Original Article

Change in color of a maxillofacial prosthetic silicone elastomer, following investment in molds of different materials

Tania Sethi, Mohit Kheur, Trevor Coward[1], Naimesha Patel[1]

Department of Prosthodontics, M.A. Rangoonwala Dental of College and Research Centre, Pune, Maharashtra, India, [1]Department of Maxillofacial Prosthetic Technology, Kings College, London, United Kingdom

Abstract

Purpose: In the authors' experience, the color of silicone elastomer following polymerization in molds made of gypsum products is slightly different from the color that was matched in the presence of the patient, before the silicone is packed. It is hypothesized that the investing materials and separating media have an effect on the color during the polymerization process of the silicone.

Materials and Methods: This study compares and evaluates the change in color of silicone elastomer packed in three commonly used investing materials - Dental stone (white color), dental stone (green color), and die stone (orange color); coated with three different separating media – Alginate-based medium, soap solution and a resin-based die hardening material. Pigmented silicone samples of dimensions 1.5 cm × 2 cm × 0.5 cm were made from the elastomer in the above-mentioned mold materials using combinations of the mentioned separating media. These served as test group samples. Control group samples were made by packing a mix of the same pigmented elastomer in stainless steel molds. The L^*, a^*, b^* values of the test and control group samples were determined using a spectrophotometer. The change in color (Delta E) was calculated between the control and test groups.

Results: The mean L, a, b values for the control group were, 31.8, 26.2, and 36.3, respectively. Average values of change in color (Delta E) for samples packed utilizing alginate-based medium, die hardener, and soap solution, respectively in white dental stone (2.70, 2.74, and 2.88), green dental stone (2.19, 2.23, 2.42), and orange die stone (3.19, 2.72, 2.80) were tabulated.

Conclusion: Among the investing materials studied, die stone showed the most color change (3.19), which was statistically significant. Among the separating media, die hardener showed the least color change (2.23). The best combination of an investing material and separating media as per this investigation is a dental stone (green) and alginate-based separating medium.

Key Words: Color, investing materials, maxillofacial silicone, polymerization

Address for correspondence:
Dr. Mohit Kheur, 1132/3, Vishnu Darshan Apartments, Next to Hotel Lalit Mahal, F.C. Road, Shivajinagar, Pune - 411 016, Maharashtra, India.
E-mail: mkheur@gmail.com

Received: 29th March, 2015, **Accepted:** 07th April, 2015

Access this article online	
Quick Response Code:	Website: www.j-ips.org
	DOI: 10.4103/0972-4052.158077

INTRODUCTION

Maxillofacial prosthetic rehabilitation plays a key role in the treatment of patients who have undergone extensive surgery following tumor resections, trauma or have congenital defects. Silicone materials have overtaken conventional acrylic resins and have become the materials of choice for the fabrication of facial prostheses. However, such prostheses need to be periodically replaced due to degradation of their color and physical properties.[1-6]

The color change following weathering of silicone elastomers has been investigated and documented. These investigators have stated that the main factors contributing to the change in color of the elastomer is exposure to ultraviolet radiation, temperature changes, humidity, the use of adhesives, cosmetics, cleansing agents, and exposure to body fluids.[7-11]

It is the experience of the authors, working in different Maxillofacial Prosthetic Rehabilitation centers, that during the setting of the silicone, there is a slight-to-significant change in the color of the mix, from the point when it is packed into the mold till it is divested. The type of investing material (gypsum product) can have a significant effect on the color change of the elastomer during its curing. This can be due to some of the colorants added to the dental stones or the micro-structure of the stone following its manufacture or a combination of both.

This effect is particularly more pronounced when the pigment loading in the mix is higher, as is the case when prostheses are made for individuals with darker skin tones. The authors hypothesize that this effect could occur due to the heat application during the curing process or due to leaching of some constituents of the investing material and separating media into the silicone.

The aim of this study was to evaluate the effect of different investing materials-dental stone (white), dental stone (green), and die stone (orange) along with different separating agents-alginate based medium, die hardener, and soap solution on the color change during polymerization of a commonly used maxillofacial silicones (M511) (Technovent Ltd., South Wales, United Kingdom).

MATERIALS AND METHODS

A commonly used silicone elastomer M511 (Technovent Ltd., South Wales, United Kingdom) with base catalyst ratio 10:1 [Figure 1] was used in this study. The separating media evaluated were Unifol (Perident Dental Products, Italy) – an alginate based separating medium, die hardener (Yeti Products GmbH, Germany), and soap solution (Dove, Herbal Concepts Ltd., India) [Figure 2]. The investing materials evaluated were dental stone (white) (Orthokal, Kalabhai Karson Pvt. Ltd., India), dental stone (green) (Asian Chemicals Ltd., India), and Die stone (orange) (Ultrarock, Kalabhai Karson Pvt. Ltd., India) [Figure 3].

A mold for packing the silicone was made from each of the above investing materials. A 20 mm thick rectangular base of the investing material was made. Wax strips of

Figure 1: Silicone elastomer used: M511

Figure 2: Separating media used: (a) Unifol, (b) die hardener, and (c) soap solution

Figure 3: Molds fabricated using various materials: (a) Dental stone (white), (b) dental stone (green), and (c) die stone (orange)

1.5 cm × 2 cm × 0.5 cm were placed on the base and a counter was poured. The wax was then boiled out.

For each investing material studied, three such molds were made. Each mold was coated with a different separating medium, which was applied as a single thin layer with a clean paint brush. The separating medium was allowed to dry for 30 min. Care was taken to ensure that the mold was dry before packing the silicone. Thus, nine such molds were made of different combinations of the three investing materials and three separating agents. Each mold was made to accommodate 12 silicone samples. 200 g of base and 20 g of catalyst were weighed out on a digital scale and mixed. Pigments (Cosmesil pigments, Technovent Ltd., United Kingdom) were added to the mixture to obtain the Asian skin color (umber 0.1 g, ochre 0.1 g, red 0.01 g, and blue 0.01 g). The silicone was vacuum mixed for 20 min under 30 inch Hg.[12]

The mix was then uniformly packed in the various molds. The mold was closed by placing the counter on it and was clamped under pressure up to 30 psi.

All the molds were left at room temperature (21–28°C) for 24 h for the material to polymerize. The samples were retrieved after 24 h [Figure 4].

The surface to be tested was wiped with a layer of acetone to remove any impurities.

The 10 samples from each of the nine molds served as test group samples.

The samples of the control group were fabricated by packing silicone from the same mix, in a stainless steel mold with no investing material and no separating media.

All the samples were cured at ambient room temperature with no external heat application.

A spectrophotometer was used for testing the color of the samples.[13,14] The Commission Internationale d'Eclairage L, a, b system were used to assess the color difference between the test and control samples. The L* parameter corresponds to the degree of lightness and darkness (100 ideal white, 0 ideal black), while a* and b* coordinates correspond to red or green chroma (+a = red, –a = green) and yellow or blue chroma (+b = yellow, –b = blue), respectively.

The L*, a*, b* values were obtained. The Delta E (change in color) value was calculated as a difference between the control and the respective samples. The mean Delta E of each group was calculated using the formula:[15]

Delta E = ([Delta L*]^2+ [Delta a]^2+ [Delta b*]^2)^{½}

Where Delta L*, Delta a*, and Delta b* are the difference in L*, a*, and b* values between the control (L_1*, a_1*, b_1*) and test samples (L_2*, a_2*, b_2*).

The data were submitted to a two-way ANOVA test. The graphs obtained after subjecting the data to statistical analysis are represented in [Figures 5 and 6].

RESULTS

The mean L*, a*, b* values for the control group were 31.8, 26.2, and 36.3, respectively. The delta E for the test groups is presented in Table 1.

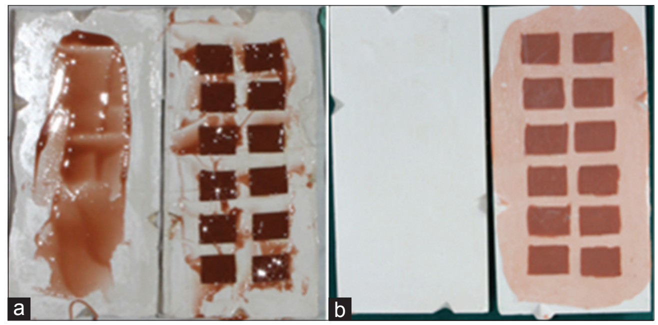

Figure 4: Fabrication of samples: (a) Packing of mold and (b) cured samples

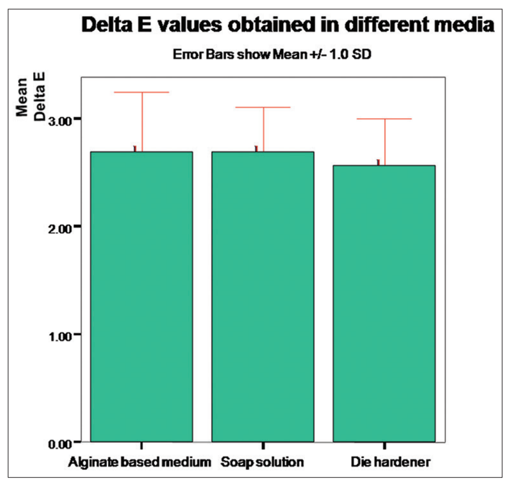

Figure 5: Comparison of color change of different investing materials with different separating media

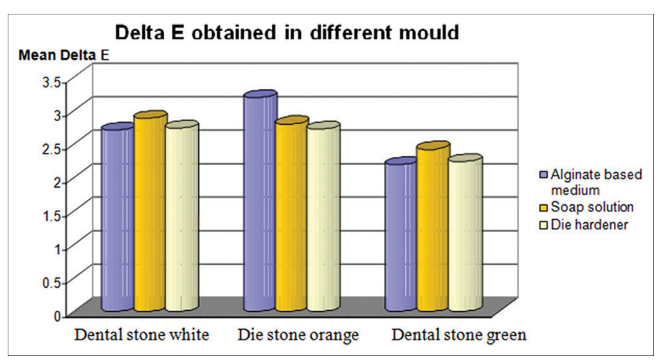

Figure 6: Comparison of color change of samples of different separating media using different investing materials

Table 1: Delta E values obtained for the nine study groups

Investing material	Separating media		
	Alginate based medium	Soap solution	Die hardener
Dental stone (white)	2.7080±0.26153	2.8820±0.28276	2.7757±0.25051
Dental stone (green)	2.1930±0.56904	2.4190±0.50287	2.2330±0.48215
Die stone (orange)	3.1930±0.22396	2.8000±0.27801	2.7210±0.38786

Values are mean±SD of ΔE. SD: Standard deviation

DISCUSSION

The color of the prosthesis plays a vital role in the overall esthetic outcome of the patient's rehabilitation. The prosthetist tries his best to obtain a color as close to the patient's skin color as possible with intrinsic pigments. Hence, the intrinsic coloring of the silicone is critical in obtaining prosthesis with a perfect color match. While some clinicians prefer to choose colors manually, the use of devices like the Spectromatch (Spectromatch Ltd., UK) is popular for color formulations and limiting effects of metamerism.[16]

Numerous authors have studied and reported a color change in silicones due to the ageing process and the factors responsible for the same.[7-11,17] In the authors' observation, the color of the final cured prosthesis is consistently different from the color that was matched in the presence of the patient. This seems to be the case more often with the silicone mixes of darker shades where the pigment loading is higher. Hence, this study was designed to try and find out the possible causes of contamination of the intrinsic color mix.

The results of this study indicate that there is a definite change in the color of the silicone following curing when each mold material is used, the maximum color change of the pigmented silicone occurs when die stone (orange) was used. It is probable that the beige color of this gypsum product was leaching into the silicone that was packed in it. Green colored dental stone produced the least color change. The mold separating agents have some protective barrier effect against the color constituents of the mold material leaching into the pigmented silicone. The dental stone (green) is prepared by calcination under pressure while the die stone (orange) is manufactured by a steam processing procedure. The dyes used during the fabrication of these mold materials could probably be leaching into the silicone causing a color change.

The mean L*, a*, b* values for the Control group were 31.8, 26.2, and 36.3, respectively. Average values of change in color (Delta E) for samples packed in dental stone (white) were 2.7080 (alginate-based medium), 2.7370 (die hardener), and 2.8820 (soap solution); for dental stone (green) were 2.1930 (alginate-based medium), 2.2330 (die hardener), and 2.4190 (soap solution); and die stone (orange) were 3.1930 (alginate-based medium), 2.7210 (die hardener), and 2.8000 (soap solution).

Kiat-Amnuay *et al*.,[6] Lemon *et al*.[8] and Haug *et al*.[18] have reported that Delta E > 1 unit and Beatty *et al*.[12,13] and Polyzois *et al*.[15] reported that Delta E > 2 units is a perceptible color change. All the values obtained in this study were higher than the threshold value that the human eye can perceive. This indicates a significant color change happened during polymerization of the silicone.

A cyanoacrylate based mold release agent (die hardener) was also tried out in this study. This agent was applied in a single coat. It produced the least color change in the silicone samples. The cyanoacrylate agent also produced very easy separation of the silicone samples from the molds with least porosity, though this was not quantified. However, it produced samples with a matte finish and the effect of cyanoacrylates on the surface of silicones could bear further investigation.

CONCLUSION

Among the investing materials studied, die stone produced the maximum color change (Delta E 3.1) in the silicone, which was statistically significant. Dental stone (green) showed the least change and dental stone (white) showed intermediate results.

Among the separating media studied, die hardener produced the least amount of color change (2.5).

Use of soap solution produced the maximum color change, but this was not statistically significant. The best combination of an investing material and separating media is a dental stone (green) and alginate-based medium.

This study was carried using the commonly used investing materials and mold release agents in India. The same results may or may not be obtained by other materials used in different countries. We recommend that maxillofacial prosthetic technology units be encouraged to go in for a 1-time testing of their stone/plaster and separating media for the color change they produce on the silicone elastomer which they use. Doing so would minimize any problems of change in color of the silicones during their polymerization process.

Clinical implications

Materials used for mold fabrication and separating media have a definite impact on the color of silicone. A 1-time testing of the mold materials and separating media available to the prosthetic laboratory for their color change in silicones should be carried out hereby selecting the best mold material-separating medium combination. This would allow the prosthetist to obtain consistently good results with facial prostheses.

REFERENCES

1. Hatamleh MM, Watts DC. Effect of extraoral aging conditions on color stability of maxillofacial silicone elastomer. J Prosthodont 2010;19:536-43.
2. Kurunmäki H, Kantola R, Hatamleh MM, Watts DC, Vallittu PK. A fiber-reinforced composite prosthesis restoring a lateral midfacial defect: A clinical report. J Prosthet Dent 2008;100:348-52.
3. Scolozzi P, Jaques B. Treatment of midfacial defects using prostheses supported by ITI dental implants. Plast Reconstr Surg 2004;114:1395-404.
4. Lontz JF. State-of-the-art materials used for maxillofacial prosthetic reconstruction. Dent Clin North Am 1990;34:307-25.
5. 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.
6. Kiat-Amnuay S, Mekayarajjananonth T, Powers JM, Chambers MS, Lemon JC. Interactions of pigments and opacifiers on color stability of MDX4-4210/type A maxillofacial elastomers subjected to artificial aging. J Prosthet Dent 2006;95:249-57.
7. Andres CJ, Haug SP, Munoz CA, Bernal G. Effects of environmental factors on maxillofacial elastomers: Part I – Literature review. J Prosthet Dent 1992;68:327-30.
8. Lemon JC, Chambers MS, Jacobsen ML, Powers JM. Color stability of facial prostheses. J Prosthet Dent 1995;74:613-8.
9. Chen MS, Udagama A, Drane JB. Evaluation of facial prostheses for head and neck cancer patients. J Prosthet Dent 1981;46:538-44.
10. Fine L, Robinson JE, Barnhart GW, Karl L. New method for coloring facial prostheses. J Prosthet Dent 1978;39:643-9.
11. Jani RM, Schaaf NG. An evaluation of facial prostheses. J Prosthet Dent 1978;39:546-50.
12. Haug SP, Andres CJ, Moore BK. Color stability and colorant effect on maxillofacial elastomers. Part III: Weathering effect on color. J Prosthet Dent 1999;81:431-8.
13. Beatty MW, Mahanna GK, Jia W. Ultraviolet radiation-induced color shifts occurring in oil-pigmented maxillofacial elastomers. J Prosthet Dent 1999;82:441-6.
14. Beatty MW, Mahanna GK, Dick K, Jia W. Color changes in dry-pigmented maxillofacial elastomer resulting from ultraviolet light exposure. J Prosthet Dent 1995;74:493-8.
15. Polyzois GL, Tarantili PA, Frangou MJ, Andreopoulos AG. Physical properties of a silicone prosthetic elastomer stored in simulated skin secretions. J Prosthet Dent 2000;83:572-7.
16. Seelaus R, Coward TJ, Li S. Coloration of silicone prostheses: Technology versus clinical perception. Is there a difference? Part 2, clinical evaluation of a pilot study. J Prosthodont 2011;20:67-73.
17. Hanson MD, Shipman B, Blomfield JV, Janus CE. Commercial cosmetics and their role in the coloring of facial prostheses. J Prosthet Dent 1983;50:818-20.
18. Haug SP, Andres CJ, Munoz CA, Bernal G. Effects of environmental factors on maxillofacial elastomers: Part IV – Optical properties. J Prosthet Dent 1992;68:820-3.

How to cite this article: Sethi T, Kheur M, Coward T, Patel N. Change in color of a maxillofacial prosthetic silicone elastomer, following investment in molds of different materials. J Indian Prosthodont Soc 2015;15:153-7.

Source of Support: Nil, **Conflict of Interest:** None.