Translucency of Flowable Bulk-filling Composites of Various Thicknesses

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Objective: *To evaluate the translucency characteristics of new flowable bulk-filling resin composites at various thicknesses. Experimental short fibre-reinforced composite was also tested.*

Methods: *Two new brands of flowable bulk composites (Venus Bulk Fill and SureFil SDR Flow), experimental short fibre-reinforced resin composite (FC) and, as control, conventional flow (Filtek Supreme Flow XT A3) and universal (Filtek Universal Supreme XTE A3B) resin composites were investigated. Translucency parameter was calculated for various thicknesses of composite (1, 2, 3, 4, 5 and 6 mm) over white and black backgrounds using spectrophotometry to determine the CIELAB values of each specimen. Data were statistically analysed with analysis of variance.*

Results: *Translucency values significantly correlated with thickness of resin composite specimens ($P < 0.05$). For the new types of flowable bulk-filling material, translucency was observed for thicknesses up to 5 to 6 mm, whereas for experimental FC composite, the effect was observed up to 4 to 5 mm, and for control flow and universal filling composites, up to 2 to 3 mm.*

Conclusion: *New flowable bulk-filling resin composites have less masking ability than conventional universal filling resin composite materials, which should be taken into account when optimum colour match and aesthetic results are to be achieved.*

Key words: *translucency, flowable resin composite, universal resin composite.*

Translucency is the ability of a layer of coloured substance to allow the appearance of an underlying background to show through[1]. It is usually determined by the translucency parameter (TP) or contrast ratio (CR)[1,2]. TP refers to the colour difference between two samples of a material of uniform thickness when one is placed on a black background and one on a white background; it corresponds directly to common visual assessments of translucency[3]. CR is the ratio of the reflectance of a specimen on a black background to one on a white background of a known reflectance, and is an estimate of the opacity of a 1-mm thick specimen[2]. Since the translucency of a substance is a function of wavelength[4], the reduction of translucency spectrum (wavelength-dependent CR values) to a single parameter (TP) provides a simpler method by which to compare translucency[1].

Flowable bulk-filling composites are low-viscosity resin composites; these are more fluid than universal resin composites and have easy-handling properties[5]. There are many advantages to flowable resin composites, including: *(1)* high flowability, which means they can be applied using a small-gauge dispenser, making them especially useful for cavities that are difficult to access; *(2)* ability to form layered structures, which

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Table 1 Materials used in the study

Brand name	Manufacturer	Lot no.	Composition
Venus Bulk Fill	HerausKultzer, USA	010029	UDMA, EBADMA, barium silicate glass and silica 60 wt%
SureFil SDR Flow	Dentsply, USA	101006	TEGDMA, EBADMA, barium borosilicate glass
Filtek Supreme Flow XT A3	3M, St Paul, MN, USA	0143829	bis-GMA, bis-EMA, TEGDMA, silica and zirconia silanised, 65 wt%
Filtek Universal Supreme XTE A3B	3M, St Paul, MN, USA	0144828	bis-GMA, bis-EMA, TEGDMA, silica and zirconia silanised, 72.5 wt%
Experimental short fibre-reinforced composite	Stick Tech Ltd, Turku, Finland	-	bis-GMA, PMMA, TEGDMA, short E-glass fibre filler, barium glass silanised, amorphous silica,

bis-GMA, bisphenol-a-glycidyl dimethacrylate; bis-EMA, bisphenol-a-dyethoxy dimethacrylate; EBADMA, ethoxylated bisphenol-a-dimethacrylate; PMMA, polymethylmethacrylate; TEGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate.

helps to reduce or eliminate air inclusion or entrapment; *(3)* high flexibility, which makes them less likely to be displaced in stress-bearing areas[6,7].

When determining the properties of flowable resin composites, manufacturers have focused on the flow characteristics of these materials and developed them to meet the clinical demands for improved functionality[8,9]. These materials have a relatively low filler content compared with universal resin composites[6,7]; therefore, because the composition and filler content both play important roles in the optical properties of resin composite[10], the flowable bulk resin composites are likely to exhibit different translucency when compared with the universal resin composites. Several manufacturers now offer a wide variety of flowable bulk-filling composites intend for use in large restorations. When a layering technique is to be used, it would be beneficial to have information on the optical properties of each resin composite in order to establish which will provide a successful colour match. Further, it is important to obtain optical information on the influence of the thickness of composite layers. Therefore, the purpose of this study was to evaluate the translucency characteristics of new flowable bulk resin composites of different thicknesses.

Recently, the present authors showed that the use of semi-IPN matrix in combination with short glass fibres in restorative filling resin composite gives encouraging results[11-13]. Thus, the translucency of the experimental short fibre-reinforced resin composite was also evaluated.

The null hypothesis of this study was that the translucency of new flowable bulk resin composites at different thicknesses does not significantly differ from that of universal resin composites.

Materials and methods

Four light-cured flowable resin composites were investigated (Table 1). Two were new flowable bulk-filling resin composites (Venus Bulk Fill, HerausKultzer, USA, and SureFil SDR Flow, Dentsply, USA). A conventional flowable resin composite (Filtek Supreme Flow XT A3, 3M ESPE, St Paul, MN, USA) and a universal resin composite (Filtek Universal Supreme XTE A3B, 3M ESPE) were used as controls. A new experimental fibre-reinforced resin composite (FC), reinforced with short glass fibres, was also tested. The FC composite was prepared as described previously[11].

Disks of each resin composite material 10 mm in diameter and of various thicknesses (1.0, 2.0, 3.0, 4.0, 5.0 and 6.0 mm) were prepared (n = 3) using metal moulds. The resin composite was pressed between glass plates to flatten and smooth the surfaces. The composite resin was photopolymerised for 40 s from both sides using a light source with an irradiance of 800 mW/cm^2 (Optilux-500, Kerr, CT, USA). After curing, the celluloid strips and glass plates were removed and specimens stored dry at room temperature for 24 h before measurement.

Colour was measured according to the CIELAB colour scale relative to the standard illuminant D65 over a white tile (CIE L* = 99.25, a* = −0.09 and b* = 0.05) and a black tile (CIE L* = 0, a* = 0.01 and b* = 0.03) using a reflection spectrophotometer (CM-700d, Konica-Minolta, Japan). The aperture size was Ø 3 mm, and the illuminating and viewing configuration was CIE diffuse/10 degrees geometry with specular component included (SCI) geometry[14].

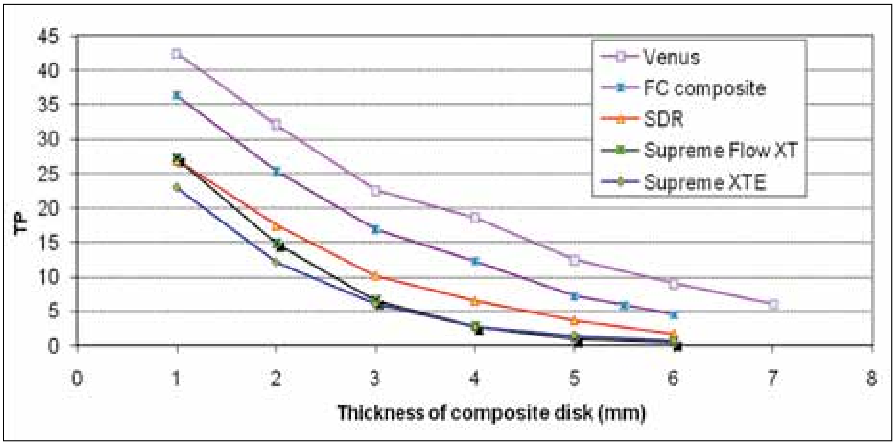

Fig 1 Mean TP values of the tested resin composites at various thicknesses.

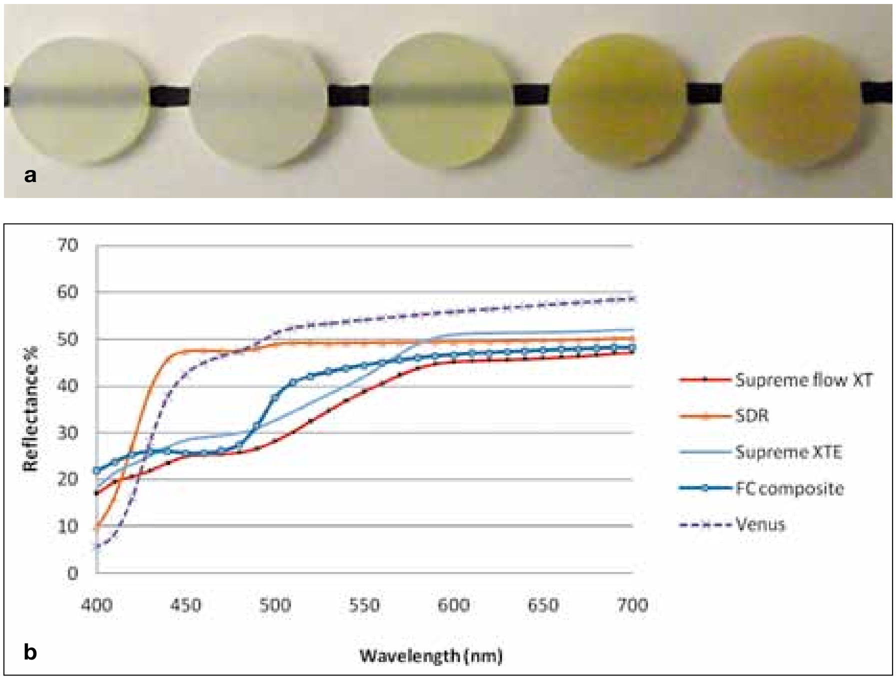

Fig 2 a) Visual image of 2-mm thick resin composite specimens placed over a black line. From left: Venus, SDR, FC, Filtek Supreme XT Flow, Filtek Supreme XTE. b) Reflectance spectra (D65) of 2-mm thick resin composite specimens with SCI specular component.

The translucency of the resin composites at various thicknesses was obtained by calculating TP using the colour difference between specimens over the white background and specimens over the black background:

$$TP = [(LW* - LB*)^2 + (aW* - aB*)^2 + (bW* - bB*)^2]^{1/2}$$

where the subscript W refers to the colour coordinates over the white background and the subscript B refers to those over the black background[15,16].

To evaluate the differences in translucency between the tested resin composites at various thicknesses, data were statistically analysed using analysis of variance (ANOVA) at the $P < 0.05$ significance level with SPSS version 13 (Statistical Package for Social Science, SPSS, Chicago, IL, USA), followed by Tukey's post hoc analysis to determine the differences between the groups.

Results

The TP values of the tested resin composites at various thicknesses are shown in Fig 1. The background effect characterised using TP values significantly correlated with thickness of composite disk ($P < 0.05$): as thickness increased, the TP value decreased for each material. Comparing between the brands of resin composite used, for each thickness Venus Bulk Fill showed statistically the highest TP value while Supreme (XTE, FlowXT) composite showed the lowest TP value ($P < 0.05$).

A visual image of 2-mm thick specimens is shown in Fig 2a. The spectral reflectance of all composite materials with 2 mm thickness under D65 illumination is presented in Fig 2b. At short wavelength (blue shades) the reflectance patterns for Venus and SDR were slightly different compared with FC composite and both Filtek composites, which revealed higher absorption in that range.

The new-type flowable bulk-filling composite (Venus) revealed translucency up to 5 to 6 mm, whereas SDR and experimental FC composites were translucent up to 4 to 5 mm, while control Supreme XT flowable and XTE universal filling composite were translucent to between 2 and 3 mm.

Discussion

Colour strongly influences the final appearance of a restoration, but optical attributes such as translucency also influence appearance[17]. In ‘through-and-through’ class III and IV restorations or in the presence of discoloured tooth structure, the harmonisation of restoration colour with the natural tooth material is made even more difficult by the transmission of background colour[18]. The TP of a material measures the observed difference in colour between a uniform thickness of the material over a white background and the same thickness of the material over a black background. TP provides a value corresponding to the common visual perception of translucency[15]. A higher value for TP represents greater translucency; if the material is completely opaque, the value of TP is zero[15,19].

Although there have been several studies on the translucency of resin composites, none has examined the new flowable bulk-filling composites, which have been launched for use in thick layers. The current study provides information on the relative translucency of two new brands of flowable bulk-filling resin composite and one promising experimental short fiber-reinforced resin composite, which is intended to be used in large-cavity restorations.

Altering the thickness of resin composites can affect the colour of the final result[20]. Accordingly, in the present study, specimens of various thicknesses (1.0, 2.0, 3.0, 4.0, 5.0 and 6.0 mm) were made and tested. It has been reported that a 4 mm thickness of resin composite is sufficient to prevent any influence of background colour, and that the colour of a 4-mm thick layer can be considered the inherent colours of a resin composite[21]. In our study, the critical thickness for Venus composite (flowable bulk-filling material) was 5 to 6 mm, at which TP dropped below 8.0, masking the background colour. This can be explained by the fillers and matrix resin of the composite having similar refraction indices. In contrast, the critical thickness for SDR composite (flowable bulk-filling material) and experimental FC composite was 4 to 5 mm. Supreme flowable and universal filling resin composites (controls) had critical thicknesses between 2 and 3 mm.

Differences in spectral reflectance between the groups are likely to be related to the absorption of camphorquinone photoinitiator, which has strong absorption at 470 nm. FC and Filtek might use camphorquinone with a high concentration as the photoinitiator. SDR and Venus might include another photoinitiator, such as 2,4,6-trimethylbenzoyl-diphenylphosphine oxide (TPO), which has an absorption-peak with more UV-range.

Le Bell et al[22] and Lehtinen et al[23] have shown that unidirectional E-glass fibre-reinforced composites conduct and scatter light better than conventional resin composites. This might explain the higher TP value of experimental FC composite compared with universal filling resin composite. They also showed that polymerisation of the monomer system to polymer improves light scattering. However, the short E-glass fibres in the experimental FC composite are randomly oriented. Future studies will focus on the effect of short-fibre fillers (fibre length and volume) on the translucency of filling resin composite.

Our findings are in agreement with a study by Yu and Lee which showed that mean TP values of a flowable resin composite at different thicknesses were higher than those of the corresponding universal resin composite of the same brand, which reflects the fact that the lower the filler content, the higher the translucency[16]. We have also shown that translucency of resin composites increases exponentially as thickness decreases; this is in accordance with a previous study by Kim et al[18].

It has been reported that translucency of aesthetic restorative materials is determined not only by the more macroscopic properties, such as matrix and filler composition and filler content, but also by relatively minor pigment additions and potentially by all other chemical components of these materials[24]. The translucency differences investigated in the present study are likely to have resulted from differences in the components of the materials. Hence, accurate knowledge regarding the translucency of resin composites together with the accumulated experience of the individual clinician seem to be fundamental requirements for the layering technique. Therefore, we should always be aware of the optical properties of dental restorative materials, such as the translucency of newly developed products, for successful aesthetic restorations.

Conclusion

New flowable bulk-filling resin composites have different masking abilities than conventional universal filling resin materials, which clinicians should take into account to achieve optimum colour matching and aesthetic results.

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