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Effect of Different Surface Treatments on the Bond Strength of Soft Liners to Denture Base Resins: A Systematic Review

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Abstract

background: The serviceability of a relined prosthesis is adversely affected by repeated de-bonding of the soft liner from the denture base resin.
Aim: to evaluate the bond strength between the denture bases and commercially available soft liners when using different surface treatments.
Material and method: An extensive systematic review was conducted across databases such as PubMed, Google Scholar, and Scopus, involving all articles from January 2011 to June 2024. The 110 records from the research search were screened, resulting in the exclusion of 30 duplicates and 38 papers that did not meet the inclusion criteria of the current study. Twelve were excluded because they were not downloadable for analysis. Thirty-one articles meeting the requirements were identified for full review.
Result: Using database searches, 110 articles were first found. Of these, 31 satisfied the requirements for qualitative analysis. Nine out of twelve articles reported that laser preparation of denture base resins improved their adhesion to soft liners. Six studies concluded. According to six out of seven studies, monomer treatment strengthened the liner-resin connection in the liner. According to six out of seven trials, monomer treatment strengthened the liner-resin connection. According to four investigations, binding strength was also enhanced by the acid etching procedure.
Conclusions: The tensile test has been frequently used in assessing the adhesive bond strength between the denture base and soft liner. Several types of surface pretreatments, including laser, air abrasion, silica coating, acid etching, and monomer treatment, have been developed to enhance the adhesion between soft liners and denture base resins.

Introduction:

For the denture base resins to be effective, they must possess satisfactory mechanical properties and a durable connection with artificial teeth, as well as stable adhesion to soft liners. The inner surface of a denture base can be lined with a resilient material to ensure more even stress distribution at the junction between the bone, tissue, and the denture (1-3). These liners are especially indicated for bruxism, xerostomia, abnormal bone resorption, thin atrophic mucosa, undercut bone situations, immediate dentures, or post-implant bone healing. The resilient lining materials are primarily classified into two groups: soft acrylic resin and silicone elastomers. Soft acrylic liners are plasticized, relying on ethyl alcohol or ethyl acetate for softening of the acrylic matrix. Silicone liners are comprised of dimethyl hexane elastomers. However, both materials suffer from several disadvantages, including poor adhesion to the denture base, porosity, color instability, and low long-term elastic and wear properties (4-6). The resilience of the lining material and the denture base must have a suitable durability relationship so that this restoration can function properly (7-9). Commercial products that have demonstrated sufficient adhesion are few. For the most part, their clinical performance is a function of the quality of the bond with the acrylic base material (10).To improve this adhesion, some surface treatments were studied: alumina sandblasting, laser-surface treatment(2,11), chemical conditioning or primers, and mechanical-roughening with acrylic burs and the insertion of mesh-type glass fibers(12). This study systematically reviewed the experimental knowledge (the effective treatments) on the bond strength of elastic denture liner materials bonded to denture base resins, which is dependent on surface pre-treatment. Some studies have yielded controversial results on this topic, prompting a meta-analysis to assess and compare the findings of different studies. The purpose of this review is to identify the different testing methods used for testing bond strength between denture base materials and soft liners using various surface treatment techniques, and also to recognize the frequently used method in testing bond strength.

Materials and Methods

The search was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement. The research question addressed is: “Does the treatment of denture base with different surface treatments improve the bond strength between acrylic denture base and silicon liner?”

This review article presents original in vitro experimental studies that evaluated the effect of surface treatments on the bond strength between acrylic denture base materials and resilient lining resins. The time period for these studies ranged from January 2011 to June 2024.

Eligibility guidelines and search strategy

All included studies have been published in peer-reviewed journals. Initially, by examining the titles of these studies, those that did not evidently investigate the impacts of bond strength were excluded. If the titles of the publications were not descriptive enough to make a judgment, the abstracts were examined to ensure their eligibility for the study. These studies were subject to strict main criteria. They were as follows: full publications in English, original, in vitro studies investigating the impact of different surface treatments on the bond strength between acrylic denture bases and resilient denture liners. Furthermore, these studies employed various surface treatments, incorporating integrated statistical analysis. All studies not involving surface treatments, literature reviews, review articles, abstracts, case report studies, letters to the editor, non-integrated studies, commentaries, and papers published in languages other than English were excluded. To identify relevant, eligible published studies, a set of scientific databases (Google Scholar, PubMed, Scopus, and Web of Science) was utilized, with the time period for these studies spanning from January 2011 to June 2024. The Keywords were: denture base resin, surface treatments, soft liner, peel bond strength, shear bond strength, or tensile bond strength. Following the electronic search, a manual search was conducted to identify the references of relevant review articles. Studies in which data were not distinctly mentioned were thrown out of this review.

Results and Discussion

Among 110 articles identified through PubMed, Google Scholar, Web of Science, and Scopus searches, a total of 31 were eligible in Figure (1). Tensile testing proved to be the most commonly used technique for estimating bonding resistance among the various tests. The findings of the most retrieved studies Table (1) revealed that laser surface treatment improved bonding intensity between resilient soft liners and denture base resins (1, 13-17, 36, 41). Likewise, several investigations have noted an enhancement in the interfacial adhesion between these two materials when they were sandblasted (13, 14, 18-20, 32, 33). Increased adhesion was also observed after the application of monomer, as reported in investigations (21-26). Furthermore, on the other hand, air-borne particle abrasion led to the reduction in bond strength of soft liners to denture base resins (2, 13, 21, 23, 26, 29-31). In some of the studies, it was concluded that, contrary to popular thought, laser action did not enhance bond strength between denture base materials with soft liners (17, 29). According to the current literature search, the tensile test was the most widely used method for evaluating the binding strength between resilient lining materials and denture base materials. This might be due to the tensile test's easier implementation and more dependable findings. The tensile test measures the strength of the connection between the base material and the resilient liner material by applying a static, gradual force. Because of its many benefits, dentists favor silicone-based robust lining material, which is why it is used more frequently.

Tensile bond strength

In silicon based resilient lining material subjected to tensile test, Akin et al. (13) found that Er: YAG laser treatment at 200 mJ, 10 Hz, and 2 W for 20 seconds strengthened the bond strength between the PMMA denture base and liner. While Nakhaei et al. (14), found that Er: YAG laser irradiation strengthened the tensile bond strength of liners to PMMA resin. Er: YAG laser treatment of 300 mJ, 3 W, and a pulse duration of 700 μm improved the binding strength of silicone-based liner to UDMA resin, according to another study by Akin et al. (1). Similar findings were reported by Yildirim et al. (15), Tugut et al. (16), and Gorler et al. (17). The laser tip's scanning rate and distance from the surface are two variables that might influence the laser group's results in various researches. The scan rate may cause multiple cavities on the acrylic resin's surface. The ability of the laser beams to form pits can also be impacted by whether the laser is used in the focus or defocus mode (14). According to Khanna et al.(18) the adhesion of acrylic resin and silicone-based resilient liners to denture bases was enhanced when the surface of the acrylic resin denture was abraded using 250 mm of alumina. By creating imperfections that aid in mechanical interlocking between the acrylic resin and the liner, airborne-particle abrasion of acrylic resin denture bases with 110-mm alumina enhances their bonding with robust liners, according to Nakhaei et al. (14) Baboli et al.(19) Shaaban (20)and Akin et al.(13) all reported comparable outcomes. According to Nakhaei et al. (14) the combination of laser and air abrasion strengthened the connection. The bigger size of the alumina particles in this study may have contributed to the increased bond strength by forming larger pits and depressions, making it easier for the robust lining material to enter. This was demonstrated by distinct cavities on surfaces struck by aluminum oxide particles. Conversely, compared to smaller particles, these bigger particles are easier to remove from the liner's and acrylic resin's surface, leaving fewer leftover particles that interfere less with the bonding process (14). Monomer strengthened the connection between denture bases and robust liners, according to Kulkarni and parkhedkar (21), Cavalcanti et al. (22), Surapaneni et al. (23), Haghi et al. (24) and Almuraikhi (25). Atsu and Keskin (26) observed a similar result with primer application. Applications of acetone and monomer wetting may cause the creation of several 2mm of diameter pits and the progression of superficial cracks (27). When the monomer is applied, the acrylic resin denture base swells up, making it easier for the liner adhesive primer to penetrate the pits and fractures. This results in less microleakage and a stronger connection (28). Because it can penetrate deeply into polymer chains, methyl methacrylate monomer makes it easier for the adhesive primer to penetrate (23). Gundogdu et al. (29) Vishwanath et al. (30) and Brahmanda et al. (31) concluded that the best way to strengthen bonds was to etch denture bases with 36% phosphoric acid. But according to Atsu and Keskın (26), silane, adhesive, and silica coating caused the binding strength to deteriorate. The 30-mm imperfections produced by silica coating systems, which were insufficient to allow the soft lining material to flow into the denture foundation acrylic resin, can be used to explain these findings. According to Cavalcanti et al. (22), acetone and ethyl acetate strengthened bonds. According to Surapaneni et al. (23), acetone strengthened bonds. To strengthen the tensile bond strength and enable mechanical interlocking between PMMA and the denture liner, the ethyl acetate and acetone treatments can permeate over the PMMA surface, infiltrating between polymer chains and depolymerizing the polymer subsurface layer. Without changing the surface characteristics, these surface treatments increased the PMMA surface's disintegration, strengthening the tensile bond. In silicon based resilient lining material subjected to tensile test, Gundogdu et al. (29) and Akin et al. (13) found that abrasion of the acrylic resin denture base by airborne particles using 50mm alumina reduced the binding strength between the denture base and the liner material. Kulkarni and parkhedkar (21), Surapaneni (23), Vishwanath (30), Brahmanda (31) and Akin [2] observed similar findings. Atsu and Keskin (26) found that the binding strength between acrylic resin denture bases and liners decreased when denture bases were pretreated with 50mm alumina and 30mm silica-coated alumina. Stresses created at the contact between the robust liner and the acrylic resin denture foundation can account for these results. The imperfections created by airborne particle abrasion may be too small for the lining material to pass through. Atsu and Keskin (26) found that the silica-coated + silane coupling agent decreased the binding strength. These outcomes could be explained by silica coating systems producing rough surfaces and imperfections that are too small to allow the passage of the soft, resilient lining material into the base resin. 30-µm silicon dioxide particles cause these irregularities. According to Akin et al. (1), the Eclipse bonding agent decreased the bond strength. This may be because the soft liner material and the Eclipse Bonding Agent could not form a chemical link. This outcome might be impacted by the soft liner's substance (dimethyl siloxane polymer). This outcome can also be explained by the bonding agent's failure to dissolve the surface layer and increase the bonding surface area. According to Gorler et al. (17) , the HO: YAG laser decreased binding strength. Gundogdu et al. (29) found that PMMA resin's binding strength to silicone-based soft liners was not strengthened by Er: YAG laser treatment at 150 mJ and 100 mm.

Shear bond strength

In denture-based resilient lining material subjected to shear test, Karaokutan and Ayvaz (32) and Hareesh et al. (33) reported that air abrasion improved bond strength. This is said to happen because two contact surfaces moving relative to one another create a functional force that must be overcome with more power (33). According to Park and lee (34), the rocatec method strengthened bonds. Blasting Al_2O_3 and silica-modified Al_2O_3 is believed to boost mechanical retentions as surface irregularity, roughness, and bonding area increase. Furthermore, following silica coating, chemical linkages with silane were created when the silica concentration on the resin surface rose

(34). Acetic acid strengthened bonds, according to Koetaryan and Havezeqoran (35). The chemical interaction between the acid and the polyamide matrix is largely responsible for this improvement. These modifications encourage the development of an interpenetrating polymer network by facilitating monomer diffusion and interfacial entanglement between the denture base and the reline resin. Furthermore, the adhesive interface is improved by the deeper penetration of monomer molecules made possible by the acid-swollen polymer matrix. According to Sree et al. (36) the increased surface roughness produced by laser irradiation and sandblasting strengthened the shear binding between the silicone soft liner and the denture base resin. Three-dimensional surface texture analysis revealed well-defined peaks and valleys in both treated groups, with roughness values of 1.40 µm for sandblasting and 1.59 µm for laser irradiation, compared to only 0.449 µm in the untreated control group. This increased surface irregularity provided greater mechanical interlocking between the liner and the resin. Osathananda and Wiwatwarrapan (37) reported that methyl formate –methyl acetate increased bond strength. When MF-MA was applied, it dissolved and swelled the surface layer of the polymethyl methacrylate (PMMA) denture base. Upon evaporation, this process left behind a porous surface, which allowed better penetration of the monomer from the reline resin. This facilitated the formation of an interpenetrating polymer network, resulting in stronger mechanical interlocking (37). Khalid (38) reported that CO_2 increased bond strength. Water from the heat-cured acrylic resin may have instantly evaporated due to the effect of the CO_2 laser's high-energy pulse, which might have led to a significant volumetric expansion. The surrounding material may have ablated due to this expansion, increasing the treated acrylic's surface area by creating surface roughness (38). In a denture-based resilient lining material subjected to shear test, Hamanaka et al. (39) and Khalid (38) found that air abrasion decreased binding strength. This may be explained by the fact that micro-pitting created a depression and elevation on the denture base material's surface. The rough surface reduced surface tension, which in turn affected interface adhesion. The elevation peaks serve as stress points to weaken the bond interface. Karaokutan and Ayvaz (32) reported that monomer reduced bond strength. The study suggests that the monomer may have softened the surface layer of the CAD-CAM denture base, compromising its mechanical properties and structural integrity. This softening likely weakened the substrate rather than enhancing adhesion. Unlike methods that increase surface roughness or promote chemical bonding, monomer treatment did not produce sufficient mechanical interlocking or surface activation, making it less effective for improving adhesion in CAD-CAM processed materials.

Peel bond strength

In denture based resilient lining material subjected to peel test, Ahmed et al. (40) found that ethyl acetate, sandblasting and SiC papers strengthened the bond strength while silicon carbide paper decreased bond strength. This is because ethyl acetate can cause the surface to swell, allowing the primer to diffuse to the denture base resin and improving peel resistance. Surface porosities produced by sandblasting and SiC sheets also improve primer dispersion, strengthening the peel (40). Korkmaz et al. (41) and Fadhil and aziz (42) concluded that laser pretreatment increased the peel bond strength of a silicone-based liner to the acrylic denture base resin. The laser irradiation produced homogenous surface irregularities and micro-porosities, as confirmed by SEM analysis, which facilitated the penetration of the soft liner into the denture base. This resulted in improved adhesion at the interface. Additionally, the laser's air/water spray system helped maintain a low surface temperature, preventing thermal damage while promoting controlled ablation. The increased surface area and reduced contact angle contributed to better wettability and bonding efficiency. Korkmaz et al. (41) reported that air abrasion showed decreased bond strength. This due to the irregularities created by alumina abrasion might not be sufficient for the soft liner to flow into, limiting mechanical interlocking. The presence of surface debris and stress concentration points caused by roughening can further weaken the bond. Moreover, the viscosity and contact angle of the soft liner material may hinder its penetration into the micro-irregularities, reducing adhesion.

Conclusions:

The following conclusions can be made within the limitations of this study:

1. The tensile test was the most widely used method to evaluate the binding strength between resilient lining materials and denture foundation materials.
2. Laser pretreatment, air abrasion, acid etching, silica coating, and monomer application may effectively increase the binding strength between denture base resins and resilient soft liners.
3. The connection between soft liners and denture base resins was weakened by airborne particle abrasion.

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Conflicts of Interest

No conflicts of interest.

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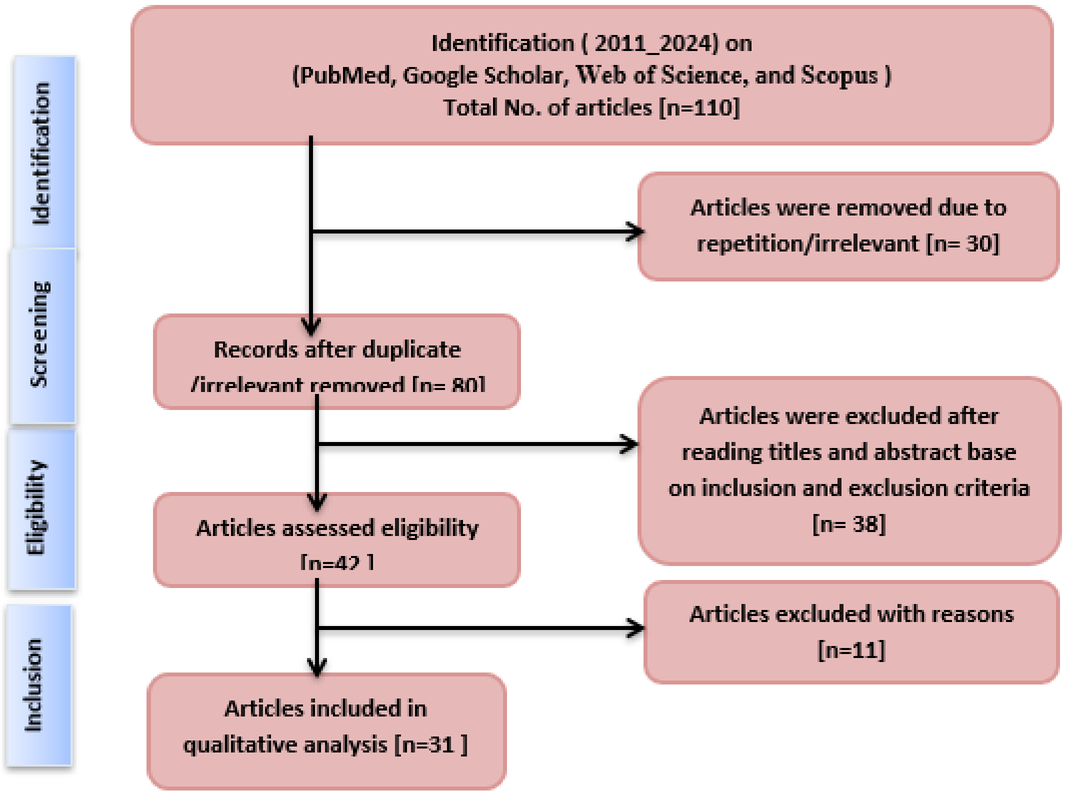

Figure (1): Information flow during the different stages of the current systematic review.

Table (1).studies comparing the effect of different surface treatment on bond strength of surface pretreated denture bases to soft liner

Author/year	Method	groups	Liner material	Study objectives	Outcomes
1. Kulkarni and Parkhedkar ,2011 (21)	Tensile bond strength	G 1: no treatment G 2: a sandblasting G 3: monomer	Super-Soft and Mollopl ast B	Monomer treatment and sandblasting influence the tensile bonding between the denture base resin and the two liners.	**G 3:** showed increased bond strength. **G 2:** showed lower bond strength
2. Atsu and Keskin,2013 (26)	Tensile bond strength	G 1: adhesive (control) G2: airborne particle abrasion G 3: a silica coated and a salinized with the saline couple agent G 4 : a silica coated and an adhesive. G 5 : a silica coated, a saline application, and an adhesive treatment	Ufi Gel P	The impact of a various surface treatment on the tensile bond between a denture base material and an auto polymerizing silicone denture lining	**Group 1:** highest bond strength **Groups [2, 3, 4, 5]** showed decreased in bond compared with the group 1
3. Park and Lee,2022a (34)	Shear bond strength	G 1:no treatment (C), G 2: Tokyama Rebase II (A). G 3: a sandblasting P. G 4: a sandblasting and an adhesive (PA) G 5: a sandblasting and a saline (PS). G 6: the Rocatec system (PPS).	Tokuyama Rebase II Normal	Examine the shear bond, based on surface treatment, between the 3d-printted a denture base and relining material.	**Group 6:** had a stronger shear connection. **Group 1:** had a lowest shear connection. **Groups 3 and 4** displayed higher bond strengths than [group 1]
4. Nakhaei et al.,2016 (14)	Tensile bond strength	G 1: no treatment. G 2: airborne particle abrasion. G 3: laser treatment G 4: a sandblasting + laser treatment	Mollopl ast B	The effect of three distinct surface treatments on the silicone lining material's tensile strength in relation to denture resin.	**Groups 2, 3, 4:** tensile bond strength was much higher compared to **group 1**.
5. Cavalcanti et al,2014 (22)	Tensile bond strength	**G 1:**no treatment (control). **G 2:**methyl methacrylate . **G 3:**acetone . **G 4:**ethyl acetate .	(Zetala bor; Zhermack)	Impact of surface treatments on silicone denture liners' adherence	**G 4**: It was superior bond to the other groups **G 3 :** had the lowest tensile bond strength than G 2 and G 3 .
6. Gundogdu et al,2014 (29)	Tensile bond strength	**G 1**: no treatment **G 2:** 36% phosphoric acid etching **G 3:** Laser **G 4**: air an abrasion **G 5**: Acid etching, laser treatment **G 6:** airborn particle abrasion + laser treatment	Mollopl ast B and Ufi Gel P	Effect of various treatments on bond strength between two resilient lining materials and an acrylic denture base.	**G2:** had the highest tensile bond. **G4:** had the weakest tensile bond. **G [3 , 5 , 6]** didn't increase the tensile bond strength over G 1.
7. Hamanaka et al,2017 (39)	Shear bond strength test	G 1: no treatment. G 2: air an abrassion. G 3: methylene chloride G 4: ethyll acetate.	Tokuyama Rebase II	Bond strength of reline resin to injection-molded thermoplastic denture	**Group 8:** the most effective surface treatments **Group 2** :showed

		G 5: 4-MEETA/MMA-TBBB resin. G 6: air an abrasion, 4-MEETA/MA-TBBB resin. G 7: tribo chemical a siliica coating. G 8: tribo chemical asilica coating, 4-MEETA/MA-TBBB resin)		base resin	lowest bond strength
8. Khanna et al,2015 (18)	shear bond strength	**G 1: no treatment .** **G 2: a sandblasting.** **.G 3: monemer** **G 4: a lining material processed with acrylic resin dough**.	Luci-Sof and Super-Soft	To assess and contrast the shear bond between two liners and denture base resin made of polymethyl methacrylate (pmma) with various surface treatments.	**Group 3:** had the strongest bond strength. [**Group 4]**: had the lowest bond strength.
9. C et al,2016 (33)	Shear bond strength	G 1: no treatment. G 2: a sandblasted with the50 µ AL_2O_3 G 3: sandblasted with the150 µ AL_2O_3 G 4: sandblasted with the250 µ AL_2O_3	Mollopl ast B , GC softline r	Surface treatment's impact on soft denture liners' bond strength	Increase in shear bond strength after sandblasting. G 2: the best bond strength. G 1: showed the lowest bond strength.
10. Park and Lee,2022b (34)	Shear bond strength	**G 1:** no treatment (C). **G 2: a** Tokuyama Rebase II Normal **G 3 :** an adhesive (A), **G 4:** a sandblasting (P), **G 5**: a sandblasting and an adhesive(PA), **G 6 :** a sandblasting, a silane [PS]. **G 7 :** Rocatec systim [PPS].	Tokuya ma Rebase II	Impact of different surface treatment on the shear bond between the relining material and the 3d-printed denture base.	**Group 7:** had an excellent adhesive strength. **Group 2:** had the lowest bond strength
11. Surapaneni et al,2013 (23)	Tensile bond strength	G 1: no treatment. G 2: a sandblasting. G 3: monomer G 4: acetone.	Cure Ufi Gel P , GC Reline Soft	To assess and contrast the tensile bond of soft lining materials made of silicone (ufi gel p and gc reline soft) with various pretreatments of a denture base acrylic resin.	**[Group 3]**: had an excellent bond strength followed by [group 4] and the [group 1] **Group 2** : showed decreased in bond strength over control.
12. Koodaryan and Hafezeqor an,2016 (35)	Shear bond strength	**G N**: No treatment **G S**: Silica coating (Rocatec) and silane application. **G A**: acetic acid	GC ,Triplex	Bond strength, reline resin, polyamide and surface modification, acetic acid	**Group A :** had the greatest bond strength **Group N** :Control group the lowest bond strength
13. Fadhil and Aziz,2024 (42)	Peel bond strength	Fiber laser	Mallopl ast.	To investigate the impact of heated-cured acrylic resin, two ratios of copper oxide nanoparticles, and fiber laser treatment on the peel strength between silicone and acrylic	Laser treatment improved peel bond strength.

14. Vishwanath et al,2017 (30)	tensile bond strength	**G 1:** a sandblasted 50 µm AL_2O_3 **G 2:** 36% phosphoric acid etching. **G 3:** Control Group.	Mollopl ast B , Ufi Gel	Air an abrasion and acid etching treatments of denture base have an effect on the tensile strength of two resilient liners.	**G 2:** showed highest tensile bond strength. **G 1:** showed lowest bond strength
15. Baboli et al,2019 (19)	tensile bond strength	**G 1**: no treatment with molllosil softlliner **G 2**: no treatment with GC soft liner. **G 3:** a sandblasted 50 µm AL_2O_3 ,mollosil soft liner **G 4:** a sandblasted 50 µm AL_2O_3, GC soft liner.	Mollosil softliner, GC softliner	How sandblasting affects the soft liners' tensile binding strength to the denture base	**G 3:**showed highest bond strength **G 2:** showed lowest bond strength
16. Karaokutan and Ayvaz,2024 (32)	Shear bond strength	G 1: monomer G 2: a sandblasted 50 µm AL_2O_3 G 3: a sandblasted 110 µm AL_2O_3 G 4: tungsten carbide bur.	(Paladur)	This study sought to determine how various treatments and production techniques affected the shear bond between acrylic denture bases and reline material.	**Group 2:** showed the highest SBS. **Group 1:** showed the lowest SBS
17. Akin et al ,2013 (1)	Tensile bond strength	G 1: no treatment. G 2: Eclipse Bonding Agent Applied G 3: Laser-Irradiiated.	(Mollop last-B).	effect of the different treatments on the soft denture liner's tensile binding strength to the silicone denture base resin.	**Group 3:** (Group EL) exhibited the higher bonds strength **Group 2:** showed significantly less bond strength.
18. Sree et al,2019 (36)	Shear bond strength	G 1: untreated surface. G 2 : (Air abrasion) G 3 : Laser	GC liner	Examine how two distinct surface treatments affect the shear bond strength between the heat-polymerized denture base resin and silicone soft liner during thermo cycling.	**Group 3:** exhibited the higher 'shear bond strength compared to air abrasion and control. **Control group** showed significantly less bond strength.
19. Shaaban et al,2023 (20)	tensile bond strength	**G 1:** no treatment . **G 2** : treatment with 125 µm Al2 O3 airborne-particle abrasion	Kettenbach,	Assess the impact of AL_2O_3 treatment on the bond between 3d-printed denture base and silicon-based material.	**Group 2**:Surface treatment with 125 µm Al2O3 and enhances the tensile bond strength. **Group 1:** showed significantly less bond strength.
20. Haghi et al,2020 (24)	Tensile bond strength	G 1: No preparation. G 2: Phosphoric acid (36%). G 3: laser. Group 4: Grit-blasting group. Group 5: Monomer group.	Mollopl ast-B, PermaFlex, AcroSoft.	Both synchronous and asynchronous processing techniques, as well as various surface treatments, were used to compare the binding strengths of three distinct kinds of silicone and acrylic	**Group 5**: exhibited the higher bonds strength **Group 4:** showed less bond strength.

				soft liners to the denture-based and various surface treatments	
21. Almuraikhi,2022 (25)	Tensile bond strength	G 1: no treatment G 2: (MMA) monomer. G 3: Phosphoric acid.	Mollopl ast-B	To assess a soft liner's tensile binding strength to the denture base resin using various surface treatment methods.	**Group 2**: the highest bond strength were seen with group treated with monomer. **Group 1**:the lowest bond strength .
22.Brahmandabheri et al,2022 (31)	Tensile bond strength	group1: control group group 2: 36% phosphoric acid. group 3: a sandblasted50 µm Al2O3 group 4: laser	(Mollop last B)	To evaluate and contrast how surface treatments, such as thermo cycling, affect the tensile bond strength of silicone soft liners with acrylic resin bases in a mimicked oral environment.	**group 2:** had the higher bond strength **group 3:**the specimens of abraded groups had lowest bond strength
23.Osathananda and Wiwatwarrapan,2016 (37)	Shear bond strength	methyl formate–methyl acetate	[Unifast trad (UT), Tokuyama RebaseII Fast (TR), Ufi gel hard (UG)]	Bond strength, denture-reline resins, methyl format-methyl acetate	methyl format–methyl acetate with ratio [25:75] enhance bond strength
24. Ahmed et al,2024 (40)	Peel bond strength	Group 1: Sandblasting. Group 2:a 80 grit SiC paper. Group 3: an ethyl acetate .	Vertex-soft	Assessment of peel bond strength following various acrylic surface treatment techniques between heat polymerized acrylic and heat cured acrylic-based denture soft lining material	**group 3 :** had the highest peel strength values **group 2:** silicon carbide paper group had the lowest peel strength values.
25. Yildirim et al,2020 (15)	Tensile bond strength	G 1: no treatment. G 2: argon plasma treatment . G 3: Er:YAG laser treatment.	Mollopl ast B, Mollosi l,	To assess how acryli c resin's binding stren gths to two denture li ners are affected by a rgon plasma and Er: yag treatments.	**group 3:**had the highest bond strength **group1 : had** the lowest bond strength
26.Khalid, 2018 (38)	Shear bond strength	G 1: no treatment. G 2: air-abrasion (AL2O3). Group3: was treated with CO2 laser.	Vertex ™ Soft	Co2 laser surface treatment impacts the heat-cured soft liner's bond strength to high impact acrylic denture base material.	Group 3: highest mean values in shear bond strength Group 2: lowest mean values in shear bond strength.
27. Tugut et al,2012 (16)	tensile bond strength	Er:YAG laser	Permaflex	Examine the tensile strength between polymethyl methacrylate denture	Compared to extremely short pulse duration treatments, the extended pulse

				base resin and silicone lining material following er: yag laser therapy with varying energy levels and pulse lengths.	duration treatments produced stronger bonds.
28. Görler et al,2015 (17)	tensile bond strength	**G1 : No treatment** **G2:ER:YAG** **G3: ND:YAG** **G4: Ho:YAG**	Mollopl ast B	How treatments with er: yag, nd: yag, and hO: yag lasers affect the tensile strength between an acrylic denture and a silicone-based resilient lining.	**Group 2**: increased the tensile bond strength. **Group 4:** reduced tensile bond strength.
29. Akin et al,2011a (13)	tensile bond strength	**Group 1:** (sandblasting. **Group 2: [**Er:YAG] **Group 3: [**Nd:YAG]. **Group 4: [**KTP lasers]	(Permaf lex	The impact of different treatments on the tensile strength of silicone based soft denture liners, including sandblasting, er: yag, Nd: yag, and ktp.	**group 2:** increased the bond strengths , **group 1:** decreased the bond strength
30. Akin et al,2011b (2)	tensile bond strength	G 1): untreated (control) G 2): [sandblasted 50 µm Al_2O_3] G 3): [sandblasted60 µm Al2O3] G 4): [sandblasted 120 µm Al2O3] G 5): 250 µm Al2O3	(Permaf lex	Examine the bonding characteristics between a silicone-based soft denture liner and a denture base sandblasted with various- sized aluminum oxide particles.	**Group** 4: improve strength of the bond. **Group 2:** less bond strength strength .
31. Korkmaz et al,2013 (41)	Peel bond strength	**group 1:** laser treatment, **group 2:**air-abrasion	Mollopl ast B	The impact of laser treatment and air abrasion on peel bond strength of the silicon-based soft denture liner against various denture resins.	**group 1** :showed increased peel strength. **group 2:** showed significantly lower peel strength.

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