Journal of Applied Dental and Medical Sciences
NLM ID: 101671413 ISSN:2454-2288
Volume 2 Issue4 October- December 2016

Review Article

Color stability of maxillofacial elastomers: A literature review

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ARTICLE INFO

Keywords:
room temperature vulcanized silicone, color stability, pigments, aging conditions.

ABSTRACT

Purpose: maxillofacial prosthesis is best solution for patients suffering from trauma, congenital defect, cancer etc. Success of prosthesis is mainly depend on its color stability. In past few years many research studies has been carried out to improve the color stability of maxillofacial prosthesis under artificial and natural aging condition. In an attempt to enhance its color stability different fillers like different pigment, nano particle , opacifier etc has been added. This article gives you detail review of maxiilofacial material and attempts made to increase its color stability in last 10 years.

Material and method: an electronic search was carried out in pubmed, google search,ebscohost from january 2005 to december 2015 with the help of search term "color stability of maxillofacial material", "color stability of silicone elastomer", "effect of outdoor weathering on maxillofacial silicone elastomers", "effect of artificial aging on maxillofacial material", "pigments and its effect on maxillofacial silicone elastomers", " opacifier used in maxillofacial silicone elastomer**.** Out of 79 article only 12 had relevant data

Result : room temperature shows accepted color change**.**

Conclusion: as compared to external pigment, internal pigments exhibit less loss of colour. Opacifiers protect facial silicone.decrease in size of nano particle pigment results in increased color stability of the material.

Introduction

Facial expressions and appearance are important in a humans social and personal life. Facial abnormalities due to trauma, cancer or congenital defect can decrease ones self-esteem and self-confidence [1,2.] Maxillo-facial prosthesis is the ultimate option for such patients [3,4].

Color stability is the key for the success of facial prosthesis which depends on environmental factors, adverse habits, storage and disinfection conditions [3-7.] Different materials used for fabrication of the prosthesis are acrylic resin, polyvinylchloride and copolymer, chlorinated polyethylene, polyurethane elastomer, thermoset elastomer and silicone elastomers [1,8,9]

Material and method

An electronic search was carried out in Pubmed, Google search,Ebscohost from January 2005 to December 2015 with the help of search term "color stability of maxillofacial material", "color stability

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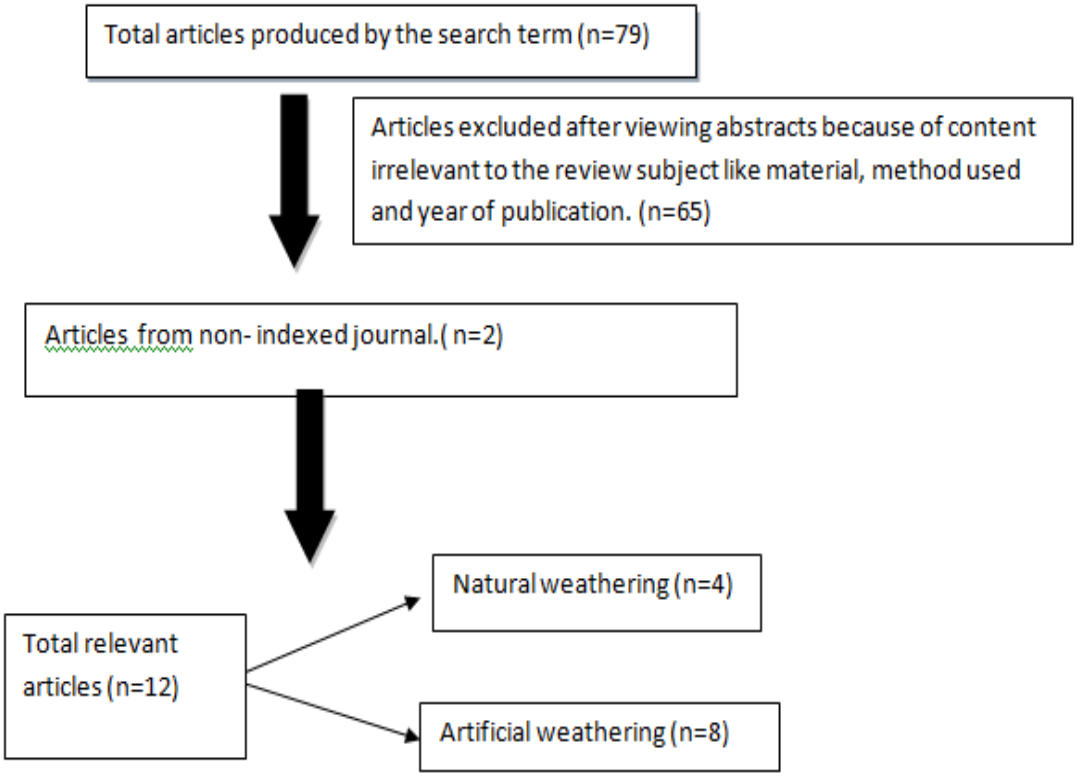
1.a Natural weathering

Sr. No	Name of author (year)	Study conducted	Materials used	Material incorporated	Conclusion
1	Rosita Kantola et al.[19] J Adv prostho dont 2013	Color stability of thermochromic pigment in maxillofacial silicone	MDX4-4210	Functional intrinsic silicone coloration II: white (FI-200) flesh ferro (I-100-S) " yellow (FI-202) " blue (FI-203) " buff (I-206) " redbrown (I-207) " red (I-204) " tan (I-215) " Rayon fiber flocking: brown (H-110-B) red (H-101-R) " ChromaZone Free Flowing Powder, pigment red	The thermochromic pigment used in this study is very sensitive to UV irradiation, and is not suitable, as such, to be used in the fabrication of maxillofacial silicone elastomer prostheses
2	R. N. Akash et al.[20] J Prosthet Dent 2015	Effect of Incorporation of Nano-Oxides on Color Stability of Maxillofacial Silicone Elastomer Subjected to Outdoor Weathering	M511	Titanium dioxide Zinc oxide along with intrinsic pigment	The present findings suggest that incorporation of nano-oxides improved the color stability of Cosmesil M511 silicone elastomer and also acted as an opacifier. ZnO-incorporated Cosmesil M511 specimens showed minimal or no color change and proved to be most color stable after being subjected to outdoor weathering

3	Fahad A. Al-Harbi et al.[9] J Prosthet Dent 2015	Mechanical behavior and color change of facial prosthetic elastomers after outdoor weathering in a hot and humid climate	TechSil S25, A2186, MED 4210	P-409	Outdoor weathering caused unacceptable color changes in pigmented TechSil S25, A-2186, and MED-4210 silicone elastomers
4	Emily S. Willett et al.[2] J Prosthet Dent 2015	Outdoor weathering of facial prosthetic elastomers differing in Durometer hardness ,	A221-05 A223-30 A225-50 A225-70 A2186		After 3000 hours of outdoor weathering, color changes were generally low. Durometer 5, 30, and A-2186 underwent color changes that were visually perceptible but not unacceptable

Figure 1: Methodology



1b Artificial aging

Sr. No	Name of author (year)	Study conducted	Materials used	Material incorporated	Conclusion
1	Sudarat Kiat-amnuay et al.[21] J Prosthet Dent 2006	Interactions of pigments and opacifiers on color stability of MDX4-114210/type A maxillofacial elastomers subjected to artificial aging	MDX 4210 Silastic medical adhesive silicone type A	Georgica kaolin powder neutral, Kaolin powder calcined, Artskin white, Dry pigmented Ti white, Ti white artist oil color,Cadmium barium red deep, Yellow ochre, Burnt sienna red deep, Yellow ochre, Burnt sienna	At all 3 concentrations, oil pigments mixed with opacifiers helped protect the MDX4-4210/type A silicone elastomer from color degradation over time. Dry pigment Ti white remained the most color stable over time, followed by the pigments mixed with kaolin powder calcined, Georgia kaolin, Artskin white, and Ti white artists' oil color
2	Panagiota N. Eleni et al.[8] Dent Res J 2008	Color Stability of Facial Silicone Prosthetic Elastomers after Artificial Weathering	Episil silicone prosthetic elastomers (Dreve-Dentamid GmbH, Unna, Germany), an additiontype RTV (room temperature vulcanizing) elastomers	Episil Europe 1 Episil Europe 2 Episil Europe 3 Episil Africa 3	Artificial weathering caused significant eye detectable color changes in Episil Europe 2 and Episil Europe 3 samples that approached clinically unacceptable changes. Contrary, color changes in Episil Europe 1 and Episil Africa 3 were below detection limits for the naked eye.

3	Daniela Nardi Mancuso(a) et al.[22] Braz oral Res 2009	Color stability after accelerated aging of two silicones, pigmented or not, for use in facial prostheses.	Silastic 732 and Silastic MDX4-4210.	Intrinsic pigment-ceramics, cosmetics or iron oxide	During spectrophotometric analysis, both Silastic 732 and MDX4-4210 presented color instability during the different periods of time analyzed. The materials without the incorporation of pigments presented similar color alteration values, and did not differ statistically. The cosmetic powder used in this study was the pigment that most altered the color of the test specimens.
4	Ying han et al.[16] J Prosthet Dent 2010	Color stability of pigmented maxillofacial silicone elastomer: Effects of nano-oxides as opacifiers	A 2186	Functional intrinsic colors (red) Functional intrinsic colors (yellow) Functional intrinsic colors (blue) Nano-TiO2 (rutile, 30–40 nm) Nano-ZnO (20 nm) Nano-CeO2 (50 nm)	1% nano-CeO2 and 2% and 2.5% nano-TiO2 by weight used as opacifiers for silicone A-2186 maxillofacial prostheses with mixed pigments exhibited the least color changes when subjected to artificial aging at 450 kJ/m2. Yellow silicone pigment mixed with all three nano-oxides significantly affected color stability of A-2186 silicone elastomer and should be used with caution.

5	Daniela Micheline dos Santos et al.[23] J Prosthet Dent 2011	Influence of Pigments and Opacifiers on Color Stability of an Artificially Aged Facial Silicone	MDX4–4210	Two inorganic pigments, ceramic powder (Clarart, Brasilia, Brazil) and oil paint (Acrilex, Sao Paulo, Brazil), and one barium sulfate-based opacifier (Wako, Osaka, Japan)	The opacifier protects facial silicones against color degradation, and oil paint is a stable pigment even without addition of opacifier.
6	Marcela Fili´e Haddad et al.[3] J Biomed Opt. 2011	Color stability of maxillofacial silicone with nanoparticle pigment and opacifier submitted to disinfection and artificial aging	Silastic MDX4-4210	ceramic powder and BaSO4.	The association between ceramic nanoparticles and BaSO4 opacifier was the most stable condition in relation to color maintenance,without considering disinfection and the aging period. All_E values obtained in the present study, independent of the disinfectant and of the period of artificial aging, were considered clinically acceptable.
7	Ying Han et al.[24] J Prosthet Dent 2013	Effect of opacifiers and UV absorbers on pigmented maxillofacial silicone elastomer, part 1: Color stability after artificial aging	Silastic MDX4-4210 medical-grade elastomer Silastic medical adhesive silicone type A	UV Protecting Mineral-Base Sunforgettable SPF 30, All Clear Dry pigment titanium white, Functional intrinsic silicone white, Functional intrinsic silicone red, Functional intrinsic silicone yellow,	All opacifiers used in this study protected pigmented silicone MDX4-4210/Type A from color degradation. UV mineral-based light protecting agent groups produced the smallest color changes

				Functional intrinsic silicone blue, Cadmium-barium, red deep Yellow ochre French ultramarine blue	
8	Blessy Susan Bangera et al.[25] J Prosthet Dent 2014	Evaluation of varying concentrations of nano-oxides as ultraviolet protective agents when incorporated in maxillofacial silicones: An in vitro study	M511	Titanium dioxide Zinc oxide	Compared with Ti nano-oxides (2% to 2.5%), Zn nano-oxides in lesser concentrations provided more significant and consistent ultraviolet protection in Cosmesil M511 elastomer

of silicone elastomer", "effect of outdoor weathering on maxillofacial silicone elastomers", "effect of artificial aging on maxillofacial material", "pigments and its effect on maxillofacial silicone elastomers", " opacifier used in maxillofacial silicone elastomer**.**

The searches from the various databases were combined and duplicate articles subsequently removed. By examining the bibliographies of retrieved articles, additional articles were identified.

Only those articles are included in which outdoor weathering and artificial weathering has been used to check the color stability of maxillofacial silicone elastomers (Figure1).

Inclusion and exclusion criteria were as follows:

Inclusion criteria: Articles published in English language from indexed journal only were considered for inclusion. The articles from January

2005 to December 2015 were considered. Only in vitro studies were considered. The article should have include room temperature vulcanized silicone. Materials other than Room temperature vulcanized silicone elastomer were not included.

Discussion

Silicones introduced by Barnhart in 1960 are the choice of material for extra oral prosthesis[1,10]. Although it is widely used it has a disadvantage of color instability over a period of 6months to 1year afterword patients required replacement of prosthesis[3,7,11,12]

Maxillofacial material should have physical and mechanical properties analogous to human tissue and ideally maintain those characteristics during function. Among all the maxillofacial material silicones are widely used material for facial prosthesis [13].

Silicones:

It is chemically known as polydimethyl siloxane. They are a combination of organic and inorganic compounds [13]. To obtain more lifelike natural appearance they can be stained either intrinsically or extrinsically. different combination of pigment and

opacifier are used to produce more color stable prosthesis[14]. If silicones are adequately cured they resist absorption of organic material which leads to bacterial growth[15].

Based on method of vulcanization silicones are further divided into two basic types.[1,13]

1. Room temperature vulcanizing (RTV) Silicone
2. Heat vulcanizing (HTV) Silicone

Although it has been stated that as compared to room temperature vulcanizing (RTV) silicone, high temperature vulcanizing (HTV) silicones have the advantages of excellent thermal stability and physical properties along with color stability ,some recent studies have reported good color stability of the RTV silicone [9,16].

The majority of respondents from survey by Andres et[7,17] al used RTV silicone elastomers in facial prosthesis. Hence present article focusing only on RTV silicone elastomers.

Facial prosthesis is intended to replicate the form of natural skin. For that color matching with adjacent skin can be successfully achieved by adding different pigments.

Pigments:

They are classified into 2 groups i) organic ii) inorganic

Organic pigment are derived from carbon and hydrogen where as inorganic pigments are mineral in origin, they contain metal atoms. Organic pigments have a limited life span and are more prone to decay on aging and exposure to adverse environmental conditions [7,18].

There are 2 methods of application of pigments ,intrinsic and extrinsic.

Dry earth pigments, rayon flocking fibers (most commonly used), artist's oil pigments, or a combination of these materials for intrinsic tinting. Kaolin material was commonly used as an opacifier.

The most-used extrinsic colouring method was Medical Adhesive Type-A mixed with Xylene as a retarder/thinner tinted with dry earth pigments or artist's oil pigments applied to the surface of the prosthesis in a thin layer.

The introduction of silicone colourant technology began in 1992 with Factor II's silicone intrinsic colourants. In 1999, the silicone colourants were further refined using a cross-linking fluid to maintain viscosity to allow drop-by-drop dispensing. Silicone extrinsic paste pigments (Factor II) with additional pigment to the cross-linking fluid were introduced shortly after [7]

Aging of material can be done by 3 methods natural or artificial or both

i) Natural weathering :

In this specimens/ samples are subjected directly to natural weathering for a particular period and hours. Duration is decided with the help of meteorological data of that particular area[7].

ii)Artificial weathering:

Many times accelerated aging is used which simulates/creates the natural weathering and the help of aging chamber/ weatherometer/weathering chamber which gives the esteem of the in-service of material but, it could also affect the mechanism of degradation and could lead to inaccurate estimates of the materials life time. Hence to predict the life time of material outdoor weathering under regional service conditions is preferable than accelerated/artificial[9]. The results obtained by researches are listed in table 1a and 1b

Conclusion

Most of the RTV silicone elastomers and pigments show acceptable colour changes.

As compared to external pigment, internal pigments exhibit less loss of colour because there are less chances of internal pigments to be dissolved during cleaning of the prosthesis.

Opacifiers protect facial silicone.

Decrease in size of nano particle pigment results in increased color stability of the material.

Proper daily care and maintenance of the facial prosthesis should be specified in the literature given to the patient.

The patient should be instructed to avoid exposure to direct sunlight, application of water base or other makeup/ any cosmetic on prosthesis, use of isopropyl alcohol to clean the prosthesis.

Patient should be advised to use hats and sunglasses and quit smoking to increase the life of prosthesis.

The possibility of using UV absorbers may be a partial solution regarding pigment stability of facial prosthesis. UV absorber may help in case of facial prosthesis to increase the color stability.

Besides applying UV protection internally to the silicone prosthesis, external protection from a spray with a UV inhibitor should be investigated.

The patient should be trained on how to insert and remove the prosthesis.

Research may need to be directed towards minimizing the degree of colour changes and effect of human environment (sebum, alkaline perspiration) on color stability of maxillofacial prosthesis.

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