2025 • Vol. 3, No. 1 • (**Special Issue**)
pp. 26-32
Future Dental Research (FDR)

Print ISSN: 3006-0516
Online ISSN: 3006-0354
NABEA AL-AJYAL FOUNDATION PRESS
Future Dental Research (FDR)

Evaluation of the Shear Bond Strength of Denture Soft Liner Reinforcement with Copper Oxide Nanoparticles

Maha H. Dewan[1,*], **Hawraa K. Aziz**[2]

[1] *Department of Prosthetics Dental Techniques, College of Health and Medical Techniques, Al-Mustaqbal University, Hillah 51001, Iraq*

[2] *College of Health and Medical Techniques, Middle Technical University, Baghdad 10011, Iraq*

**Corresponding Email:* Maha.Hussain.Dewan@uomus.edu.iq

Access this article online

ORIGINAL A R T I C L E
Received: 05.04.2025 **Revised:** 20.05.2025
Accepted: 14.06.2025
DOI: 10.57238/fdr.2025.152576.1004

OPEN ACCESS

ABSTRACT

Aim: This research aims to analyze an alteration in the shear bond strength of soft denture lining materials by the addition of copper oxide nanoparticles with various percentages. Materials and Methods: Three groups of 10 were formed from the total of 30 acrylic block samples (25 mm × 25 mm × 3 mm). Ten specimens without any added CuO Nano Filler made up the control group, or Group A; 10 specimens in the second group (Group B) were modified with 0.3% CuO added Nano Filler, while the 10 specimens in the last group (Group C) had 0.5% CuO added Nano Filler. The universal Instron device was utilized to measure each sample, which tested the shear bond strength. In addition, the utilization of a statistical package for social science (SPSS) and the ANOVA evaluation for a statistical testing of the information and a determination of the truthfulness of the statistical hypothesis, respectively. Results: Descriptive statistics for the shear bond strength for the aforemen-tioned specimen categories, which are detailed in Table 1 have shown a change in mean values between groups A, B, and C, with group C being the lowest out of the three groups (0.31±0.043). Conclusions: There is an inverse relationship between the addition of CuO Nano Filler and the shear bond strength.

Keywords: Abutment Interfaces, Abutment Types, Prosthesis Retention

1 Introduction

SEVERAL clinical trials were conducted in which resilient liner materials were used for removable complete or partial dentures in edentulous patients to reduce the feeling of pain and soreness for the underlying supporting mucosa, to improve retention, stability, and comfort during chewing, to significantly improve speech, and to wear the denture for a longer period of time [1]. Soft denture liners should possess high compatibility, permanent soft-ness, viscoelasticity, no color or dimensional changes during or post-processing, an adequate look, abundant mechanical strength, and tear resistance. Resistance, low hydro-absorption and solubility, scrape resistance, and fungal growth. Inhibition, sufficient bonding to (PMMA) to circumvent separating while in use [2].

For over a century, materials for soft denture lining have been implemented and used in medicine. Its superiority in conforming and distributing mastication forces over hard acrylic resins makes it somewhat of a shock absorption layer among denture occluded surfaces and the underlying oral mucosa [3]. Bonding failure within the denture bases and a lining material is seen as a significant issue of using these materials because it provides a surface that encourages and retains bacterial and fungal development, as well as plaque and calculus production [4]. Several attempts have been made to saturate the filler agents into soft liner material such as nanoparticles of ZrO_2 or Chitosan Nano powder, CuO, certain plant extracts such as Aloe Vera and Coconut Oil, or some chemicals such as Chlorhexidine Diacetate in the form of salt [5]. Disease diagnosis, such as cancer, therapy, prevention, restorative, and implant. Dentistry, as well as molecular imaging, are all examples of an application and

Implementation of Nanotechnology in Medicine [6]. Nanomaterials vary in size (1–100 nm) and composition, which can be natural or manufactured [7]. Lately, the utilization of copper oxide nanoparticles in various areas of scientific and technological use can be attributed to their adequate thermal and electrical conductivity as well as their low cost [8]. Processing these materials can be done both naturally and through chemical synthesis [9]. Moreover, these nanoparticles are formed by the process of oxidation in air or water. Copper particles are like other metal nanoparticles, which come in various shapes and sizes. High surface area to volume ratio. And a distinctive distribution. Possessing these features further improves many functions and properties, such as the Bio-physiological and chemical functionality, the antimicrobial activity, as well as the biocompatibility of these nanoparticles. The antimicrobial and biofilm formation inhibition properties of CuO nanoparticles were reported [10]. The antimicrobial activity of these nanoparticles is further improved upon by their high surface area-to-volume ratio [11]. When compared to silver/gold particles, CuO is cheaper and can be easily mixed and manipulated with polymers due to its stability [12].

2 Materials and Methods

2.1 *Grouping of samples*

Three groups of 10 were formed from the total of 30 acrylic block samples (25mm × 25mm × 3mm). Ten specimens without any added CuO Nano filler made up the control group, or Group A; 10 specimens in the second group (Group B) were modified with 0.3% CuO added Nano filler, while the 10 specimens in the last group (Group C) had 0.5% CuO added Nano filler.

2.2 *Designing of specimens*

A plastic pattern with dimensions of 75mm length, 25mm width, and 5 mm depth, with a stopper of depth around 3 mm, was used to fabricate acrylic blocks for the shear bond test between denture base and soft lining material. Every sample is composed of two acrylic blocks set over each other, creating an area between them that measures 25 mm in length, 25 mm in width, and 3 mm in depth for application of soft lining materials. The handle should possess a thickness equal to 13 mm to have a maximum clamping of samples with an Instron testing machine [5]. This can be shown in Figure 1.

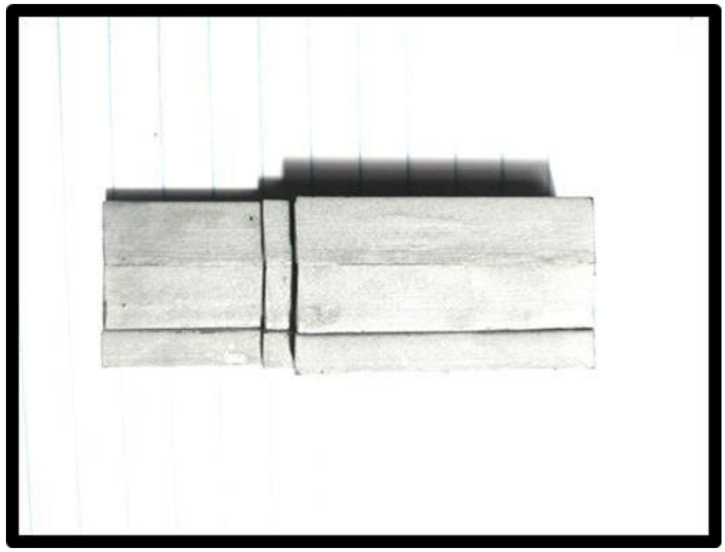

Fig. 1. Plastic specimens used in this study for the preparation of molds.

2.3 *Mould prepared*

The plastic patterns were fabricated with measurements of 75mm length, 25mm width, and 5 mm depth with 3mm depth. An additional silicone impression material was used to invest the plastic pattern. After silicone setting, a freshly mixed dental stone which was mixed according to the manufacturer's instructions (W/P ratio: 25ml/100g) and poured in the lower half of the flask, then the plastic pattern with the silicone mold were invested, and the remaining fabrication procedures for the silicone-stone mold were completed to create a silicone mold as shown in Figures 2 and 3.

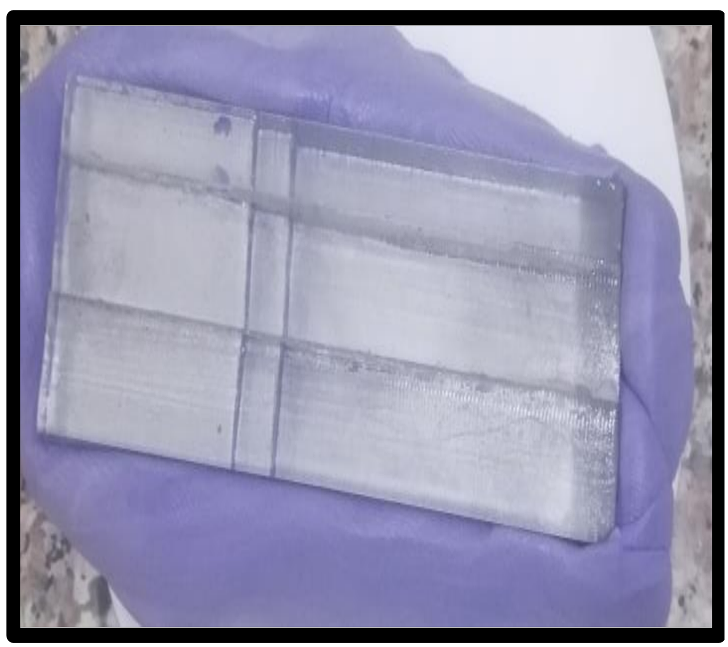

Fig. 2. Silicon mould.

Fig. 3. Flasking of the silicon mould.

2.4 *Addition of Nano-filler*

In two groups, Nano-filler powder was added by weight, with 0.3% and 0.5% to the liquid [13]. A sensitive balance with high accuracy was used, as seen in Figure 4, the filler added into the liner monomer was dispersed for 3 minutes by employing a probe sonication apparatus at 120 W and 60 KHz (14). Figure 5 had homogeneous mixing.

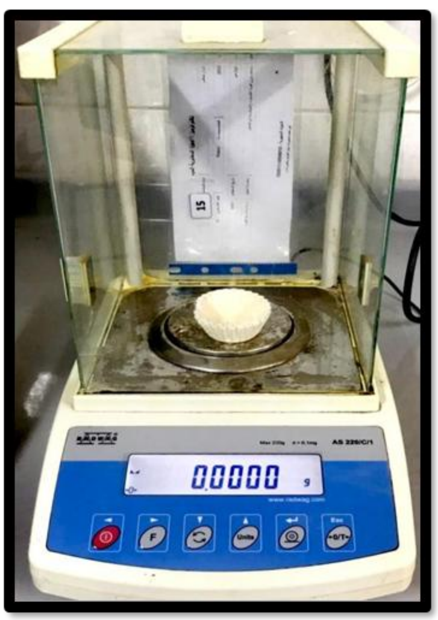

Fig. 4. Sensitive balance.

2.5 *Proportioning and mixing of heat-cure acrylic resin*

Heat-cure acrylic resin was mixed according to the manufacturer's instructions (P/L ratio: 2.2g of powder for each 1ml of liquid monomer). The mixing was done in a dry and clean glass container till the dough stage was reached, the mixture was covered and left.

2.6 *Packing*

When the acrylic resin reached the dough stage, it was packed into the mold space. Then both parts of the flask were gathered and transferred under the hydraulic press with the application of continuous pressure to distribute the acrylic resin equally through the mold space, then the pressure was reduced and the flask was unlocked and the excess material were taken off by sharp knife then both parts of the flask were lastly gathered under pressure till metal to metal contact had been confirmed and left for 5 minutes under press 100Kg/cm^2. Then, the flask was clamped and transferred for curing in the water bath and finishing and polishing of the sample Figure 5.

Fig. 5. Flasking of the silicon mould.

Each specimen consisted of two acrylic blocks that set one over the other Figure 6 forming space with dimension of 25mm length, 25mm width and 3mm depth filled with wax, then invest the acrylic blocks to place them inside a custom-fabricated flask which was poured with newly mixed dental stone to invest totally the acrylic blocks. After setting of dental stone, the cover of the custom-fabricated flask was painted with separating medium and left to dry, then placed over the lower portion and screwed to perform the procedure of wax elimination. Then, hot water with soap was used for cleaning the mold from wax remnants and left to dry.

Fig. 6. Two acrylic blocks that set one over the other.

Then the space which was made between the two acrylic blocks was filled with the soft liner, the flask was placed under continuous application of pressure, then the press was released, and curing in water path, and when cooling open it and do finishing of the sample for testing.

2.7 *Testing procedure*

Testing procedure was performed at the University of Technology by utilizing an Instron testing machine shown in Figure 7, with a load cell capacity of one thousand kilograms and the speed of cross head equal to 0.5mm/min.

According to ASTM specification D-638, 1986 formula, the readings that were obtained from the digital display of the device represented the maximum load of failure, while the value of bond strength was measured by dividing the maximum load of failure by the cross-sectional area of each specimen was (25 mm* 25 mm=625 mm).

Fig. 7. Instron testing machine.

Formula:

$$\text{The value of bond strength (N/mm2)} = \frac{\text{The maximum load of failure}}{Cross - sectional\ area}$$

3 Results

This study investigated using the Statistical Package for the Social Sciences (SPSS) software, a version used for 70 samples. We also utilized Microsoft Excel 2016 for the graphical presentation.

The descriptive statistics for sheer bond strength across all experimental groups, as presented in Table 1, indicated that the mean value for the 0.5% CUONPs group was the lowest among all groups (0.31±0.043).

Levene's test for homogeneity of variances of shear bond strength across all experimental groups indicated homogeneity, revealing no statistically significant variation among the variances of the groups, as presented in Table 2. The one-way ANOVA test demonstrated a statistically significant difference across the groups, with a p-value of 0.001, as illustrated in Table 3 below.

The source of statistical difference was further investigated by analysis of data using the Tukey HSD test, as in Table 4 and Figure 8. The Table illustrated a statistically significant difference between each of the three groups with a p-value of 0.001.

TABLE 1. Descriptive statistics for sheer bond strength for all experimental groups.

Groups	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Control group	.355671	.0278449	.0088053	.335752	.375590	.3202	.4128
0.3% CUONPs group	.308740	.0151827	.0048012	.297879	.319601	.2857	.3312
0.5% CUONPs group	.265733	.0222597	.0070391	.249810	.281657	.2354	.2982
	.310048	.0431445	.0078771	.293938	.326159	.2354	.4128

TABLE 2. Test of Homogeneity of Variances for shear bond strength group.

		Levene Statistic	df1	df2	Sig.
Shear bond strength group	Based on the Mean	1.660	2	27	.209

TABLE 3. One-way ANOVA test for shear bond strength of all experimental groups.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.040	2	.020	40.434	0.001
Within Groups	.014	27	.001		
Total	.054	29			

TABLE 4. Tukey HSD.

(I) Groups	(J) Groups	Mean Difference (I- J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control Group	0.3% CUONPs	.0469310*	.0100045	0.001	.022126	.071736
	group					
Control group	0.5% CUONPs group	.0899381*	.0100045	0.001	.065133	.114743
0.3% CUONPs Group	0.5% CUONPs group	.0430070*	.0100045	0.001	.018202	.067812

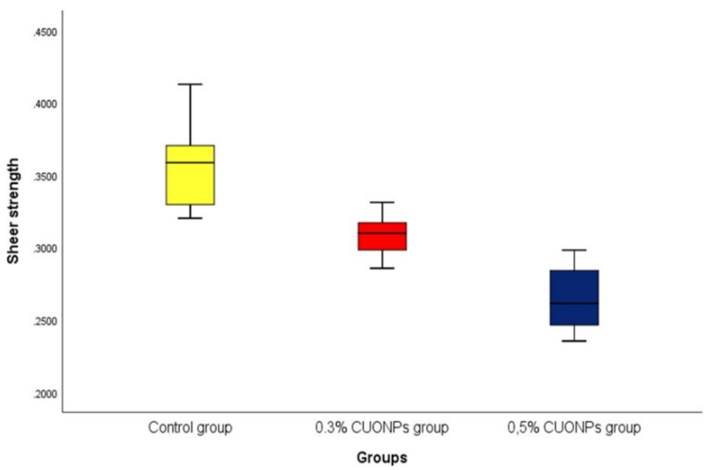

Fig. 8. Tukey HSD.

4 Discussion

Soft denture lining materials are durable substances that ensure uniform distribution of functional load across the residual ridge, hence preventing stress concentrations in the denture-bearing area [15]. Following a duration of usage in the oral cavity, the adhesion between the denture base and the soft denture liner deteriorates or fails. The failure of the bond fosters an environment conducive to bacterial and fungal colonization, hence diminishing the longevity of the relining material. [15].

The shear bonding strength was used to evaluate the connection strength between soft denture base and denture lining material because the forces that are subjected to soft denture lining material in a clinical state are characterized more carefully by shear and tear [16].

The result of this study is that the increased weight percentage of the addition of Nano Copper oxide filler leads to a decrease in shear bond strength of acrylic samples. This agree with study that aimed to improve the mechanical properties and prevent the accumulation of microorganism on the surface with the use of MgONPs, In our result the adding of 5 % MgO NPs in to soft liner showed no statistical improvement in the tensile strength, The explanation of this finding is perhaps due to the factors which affects the curing system like (crosslink density, concentration of filler and molecular weight of the polymer, interaction of polymer and fillers). This finding is in agreement with the result obtained by [17]. The results of this study also demonstrate a closer correlation to a previous study that indicated a non-significant difference in the shear bond strength of heat-cured acrylic resin with an acrylic-based soft liner reinforced by 2% titanium oxide nanoparticles [18]. Conversely, the present study's findings contradict those of another investigation, which demonstrated that the incorporation of 2% silanated alumina and 5% silica nanoparticles into the denture base significantly enhances the bond strength between the heat-cured acrylic resin denture base and the heat-cured acrylic denture liner [19]. Reddy et al. integrated 1% AgNPs into the orthodontic glue (Transbond) and observed a substantial decrease in shear bond strength [20]. The incorporation of 0.11%, 0.18%, and 0.33% (w/w) of AgNPs into the orthodontic adhesive (Transbond) primer similarly diminished the shear bond strength of the experimental adhesive [21]. Riad et al. conducted another experiment that indicated a reduced shear bond strength of the experimental adhesive using AgNPs [22].

5 Conclusion

Under the borders of this in vitro study, the subsequent inferences were drawn: An Increase in weight percentage of the addition of Nano Copper oxide filler led to a decrease in shear bond strength of acrylic samples.

Conflict of Interest: The authors declare no conflict of interest.
Financing: The study was performed without external funding.
Ethical consideration: The study was approved by Al-Mustaqbal University, Hillah, Iraq.

REFERENCES

[1] Rathi S, Verma A. Resilient liners in prosthetic dentistry:An update. *Int J Appl Dent Sci.* 2018;4(3):34-8.

[2] Iwasaki N, Yamaki C, Takahashi H, Oki M, Suzuki T. Effect of long-time immersion of soft denture liners in water on viscoelastic properties. *Dental materials journal*. 2017;36(5):584-9. doi: 10.4012/dmj.2016-320

[3] Kreve S, Dos Reis AC. Denture liners: A systematic review relative to adhesion and mechanical properties. *The scientific world journal*. 2019;2019. doi: 10.1155/2019/6913080. eCollection 2019.

[4] Muddugangadhar BC, Mawani DP, 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(6):800-806.e6. doi:10.1016/j.prosdent.2019.06.013.

[5] Abdulwahhab AR, Jassim RK. The effect of aloe vera extract on adherence of *Candida albicans* and other properties of heat-cure denture soft lining material. *Int J Sci Res (IJSR).* 2018;7(3):94-103.

[6] Foong LK, Foroughi MM, Mirhosseini AF, Safaei M, Jahani S, Mostafavi M, et al. Applications of nanomaterials in diverse dentistry regimes. *RSC Adv.* 2020;10(26):15430-15460. doi:10.1039/D0RA01767H.

[7] D'Mello SR, Cruz CN, Chen M-L, Kapoor M, Lee SL, Tyner KM. The evolving landscape of drug products containing nanomaterials in the United States. *Nat Nanotechnol.* 2017;12(6):523-529. doi:10.1038/nnano.2017.67.

[8] Alswat AA, Ahmad MB, Hussein MZ, Ibrahim NA, Saleh TA. Copper oxide nanoparticles-loaded zeolite and its characteristics and antibacterial activities. J Mater Sci Technol. 2017;33(8):889-896. doi:10.1016/j.jmst.2017.03.015.

[9] Ermini ML, Voliani V. Antimicrobial nano-agents: the copper age. *ACS Nano.* 2021;15(4):6008-6029. doi:10.1021/acsnano.1c01234.

[10] Anu K, Maleeka Begum S, Rajesh G, Renuka Devi K. Wet biochemical synthesis of copper oxide nanoparticles coated on titanium dental implants. *Int J Adv Res Sci Eng Technol.* 2016;3:1191-1194.

[11] Soltani Nezhad S, Rabbani Khorasgani M, Emtiazi G, Yaghoobi MM, Shakeri S. Isolation of copper oxide (CuO) nanoparticles resistant Pseudomonas strains from soil and investigation on possible mechanism for resistance. *World J Microbiol Biotechnol.* 2014;30:809-817.

[12] Siddiqi KS, Husen A. Current status of plant metabolite-based fabrication of copper/copper oxide nanoparticles and their applications: a review. *Biomater Res.* 2020;24(1):1-15.

[13] Shoeib AM, Shaker MM, Abdeen RM, El-Segai AA. Evaluation of silver and copper oxide nanoparticles release from different prosthetic materials incorporated with nanoparticles. *Egypt Dent J.* 2019;65(3):2849-2855. doi:10.21608/edj.2019.72681.

[14] Hasan WY. Evaluation of thermal behaviors and some mechanical properties of heat-cured denture soft liner reinforced by halloysite nanotubes. *Baghdad J Pharm Sci.* 2018;16(1):75-82. doi:10.13005/bpj/1516.

[15] Rashid AAL. Evaluating the effect of *Artemisia* aerial parts extracts on *Candida albicans* growth and shear bond strength of soft denture liner. *J Technol.* 2021;3(2):86-95. doi:10.51173/jt.v3i2.321.

[16] Alaa'a MS. Shear bond strength of three silicone lining materials bonded to heat-cured denture resin. *King Saud Univ J Dent Sci.* 2013;4(1):17-20. doi:10.1016/j.ksujds.2012.11.003.

[17] Meran Z, Salem SA-L. The effect of magnesium oxide nanoparticles impregnated into silicone facial prostheses against *Candida albicans* and *Staphylococcus epidermidis*. *Crescent J Med Biol Sci.* 2020;6(4):1-6.

[18] Ahmed AQ, Ali M. The influence of titanium dioxide nanoparticles incorporation into soft denture lining material on *Candida albicans* adherence and some mechanical and physical properties. *J Pure Appl Microbiol.* 2018;12(2):783-791. doi:10.22207/JPAM.12.2.39.

[19] Al-Judy HJ. The influence of silica dioxide and aluminum oxide nanofillers reinforced heat-cured acrylic denture base material and thermocycling on tensile and shear bond to denture soft lining material. *Mustansiria Dent J.* 2017;14(1):99-109.

[20] Reddy AK, Kambalyal PB, Patil SR, Vankhre M, Khan MYA, Kumar TR. Comparative evaluation and influence on shear bond strength of incorporating silver, zinc oxide, and titanium dioxide nanoparticles in orthodontic adhesive. *J Orthod Sci.* 2016;5(4):127-132. doi:10.4103/2278-

0203.192115.

[21] Degrazia FW, Leitune VCB, Garcia IM, Arthur RA, Samuel SMW, Collares FM. Effect of silver nanoparticles on the physicochemical and antimicrobial properties of an orthodontic adhesive. *J Appl Oral Sci.* 2016;24(4):404-410. doi:10.1590/1678-775720160154.

[22] Eslamian L, Borzabadi-Farahani A, Karimi S, Saadat S, Badiee MR. Evaluation of the shear bond strength and antibacterial activity of orthodontic adhesive containing silver nanoparticle: an in vitro study. *Nanomaterials.* 2020;10(8):1466. doi:10.3390/nano10081466.

How to cite this article

Dewan M.H.; and Aziz H.K.; Evaluation of the Shear Bond Strength of Denture Soft Liner Reinforcement with Copper Oxide Nanoparticles. Future Dental Research (FDR). 2025;3(1) (**Special issue**):26-32. doi: 10.57238/fdr.2025.152576.1004