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Colour Matching of Composite Resin Cements with their Corresponding Try-In Pastes

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Abstract - *Two shades of four resin cements (Calibra, Clearfil Esthetic, Insure, Variolink II), in light- and dual-curing modes, were tested for colour matching with their corresponding try-in pastes, immediately after photopolymerization and after 24-hour dry and dark storage. Colour measurements were performed for 0.8 mm-thick specimens through a 0.8mm-thick ceramic plate. For each resin cement, colour differences (ΔE) were calculated between the two curing modes, and between the corresponding try-in paste, at baseline and after 24h. ΔE>0 values were detected between all resin cements and their try-in pastes, which were brand/shade/curing mode depended. The try-in pastes of the Variolink II system demonstrated the best colour matching (ΔE<2). Try-in pastes of Calibra and Insure, at both curing modes, did not match at an acceptable value, the shade of their corresponding resin cements (ΔE>3.3). Calibra presented the highest colour differences. ΔE values of the Clearfil Esthetic system immediately after photo-activation ranged between 2 and 3 units. A ceramic restoration may fail aesthetically as a result of not acceptable colour match (ΔE>3.3) between the shade of certain resin cements and their relevant try-in pastes.*

KEYWORDS: resin cement, try-in paste, polymerization mode, colour matching

INTRODUCTION

The advent and increasing use of all-ceramic and indirect composite esthetic restorations has led to the extensive use of tooth-coloured composite resin cements. They are available in a variety of shades, aiming to select the appropriate shade for optimum matching of the aesthetic restoration to the adjacent teeth.

The final shade reproduction of an aesthetic indirect restoration, made of ceramic or composite resin, is determined by the choice of the correct shade in the restoration itself, but also by the thickness and the degree of translucency of the restoration, the colour of the underlying hard tissues, the colour of the surrounding tissues, and the colour and thickness of the luting agent[1-4]. As far as the resin cement is concerned, controversial data in the literature describe its contribution to the resultant shade. Researchers have found that the shade of the resin cement plays a minor role in the final colour[3,5-7]. However, others have reported that the presence of the cement altered the colour of the all-ceramic restoration to a clinically detectable degree[8-10], especially after accelerated aging[11]. In that case, the cement shade affected the body and/or the cervical area of the restoration depending on the restorative material, but not the incisal third[10].

During try-in procedures, non-activated composite luting resin could be used to evaluate the shade match of the restorations. However, this procedure could diminish the bond strength of the restoration to the tooth[12]. Therefore, corresponding water-soluble try-in pastes have been developed and are included in the commercially available resin cement systems to be used for a preliminary shade selection of the appropriate composite resin cement. Nevertheless, there is a lack of adequate clinical and experimental data on whether the try-in pastes reproduce the final shade of their corresponding resin cements. In vitro studies have pointed out that between resin cement systems and the relevant try-in pastes various differences exist, sometimes clinically detectable, which were material dependent[13-15].

The aim of this in vitro study was to assess the colour match of two shades of four commercially available resin cements, polymerized by light- or dual-cured modes, with their corresponding try-in pastes immediately after photoactivation and 24 hours later after storage under dry and dark environment.

The null hypothesis was that there is no colour difference between the try-in pastes and their corresponding resin cement shades, either in the light- or in the dual-cured polymerization mode, immediately and after 24-hours of photoactivation.

MATERIALS AND METHODS

Two shades of four resin cements, a translucent and a universal shade, polymerized by light- (LC) and dual-curing (DC) modes and the corresponding try-in paste of each shade were evaluated (Table 1).

For sample preparation, two rectangular ceramic plates (IPS e.max Press, medium translucency, shade A1, Ivoclar, Schaan, Liechtenstein) with difference in dimensions were manufactured: plate A: 7x7 mm and 0.8 mm thick and plate B: 6x6 mm and 0.8 mm thick). The plates were placed one over the other and an impression was made using putty addition silicon, as shown in Figure 1A. Thus, a silicon mould was fabricated having an empty space for

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the preparation of the resin cement samples and for colour measurements (Figure 1A).

For the light activated specimens only the light-curing paste of the resin cement system was used. For the dual activated samples, the light-curing paste was mixed with the relevant catalyst, according to the manufacturers' instructions. The resin cement was placed in the empty space of the silicon mould (Figure 1B). The ceramic plate A was covered with disposable plastic wrap and standard pressure was applied until it was completely seated into the upper silicone mould recess. The excess material was carefully removed with a dry cotton pellet. The light-cured resin cement (LC) was immediately photo polymerized through the ceramic disc with a halogen photopolymerization unit at 800 mW/cm^2 (Elipar TriLight , 3M Espe, Seefeld, Germany) with an 8 mm wide light-guide centrally placed on the specimen for 60 sec. Additional light polymerization was executed for 20 sec at each corner of the plate.

For the dual-cured resin cements (DC) the mixed cement was placed in the mould recess and left for 4.5 minutes before photopolymerization. The try-in samples were prepared likewise, with the difference that no light activation followed the placement in the mould according to the procedure recommended. Two groups per resin cement for each shade, representing the LC and DC mode, and one group of the corresponding try-in paste (tp) were prepared. Each group consisted of eight samples (n=8). This sample size is appropriate, according to the performed power analysis; while the effect size for the relationship between independent variables and the outcome was large (at least 0.90) and assuming a=0.05, the achieved statistical power was found >0.82 with the use of G*Power Calculator.

Colour measurements at the upper-free surface of the porcelain plates were performed with a colourimeter (Dr Lance Micro Colour, Braive Instruments, Vise, Belgium) according to the CIELab colour space system. The silicon mould fitted repeatedly at the same position on the sensor of the colourimeter. For the colour measurements, the polymerized resin cement samples were adapted against the porcelain disc after removal of the disposable plastic wrap with a film of glycerine, in order to create a continuous optical interface.[13]

Table 1. *The resin cements and the corresponding try-in pastes tested.*

Resin cement-Shade	*Batch No*
Calibra-Translucent	try-in:060614 base:067121 catalyst:061213
Calibra-Medium	try-in:060321 base:061211 catalyst:061213
Clearfil Esthetic Cement-Clear	try-in:00004A cement:0001AA
Clearfil Esthetic Cement-Universal	try-in:00005A cement:0002AA
Insure-Clear	try-in:604101 base:602101 catalyst:602108
Insure-Red Yellow Universal	try-in:604103 base:602103 catalyst:602108
Variolink II-Translucent	try-in:J22192 base:J27183 catalyst:J08416
Variolink II-Yellow	try-in:J20707 base:J26042 catalyst:J26626

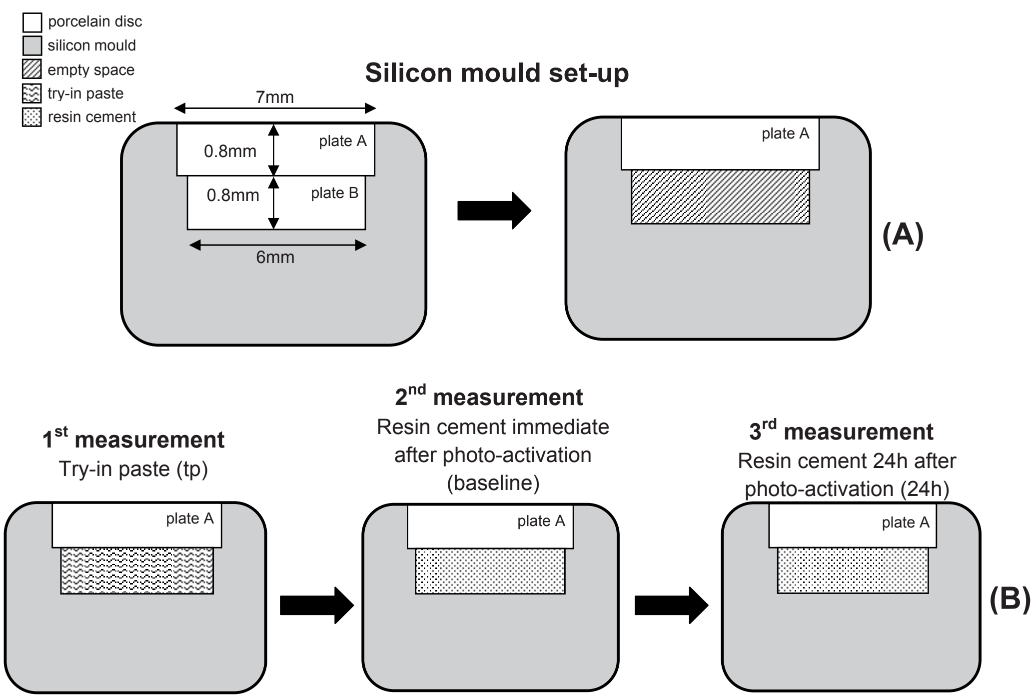

Figure1. *A schematic presentation of the silicon mould preparation (A) and of the set-up for sample preparation and measurements (B).*

The colourimetric evaluation of the composite resin cement samples was conducted immediately after photo-activation (baseline), while the try-in paste samples were evaluated immediately after placement (tp). In addition, the measurement of all resin cement samples was repeated 24 hours later, after storage in dark and dry conditions (24h). The colour of each sample was measured five consecutive times and the mean value of each of the L, a and b parameters was used. After colour measurement of each try-in sample, the paste was washed-out from the mould with water-spray and dried with compressed air.

The colour difference (ΔE) was derived from the following equation:

$\Delta E = [(L_1-L_2)^2 + (\alpha_1-\alpha_2)^2 + (b_1-b_2)^2]^{1/2}$

Differences (ΔE) were calculated between: 1) corresponding try-in paste and resin cement of LC and DC modes at baseline measurement (tp-baseline), 2) corresponding try-in paste and resin cement of LC and DC modes at 24h measurement (tp-24h) and, 3) resin cement of LC and DC modes at baseline and after 24-hour storage (baseline-24h).

The results were subjected to statistical analysis (SPSS, IBM, Chicago, IL, USA) by two-way Anova (Table 2). The independent variables were resin cement/shade and cure mode. Afterwards, one-way Anova followed by Tukey HSD post-hoc statistical test (a=0.05) was performed, to discriminate among resin cements/shades of the same cure mode and, independent samples t-test to detect differences between the two cure modes per resin cement/shade (a=0.05).

RESULTS

Two-way Anova statistical analysis detected significant effect of resin cement/shade and cure mode at baseline and after 24h measurement. However, a high interaction was observed between the two variables evaluated, the resin cement/shade and the cure mode in both of the time-periods assessed. Therefore, one-way Anova was performed, to discriminate among resin cements/shades of the same cure mode as described above.

The mean colour differences (ΔE) with standard deviations between the resin cements immediately after light-activation and their corresponding try-in pastes are showed in Table 2. Statistically significant ΔE differences among the resin cement/shade groups and between the modes of polymerization were observed.

At baseline measurement, both shades of Calibra demonstrated the highest ΔE values whereas Variolink II the lowest ones in light and in dual-cured mode. Insure shades presented statistically higher ΔE values relative to Clearfil Esthetic analogues in light mode. Both shades of Calibra and the Clearfil Esthetic Universal under dual-cured activation exhibited statistically significant less ΔE with their try-in pastes than the light-cured analogues. The remaining resin cement/shade groups revealed no colour differences between the curing modes.

In Table 3, the ΔE values between the resin cement/shade groups after 24h-storage and their corresponding try-in pastes are depicted. In light-cured mode, both shades of Calibra and Variolink II provided the highest and lowest ΔE values, respectively. No difference was noted between Variolink II shades and the Universal shade of Clearfil Esthetic. In the dual-cured mode, both shades of Calibra cement showed the highest colour differences followed by Insure Clear. The rest of the resin cement/shades were all grouped together. In every shade group, except of the Insure Clear, there was statistically significant difference between the two cure modes.

Table 2. *Mean colour differences (ΔE) between the resin cements and their corresponding try-in pastes immediately after photo-activation.*

Resin cement-Shade	ΔE	
	tp-LC	*tp-DC*
Calibra-Translucent	6.35±0.34^{a}	5.84±0.51^{A}
Calibra-Medium	6.68±0.32^{a}	5.64±0.41^{A}
Clearfil Esthetic Cement-Clear	2.73±0.25^{c,1}	2.65±0.13^{C,1}
Clearfil Esthetic Cement-Universal	2.01±0.08^{d}	2.46±0.15^{C}
Insure-Clear	3.97±0.43^{b,2}	4.01±0.19^{B,2}
Insure-Red Yellow Universal	3.50±0.33^{b,3}	2.02±0.60^{CD,3}
Variolink II-Translucent	1.46±0.11^{d,4}	1.62±0.26^{D,4}
Variolink II-Yellow	1.60±0.12^{d,5}	1.81±0.24^{D,5}

Same letters within the columns indicate no statistically significant differences among the groups. Same numbers within the rows indicate no statistically significant differences between the groups (tp: try-in paste, LC: light-cured, DC: dual-cured).

Table 3. *Mean colour differences (ΔE) between the resin cements and their corresponding try-in pastes after 24h-storage under dry/dark conditions.*

Resin cement-Shade	ΔE	
	tp-LC	*tp-DC*
Calibra-Translucent	7.64±0.35^{a}	6.51±0.24^{A}
Calibra-Medium	7.69±0.62^{a}	5.90±0.58^{A}
Clearfil Esthetic Cement-Clear	2.78±0.24^{c}	2.16±0.19^{C}
Clearfil Esthetic Cement-Universal	1.72±0.14^{d}	2.58±0.08^{C}
Insure-Clear	4.55±0.22^{b,1}	4.36±0.51^{B,1}
Insure-Red Yellow Universal	4.12±0.36^{b}	2.28±0.58^{C}
Variolink II-Translucent	1.44±0.19^{d}	2.41±0.33^{C}
Variolink II-Yellow	1.76±0.28^{d}	2.47±0.09^{C}

Same letters within the columns indicate no statistically significant differences among the groups. Same numbers within the rows indicate no statistically significant differences between the groups (tp: try-in paste, LC: light-cured, DC: dual-cured).

Table 4. Mean colour differences (ΔE) of the resin cements immediately after photo-activation and after 24h-storage under dry/dark conditions.

Resin cement-Shade	ΔE	
	LC	*DC*
Calibra-Translucent	1.55±0.51^{a,1}	1.03±0.35^{AB,1}
Calibra-Medium	1.48±0.42^{a}	0.61±0.62^{B}
Clearfil Esthetic Cement-Clear	1.10±0.34^{ab,2}	1.24±0.24^{A,2}
Clearfil Esthetic Cement-Universal	0.72±0.13^{bc,3}	0.59±0.14^{B,3}
Insure-Clear	1.08±0.23^{ab,4}	0.65±0.22^{AB,4}
Insure-Red Yellow Universal	0.73±0.32^{bc,5}	0.43±0.36^{B,5}
Variolink II-Translucent	0.50±0.04^{bc,6}	0.75±0.18^{AB,6}
Variolink II-Yellow	0.44±0.14^{c}	0.80±0.19^{AB}

Same letters within the columns indicate no statistically significant differences among the groups. Same numbers within the rows indicate no statistically significant differences between the groups (tp: try-in paste, LC: light-cured, DC: dual-cured).

From baseline to 24 hours after photoactivation, all resin cements presented colour difference (ΔE>0), as shown in Table 4. In the light-cured mode, both shades of Calibra, and the Clear shade of Clearfil Esthetic and Insure presented the statistically highest colour change. For the dual-cured mode, Clearfil Esthetic Clear and Calibra Transluscent, Insure Clear and both shades of Variolink II presented the statistically highest colour change from baseline to 24 hours later. Regarding ΔE of light- versus the dual-cured mode, only Calibra Medium and Variolink II Yellow provided statistically significant differences.

DISCUSSION

In general, variance in composition between materials leads to differences in optical properties[16-17]. Ideally, try-in pastes should be manufactured with the same or similar synthesis as the luting resin except for the absence of a polymerization system to aid in extending trial time for the veneer. Thus, perfect colour matching to the corresponding cements would be achieved. However, for easier clinical application, all the contemporary try-in products are provided as water-soluble pastes. Since the resin cements comprise essentially water-resistant methacrylate monomers, the organic part in the try-in pastes has been substituted by water-soluble, colourless transparent glycerine. Therefore, try-in pastes are a mixture of glycerine with all or several of the filler types utilized to formulate the corresponding resin cement and with suitable colour pigments. The particular components, fillers and pigments, aim to provide a try-in paste with optical properties similar to the corresponding polymerized resin cement.

The current experiment was an in vitro study that evaluated the colour match of the try-in pastes to their corresponding light- and dual-cured resin cements immediately and after 24 hours photoinitiation. It is important to mention that the colour measurements for resin cements and try-in pastes were performed through a ceramic plate in order to simulate, as far as possible, the clinical conditions.

Colourimeters such as the one used to conduct the colour measurements in the present study, are capable of spotting colour differences, which are not always detectable to the human eye. It has been determined that colour difference ΔE=1 for non-translucent materials can be detected in a controlled research setting by 50% of the observers[18]. Under laboratory conditions, colour differences of translucent dental materials were perceptible to 100% of the observers when it exceeded a ΔE value of 2[19]. In laboratory conditions, colour difference acceptability threshold was set at 3.3 ΔE units[20]. In clinical conditions, the 50% perceptibility threshold was defined as 3.7 units[21]. For the purposes of this study ΔE=3.3 was selected as the threshold for acceptable colour differences.

Taking the ΔE value of 3.3 as the acceptability cut-off value, it becomes obvious that the try-in pastes of Calibra and Insure did not match the shade of their corresponding resin cements immediately after the light activation. This applies to both light- and dual-cured modes of the resin cements. The try-in pastes of Insure presented better shade match than those of Calibra at a statistically significant level (a=0.05). The ΔE values of the Clearfil Esthetic system immediately after photo-activation ranged between 2 and 3 units, which is perceptible, but clinically acceptable[19]. The try-in pastes of the Variolink II system demonstrated the best colour matching, since ΔE values were below 2. The amount and type of fillers as well as the suitability of the combined pigments may cause the successful colour performance recorded.

In the current investigation, the two shades selected per resin cement were the most translucent and an available medium translucency one. It is expected that considerably different colourants are utilized to produce their corresponding try-in pastes, which, in sequence, may facilitate different colour matching behaviour between the shades. However, similar pattern of behaviour was noticed for most of the shade pairs in both, light- and dual-cured pastes.

The try-in pastes should colour match with the thoroughly polymerized luting composite. Thus, the colour matching between try-in and resin cements was assessed not only immediately after photo-activation but also 24 hours later. In resin-based materials, due to the post-curing phenomenon, colour changes in the course of time have been recorded[22-23]. This tendency was confirmed by the findings of the present study for the resin cements evaluated, although the ΔE values were remarkably lower than the acceptability threshold (Table 4). The resin cement curing mode, light or dual-cured, was not proved as a contributory factor in terms of the colour matching for all the cements evaluated immediately after photo-activation except for the two Calibra shades and the Universal shade of Clearfil. On the contrary, at the 24-hour recording, significant differences were detected among the ΔE values of light- versus the dual-cured corresponding specimens of all brands and shades except of Insure Clear. No similar trends for all the resin cements were observed with respect of ΔE increase or decrease between the curing modes up to 24-hour post-curing. Several resin cement/shades demonstrated lower ΔE values in dual-cured relative to light-cured analogue (e.g. Calibra) and others higher (e.g. Variolink II).

According to the results obtained, the research hypothesis was rejected because colour match differences, as expressed in ΔE units, were detected between resin cement and their corresponding try-in pastes, which were brand/shade/curing mode dependent. The colour measurements conducted in this study were realized through a ceramic disc and the thickness of the luting agent was 0.8 mm. In the clinical practice, the luting agent usually takes up less space underneath the restoration. This means that colour differences might be magnified in this study, and probably ΔE would be less when the thickness of the cement and the try-in paste is 50-150 μm[13-14]. However, according to Vichi et al[3], thickness of luting agent at a level of 100 μm might be able to affect the colour of the restoration.

The thickness of the ceramic and its translucency may also affect the colour mismatch between the resin cements and their corresponding try-in cements. Future studies should examine the colour match between resin cements and their corresponding try-in pastes using samples 0.3 mm thick simulating thin laminate veneers and 1.2 mm thick simulating anterior crowns. Additionally, the effect of lithium disilicate translucency should be studied.

CONCLUSIONS

Colour differences were detected between resin cements in light- and dual-curing modes, and their corresponding try-in pastes, immediately after polymerization and 24hour post-photoactivation. These colour differences varied among the four brands examined. The try-in pastes of Calibra and Insure failed to match the shade of their corresponding resin cements, under the consideration that the colour differences (ΔE) determined were not acceptable (ΔE>3.3). On the contrary, Clearfil Esthetic and Variolink II presented the most accurate colour matching (ΔE<3.3). Variolink II showed the lowest of all resin cements colour difference relative to its corresponding try-in pastes.

MANUFACTURERS' DETAILS

- Calibra (Dentsply Caulk, Konstanz, Germany)
- Clearfil Esthetic Cement (Kuraray Medical Inc, Okayama, Japan)
- Insure (Cosmedent Inc., Chicago, ILL, USA)
- Variolink II (Ivoclar Vivadent, Schaan, Liechtenstein

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