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ORIGINAL ARTICLE

Effect of deproteinization on composite bond strength in hypocalcified amelogenesis imperfecta

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OBJECTIVE: The aim of this study was to evaluate the effect of the treatment of sodium hypochlorite (NaOCl) after acid conditioning of the enamel and dentin of the primary teeth affected with hypocalcified amelogenesis imperfecta (HCAI) on the shear bond strength of the composite material.
MATERIALS AND METHODS: Primary teeth from a 12-year-old girl affected with HCAI and primary teeth collected from apparently healthy children were used. A total of four groups, experimental and control with and without NaOCl treatment were specified. In the control group conventional composite procedure was performed and in the treatment group 5% NaOCl was applied after acid conditioning and then the procedure continued as in the control group.
RESULTS: In teeth affected with HCAI, enamel shear bond strengths were significantly enhanced in the treatment group compared with the conventional procedure.
CONCLUSION: Deproteinization could be attributed as effective in enhancing the enamel bonding in HCAI teeth and could be used to overcome the high failure rates of adhesive restorations in HCAI cases.
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Keywords: amelogenesis imperfecta; sodium hypochlorite; adhesives; shear-bond strength

Introduction

The diagnosis of AI in a young patient can present many complex restorative and orthodontic challenges for the pediatric dentist (Rosenblum, 1999). The long-term aim of the treatment is to maintain the maximum amount of hard dental tissue possible until the patient reaches an age at which advanced restorative techniques can be employed to rehabilitate the dentition (Hunter and Stone, 1997). However in the short term, because a significant complication of AI is poor esthetics an important aspect of clinical management is the improvement of the appearance using bonded restorations (Rada and Hasiakos, 1990; Harley and Ibbetson, 1993; Seow, 1993, 1995).

In many patients with AI, adhesive restorations may show high failure rates that are associated with inadequate bonding between the restoration and enamel (Seow and Amaratunge, 1998). Ultrastructurally, hypocalcified amelogenesis imperfecta (HCAI) enamel has been shown to be more porous and has a lower mineral content per volume than normal enamel (Wright *et al*, 1993). The fact that acid etching produced all three classical etch patterns suggested that the prism structure in this variant may be generally normal (Seow and Amaratunge, 1998) but HCAI enamel may have 3–4% protein by weight compared with 0.5% for normal enamel. As the bond between enamel and restoration is highly dependent on the enamel surface alterations, removal of excess proteins may provide an advantage on the bonding of the restoration (Wright *et al*, 1993; Venezie *et al*, 1994).

Sodium hypochlorite (NaOCl) is known to be an excellent protein denaturant (Inaba *et al*, 1995; Perdiago *et al*, 2000). In this regard pretreatment of HCAI-affected enamel with 5% NaOCl may be effective in deproteinization of the excess protein and enhancement of the bond strengths (Venezie *et al*, 1994).

The purpose of this study was to evaluate the effect of 1 min exposure to 5% NaOCl after acid conditioning of the enamel and dentin of the primary teeth affected with HCAI on the shear bond strength of adhesive system.

Materials and methods

A 12-year-old girl, who suffered from considerable sensitivity and was very self-conscious about the appearance of her teeth, was referred to the department of pediatric dentistry for treatment. Intraorally,

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advanced destruction of all the teeth was noted (Figure 1). The dentition showed a generalized yellow-brown discoloration of the enamel. In the facial surfaces it was seen that the enamel had chipped away, exposing large areas of dentin. However, the clinical appearance of the cervical enamel seemed to be normal. Radiographically, there was minimal contrast between enamel and dentin (Figure 2). The diagnosis of the case was made, according to the criteria described by Witkop (1989), as HCAI. Examination of the family revealed no other effected person. Upon questioning, her father answered that only one of his grandfathers had suffered from a similar condition but to a lesser degree.

Seven primary teeth were collected from the girl affected with HCAI. Comparable seven teeth collected from apparently healthy children were used as control. All the teeth were cleaned, soaked in deionized water until used and then were divided into two mesiodistally. A flat surface of 3 mm in diameter was prepared on the buccal and lingual enamel surfaces of all teeth by moist grinding on 200–400 and 600-grit silicon carbide paper. After enamel bonding tests the procedure was repeated on the dentin surface following removal of the enamel layer on all teeth. The buccal and lingual enamel surfaces were ground flat to expose peripheral dentin and polished wet 200–400 and 600-grit silicon paper for a total of 28 prepared dentin specimens. The specimens were observed with a dissecting microscope to ensure that no enamel remained.

The specimens were randomly assigned to treatment sequences ($n = 7$) as follows:

Group 1 (control group): Enamel and dentin surfaces of HCAI and sound primary teeth were etched for 20 s with 20% phosphoric acid (Heraus Kulzer, Germany), then rinsed with water for 5 s and gently air dried for 1–2 s.

Figure 1 Initial intra-oral photograph of the patient

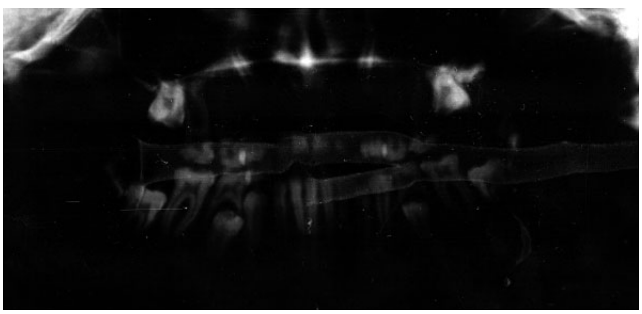

Figure 2 Panoramic radiograph of patient's dentition

Group 2 (treatment group): A solution of 5% NaOCl was applied for 1 min after acid conditioning of the enamel and dentin surfaces and then rinsed with water spray before application of the bonding.

After conditioning procedures two layers of Gluma One Bond (Heraus Kulzer, Germany) were applied to enamel and dentin using an application tip and light cure for 20 s (Polofil Lux Unit, Voco, Germany). A cylindrical split teflon mold (3 mm diameter, 1 mm height) was filled with Charisma microfilled composite (Heraus Kulzer, Germany) in one increment, covered with a transparent matrix and light cured for 60 s. Enamel and dentin specimens were immersed in deionized water at 37°C for 24 h.

The samples were then thermocycled for 500 cycles between 5 and 55°C with a dwell time of 30 s in each bath. Shear bond strength was measured in a Lloyd Universal Testing Machine (Lloyd LRX; Lloyd, Foreham, Herts, UK) 24 h after thermocycling. A parallel knife-edge shearing device was aligned 0.05 mm from the bonded interface and force was applied to failure using a crosshead speed of 1 mm min^{-1}. The data were analyzed using one-way ANOVA and Duncan's multiple range test, to evaluate differences among groups.

Results

The mean shear bond strengths for all groups are shown in Tables 1 and 2.

A statistically significant difference at $P < 0.05$ level was detected when comparing the enamel bond strength between HCAI (13.92 MPa) and the sound primary teeth (27.77 MPa).

The effect of deproteinization was tested and found to have no statistically significant influence on the enamel and dentin shear bond strengths of normal primary teeth ($P > 0.05$).

However, when the enamel shear bond strengths of the control and treatment groups were compared in HCAI teeth, significantly lower bond strengths were found in the control group ($P < 0.05$).

Bond strength to HCAI dentin (10.08 MPa) was significantly lower than the normal teeth dentin (18.52 MPa). Deproteinization did not affect shear bond strength of dentin in either the HCAI or the normal primary teeth. ($P > 0.05$).

Discussion

Amelogenesis imperfecta carries a high morbidity; its sufferers frequently present with sensitive and discolored teeth. Poor dental esthetics in AI is usually the result of surface roughness staining and abnormal crown shapes from enamel loss. Several strategies may be used to overcome the compromised esthetics, such as composite bonding, over-dentures, dentine-bonded ceramic crowns, porcelain veneers (Seow, 1993; Rosenblum, 1999).

Table 1 Mean shear bond strengths of control and deproteinized enamel surfaces (MPa)

Treatment group	*HCAI*	*Sound primary teeth*
Control	13.92 ± 4.56[a]	27.77 ± 11.6[b]
Deproteinized	27.36 ± 7.28[b]	23.74 ± 8.74[b]

Groups identified by different superscript letters were significantly different at $P < 0.05$. $n = 7$ in all groups.
HCAI, hypocalcified amelogenesis imperfecta.

Table 2 Mean shear bond strengths of control and deproteinized dentin surfaces (MPa)

Treatment group	*HCAI*	*Sound primary teeth*
Control	10.08[a]	18.52[b]
Deproteinized	9.13[a]	19.91[b]

Groups identified by different superscript letters were significantly different at $P < 0.05$. $n = 7$ in all groups.
HCAI, hypocalcified amelogenesis imperfecta.

Anterior composite restorations are appropriate in a growing child as definite restorations are contraindicated until eruption of the clinical crown is complete. This may solve the problem of sensitivity and esthetics (Brennan *et al*, 1999). However, while bonding to normal teeth has been studied extensively, only a few studies have addressed resin bonding to AI teeth and most of these studies reported high failure rates in resin bonding to AI teeth (Rada and Hasiakos, 1990; Venezie *et al*, 1994; Almushayt *et al*, 1999). Chemical, morphological and micromorphological differences between sound and AI teeth are thought to be responsible for this failure (Seow, 1993; Seow and Amaratunge, 1998).

There is only one study comparing the shear bond strengths of AI teeth and sound teeth. Almushayt *et al* (1999) found that the shear bond strength of primary hypomaturation type AI enamel (10.03 MPa) was significantly lower than normal primary teeth enamel (13.02 MPa). In the present study it was also found that both the enamel and dentin shear bond strengths of primary HCAI-affected teeth (13.92 and 10.08 MPa, respectively) are significantly lower than the normal unaffected primary teeth (27.77 and 18.52 MPa, respectively). This may be a result of the presence of mineralization abnormalities and morphological changes detected at the crystallite level in the HCAI teeth. Imbibition studies show that HCAI enamel can be more porous and ultrastructural analyses show it has rougher crystallites than normal enamel. Furthermore, HCAI enamel can have a markedly elevated protein content because of protein retention during development (Wright *et al*, 1993).

In a previous clinical and SEM study, Venezie *et al* (1994) found that the 5% NaOCl pretreatment technique produced success in bonding an orthodontic bracket to a tooth affected by HCAI. They suggested that 5% NaOCl enhanced enamel bonding in HCAI by removing excess protein that interfered with establishing a clinically successful acid etch pattern. However, except this case report based on a single tooth, there has been no previous study comparing the effect of treatment with 5% NaOCl in HCAI enamel and dentin. Based on the findings of the present study, treatment of acid-etched enamel surfaces with 5% NaOCl in HCAI teeth enhanced the shear bond strengths. Thus we predicted that treating acid-etched enamel surface with NaOCl could make the enamel crystals more accessible to the bonding agent resulting in a clinically more favorable bond strength.

There are conflicting results about the effect of NaOCl treatment on the dentin bond strengths. In some of the studies it has been shown that NaOCl treatment has enhanced the shear bond strengths by removing the collagen smear layer (Prati *et al*, 1999; Phrukkanon *et al*, 2000). However, Perdiago *et al* (2000) have shown that treatment of the dentine with NaOCl resulted in a decrease in bond strengths in spite of a deeper penetration of the adhesive. The results of the present study showed that deproteinization did not influence dentin bonding in both normal and HCAI teeth. In a study of Sanchez-Quevedo *et al* (2004), it was shown that in HCAI teeth, dentin was also affected from the anomaly. SEM images revealed a morphological pattern of dentin characterized by thickening of the peritubular dentin and partial obliteration of the dentin tubules. This morphological pattern corresponds to the so-called sclerotic dentin. It has been indicated that resin bond strengths to sclerotic dentin are lower than bonds made to normal dentin. This is thought to be as a result of tubule occlusion by mineral salts, preventing resin tag formation (Tay and Pashley, 2004). So this could be the explanation of the lower bond strengths in HCAI dentin compared to normal dentin.

In the present study primary teeth were used because extracted permanent teeth affected with HCAI could not be found. There are conflicting results in comparing the bond strengths of the primary and permanent teeth. In some studies it has been shown that the bond strengths of the primary teeth were lower than those of the permanent teeth (Salama and Tao, 1991; Bordin-Aykroyd *et al*, 1992; el Kalla and Garcia-Godoy, 1998; Burrow *et al*, 2002). On the other hand there are studies showing no differences between primary and permanent teeth bond strengths (Baghdadi, 2000, 2001, 2003; Shimada *et al*, 2002). For this reason we think that the results of this study with primary teeth could be similar to the permanent teeth bonding.

It is generally accepted that shear bond strengths of 17–24 MPa are required to effectively resist the polymerization contraction forces of composite resin (Barkmeier *et al*, 1986; Gilpatrick *et al*, 1991; Gwinnett and Kanca, 1992; Swift *et al*, 1995). Such bond strengths provide routinely successful retention of resins for a variety of clinical applications including direct anterior and posterior composite restorations. In our study it is shown that NaOCl treatment of HCAI teeth increased enamel shear bond strengths from 13.92 to 27.36 MPa, which is above the required levels. So this method could be attributed as effective in enhancing the enamel bonding in HCAI teeth.

Wright *et al* (1995) claimed that decreased mineral content and increased protein was found not only in HCAI, but also in the hypomaturation and hypoplastic variants. This suggests that pretreatment with NaOCl is likely to be of value in enhancing the effect of acid etching in cases of AI in general. The improvement in bonding and resin materials is one potential factor influencing the bond strength. So further researches are required in this field.

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