ORIGINAL ARTICLE

4

투고일 : 2015. 9. 4　　심사일 : 2015. 9. 25　　게재확정일 : 2015. 10. 15

Removal of superficial dentin surface to restore decreased bond strength caused by sodium hypochlorite

Department of Conservative Dentistry, School of Dentistry, Chosun University, Gwang-Ju, Korea.

Mi-Yeon Song, Ho-Keel Hwang, Hyoung-Hoon Jo *

ABSTRACT

Removal of superficial dentin surface to restore decreased bond strength caused by sodium hypochlorite

Department of Conservative Dentistry, School of Dentistry, Chosun University, Gwang-Ju, Korea.
Mi-Yeon Song, Ho-Keel Hwang, Hyoung-Hoon Jo *

Objective: Sodium hypochlorite (NaOCl) decreases the bond strength of resin composite. The purpose of this study was to compare the effect of antioxidant and superficial dentin surface removal on the microtensile bond strength of NaOCl-treated dentin.

Materials and Methods: Twenty non-carious human third molars were used in this study. The dentin surfaces were treated with 5.25% NaOCl for 10 min, followed either by treatment with 10% ascorbic acid or superficial dentin surface removal. Two-step self-etch adhesive and resin composite were used for restoration. The bonded specimens were subjected to the microtensile bond strength test. Statistical analysis was performed using one-way analysis of variance (ANOVA) and Tukey's test ($p < 0.05$).

Results: The bond strength after removal of the superficial dentin surface following NaOCl irrigation was similar to that in the control group. The group treated with 10% ascorbic acid demonstrated significantly higher bond strength than the other groups.

Conclusion: NaOCl irrigation-induced reduction in dentin bond strength could be recovered by either treatment with 10% ascorbic acid or simple removal of the superficial dentin surface.

Key words : Sodium hypochlorite, Dentin surface, Antioxidant, Self-etch adhesive, Micro-tensile bond strength

Corresponding Author
Hyoung-Hoon Jo
Department of Conservative Dentistry, School of Dentistry, Chosun University, 309 Pilmun-Daero, Dong-Gu, Gwang-Ju, 501-759, Korea.
Tel : +82-62-220-3840, Fax : +82-62-223-9064, E-mail : joyendo@hanmail.net

Ⅰ. Introduction

Effective cleaning and shaping of the root canal, as well as creation of an apical seal are essential for successful endodontic treatment. Recently, more attention has been focused on procedures performed to achieve effective coronal sealing immediately after the completion of root canal therapy. Immediate sealing of endodontically treated teeth using restorative materials is a powerful tool for prevention of early coronal leakage[1~3]. The importance of coronal restoration in successful endodontic outcomes is widely accepted and has been supported by Ray and Trope[4]. Among definite restorative materials, dentin adhesives have been advocated for use within the pulp chamber in an attempt to work as a durable barrier against apical and coronal microleakage.

Sodium hypochlorite(NaOCl) is the most widely recommended irrigant in endodontics because of its ability to dissolve necrotic tissue remnants[5]. According to many articles, NaOCl reduces the bond strength between resin composites and dentin[6~8]. This is thought to be due to remnants and by-products of NaOCl exhibiting negative effects on the polymerization of dental adhesive systems.

To restore the bond strength to the normal range, 10% sodium ascorbate or 10% ascorbic acid were introduced for application on the NaOCl-treated dentin[9]. Some authors recommended treatment with ascorbic acid or sodium ascorbate for 10 min[10]. However, this is not practical in a clinical situation.

Some clinicians remove a minimum amount of pulpal wall to obtain a clean dentinal surface after the canal obturation procedure. However, no study demonstrated the effect of dentin surface removal after NaOCl-treatment on the microtensile bond strength.

The purpose of this study was to compare the effect of superficial dentin surface removal with that of an antioxidant(ascorbic acid) on microtensile bond strength of NaOCl-treated dentin to resin composites.

Ⅱ. Materials and Methods

1. Specimen preparation

Twenty non-carious human third molars were used in this study. The teeth were cleaned to remove periodontal tissue residue using a periodontal scaler and were stored in distilled water at room temperature. The storage water was replaced daily. The occlusal enamel was removed by sectioning the crown perpendicular to the long axis of the tooth using a model trimmer(Se-ki, Seoul, Korea) under copious water lavage to achieve a flat superficial dentin surface. The dentin surface was wet-polished with a 600-grit SiC abrasive paper under running tap water for 1 min to obtain smooth dentin surface, followed by rinsing for 1 min.

The teeth were randomly divided into four groups and each group had 5 specimens. The materials used in the study are listed in Table 1.

The treatment of the dentin surface in the

Table 1. Materials used in the study

Brand	Material	Composition	Manufacturer
Clearfil™ SE Bond	Two-step self-etch adhesive	Primer; MDP, HEMA, hydrophilic dimethacrylate Bond: MDP, Bis-GMA, HEMA, hydrophilic dimethacrylate, DL-camphorquinone, N,N-diethanol-p-toluidine and silanated colloidal silica	Kuraray, Osaka, Japan
Filtek™ Z250	Composite resin	Bis-GMA, BisEMA, UDMA, TEGDMA, Silane-treated ceramic	3M ESPE, St. Paul, MN, USA

different groups was as follows:

Control: The dentin surface was irrigated with 0.9% NaCl for 10 min and rinsed with 10 mL distilled water.

Group 1: The dentin surface was irrigated with 5.25% NaOCl(Yuhanclorox, Seoul, Korea) for 10 min per tooth and then rinsed with 10 mL distilled water.

Group 2: After treatment as in group 1, 0.1 mm of the dentin surface was removed with a coarse diamond bur(TR 14, MANI, Utsunomiya Tochigi, Japan) and then rinsed with 10 mL distilled water.

Group 3: After treatment as in group 1, freshly prepared 10% ascorbic acid(Junsei, Tokyo, Japan) was applied to the dentin surface for 10 min, followed by rinsing with 10 mL distilled water.

After pre-treatment, the specimens were dried with an air syringe, and Clearfil SE Bond (Kuraray, Osaka, Japan) was applied to the dentin surfaces, according to the manufacturer's instructions. Spectrum 800(Dentsply Caulk, Milford, DE, USA) with output intensity of 400 mW/㎠ was used for light curing. Resin com posites(Filtek Z250; 3M ESPE, St. Paul, MN, USA) build-ups were constructed in three 1.5-mm increments. Each increment was light-cured for 40 s, and the specimens were stored in distilled water at 25℃ for 24 h.

2. Microtensile bond strength test

After being stored in distilled water at 25℃ for 24 h, the specimens were embedded in acrylic blocks using sticky wax(Kerr corporation, Orange, CA, USA). They were then placed on a low-speed diamond saw(Isomet; Buehler, Lake Bluff, IL, USA) to produce 1 × 1 mm adhesive surface area beams under water cooling. Each beam consisted of composite resin and dentin. The dimension of each beam was measured using a digital caliper, and the bonded area was calculated for subsequent conversion of microtensile bond strength values into units of stress(MPa).

The beams were attached with a cyanoacrylate adhesive(Zapit; DVA, Corona, CA, USA) to a testing apparatus, and tensile load was applied with a microtensile tester(Micro Tensile Tester; Bisco, Schaumburg, IL, USA) at a cross-head speed of 0.5 mm/min(Figure 1).

The specimen preparation procedure is schematically illustrated in Figure 2.

3. Statistical analysis

The microtensile bond strength data were analyzed for statistically significant differences by one-way analysis of variance(ANOVA) and Tukey's test using SPSS Ver 12.0(SPSS Inc, Chicago, IL, USA). Statistical significance was defined as $p < 0.05$.

Ⅲ. Results

1. Microtensile bond strength

The mean microtensile bond strength value and standard deviation of each group are shown in Table 2 and Figure 3. One-way ANOVA revealed that there were significant differences between surface treatment methods($p < 0.05$). The NaOCl-treated dentin(group 1) demonstrated significantly lower bond strength compared to the control group($p < 0.05$). There were no significant differences in the bond strength

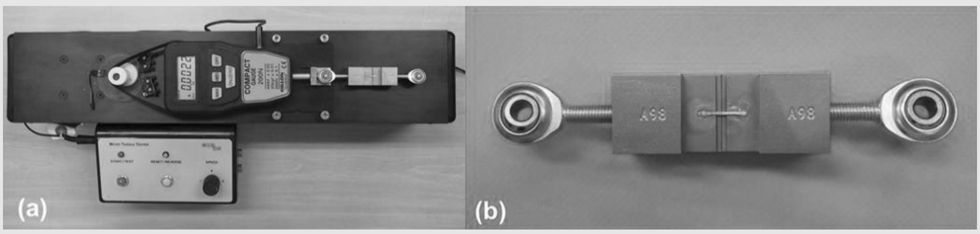

Fig. 1. (a) Microtensile tester (b) Beam attached to the microtensile device

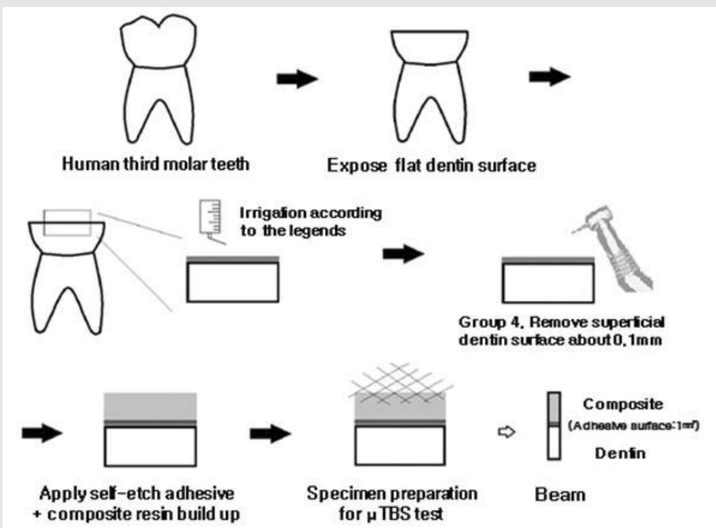

Fig. 2. Schematic representation of specimen preparation for microtensile bond strength test

between the superficial dentin surface removal group(group 2) and the control group($p > 0.05$). The 10% ascorbic acid-treated group(group 3) demonstrated significantly higher bond strength than the other groups($p < 0.05$).

Ⅳ. Discussion

The aim of this study was to investigate the effect of superficial dentin surface removal on NaOCl-induced decrease in microtensile bond strength of dentin to resin composites. NaOCl is widely used in root canal treatments to provide gross debridement, disinfection, lubrication, and dissolution of tissues[11]. NaOCl causes alterations in cellular metabolism and phospholipid destruction. It has oxidative effects that cause deactivation of bacterial enzymes and lipid and fatty acid degradation[12].

Several studies have reported that dentin that has been exposed to NaOCl exhibits significantly

Table 2. Mean microtensile bond strength (MPa) of dentin after different surface treatments

Group	Number	Mean	S.D.
Control (NaCl)[a]	30	27.26	5.74
1 (NaOCl)[b]	30	19.44	4.49
2 (Dentin removal)[a]	30	26.09	5.25
3 (Ascorbic acid)[c]	30	31.96	8.48

Groups identified by different superscript letters are significantly different ($p < 0.05$).

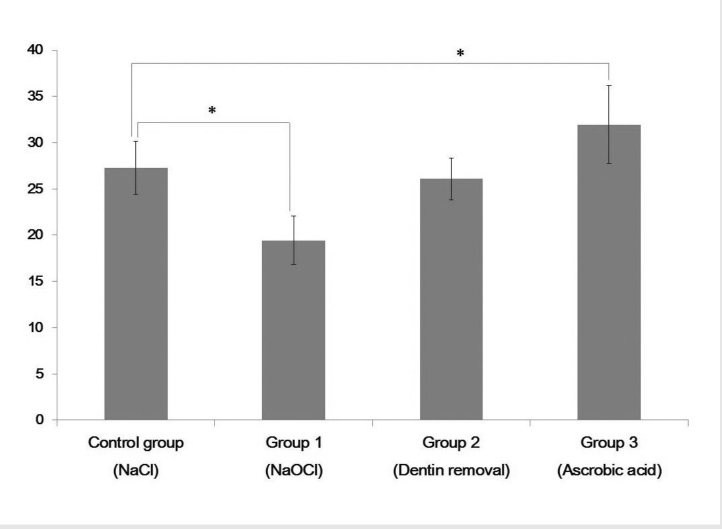

Fig. 3. Mean microtensile bond strength (MPa) to dentin after different surface treatments. The groups connected by lines showed significant differences (*$p < 0.05$)

lower bond strengths than untreated dentin[6~9, 13]. One study reported bond strengths as low as 8.5 MPa[7], and increased microleakage was also reported[14]. The results of this study showed that NaOCl irrigation generally decreases the bond strength of self-etch adhesive to dentin. This result was consistent with those of previous studies[7, 15, 16].

Dentin bonding is based on the formation of a resin-infiltrated layer in the conditioned intertubular and peritubular dentin. After polymerization, resin monomers may form a micro-mechanical bond with the primed dentin, so-called hybrid layer[17]. Thus, to achieve satisfactory dentin adhesion, open tubules and exposed collagen-rich meshwork should be completely and homogenously infiltrated by resin monomers. However, NaOCl damage the organic matrix, mainly collagen. Therefore, a weak hybrid layer is formed, and the microtensile bond strength is significantly decreased.

NaOCl removes any exposed organic matrix, mainly the collagen or soft tissue, from the dentin and leaves a mineralized surface less receptive to bonding with resin composites[10]. It is likely that NaOCl acts to oxidize a component in the dentinal matrix that interferes with free radical propagation at the resin-dentin interface, leading to lower bond strength. In addition, when NaOCl breaks down, oxygen is generated and causes strong inhibition of interfacial polymerization of adhesive materials[18]. According to Lai et al., NaOCl-treated dentin may contain some reactive residual free-radicals, which might compete with the propagating vinyl free radicals generated during light activation of the adhesive system, resulting in premature chain termination and incomplete polymerization[9]. Furthermore, decrease in the calcium and phosphorus levels[19] and in the mechanical properties of dentin, such as elastic modulus, flexural strength, and microhardness, were reported after irrigation of root canals with 5% NaOCl, which can also contribute to a decrease in the micromechanical interaction between adhesive resins and NaOCl-treated dentin[20].

Morris et al. showed that application of 10% ascorbic acid or 10% sodium ascorbate, both of which are antioxidant/reducing agents, reversed the effects of NaOCl and restored the bond strengths to normal levels[6], and these results were comparable with those of other studies[9, 14]. 10% ascorbic acid(pH = 4) was as effective as 10% sodium ascorbate(pH = 7) in restoring the decreased bond strength of NaOCl-treated dentin[6]. In this study, treatment of NaOCl-treated dentin with 10% ascorbic acid for 10 min(group 3) led to significantly higher bond strength than the other groups. By treating dentin with 10% ascorbic acid, the micro-environment of the dentin is converted to a reduced substrate from an oxidized substrate. It appears that this redox potential recovery can restore the bond strength to the normal range.

Many studies have described the effect of antioxidants on the reversal of bond strength of the NaOCl-treated dentin[6, 10, 21]. However, in clinical situations, application of 10% ascorbic acid to a pulp chamber for 10 min is time consuming and the wait is long for both patients and dentists. Therefore, this study was designed to find a simple way to restore the decreased bond strength caused by NaOCl. A study on the effect of NaOCl on human root dentin reported that exposure to 5% NaOCl rendered the superficial 80-100 ㎛ of intertubular dentin permeable to basic fuchsin[22]. Therefore, additional removal of 0.1 mm of the superficial dentin layer before the bonding procedure exposed the fresh dentin and restored the bond strength, reducing coronal leakage. It is difficult to standardize the removal depth with a bur so that one examiner prepared all the specimens after pre-testing in this study.

Two step self-etch adhesive was used to test the microtensile bond strength in this study. Restoration of endodontically treated teeth with self-etch adhesives and composites may offer some advantages over the use of total-etch adhesives. Self-etch adhesives have weak acids in their primer composition, resulting in less change in the dentinal wall structure compared to that caused by the strong acids of total-etch systems. In addition, primers were applied without air-drying, and therefore, collapse of collagen fibrils is avoided, thereby reducing technique-sensitivity[24].

There are some limitations in this study. The microtensile bond strength test allows testing of small areas promoting a better stress distribution throughout the specimen and induces failure of materials that are closer to their true ultimate strengths and are mostly adhesive failures[25]. However, the correlation between bond strength and microleakage is not well established, and bond strength data alone are not sufficient to evaluate the sealing ability of resins. According to this, the rationale involving microtensile bond testing of endodontic surfaces is that better adhesion of restorative materials to dentin increases the opportunity for good marginal sealing, longer life of the restoration, and withstanding of mechanical stress.

Further research should focus on the optimal amount of dentin removal after exposure to NaOCl. Microleakage studies should also evaluate the sealing properties of resin over a period of time. The structure of the pulp chamber wall dentin differs from that of the other dentin regions of the teeth. Therefore, additional experiments with a pulp chamber wall dentin are necessary because flat occlusal dentin was used in this study.

Because NaOCl is likely to remain the primary irrigant used in endodontics in the near future, and adhesive resin materials are used routinely for restoration of endodontically treated teeth, this issue will have to be addressed. Future adhesive resin products for endodontic applications may contain a reducing agent to reverse the effects of NaOCl. A non-oxidizing irrigant would also solve this problem.

In conclusion, within the limitations of this study, NaOCl irrigation resulted in a significant reduction in dentin bond strength, and either simple superficial dentin surface removal or 10% ascorbic acid treatment could be used as a way of restoring the bond strength of NaOCl-treated dentin.

참 고 문 헌

1. Belli S, Zhang Y, Pereira PN, Pashley DH. Adhesive sealing of the pulp chamber. J Endod 2001; 27: 521-526.
2. Belli S, Zhang Y, Pereira PN, Ozer F, Pashley DH. Regional bond strengths of adhesive resins to pulp chamber dentin. J Endod 2001; 27: 527-532.
3. Galvan Jr RR, West LA, Liewehr FR, Pashley DH. Coronal microleakage of five materials used to create an intracoronal seal in endodontically treated teeth. J Endod 2002; 28: 59-61.
4. Ray H, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endo J 1995; 28: 12-18.
5. Zehnder M. Root canal irrigants. J Endod 2006; 32: 389-398.
6. Morris MD, Lee K-W, Agee KA, Bouillaguet S, Pashley DH. Effects of sodium hypochlorite and RC-prep on bond strengths of resin cement to endodontic surfaces. J Endod 2001; 27: 753-757.
7. Erdemir A, Ari H, GüngünesH, Belli S. Effect of medications for root canal treatment on bonding to root canal dentin. J Endod 2004; 30: 113-116.
8. Nikaido T, Takano Y, Sasafuchi Y, Burrow M, Tagami J. Bond strengths to endodontically-treated teeth. Am J Dent 1999; 12(4): 177-80.
9. Lai S, Mak Y, Cheung G, Osorio R, Toledano M, Carvalho RI. Reversal of compromised bonding to oxidized etched dentin. J Dent Res 2001; 80: 1919-1924.
10. Weston CH, Ito S, Wadgaonkar B, Pashley DH. Effects of time and concentration of sodium ascorbate on reversal of NaOCl-induced reduction in bond strengths. J Endod 2007; 33 :879-881.
11. Spangberg L, Engström B, Langeland K. Biologic effects of dental materials: 3. Toxicity and antimicrobial effect of endodontic antiseptics in vitro. Oral Surg Oral Med Oral Pathol 1973; 36: 856-871.
12. Estrela C, Estrela CR, Barbin EL, Spano JC, Marchesan MA, Pecora JD. Mechanisms of action of sodium hypochlorite. Braz Dent J 2002; 13: 113-117
13. Ari H, Yasar E, Bellí S. Effects of NaOCl on bond strengths of resin cements to root canal dentin. J Endod 2003; 29: 248-251.
14. Yiu C, Garcia-Godoy F, Tay F, Pashley D, Imazato S, King N, et al. A nanoleakage perspective on bonding to oxidized dentin. J Dent Res 2002; 81: 628-632.
15. Ozturk B, Özer F. Effect of NaOCl on bond strengths of bonding agents to pulp chamber lateral walls. J Endod 2004; 30: 362-365.
16. Ishizuka T, Kataoka H, Yoshioka T et al. Effect of NaClO treatment on bonding to root canal dentin using a new evaluation method. Dent Mater J 2001; 20: 24-33.
17. Nakabayashi N. Dentinal bonding mechanisms. Quintessence Int 1991; 22: 73.
18. Rueggeberg F, Margeson D. The effect of oxygen inhibition on an unfilled/filled composite system. J Dent Res 1990; 69: 1652-1658.
19. Ari H, Erdemir A. Effects of endodontic irrigation solutions on mineral content of root canal dentin using ICP-AES technique. J Endod 2005; 31: 187-189.
20. Sim TP, Knowles JC, Ng YL, Shelton J, Gulabivala K. Effect of sodium hypochlorite on mechanical properties of dentine and tooth surface strain. Int Endo J 2001; 34: 120-132.
21. Vongphan N, Senawongse P, Somsiri W, Harnirattisai C. Effects of sodium ascorbate on microtensile bond strength of total-etching adhesive system to NaOCl treated dentine. J Dent 2005; 33 :689-695.
22. Marending M, Luder H, Brunner T, Knecht S, Stark W, Zehnder M. Effect of sodium hypochlorite on human root dentine?mechanical, chemical and structural evaluation. Int Endo J 2007; 40: 786-793.
23. Trope M, Maltz DO, Tronstad L. Resistance to

참 고 문 헌

fracture of restored endodontically treated teeth. Endod Dent Traumatol 1985; 1: 108-111.

24. Frankenberger R, Perdigao J, Rosa B, Lopes M. 'No-bottle' vs 'multi-bottle' dentiv adhesives - a microtensile bond strength and morphological study. Dent Mater 2001;17:373-380.
25. Pashley DH, Sano H, Ciucchi B, Yoshiyama M, Carvalho RM. Adhesion testing of dentin bonding agents: a review. Dent Mater 1995;11:117-125.