Short Communication

Effect of External Light Conditions During Matching of Tooth Color: An Intraindividual Comparison

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The aim of this study was to investigate color matching under natural daylight and daylight lamp conditions. Twenty-nine preclinical students underwent a training course and then matched randomly chosen shade tabs of Vita 3D-Master Shade Guide under both natural daylight and daylight lamp conditions. Color difference (ΔE_{ab}) between presented and selected shade tabs was calculated. Statistical differences were explored by use of multivariate analyses. Mean ΔE_{ab} was 2.5 (1.0 to 4.3) with daylight lamp and 3.4 (0.9 to 7.4) with natural daylight. The difference was statistically significant ($P < .001$). The use of a daylight lamp helps to standardize light conditions and significantly improve the ability to match colors.
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Color assessment substantially affects the acceptance of dental prostheses by patients.[1] Color determination in dentistry can be performed either visually or instrumentally. Instrumental methods, which use computerized quantification of color, have not yet been widely accepted because of their disadvantages: cost, the need for accurate reproducible positioning, and the effect translucency and tooth surface have on color determination. Visual methods of comparing tooth color with prefabricated shade guides are currently the standard method in color assessment.[2]

External light conditions are important for visual color assessment because spectral composition of standard light sources differs from that of daylight, leading to metamerism, ie, invisible spectral differences that become visible under daylight conditions.[3] Daylight lamps (D_{65}) alone emit radiation of spectral composition comparable with that of natural light. Diffused northern light at noon is regarded as standard but cannot always be achieved.

The objective of this study was to investigate whether a color-matching process under natural daylight conditions, as used in dental practice, is as good as color matching under the standardized optimum light conditions created by a daylight lamp.

Materials and Methods

Participants were recruited from a preclinical student course at the University of Heidelberg (n = 29; 69% female, 31% male) and aged from 23 to 35 years (mean age: 26 years). The exclusion criterion was color blindness, monitored by the Ishihara test.

Before the investigation, all participants attended a 60-minute lecture on basic knowledge about tooth color and underwent a standardized theoretical and practical training program using Toothguide Training Box (TTB) (Vita Zahnfabrik) (Fig 1). The box is based

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Fig 1 Toothguide Training Box (selection of lightness group).

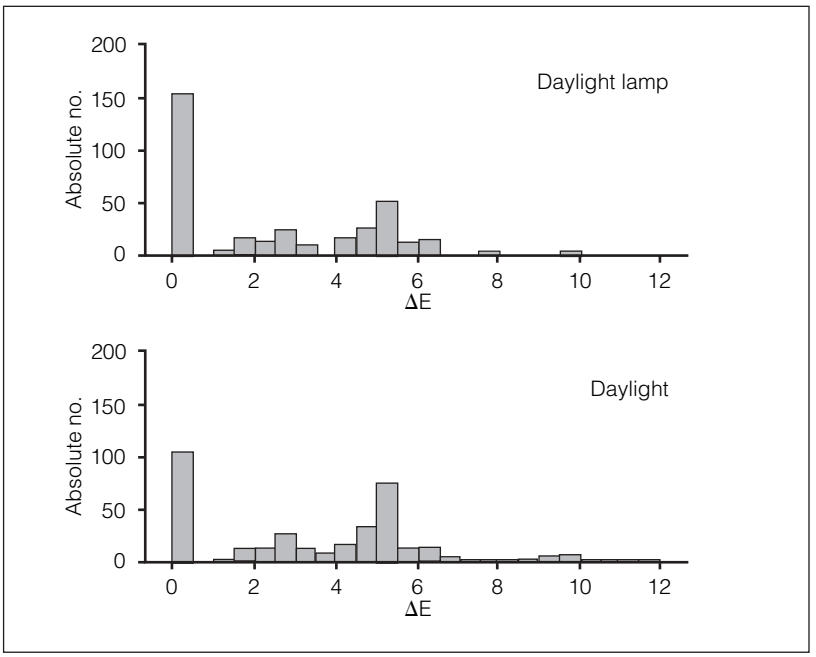

Fig 2 ΔE_{ab} for all attempts of the 29 participants (n = 700).

on the systematically arranged 3D-Master shade guide (Vita Zahnfabrik). It randomly presents 1 of 26 shade tabs and asks the user to determine, by comparison with other shade tabs, the lightness group, chroma, and hue. The lightest and darkest lightness groups do not distinguish between different hues and were, because of better matching by chance, not included in this analysis.

In the first part of the study, participants had to determine 15 randomly chosen shade tabs under daylight conditions, at the window facing north on a partly cloudy day in early July before noon. In the second setting, a daylight lamp for dental use (Dialite color 7, DS/E – PLS/E) was placed directly over the TTB and again, 15 samples were matched.

Mean ΔE_{ab} for every participant was calculated separately for each light condition. ΔE_{ab} is a unit of measurement quantifying perceived difference among color shades and corresponds to the distance between 2 color locations in color space. Mixed-effects regression models were used to investigate the simultaneous effects experimental light conditions, lightness group of the sample, and sex of the clinician had on the outcome (ΔE_{ab}) with the identity as a random factor. For all statistical testing alpha was set to .05.

Results

ΔE_{ab} under natural daylight conditions ranged from 0 to 11.8; ΔE_{ab} ranged from 0 to 10.6 when using the daylight lamp (Fig 2). Mean ΔE_{ab} under natural daylight was 3.4 and 2.5 under daylight lamp conditions.

The difference was statistically significant ($P < .001$) (Table 1). Sex of the clinician was not associated with ΔE_{ab} ($P = .106$).

Discussion

Significantly greater ΔE_{ab} indicates less reliable color matching in the natural daylight setting in comparison with the daylight lamp setting.

In the literature, the magnitude of ΔE_{ab} is recorded as being distinguishable for most patients. This finding is highly controversial. In vitro, 50% of observers perceived a color difference of $\Delta E_{ab} = 1$[4], whereas porcelain specimens were correctly judged by observers 100% of the time when $\Delta E_{ab} = 2$.[5] Because mean ΔE_{ab} under natural daylight and daylight lamp conditions varied by 0.89, one can assume the difference is not clinically relevant.

Nevertheless, "ideal" daylight conditions, as used in this study, cannot always be achieved. However, "ideal" conditions provided for a range of color matching that was greater than when using the daylight lamp, increasing the clinical risk of choosing the wrong color.

No significant difference in color matching was found between sexes. Therefore, the opinion that women perceive color more accurately than men could not be confirmed by this study.

Table 1 Results from Multivariate Analyses

Variable	Estimate	95% CI estimate Lower	Upper	*t*	Significance
Constant	3.10	2.05	4.10	6.12	.000
Experimental conditions					
Daylight lamp	−0.89	−1.23	−0.55	−5.10	.000
Natural daylight	0				
Lightness group					
2 (light)	−0.042	−1.22	1.14	−0.08	.939
3	0.18	−1.04	1.40	0.31	.764
4 (dark)	0				
Sex					
Male	0.70	−0.16	1.56	1.67	.106
Female	0				

Conclusion

Within the limitations of this study, use of a daylight lamp with spectral radiance corresponding to daylight and well-defined light intensity helped to standardize light conditions and significantly improve the ability to match colors. It should therefore be considered for implementation in daily practice.

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Literature Abstract

Technical complications of implant-supported fixed partial dentures in partially edentulous cases after an average observation period of 5 years

This prospective long-term study evaluated the incidence of technical complications, including screw loosening, screw fracture, framework fracture, and fracture of veneering material in implant-supported FPDs. Seventy-six partially edentulous patients were rehabilitated with 112 implant-supported restorations (46 PFM single crowns, 81 splinted crowns in the form of 36 units and 7 PFM FPDs, and 23 FPM cantilever FPDs) on 205 implants (3i). After a follow-up time of 5 years, the FPD survival rate was 94.5% (95% CI: 90.1 to 98.8), 80% (95% CI: 72.7 to 87.3) of the restorations remained free of any complication. The incidence of screw loosening (none of the screw loosening occurred with splinted crowns or FPDs) within a loading time of 5 years was 6.7% (95% CI: 1.8 to 11.5). Incidence of screw fractures was 3.9% (95% CI: 0.1 to 7.7). Fractures of the veneering porcelain, which only occurred in cantilever FPDs and single crowns, were 5.7% of the restorations. The probability for framework fractures was 1% (95% CI: 0 to 2.9). The lowest event-free survival rate was found for the implant-borne cantilever FPDs (68.6%, 95% CI: 50 to 87.3), followed by single crowns (77.6%, 95% CI: 53.3 to 100) and splinted crowns (86.1%, 95% CI: 59.5 to 100). No complications were recorded for implant-supported FPDs. In this investigation, the screw-abutment connection seemed to be most susceptible to technical complications during the 81-month follow-up time. The authors concluded that technical complications occurred at low rates for FPDs supported by 3i implants. However, they always cause extra chairtime for patients. Therefore, a patient should be informed about possible maintenance requirements on implants. Numbers of patients dropping-off from the study significantly increased at the 72-month and 81-month reviews. From the 76 patients of the original treatment group, there were only six and two patients left, respectively.

Kreissl ME, Gerds T, Muche R, Heydecke G, Strub JR. *Clin Oral Implants Res* 2007;18:720–726. **References:** 55. **Reprints:** Dr Marion E. Kreissl, Department of Prosthodontics, University Hospital, Hugstetter Str 55, 79106 Freiburg, Germany. Tel: + 49 761 270 4906. Fax: +49 761 270-4925. Email: marion.kreissl@uniklinik-freiburg.de—*Huong Nguyen, Singapore*