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Challenges for Orthodontic Bonding in Modern Times; an Overview

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Abstract
The evolution of bonding have brought remarkable changes in orthodontics from welding of orthodontic metal brackets to metal bands to bonding of brackets to enamel surface. Due to increase public awareness for esthetics and good smile, the demand for orthodontic treatment among adults have increased tremendously. Thus, the interest to find ideal bonding adhesive and methods to bond orthodontic brackets to different surfaces such as amalgam, porcelain, zirconia etc. which is frequently found in adults had led to significant changes in properties of recently developed resin-based bonding materials. Although, availability of these new generation primers has made treatment for adult patients easier and more esthetic. However, there is still no full- proof method or an ideal adhesive which can deliver satisfactorily clinical bond strength on enamel and other surfaces to prevent bond failure. Thus, the purpose of this overview is to understand the prevailing ways in current times to bond orthodontic brackets in difficult clinical situations and on enamel and different surfaces.

Keywords: *Orthodontic brackets, bonding, surface treatment*

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I. Introduction

Fixed orthodontic treatment requires attachment of the brackets or any other material on the teeth to enable a force system which can bring about tooth movement. Brackets, either welded to bands or bonded to enamel, provide these attachments on the teeth. The first revolutionary step in bonding came when Buonocore[1] (1955) introduced Acid etch technique. Thus, bonding directly to enamel had eliminatedthe long and arduous task of banding all the teeth to be moved during orthodontic treatment. He embarked on his bonding research[2] in July 1954 by etching the enamel for 30 seconds with 85% phosphoric acid, and then rinsing the surface with water. Therefore, the development of directly bonding orthodontic attachments to enamel is perhaps among the most significant advances in orthodontics in the past 50 years.

Bond strength between and bracket and enamel depends on many factors such as type of enamel conditioner, acid concentration, length of etching time, composition of the adhesive, adhesive layer thickness, bracket base design, type of bracket material and type of bonding surface. There are many investigations in the literature about effect of these factors on bond strength. However, there is no consensus in literature about effective and efficient method for surface treatment of enamel and other restorative surfaces with minimal damage to bonding surface. Hence, this review is an attempt to assess the different ways to treat the enamel and other surfaces and to identify the different primer bonding system available to achieve desired bond strength without detrimental to bonding surface.

II. Surface treatment of enamel

The resin-based bonding materials have changed significantly in their properties and the mode adhering to the enamel surface in past three decades. The bonding material must be able to wet the surface, by having a low surface energy than enamel or dentin[3] .Thus, etching of the enamel changes the low, hydrophobic surface to a hydrophilic high-energy surface which reduces the contact angle by increasing the wettability. Hence, there is a quest to find bonding material which can bond to hydrophilic surface with increased wettability providing acceptable clinical bond strength.

Ortho-phosphoric and other acids

Currently, bonding systems based on a micromechanical retention is popular and this type of micromechanical interlocking is achieved with 37% ortho-phosphoric acid, which clean the enamel surface and dissolve its minerals, creating porosities. The adhesive used to bond brackets to enamel form resin tags which helps in micro-mechanical retention. The resin bonding material manages to reach these etched areas and polymerize to give retention. Many studies have [4,5,6]compared the effects different etching timeswith no appreciable differences in the appearance of the enamel. Thus, it could be considered that etching time has no significant effect on shear bond strength on normal enamel surface of permanent teeth.

High concentration of phosphoric acid is detrimental to enamel; with little effect on shearbond strength [7,8]. Various chemicals such as 10% maleic acid, 10% citric acid, 1.6% oxalic acid and 2.5% nitric acid has been used as etchant. Poly-acrylic acid with residual sulfate is reported to provide retention areas in enamel similar to those after phosphoric acid etching with less risk of enamel damage at debonding. Davari and others[9]found similar bond strength while comparing the use of 10% maleic acid with 37% phosphoric acid. Scanning electron microscopy of the enamel surface treated with 10% maleic acid and 37% phosphoric acid showed a similar pattern, but the intensity of etched surface was quite less with maleic acid.

Laser Etching

Laser etching [10]causes thermally induced changes on the enamel surface. It causes surface roughening and irregularity similar to that of acid etching to a depth of 10 to 20 m, depending on the type of laser and the energy applied to the surface. In effect, the etching is through a process of continuous vaporization and micro-explosions resulting from vaporization of water trapped in the hydroxyapatite matrix. A neodymium doped yttrium–aluminum garnet laser gives a honeycomb-like enamel microstructure similar to acid etching[11,12.].In a study by Ozer[10] et al it was reported that Irradiation with a 1.50-W laser produced sufficient etching for orthodontic bonding, but irradiation with the 0.75-W laser did not. Laser irradiation helps in roughening the enamel surface, but there is always a possibility of pulpal damage due to heat generated during irradiation.

Air-abrasion

Sandblasting or air-abrasion [10]using alumina particles increases surface roughness without demineralizing enamel and hence this method is consider relatively conservative to achieve etching of enamel. However, according to several authors [11, 13] using 50 µ aluminum oxide particles produces insufficient shear bond strength between bracket and enamel. Many investigations[13,14] have shown increase in bond strength when sandblasting and acid etching is combined to surface treat the enamel.

III. Bonding on challenging clinical surfaces

Bonding of any attachment on second molars or on partially erupted teeth & on impacted teeth is really challenging due to possibility of blood or moisture contamination. This led to the development of Hydrophilic or moisture insensitive primers can bond in wet fields. Thus suitable for recently introduced the self-etching systems[15] or acidic primers eliminates the need for rinsing by combining the etching and priming steps. The main ingredientof the self-etching primers is a methacrylated phosphoric ester. Phosphoric acid and a methacrylate group are combined into a molecule that etches and primes simultaneously. The phosphate group on the methacrylated phosphoric acid ester dissolves the calcium and removes it from the hydroxyapatite[15,16]. The primer molecules penetrate the enamel rods concurrent with etching. The etching process is hampered because the phosphoric acidforms a complex with the dissolved calcium. Furthermore, the solvent is driven from the primer during the air-burst step and the primer monomers polymerize during light curing.Etching pattern of enamel seen with self-etching primers appears to be different from conventional etching with phosphoric acid. Studies [17,18]reported showed reduced shear bond strength values of a self-etching primer compared with a conventional phosphoric acid etching system.

Bonding on fluorosis and deciduous teeth

Mottled enamel which contains higher concentration of fluoride does not require more concentrated acid solutions[19] or longer etching times because the dissolution rate of fluoridated enamel is not different from normal enamel. Enamel of deciduous teeth contains prismless enamel on the outer surface[4]. Thus, performing sandblasting the enamel with 50 µm aluminum oxide for 3 seconds to remove some outer most aprismatic enamel & then etch for 30 sec. has resulted in bond failure rate being less than 5%.

IV. Bonding on restorative surfaces

Even though, most bond failures on enamel surface results from poor moisture control and not because of the bonding adhesive or quality of the brackets being used. There is a continuous quest worldwide to find an ideal adhesive which provides sufficient bond strength against any bonding surface including enamel with minimal detrimental to any bonding surface and which needs no moisture control during bonding procedure.

The Micro-etcher uses aluminum oxide particles at pressure helps in bonding to different artificial surfaces. Bonding to porcelainsurface by etching the porcelain with hydrofluoric acid and then chemically using a silane coupling agent for bonding produces satisfactory bond strength.[20,21] However, the Hydro-fluoric acid is potentially dangerous to soft tissues which creates a porous, roughened surface in the porcelain, much like etched enamel.[21] It removes the outer layer called as glaze, which is difficult to achieve after treatment.

Bonding on amalgam restorations needs modifying the metal surface by sandblasting and using intermediate resins such as All-Bond 2, Enhance & Metal primer[21] .30μm silane-coated aluminum oxide particle Air abrasion shows promising results compared to the standard 50 μm aluminum oxide particles[20].

Adhesion promotersapplied on tooth surface claimed to raise the bond strength of composite resin to tooth or non- enamel surfaces. These adhesive resins that bond chemically to metal alloys are 4META and 10 MDP bis- GMA resins. Some adhesion promoters are Pro Seal (flouride release), Enhance primer is useful with fluorosed, hypo-calcified, deciduous teeth, metals and amalgam surfaces[20,21]. Assure is recommended on slightly contaminated surfaces, metal & amalgam. Roughened surface of old composite restorations either achieved by diamond or tungsten carbide burs or by performing air abrasion is found to be clinically successful to attain sufficient bond strength[21].

Resin Modified glass inomer cement has more strength than conventional cement. Conventional glass ionomers bonds chemically to enamel through calcium bridges, hydrogen bonds or Vander waal forces[22] and resin modified set through both an acid– base reaction and through polymerization. As a result, Resin-modified glass ionomers have shownhigher tensile bond strengths and less failure rates than conventional glass ionomers[23]. Although acid etching of the enamel surface is not necessarily required to bond glass ionomers to enamel; thereby no damage to enamel. But application of a conditioner (usually poly-acrylic acid) is recommended for the resin-modified glass ionomers. Still resin modified cements have not become popular asit does not provide adequate bond strength to prevent bracket bond failure.

V. Conclusion

The evolution of bonding have brought remarkable changes in orthodontics from brackets being welded to metal bands to bonding of brackets to adhesive resin. The journey of orthodontic bonding has seen many aspects from unrefined, slow-setting, weak powder and liquid adhesives, to single-paste, fast-setting adhesives with ample working time that adhere to both enamel and dentinal surfaces. The ability to bond fixed appliances to dentin, amalgam, porcelain, and zirconia crowns with new-generation primers has made adult treatment easier and more esthetic. Moisture contamination especially with saliva has been overcome by introduction of many hydrophilic primers to bond in a slightly wet environment. Major challenge in future will be to develop ideal adhesive which will be hydrophilic, would not require acid etching of enamel and can achieve higher shear bond strength a s the demand for esthetics has made the orthodontic materials manufacturers to introduce much smaller and less conspicuous brackets and hence resulted in more focus to strive ideal adhesive for orthodontic bonding.

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