smoking, and the part which is easily stained is the clear elastic ties that hold the archwire to the brackets. Stained ties have to be replaced because it cannot be cleaned.[21] While undergoing orthodontic treatment with ceramic brackets, certain food items should be

avoided, but there is no need to ignore it completely. There are few lists of the food products which have to be avoided when the brace treatment with ceramic braces is going on. Certain foods which have to be avoided include red stains caused by tomatoes and food with tomato pastes because these red color stains are difficult to remove, mustard will stain yellow, so it has to be avoided, and drinks such as coffee, tea, chocolate, drinks, and soda drinks with bright and dark color have to be avoided. The cigarette gives a yellow color due to the presence of nicotine in their content which removes the esthetic appeal of the braces, and the biggest disadvantage with this stain is that it does not get removed on normal cleaning as these stains remain permanent, and different ways of cleaning have to be followed if these stains are to be removed.[4] It is believed that ceramic brackets can be free from stains with the help of whitening toothpaste, but it is actually the reverse of it. The whitening process will make the brackets and teeth white when we are undergoing orthodontic treatment, but the actual problem is seen when we get the braces removed. After using whitening toothpaste, a clear demarcating line which actually looks ugly is seen between the areas whitened and the area below the bracket which was removed. It is much better to avoid whitening toothpaste for the bright smile. There are other ways like properly cleaning your brackets rather than using a whitening toothpaste for the same. Along with the brushing, flossing, and rinsing, the mouth with mouthwash/water keeps a check of all the dirt and keeps the mouth clean, by even cleaning the areas where your toothbrush does not reach with ease. If not being done properly and regularly, the ceramic braces would start showing some color changes and, finally, become stained.

Operational Risk

The accidental ingestion or aspiration of a bracket during bonding or debonding is the main operational risk for the patients with ceramic brackets. There is an increased risk of the aspiration of ceramic brackets due to improper debonding techniques, because of their radiolucency; ceramic brackets may not be detected on radiographs if aspired There is an increased risk of oral soft tissue damage and the patient, clinician, and assistant to eye injury during debonding of ceramic brackets. The solution for this is to use caution and protective equipment during bonding and debonding. Patient has to be instructed to bite on a cotton roll during debonding which helps reduce the risk of dislodging brackets and/or fragments into the oral cavity and throat. The clinician and the assistant should wear protective glasses and a mask. The patient should wear protective glasses as well or at least keep both the eyes shut. Removal of ceramic brackets with debonding pliers by a squeezing pressure at the bracket-adhesive interface results in tensile bond failure, and it is the safest method of removal with enamel damage and without any operational risk. Due to the high heat generated, grinding of ceramic brackets with a low-speed handpiece with no water coolant may cause permanent damage or necrosis of dental pulp. Water cooling of the grinding sites is necessary.[22]

CONCLUSION

As the demand for adult orthodontic treatment increases and the popularity of esthetic dentistry grows, orthodontists are often faced with the challenge of bonding attachments on teeth restored with porcelain. The bond strength should be not only high enough to resist accidental debonding during treatment but also low enough so that no excessive force is necessary during debonding at the end of the treatment, since the restorations generally remain in the mouth after treatment. Ceramic brackets are popular as an esthetic appliance in the field of orthodontics. Its main advantage is esthetics, but it has various disadvantages. The introduction of ceramic brackets was a much-heralded development in the orthodontic treatment of adult patients.[23] The acceptances of ceramic brackets by the patients undergoing orthodontic treatment are increasing day by day due to its esthetics property and contributed significantly in the expansion and development of contemporary orthodontic therapeutic modalities. Ceramic brackets must be used after careful evaluation of the individual malocclusion and orthodontic treatment plan. Ceramic brackets have both esthetic advantage and clinical complications. However, there is still scope for improvement in some of the bracket characteristics, so further development is much needed to overcome the disadvantage before they are able to largely replace the use of metallic brackets, in the manner that direct bracket bonding replaced banding of teeth!!

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