A Simple Technique to Fabricate a Positioning Template for Portable Colorimeters

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Objective: *To describe a technique of fabricating a positioning template with silicone materials intraorally for dental colorimeters and assess the reproducibility of this technique under* in vivo *condition.*

Methods: *The template was fabricated using silicone materials. A 5 mm punch was used to create a circular opening on the labial side of the template. The elastic touch probe of the colorimeter was then placed in the opening to check if there was any space between the touch probe and the template. If so, the space was filled with light body silicone material. An* in vivo *study was performed to assess the reproducibility of this technique. The L*, a*, b* values of 36 anterior teeth were measured by two examiners. Intra- and inter-examiner reproducibility were assessed by calculating intra-class correlation coefficients (ICCs) and the limits of agreement.*

Results: *The results of ICCs showed that the colorimeter with the silicone template had better intra-/inter-examiner reproducibility than without the silicone template. Furthermore, the limits of agreement of the colorimeter with template showed a narrower measuring range compared with the colorimeter without the template.*

Conclusion: *With the use of the template, repositioning of the colorimeter or spectrophotometer for each colour measurement can be precise. This kind of template enables clinicians to evaluate colour changes of teeth and restorations consistently. This technique is convenient and timesaving, and it may be helpful when using other hand-held colorimeters or spectrophotometers for colour evaluation.*

Key words: *silicone material, positioning template, colorimeter, spectrophotometer, colour measurement*

Cosmetic dentistry has become a very important part of restorative dental practice. Tooth bleaching to improve appearance has become a popular option for patients seeking aesthetic improvement[1-3]. There are three types of clinical methods currently used for evaluating the colour differences of teeth before and after bleaching: visual assessment with a shade guide, instrumental measurement with a spectrophotometer or colorimeter, and computer-assisted image analysis. Visual colour assessment is a combination of physiological and psychological responses to radiant-energy stimulation. Alterations in perception can occur as a result of many uncontrolled factors, including fatigue, ageing, emotions, lighting conditions and metamerism[4].

The use of colorimetric and photometric devices to quantify tooth colour could potentially eliminate the subjective aspects of colour assessment[5]. Colour is often expressed in terms of the Commission Internationale d'Eclairage (CIE) Lab colour space. The CIE Lab colour

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space represents a uniform colour space, with equal distances corresponding to equal perceived colour differences. When analysed mathematically, the CIE Lab units (L*, a*, b*) can compare the colour parameters of different objects[6-8]. However, the heterogeneous character of teeth adversely affects the repeatability of the spectrophotometer and colorimeter when minor movement or slight positioning errors occur in the area measured[9]. Owing to the deviations of the tooth area measured by the colorimeter and spectrophotometer, the use of a positioning device is preferred[10]. In the literature, several designs of positioning devices have been reported for the colorimeter and spectrophotometer. Douglas[11] fabricated a positioning jig by adapting a specially formulated white polyvinyl silicone putty material to the teeth and palate model and the replica measuring head. Matis et al[12] used a study model to construct a positioning jig with full palatal coverage, which was indexed with a dual-prong precision attachment. Shimada et al[13] designed a custom template using a translucent polymer sheet with labial or facial openings prepared for the proper positioning of the colorimeter touch probe. However, the previous methods are time-consuming and inconvenient. This paper will outline a simple technique to fabricate a positioning template for a hand-held colorimeter directly inside the patient's mouth.

Materials and Methods

Figures 1 to 6 illustrate the technique for fabricating a custom-fabricated positioning template for colour measurements of the maxillary anterior teeth. The colorimeter (Shade Eye NCC, Shofu, Kyoto, Japan) described in this article has an elastic polymer touch probe with a 5 mm diameter.

The template was made after completely cleaning the teeth with fine pumice. Two equal parts of the base and catalyst of the silicone putty material (Silagum Putty Soft, DMG, Hamburg, Germany) were mixed homogeneously and directly adapted onto the tooth surfaces buccally and palatally with sufficient thickness inside the patient's mouth. The fabricated template with full palatal coverage can be manipulated according to which teeth are needed for the colour measurements. The patient was asked to bite gently so that the incisal and occlusal edges of the mandibular teeth were printed on the template; this helped ensure the stability of the template during the colour measurement (Fig 1).

After complete polymerisation of the silicone material, the template was gently removed from the patient's mouth. The excess parts of the template were then cut away with a sharp blade. The template should be thick enough not only for its own rigidity, but to control the contact angle between the probe of the colorimeter and the tooth surface at each measurement. A 5-mm punch was used to create a circular opening on the labial side of the template (Fig 2). This diameter was needed for the proper placement of the colour measurement cone. It was ensured that the position of the opening was appropriate (Fig 3). The size of the opening can be changed according to the diameter of the touch probe of the colorimeter used.

Fig 1 Facial view of the template fabricated with silicone putty material.

Fig 2 The punch to make the facial opening.

Fig 3 Circular opening cut in the appropriate position.

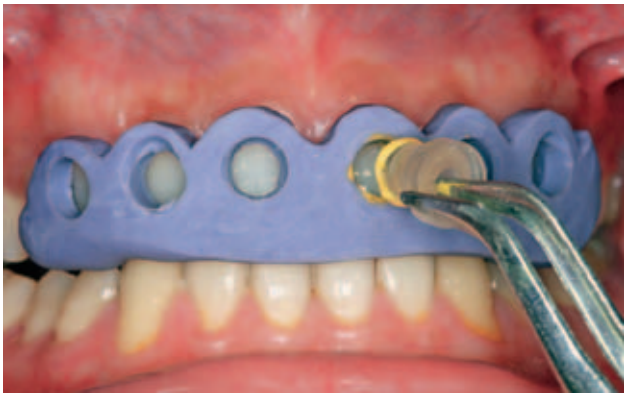

Fig 4 The facial opening filled with light body silicone material and an elastic touch probe.

Fig 5 Facial view of the final positioning template.

Fig 6 Colorimetric evaluation with the colorimeter and the positioning template.

The elastic touch probe of the colorimeter was then placed in the opening to check if there was any space between the touch probe and the template. If so, the space was filled with light body silicone material (Silagum Light, DMG) (Figs 4 and 5).

The colorimeter can be used to measure the colour of the teeth with the positioning template (Fig 6).

After the colour measurement, the template was disinfected in 5.25% NaOCl solution. The template can be placed intraorally at each subsequent appointment, and the evaluation of the colour change over time using the colorimeter will be in the same location.

In order to test the reproducibility of Shade Eye NCC with the silicone positioning template, colour measurements were taken from 36 anterior teeth *in vivo*. The measurements were carried out by two examiners with/without the technique described in this manuscript. The colour parameters (L*, a*, b*) of the middle third of the teeth were measured twice within an interval of 3 days by two examiners. The comparisons were made to evaluate the influences of silicone material's colour on the reproducibility of Shade Eye NCC with this technique. Intra-class correlation coefficients (ICCs) and limits of agreement according to Bland and Altman were performed to assess the intra/inter-reproducibility[14,15]. Furthermore, ten composite resin specimens (diameter 10 mm, shade A3) were used to evaluate the differences in the colour measurements between with and without the silicone template.

Results

Data of the intra-examiner reproducibility for Shade Eye NCC with/without this technique are shown in Table 1. Inter-examiner reproducibility analyses on different days are shown in Table 2. The ICCs revealed an excellent intra-/inter-examiner reproducibility (all > 0.75) of Shade Eye NCC with the silicone template. Moreover, a comparatively narrow range of limits of agreement confirmed this conclusion. Mean differences in the colour measurements of the composite resin specimens between the results with the silicone template and without are listed in Table 3. The differences of the colour of the silicone materials (blue and red) did not affect the reproducibility of the colorimeter with the silicone template (overall ICCs: 0.922 vs. 0.905).

Discussion

Using a colorimeter or spectrophotometer with a positioning device to evaluate the colour changes of teeth and restorations has been suggested. Although several kinds of positioning devices were introduced in the previous studies, they were mostly fabricated indirectly using a study model, which would require two visits. These procedures are time-consuming and inconvenient, especially when an in-office bleaching procedure is selected, and immediate colour measurements within the same clinical visit are needed. The technique described in the

Table 1 Intra-examiner reproducibility for analysis of colour parameters on different days

	Day 1						Day 2					
	With silicone template			Without silicone template			With silicone template			Without silicone template		
	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
ICC	0.945	0.956	0.920	0.930	0.711	0.934	0.907	0.884	0.955	0.858	0.640	0.859
Limits of agreement	-4.36, -0.32	-2.69,0.23	-1.32, 1.64	-3.81, 1.11	-2.16, 1.20	-3.09, 1.43	-3.32, 0.99	-0.78, 1.43	-1.51, 1.48	-2.22, 3.27	-1.33, 3.40	-3.12, 1.39

Table 2 Inter-examiner reproducibility for analysis of colour parameters by two examiners

	With silicone template			Without silicone template		
	L*	a*	b*	L*	a*	b*
ICC	0.980	0.891	0.955	0.858	0.742	0.905
Limits of agreement	-2.01, 2.75	-2.40, 0.76	-2.95, 2.85	-2.95, 6.25	-2.35, 2.60	-3.14, 1.42

Table 3 Mean differences in colour parameters between with and without silicone template

Group	ΔL*	Δa*	Δb*
Silicone template (colour: red) vs. without template	-0.71	2.44	1.12
Silicone template (colour: blue) vs. without template	1.15	-2.03	-1.77

ICC, intra-class correlation coefficient.

present article offers several advantages over the traditional approaches. The main advantage is that this technique is direct, convenient, and time-saving. If a clinician wants to measure the colour difference caused by in-office bleaching, fabricating a positioning alignment with the previous methods is time-consuming, and the positioning alignment can only be constructed when a working cast of the patient has been fabricated. However, the technique described in this article can be used to solve this problem. The silicone positioning template can be easily fabricated intraorally in a short time and in one visit. Other advantages may include: 1) it is economical, requiring only silicone materials and no laboratory work; 2) the template can be customised for a whole dental arch or a single tooth according to the purpose of the colour evaluation; 3) it is simple and requires minimal technical skills. The facial opening of the template has a good fit with the touch probe of the colorimeter so that the contact angle between the probe and the tooth surface can be properly controlled and the colorimeter can be precisely repositioned at each evaluation.

Based on the data obtained in the *in vivo* measurement, Shade Eye NCC with the positioning template showed better reproducibility than without the positioning template. The overall ICCs for the with-positioning group were higher than for the without-positioning group. The limits of agreement reached a comparatively narrow range in the with-positioning group. Although there were minor differences in the colour measurements using different coloured silicone templates, they all showed excellent reproducibility (all ICCs > 0.9). Owing to the fact that the aim of using the positioning template is to improve the repeatability of the colour measurement, either red or blue silicone materials could be used to fabricate the positioning template. In literature, ICCs between 0.75 and 1.00 can be considered as excellent reproducibility[15]. The present findings confirm that Shade Eye NCC, with the silicone positioning template, reliably measured the colour of natural teeth. However, there are some points that should be noted. Firstly, as the silicone material adopted here is opaque, special attention should be paid to confirm that the probe of the colorimeter completely contacts the tooth or restoration surface. Based on our experience, training in the use of Shade Eye NCC with the silicone template is necessary. Secondly, Clearly Affinity (Clinicians Choice, Ontario, Canada), a commercially available clear silicone material, might be helpful when applying this technique.

The disinfection of the alignment device between appointments still presents a challenge similar to the other methods previously described. The silicone positioning template becomes contaminated with the patient's saliva and bacterial plaque. None of the disinfectants are universally accepted as standard. The disinfectant solution described in this article was 5.25% NaOCl, which is widely used[16]. Recent research showed that use of

NaOCl resulted in acceptable levels of dimensional stability for silicone impression materials[17].

This technique could not only be used for the colorimeter described but also be helpful when using other hand-held colorimeters or spectrophotometers with a touch probe for colour evaluation. With the positioning template, the colorimeter or spectrophotometer can be used to evaluate not only the colour difference caused by tooth bleaching, but also the colour changes of the teeth or restorations caused by other reasons. It is important to note that the location of the labial opening of the template can be changed. In this way we could evaluate the colour of gingivae, or the middle or incisal third of the tooth according to the research objectives. Furthermore, owing to the flexibility of the silicone materials, the template could be used even if there is minor tooth movement during the testing time period. With good stability of the silicone materials, the colorimeter or spectrophotometer with the template can be used to measure the colour periodically at the same location.

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