Metamerism of Three Different Pigments for Facial Prostheses and a Method to Improve Shade Evaluation

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Purpose: To assess the illuminant metamerism of three different pigments used for maxillofacial prostheses under three different illumination sources and to standardize subjective shade-matching and observation protocols. Materials and Methods: Nine silicone shade tabs were constructed for three volunteers who had light, medium, and dark skin tones using make-up, oil paint, or silicone pigments (three shade tabs per volunteer). A shade recipe was recorded during session one, and further tabs were constructed by following the recipe at two subsequent sessions. Using an observation protocol, expert examiners rated the shade match under three different illuminants. Results: The intra-rater and inter-rater reliability revealed acceptable reliability (ICC > 0.6). Two-way analysis of variance revealed significant differences (P < .05) for pigments and illuminants and for the interaction of pigments with illuminant on the raters’ scores. Conclusion: Illuminant metamerism affected the appearance of the silicone shade tabs. Oil paint with fluorescent or incandescent illumination had the worst effect. It was found possible to construct a consistent shade guide and to recommend an observation protocol, which should be repeatable if similarly experienced examiners are used. Int J Prosthodont 2018;31:607–609. doi: 10.11607/ijp.5916

Shade-matching for maxillofacial prostheses has traditionally been accomplished with subjective or trial-and-error methods.¹ Compared with non-standardized subjective methods, objective methods involve the use of spectrophotometers, colorimeters, or spectroradiometers.² However, these instruments are time-consuming and expensive, and a correlation with clinical results has not been definitively established.¹

The aim of this in vitro study was to evaluate a subjective shade-matching protocol, as well as an observation/assessment protocol, for different pigments under different illuminants. These data may then be used to establish standardized subjective shade-matching/observation methods, be useful in the production of shade guides, and improve cost-effective techniques for constructing maxillofacial prostheses.

Materials and Methods

Nine silicone (A2000, Factor II) shade tabs with a volume of 600 mm³ (20 × 10 × 3 mm) were pigmented intrinsically and constructed for matching against three volunteers with light, medium, and dark skin tones.

In session one, three shade tabs were pigmented and constructed in one room with standard artificial daylight (Philips L36/954 light tubes, color temperature 5400 K, Ra > 90). Following the shade-matching protocol, the formula for creating a base shade was recorded. The pigments used were:

- Group 1: Silicone pigments (Factor II)
- Group 2: Oil paints (Winsor and Newton)
- Group 3: Make-up (Kryolan)

The base shade was added to the silicone elastomers in a pigment-loading concentration that ranged between 0.1% and 2%, depending on the shade of the volunteer.² The silicone was processed according to the manufacturer’s instructions.

The silicone pigmentation and mixing was replicated twice at 1-week intervals by following the formula created in the first shade-matching session. The completed base shade tabs were coded thereafter.

Four expert examiners who had passed the Ishihara Color Vision test were calibrated for the use of an observation protocol (Fig 1) derived from the
Position

Position the subject so that the area of interest (focal area) is situated at the same vertical and horizontal distance from the illuminant at each observation session.

Subject

Wear a neutral color (eg, white or gray).

Observer

• Position yourself at least 50 cm from the focal area.
• Assess the patient at a 0-degree observation angle for no more than 5 seconds.
• Now assess the patient at a 45-degree angle, from left and right, for no more than 5 seconds at a time.
• You may look at the area as many times as you require to make your decision, but you must look at a neutral gray card between each 5-second evaluation to re-sensitize your eyes.
• Rate the shade match on a scale from 0 to 10, where 0 = completely unacceptable and 10 = an excellent color match.
• Complete this for each shade tab under all three illuminant conditions.

Fig 1  The observation/assessment protocol.1,3,4

Literature.1,3,4 Following this protocol, the examiners assessed the base shade tabs against the relevant volunteer using a visual analog scale (VAS) under different illuminants: artificial daylight (color-corrected light; 5400 K), white light (Fluorescent F36W/33 light tubes, 4000 K, Ra 58, Philips), and incandescent light (STD 60W B22 Clear, 2500 K, Ra > 90, Philips). There was no exogenous illuminant source.

Data were recorded (Excel, Microsoft) for each shade tab and skin tone for a total of six data subsets, and the following analyses were completed (SPSS, IBM): descriptive statistics; intra- and inter-examiner reliability using intraclass correlation coefficient (ICC); and three-way analysis of variance (ANOVA) to determine the fixed and random effects of the observer on pigments and illuminant.

The raters’ scores were averaged for each evaluation, and a two-way ANOVA for pigment, illuminant, and their interaction completed. Post hoc Tukey honest significant difference (HSD) analyses were completed. Estimated marginal means and confidence intervals (CI) illustrated the interaction effect. A 5% significance level was used.

Results

The inter-examiner reliability across observers per observation session was above the threshold of 0.6 and ranged from an average of 0.778 to 0.853. The two-way ANOVA revealed significant differences ($P < .001$) for pigment and illuminant for the light, medium, and dark groups ($P < .001$; $P < .05$; and $P < .05$, respectively), with make-up and color corrected–light scoring the highest. There were also significant differences for the interactions between pigment and illuminant for the light, medium, and dark groups ($P = .011$; $P = .016$; and $P = .017$, respectively) (Fig 2).

Discussion

Oil paint had the worst scores, which may indicate that make-up and silicone pigments have a smaller learning curve and greater ease of use for pigmenting silicone elastomer. Make-up is also cost-effective, readily available, and allows patients to use it as a masking agent. Shade tabs were scored significantly lower under fluorescent lighting, indicating that illuminant metamerism affected shade perception.

Shade assessment and mixing of maxillofacial prostheses should therefore be completed under color-corrected light. Furthermore, the interaction between oil paint and fluorescent lighting consistently produced lower scores.

The number of calibrated expert examiners may be considered low, but these examiners were the ones with the most experience in shade matching in this particular clinic. Although efforts were made to control shade matching and assessment methods as much as possible, factors such as differences in visual acuity cannot be accounted for. However, the statistical analyses showed that the examiners tended to score a tab in a similar manner as on a VAS, which indicates the reliability of this method if other similarly experienced examiners were to be used. Although the ICC could not account for the range of scores between examiners (ie, the precision and specificity), the range (1.01 for the dark group to 2.18 for the light group) was considered clinically acceptable.

There appears to be sufficient evidence for the method of constructing base shade tabs and for their use in shade-matching following the observation protocol. It is suggested that the formula be used to establish an initial base shade, which can be enhanced with other techniques (eg, flocking) to improve the visual properties. Future studies should evaluate the ease of use of such shade tabs for constructing maxillofacial prostheses and the effect of these pigments on silicone’s mechanical properties, as well as shade degradation. Objective shade assessment methods may also be compared using this standardized subjective approach.

Conclusions

Illuminant metamerism affected the appearance of the silicone shade tabs, and
oil paint with fluorescent or incandescent illumination scored the worst on the VAS for shade-matching. A consistent shade guide was constructed, and an observation protocol can be recommended that should be repeatable if similarly experienced examiners are used.

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References