Color matching in facial prosthetics: A systematic review

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Abstract

Color matching to the surrounding skin is extremely important in patients wearing maxillofacial prostheses. It is of utmost importance to know the different techniques of color matching and coloring in maxillofacial prostheses. The purpose of this study is to review the literature data with regard to color matching in maxillofacial prosthetics. An electronic search of peer review restricted to English language dental literature was conducted to identify the relevant scientific article on color matching and coloring in maxillofacial prostheses. The publication year was up to December 2015 so that the search could include all the articles provided in that particular database. Two independent observers independently read the abstracts and later preselected full-text articles. A full-text review was carried out only for 15 articles. Out of the 15 articles, 7 were related to coloring using tinting, spraying, milling, and use of commercial cosmetics. Three studies were related to shade matching in maxillofacial prostheses. Two studies conducted the measurement of color in maxillofacial prostheses. Only one study had explained color and its relevance in maxillofacial prosthetics. Only one study was done for reproducing silicone shade guide matching Indian skin color. In addition, a single pilot study was done to measure facial skin and lip color in a human population sample stratified by race, gender, and age. Currently, there is no evidence discussing the best technique available for perfectly matching the color for the fabrication of maxillofacial prostheses. However, the latest instruments such as spectrophotometer and colorimeters are believed to have improved efficiency in matching the color.

Key Words: Color, color matching, facial prosthesis, spectrophotometer

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INTRODUCTION

Color matching has always been a challenge to the maxillofacial prosthodontists. Matching accurate color information of human skin is an important step in the fabrication of facial prosthesis.[1] Facial prostheses are fabricated using restorative material such as acrylic resin[2] or silicone,[3] and the color results from the addition of colorants to them. Colorants are dyes or pigments that give color to otherwise colorless objects or modify perceived color.[4] When prosthesis is indiscernible to the surrounding skin, there will be best esthetic outcomes.

Various subjective and objective techniques have been used to achieve an accurate skin looking match. The subjective technique includes chairside visual trial and error method.[5] Ouellette[6] developed a spraying technique for coloring facial prosthesis which provided a feasible method for realistically

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tinting silicone prostheses following which tinting,[7] tattooing methods,[3] milling machine method,[8] and use of commercial cosmetics[9] evolved.

Compared with a chairside visual trial-and-error method[5] and facial skin shade guides,[10] instrumental colorimetric or photometric techniques were noted to provide more quantitative, reliable, and consistent assessment of an object's color under controlled conditions.[11,12]

There are many studies regarding different color matching techniques.[6-12] However, so far, no systematic reviews on color matching in maxillofacial prostheses had been reported. Hence, the purpose of this article is to review the available literature with regard to color matching in maxillofacial prosthetics.

MATERIALS AND METHODS

The overall search strategy is shown in Table 1. The assessment criteria were defined in accordance with the Population or Patient, Intervention, Comparison or Control, Outcome and Study type criteria [Figure 1].

The review included all the studies, in which participants wore facial prostheses (ocular, orbital, auricular, and lip and nasal prostheses). Neither there were restrictions regarding the sex or age of participants nor on the article types. None of the included studies (n = 15) described color matching objectively, so it was assumed that patient acceptance of the prosthesis indicated an appropriate color match. Hence, the main outcome parameter was defined as acceptability of the prosthesis by the patients.

Table 1: Systematic search strategy

Focus question: In patients with maxillofacial defects, what is the most commonly used method of color matching in maxillofacial prostheses?
Population
Patients with extraoral maxillofacial defects seeking prosthetic rehabilitation
Intervention
Different techniques of color matching of extraoral maxillofacial prosthesis
Comparison
Techniques used earlier and techniques used currently for color matching in maxillofacial prostheses
Outcome
Closest color match to patient's skin shade
Search combination
Maxillofacial prostheses and color matching
Maxillofacial prostheses and color
Maxillofacial prostheses and spectrophotometer
Maxillofacial prostheses and colorimeter
Electronic database searched
PubMed/MEDLINE
Selection based on inclusion criteria
Articles in English
All article types
Articles related only to color matching of facial prosthesis
Selection based on exclusion criteria
Studies in languages other than English
Articles related to any other step of fabrication of facial prosthesis except color matching such as color stability and impression technique
Articles related to somatoprosthesis
Studies with animal models or experimental *in vitro* studies

English language peer-reviewed dental literature was electronically searched to identify the relevant scientific article on color matching in maxillofacial prostheses. MEDLINE and PubMed searches were carried out by using the following index word and phrase searches: maxillofacial prostheses and color, maxillofacial prostheses and color matching, maxillofacial prostheses and spectrophotometer, and maxillofacial prostheses and colorimeter. The publication year was from January 1900 to December 2015 so that the search could include all the available articles provided in that particular database. Two independent observers independently read the abstracts and later the preselected full-text articles.

For studies meeting the inclusion criteria, articles with full text were obtained and evaluated further. The titles and abstracts of all the screened articles were assessed and reviewed for appropriateness so as to fulfill the purposes of the systematic review. Finally, a further manual search, including the citations of the finally obtained articles, was done to improve the electronic search.

RESULTS

The electronic search in the PubMed database provided a total of 194 articles that were considered potentially relevant. The text found using the "and" Boolean operator in between the search words namely; Maxillofacial prostheses and color matching, Maxillofacial prostheses and color, Maxillofacial prostheses and spectrophotometer, Maxillofacial prostheses and colorimeter were 10,158,20 and 6 respectively.

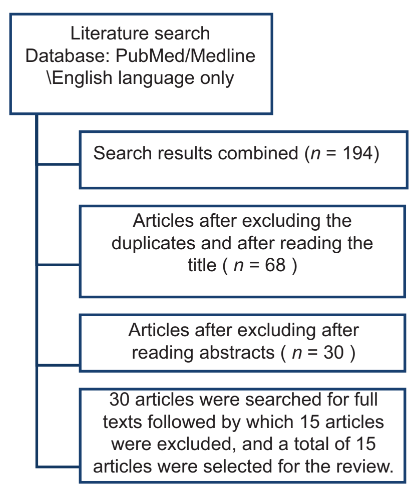

Figure 1: Systematic search strategy

In the second phase of article selection, duplicate articles (34) were excluded and 92 articles were excluded after studying the title. Subsequently, in the third phase of the study, 38 studies were excluded after reading the abstract, and then a full-text review of 30 articles was eventually carried out. After reading the full text, 15 articles were excluded, and a total of 15 articles were selected for the systematic review.

Out of the 15 selected studies, 7 studies were regarding coloring the maxillofacial prostheses using spraying technique by Ouellette,[6] tinting method by Firtell and Barlett,[7] tattooing technique by Schaaf,[3] milling technique by Chalian *et al.*,[8] use of commercial cosmetics by Hanson,[9] use of cosmetic pigments by Aina *et al.*,[13] and a new method for coloring facial prostheses. Three studies were there for developing shade guides for matching the color of facial prostheses. Two studies investigated the measurement of color in maxillofacial prostheses. Only one study had explained color and its application in maxillofacial prosthetics. Only one study was conducted for reproducing silicone shade guide matching in Indian skin color. In addition, a single pilot study was done to measure facial skin and lip color in a human population sample stratified by age, gender, and race.

DISCUSSION

Special techniques in tinting and coloring of prostheses to obtain realistic effects are required due to the heterogeneity of tones and shades, the illusion of depth, and the varying degrees of translucency present in human skin. Studies regarding the coloration techniques and color matching for maxillofacial prostheses are heterogeneous because of the multiple techniques available for color matching based on skin translucency, skin tones, population, etc., [Table 2].

There is no randomized controlled trial (RCT), systematic review, or literature review available regarding the color matching in maxillofacial prostheses. However, a single literature review for the measurement of color stability in maxillofacial prostheses was available. Most of the studies included in this systematic review were techniques related to color matching and case reports.

Autopolymerizing acrylic resin for the fabrication of shade guide was used by Schaff because of its availability, and its use is understood by most dentists. Color tabs of thickness of 1.5 mm were established for the shade guide, which approximated the usual thickness of acrylic resin prosthesis. Thickness must be taken into account in selecting a color because the background of the anatomical defect will influence the color of the prosthesis.[3] Godoy prepared an acrylic resin shade guide by mixing various colors of autopolymerizing acrylic resin or by combining the different color mixes with dry earth pigments.[2] Guttal *et al.* developed a silicone shade guide for Indian skin color using stock powder with pigments. The predominant colors that match the Indian skin color are light red, burnt umber, yellow ochre, burnt sienna, and Vandyke brown.[16]

Five pigments such as melanin, melanoid, reduced hemoglobin, oxyhemoglobin, and carotene, which are found in various layers of the skin, were attributed to skin color according to Edwards and Duntley.[19] The absorptive uniqueness of these skin pigments, especially of melanin, provided the total reflected light and determines the value, hue, and saturation of the skin color. Wasserman conducted spectrophotometric analysis of skin color in different racial groups and found that irrespective of race, the dominant reflected hue is red.[20] Dissimilarity between races and the different variances in the same population are governed by the melanin content. Gillman and Cantor *et al.* stressed the importance of tinting facial materials with pigments that will result in spectrophotometric curves close to those of human skin and so affect an acceptable color match. The closer the spectral curves, the less of a problem metamerism becomes.[21,22]

Hanson *et al.* reported that the use of combinations of premixed cosmetic earth pigments in facial prosthesis coloring techniques provides an efficient and predictable method of fabricating skin-colored prostheses.[9]

Newer studies occurring on the change in color of the maxillofacial prosthesis depending on the investment mold used for packing procedures show that die stone shows most statistically significant color change, hence color matching is influenced by the type of mold.[23]

Most of the times, shade matching for maxillofacial prosthesis is done using trial and error method during packing procedure either for resin prosthesis or silicone prosthesis.[24] Tinting of the prosthesis using oil color is also a commonly advocated technique for color matching of ocular prosthesis.[25]

Currently, there is no evidence discussing the best technique available for perfectly matching the color for the fabrication of facial prostheses. However, the newer techniques such as spectrophotometer and colorimeters are believed to have improved efficiency in matching the color.

In addition, there is no RCT indicating the superiority of one method of color matching over the other for producing the best color match, so more research in the area and in particular RCT studies are clearly indicated to determine the best technique for color matching.

Out of the total 194 articles, a few studies were found related to the fabrication of facial prostheses and basic color matching techniques, but studies related to advanced color matching techniques were scarce. This suggests that long-term longitudinal studies should be done in advanced color matching techniques.

Table 2: Studies regarding coloration techniques

Study (years)	Purpose	Coloring technique	Assessment/outcome
Ouellette (1969)[6]	To develop a spraying technique for coloring facial prosthesis	External spraying was done after the basic shade has been casted	This technique provides a feasible method for realistically tinting silicone prostheses
Firtell and Barlett (1969)[7]	To describe a method for tinting external facial prostheses	Four steps Preparation of stock color Blending of base shade Surface tinting Record keeping	Reproducible surface tinting of external maxillofacial prostheses
Schaaf (1970)[3]	Developing a tattooing method for color-characterizing silicone rubber facial prostheses	Painting a coloring material on prosthesis surface, then penetrating the paint with a needle to a depth of 1–2 mm, thus carrying some of the pigments below the surface	Tattooing method for color-characterizing facial prosthesis
Chalian *et al*. (1974)[8]	To develop a milling machine primarily to simulate skin color and texture in the final prostheses	When the milling machine is switched on, intrinsic colors are incorporated in the silicone material by adding small chunks of silicone material that have just a dab of the color or colors that are needed to match the patient's skin	A portable milling machine designed for intrinsic coloring of heat-vulcanizing silicone materials for extraoral prostheses
Fine (1978)[4]	To study color and its application in maxillofacial prostheses	Various methods for coloring were studied	Color matching may be accomplished on a trial and error visual basis or by the utilization of instrumental and computational methods
Fine *et al*. (1978)[14]	To study the new method of coloring facial prostheses	A review of previous techniques available were studied, and a new technique was given	Technique involves the use of a completely different colorant, namely, different-colored rayon flock fibers, and the elimination of the silicone fluid used previously as a thinner
Aina *et al*. (1978)[13]	To study the color matching in Negro patients	Three Negro patients were selected to represent the three basic tones within the wide range of skin color found in Negroes. The area of skin initially chosen for matching was the left zygomatic prominence The final matching was made in bright daylight	Skin tones for Negro patients were developed
Hanson *et al* (1983)[9]	To study the role of commercial cosmetic in coloring maxillofacial prostheses	Two cosmetic manufacturers were consulted: Mary Kay Cosmetics and Elizabeth Arden. The former manufacturer supplied liquid samples of its cosmetics, which were incorporated directly into the clear, uncured Dow Corning MDX4-4210 silicone polymers	The use of combinations of premixed cosmetic earth pigments in facial prosthesis coloring techniques provides an efficient and predictable method of fabricating skin-colored prostheses
Ma *et al*. (1988)[5]	Not specified	Used for color verification of facial prosthesis before the final processing	Rectangular wedge-shaped medical grade silicone specimen
Godoy *et al*. (1992)[2]	Not specified	Acrylic resin shade guide by mixing different dry earth pigments with a roch wax carver and a Hu-Friedy Cleoid discoid carver, which carried loads of up to an average of 0.0158 g and 0.0024 g, respectively	Acrylic shade guide (color acrylic tabs of 6 cm×3 cm×1.5 mm were prepared)
Over *et al*. (1998)[10]	To determine if using CIE L*a*b* color measurements of white facial skin could be correlated to those of silicone shade samples that visually matched the skin	-	There was a good correlation between the patient's colorimeter measurements and the silicone samples, with the b* color dimension the most reproducible, followed by the L* and the a*
Gozalo-Diaz *et al*. (2007)[15]	The purpose of this study was to determine the color of vital craniofacial structures and evaluate the validity and test–retest reliability of a noncontacting 45°/0° optical configuration	A spectroradiometer and an external light source were configured in a noncontacting 45°/0° (45° illumination and 0° observer) optical configuration to measure the color of patients' vital craniofacial structures (central and lateral incisor and canine, attached gingiva, lips, and facial skin)	Given its acceptable validity and reliability, the use of a noncontacting 45°/0° optical configuration is recommended as a viable alternative to obtained CIE L*a*b values for shade replication in craniofacial prosthetic rehabilitation

Contd...

Table 2: Contd...

Study (years)	Purpose	Coloring technique	Assessment/outcome
Guttal *et al*. (2008)[16]	The purpose was to develop a shade guide for Indian skin color	Four step wedge of silicone 1, 2, 4, and 6 mm were made and powder pigments were added, measured by digital analyzer, tested in malar region	Silicone shade guide of three basic skin tones: light, medium, and dark complexion
Hu *et al*. (2010)[17]	To compare the accuracy of contact and noncontact measuring systems	Twenty-four thick MFE specimens approximately 23 mm in diameter and differing in translucency were made with A-2000, a platinum silicone elastomer (factor II) mixed with five pigments, i.e., tan, black, red, yellow, and titanium dioxide powder. Five instruments were utilized, and the color of each elastomer was measured three times by each instrument studied	Within the limitations of this study, the noncontacting measuring system performs differently in accuracy but comparable in precision when compared with contact measuring systems
Wee *et al*. (2013)[18]	To develop a skin shade guide for human skin of different racial groups	One hundred and nineteen participants were screened and asked to remove any facial makeup, seated with lower jaw and forehead resting lightly on head frame, and spectrophotometric scan was done	Five distinct skin shade tabs' clustering analysis

CONCLUSION

Color matching is a crucial step in the fabrication of maxillofacial prostheses. There are diverse methods to match the color to facial skin in maxillofacial prosthetics. With the advent of newer methods, the procedure of coloration has been more accurate and less time taking.

This systematic review demonstrated that the most common technique utilized in clinical practice for color matching of facial prostheses is trial and error method. Although the available data for color matching of facial prostheses are limited, there is no current evidence indicating the superiority of one technique over the other.

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Conflicts of interest
There are no conflicts of interest.

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