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Original article

Comparative effect of different types of artificial teeth and the effect of different surface treatments on the shear bond strength to CAD/CAM denture base

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ABSTRACT

Background: *Complete tooth loss reduces a patient's quality of life. The most suitable treatment option is complete denture fabrication, which provides an acrylic-based removable prosthesis as a substitute for all dentition and related structures.* ***Purpose:*** *This study aims to evaluate the shear bond strength (SBS) of three types of artificial teeth—acrylic, composite, and computer-aided design and computer-aided manufacturing (CAD/CAM) milled denture teeth—and the effects of three surface treatments: bur roughening, air abrasion (AB), and dichloromethane (DCM).* ***Methods:*** *Milled CAD/CAM denture base resin was used to test three types of denture teeth: acrylic, composite, and milled CAD/CAM. A total of 120 maxillary right central incisors were used, with 40 of each tooth type. Each type was divided into four groups based on the treatment surface: control (no treatment), AB, bur roughening, and DCM. Universal testing equipment was used to measure SBS. Data were statistically analyzed using ANOVA, and Duncan's multiple range test was applied to compare mean values among groups.* ***Results:*** *Acrylic and CAD/CAM milled teeth demonstrated higher SBS compared with composite teeth. Teeth treated with AB and DCM surface treatments exhibited increased SBS across all tooth types compared with the control groups.* ***Conclusion:*** *Acrylic and CAD/CAM milled teeth show superior SBS compared with composite teeth. AB and DCM treatments effectively enhance SBS in all types of teeth.*

Keywords: *artificial teeth; denture base; denture teeth; shear bond strength; surface treatment*
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INTRODUCTION

Full tooth loss substantially impacts the esthetics, acoustics, and mastication of the articular region, resulting in a lower quality of life for patients. The most practical treatment option is the preparation of complete dentures, where the edentulous person is provided with a removable acrylic-based denture that acts as a replacement for all teeth and accompanying structures.[1,2]

Artificial teeth are an essential component of prostheses. Various materials, including acrylic, composite, and porcelain, have been employed with varying degrees of success.[3] The most common issue affecting denture function is the separation of the prosthetic teeth from the denture. This problem may occur due to excessive chewing force, which increases the risk of prosthetic tooth displacement.[4] Tooth separation is believed to account for 22%–30% of denture repairs, with the front portion being the most prone to separation.[5]

Dentures can be created using computer-aided design and computer-aided manufacturing (CAD/CAM) or 3D printing, in addition to the traditional methods of heat-cured and self-curing denture fabrication. CAD/CAM dentures involve the milling of the acrylic denture base, followed by bonding traditional or CAD/CAM-milled dentures to the denture base with a bonding agent.[6] Digital denture production technologies, such as CAD/CAM, reduce the steps involved in connecting teeth to the denture base resin (DBR) during the heat polymerization process, producing an ideal bond with a cross-linked polymer system.

According to one study, selecting the most appropriate acrylic denture teeth and DBR may prevent prosthesis

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failure and associated repairs, saving the patient time and money.[7] A denture base can also be manufactured as a single block using CAD/CAM technology, bonding prosthetic teeth or CAD/CAM-milled teeth using a suitable adhesive or through cold or thermal polymerization, with most manufacturers recommending a bonding agent as the best option.[8]

Several modifications can be made to the ridge lap portion of artificial teeth, such as chemical or mechanical alterations, to increase or strengthen the contact between denture teeth and an acrylic resin denture base.[9] Mechanical preparation may involve roughening the surface to improve bond strength. This treatment removes the glaze from the tooth and enhances the bonding surface area by creating grooves and holes. Chemical agents such as polymethyl methacrylate (PMMA) monomer, acetone, ethylene, dichloromethane (DCM), and non-polymerizing solvents like chloroform or ethyl acetate can also be used to treat the tooth surface.[10]

The shear bonding force test is the most common method for determining the binding strength between prosthetic teeth and a denture base.[11] The present study aimed to establish the shear bond strength (SBS) of three types of teeth—acrylic, composite, and CAD/CAM-milled—to a CAD/CAM DBR.

MATERIALS AND METHODS

Preparation of rectangular stone base: A plastic mold was used to prepare a stone base (18 mm thickness, 90 mm length, and 60 mm width). This plastic mold was placed on the surveyor table, which was positioned and fixed parallel to the horizontal plane (the zero plane).

Figure 1. A milling machine is used to cut the ridge lap part of synthetic teeth.

The dental stone (Elite Rock, Zhermack, Mundka Industrial Area, India) was mixed according to the manufacturer's instructions (water/powder ratio: 21 ml/100 g) and then poured into the plastic mold. The incisal portion of the central incisors was embedded in the stone (about 4 mm of the incisal edge) before setting in such a way that only the ridge lap of the artificial tooth appeared outside the stone mixture. The long axis of each incisor was positioned perpendicular to the stone base using a dental surveyor (SJK Technic, USA) with a surveyor's analyzing rod. Using this method, one incisor was placed at the center of the plastic mold, and four incisors were placed at the periphery of the mold. After the dental stone was set, the stone was removed from the plastic mold. Using this approach, all the incisors were placed and fixed in a standard position. Eight stone bases were prepared for the acrylic teeth, and eight stone bases were prepared for the composite teeth.

Ridge lap surface preparation: A milling machine was used to prepare the artificial teeth, allowing only horizontal movement of the handpiece. The stone base was placed on the table of the milling machine and fixed in position with screws. A handpiece with a constant speed of 4,000 rpm and a disk were used to cut the ridge lap portion of the synthetic teeth in a single direction (Figure 1).

Preparation of the CAD/CAM specimens: The physical CAD/CAM samples were created in SketchUp Pro (2020) and saved as standard tessellation language (STL) files. The denture base samples were 5 mm in diameter and 2.5 mm thick, which is the same as the denture base thickness specified in ADA Specification No. 12, 1975. The STL files were then imported into CAD software (Exocad Dental DB), which was linked to a milling machine for manufacturing the milled denture base from pre-PMMA blocks (Ivotion Base, Ivoclar, Germany). Polymerized (SPEC 98.5x30 monolayer pink shade) blocks were milled using CAD/CAM milling equipment (MAXX DS 200-5Z, Korea) with grinding burs (2.50, 1, and 0.5 mm) through a subtractive dry grinding process with five axes.[12–15]

CAD/CAM teeth preparation: The virtual CAD/CAM design of the milled tooth was obtained by scanning the right maxillary central incisor of the investigated teeth with an Ios Hero U.S.A. dental scanner. The prepared scanned right maxillary central incisor was then stored and converted into an STL file.[16] The STL files were imported into a CAD application (Exocad Dental DB) and connected to milling equipment to manufacture the milled specimens (Telio CAD, Schaan, Germany).

Surface treatment: Surface treatment was performed for each tooth type. The ridge lap surfaces of the first subgroups were treated with particles of alumina (Edelkorund, Germany), and the samples were placed in an air abrasion (AB) machine (Twinpen Dental Sand Cleaning Machine, Korea) for approximately 15 seconds. For the roughening subgroups, tooth surfaces were roughened with a straight, rounded-end blue diamond bur (314.142.514 - 882FG-014 Diamond Burs, Verdent, Poland) in one direction. The tooth was maintained parallel to the tooth surface for 5 seconds

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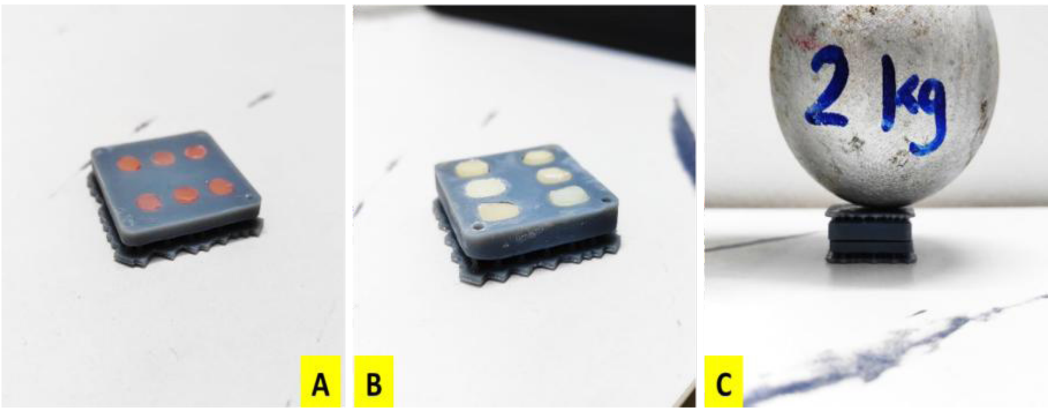

Figure 2. Bonding of the specimens: (A) Denture base material index, (B) Teeth specimen index, (C) Bonding of the two specimens.

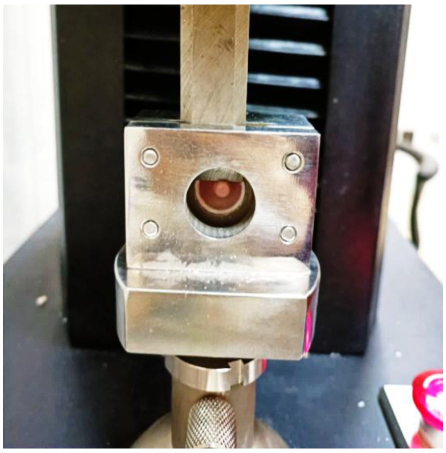

Figure 3. Shear bond strength testing apparatus.

during the roughening process. For the DCM subgroups, the teeth were treated with methylene chloride (Central Drugs House, Delhi, India). DCM was applied using a small brush and left for approximately 10 seconds before bonding the teeth to the CAD/CAM denture base specimen.[10]

Specimen bonding: An index was constructed and saved as an STL file to standardize the bonding of the tooth to the CAD/CAM DBR sample. The index was then printed using 3D printed material (3D Temp Resin, Sendrex, Turkey) and a 3D printer (CREALITY). Two indices were created: one for the teeth and one for the denture base sample. The teeth and denture base were inserted into the index holes. The bonding agent (Ivotion Bond) was mixed according to the manufacturer's recommendations and applied to the surface of the denture with an applicator syringe within 10 minutes, following the manufacturer's instructions.

The CAD/CAM denture base indication was then placed on top of the tooth. The ridge lap surface of the teeth served as the second indicator. A 2 kg load was placed on the indicator to hold the components in place until the bonding agent was set. To complete the polymerization, the samples were held at room temperature for approximately 12 hours without any stress (Figure 2).[10]

SBS testing: After completing the samples, each sample was embedded in a cylindrical plastic ring with a diameter of 1.4 cm and a height of 4 cm. The ring was placed over each sample, and a mixture of cold-cured acrylic resin was poured and left to set. The samples were then placed inside a special holder to test the SBS. The bonding strength between the denture base and the prosthetic teeth was tested in shear mode at a cross-head speed of 1 mm/min using universal testing equipment (Figure 3).[16,17]

SPSS software was used to analyze the results. A Shapiro–Wilk test of normality was initially performed within the normal distribution (P-value < 0.05) to assess the SBS data of the CAD/CAM milled denture base. The results indicated that the data was parametric and normally distributed.

RESULTS

The results of SBS (MPa) showed the mean and standard deviation for the CAD/CAM denture base across three different types of teeth and surface treatments (Table 1). The effect of tooth type (acrylic, milled, and composite CAD/CAM) on SBS demonstrated a significant difference ($P = 0.00001$) between the groups (Table 2). Acrylic and CAD/CAM milled teeth had higher mean values than composite teeth. There was no significant difference in SBS between acrylic teeth and CAD/CAM teeth, while composite teeth showed significantly lower SBS compared with acrylic and CAD/CAM teeth (Figure 4).

The effect of surface treatments (air abrasive, roughening, and DCM) on the SBS of acrylic teeth showed a highly significant difference ($P < 0.05$) between the groups (Table 3). There was no significant difference between the control group and the bur roughening group. The air abrasive and DCM-treated groups showed no significant difference from each other but had higher SBS values than the control and bur roughening groups (Figure 5).

The influence of surface treatment (air abrasive, roughening, and DCM) on the shear bond force of the

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Table 1. Descriptive statistics of CAD/CAM milled denture base

	CAD/CAM Milled teeth (n = 10) (mean ± SD)		
	Acrylic	Composite teeth	CAD/CAM milled teeth
Control	11.5 ± 0.35	5.7 ± 0.17	10.7 ± 0.34
Air-abrasive	27.25 ± 0.91	6.6 ± 0.21	15.3 ± 0.57
Bur-roughening	12.2 ± 0.43	4.6 ± 0.0.3	12.5 ± 0.57
DCM	28.7 ± 0.8	9 ± 0.3	16.9 ± 0.37

n = Samples number, SD = Standard deviation

Table 2. Shear bond force statistical test (MPa) among groups of teeth

	Squares sum	Df	Square mean	F	Sig
Between groups	202.8120	2.0	101.4	11.58	0.00001
Within groups	236.389	27	8.8		
Total	439.201	29			

MPa = mega Pascal, one-way ANOVA

Table 3. Shear bond strength (MPa) comparing groups of acrylic tooth surface treatment

		Squares sum	Df	Mean square	F	Sig
Acrylic Teeth	Between groups	2616.1	3	872	19.64	0.0001
	Within groups	1598.5	36	44.4		
	Total	4214.7	39			

Df = degree of freedom, one way ANOVA

Table 4. Shear bond strength (MPa) between groups

		Squares sum	Df	Mean	F	Sig
Teeth Composite	Between groups	107.8	3	35.94	8.2	0.00001
	Within groups	157.34	36	4.37		
	Total	265.16	39			

Df = degree of freedom, MPa = mega Pascal

Table 5. Shear bond strength (MPa) among groups of CAD/CAM milled teeth

		Squares sum	Df	Mean	F	Sig
CAD/CAM	Between groups	226.880	3	75.627	3.376	0.029
	Within groups	806.495	36	22.403		
	Total	1033.375	39			

MPa = mega Pascal, Df = degree of freedom, one way ANOVA

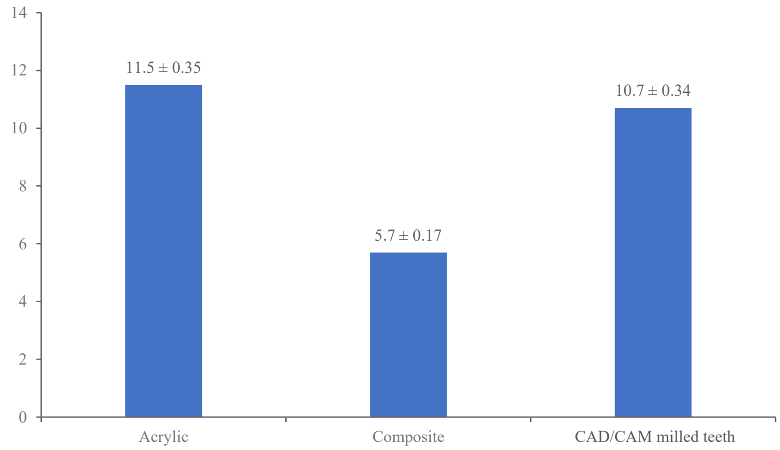

Figure 4. Duncan's multiple range test with three different types of teeth glued to CAD/CAM milled denture bases. Bars with similar letters indicate non-significant differences (P > 0.05), while bars with different letters indicate significant differences (P < 0.05).

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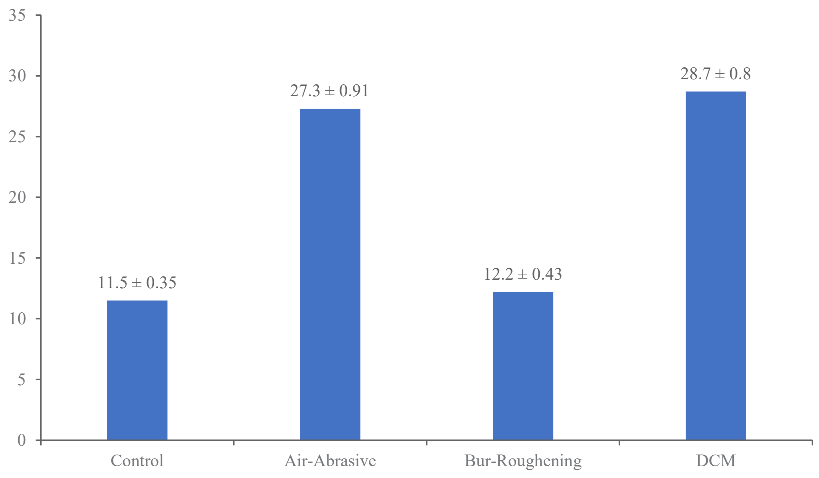

Figure 5. Surface treatment of acrylic teeth glued to CAD/CAM milled denture bases. Bars with similar letters indicate non-significant differences (P > 0.05), while bars with different letters indicate significant differences (P < 0.05).

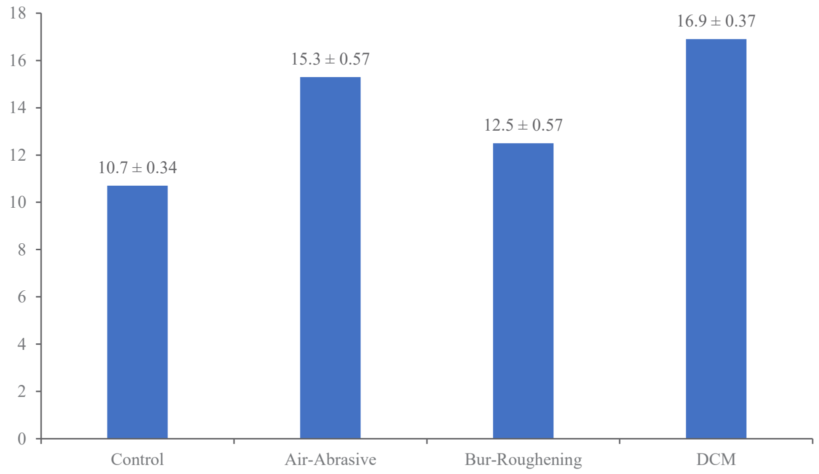

Figure 6. Surface treatment of composite teeth bonded to CAD/CAM milled denture bases. Bars with similar letters indicate non-significant differences (P > 0.05), while bars with different letters indicate significant differences (P < 0.05).

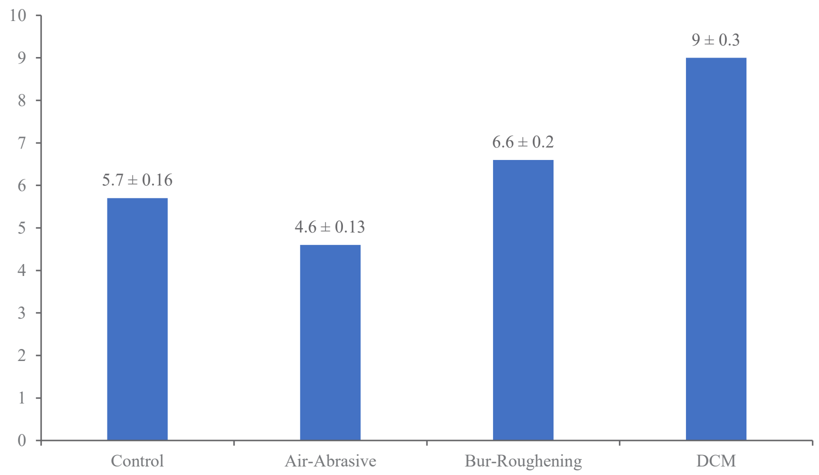

Figure 7. Surface treatment of CAD/CAM milled teeth. Bars with similar letters indicate non-significant differences (P > 0.05), while bars with different letters indicate significant differences (P < 0.05).

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composite tooth showed a significant difference ($P < 0.05$) between groups (Table 4). As indicated in Figure 6, Duncan's multiple range test revealed that the group associated with teeth treated with DCM and air abrasives had no significant difference from each other but had a higher mean value than the control group. The bur roughening group showed no significant difference from either the air abrasive or DCM-treated groups.

The influence of surface treatment (air abrasive, roughening, and DCM) on the SBS of CAD/CAM milled teeth revealed a significant difference ($P < 0.05$) across the groups (Table 5). The group bonded to DCM-treated teeth had a higher mean value compared with the bur roughening, air abrasive, and control groups. The control group showed no significant difference from the air abrasive or bur roughening groups (Figure 7).

DISCUSSION

The purpose of this laboratory study was to investigate how different tooth types and surface treatments affected the SBS of a CAD/CAM milled denture base. Three types of teeth for pre-polymerized CAD/CAM denture bases (acrylic, CAD/CAM milled teeth, and composite teeth) were used, along with three surface treatments (AB, diamond roughness by bur, and DCM solvent) applied to the ridge lap surfaces of the teeth. Our findings show considerable differences in SBS among the three types of denture teeth bonded to the CAD/CAM DBR, as well as the effects of surface treatment for each tooth type.

The average SBS of acrylic teeth and CAD/CAM milled teeth was higher in the untreated (control) groups compared with composite teeth. The ability of acrylic teeth to form a chemical bond with the denture base may explain these findings. This chemical bond is generated by monomer absorption into the surface layers of the teeth. When comparing monomer diffusion during the bonding process, acrylic teeth exhibited a higher diffusion rate than cross-linked and composite teeth.[18]

While composite teeth have lower SBS than acrylic teeth, this may be due to the difference in polymer type between composite (urethane dimethacrylate) and CAD/CAM DBR (PMMA), as well as the bonding agent (PMMA-based bonding material). Consequently, the chemical bond between composite teeth and CAD/CAM DBR differs from that of acrylic teeth. According to these findings, acrylic and CAD/CAM milled teeth have a higher average SBS value than composite teeth.[10]

When bonded to a CAD/CAM denture base, there is no significant difference in SBS values between CAD/CAM milled teeth and acrylic teeth. This result can be explained by the fact that CAD/CAM milled teeth and denture bases are made of pre-polymerized materials and are available as grinding disks/discs. The bond quality is thought to be governed by the availability of free monomers during processing, as the binder spontaneously polymerizes PMMA. Adequate monomer availability is essential for bonding between polymerized denture teeth and polymerized DBR because this monomer can penetrate and integrate into the polymer chains of the denture teeth.[16]

The ability of the monomer to permeate denture resin, as indicated by the presence of swelling, is connected to the bonding efficiency between denture teeth and the DBR. The extent of swelling is proportional to the degree of polymer cross-linking.19 As a result, if the polymer is highly cross-linked, such as in CAD/CAM acrylic materials (denture base and teeth), the bond between the teeth and denture base is strengthened. However, this conclusion contrasts with the findings of Han et al.,[20] who stated that while an increased degree of cross-linking enhances hardness and abrasion resistance, it also inhibits the penetration of methyl methacrylate monomer from the DBR into the resin tooth matrix.

Our study found that CAD/CAM adhered to teeth with air abrasive surface treatment, which exhibited high SBS across all tooth types. The roughness of the ridge surface of acrylic teeth causes the breaking of the glassy surface and increases the surface area available for bonding to the denture base, as expected. AB removes the tooth's saturated surface layer, exposing the underlying layer.[21] As a result, this layer has high surface energy, and the freshly alumina-blown resin surface exhibits higher free surface energy than untreated surfaces. This may lead to improved bond strength.[22]

This finding aligns with the results of Boonpitak et al.,[23] who discovered that AB treatment of the lap region of denture teeth and DBRs increased SBS regardless of polymerization type. Our findings also show that DCM-bonded CAD/CAM denture bases (CH_2Cl_2—a biological solvent that can dissolve the polymer template of PMMA) exhibit strong SBS across all tooth types.

DCM increases the permeability of the dental acrylic resin's outer surface, allowing the polymerizable acrylic resin monomer in the base to penetrate the synthetic teeth and form a substantial cross-linked polymer network. Enhanced bond strength may also result from the micro-roughness generated by DCM on tooth surfaces, which leads to improved mechanical bonding.

This finding is consistent with Jain et al.,[24] who found that DCM improves the dental bond strength of both traditional and highly bonded acrylic teeth, increasing it up to three times the initial rate of untreated teeth. However, it is inconsistent with Helal et al.,[10] who discovered that none of the surface treatment procedures enhanced SBS between prosthetic teeth and milled CAD/CAM denture bases.

In conclusion, this study found that CAD/CAM adhered to teeth with air abrasive surface treatment, which exhibited high SBS across all tooth types. The roughness of the ridge surface of acrylic teeth causes the breaking of the glassy surface and increases the surface area available for bonding to the denture base, as expected. AB removes the tooth's saturated surface layer, exposing the underlying layer. As a result, this layer has high surface energy, and

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the freshly alumina-blown resin surface exhibits higher free surface energy than untreated surfaces. This may lead to improved bond strength. The DCM increases the permeability of the dental acrylic resin's outer surface, allowing the polymerizable acrylic resin monomer in the base to penetrate the synthetic teeth and form a substantial cross-linked polymer network. Enhanced bond strength may also result from the micro-roughness generated by DCM on tooth surfaces, which leads to improved mechanical bonding. The DCM improves the dental bond strength of both traditional and highly bonded acrylic teeth, increasing it up to three times the initial rate of untreated teeth.

REFERENCES

1. Prots H, Rozhko M, Paliichuk I, Nychyporchuk H, Prots I. Study of bone resorption as a risk factor in dental implantation in patients with generalized periodontitis. Georgian Med News. 2023; (335): 73–8.
2. Al-Dwairi ZN, Tahboub KY, Baba NZ, Goodacre CJ, Özcan M. A comparison of the surface properties of CAD/CAM and conventional polymethylmethacrylate (PMMA). J Prosthodont. 2019; 28(4): 452–7.
3. Peeters HH, Judith ET, Silitonga FY, Zuhal LR. Visualizing the velocity fields and fluid behavior of a solution using artificial intelligence during EndoActivator activation. Dent J. 2022; 55(3): 125–9.
4. Al-somaiday HM, Moudhaffer MAM, Alsamydai MJ. Comparing the shear bond strength with acrylic teeth, hardness, surface roughness and cost-benefit of three different denture base materials. Biomed Pharmacol J. 2018; 11(4): 2181–90.
5. Choi JJE, Uy CE, Plaksina P, Ramani RS, Ganjigatti R, Waddell JN. Bond strength of denture teeth to heat-cured, CAD/CAM and 3D printed denture acrylics. J Prosthodont. 2020; 29(5): 415–21.
6. Suratno IR, Dwiandhono I, Purnama RB. Pomegranate (Punica granatum L.) gel extract as an antioxidant on the shear bond strength of a resin composite post-bleaching application with 40% hydrogen peroxide. Dent J. 2021; 54(2): 87–91.
7. Almulayounis M, Al-Ali A. Effect of heat treatment duration and cooling conditions on tensile properties and hardness of selective-laser-melted cobalt-chromium alloy. Georgian Med News. 2023; (337): 38–42.
8. Infante L, Yilmaz B, McGlumphy E, Finger I. Fabricating complete dentures with CAD/CAM technology. J Prosthet Dent. 2014; 111(5): 351–5.
9. Dandiwal N, Kumar S, Jain S, Aggarwal R, Singla N, Reddy NK. Evaluation of Shear bond strength of three different acrylic resin and artificial denture teeth with and without monomer application. J Contemp Dent Pract. 2019; 20(1): 94–100.
10. Helal MA, Al-Gazzar AE, Abas M, Akhtar S, Gad MM, Al-Thobity AM. Comparative effect of different surface treatments on the shear bond strength of two types of artificial teeth bonded to two types of denture base resins. J Prosthodont. 2022; 31(5): 427–33.
11. Sirisha K, Ravishankar Y, Ravikumar P, Rambabu T. Validity of bond strength tests: A critical review-Part II. J Conserv Dent. 2014; 17(5): 420.
12. Hafez AMF, Abdelrahim R, Abdel Hameed B. Assessment of hardness, flexural modulus, and bond strength of acrylic denture bases fabricated by 3D digital methods. Egypt Dent J. 2021; 67(3): 2559–66.
13. Vásquez-Niño AF, Ochoa-Alzate JR, Osorio-Amariles D, Rodríguez-Quirós HA. Denture base polymers for analog and digital manufacturing: comparative study of the flexural strength, elastic modulus, and compressive strength of their mechanical properties. Rev Fac Odontol. 2021; 33(1): 6–16.
14. Jain S, Sayed M, Ahmed WM, Halawi AHA, Najmi NMA, Aggarwal A, Bhandi S, Patil S. An in-vitro study to evaluate the effect of denture cleansing agents on color stability of denture bases fabricated using cad/cam milling, 3D-printing and conventional techniques. Coatings. 2021; 11(10): 1177.
15. Al-Dwairi ZN, Tahboub KY, Baba NZ, Goodacre CJ. A comparison of the flexural and impact strengths and flexural modulus of CAD/CAM and conventional heat-cured polymethyl methacrylate (PMMA). J Prosthodont. 2020; 29(4): 341–9.
16. Al-Shaibani M, Al-Saffar M, Mahmood A. The impact of aloe vera gel on remineralization of the tooth and its effect against Enterococcus faecalis: an in vitro study. Georgian Med News. 2023; (338): 63–8.
17. Ahmed AA, Hasan RH. Evaluation of tensile bond strength of artificial teeth to nano particles reinforced heat cured denture base material. J Glob Sci Res Med Dent Sci. 2022; 7(1): 2022–7.
18. Kane B, Shah KC. In vitro analysis of shear stress: CAD milled vs printed denture base resins with bonded denture tooth. J Prosthodont. 2023; 32(S1): 29–37.
19. Meloto CB, Silva-Concílio LR, Rodrigues-Garciai RCM, Canales GT, Rizzatti-Barbosa CM. Effect of surface treatments on the bond strength of different resin teeth to complete denture base material. Acta Odontol Latinoam. 2013; 26(1): 37–42.
20. Han SY, Moon Y-H, Lee J. Shear bond strength between CAD/CAM denture base resin and denture artificial teeth when bonded with resin cement. J Adv Prosthodont. 2020; 12(5): 251.
21. Bahrani F, Khaledi AAR. Effect of surface treatments on shear bond strength of denture teeth to denture base resins. Dent Res J (Isfahan). 2014; 11(1): 114–8.
22. Consani RL, Naoe HT, Mesquita MF, Sinhoreti MA, Mendes WB. Effect of ridge-lap surface treatments on the bond of resin teeth to denture base. J Adhes Dent. 2011; 13(3): 287–93.
23. Boonpitak K, Wongkamhaeng K, Sanpanyawai P, Somsat N, Aunaumporn A, Klaisiri A, 1. Experimental article comparative effect of different surface treatments on the shear bond strength between 3D-printed artificial acrylic teeth and 3D-printed denture based resins. J Int Dent Med Res. 2022; 15(4): 1416–22.
24. Jain G. The effect of different chemical surface treatments of denture teeth on shear bond strength: a comparative study. J Clin Diagnostic Res. 2014; 8(6): ZC15-8.

DOI: 10.20473/j.djmkg.v58.i1.p74–80