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Orthodontic Bracket Adhesion to Hypoplastic Enamel

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Review Article

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Abstract: Developmental defects of enamel (DDE) are frequently observed in both pediatric and orthodontic dental practices. DDE consist mainly of hypoplasia, diffuse and demarcated opacities. Often, a combination of enamel defects may be recognized in the same child. Molar Incisor Hypomineralization (MIH) is a specific pattern of DDE in which there is hypomineralization of systemic origin usually affecting one to four permanent first molars and incisors. Patients may complain of one or more of the following: poor esthetics, thermal and mechanical sensitivity, attrition, secondary caries, tooth discoloration, malocclusion and periodontal problems. Early diagnosis of DDE is important for appropriate treatment planning and for prevention of future complications. An accurate diagnosis may improve the clinician's dental care in many aspects: caries risk assessment, aesthetics, improved adhesion, retention, durability and debonding of orthodontic bands and brackets. Moreover; financial considerations, behavioral management, and medico-legal issues can be affected by early identification of DDE. The purpose of this article is to discuss those pre-treatment and treatment considerations that may affect: a) The management of the young patient diagnosed with demarcated opacities and b) Choice of adhesive material and technique used for bonding and debonding of orthodontic brackets in a patient affected by demarcated opacities.
Keywords: enamel hypoplasia, amelogenesis imperfecta, hypomineralized teeth, bracket adhesion.

INTRODUCTION

Enamel hypoplasia is a defect in tooth enamel that results in less quantity of enamel than normal. The defect can be a small pit or dent in the tooth or can be so widespread that the entire tooth is small and/ mis-shaped. This type of defect may cause tooth sensitivity, may be unsightly or may be more susceptible to dental cavities. Some genetic disorders cause all the teeth to have enamel hypoplasia.

Enamel hypoplasia (EH) can occur on any tooth or on multiple teeth. It can appear white, yellow or brownish in colour with a rough or pitted surface. In some cases, the quality of the enamel is affected as well as the quantity.

Environmental and genetic factors that interfere with tooth formation are thought to be responsible for EH. This includes trauma to the teeth and jaws, intubation of premature infants, infections during pregnancy or infancy, poor pre-natal and post-natal nutrition, hypoxia, exposure to toxic chemicals and a variety of hereditary disorders [1].

Treatment options depend on the severity of the EH on a particular tooth and the symptoms associated with it. The most conservative treatment consists of bonding a tooth coloured material to the tooth to protect it from further wear or sensitivity. In some cases, the nature of the enamel prevents formation of an acceptable bond. Less conservative treatment options, but frequently necessary include use of stainless steel crowns, permanent cast crowns or extraction of affected teeth and replacement with a bridge or implant [1].

REVIEW OF LITERATURE

Amelogenesis imperfecta (AI) is a hereditary defect of enamel affecting both the primary and permanent dentition. It includes only those cases where enamel defects occur in the absence of other syndromes or metabolic disorders. Patients with AI often need orthodontic treatment due to dental and/or skeletal problems. The challenge of using fixed orthodontic appliances is to manage the defective enamel and determine whether the defective enamel can withstand the force that applied during the treatment and when removing the appliances [2]. To date, many methods such as using plastic brackets, glass ionomer cement base adhesives, and traditional banded appliances can be used to improve appliance retention but the evidence is weak. Morever, the lack of uniformity of enamel means that the second and third order bends which are part of a pre-adjusted appliance prescription are not fully expressed and more detailing bends at the finish stage of orthodontic treatment are needed [2]. Achieving perfect occlusion is not always the treatment goal at the end of the orthodontic treatment as the main principle is often to place the teeth in a position that facilitates the placement of restorations. Bouvier *et al*. reported an AI case that underwent orthodontic treatment successfully without any problems arising from the placing of brackets on the preformed stainless steel crown and polycarboxylate crowns [3].

Hypocalcified AI (HCAI) types are thought to result primarily from defects in nucleation and early enamel mineralization. However, later stages of enamel mineralization may also be abnormal. The inheritance pattern for HCAI is reported as being autosomal dominant or recessive. The typical clinical features of affected enamel include a yellow to brown colour and normal enamel thickness. Affected enamel may be variably located on the tooth. Cervical enamel frequently is less affected than more coronally located enamel. Ultra-structurally, HCAI enamel has been shown to be more porous and have a lower mineral content per volume than normal enamel. Differences in enamel protein content and composition have been demonstrated and could be diagnostic for the different AI types. Certain types of AI can have enamel protein content much greater than normal enamel. For example, HCAI enamel may have 3 to 4 % protein by weight compared with 0.5 % for normal enamel. There may be an association between higher protein content and more severely affected enamel.

It is believed that bonding composite resin by the acid etch technique to enamel affected by AI is more difficult than bonding to normal enamel (reviewed by Seow [4]). Sodium hypochlorite (NaOCl) is known to be an excellent protein denaturant that should be capable of removing excess enamel protein. Thus, we predicted that pretreating AI enamel with sodium hypochlorite would make the enamel crystals more accessible to the etching solution, resulting in a clinically more favourable etched surface. A novel method for enhancing the bonding of an orthodontic bracket to a tooth affected with HCAI is by pretreating the tooth for 1 min with 5% NaOCl.

NaOCl is an effective protein denaturant that does not appear to alter the structure or mineral content of normal or HCAI enamel crystallites [5]. It enhances bonding by removing excess protein, which interferes with establishing a clinically successful acid etch pattern. HCAI enamel can have markedly elevated protein content due to protein retention during development. This interferes with the development of a typical etch pattern using 37% phosphoric acid. NaOCl likely produces a more favourable acid etch by exposing the enamel mineral previously encased in acid-insoluble proteins. The technique would be ineffective or possibly detrimental in certain situations e.g. some AI enamel has normal protein content, and NaOCl pretreatment would probably have no effect on its surface topography. On the other hand, hypomaturation AI (HMAI) enamel exhibits very high protein content with small, disorganized enamel crystals [6]. It is possible that NaOCl pretreatment of HMAI enamel could result in excessive destruction of enamel due to removal of large quantities of protein. Morever, the enamel mineral content may be as low in these teeth as to make bonding unsuitable. In other words, enamel that is severly deficient in mineral content (e.g. less than 70% mineral per volume) would probably be a poor risk for any composite bonding technique due to the inherent weakness of the enamel. The enamel that can be penetrated easily with an explorer would not be a good candidate for NaOCl pretreatment and bonding.

The risk of enamel fracture during orthodontic appliance removal is dramatically increased for patients affected with AI, and the patient should be informed beforehand.

Appliance adhesion and debonding technique and materials used in hypomineralized teeth

The aspects that should be discussed include [7]:

- Type of adhesive etching, priming and bonding.
- Enamel prophylaxis and fluoride exposure (prior to bonding).
- Anti-cariogenic effect of adhesives and fluoride release.
- Debonding and residual adhesive removal.
- Debonding of brackets with pliers followed with residual adhesive removal by slow-speed tungsten carbide bur.

Type of adhesive etching, priming and bonding

Enamel may be conditioned in different ways: 10% Polyacrylic acid, a non-rinse conditioner, and conventional two-stage etching and priming process with 35-37% phosphoric acid. Non-rinse conditioners and self-etching primers are used for etching purposes. The ph of these acidified or self-etching primers has been reduced to the extent that they can effectively etch enamel to the same degree as phosphoric acid. The adhesive materials used are: GIC, RMGIC, polyacid modified Glass ionomer (compomer) and Resin composite.

Self-etching primer adhesive system (SEPAS), and RMGIC based adhesives may be more advantageous when orthodontic adhesion to hypomineralized enamel is required. The use of conventional etching and priming is discouraged since phosphoric acid may cause more enamel loss than self-etching primers.

New self-etching adhesives may offer an alternative that meets the challenge of adhesion to hypomineralized enamel better:

- They cause less enamel loss.
- They are simpler to use.
- Rinsing is omitted. Therefore wet conditions that inhibit resin infiltration are prevented.
- Some SEPBS bond both micromechanically and chemically to hydroxyapatite due to incorporation of the 10-Methacryloxydecyl Dihydrogen Phosphate (MDP) molecule whereas conventional bonding relies primarily on micromechanical retention.
- Some SEPBS have fluoride-releasing qualities and some also have an antibacterial component.
- The improved adhesion and diminished microleakage of some self-etching primers in adhesion to normal enamel might also be seen in adhesion to hypomineralized enamel, since the demineralization and resin penetration occur concurrently, therefore the etching depth and the resin penetration depth might be similar.
- SEPBS cause less postoperative sensitivity, which may be important in severely hypomineralized teeth.
- Self-etching primer systems have also been reported to produce good ARI (Adhesive Remnant Index) scores as compared to traditional acid-etch technique [8].

The use of self-etching bonding systems is associated with few drawbacks as under

- They may not possess the same capacity as phosphoric acid to effectively etch uncut or unprepared enamel as is the case with orthodontic brackets adhesion to enamel [9].
- Auto-cure orthodontic resins do not work well with the self-etch systems because the primer's acidity has been shown to interfere with the resins' polymerization.
- Some of those Self etching primers may not work well with common LED curing light that do not cover the range of 400-515 nm.

Another alternative for orthodontic bracket adhesion is RMGIC, which possess the inert advantages of fluoride release, ease of removal, lower Adhesive Remnant Index (ARI) scores and a lower risk of damaging enamel surface following orthodontic bracket removal [10]. The combination of self-etching primer system with RMGIC was found (in-vitro) to enhance Shear Bond Strength of orthodontic brackets to normal bovine enamel [11].

Enamel prophylaxis and fluoride exposure (prior to bonding)

Most adhesive manufacturers recommend cleaning teeth of organic enamel pellicle and plaque by using prophylaxis paste or pumice prior to adhesion of orthodontic brackets. A rubber cup is preferred over a bristle brush since it causes less enamel loss [12]. The abrasive paste used is less detrimental than the type of brush. Pumice prophylaxis prior to bonding reduces bond failure rates [13].

Prophylaxis pastes containing upto 13,500 ppm F were not found to adversely affect the adhesion of orthodontic brackets to normal enamel [14]. The application of NaF fluoride varnish has not adversely affected the adhesion of orthodontic brackets to normal enamel, but application of APF fluoride gel prior to orthodontic brackets adhesion resulted in lower adhesion [15, 16].

Anti-cariogenic effect of adhesives and fluoride release

The fluoride released from adhesives based on RMGIC is significantly greater than from resin based adhesives such as Transbond XT. Resin composite based adhesives with internal release capability of fluoride were found to slow down demineralization when compared to regular resin composite adhesive even though less effectively than the RMGIC based adhesives[17].

Debonding and residual adhesive removal

The debonding of brackets and bands might cause further break-down of enamel. The amount of enamel loss depends on the bracket material, bonding and adhesive methods used and on the method of debonding. Ceramic brackets reportedly cause more enamel loss and fracture at debonding than metal brackets [18]. Metal bracket removal after adhesion with a resin composite resulted in 7.4 micron on average loss of enamel surface [19].

The adhesives based on RMGIC have excellent results in ease of removal, lower Adhesive Remnant Index (ARI) scores, and a lower risk of damaging enamel surface [10]. Self etching primer systems have also been reported to produce good ARI scores as compared to traditional acid-etch technique [8, 20].

The removal of the residual adhesive can be accomplished via debonding pliers, ultrasonic scaler, high-speed tungsten carbide bur or by low-speed tungsten carbide bur. Debonding pliers cause the least enamel loss, however more residual adhesive remained [20]. The least enamel loss was reported to occur with self-etching primer and after enamel clean-up with a slow-speed tungsten carbide bur with water [20].

Orthodontic management of enamel hypomineralization

Clinical recommendations for orthodontic management of enamel hypomineralization are as under [7]:

Preliminary dental treatment prior to fixed orthodontic appliance adhesion

- Early diagnosis and risk assessment.
- Informed consent from the guardians/patient.
- Prevention of dental caries and post-eruption breakdown, enhance remineralization and desensitization and maintenance with frequent recall appointments.

Active follow up and observation involving: oral hygiene instructions, dietary consultation, application of Casein phosphopeptide-amorphous calcium phosphate (CPP-ACP), and topical or systemic home and/or office fluoride regimen as indicated.

Considering long term prognosis of affected teeth and, if found necessary decide upon extractions or restoration.

Modifications necessary for adhesion to hypomineralized enamel

- Prophylaxis with rubber cup and a paste containing up to 13,500 PPM Fluoride.
- Metal brackets or ceramic brackets with metal channel that debond like metal brackets are recommended.
- The adhesive system preferred for adhesion of orthodontic brackets to hypomineralized teeth is dependent upon the lesion hardness and colour:

Large yellow-brown opacities

Option A) removal of all defective enamel, prior to a composite resin restoration.

Option B) pre-treatment with 5% sodium hypochloride followed by a self-etching primer-bonding system (SEPBS) [7].

White-creamy or creamy-yellow opacities

Option A) self-etching system and adhesion of the orthodontic bracket with a conventional composite resin based adhesive.

Option B) enamel pretreatment with self-etching primer may be considered in combination with a Resin-modified Glass ionomer cement (RMGIC) [7].

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