International Journal of Dental Research and Allied Sciences
2022, Volume 2, Issue 1, Page No: 8-12

Available online at: www.tsdp.net

Turkish Specialized Dental Publication

Review Article

A Systematic Review on the Color Stability of Maxillofacial Silicone Materials after Disinfection and Aging Procedures

Suji Daivasigamani[1], Ahila Singaravel Chidambaranathan[2]*, Muthukumar Balasubramanium[2]

[1]SRM Dental College, Ramapuram, Chennai, Tamil Nadu, India.
[2]Department of Prosthodontics, SRM Dental College, Ramapuram, Chennai, India.

***E-mail** ✉ Ahilasc@yahoo.co.in

Received: 09 February 2022; **Revised:** 11 March 2022; **Accepted:** 14 March 2022

ABSTRACT

Maxillofacial prostheses are intended to restore the appearance of individuals and ensure the maintenance of their normal psychological state and quality of life. The longevity of these silicone prostheses is closely related to their color and mechanical properties. To systematically evaluate the current research on the color stability of maxillofacial silicone materials after disinfection and aging for 10 minutes, a comprehensive search was conducted on Google Scholar and PubMed, covering studies published between January 2000 and December 2020. In addition, a manual search of standard dental journals from 2000 to 2020 was carried out using keywords such as color stability, maxillofacial silicone, disinfection, and aging. A total of 52 studies were identified, and 6 in vitro studies were included in this review. The results showed that the color stability of maxillofacial silicone materials is affected by disinfection and aging processes.

Keywords: Maxillofacial silicone, Nanoparticles, Aging process, Disinfection, Colour stability, Maxillofacial prosthesis

How to Cite This Article: Daivasigamani S, Chidambaranathan AS, Balasubramanium M. A Systematic Review on the Color Stability of Maxillofacial Silicone Materials after Disinfection and Aging Procedures. Int J Dent Res Allied Sci. 2022;2(1):8-12.

Introduction

Color is a key aspect valued by patients who receive maxillofacial prostheses [1, 2]. The primary goal of a maxillofacial prosthodontist is to restore the patient's appearance, boost their self-esteem, and support them in leading as normal a life as possible [3]. The typical lifespan of maxillofacial silicone is about one year. To prevent contamination, patients are required to clean their prosthesis daily for 3 to 5 minutes using a brush [4]. Various disinfection methods and materials are available for cleaning maxillofacial prostheses, with chlorhexidine being regarded as one of the most effective disinfectants in dentistry [5].

Chemical disinfection can lead to alterations in the properties of maxillofacial silicone materials used to create prostheses, making it crucial to assess these changes during the fabrication process when chemical disinfection is intended. Additionally, these disinfectants must be non-reactive to human tissues and preserve the properties of the maxillofacial silicones [6]. Various disinfectants, such as 2% to 4% chlorhexidine, 1% sodium hypochlorite, neutral soap, and cleansing tablets, have been utilized in numerous studies [1, 4, 7].

Nanomaterials like titanium dioxide, fumed silica, silane silica, cerium oxide, zinc oxide, magnesium silicate, polyhedral silsesquioxane, and tulle have been employed as reinforcement agents in maxillofacial silicone. These additions have been found to enhance various mechanical properties of silicone, including tensile strength, tear strength, elongation, hardness, dimensional stability, and color retention [8].

There has been a lack of systematic reviews focusing on the color stability of maxillofacial silicone after disinfection. Consequently, this review aimed to investigate how disinfection and aging over 252, 504, and 1004 hours affect the color stability of maxillofacial silicone. The primary research question guiding this review was: "What impact does the disinfection solution have on the color stability of maxillofacial silicones?"

Materials and Methods

This review was conducted following the PRISMA guidelines [9]. A thorough electronic search was performed on PubMed and Google Scholar for relevant articles published from January 2000 to December 2018, using the search terms "color stability of maxillofacial silicone" and "disinfection of maxillofacial silicone," both individually and in combination with "AND" or "WITH." Furthermore, a manual search was carried out for articles published between January 2000 and December 2020 in journals such as the Journal of Prosthetic Dentistry, International Journal of Prosthodontics, Journal of Prosthodontics, Journal of Prosthodontic Research, Journal of Advanced Prosthodontics, Journal of Indian Prosthodontic Society, and Indian Journal of Dental Research.

Eligibility criteria

The studies selected for inclusion were in vitro investigations focused on color stability, published in English. Exclusion criteria encompassed animal studies, case reports, and review articles.

Study selection

2 reviewers, SD and ASC, independently screened the titles. Studies that fulfilled the inclusion criteria were then collected.

Results and Discussion

A total of 52 studies were found through database searches, with 18 from PubMed/Medline and 34 from Google Scholar. After applying the inclusion/exclusion criteria and eliminating duplicate articles, 12 studies were excluded. Ultimately, 6 studies were selected for the systematic review **(Figure 1)**.

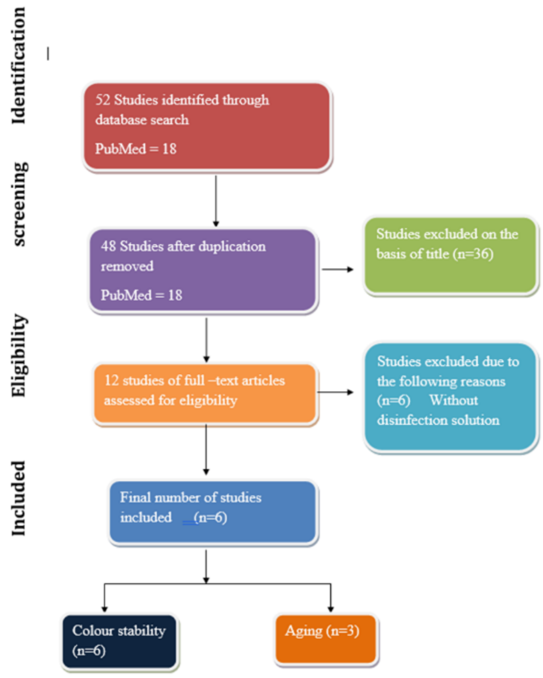

Figure 1. Diagram of the search strategy

This systematic review aimed to assess the color stability of maxillofacial silicone materials following disinfection and aging processes. Recent studies have indicated that the addition of oil-based pigments, nanoparticles, and opacifiers to silicone materials enhances the longevity of maxillofacial silicone prosthetics, improves color stability, and provides protection against UV rays [6, 10-13].

Disinfection refers to the process of removing microorganisms from surfaces using chemical agents. It is essential that this process does not harm human tissues and that it preserves the properties of silicone. Key factors in choosing disinfectants include their antimicrobial effectiveness, compatibility with the material, and their ability to maintain the material's properties [14]. Various disinfectants, including neutral soap, sodium hypochlorite solution, 4% chlorhexidine, Efferdent tablets, plant extracts, and commercial disinfecting solutions, have been shown to cause some changes in the properties of maxillofacial silicone materials [6, 15-17].

The aging device is used to simulate environmental conditions such as heat, humidity, and radiation to observe how materials respond under natural conditions [7]. Photooxidation refers to the potential of heat and light to alter the chemical composition of materials. Researchers have recognized that changes in the properties of maxillofacial silicone materials are largely due to the effects of ultraviolet radiation on their mechanical and optical characteristics, which allows for the assessment of how these materials interact with their environment [18-21].

In this systematic review, the color stability of maxillofacial silicone materials was evaluated using an ultraviolet-visible reflection spectrophotometer **(Table 1)**.

Table 1. Characteristics of studies included

Reference	Material	Instrument	Disinfectant Solution	Duration	Aging	Significance
Goiato *et al.* [2]	MDX 4-4210 Silastic 732	Visible UV Reflectance E Spectrophotometer	Neutral soap Efferdent	Three days a week for sixty days	Nil	Significant Not significant
Goiato *et al.* [22]	MDX4-4210 MDX4-4210 with barium sulfate MDX4-4210 with titanium dioxide	Visible Ultraviolet Reflection Spectrophotometer	Efferdent effervescent tablet Neutral soap 4% chlorhexidine gluconate	Three times a week for two months for fifteen minutes	252, 504, and 1008 h of artificial aging	Significant Significant Significant
Haddad *et al.* [23]	MDX4-4210 silicone MDX4-4210 silicone pigmented with ceramic powder MDX4-4210 silicone pigmented with BaSO4 MDX4-4210 silicone pigmented with BaSO4 and ceramic powder	UV reflection Spectrophotometer	Neutral soap Efferdent evervescent Tablets 4% chlorhexidine	Three days a week for sixty days	252, 504, and 1008 h of artificial aging	Significant Significant Significant
Pesqueir *et al.* [6]	1. Silastic MDX 4-4210 2. Silastic MDX 4-4210 (ceramic powder) 3. Silastic MDX 4-4210 (makeup	Visible ultraviolet Reflection Spectrometer	neutral soap effervescent tablets	Three days a week for sixty days	252, 504, and 1008 h of artificial aging	Significant Significant
Eleni *et al.* [16]	polydimethylsiloxane (PDMS) chlorinated polyethylene (CPE)	MiniScan XE Spectrophotometer	Microwave sodium hypochlorite, neutral soap Commercial disinfecting soap	Five minutes per day for one year (thirty hours)	Nil	Significant Not clinically acceptable Not clinically acceptable Not clinically acceptable
Guiotti *et al.* [21]	MDX4-4210 (polydimethylsiloxane) Functional Intrinsic II – silicone coloring system (medium-shade) Functional intrinsic II – silicone coloring system (dark shade) Dry opacifier (Zinc oxide – ZnO)	Ultraviolet-visible Reflection Spectrophotometer	Saline solution Neutral soap Chlorhexidine 4% Hydrastis canadensis (Hydrastis) Cymbopogon nardus (Cytronella	Daily for thirty days for ten minutes	1008 hours	Not clinically acceptable

The analysis of maxillofacial silicone materials' color stability, following the addition of pigments and opacifiers, was conducted after disinfection with both conventional and plant-based solutions over 30 days, combined with accelerated aging for 1008 hours. The results showed that MDX 4-4210 silicone demonstrated significant color changes, deemed clinically unacceptable, regardless of the disinfection method used [20]. In a separate experiment, the color stability of polydimethylsiloxane (PDMS) and chlorinated polyethylene (CPE) materials was tested after disinfection and microwave exposure. The findings suggested that microwave disinfection was the preferred method for both materials when used with sodium hypochlorite solution [16]. For maxillofacial silicone MDX 4-4210, variations in pigmentation revealed that ceramic powder provided superior color stability compared to both makeup pigments and colorless versions, after disinfection and aging over 252, 504, and 1008 hours [6]. A different study on maxillofacial elastomer materials mixed with opacifiers or nanoparticles, subjected to artificial aging and disinfection, found that samples incorporating $BaSO_4$ opacifiers and ceramic nanoparticles exhibited the best color stability [21]. Additionally, when testing the color stability of MDX 4-4210 after disinfection and accelerated aging, chlorhexidine caused more significant color changes than neutral soap or Efferdent tablets. The study also showed that accelerated aging had a notable effect on the color stability of all the silicone materials. Among these, barium sulfate opacifiers were more stable compared to titanium dioxide [23]. Lastly, when Silastic 732 RTV and MDX 4-4210 were disinfected with neutral soap and Efferdent tablets, the neutral soap exhibited a smaller effect on color stability than the Efferdent tablets [22].

Conclusion

The authors concluded that the color stability of maxillofacial silicone materials was influenced by both the disinfection solution and the aging process. Among the various disinfectants tested, chlorhexidine caused the most significant color changes in the silicone materials during different aging intervals.

Acknowledgments: The authors express their sincere gratitude to the scholars whose work has been cited and referenced in this article. They also extend their appreciation to the authors, editors, and publishers of the journals, articles, and books whose literature was reviewed and discussed in the preparation of this manuscript.

Conflict of Interest: None

Financial Support: None

Ethics Statement: Ethical approval for this study was obtained from the Institutional Review Board (IRB) of SRM University, Chennai, with registration number SRMU/M&HS/SRMDC/2022/S/003.

References

1. Babu AS, Manju V, Gopal VK. Effect of chemical disinfectants and accelerated aging on maxillofacial silicone elastomers: an in vitro study. Indian J Dent Res. 2018;29(1):67-73. doi:10.4103/ijdr.IJDR_272_16
2. Goiato MC, Pesqueira AA, da Silva CR, Gennari Filho H, Dos Santos DM. Patient satisfaction with maxillofacial prosthesis. Literature review. J Plast Reconstr Aesthet Surg. 2009;62(2):175-80. doi:10.1016/j.bjps.2008.06.084
3. Sheets JL, Pinkston DJ, Yuan JC, Sukotjo C, Wee AG. US maxillofacial prosthetics programs: fellows' and directors' perspectives. J Dent Educ. 2018;82(12):1335-42.
4. Goiato MC, Haddad MF, C Sinhoreti MA, dos Santos DM, Pesqueira AA, Moreno A. Influence of opacifiers on dimensional stability and detail reproduction of maxillofacial silicone elastomer. Biomed Eng Online. 2010;9(1):85. doi:10.1186/1475-925X-9-85
5. Ariani N, Visser A, Teulings MR, Dijk M, Rahardjo TB, Vissink A, et al. Efficacy of cleansing agents in killing microorganisms in mixed-species biofilms present on silicone facial prostheses-an in vitro study. Clin Oral Invest. 2015;19(9):2285-93. doi:10.1007/s00784-015-1453-0
6. Pesqueira AA, Goiato MC, dos Santos DM, Haddad MF, Ribeiro PD, Coelho Sinhoreti MA. Effect of disinfection and accelerated aging on color stability of colorless and pigmented facial silicone. J Prosthodont. 2011;20(4):305-30. doi:10.1111/j.1532-849X.2011.00693.x
7. Mat-Rani S, Chotprasert N, Srimaneekarn N, Choonharuangdej S. Fungicidal effect of lemongrass essential oil on candida albicans biofilm pre-established on maxillofacial silicone specimens. J Int Soc Prev Community Dent. 2021;11(5):525-30. doi:10.4103/jispcd.JISPCD_63_21
8. Pinar C, Serdar P, Ayse ND. Effects of the addition of titanium dioxide and silaned silica nanoparticles on the color stability of a maxillofacial silicone

elastomer submitted to artificial aging. Cumhuriyet Dent J. 2016;19(1):9-15.

9. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med. 2009;151(4):264-9. doi:10.7326/0003-4819-151-4-200908180-00135
10. Hu X, Pan X, Johnston WM. Effects of pigments on dynamic mechanical properties of a maxillofacial prosthetic elastomer. J Prosthet Dent. 2014;112(5):1298-303. doi:10.1016/j.prosdent.2014.04.004
11. Kiat-amnuay S, Lemon JC, Powers JM. Effect of opacifiers on color stability of pigmented maxillofacial silicone A-2186 subjected to artificial aging. J Prosthodont. 2002;11(2):109-16.
12. Kiat-Amnuay S, Mekayarajjananonth T, Powers JM, Chambers MS, Lemon JC. Interactions of pigments and opacifiers on color stability of MDX4-4210/type a maxilla-facial elastomers subjected to artificial aging. J Prosthet Dent. 2006;95(3):249-57. doi:10.1053/jopr.2002.124357
13. Dos Santos DM, Goiato MC, Moreno A, Pesqueira AA, Haddad MF. Influence of pigments and opacifiers on color stability of an artificially aged facial silicone. J Prosthodont. 2011;20(3):205-8. doi:10.1111/j.1532-849X.2010.00657.x
14. Abdul-Ameer FM. Effect of plant-extract disinfectant solutions on the specific properties of reinforced maxillofacial silicone elastomers with Nanofiller and intrinsic pigment. Eur J Gen Dent. 2020;9(02):55-61. doi:10.4103/ejgd.ejgd_86_19
15. Charitidis CA, Ziomas I, Gettleman L. Tensile and micro indentation properties of maxilla-facial elastomers after different disinfecting procedures. J Mech Behav Biomed Mater. 2013;28:147-55. doi:10.1016/j.jmbbm.2013.07.013
16. Eleni PN, Krokida MK, Polyzois GL, Gettleman L. Effect of different disinfecting procedures on the hardness and color stability of two maxillofacial elastomers over time. J Appl Oral Sci. 2013;21(3):278-83. doi:10.1590/1679-775720130112
17. Eleni PN, Krokida MK, Polyzois GL, Gettleman L. Dynamic mechanical thermal analysis of maxillofacial prosthetic elastomers: the effect of different disinfecting aging procedures. J Craniofac Surg. 2014;25(3):e251-5. doi:10.1097/SCS.0000000000000556
18. Bilge TB, Merve BG, Seçil KN, Cemal A, Yeliz KA. Effect of ultraviolet protective agents on maxillofacial silicone elastomer, part 1: color stability after artificial aging. J Prosthet Dent. 2021; Article in press. doi:10.1016/j.prosdent.2021.06.033
19. Chamaria A, Aras MA, Chitre V, Rajagopal P. Effect of chemical disinfectants on the color stability of maxillofacial silicones: an in vitro study. J Prosthodont. 2019;28(2):e869-72. doi:10.1111/jopr.12768
20. Cifter ED, Ozdemir-Karatas M, Cinarli A, Sancakli E, Balik A, Evlioglu G. In vitro study of effects of aging and processing conditions on colour change in maxillofacial silicone elastomers. BMC Oral Health 2019;19(1):122-32. doi:10.1186/s12903-019-0798-1
21. Guiotti AM, Goiato MC, Dos Santos DM, Vechiato-Filho AJ, Cunha BG, Paulini MB, et al. Comparison of conventional and plant-extract disinfectant solutions on the hardness and color stability of a maxillofacial elastomer after artificial aging. J Prosthet Dent. 2016;115(4):501-8. doi:10.1016/j.prosdent.2015.09.0092
22. Goiato MC, Haddad MF, Pesqueira AA, Moreno A, Dos Santos DM, Bannwart LC. Effect of chemical disinfection and accelerated aging on color stability of maxillofacial silicone with opacifiers. J Prosthodont. 2011;20(7):566-9. doi:10.1111/j.1532-849X.2011.00755.x
23. Haddad MF, Goiato MC, Dos Santos DM, Moreno A, Pesqueira AA, D'almeida NF. Color stability of maxillofacial silicone with nanoparticle pigment and opacifier submitted to disinfection and artificial aging. J Biomed Opt. 2011;6(9):095004-6. doi:10.1117/1.3625401