Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

Comparison of Adhesion of Soft-Liner between Conventional PMMA and 3D Printed Resin Denture Bases

***Dawood Jadaan[1,2], Juzailah Roffie[2], Husniyati Roslan[2], Nahas P[3]**

[1] *College of Dentistry, Tikrit University, Tikrit, Salahddin , Iraq*

2 Advanced Medical and Dental Institute, University Sains Malaysia, Kepala Batas, Pulau Pinang, Malaysia

[3] *Faculty of Dental Medicine, Lebanese University, Hadat, Beirut, Lebanon*

Abstract

Aims: The purpose of this study was to evaluate the tensile strength of the soft-liner (Molloplast-B®) between the denture foundation made of 3D printed resin and traditional acrylic (PMMA).

Materials and Methods: In this experiment, 60 acrylic specimens in the shape of reverse dumbbells were employed. The first group consisted of 24 specimens made from traditional acrylic polymethyl methacrylate (PMMA) (Vertex, Veracril, and Duradent) while the second group consisted of 24 specimens made from 3D printed resin (Dentona). The third group consisted of 12 samples that were packed at the dough stage of acrylic and soft liner at the same time.

After that, the samples from the first and second groups were split in two, with one half receiving no surface treatment and the other half undergoing sandblasting. Every sample is separated into two halves with precise measurements. The thickest and thinnest sections were 80 mm in length (10 mm x 25 mm) and 8 mm x 15 mm, respectively, and were joined in the middle by the soft-liner material. The experiment's tensile strength was examined in two separate directions to ascertain the soft-liner material's strength of adhesion to the sample's chosen materials.

Results: The data analysis of the tensile strength test revealed a statistically significant difference in the soft-liner adhesion strength between the 3D-printed acrylic resin with sandblast treatment (0.2133 ± 0.03939 kN/mm²) and the 3D-printed acrylic resin without surface treatment (0.1567 ± 0.04677 kN/mm²). Similar results were observed for conventional acrylic PMMA, where the sandblasted acrylic PMMA (0.0950 ± 0.03606 kN/mm²) exhibited significantly better bond strength compared to the untreated acrylic PMMA (0.0875 ± 0.02491 kN/mm²). Dough stage samples had better values complared to traditional acrylic (0.1483± 0.03689 kN/mm²).

Conclusion: The results demonstrate that sandblast treatment significantly improves the soft-liner adhesion strength of both 3D-printed acrylic resin and conventional acrylic PMMA. Surface treatment enhances bond strength compared to untreated materials. These findings suggest that sandblasting is an effective method for improving adhesion in acrylic-based materials.

Keywords: Heat polymerized acrylic, Sandblast, Soft-liner, Tensile strength.

Citation: Jadaan D, et al. (2025) Comparison of Adhesion of Soft-Liner between Conventional PMMA and 3D Printed Resin Denture Bases. Dentistry 3000. 2.a001 doi:10.5195/d3000.2025.785
Received: November 29, 2024
Accepted: February 1, 2025
Published: February 5. 2025

Email: dawoodsalmantech@gmail.com

Introduction

Long-term use of dentures can lead to significant changes in the supporting structures, often resulting in chronic pain and discomfort, particularly in the mandible [1]. Accelerated resorption of the alveolar ridges leads to the formation of a sharp, narrow crest, which generates excessive pressure, causing severe complications for the patient. As a result, it becomes essential to adopt denture design that provides adequate ridge protection [2]. Relining procedures play a critical role in addressing denture related problems [3]. This procedure is non-invasive, cost-effective, and offers greater patient comfort compared to fabricating new dentures [4,5]. There are two types of denture liners: stiff (usually made of polymethyl methacrylate) and resilient [6]. Resilient liners fall into two categories: short-term and long-term liners. In contrast to

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

short-term liners, which are intended to be worn for a maximum of 30 days, long-term liners can be worn for up to a year and maintain their durability for more than 30 days [7–9]. Resilient denture lining materials are preferred over hard denture liners because they engage soft tissue undercuts to increase prosthesis retention, relieve constrained pressure, and cushion the fitting surface of dental prostheses to enable more uniform force delivery [4]. However, surface imperfections and porosity, residual palatable after use, odor and water absorption, color instability, difficulties maintaining hygiene, and early thickening due to plasticizer solubility are some of the issues with resilient denture liners [7]. One major issue with denture liners is the liner's inability to adhere to the acrylic resins [10,11]. To prevent interfacial separation at the borders of the denture, it is recommended that the acrylic resins and denture liners retain a robust and durable binding. Additionally, the disintegration of the adhesive between the soft liners and the acrylic resins encourages the growth of bacteria and speeds up the deterioration of the soft lining material. [12,13]. Previous studies have suggested several techniques to increase the adhesion of liners to the denture base. These include airborne particle abrasion, bur roughening acrylic, chemical etching, and lasing to give the denture base a rougher surface [8, 14–18].

Denture processing techniques have changed dramatically in recent years due to the application of computer-aided design and manufacturing (CAD/CAM) technology [19–21]. Although dentures have been made using CAD/CAM technology since the 1990s, the lack of scientific evidence still makes them appear to be a relatively new technique [22]. CAD-CAM-fabricated dentures have better material properties and require fewer treatment visits, which saves money and time for both patients and physicians. Every day, more and more professional dentistry practices are utilizing CAD/CAM technology. Nevertheless, there is little scientific data on the bonding properties of denture liners to denture resins made using CAD/CAM technology [3]. Research on the use of 3D-printed denture resins is limited, with existing studies indicating that the adhesion strength of 3D-printed denture resins is generally lower than that of traditional acrylic. While many studies have focused on mixing powder and liquid soft-liner materials, this study utilizes a pre-made silicone-based soft liner (Molloplast B®), which is commonly used in maxillofacial prosthetics.

The aim of this study is to evaluate the adhesion properties between resilient denture liners and various denture base materials, including those fabricated using traditional methods and advanced CAD/CAM or 3D printing technologies.

Material and Methods

Materials

The materials used are listed in the following table (Table 1).

Table 1. Materials used in the study.

Item	Brand	Country
Soft liner pest-silicon based	Molloplast ® B (detax)	Germany
Heat cure acrylic polymer and monomer	Duradant	Turkey
3D printer resin denture base	Dentona®	Germany
Dental stone type 4	Efes dental	Turkey
Wax disc milling for	Vericom /Mazic wax	Korea

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

CAD/CAM		
Separating medium	Duradent	Turkey
Water	Tap water	Iraq
Sand	Renfert ®	Germany
Alcohol	Clear logo	Iraq
Modeling wax	Dura dent	Turkey

Fabrication of the samples

Three types of samples were prepared: PMMA samples, 3D printed resin samples, and dough stage samples. Samples were prepared by joining two rectangular blocks of acrylic (PMMA) with a soft-liner material, while another group consisted of two rectangular blocks fabricated from 3D printed resin denture material connected by the soft liner (Figure 1).

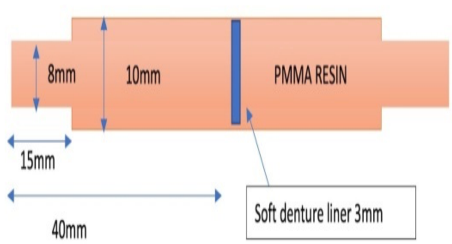

Figure 1. Sample measurements.

The preparation of the samples involved two distinct groups: acrylic (PMMA) and 3D printed resin. For acrylic samples, a traditional technique was employed. A wax pattern was first designed and cut to the desired measurements. The wax pattern was placed inside a flask and fixed in position using dental stone (Figure 2). After the wax was eliminated, a mold space was created and was ready to be packed with acrylic material. After that, the acrylic was cured inside a water bath for one hour after reaching boiling state. Once curing was completed, the specimens were removed from the mold and finished. The acrylic samples were divided into two groups: one group underwent sandblasting with air pressure to treat the surface, while the other group was left untreated.

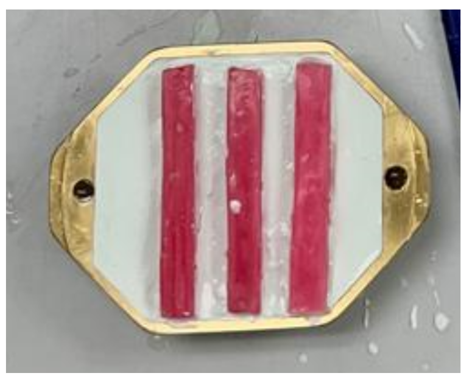

Figure 2. Wax patterns inside the dental stone.

For the 3D printed resin samples, the required dimensions for the tensile testing were designed using Autodesk (Figure 3). The design was then sent as an STL file to a 3D printer, which used Dentona® resin for removable dentures. After printing, the samples were removed from the machine and cleaned using an ultrasonic device with alcohol to ensure thorough cleaning. The samples were then light cured for two minutes and divided into two groups: one group was sandblasted to treat the surface, and the other remained untreated.

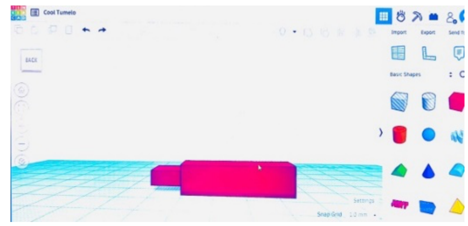

Figure 3. Autodesk software.

The next steps were similar for both groups. Acrylic samples (Those made by traditional method and 3D printed samples) were joined in the middle by wax and place inside a dental flask filled with dental stone (Figure 4). After wax elimination, a mold space was created to be packed with the soft-liner material. The soft-liner material (Molloplast-B®) was then packed into the mold space, with the flask placed under pressure for five minutes. It was transferred to a clamp to maintain pressure and submerged in a water bath at room temperature. The curing process involved dipping the flask into a water bath heated to 70°C for 90 minutes, followed by raising the temperature to 100°C for 30 minutes. After curing, the flask was removed and allowed to cool gradually to ambient temperature for 30 minutes, followed by an additional 15 minutes of cooling under running water.

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

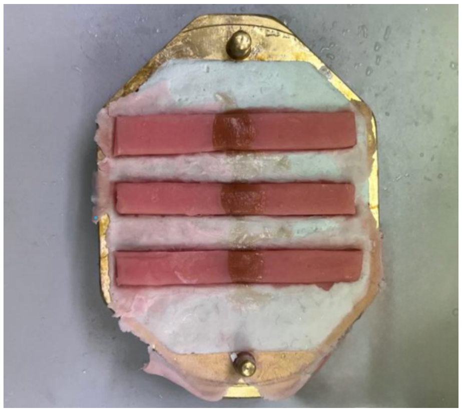

Figure 4. Samples are connected by wax that was replaced by soft-liner.

For dough stage samples, both the PMMA acrylic and the soft liner were packed together inside the dental mold at dough stage. This was followed by curing as mentioned earlier.

In all cases, the preparation process involved careful handling, curing, and cooling to ensure the proper bonding of the soft-liner material with the acrylic or 3D printed resin base.

Study design

The experiment employed 60 specimens in the form of reverse rectangular blocks. 12 specimens were dough stage packed specimens which received no treatment. 24 of the specimens were made from 3D printed resin (Dentona® optiprint® laviva), while the other 24 specimens were made from traditional heat-cured acrylic PMMA resin (Veracril®, Duradent®). In line with Chladek et al. 2014 (Figure 1), the specimens were designed as follows: the entire length of 80 mm of resin (acrylic PMMA or 3D printed) was split into two sections of 40 mm each, separated by 3 mm. The surface was sanded and air-treated, with 25 mm having a thickness of 10 mm. On the other hand, the borders of 15mm were 8mm thick.

Surface treatment

Half of the sample underwent the surface treatment before the bonding of the soft reline material (Molloplast B®). The surface treatment was done using airborne-particle abrasion to the bonded surface by sandblast size 90–150-micron alumina with air pressure of 3- 4 bar. This was to increase the surface roughness to increase the mechanical boned between the materials.

Tensile bond strength test

The testing procedure was carried out at the University of Tikrit College of Engineering using a HOYTOM D1922fI testing machine (Figure 5) with a load cell capacity of 170 KN and a crosshead speed of 0.5mm/min. The readings obtained from the device's digital display represented the maximum load of failure, and the value bond strength was calculated by dividing the maximum load of failure by the cross-sectional area of each sample

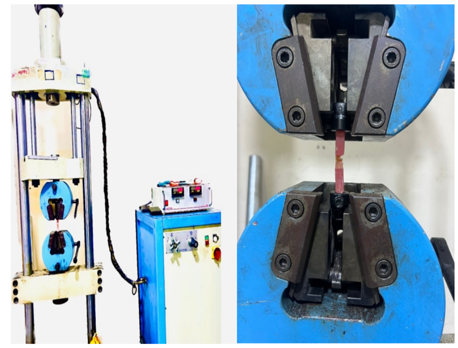

Figure 5. Hoytom testing machine.

Statistical analysis

The statistical analysis involved the use of One-Way ANOVA at P ≤0.05 to reveal if there were any differences between the groups.

Results

Tensile strength test

The adhesion strength of soft liners was found to be significantly higher with 3D printed resin denture bases compared to conventional PMMA. There were highly significant differences between the five groups as revealed by one-way Anova test. Surface treated 3D printed resin samples had the highest value of tensile bond strength (0.2133) followed by untreated 3D printed resin (0.1567), dough stage samples (0.1483), surface treated PMMA samples (0.0950), while the lowest value was recorded for the untreated PMMA samples (0.0875) as indicated in (Tables 2 and 3).

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

Evaluation sample under the Scanning electron microscope (SEM).

All samples were sent for SEM evaluation to determine the morphology of the denture bases before and after treatment by the sand airborne-particle abrasion surface treatment (Figure 6).

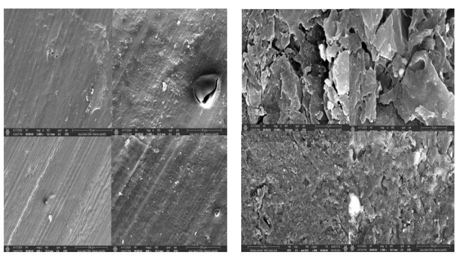

Figure 6. Scanner electron microscopic (SEM), right are the untreated samples, left are the treated samples.

Discussion

This study compares the tensile strength of soft liners between conventional PMMA and 3D-printed resin denture bases. The results show that the soft liner, Molloplast-B®, adheres better to 3D-printed samples compared to conventional acrylic specimens. The tensile bond strength of 3D-printed samples was significantly higher than that of acrylic PMMA samples (traditional and dough stage), particularly when the 3D-printed surfaces were treated with sandblasting and air pressure (0.2133 ± 0.03939 kN/mm²), compared to untreated 3D-printed surfaces (0.1567 ± 0.04677 kN/mm²). This could be related to the printing process which can results in a micro-roughness and irregularities that can improve mechanical interlocking between the soft liner and the 3D printed sample. This roughness increases the surface area available for bonding, promoting stronger adhesion through mechanical bonding (micromechanical interlocking) between the liner and the resin [23]. In contrast, conventional PMMA samples, tends to have a smoother, more homogeneous surface. While sandblasting can induce surface roughness by creating micro-abrasions, the overall roughness of PMMA samples remains lower than that of 3D-printed resin surfaces, which may explain the lower bond strength observed in the untreated acrylic samples [24-29]. In some cases, the sandblasted 3D-printed resin samples showed failure of the soft liner without separating from the bond surface, indicating strong adhesion.

For conventional PMMA, sandblasting improved the bond strength of Molloplast-B® soft liner, with a bond strength of 0.0950 ± 0.03606 kN/mm², compared to untreated PMMA (0.0875 ± 0.02491 kN/mm²). In the case of the 3D-printed resins, surface treatments like sandblasting and air pressure can enhance the bonding sites by increasing surface energy [29, 30]. Sandblasting causes the surface to become microscopically rougher, which can expose more reactive functional groups, increasing the surface's affinity for chemical bonding with the liner [31-33].

Polymerization and the degree of crosslinking in the resin also play a role in determining the bond strength. 3D-printed resins generally exhibit better control over polymerization, allowing for a more uniform and complete curing process [34]. This results in a more stable, tightly packed polymer matrix that can provide superior adhesion. In contrast, PMMA, while also polymerized, may not have as consistent or efficient a curing process as 3D-printed resins, leading to slight variations in surface hardness and cohesion [36].

Traditional PMMA denture bases can also suffer from degradation over time due to the migration of plasticizers, which are used to modify the material's flexibility. This can weaken the surface and reduce its ability to maintain a strong bond with soft liners like Molloplast-B® [37]. 3D-printed resins, however, often have a more

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

stable polymer matrix and less plasticizer migration, which can result in better long-term adhesion [38].

In addition, the surface energy of a material is a key factor in determining how well it bonds to another material. 3D-printed resins typically have higher surface energy compared to PMMA, especially after surface treatments like sandblasting. This increased surface energy improves wettability, which enhances the ability of the soft liner to spread evenly over the denture base and form a stronger bond [39]. In comparison, untreated PMMA has lower surface energy, leading to poorer wetting and a weaker bond [40].

As mentioned above, dough stage samples had better tensile strength values compared to PMMA samples packed by the traditional methods. This is because packing both acrylic and soft liner at the dough stage allows the materials to intermingle or bond more effectively during the molding process. When packed with acrylic at the dough stage, the two materials have a better chance of distributing the applied tensile stress more evenly across the surface. This means that the soft liner can absorb some of the forces, reducing localized stress points. At the dough stage, both acrylic and soft liners are in a form that allows for better molecular interaction [41]. Acrylic resins are typically polymerized during curing, and when mixed with soft liners, the soft liner's material may undergo some crosslinking or slight interaction with the acrylic. This can result in a composite material with enhanced mechanical properties which explains the high tensile strength compared to PMMA [42].

Conclusions

This study provides valuable insights into the adhesive properties of soft-liners when used with different denture base materials. The superior performance of 3D printed resin denture bases in terms of adhesion strength suggests that these materials could offer improved outcomes for patients requiring dentures with soft liners. However, the need for surface treatment, such as sandblasting, remains critical to optimizing the bond strength. These findings contribute to the growing body of evidence supporting the use of advanced manufacturing techniques in prosthodontics and underscore the importance of continued research in this evolving field.

Conflicts of interest

The authors declare no competing interest.

References

1. Boucher, C.O. Complete denture prosthodontics—The state of the art. J. Prosthet. Dent. 2004,92, 309–315.

2. Mahboub, F.; Salehsaber, F.; Parnia, F.; Gharekhani, V.; Kananizadeh, Y.; Taghizadeh, M. Effect of denture cleansing agents on tensile and shear bond strengths of soft liners to acrylic denture base. J. Dent. Res. Dent. Clin. Dent. Prospect. 2017, 11, 183–188.

3. Choi, J.E.; Ng, T.E.; Leong, C.K.; Kim, H.; Li, P.; Waddell, J.N. Adhesive Evaluation of Three Types of Resilient Denture Liners Bonded to Heat-Polymerized, Autopolymerized, or CadCam Acrylic Resin Denture Bases. J. Prosthet. Dent. 2018,120, 699–705.

4. Nowakowska-Toporowska, A.; Raszewski, Z.; Wieckiewicz, W. Color change of soft silicone relining materials after storage inartificial saliva. J. Prosthet. Dent. 2015,115, 377–380.

5. Kutlu, I.U.; Yanikoˇglu, N.D.; Kul, E.; Duymu¸s, Z.Y.; Saˇgsöz, N.P. Effect of sealer coating and storage methods on the surface roughness of soft

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

liners. J. Prosthet. Dent. 2015, 115, 371–376.

6. Bail, M.; Jorge, J.; Urban, V.M.; Campanha, N.H. Surface Roughness of Acrylic and Silicone-Based Soft Liners: In Vivo Study in a Rat Model. J. Prosthodont. 2013,23, 146–151.

7. Kreve, S.; Dos Reis, A.C. Denture Liners: A Systematic Review Relative to Adhesion and Mechanical Properties. Sci. World J.2019, 2019, 1–11.

8. Atsu, S.; Keskin, Y. Effect of silica coating and silane surface treatment on the bond strength of soft denture liner to denture base material. J. Appl. Oral Sci. 2013, 21, 300–306.

9. Valentini, F.; Luz, M.S.; Boscato, N.; Pereira-Cenci, T. Biofilm formation on denture liners in a randomised controlled in situ trial. J. Dent. 2013, 41, 420–427.

10. Elias, C.; Henriques, F.Q. Effect of thermocycling on the tensile and shear bond strengths of three soft liners to a denture base resin. J. Appl. Oral Sci. 2007,15, 18–23.

11. Emmer, T.J.; Emmer, T.J.; Vaidynathan, J.; Vaidynathan, T.K. Bond strength of permanent soft denture liners bonded to the denture base. J. Prosthet. Dent. 1995, 74, 595–601.

12. Al-Athel, M.; Jagger, R.; Jagger, D. Effect of ageing on the bond strength of a permanent denture soft lining material. J. Oral Rehabil. 2002, 29.

13. 13. Pinto, J.R.R.; Mesquita, M.F.; Nóbilo, M.A.D.A.; Henriques, G.E.P. Evaluation of varying amounts of thermal cycling on bond strength and permanent deformation of two resilient denture liners. J. Prosthet. Dent. 2004, 92, 288–293.

14. Jacobsen, N.L.; Mitchell, D.L.; Johnson, D.L.; Holt, R.A. Lased and sandblasted denture base surface preparations affecting resilient liner bonding. J. Prosthet. Dent. 1997, 78, 153–158.

15. Bulad, K.; Taylor, R.L.; Verran, J.; McCord, J.F. Colonization and penetration of denture soft lining materials by Candida albicans. Dent. Mater. 2004, 20, 167–175. [Google Scholar]

16. Mack, P.J. Denture soft linings: Clinical indications. Aust. Dent. J. 1989, 34, 454–458.

17. El-Hadary, A.; Drummond, J.L. Comparative study of water sorption, solubility, and tensile bond strength of two soft lining materials. J. Prosthet. Dent. 2000, 83, 356–361.

18. Usumez, A.; Inan, O.; Aykent, F. Bond strength of a silicone lining material to alumina-abraded and lased denture resin. J. Biomed. Mater. Res. 2004, 71B, 196–200.

19. Al-Fouzan, A.F.; Al-Mejrad, L.A.; Albarrag, A.M. Adherence of Candida to Complete Denture Surfaces In Vitro: A Comparison of Conventional and Cad/Cam Complete Dentures. J. Adv. Prosthodont. 2017, 9, 402–408.

20. Saber-Sheikh, K.; Clarke, R.L.; Braden, M. Viscoelastic properties of some soft lining materials. II-Ageing characteristics. Biomaterials 1999, 20, 2055–2062.

21. Atalay, S.; Çakmak, G.; Fonseca, M.; Schimmel, M.; Yilmaz, B. Effect of Thermocycling on the Surface Properties of Cad-Cam Denture Base Materials after Different Surface Treatments. J. Mech. Behav. Biomed. Mater. 2021, 121, 104646.

22. Gruber, S.; Kamnoedboon, P.; Özcan, M.; Srinivasan, M. Cad/Cam Complete Denture Resins: An In Vitro Evaluation of Color Stability. J. Prosthodont. 2020, 31, 13246.

23. Goodacre, B.J.; Goodacre, C.J.; Baba, N.Z.; Kattadiyil, M.T.

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

Comparison of denture base adaptation between CAD-CAM and conventional fabrication techniques. J. Prosthet. Dent. 2016, 116, 249–256.

24. Wimmer, T.; Gallus, K.; Eichberger, M.; Stawarczyk, B. Complete denture fabrication supported by CAD/CAM. J. Prosthet. Dent. 2016, 115, 541–546.

25. Botega, D.M.; Sanchez, J.L.L.; Mesquita, M.F.; Henriques, G.E.P.; Consani, R.L.X. Effects of Thermocycling on the Tensile Bond Strength of Three Permanent Soft Denture Liners. J. Prosthodont. 2008, 17, 550–554

26. Chladek, G.; ˙Zmudzki, J.; Kasperski, J. Long-Term Soft Denture Lining Materials. Materials2014,7, 5816–5842.

27. Parvizi, A., Lindquist, T., Schneider, R., Williamson, D., Boyer, D., & Dawson, D. V. (2004). Comparison of the dimensional accuracy of injection-molded denture base materials to that of conventional pressure-pack acrylic resin. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry, 13(2), 83-89.

28. Dohiem, M. M. (2022). Comparison of Bond strength between acrylic based soft liner and two different denture bases (3Dprinted and conventional denture base). Egyptian Dental Journal, 68(1), 659-663.

29. Muddugangadhar, B.C.; Mawani, D.P.; Das, A.; Mukhopadhyay, A. Bond strength of soft liners to denture base resins and the influence of different surface treatments and thermocycling: A systematic review. J. Prosthet. Dent. 2020, 123, 800–806.

30. material article the soft denture liner adhesion to conventional and CAD/CAM processed poly (Methyl methacrylate)Acrylic denture resins –an in – vitro study

31. Dawood A, Marti Marti B, Sauret-Jackson V, Darwood A. 3D printing in dentistry. Br Dent J. 2015 Dec;219(11):521–9.

32. 3D printed dental model using this technologySim J-Y, Jang Y, Kim W-C, Kim H-Y, Lee D-H, Kim J-H. Comparing the accuracy (trueness and precision) of models of fixed dental prostheses fabricated by digital and conventional workflows. J Prosthodont Res. 2019 Jan;63(1):25–30.

33. van Noort R. The future of dental devices is digital. Dent Mater Off Publ Acad Dent Mater. 2012 Jan;28(1):3–12.

34. Barazanchi A, Li KC, Al-Amleh B, Lyons K, Waddell JN. Additive Technology: Update on Current Materials and Applications in Dentistry: Additive Technology. J Prosthodont. 2017 Feb;26(2):156–63.

35. US – TURKEY Workshop on Rapid Technologies, September 24 - 25, 2009

36. Gozalo-Diaz, D. J., et al. (2012). "Impact of 3D printing on the performance of denture bases." International Journal of Prosthodontics, 25(3), 237-244

37. Mutluay, M. M., et al. (2008). "Surface treatments of PMMA denture base resin to improve adhesion of soft denture liners." Journal of Prosthetic Dentistry, 99(5), 393-398.

38. (Anadioti et al., 2018). Anadioti, E., Kane, B. and Soulas, E. (2018). Current and emerging applications of 3D printing in restorative dentistry. Current Oral Health Reports, 5(2), pp.133-139

39. Awad, A.N., Cho, S.H., Kesterke, M.J. and Chen, J.H. (2021). Comparison of tensile bond strength of denture reline materials on denture bases fabricated with CAD-CAM

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

technology. The Journal of Prosthetic Dentistry

40. Braden, M., Wright, P. S., & Parker, S. (1995). Soft lining materials--a review. European Journal of Prosthodontics and Restorative Dentistry, 3(4), 163-174.

41. Saeed F, Muhammad N, Khan AS, Sharif F, Rahim A, Ahmad P, Irfan M. Prosthodontics dental materials: From conventional to unconventional. Materials Science and Engineering: C. 2020 Jan 1;106:110167.

42. Haghi HR, Shiehzadeh M, Gharechahi J, Nodehi D, Karazhian A. Comparison of tensile bond strength of soft liners to an acrylic resin denture base with various curing methods and surface treatments. Int J Prosthodont. 2020 Jan 1;33(1):56-62.

Table 2. Statistical analysis for tensile bond strength.

Vickers microhardness		
Group	Mean	±SD
Acrylic without sandblasting A	0.0875	0.02491
Acrylic with sandblasting B	0.0950	0.03606
3D printed resin without sandblasting C	0.1567	0.04677
3D printed resin with sandblasting D	0.2133	0.03939
Dough stage	0.1483	0.03689
ANOVA: F=22.448; p=0.000 Levene statistics=0.080, p-value=0.923		

Dentistry 3000
Vol 13 No 1 (2025) DOI 10.5195/d3000.2025.785

Table 3. Post-hoc Tukey's test results.

I	J	Mean Difference (I-J)	Standard Error	p-value
Acrylic without sandblasting	Acrylic with	-0.00750	0.01530	0.988
	3D without	-0.06917	0.01530	0.000
	3D with	-0.12583	0.01530	0.000
	Dough stage	-0.06083	0.01530	0.002
Acrylic with sandblasting	Acrylic without	0.00750	0.01530	0.988
	3D without	-0.06167	0.01530	0.002
	3D with	-0.11833	0.01530	0.000
	Dough stage	-0.05333	0.01530	0.008
3D printed resin without sandblasting	Acrylic without\	0.06917	0.01530	0.000
	Acrylic with	0.06167	0.01530	0.002
	3D with	-0.05667	0.01530	0.004
	Dough stage	0.00833	0.01530	0.982
3D with sandblasting	Acrylic without\	0.12583	0.01530	0.000
	Acrylic with	0.11833	0.01530	0.000
	3D without	0.05667	0.01530	0.004
	Dough stage	0.06500	0.01530	0.001