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Original Article

Effect of sandblasting on the tensile bond strength of two permanent silicone soft liners to the denture base

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Abstract

Introduction: Soft liners are materials used in removable dental prostheses to maintain the health of inflamed mucous membranes. The materials bond strength to acrylic bases can be modified by several methods; One of which includes sandblasting. The aim of this study is to investigate the effect of sandblasting on the tensile bond strength(TBS) of two permanent silicone soft liners.

Material & Methods: 36 dumbbell-shaped heat-cured polymethylmethacrylate acrylic specimens were fabricated in denture flasks with a length of 75 mm, width of 12 mm and a thickness of 7 mm in the thinnest section. 3 mm of the material of all specimens was cut using a low-speed diamond saw with water cooling. Then according to the surface treatment and sofliners, the specimens were divided into four groups: no surface treatment with mollosil softliner, no surface treatment with GC softliner, sandblasting with 50 µm Al2O3 particles and then using mollosil soft liner and sandblasting with 50 µm Al2O3 particles and then using GC soft liner. After polymerization of all specimens, TBS was evaluated with universal testing machine at a crosshead speed of 5 mm/min until failure. Finally, two-way ANOVA and independent T-test were used to analyzing the data.

Results: The mean of TBS in the groups of sandblasting was significantly higher than other group and the mean of TBS in the group of mollosil was higher than GC group with or without sandblasting. (p=0.001)

Conclusion: Sandblasting increases the TBS of silicone soft liners to the acrylic bases; moreover, Mollosil softliners are more tenacious compared to GC.

Keywords: Denture liners, Tensile strength, Denture relining

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بررسی تأثیر سندبلاست بر استحکام باند کششی دو لاینر سیلیکونی دائمی به بیس دنچر

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چکیده

مقدمه: سافت لاینرها موادی هستند که در پروتزهای متحرک به منظور حفظ سلامت مخاط ملتهب استفاده می شوند. روش های متعددی برای تغییر استحکام باند آنها به بیس آکریلی وجود دارد که یکی از این روش ها سندبلاست می باشد. هدف از این مطالعه بررسی تأثیر سندبلاست بر استحکام باند کششی دو لاینر سیلیکونی دائمی می باشد.

مواد و روش ها: ۳۶ نمونه آکریلی گرما سخت به شکل دمبل در اندازه های ۷۵ میلیمتر طول، ۱۲ میلیمتر قطر و ۷ میلیمتر در نازک ترین قسمت ساخته شدند. از قسمت میانی تمامی نمونه ها به اندازه ۳ میلیمتر و با استفاده از دستگاه برش و تحت خنک کننده آبی، بریده شد. سپس مطابق با تغییرات سطحی و نوع سافت لاینرها نمونه ها به ۴ گروه تقسیم شدند: گروه بدون تغییرات سطحی با سافت لاینر مولوسیل، گروه بدون تغییرات سطحی با سافت لاینر GC، گروه آماده سازی شده با ذرات آلومینیوم اکساید ۵۰ میکرون با سافت لاینر مولوسیل و گروه آماده سازی شده با ذرات آلومینیوم اکساید ۵۰ میکرون با سافت لاینر GC استحکام باند کششی میان سافت لاینر و رزین آکریلی در تمامی نمونه ها با دستگاه Universal testing و با سرعت 5 mm/min تحت نیروی کششی سنجیده شد از تست ANOVA دو طرفه و T مستقل برای ارزیابی داده ها استفاده گردید.

یافته ها: میانگین TBS در گروه های سند بلاست شده بطور معناداری بیشتر از سایر گروه ها بود و میانگین TBS در گروه مولوسیل نسبت به گروه GC با یا بدون سند بلاست بیشتر بود. (p=0.001)

نتیجه گیری: سندبلاست باعث افزایش استحکام باند کششی سافت لاینر سیلیکونی به بیس پروتز میشود. علاوه بر این سافت لاینر مولوسیل در مقایسه با GC مستحکم تر به نظر می رسد.

واژگان کلیدی: لاینر دنچر، استحکام کششی، ریلاین کردن دنچر

Introduction

Liners or denture lining materials are used as tissue conditioners for traumatized areas, and to prevent chronic pain after prosthesis delivery to the patient.[1] In complete and partial removable prostheses, the liners resemble a cushion through distributing equal force and decreasing localized pressure exerted on the atrophic crest of the ridge. They also improve prosthesis retention via engaging undercuts and play a key role in maintaining the health of inflamed mucosa in removable dental prostheses .[2-4] Liners are divided into two general categories: short-term and long-term soft liners. The short-term liners are used as tissue conditioners, and the long-term soft lining materials are applied to compensate for the lost mucoperiosteal tissue as well as to absorb the functional or para-functional impact forces. however, plastic acrylic resins and elastomeric polymers, called "silicone", are the most commonly used long-term soft liners.[3,5,6] Silicone-based liners are differentiated from other liners due to characteristics such as high resistance to temperature variations, low degradation rate and high tear strength. Moreover, silicone-based liners, compared to acrylic liners, have higher longevity and higher mechanical strength, and would bond poorly to the prosthetic resin base with or without chemical adhesion. [1, 5]

There are several problems associated with the use of flexible silicon liners, including: bond failure between the liner and prosthesis base, water absorption, solubility, porosity, colonization by Candida albicans, poor tear strength and loss of softness. [7,8] However, bond failure between the liner and prosthesis base is identified as the most serious problem regarding to silicone liners.[9] The most common reason for this bond failure could be the fundamental structural differences between the chemical composition of the liner and prosthesis base and the absence of chemical interactions in between.[2,5] In the absence of an adequate bond between liner and the prosthesis base, all of its desired properties are useless.[4] This is because of the fact that the bond failure between the liner and the prosthesis would create a potential surfaces for bacteria growth, plaque and calculus, and soft liner breakdown acceleration.[7,10]

Various parameters affect the bond between the liner and prosthesis base including the use of primer on the prosthetic surface and the prosthetic base composition .[4] However, another aspect that reinforces the bond strength between the resin-based prosthesis and silicone-based liners is the roughness and free energy of the resin-based prosthesis.[5] For this purpose, different surfaces are prepared by roughening the bonding areas to increase the bond strength and to evaluate micro-leakage between the liner and denture base. [1] some study analysis displayed elevated bond strength levels between the liners and denture base as a result of increased of surface area, surface reactivity and adhesive penetration.[5,6] Generally, the mechanical modification of surfaces can be gained through laser abrasion, metal-oxide airborne particle abrasion, or mechanical abrasion (with abrasive paper or rotary instruments).[6]

In the current study, two soft liners including a) Mollosil: a-silicone based, permanently soft liner and long term relining material, and b) GC: a-silicone based, permanently soft liner, no heat irritation and good retention were used. Therefore, the tensile bond strength (TBS) of these two silicone liners (Mollosil and GC) to heat-cured resin base in two conditions (with and without sandblasting) has been evaluated to clinically use a method in which the effect of sandblasting on TBS of a liner to the prosthesis base is more.

Material & Methods

This experimental study was approved by Ethical Committee of Babol University of Medical Sciences (Ethical number: mubabol.rec.1395.4178).

Making wax specimens: First, a dumbbell-shaped wax specimen was prepared with a length of 75 mm, width of 12 mm and a thickness of 7 mm in the thinnest section under the heat using a wax (Betadent-Maku-Iran) and spatula (Asa Dental-Bozzano-Italy). Then, the agar (Kettenbach Gmbh & CO-Eschenburg-Gemany) was gradually melted in a steel container under the heat to change to gel phase. The flasks (Heraeus Kulzer GmBH-Hanau-Germany) have already been prepared for this impression material, and the original wax sample was put in the lower part of the flask. Then, the melted agar gently entered into the flask via the holes placed on top of the flask to fully cover the original wax.

After cooling, agar changed into sol phase. Next, the flask was gently opened and the original wax sample was slowly removed from agar mold without damaging the sides of the wax. After extracting the original sample from the mold, the full molten wax (Betadent-Macu-Iran) was thoroughly poured in a negative imprint, and we waited until the specimen was cooled. This molding was replicated 36 times to get the number of samples required for this study.

Making acrylic specimens: To prepare the flasks (Moldabaster S, Heraeus Kulzer GmBH, Hanau, Germany), first, the two upper and lower halves were opened and thin layer of vaseline was applied to entire surface of flasks. Then, dental stone was mixed with water in the flasking process and the mixture was completely filled up to the lower half of the flask. Three wax specimens were horizontally put in the lower half and the additional plaster around the specimen and flasks was removed using spatula so that there were no undercuts. After the plaster was set, its entire surface was applied with vaseline and the upper half was placed on the lower half of the flask. Then, the upper half was filled with dental stone under the vibration. The upper lid was closed and the flask was pressed for 40 minutes. The flask was removed from the press after the plaster was hardened. The flask was put in the clamp and then placed in the boiling water (100 ° C) to eliminate the wax. After about 10 min, the flask with clamp was removed from boiling water. Moreover, two halves of the flask were separated and the excess wax was removed with boiling water. After the flask was cooled, a suitable brush was used to brush off the biofilm from the plaster surfaces. Next, some monomer was poured into a container placed on a vibrator, and acrylic powder was added to saturate it. It took some time to obtain doughy acrylic. The acrylic was put in negative imprints placed in the flask as well as the upper and lower halves of the flask were positioned on top of each other and located inside the hydraulic press to reach the two edges of the flask. After waiting for the monomer to penetrate into the polymer, the flasks were removed from the press and were put in the clamp. The clamp was placed in the boiling water for 40 minutes. The oven was turned off after half an hour and the water temperature was gradually decreased. After polymerizing the acrylic specimens, two halves of flask were separated and the specimens were deflasked, trimmed and any additional plaster was eliminated.

Sandblasting the specimens: Before surface treatment with sandblast, 3 mm of all specimens (measured by the Caliper, ASA Dental-Bozzano-Italy) was cut from the thin midsection using a water-cooled diamond edge saw (Model No. 11-1280-250, Buhler Ltd., Lake Bluff, IL, USA). Then, the bonding surfaces of all specimens were polished and dried using sandpaper with grit value of 400 (Toska Industrial Supplier-Tehran-Iran). All specimens were kept in water at 37 ° C before surface treatment with sandblast, and then dried in the air for 24 hours. After these steps, 18 dumbbell-shaped acrylics were randomly selected and their bonding surfaces were prepared using sandblasting system (Lonigo-Vicenza-Italy) with 50 µm Al_2O_3 particles. In overall, all specimens were divided into two general categories:

1- Group 1: Without sandblast as control group

2- Group 2: Sandblast group (test), prepared using sandblasting

Using soft liners: Each group were divided into two subgroups of 9 specimens for better investigation of each subgroup with one type of soft liner. To put and process the liners, a wax (Betadent-Macu-Iran) thickness equal to the thickness of the liner was placed in a 3-mm space (Figure1). Then, to prevent any disturbance in the flasking process, the excess wax was removed using scaple and no 15 blade.

Figure 1. Acrylic specimens with 3mm wax in its narrowest part

Again, the lower half of the flask was filled with dental stone and the prepared specimens were horizontally put in the lower half and placed the upper half on the lower one, filled with dental stone and pressed. The flasks were extracted from the press and were placed in boiling water, and the room temperature was raised until the wax was completely removed. After removing the wax, the two halves of the flask were separated from each other. Additional wax was eliminated with boiling water. The desired liner was packed into the prepared space of 3 mm using a brass spacer. Specimens were repressed and setting the soft liners took 15 minutes. Polymerization of all liners was carried out according to the manufacturer's instructions.

As a result, 4 groups were created including:

1. Acrylic specimens without surface treatment using GC soft linear (GC Corporation ,Tokyo , Japan)
2. Acrylic specimens without surface treatment using Mollosil soft linear (DETAX, Ettlingen, Germany)
3. Acrylic specimens prepared with sandblasting using GC soft linear
4. Acrylic specimens prepared with sandblasting using Mollosil soft linear

After completing the polymerization process, the specimens were slowly deflasked and immersed in distilled water at 37 ° C for 1 week. After a week, all the specimens were extracted from distilled water and subjected to tension in a Universal Testing Machine (Koopa Pazhoohesh Co-Sari-Iran) using a crosshead speed of 5 mm/min until failure and the data were evaluated with the Test Manager software. The maximum tensile stress before failure was recorded in newtons for each specimen.

Statistical analysis: Finally, to measure the TBS, the following formula was used: S=F/A

Where S is TBS (N/mm^2), F is maximum force (N) and A is cross-sectional area (mm^2). Finally, in order to evaluate the preparation of the surfaces and determine the mean standard deviation of the standard specimens, the two-way ANOVA test and independent T-test was used. P <0.05 was considered significant level.

Results

Experiments were performed on 36 specimens in 4 groups analyzed based on the type of soft liner and sandblasting. Independent T-test and two-way ANOVA were used to compare the control and intervention groups and also to compare the two types of soft liners The tensile bond strength in control group showed that Mollosil softliner was significantly higher than that of GC (2.02±0.41 > 0.84±0.24).The mean difference was 1.17±0.16 and Significant differences were found among the control group (p=0.001). The tensile bond strength in sandblasting group showed that Mollosil softliner was significantly higher than that of GC (3.41± 0.82 > 1.78±0.36). The mean difference was 1.62±0.3 and Significant differences were found among the sandblasting groups (p=0.001). Two types of soft liners were compared using independent t-test in the control group. TBS was significantly higher in Mollosil soft liner group than GC soft linear group (p<0.001). In addition, two types of soft liners were compared in the sandblast group and it was seen that TBS was significantly higher in Mollosil than GC soft linear groups (p<0.001). Comparing two groups of control and sandblast using Mollosil soft liner suggested that TBS was significantly higher in the sandblast group than control group (p<0.001). Further, when comparing control and sandblast groups using GC soft linear, TBS was significantly higher in the sandblast group (p<0.001). Therefore, comparison of these four groups indicated that TBS was higher in the sandblast group using Mollosil soft liner than that of other groups. In the current study, two-way ANOVA showed that:

a) Sandblasting effect was significant (p<0.001, df=1, F= 46.59).

b) The effect of material was also significant (p <0.001, df=1, F = 67.21).

c) The interaction between sandblast and material was not significant (p=0.19, df=1, F=1.73).

Figure 2 represents that the mean value of tensile bond strength is the highest in the acrylic resin group altered with sandblast using Mollosil soft linear, and is the lowest in the acrylic resin group unaltered with GC soft liner.

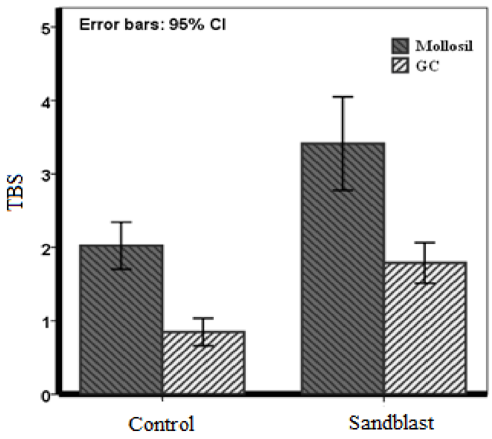

Figure 2. TBS mean in four group

Discussion

The study result demonstrated that tensile bond strength was higher in Mollosil compared to GC soft liners bonded to acrylic base. Meanwhile, sandblasting directly increases the tensile bond strength among acrylic resin bases prepared by sandblast, when compared to the control group.

Amin et al. compared the structures of heat-cured and self-cured acrylic resin bases with Coe-supersoft, Molloplast B, Coe-soft and flexibase soft liners. They believed that sandblasting of acrylic surfaces before the use of soft liners would weaken the TBS.[11]

Jacobsen et al. assessed how TBS is influenced by a specific sandblast (with 250 µm Al_2O_3 particles) and laser (with carbon dioxide (CO_2)) preparation of Prolastic soft liners to acrylic base. They reached the same result as the previous study.[12] According to both studies, the reason behind TBS weakening includes the sandblast prepared irregularity sizes not being sufficient for acrylic surfaces of the prosthetic base. These are inconsistent with our study result that concluded the TBS increased by sandblasting through enhanced acrylic surface porosity.

Sun et al. evaluated the effect of sandblast on TBS of Physio soft liner bonded to heat-polymerized acrylic resin base. They found that sandblasting decreased the TBS between soft liner and prosthesis base.[13]

On the other hand, Akin et al. not only showed the direct effect of sandblasting on increasing the TBS between soft liners and denture acrylic base, but also reported that TBS is further affected through Al_2O_3 particles differing sizes. They also observed that 120 µm Al_2O_3 particles were the best particle size to improve the

TBS.[14] In the current study, 50 µm Al_2O_3 particles were used. Akin et al. stated that the Er-YAG laser obviously enhanced the TBS of silicone-based soft liners.[15] These results were similar to that of Usumez et al. [16]

Although primer was not used in our study, Goiato et al. declared that the primer had a positive effect on TBS of Tokuyama soft liner and on heat-cured Poly Methyl Methacrylate (PMMA) acrylic resin.[17]

Like the present study, Sabarigirinathan et al. investigated the effect of acrylic prosthesis surface preparation on the heat-cured and self-cured soft liners TBS. They concluded that sandblasting with 50 µm Al_2O_3 particles significantly improved TBS. In addition, Molloplast B soft liner had higher TBS when compared to Ufi Gel P and GC soft liners.[18] Atsü et al. studied the effect of silane and silica coating on TBS of silicone-based Ufi Gel P soft liner. They concluded opposite results against the present study. They reported that due to lower surface roughness of sandblasting compared to Ufi Gel P adhesive, lower softliner to resin base TBS is found.[7] Similarly, Vishwanath et al. assessed Molloplast B and Ufi Gel P soft liners to PMMA acrylic prosthesis. They compared the effect of the two methods of sandblasting preparation including 50 µm Al_2O_3 particles and phosphoric acid etching on soft liners TBS. The result of their study represented the greater effect of acid etching compared to sandblasting, and expressed that phosphoric acid etching created more porosity in acrylic surfaces .[19] Goswami et al. evaluated the shear bond strength of composite resin bonded to alloy, and demonstrated that the effect of sandblasting with larger particle [20] is similar to the current study results.

On the other hand, Swapna et al. studied Molloplast B and VLC (light polymerizing) soft liners TBS GC, and stated that the soft liners viscosity should be increased in order to rise the surface tension for better contact. The soft liner with increased viscosity cannot easily penetrate into the porosity resulted from sandblasting; This would as a result, weakens the soft liners TBS. Various particle sizes of aluminum oxide had no significant difference in TBS.[21] Maheshwari et al. assessed the effects of sandblasting with 250 µm Al_2O_3 particles, 80 grit sandpaper, chemical etch with acetone and methyl methacrylate monomer on TBS of GC soft liner to acrylic-based prosthesis. In their study, 80 grit sandpaper had more impact on TBS when compared to sandblasting.[22] This study[22] was similar to that of Gopal which demonstrated the positive effect of 100 grit sandpaper, and higher TBS in Super soft than Molloplast B soft liners[23] Nevertheless, a study in 2013, Surapaneni et al. preferred the use of methyl methacrylate monomer to rise the TBS compared. In their study, TBS was higher in GC compared to Ufi Gel P soft liners.[1] In general, the use of sandblast on acrylic surfaces makes more roughness. This was proved by Storer in 1962 who pointed that the irregularities in the acrylic surfaces creates mechanical locking of the soft liners.[24] Khalid Aziz et al. compared the effects of CO_2 laser and sandblast with 250 µm Al_2O_3 particles on TSB of Vertex soft liner to prosthetic base. It was observed that the effect of laser on TBS was more than that of sandblast.[25]

There are some differences between acrylic- and silicone-based soft liners in terms of chemical structure. This issue was raised by Shafiei et al. which found that silicone-based soft liners exhibited more shear bond strength compared to soft-acrylic soft liners[26] However, in this study, the TBS is evaluated. In general, there are three methods to assess the bond strength between the acrylic-based prosthesis and soft liners: tensile, shear and peeling tests.[27,28] al-Athel et al. examined the effects of these three methods on TBS of soft liners to the prosthetic acrylic base. They concluded that the measured TBS strongly depends on the method used.[29] A limitation of this study was neglecting to take into account the effects of some factors such as saliva, rodent forces and thermal changes due to being time-consuming, costly and highly interfering with the results. Therefore, it is suggested to consider these factors for future research in order to obtain more accurate results on human specimens.

Conclusion

The results of the present study show that the use of sandblasting create surface roughness in acrylic resin and significantly increases the tensile bond strength of silicone-based soft liner to the acrylic resin base . The tensile bond strength is also higher in Mollosil softliner than GC.

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Conflict of interest: There was no conflict of interest.

Authors' Contributions

The study was designed by Maryam Rezaei and Kamran Amirian. The study data were collected by Soheil Khakbaz Baboli. Analysis and interpretation of data, drafting of the manuscript and critical revision of the manuscript for important intellectual content were performed by Hemmat Gholinia and Maryam Rezaei. Study supervision was conducted by Maryam Rezaei and Kamran Amirian.

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