열가소성 의치상 레진과 첨상용 레진의 접착 강도에 저온플라즈마가 미치는 효과

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Nonthermal plasma on the shear bond strength of relining resin to thermoplastic denture base resin

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Purpose: This study evaluated the effect of nonthermal plasma treatment on the bond strength of autopolymerizing relining resin to the injection molded thermoplastic denture base resins (TDBRs) with different surface treatments. **Materials and methods:** Acrylic Resin (Acrytone), Polyester (Estheshot-Bright), Polyamide (Valplast) and Polypropylene (Weldenz) were subjected to various surface treatments: No treatment, Nonthermal plasma, Sandblasting, Sandblasting and nonthermal plasma. Specimens were bonded using an autopolymerizing relining resin. Shear bond strength was tested using universal testing machine with crosshead speed of 1 mm/min. Statistical analysis by two-way analysis of variance with Tukey's test post hoc was used. **Results:** Acrytone showed significantly higher shear bond strength value among other TDBR group while Weldenz had the lowest. The sandblasting and nonthermal plasma condition had significantly higher shear bond strength value in all of the resin groups ($P < .05$). **Conclusion:** The use of nonthermal plasma treatment showed limited effect on the shear bond strength between TDBRs and relining resin, and combination of nonthermal plasma and sandblasting improved the shear bond strength between TDBR and reline material. *(J Korean Acad Prosthodont 2018;56:199-205)*

Keywords: Nonthermal plasma; Thermoplastic denture base resin; Shear bond strength; Autopolymerizing relining resin

Introduction

Thermoplastic denture base resins (TDBRs) used for removable partial dentures are derived from diamine and dibasic acid monomers.[1,2] These dentures are crafted from an injection molded resin to produce the final product which is metal free prosthesis with superior elasticity, considerably lower flexural strength at the proportional limit and a lower elastic modulus compared to polymethyl methacrylate base resin.[3] Several advantages of these resins are favorable esthetic outcome, toxicological safety to patients allergic to metals and resin monomers,[4-7] higher elasticity than conventional heat-polymerizing resins and sufficient strength for use as denture base material.[8] However, based on previous studies. TDBR are extremely difficult to adhere to an autopolymerizing resin due to difference between it's mechanical properties.[3]

Denture base repair or relining is mandatory for the prolonged service life of the prosthesis.[9] The application of chairside autopolymerizing resins seems to have increased because direct relining is more convenient and faster than indirect laboratory processed relining.[3] However, thermoplastic denture base resins have high chemical resistance due to its high degree of crystallinity causing difficulty in the penetration of monomer molecules and other resin primers into

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Article history: Received February 28, 2018 / Last Revision May 8, 2018 / Accepted May 17, 2018

polymers.[1,9-11] Therefore, it does not provide sufficient bond strength to autopolymerized resins for repairing fractured dentures or replacing dislodged teeth.[9,10,12]

Plasma treatment has been used to modify the surface of products in the industrial world.[13] Nonthermal plasma (NTP) treatment is made of partially ionized gas with ions, electrons, and uncharged particles such as atoms, molecules, and radicals. NTP has electrons at a hotter temperature than the heavy particles that are at room temperature which are usually in helium, argon, nitrogen, helium and air.[14] The method of plasma treatment advances the surface adaptation of dental materials.[15] In the previous studies, it is reported that surface modification using plasma treatment have improved the bonding strength between heat cured acrylic resin and self-curing acrylic resin.[16,17]

The purpose of this study was to evaluate the effect of nonthermal plasma treatment on the bond strength of the autopolymerizing relining resin material to thermoplastic denture base resins in comparison to different surface treatments.

Materials and methods

The four thermoplastic denture base materials are: 1. Acrylic Resin (Acrytone, HighDental Japan, Osaka, Japan)(AC); 2. Polyester (Estheshot-Bright, I-cast Co. Ltd., Kyoto, Japan)(ES); 3. Polyamide (Valplast, Valplast International Corp., New York, NY, USA)(VA), and 4. Polypropylene (Weldenz, Weldenz, Nagoya, Japan)(WE) are the test groups in the study (Table 1). The denture base specimens were relined using Tokuyama Rebase II (Tokuyama Dental Corp., Tokyo, Japan) and was manipulated according to the manufacturer' s instruction. Thermoplastic denture base resins with dimension of 10.0 mm × 10.0 mm × 3.3 mm were embedded into an autopolymerizing resin using a cylindrical silicone mould with a height of 24.0 mm and a diameter of 23.0 mm. The specimens were then trimmed and polished with 600 grit sandpaper to create a uniform ‡at surface. This served as a substrate for shear bond testing.

The specimens were subjected to various surface treatment:

1) No treatment (C) to serve as the control.
2) Nonthermal plasma (NTP) treatment for 5 minutes at a distance of 10 mm perpendicular to the treated surface.
3) Sandblasting (SB) 50 μm alumina particles, treatment for 15 seconds with a pressure of 0.28 MPa at a distance of 20 mm perpendicular to the treated surface.
4) Sandblasting and nonthermal plasma (SB + NTP) combined treatment of sandblasting for 15 seconds followed by nonthermal plasma for 5 minutes at a distance of 10 mm perpendicular to the treated surface.

A total of 160 thermoplastic denture base specimens using the different surface treatments are subdivided into 4 groups consisting of 40 specimens each were fabricated (Fig. 1). After surface treatments, Tokuyama Rebase II relining resin were bonded on all specimens with height of 3.0 mm and an inner diameter of 6.0 mm according to the manufacturer's instruction.

The specimens were subjected to the shear bond strength test using universal testing machine (AGX-KN10, Shimadzu, Kyoto, Japan) with a crosshead speed of 1 mm/min (Fig. 2). Shear bond strength was computed using the following formula: $F = N / A^2$, where F = shear bond strength (MPa), N = maximum force exerted at the specimen and A = area of bonding (mm^2).

Normality of data was analyzed using Kolmogorov-Smirnov and Shapiro-Wilk test. Two-way ANOVA with Tukey's test for post hoc was used to determine the effect of different surface treatments in various thermoplastic denture base resins ($\alpha = .05$). All Statistical analysis was analyzed using SPSS ver. 22.0 (IBM, Chicago, IL, USA).

Table 1. List of thermoplastic denture base resins and autopolymerizing relining resin

Materials	Product	Manufacturer	Processing method	Lot number
Polyester	Estheshot-Bright (ES)	I-cast Co. Ltd., Kyoto, Japan	Heat processed at 270°C for 20 min.	4D5760060
Acrylic resin	Acrytone (AC)	High Dental Japan, Osaka, Japan	Heat processed at 250°C for 20 min.	1211097
Polyamide	Valplast (VA)	Valplast International Corp., New york, NY, USA	Heat processed at 285°C for 20 min.	140213
Polypropylene	Weldenz (WE)	Weldenz, Nagoya, Japan	Heat processed at 235°C for 20 min.	111547
Autopolymerized relining resin	Tokuyama Rebase II	Tokuyama Dental Corp., Tokyo, Japan	Composition: Powder (PEMA), Liquid (AAEM 1.9-nonanediol Dimethacrylate)	137030

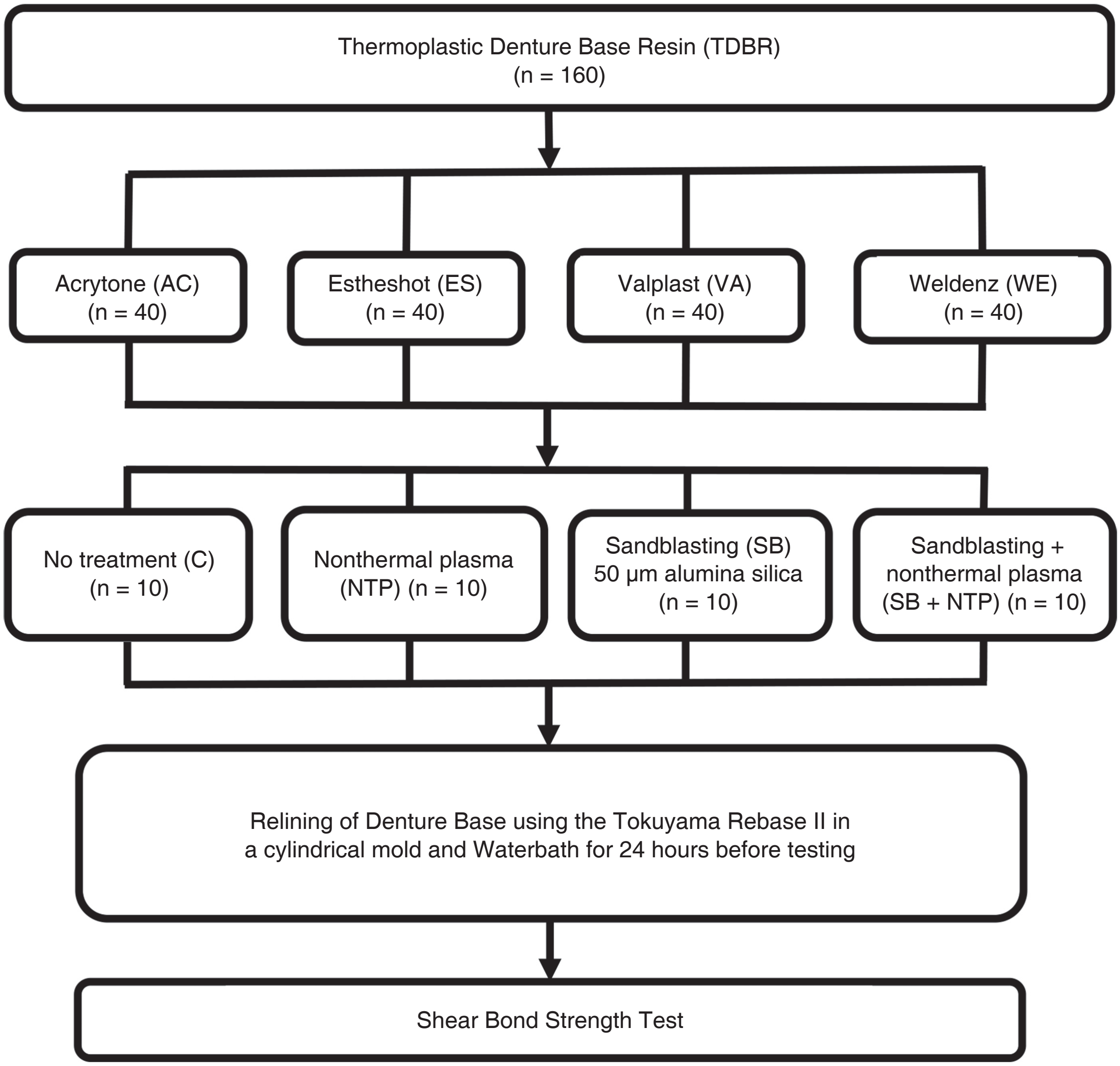

Fig. 1. Experimental study design procedure.

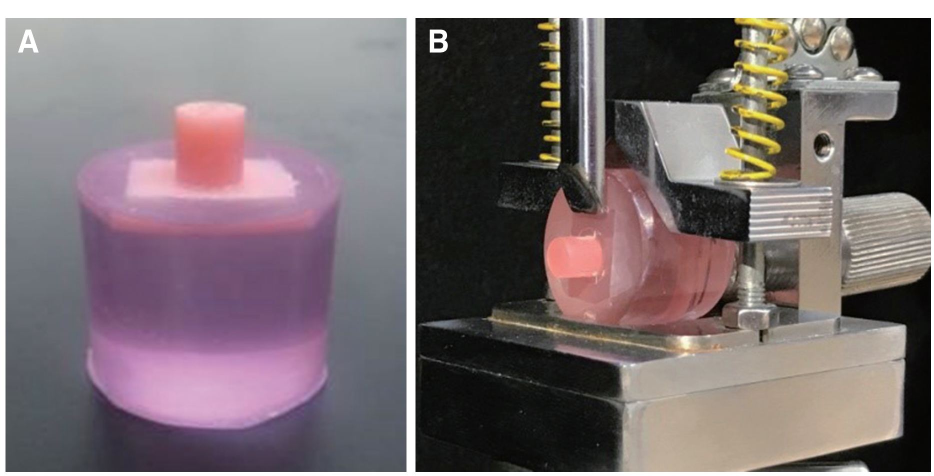

Fig. 2. (A) Image of the specimen, (B) Shear bond strength testing procedure.

Results

The mean values and standard deviation of the shear bonding strength of different TDBR after different surface treatment are shown in Table 2. Regardless of the surface treatment method, Acrytone showed significantly higher shear bond strength value among the other TDBR group while Weldenz had the lowest value ($P < .05$) (Table 2). Among the surface treatment groups, SB+NTP had significantly higher shear bond strength value in all of the resin groups ($P < .05$) (Fig. 3).

Discussion

Thermoplastic denture bases resins have higher elasticity considerably lower ‡exural strength but are extremely difficult to adhere to an autopolymerizing resin due to it's difference between mechanical properties.[3] Therefore, the bond strength of the TDBR's may be affected if used clinically and surface modification is necessary to enhance the bond strength between the thermoplastic denture base resin and relining resin. Several studies showed that the use of silica coating,[12,18] acetic acid,[9] and tribochemical silica coating combined with 4-methacryloyloxyethy trimellitate anhydride (4-META)/ methyl methacrylate (MMA) - tributylborane (TBB)[3] can improve the strength between denture bases. Although there were many attempts to improve the adhesive properties of denture base resin, limited research has been focused on thermoplastic denture base resin material. In addition, the bond strength between TDBR and relining resin is not always predictable.

The main objective of this study was to evaluate the effect of nonthermal plasma on the shear bond strength of the autopolymerizing resin bonded to thermoplastic denture bases. According to the previous research, the chemical adhesive property of two unlike resins

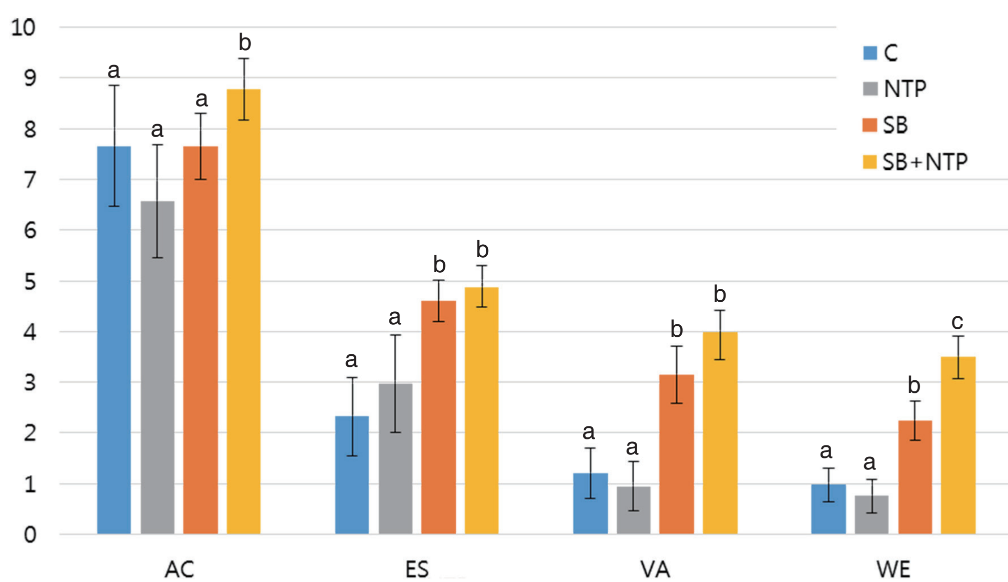

Fig. 3. Shear bond strength test between surface treatment groups. Different letters within the same material show significant difference ($P < .05$). AC: Acrytone; ES: Estheshot; VA: Valplast; WE: Weldenz; C: No treatment; SB: Sandblasting; NTP: Nonthermal plasma; SB + NTP: Sandblasting and nonthermal plasma.

Table 2. Mean shear bond strength (MPa) values of different thermoplastic denture base materials

	AC	ES	VA	WE
C	$7.66 \pm 1.19^{A;a}$	$2.32 \pm 0.78^{A;b}$	$1.21 \pm 0.50^{A;c}$	$0.98 \pm 0.33^{A;c}$
NTP	$6.57 \pm 1.11^{A;a}$	$2.97 \pm 0.97^{A;b}$	$0.95 \pm 0.49^{A;c}$	$0.76 \pm 0.33^{A;c}$
SB	$7.65 \pm 0.66^{A;a}$	$4.60 \pm 0.41^{B;b}$	$2.14 \pm 0.56^{B;c}$	$2.24 \pm 0.38^{B;d}$
SB + NTP	$8.78 \pm 0.60^{B;a}$	$4.88 \pm 0.40^{B;b}$	$3.99 \pm 0.54^{B;c}$	$3.50 \pm 0.42^{C;c}$

Different letters show a significant difference (capital letter: in the same column, small letter: in the same row, $P < .05$). AC: Acrytone; ES: Estheshot; VA: Valplast; WE: Weldenz; C: No treatment; NTP: Nonthermal plasma; SB: Sandblasting; SB + NTP: Sandblasting and nonthermal plasma.

can be improved with the use of surface modiflers such as plasma treatment.[13,19,20] Nonthermal plasma is one of the new methods that claims to improve bond strength between a base and a veneering material. The chemical changes include the improvement of the surface wettability and forming a functional group such as hydroxyl brought to the surface after exposure to plasma.[15] In this study, although NTP alone did not showed improvement of shear bonding strength, the combination of NTP with sandblasting showed signiflcantly higher value. This is maybe due to thermoplastic resin's high degree of crystallinity,[1,9-11] the NTP alone is not enough to improve the bonding strength between TDBRs and relining resin. Mechanical surface alteration increases in the surface area for bonding from sandblasting and chemical effect of NTP treatment.

In this study, the combination of mechanical and chemical surface treatments of the sandblasting and nonthermal plasma signiflcantly improved the bond strength of the TDBR and autopolymerizing relining resin material. However, other factors may in‡uence the shear bond strength of the TDBR and reline resin such as different resin primer components, thermocycling and pH changes which were not evaluated in the present study due to its low shear bond strength result. No thermocycling aging was done in this study because several studies have shown that aging did not have an effect on bond strength. But still further investigations must be done to support this research. Studies have shown that surface wettability and adhesion properties improve with the use of oxygen plasma treatment.[21] In this study, the use of NTP was limited to the recommendation of the manufacturer. The exposure time for the plasma have an effect on the adhesion and bonding of polymers.[21] Moreover, a study shows that polymethyl methacrylate and other resins have less hydrophilization, resulting to weaker shear bond strength.[22] However, the amount of time exposure must still be tested. Therefore, careful investigations in the clinical application need to be done to prove its effect.

Conclusion

Within the limitations of this study, the use of nonthermal plasma treatment showed limited effect on the shear bond strength between thermoplastic denture base resins and relining resin. However, more studies are needed to further investigate this effect.

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열가소성 의치상 레진과 첨상용 레진의 접착 강도에 저온플라즈마가 미치는 효과

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목적: 이 연구는 저온 플라즈마가 자가중합형 재이장용 레진과 주입형 열가소성 의치상 레진의 결합 강도에 미치는 영향을 다른 표면 처리 방법에서 평가하기 위함이다.

재료 및 방법: 네 가지 열가소성 의치상이 이 연구에서 사용되었다: Acrylic Resin (Acrytone), Polyester (Estheshot-Bright), Polyamide (Valplast), Polypropylene (Weldenz)에 다양한 표면처리를 시행하였다: 대조군, 저온플라즈마, Sandblasting, Sandblasting와 저온플라즈마. 표면 처리 후 모든 시편은 Tokuyama Rebase II를 이용하여 원형의 테플론 관에 접착되었다. 전단강도는 Universal testing machine을 통해 crosshead speed 1 mm/min으로 측정되었다. 통계 분석 방법으로는 이원분산분석을, 사후 검정 방법으로는 Tukey's test가 사용되었다.

결과: Acrytone이 다른 열가소성 의치상 레진 그룹에 비하여 통계적으로 유의한 수준에서 더 높은 전단강도를 보인 반면 Weldenz는 가장 낮은 값을 나타냈다. Sandblast와 저온플라즈마를 순차적으로 시행한 조건에서 모든 레진 그룹 중 통계적으로 유의한 수준에서 가장 높은 전단강도 값을 나타냈다.

결론: 열경화성 의치상 레진과 재이장용 레진 사이의 전단강도에 저온플라즈마는 제한된 효과를 나타내었으며, sandblasting 처리와 함께 처리되었을 때 두 재료간 전단강도는 향상되었다. *(대한치과보철학회지 2018;56:199-205)*

주요단어: 저온플라즈마; 열가소성 의치상 레진; 전단 강도; 자가중합 재이장용 레진

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원고접수일: 2018년 2월 28일 / 원고최종수정일: 2018년 5월 8일 / 원고채택일: 2018년 5월 17일