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Evaluation of an anatomic dual-laminate composite resin shade guide

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ABSTRACT

Background: Colour assessment in aesthetic dentistry is one of the most challenging steps for direct restorative treatment. Shade selection tools should be able to mimic closely the materials and layering technique used in the final restoration, hence the development of prefabricated anatomic dual-laminate shade guides.

Objective: This study aims to compare different shade selection techniques and determine the suitability of a prefabricated anatomic dual-laminate shade guide and its best mode of use compared to a conventional guide and a layered custom guide.

Materials and methods: CIELab coordinates of different shade guides were assessed: Vitapan Classical (tab A2; Vita); Miris2 prefabricated anatomic dual-laminate shade guide, enamel WR tab on top of dentine S3 tab and nothing in-between (M2air) or glycerin gel (M2gly) or water (M2w); custom shade guide using prefabricated silicon moulds, Miris2 enamel WR composite resin moulded directly on dentine S3 pre-polymerised base (M2cus). The average values were obtained to calculate ΔE and compare the different shade selection techniques. Additional samples and measurements were made to compare Vitapan Classical shade tabs A1, A2 and A3 and all possible combinations of Miris2 and establish the closest matching shade ($\Delta E \leq 3.3$).

Results: High ΔE values were found (6.51–9.11) when comparing M2air to Vita, M2gly M2w M2cus. Differences appeared acceptable (ΔE 2.09–2.99) between Vita, M2gly and M2w and M2cus. Seven combinations of M2 were found to match Vita tab A1 and A2 and three Miris2 combinations for Vita A3 ($\Delta E \leq 3.3$).

Conclusions: The use of Miris2 prefabricated anatomic dual-laminate shade guide with interposition of water or glycerin between the enamel–dentine tabs demonstrated acceptable ΔE values when compared to Vitapan Classical and custom guides. A chart for matching Vita shades with various combinations of Miris2 enamel/dentine shades was produced to assist the clinician in obtaining acceptable restorations.

Clinical significance: The prefabricated anatomic dual-laminate shade guide is as efficient as a custom shade guide, facilitating clinical steps and saving material when doing composite resin restorations.

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1. Introduction

Although composite resin restorations present a very mimetic behaviour and chameleon effect on the tooth structure, colour assessment in aesthetic dentistry still one of the most challenging steps due of the need to match the shade of the composite resin with a variety of shades and effects of a natural tooth. It is generally agreed that imperceptible composite resin restorations can be effectively obtained using a natural incremental layering with various shades of enamel and dentine-like materials.[1–3] Therefore, it is expected that the shade selection process and the shade guide itself should follow these principles. Yet, 58% of dental educators complain about the mismatch between the shade guides and the composite resin.[4] This discrepancy was tentatively explained by the fact that the shade guide is not made with the same material and thickness as the restoration.[5,6] In addition, the colour space of current dental shade guides is limited as they fail to represent the full spectrum of colour found in natural teeth.[7–13] Another limitation of those shade guides could be the fact that some guides have tabs made with single monolithic (bulk) shades for both enamel and dentine, other have individual tabs for enamel and dentine or a single combination of enamel/dentine layers.

As a result, striving clinicians and dental technicians often use their own layered custom guides, fabricated with the material itself. Some manufacturers (Tokuyama, Japan) even provide prefabricated moulds to facilitate the fabrication of custom guides. However, the process may be time-consuming and uses material. Hence the development of a prefabricated anatomic dual-laminate shade guide (e.g. Miris2, Coltène Whaledent Inc., Cuyahoga Falls, Ohio, USA; Inspiro, Edelweiss DR, Zug, Switzerland) in which the selected enamel tab is ''nested'' over the dentine sample. This new approach enables the combination of different shades of enamel and dentine with immediate comparison with the tooth structure. It also allows obtaining direct visual comparison of tooth structure with the enamel sample, the dentine sample and the enamel/dentine combination in a single observation (Fig. 1a and b). The manufacturer recommends blending the enamel/dentine tabs with glycerin gel or water. It is not known, however, whether this technique is able to faithfully reproduce the actual optical behaviour of the corresponding layered restoration (enamel and dentine in direct contact).

The purpose of this study was first to compare, using the CIELab (*Commission Internationale de L'éclairage*) coordinates, the different shade selection techniques and determine the acceptability of the innovative prefabricated anatomic dual-laminate shade guide and its best mode of use compared to a conventional guide and a layered custom guide (enamel/dentine). Second, CIELab coordinates of Vitapan Classical shades A1, A2 and A3 (VITA Zahnfabrik GmbH, Bad Säckingen, Germany) were compared to all possible combinations of Miris2 enamel and dentine shades. The null-hypothesis was that no difference would be found between the various combinations of shade guides and that several combinations of enamel and dentine shades of Miris2 can be used to match a single Vitapan Classical shade.

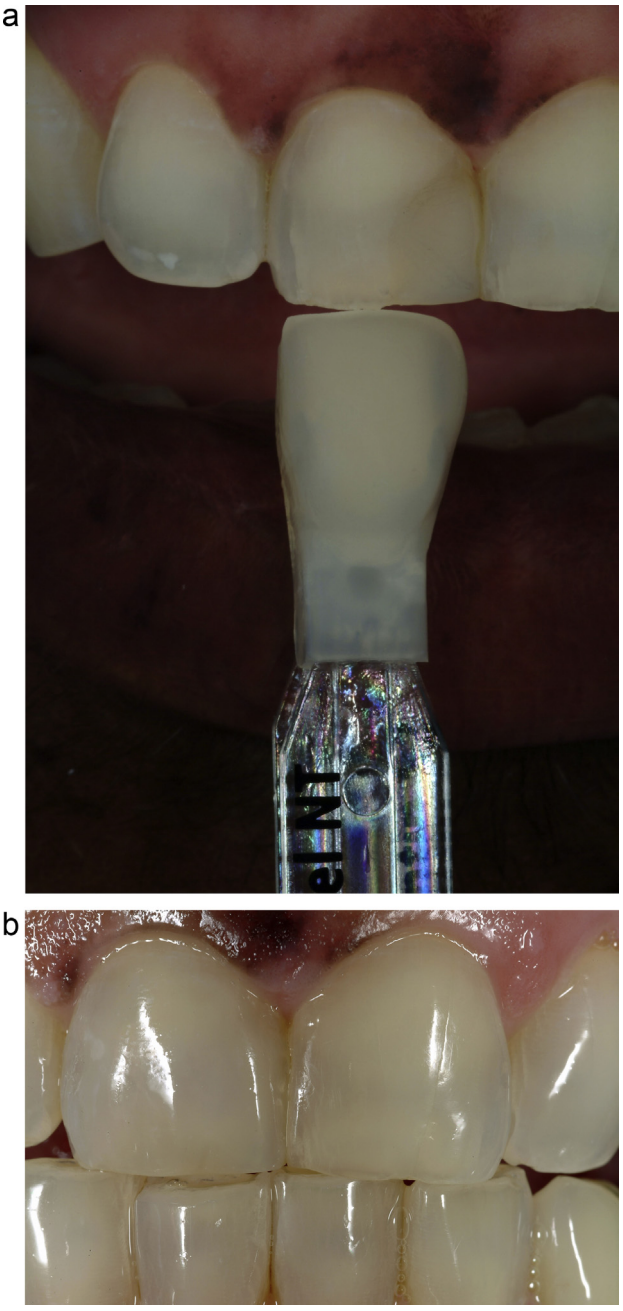

Fig. 1 – Shade selection using the Miris2 dual-laminate shade guide and cross-polarisation filter (Polar_eyes, Photomed, Van Nuys, CA, USA). Note the detailed information that can be used as a result of the dentine and enamel layers within the shade tab (a). Postoperative situation following replacement of mesio-incisal restoration with Miris2 on the right central incisor (b).

2. Materials and methods

2.1. *Specimen preparation*

The colour assessment was performed with different shade guides: Vitapan Classical (tab A2; group Vita); Miris2 prefabricated anatomic dual-laminate shade guide, enamel WR tab on

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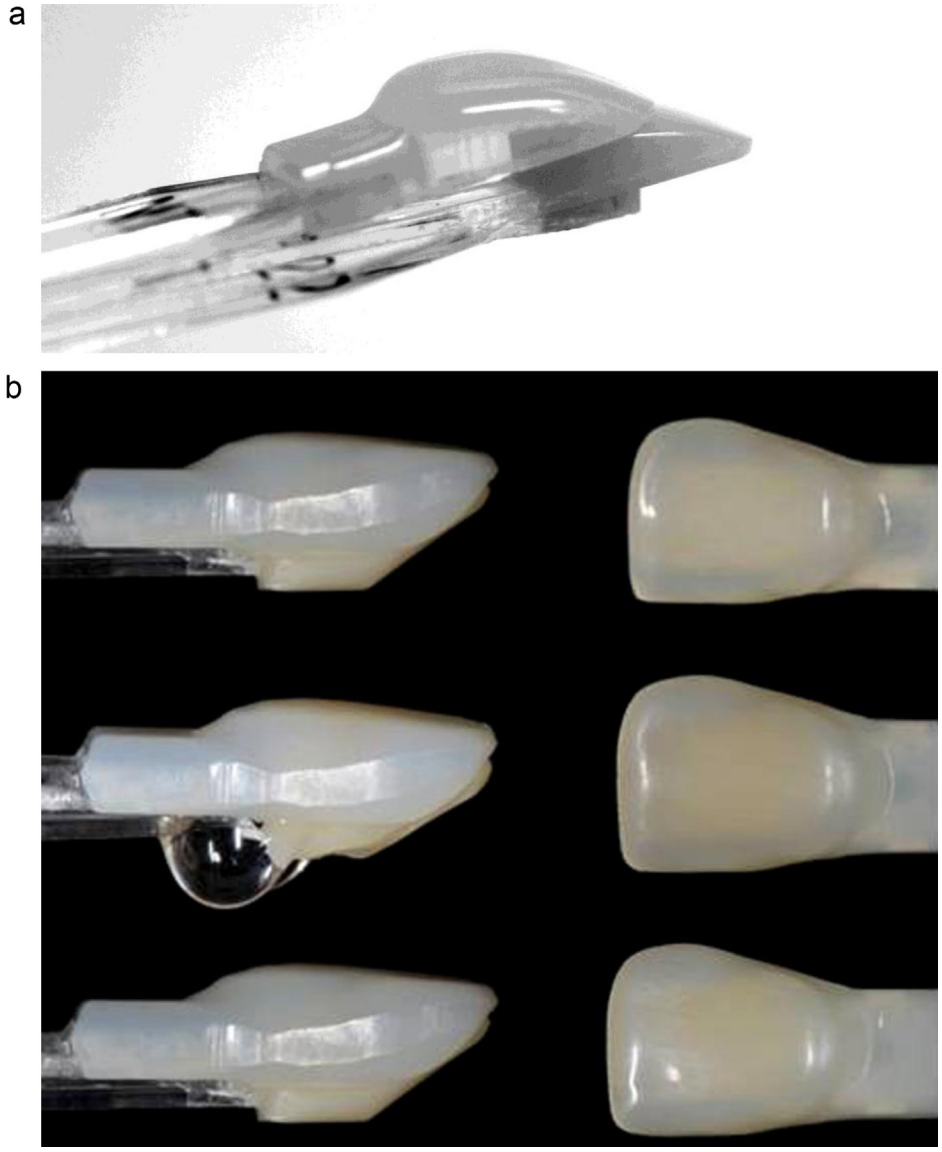

Fig. 2 – View of the anatomic dual-laminate shade guide with the dentine and enamel tabs incompletely seated (a). Enamel and dentine shade tabs seated with nothing in-between (b; top), with glycerin (b; middle) and with water (b; bottom).

top of dentine S3 tab (closest matching combination to Vita A2 according to pilot tests) and nothing in-between (group M2air) or glycerin gel in-between (group M2gly) or distilled water in-between (group M2w) (Fig. 2); custom shade guide with Miris2 enamel WR composite resin moulded directly on dentine S3 pre-polymerised base (group M2cus). For M2cus, the actual composite resin was used and moulded in a prefabricated histo-anatomic silicon mould (Custom_eyes, Emulation, Frankfurt, Germany) (Fig. 3) which enables condensation of the composite resin first into a dentine shape and second into an enamel shape, simulating the natural tooth. Special care was taken to reproduce the thicknesses of materials as in the prefabricated tab (0.95 mm of enamel and 4.79 mm of dentine for a total of 5.74 mm). The composite resin was photopolymerised 40 s each increment (Valo, Ultradent Products Inc., 100 mW/cm^2). Care was taken to avoid porosities during the specimen preparation. The specimen was carefully removed from the index and an

Fig. 3 – Custom_eyes silicon mould used to fabricate the custom shade guide. The left mould is first filled with dentine material, polymerised and then positioned in the right mould with enamel material covering the crown portion only.

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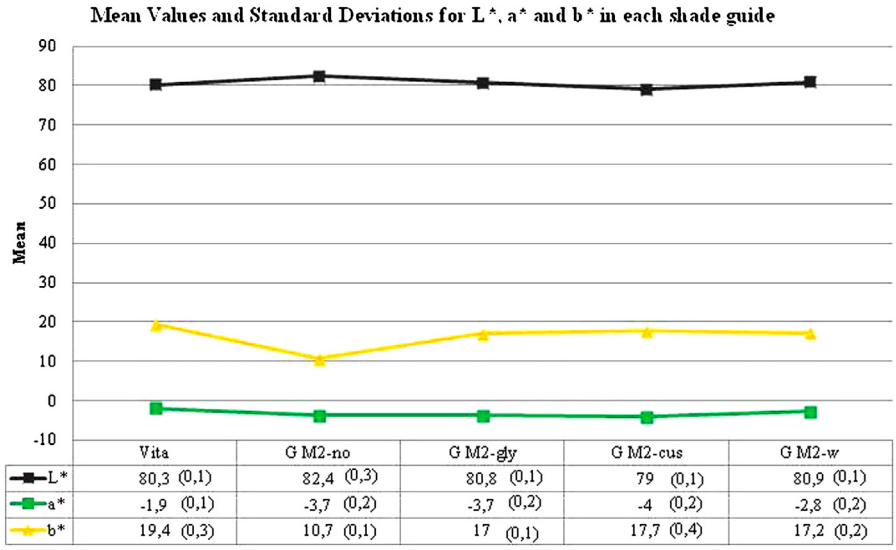

	Vita	G M2-no	G M2-gly	G M2-cus	G M2-w
L*	80,3 (0,1)	82,4 (0,3)	80,8 (0,1)	79 (0,1)	80,9 (0,1)
a*	-1,9 (0,1)	-3,7 (0,2)	-3,7 (0,2)	-4 (0,2)	-2,8 (0,2)
b*	19,4 (0,3)	10,7 (0,1)	17 (0,1)	17,7 (0,4)	17,2 (0,2)

Fig. 4 – Mean Values for L^*, a^* and b^* in each shade guide.

additional polymerisation was carried out on the buccal surface. No finishing of the composite resin surface was applied in order to keep it as smooth as possible. The Custom_eyes mould was chosen for two reasons. First to simulate a composite resin restoration in a standardised way. The root part is used mainly for repositioning purpose. Second, the mould allows the fabrication of a custom shade guide in which the root portion proves extremely useful for the shade selection in those areas of gingival recession as in some cases in Class V.

Additional samples and measurements were made to compare Vitapan Classical shade tabs A1, A2 and A3 and all possible combinations of Miris2 enamel and dentine tabs (glycerin in-between) and identify the closest matching shade.

2.2. *Colour measurements*

A spectrophotometer (VITA Easyshade, Vita) was used to assess the CIELab coordinates of the specimens placed a grey background (Kodak-R27, Boston, MA, USA). The average values of five measurements were obtained to calculate ΔE and compare the different shade selection techniques and to match the Vitapan Classical A1–A3 tabs and the various Miris2 enamel/dentine combinations. The VITA Easyshade (VES) consists of a base unit and hand piece connected by PVC stainless steel monocoil fibre optic cable. VES uses the D65 (6500 K) colour temperature for shade matching. To measure the shade of the tabs the probe tip was held 90° in contact with the surface. A silicone index with a central opening corresponding to the same diameter as the tip of the spectropho-

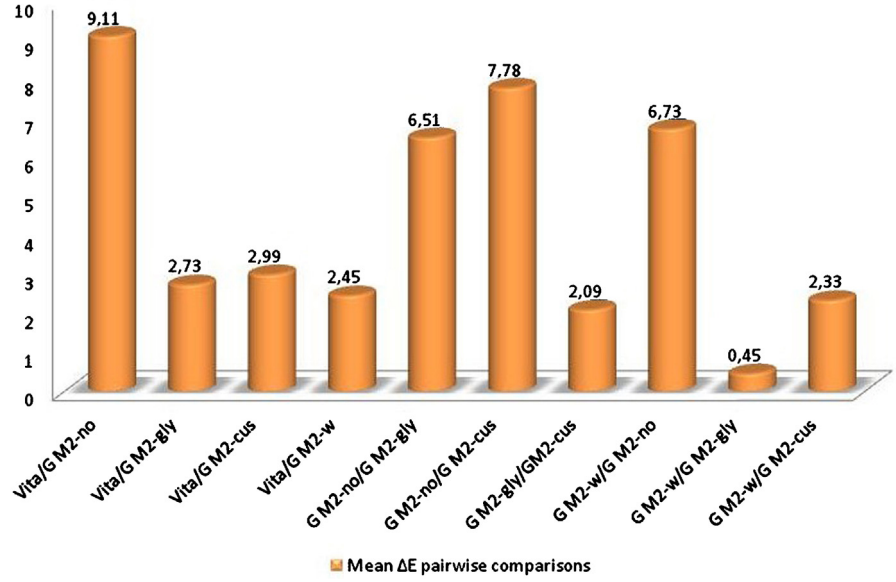

Fig. 5 – Main ΔE pairwise comparisons.

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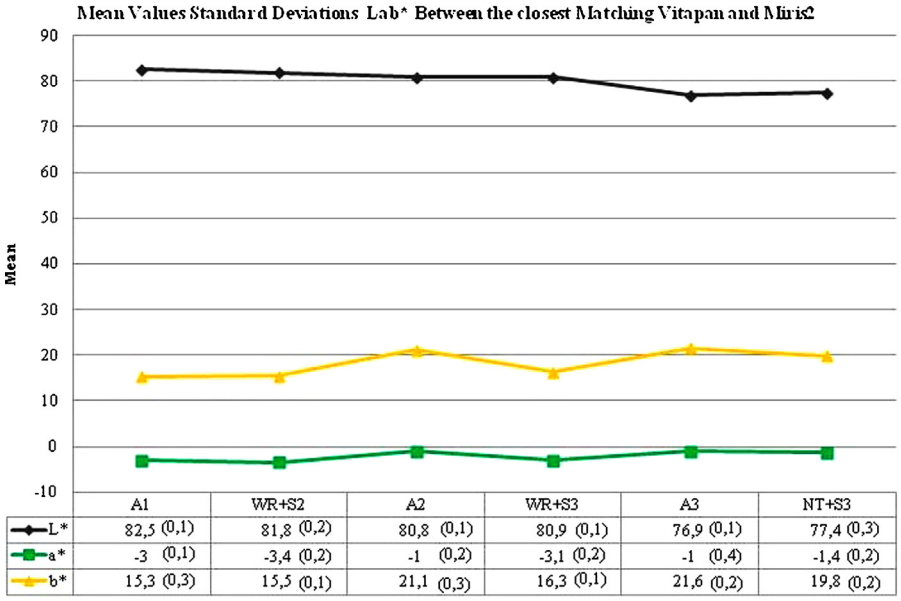

	A1	WR+S2	A2	WR+S3	A3	NT+S3
L*	82,5 (0,1)	81,8 (0,2)	80,8 (0,1)	80,9 (0,1)	76,9 (0,1)	77,4 (0,3)
a*	-3 (0,1)	-3,4 (0,2)	-1 (0,2)	-3,1 (0,2)	-1 (0,4)	-1,4 (0,2)
b*	15,3 (0,3)	15,5 (0,1)	21,1 (0,3)	16,3 (0,1)	21,6 (0,2)	19,8 (0,2)

Fig. 6 – Mean Values Lab* between the closest matching Vitapan and Miris2.

tometer was used to standardise the positioning of the probe. The neutral grey background (Kodak R-27) produces a lower deviation in shade compared to other background colours.[14] Prior the measurement, one drop of distilled water was dispensed on the grey background.

VITA Easyshade base unit provides the CIELab colour parameters (L^* – white–black, a^* – redness–greenness, b^* – yellowness–blueness). Five consecutive measurements were obtained for each tab and the average CIELab parameters were calculated and used for multiple comparisons. The difference between the different shade guides (ΔE), e.g. M2air and M2w, was calculated according to the equation:

$$\Delta E = [(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2]^{1/2}$$

where L_1 is the L colour parameter of one of the two tabs; L_2 is the L colour parameter of the other tab; a_1 is the a colour parameter of one of the two tabs; a_2 is the a colour parameter of the other tab; b_1 is the b colour parameter of one of the two tabs and b_2 is the b colour parameter of the other tab. The data were analysed descriptively by graphics and tables.

3. Results

The mean measurements for L^*, a^*, b^* of each shade guide, colour difference values (ΔE) between the groups and the closest shade match between VitaPan Classical and Miris2 are displayed in Figs. 4–6 and Table 1, respectively.

CIELab values showed an increase in L^* (characterises the lightness of a colour in the black–white axis) for M2air compared to the other groups. For a^* (defines a colour on red–green axis) the Vita tab showed deviation towards green. For b^* (defines a colour along yellow–blue axis), a marked differences was observed in M2air, showing deviation towards blue.

A threshold ΔE of 3.3 was used. This value was originally reported as 50:50% acceptability threshold (observers clearly see colour difference, but 50% consider it acceptable and 50% consider it unacceptable).[15] Systematically high ΔE values (above 3.3) were found whenever M2air was compared to others (range 6.51–9.11), showing altered results. All other comparisons not including M2air showed ΔE values below 3.3, thus experimentally matching.

For the Vitapan Classical to Miris2 correlation, only comparisons with $\Delta E \geq 3.3$ were considered as a mismatch. The closest matching shade combinations of Miris2 and Vita A1, A2 and A3 are displayed in Table 1 as a proposal to facilitate the correlation for the clinician. There were seven combinations matching Vita A1 and A2 and three for A3.

4. Discussion

The null hypothesis, namely, that no difference would be found between the various shade guides was rejected in part because M2air was different from all others, with ΔE systematically >3.3 and therefore unacceptable. However, the prefabricated anatomic dual-laminate M2 shade guide with glycerin or water in-between enamel and dentine were not different and matched the custom guide as well as Vitapan Classical A2. The second part of the hypothesis is accepted because there were several combinations of enamel and dentine shades of Miris2 matching a given Vitapan Classical shade.

Colour differences between the shade guides were analysed with an ''intra-oral spectrophotometer'' (VITA Easyshade, Vita Zahnfabrik) with a grey background that allows a reliable measurement of the shade.[14,16] This instrumental colour measurement eliminates confounding environmental variable as well as the human interpretation factor,[17,18,19] but

Table 1 – Closest shade match between VitaPan Classical and Miris2.

Vitapan Classical	Miris2 (E + D)	ΔE
A1	WB + S3	1.31
	WR + S3	1.88
	WB + S2	1.17
	WR + S2	0.83
	NR + S1	2.90
	WB + S1	2.53
	WR + S1	1.60
A2	NR + S3	2.73
	IR + S3	3.23
	WR + S3	2.73
	NR + S2	3.01
	NT + S2	3.26
	IR + S2	2.80
	IR + S1	2.81
A2	NR + S3	3.22
	NT + S3	1.99
	IR + S3	2.41

only represents a scientific tool or an assistance to the classic method with a shade guide.[20] Most advanced clinicians and ceramists still generally agree that instrumental shade selection must be complemented with a deeper analysis including shade mapping and photography with shade tabs[21,22] and a cross-polarisation filter (Fig. 1a).[23] Vitapan Classical is the most conventional shade guide and has not changed much during 50 years with 16 shades for enamel and dentine.[24] Data proved however that dentine shades should be rather available only in a single hue[1] but with a large range of chroma and present opacity close to that of natural dentine.[25] Enamel should act like a filter for the underlying dentine. This simple system, the so-called ''natural layering technique'' along with the optical properties of Miris2 allows replicating virtually all variations found in nature.[25] The present study also confirms that glycerin gel or water, which have a refractive index that approximates that of composite resins[25] (and Miris guide), must be applied in between enamel and dentine tabs to allow for an accurate shade selection and that fabrication of a custom shade guide is not required.

Another significant finding of the present work is the fact that there are generally several combinations of enamel/dentine shade of Miris2 that will match a given Vitapan Classical shade. As an example, a Vita A1 seems to be matchable with WB + S3, WR + S2 as well as NR + S1. The high chroma of S3 dentine (normally a match with A3, Fig. 6) is filtered down to an A1 by the intense value of WB enamel (White Bleach). Inversely, the matching chroma of S1 dentine (=A1) is maintained by the neutrality of NR enamel (Neutral Regular). The neutral effect of NR is confirmed by the match between S2/NR and Vita A2 and the match between S3/NR and Vita A3.

There are significant clinical advantages when using a prefabricated anatomic dual-laminate shade guide. In Vitapan Classical, each tab is actually layered but the user does not have control on the enamel layer, which is a standardised one. In Miris2, the user can take advantage of the synergy of various dentine and enamel layers. In addition, the dentine tab can be partially pushed out of the enamel veneer (Fig. 7). This provides a comprehensive understanding of the colour with

Fig. 7 – Miris2 shade guide. The dentine tab being partially pushed out of the enamel veneer.

dentine alone, the dentine/enamel combination and the enamel alone all visible at once next to the reference tooth. All the above considerations about shade selection in direct restorations are valid for indirect restorations, even though less relevant for master dental technicians who usually produce their custom shade guide. In any case, accurate shade selection is the result of a complete approach including quality ambient light,[26] complementary tools such as photographs of hydrated reference teeth, photographs of reference teeth with shade tabs,[21,22] cross-polarisation images,[23] assistance with an intra-oral spectrophotometer[17–19] and above all, the human eye as an extension of the brain.

The present study sets standards for further works that should evaluate other brands of composite resins and their corresponding application system. Additional works could be carried out to extend the chart of matching shades between systems as clinicians are often confronted to matching different materials (i.e. different shading systems) within the same segment of a mouth (e.g. matching an existing ceramic crown with a composite resin on the neighbouring tooth).

5. Conclusion

Within the limitations of the present study it can be concluded that:

1. The use of Miris2 prefabricated anatomic dual-laminate shade guide with interposition of water or glycerin between the enamel–dentine tabs demonstrated acceptable ΔE values when compared to Vitapan Classical and custom guides.
2. Various combinations of Miris2 enamel/dentine composite resin shades can match a given Vitapan Classical shade. A matching chart was produced to assist the clinician.
3. The prefabricated anatomic dual-laminate shade guide is as efficient as a custom shade guide, facilitating clinical steps and saving material by precluding the need for a custom guide or mock restoration when doing composite resin restorations.

Conflict of interest

None declared.

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