

**How to Cite:**

Gangadharappa, P., Rathore, B. S., Yaqoob, A., Agrawal, P., Patri, G., Tejaswi, C. K., & Kommuri, S. (2022). Effect of silver nanoparticle on properties of maxillofacial silicone elastomer material: An original research. *International Journal of Health Sciences*, 6(S2), 9994–10000. <https://doi.org/10.53730/ijhs.v6nS2.7622>

## **Effect of silver nanoparticle on properties of maxillofacial silicone elastomer material: An original research**

**Dr Praveen Gangadharappa**

M.D.S, Assistant Professor, Department of Prosthodontics, Jazan University- College of Dentistry, Jazan, Saudi Arabia  
Corresponding author email: [praveengmds@gmail.com](mailto:praveengmds@gmail.com)

**Dr. Bhupendra Singh Rathore**

Senior lecturer, Dept of Orthodontics & Dentofacial Orthopaedics, College of dental science & Hospital Rau, Indore, M.P.  
Email: [drbhupendra005@gmail.com](mailto:drbhupendra005@gmail.com)

**Dr. Ashfaq Yaqoob**

Assistant Professor, Department of Prosthodontics, College of Dentistry King Khalid University Abha Saudi Arabia  
Email: [ashfaqy@yahoo.com](mailto:ashfaqy@yahoo.com)

**Dr. Pratik Agrawal**

Reader, Dept of Conservative Dentistry and Endodontics, Kalinga Institute of Dental Sciences, KIIT University, Bhubaneswar, Odisha  
Email: [dr.pratikagrwal07@gmail.com](mailto:dr.pratikagrwal07@gmail.com)

**Dr. Gaurav Patri**

Head of Department, Department of Conservative & Endodontics, Institute: Kalinga Institute of Dental Sciences, KIIT Deemed to be University, Bhubaneswar  
Email: [patrigaurav@gmail.com](mailto:patrigaurav@gmail.com)

**Dr. C. Krishna Tejaswi**

Senior Lecturer - Dept of Prosthodontics, Crown & Bridge, Dhanalakshmi Srinivasan Dental College & Hospital, Siruvachur, Chennai - Trichy national highway, Perambalur, Tamilnadu  
Email: [chadalavada.tejaswi@gmail.com](mailto:chadalavada.tejaswi@gmail.com)

**Dr. Sirisha Kommuri**

PhD Scholar, Department of Prosthodontics, Narsinhbhai Patel Dental College and Hospital, Sankalchand Patel University, Visnagar, Gujarat, 384315  
Email: [k.siris88@gmail.com](mailto:k.siris88@gmail.com)

**Abstract**---Aim: The purpose of this study was to evaluate the impact of silver nanoparticle incorporation into maxillofacial silicone material on its hardness tear strength and color stability. Methodology: A total of 90 silicone specimens were fabricated. The control samples were fabricated with- out silver nanoparticles and test samples were fabricated with 20 ppm concentration of silver nanoparticles. Digital shore A hardness tests was used to measure hardness, for tear strength the specimen was placed in the jaws of the universal testing machine and stretched at a rate of 500 ram/rain, for color stability Spectrophotometer had been employed. The independent sample's "t" test was used to test significant differences. Results: The mean difference for hardness between control and test group was 0.54 and t value was 2.08 and (  $p < 0.05$ ).tear strength 0.66 and "t" value was 0.93 and (  $p < 0.05$ ) and for color stability it was -0.02 and t value was -0.92 and (  $p < 0.05$ ). Conclusion: The present study findings suggest that addition of silver nanoparticles at 20 ppm concentration decreased the hardness of silicone elastomer, and it did not affect tear strength and color stability.

**Keywords**---nanoparticle, maxillofacial prosthesis, silver, silicone elastomers.

## Introduction

Silicone was introduced in 1960; from then, it has become the most widely used and clinically accepted material for the fabrication of facial prosthesis, because of its ease of manipulation, physical and mechanical properties, and biocompatibility. Silicone material possesses a texture similar to that of human skin; its flexibility provides the patient with both well-being and comfort.[1,2] However, the silicone material has some limitations. The main problem with the currently used silicone material is its reduced clinical longevity of the prosthesis. Because of its color instability and material deterioration, for example, it exhibits modified texture, poorly fitting edges because of reduced tear strength.[3] Deteriorating changes occurring in silicone material because of environmental condition can be attributed to photo-oxidative attack that is combined action of oxygen and sunlight on the chemical structure of elastomer.[4] Sunlight is composed of many wavelengths such as infrared light, visible light, and ultraviolet (UV) light.[4] The polymer molecules are more sensitive to UV light, and when exposed, the polymer molecule absorbs photons and leads to photodegradation and the breakup of molecules into smaller pieces. It also results in the change of a molecule's shape, making it irreversible altered.[4] Various methods have been tried to overcome this polymer deterioration such as addition of pigments and opacifiers, nanoparticles, and nano-oxides.[2-4] Due to the advancement in nanotechnology, the use of nanoparticles in elastomers has been tried to enhance its properties.[4] Nano-sized particles differ in their physical, chemical, and biological properties compared to their macro-sized counterparts due to their high surface-area-to-volume ratio. Properties of nanoparticles depend on their size and concentration. Based on their concentration, nanoparticles improve the physical, chemical, mechanical, and biological properties of the material in which they are

incorporated.[5] Nanoparticles act as UV shields as the nanoparticles are smaller than the UV light wavelength, and their electrons vibrate when they hit by such radiation, thereby dissipating one portion of the light when absorbing another. Thus, the smaller the nanoparticles, the better the shielding against solar radiation.[6] Nano-sized zinc oxide (ZnO), titanium dioxide (TiO<sub>2</sub>), and cerium oxide (CeO<sub>2</sub>) are mainly used as UV shields as they have a high UV absorbing and scattering effect. Nano-sized silicone dioxide (SiO<sub>2</sub>), TiO<sub>2</sub>, and ZnO are characterized by their small size, large specific area, active function, and strong interfacial interaction with the organic polymer. Therefore, they can improve the physical properties and optical properties of the organic polymer, as well as provide resistance to environmental stress-caused aging.[7] Several nanoparticles have been tested and studies have confirmed the effectiveness of nanoparticles in improving the color stability by blocking the UV rays and also in improving the color stability, hardness, tear strength, tensile strength, percentage elongation, UV protection, and antifungal properties of silicone elastomer.

### **Aim of the Study**

The purpose of this study was to evaluate the impact of silver nanoparticle incorporation into maxillofacial silicone material on its hardness tear strength and color stability.

### **Methodology**

In total of 90 silicone specimens were fabricated. Out of which, 45 specimens were made without incorporating silver nanoparticles, which were considered as control group and the other 45 specimens which were incorporated with silver nanoparticles were considered as study group. The samples are divided into three main groups depending on the test and each group is further sub divided into two groups as control and test group for each test Group 1 –for hardness test, under which it was further divided into Group 1a –15 DS specimens without silver Nano particles and Group 1b –15 DS specimens with silver nanoparticles. Group 2 –for tear strength test, under which it was further divided into Group 2a- 15 TS specimens without silver Nano particles and Group 2b- 15 TS specimens with silver Nano particles Group 3 –for color stability test, under which it was further divided into Group 3a –15 DS specimens without silver Nano particles and Group 3b –15 DS specimens with silver nanoparticles.

*Hardness test-* Digital shore A hardness tests was used to measure hardness. Five sites were measured for each specimen with 12 mm distance between of each site and a 6 mm distance from the edge of the specimen. *Tear strength test-* The thickness of the specimen (at 3 mm, depending on the degree of mould closure) was measured at the intersection of the trouser leg with a Vernier calliper with digital readout. The specimen was placed in the jaws of the universal testing machine (Lloyd instruments, LR 50 K) and stretched at a rate of 500 ram/rain. From these measurements, the tear strength of that specimen was calculated *Color stability test-* Spectrophotometer had been employed. A tungsten lamp of D50 standard illuminate was used with a viewing angle of 2 °UV filter is positioned to 100% UV. For each specimen the color measurements were made on three randomly selected areas and average of three reading is recorded.

## Results

Effect of adding silver nanoparticles on hardness, tear strength, and color stability of maxillofacial silicone elastomer were evaluated. The mean difference and standard deviation for hardness, tear strength, and color stability of silicone without Nano particles in comparison to silicone with nanoparticles were calculated. The independent sample's "t" test was used to test significant differences in the physical properties along with the color stability. The group 1a had a mean hardness of 28.307 with a standard deviation of 0.8816. The group 1b had a mean hardness of 27.706 with a standard deviation of 1.1379 ( Table 1 ). The group 2a had a mean tear strength of 14.10 with a standard deviation of 3.013. The group 2b had a mean tear strength of 13.43 with a standard deviation of 2.487 ( Table 2 ). The group 3a had a mean of 0.67 with a standard deviation of 0.10. The group 3b had a mean of 0.69 with a standard deviation of 0.095( Table 3 ). The mean difference for tear strength between control and test group was 0.66 and "t" value was 0.93 and p value 0.35. As seen in results p value is more (  $p < 0.05$ ) and for color stability it was  $-0.02$  and t value was  $-0.92$  and p value 0.36 As seen in results p value is more (  $p < 0.05$ ). So it can be concluded that statistically there was no significant difference between the control and test group with respect to the tear strength and color stability.

## Discussion

Nanomaterials have found applications in many areas of medicine including drug delivery, vaccine development, medical imaging, diagnostics, and medical implants. [8-11] Nanotechnology can be defined as the branch of technology using materials and structures with nano scale dimensions, usually in the range of 1–100 nm. [12] The small size, colloidal behavior and propensity to adhere to surfaces [13] suggests that some nanomaterials can be used in coating applications. For instance, nanoforms of silver have been used as antimicrobial coatings in catheters [14] and wound dressings. [15] However, research effort has mainly focused on the antibacterial properties of silver nanoparticles (Ag NPs) [16,17] and limited information is available about their antifungal properties. Nevertheless, recent studies suggest that Ag NPs may be a good antifungal agent. Ag NPs have fungicidal activity against *C. albicans* at low milligram concentrations (e.g., 0.4–3.3 mg L<sup>-1</sup>) [18]; perhaps better than their antimicrobial properties for some bacteria. For example, the minimum inhibitory concentration to prevent bacterial growth of *Streptococcus mutans*, one of the common oral bacteria, is considerably higher (50 mg L<sup>-1</sup>). [19] Findings of the present study are supported by that of Nobrega et al., wherein, addition of TiO<sub>2</sub> at concentration of 1% and 2% decreased the hardness values, as the TiO<sub>2</sub> particles are smaller in size they had a difficulty in uniform dispersion and tend to agglomerate [20]. They also mentioned that, incorporation of Nano size oxides of Ti, Zn, or Ce at concentrations of 2.0 to 2.5% by weight into a silicone- based elastomer, improves hardness, but when the concentration was 3.0%, the hardness decreased. In other study which revealed that there was a small but significant increase in the hardness as the concentration of the SiO<sub>2</sub> Nano filler in the A- 2186 was increased from 0% to 3% [4]. The tear strength of silicone elastomer is clinically very important as the margins surrounding the facial prosthesis are thin and are usually glued with the medical adhesives, and highly susceptibility to tear [2].

Agglomeration of nanoparticles depends on their surface energy and its chemical reactivity, it is important to maintain the proper concentration of the fillers. Otherwise the Nano sized oxide particles may agglomerate. The agglomerated particles acts as an areas of stress concentrations under the external forces thereby decreasing the mechanical strength of the material [7]. But, in the present study, there was no statistically significant changes in tear strength, however, the maximum value obtained for tear strength for silicone with nanoparticles was less than that of the silicone elastomer without nanoparticles. In the present study, the addition of 20 ppm AgNP's did not affect the color stability, the mean values obtained were 0.69 with a standard deviation of 0.095. This properties of AgNP's depend on its particle size, shape and the concentration, mostly at different concentration and particle size it can improve the color stability of the elastomer and can be used as opacifier. Since addition of silver nano-particles did not negatively affect the properties it can be used as an antifungal agent in the maxillo-facial silicone elastomer to improve the longevity of the prosthesis.

### **Conclusion**

Within the limitations of the study addition of silver nanoparticles at 20 ppm concentration, decreased the hardness of silicone elastomer, and it did not affect tear strength and color stability.

### **References**

1. Haug SP, Andres CJ, Moore BK. Color stability and colorant effect on maxillofacial elastomers. Part I: Colorant effect on physical properties. *J Prosthet Dent* 1999;81:418-22.
2. Zayed SM, Alshimy AM, Fahmy AE. Effect of surface treated silicon dioxide nanoparticles on some mechanical properties of maxillofacial silicone elastomer. *Int J Biomater* 2014;2014.
3. Kiat-Amnuay S, Mekkarajjananonth T, Powers JM, Chambers MS and Lemon JC. Interaction of pigments and opacifiers on color stability of MDX4-4210/type A Maxillofacial elastomers on artificial ageing. *J Prosthet Dent* 2006;95:249-57.
4. Mouzakis DE, Papadopoulos TD, Polyzois GL, Griniari PG. Dynamic mechanical properties of a maxillofacial silicone elastomer incorporating a ZnO additive: The effect of artificial aging. *J Craniofac Surg* 2010;21:1867-71.
5. El-Nour KM, Eftaiha AA, Al-Warthan A, Ammar RA. Synthesis and applications of silver nanoparticles. *Arab J Chem* 2010;3:135-40.
6. Han Y, Zhao Y, Xie C, Powers JM, Kiat-amnuay S. Color stability of pigmented maxillofacial silicone elastomer: Effects of nano-oxides as opacifiers. *J Dent* 2010;38 Suppl 2:e100-5.
7. Akash RN, Guttal SS. Effect of incorporation of nano-oxides on color stability of maxillofacial silicone elastomer subjected to outdoor weathering. *J Prosthodont* 2015;24:569-75.
8. Fadeel B, Garcia-Bennett AE. Better safe than sorry: Understanding the toxicological properties of inorganic nanoparticles manufactured for biomedical applications. *Adv Drug Deliv Rev* 2010;62:362-374.

9. Sozer N, Kokini JL. The applications of nanotechnology. In: Pic\_o Y, editor. *Chemical Analysis of Food: Techniques and Applications*. Amsterdam: Academic Press; 2012. pp 145–176.
10. Juillerat-Jeanneret L, Dusinska M, Fjellesbo LM, Collins AR, Handy R, Riediker M. Biological impact assessment of nanomaterial used in nanomedicine. Introduction to the NanoTEST project. *Nanotoxicology* 2015;9:5–12.
11. Sch€utz CA, Juillerat-Jeanneret L, Mueller H, Lynch I, Riediker M. Therapeutic nanoparticles in clinics and under clinical evaluation: A review. *Nanomedicine* 2013;8:449–467.
12. Handy RD, Shaw BJ. Toxic effects of nanoparticles and nanomaterials: Implications for public health, risk assessment and the public perception of nanotechnology. *Health Risk Soc* 2007;9:125–144.
13. Christian P, von der Kammer F, Baalousha M, Hofmann T. Nanoparticles: Structure, properties, preparation and behaviour in environmental media. *Ecotoxicology* 2008;17:326–343.
14. Roe D, Karandikar B, Bonn-Savage N, Gibbins B, Roullet JB. Antimicrobial surface functionalization of plastic catheters by silver nanoparticles. *J Antimicrob Chemoth* 2008;61:869–876.
15. Tian J, Wong KK, Ho CM, Lok CN, Yu WY, Che CM, Chiu JF, Tam PK. Topical delivery of silver nanoparticles promotes wound healing. *Chem Med Chem* 2007;2:129–136.
16. Rai M, Yadav A, Gade A. Silver nanoparticles as a new generation of antimicrobials. *Biotechnol Adv* 2009;27:76–83.
17. Xiu ZM, Zhang QB, Puppala HL, Colvin VL, Alvarez PJ. Negligible particle-specific antibacterial activity of silver nanoparticles. *Nano letters* 2012;12:4271–4275.
18. Monteiro DR, Gorup LF, Silva S, Negri M, de Camargo ER, Oliveira R, Barbosa DB, Henriques M. Silver colloidal nanoparticles: Antifungal effect against adhered cells and biofilms of *Candida albicans* and *Candida glabrata*. *Biofouling* 2011;27:711–719.
19. Besinis A, de Peralta T, Handy RD. The antibacterial effects of silver, titanium dioxide and silica dioxide nanoparticles compared to the dental disinfectant chlorhexidine on *Streptococcus mutans* using a suite of bioassays. *Nanotoxicology* 2014;8:1–16.
20. Nobrega AS , Andreotti AM , Moreno A , Sinhoreti MA , dos Santos DM , Goiato MC . Influence of adding nanoparticles on the hardness, tear strength, and permanent deformation of facial silicone subjected to accelerated aging. *J Prosthet Dent* 2016;116:623–9 .

## Tables

Table 1- Mean distribution of hardness test (without nanoparticles and with nanoparticles)

Groups		Minimum	Maximum	Mean	Std. Deviation
Hardness test	Without nanoparticles (Group 1a)	26.0	30.2	28.307	0.8816
	With	25.4	30.6	27.760	1.1379

10000

	nanoparticles (Group 1b)				
--	-----------------------------	--	--	--	--

Table 2 Mean distribution of tear strength (without nanoparticles and with nanoparticles)

Groups		Minimum	Maximum	Mean	Std. Deviation
Tear strength	Without nanoparticles (Group 2a)	9	20	14.10	3.010
	With nanoparticles (Group 2b)	9	19	13.43	2.487

Table 3 Mean distribution of color stability ( $\delta e^*$ ) (without nanoparticles and with nanoparticles)

Groups		Minimum	Maximum	Mean	Std. Deviation
color stability ( $\delta e^*$ )	Without nanoparticles (Group 3a)	0.50	0.90	0.67	0.10
	With nanoparticles (Group 3b)	0.52	0.83	0.69	0.095