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AN OVERVIEW OF ORTHODONTIC BONDING

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AN OVERVIEW OF ORTHODONTIC BONDING

Abstract

Bonding brackets with composite resin is considered the gold standard in the orthodontics. However, this can be challenging especially where there is a requirement to bond to surfaces other than enamel or where the enamel is defective. A choice of bonding modalities exists for these situations, and, it is important that clinicians keep up to date with current techniques and practice. An overview of the evidence and techniques available for bonding to enamel and other surfaces (composite, porcelain, gold, amalgam and acrylic) is presented. Furthermore, a summary table providing a step-by-step guide for bonding techniques to various surfaces is provided.

Clinical Relevance

We provide an overview of the evidence and techniques available to the orthodontist for bonding brackets to enamel and other surfaces including: composite, porcelain, gold, amalgam and acrylic.

Objective Statement

The reader should understand the implications of bonding to various surfaces and materials, and the steps required to carry this out successfully.

Introduction

Advancements in restorative dentistry over the last 50 years have meant that teeth previously considered of hopeless prognosis can now be restored and maintained. Despite the obvious advantages of tooth maintenance, this poses several challenges for the orthodontist, including, the various surfaces to which brackets may need to be attached. This necessitates modifications to conventional bonding techniques.

This article provides an overview of the evidence and techniques available for bonding to enamel and other surfaces (composite, porcelain, gold, amalgam and acrylic). Furthermore, a summary table providing a step-by-step guide on bonding techniques for the various surfaces discussed is provided as an *aide memoir*.

Enamel

Direct bonding to enamel utilises 3 principal agents: an enamel surface conditioner, a primer solution and an adhesive resin.

Surface Conditioner (Figure 1): This creates micro-porosity and a high-energy enamel surface. Scanning electron micrographs are presented of normal enamel (Figure 2) and enamel that has been etched with 37% phosphoric acid for 15 seconds (Figure 3).

Primer (Figure 4): This flows into the etched surface to create resin tags so that subsequently a mechanical bond is created between the adhesive resin and the tooth surface (Figure 4).

Adhesive resin (Figure 5): This is the 'cement' which permits the bonding of materials to the tooth surface.

Buonocore originally introduced the enamel acid etch technique in 1955; he proposed conditioning with 85% phosphoric acid for 30 seconds.[1] However, as research and practice evolved, it was found that 37% phosphoric acid utilised for 15 seconds was sufficient to develop a strong, durable bond to anterior teeth.[2,3] For molars it has been suggested that an etching time of at least 30 seconds be utilised when bonding to the buccal surfaces of first molars, as it produces a more consistent bond strength compared to etching for 15 seconds.[4]

Self-etching primers (SEPs) provide a one stage alternative to conventional etching followed by primer application (Figure 6). Advantages of this approach include: ease of use, decreased technique sensitivity and a reduction in chairside time.[5]

The evidence comparing the relative benefits of SEPs and the acid etch technique is equivocal. A systematic review by Fleming et al., (2012) concluded that there was weak evidence demonstrating higher odds of failure with SEPs over a 12 month period but strong evidence for a time saving of approximately 8 minutes for full arch bonding.[6] However, a more recent review concluded that there was no useable evidence to enable conclusions about failure rates for SEPs in comparison to acid etch and which is the most appropriate concentration or etching time.[7]

Although this present article focuses on the use of composite resin for bonding, it should be noted that glass ionomer cement (GIC) is an alternative adhesive. Glass ionomer cements can release fluoride and thus may prevent enamel decalcification[8] whilst adhering to both enamel and metal.[9] The bond strength is however weaker than composite resin and they have higher failure rates.[10] There is some evidence that use of a GIC for bonding brackets may reduce the occurrence and severity of white spot lesions during orthodontic treatment,[11] however further high quality research is required.

In the absence of strong evidence in favour of either system, the choice of bonding modality remains at the discretion of the operator.

Bonding to Defective Enamel

It is not uncommon to encounter enamel surfaces that have developmental defects, such as those in amelogenesis imperfecta and molar-incisor hypomineralisation. Figures 7, 8 and 9 highlight the poor enamel formation in amelogenesis imperfecta, whilst Figures 10, 11 and 12 present a mild case of molar-incisor hypomineralisation. Clinical experience has shown that bond failure rates are higher in these cases; one reason for this may include the increased protein content of affected enamel. To address this Venezie et al., (1994) described the use of sodium hypochlorite to remove excess protein and improve the quality of etch in amelogenesis imperfecta cases.[12]. The evidence for improved bracket retention with these methods however remains weak and would not routinely be recommended.[13]

Whilst conventional etching is discouraged in these cases, as phosphoric acid may result in more enamel loss, SEPs may be used as an alternative because they produce a milder etch pattern and remove less enamel.[14,15] Furthermore, the use of SEPs may help to reduce sensitivity that may be experienced by the patient during etching, rinsing and air drying. Alternatively, the banding of molars may also be preferable.[13]

Bonding to composite labial veneers may result in increased bracket retention in cases affected by severe defects of enamel as it is proposed that bonding to a larger area of composite resin increases bond strength when compared to bonding to the defective enamel alone.

Bonding to Fluorosed Enamel

For bonding to mildly fluorosed teeth, it has been reported that there is no significant difference in sheer bond strengths compared to that of normal enamel.[16] An *in vitro* study by Isci et al., (2011) however found that SEPs showed lower shear bond strength values for orthodontic brackets bonded to mildly fluorosed enamel.[17]

Composite resin

Bonding to composite resin requires superficial roughening either through sandblasting with aluminium oxide or with diamond burs.[18] Furthermore, an *in vitro* study concluded that a clinically acceptable bond strength can be achieved by surface conditioning of aged resin composite via the application of hydrofluoric acid, sandblasting with aluminium oxide, sodium bicarbonate particle abrasion, or a diamond bur.[19] Subsequent bonding of brackets can be achieved by traditional orthodontic composites.

Porcelain

Bonding orthodontic brackets to porcelain/ceramic surfaces has a greater failure rate compared to enamel bonding.[20] Therefore several techniques have been suggested, these include:

Zachrisson and Buyukyilmaz (1993)[21]:

- Deglaze porcelain - sandblasting with 50 μm aluminium oxide (2–4 seconds)
- Etch - 9.6% hydrofluoric acid gel (2 minutes), rinse and dry
- Application of silane porcelain primer and air dry (2-3 coats)
- Application of adhesive resin bonding agent

Bourke and Rock (1999)[22]:

- Etch - 37% phosphoric acid (60 seconds), rinse and dry
- Application of silane porcelain primer and air dry (3 coats)
- Application of adhesive resin bonding agent

Grewal Bach et al., (2014)[20]:

- Etch - 9.6% hydrofluoric acid (60 seconds) or mechanically roughen porcelain (sandblasting)
- Rinse (30 seconds)
- Air-dry
- Application of silane porcelain primer and lightly air dry
- Application of adhesive resin bonding agent

Hydrofluoric acid is highly corrosive, and should be used under rubber dam isolation and with high volume suction to prevent injury to the patient. Several primers are available for bonding to Zirconium crowns, for example, Assure Plus (Reliance Orthodontic Products), All Bond Universal (Bisco, Schaumburg, Ill), and Scotch-bond Universal (3M Unitek).[23]

Gold

Conventional acid etching is ineffective in the preparation of gold surfaces for mechanical retention of orthodontic attachments. Büyükylimaz et al., (1995) suggested that intraoral sandblasting is utilised,[24] this can be followed by bonding with a methacrylolyloxyethyl trimellitate anhydride, (4-META) metal-bonding adhesive resin. Subsequent bonding of brackets can be achieved by traditional orthodontic composites. Research has shown that the bond strength achieved is comparable to that of acid-etched enamel.[24]

Amalgam

Successful bonding of orthodontic attachments to an amalgam surface requires conditioning of the amalgam (for example sand blasting), and use of a 4-META resin. Subsequent bonding of brackets to sand blasted and alloy primer coated amalgam surfaces can be achieved by traditional primers and orthodontic composites.[25]
An alternative is to use a hydrophilic primer containing biphenyl dimethacrylate, such as Assure (Reliance Orthodontic Products). This allows for composite bonding to amalgam following sandblasting without the use of a separate metal primer.[23] Subsequent bonding of brackets can be achieved by traditional orthodontic composites.

Acrylic

Acrylic teeth are often incorporated into orthodontic appliances as prosthetic teeth to mask spaces. Orthodontic brackets can be bonded to acrylic teeth using mechanical and chemical methods or a combination of both. Mechanical retention includes sandblasting with aluminium oxide particles,[26] the creation of undercut holes to facilitate a micro-mechanical 'lock' or roughening the surface with diamond or tungsten carbide burs.[27] Chemical retention can be achieved using adhesive materials such as cyanoacrylate.[28]

Discussion

Advancements in dentistry over the last 50 years have meant that teeth previously considered of hopeless prognosis can now be restored and maintained. Orthodontic clinicians must therefore possess the knowledge and skills to modify conventional bonding techniques, which are summarised in Table 1. A summary table (Table 2) has been developed as an *aide memoir* for required alterations to the enamel bonding process that allow for orthodontic brackets to be bonded to composite, porcelain, zirconia, metal and acrylic.

This article has provided an overview of some of the evidence and techniques available for bonding to enamel and other surfaces (composite, porcelain, gold, amalgam and acrylic). Despite all efforts to improve bond strength in compromising situations repeated bond failures may still occur. In these situations, it may be necessary to resort to banding teeth and accepting the associated disadvantages.

Conclusion

- There is weak evidence indicating a higher odds of failure with SEPs than etch and rinse over 12 months in orthodontic patients.
- In the absence of clear evidence to favour either system, the choice of bonding modality remains at the discretion of each operator.
- We present a convenient table to act as an *aide memoir* for readers highlighting techniques for bonding to enamel and the various restorative materials

encountered in adolescent and adult orthodontic patients.

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Appendices:

Summary Tables

Table 1: Etch and rinse vs SEP technique for bonding to enamel

Etch and Rinse	SEP
1. Thorough prophylaxis - Rinse & Dry 2. Isolate the teeth for etching. With a microbrush, dab the etching agent (phosphoric acid) onto area to be bonded 3. Allow 15-30 seconds for etching 4. Rinse & Dry for 10 seconds 5. The etched area should appear frosty white. If not, re- etch for an additional 20 seconds 6. Apply 1 coat of hydrophilic primer resin and lightly dry with air 7. Proceed with the application of adhesive resin and bracket 8. Light cure 10-20 seconds	1. Thorough prophylaxis - Rinse & Dry 2. Using a microbrush, apply a small amount of mixed solution to the enamel and scrub for 5 seconds where the bracket will be applied 3. Dry the enamel surface with 2 bursts of compressed air 4. Proceed with the application of adhesive resin and bracket 5. Light cure 10-20 seconds

Table 2: Summary of bonding techniques for bonding to composite, porcelain, zirconia, metals and acrylic

Bonding to a composite surface	Bonding to a porcelain surface	Bonding to a zirconia surface	Bonding to a metal surface (Gold, Amalgam, Stainless Steel)	Bonding to an acrylic surface
1. Thorough prophylaxis - Rinse & Dry 2. Roughen the composite surface with a fine diamond bur- Rinse & Dry 3. If there is enamel present – Etch Rinse & Dry 4. Apply 1 coat of hydrophilic primer resin and lightly dry with air 5. Proceed with the application of adhesive resin and bracket 6. Light cure for double time	1. Thorough prophylaxis - Rinse & Dry 2. Sandblast porcelain surface with 50 µm aluminium oxide for 2-4 secs– Rinse and Dry OR Isolate tooth, etch with 9.6% hydrofluoric acid for 1 minute, Rinse 30 seconds & Dry 3. Apply 1 thin layer of silane coupling agent- lightly dry with air 4. Apply 1 coat of hydrophilic primer resin & air dry 5. Proceed with application of adhesive resin and bracket 6. Light cure for double time	1. Sandblast metal surface with 50 µm aluminium oxide for 2-4 secs– Rinse and Dry OR Isolate tooth, etch with 9.6% hydrofluoric acid for 1 minute, Rinse 30 seconds & Dry Apply 1 thin layer of silane coupling agent- lightly dry with air 2. Apply 1 coat of hydrophilic primer resin & air dry 3. Light cure resin for 10 seconds 4. Proceed with application of adhesive resin and bracket 5. Light cure for double time	1. Thorough prophylaxis - Rinse & Dry 2. Sandblast metal surface with 50 µm aluminium oxide for 2-4 secs– Rinse and Dry If no enamel present proceed to Step 4. 3. If there is enamel present – Etch Rinse & Dry 4. Apply 1 coat of hydrophilic primer resin & air dry 5. Proceed with application of adhesive resin and bracket 6. Light cure for double time	1. Roughen the acrylic surface with a fine diamond bur - Rinse & Dry 2. Apply one coat of hydrophilic primer resin and lightly dry with air 3. Proceed with the application of adhesive resin and bracket 4. Light cure for double time

Figure 1. Example of surface conditioner, Etchant Liquid 37% (Henry Schein®).

Figure 2. Scanning electron micrograph of normal enamel.

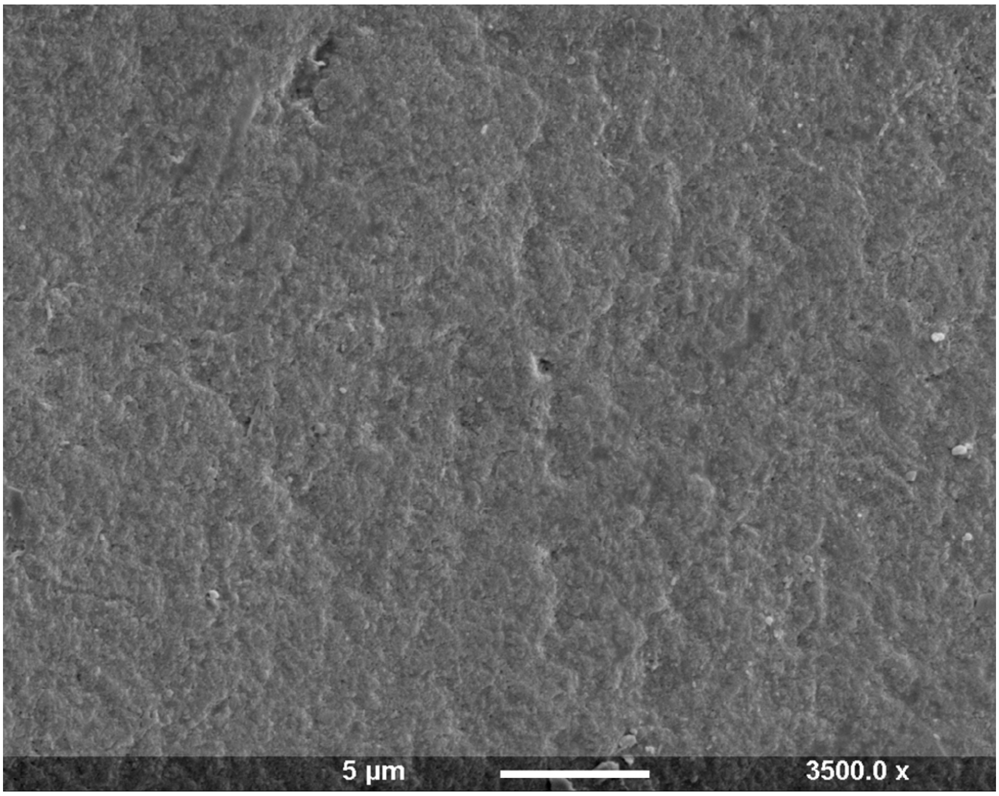

Figure 3. Scanning electron micrograph of enamel etched with 37% phosphoric acid for 15 seconds.

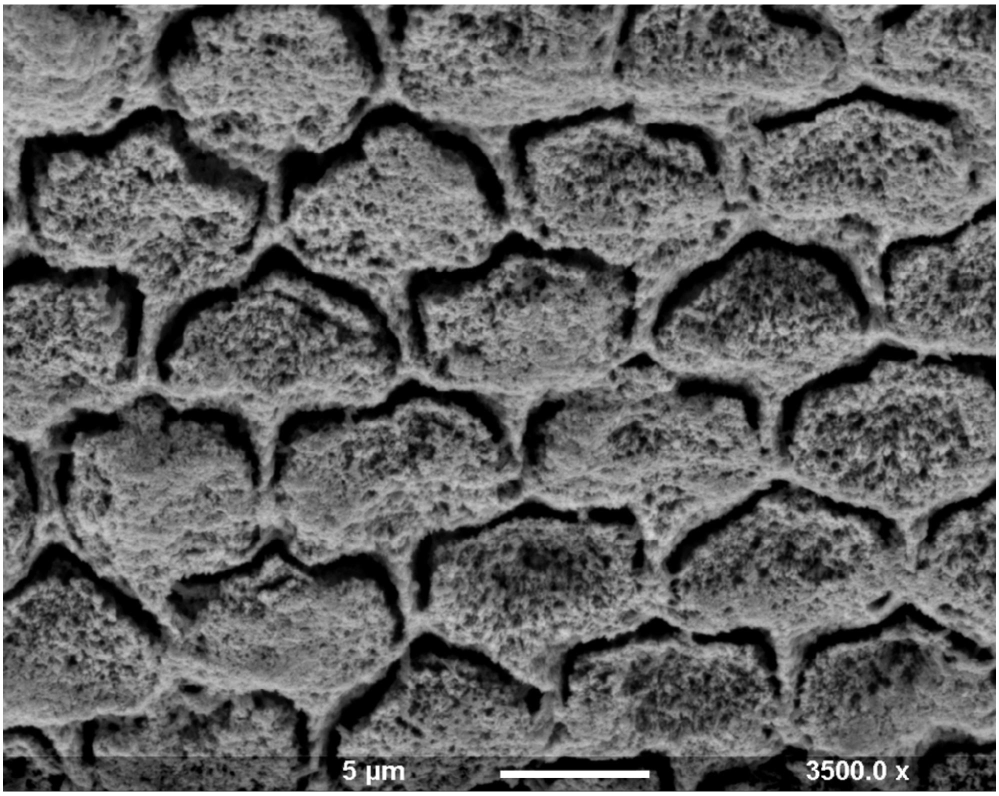

Figure 4. Example of primer, Transbond™ XT (3M Unitek).

Figure 5. Example of adhesive resin, Transbond™ XT (3M Unitek).

Figure 6. Example of self-etching primer, Transbond™ Plus Self Etching Primer (3M Unitek).

Figure 7. Amelogenesis imperfecta labial view.

Figure 8. Amelogenesis imperfecta upper occlusal view.

Figure 9. Amelogenesis imperfecta lower occlusal view.

Figure 10. Molar-incisor hypomineralisation labial view.

Figure 11. Molar-incisor hypomineralisation upper occlusal view.

Figure 12. Molar-incisor hypomineralisation lower occlusal view