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Research Article

# An Investigation into the Effect of Resin Cement Shade and Porcelain Thickness on the Final Colour of Porcelain Veneers

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## Abstract

**Objectives:** To assess how different shades of try-in pastes and resin cements affect the colour of different thicknesses porcelain veneer restorations.

**Methods:** Porcelain veneers of shade Vita 1M1 and 1mm and 0.6mm thick were applied to bovine teeth using 3 shades of resin cement and their try-in paste produced by 3 manufacturers. Analysis of variance was carried out on the colour difference (ΔE*) between the Aquagel and both the try-in paste and cured resins. An assessment of the clinical significance of ΔE* between the try-in paste and the cured resin and between the uncured and cured resin was made when using two different veneers thicknesses.

**Results:** There were statistically significant differences in veneers' colours when using different shades of both Calibra and Nexus resin cements ($p < 0.05$). Also, statistically significant differences were noticed when using different shades of both Rely-X and Nexus try-in pastes ($p < 0.05$). Colour differences produced between the try-in pastes and the corresponding shades of cured resin cement was clinically acceptable (ΔE* 1.05 - 3.34). The colour differences between uncured and cured resins of the same shade were around the perceptibility threshold (ΔE* 0.78 - 1.41). Moreover, no significant differences were noticed in the colour change caused by try in pastes and resin cement when changing the veneers thickness.

**Conclusions:** Clinically unacceptable differences were found between try-in pastes and the cured resin of the same shade, however, there were relatively imperceptible changes measured between un-cured and cured resins for both ceramic thickness used. Therefore, colour match achieved by the try-in paste should be treated with caution and further assessment of the restoration made with the resin in place before curing regardless of the thickness of the ceramic veneers used.

***Keywords:*** *Colour Difference; Resin Cement; Ceramic Veneers*

## Introduction

Nowadays, patients are more aware of their teeth appearance which might affect their personalities [1-3]. It is also the case that patients are now better informed of the options for improving the aesthetics of their teeth [1,2]. One option for aesthetic restoration of anterior teeth is the use of porcelain veneers.

Resin cements are the adhesive of choice for veneers as they have a good longevity and satisfactory clinical performance [4]. It has been shown that a considerable change in colour may happen during polymerisation of the resin cement and that this should be taken into consideration during shade selection and manufacture [5]. Resins are produced by several manufacturers and are produced in different shades. Each of the resins is supplied with a try-in paste to give an approximate indication of the colour of the final restoration before final cementation. The stated purpose of these different shades of resin and try in pastes is to improve the colour matching and aesthetics of the final restoration. Comparing the colour of try-on paste to the colour of the set resin cement has been suggested to ensure that the desired veneer colour is achieved [6-8].

All porcelain veneers provide some masking of the underlying tooth structure when cemented with a resin composite luting agent [9]. The shade of a porcelain veneer is determined by several factors which include the colour and the thickness of the porcelain veneer, the thickness and the colour of the luting cement and the colour of the underlying tooth structure [10]. When the thickness of porcelain restoration was less than 1mm, substrate colour significantly influenced the colour of the completed porcelain restoration [7,11]. Moreover, it has been demonstrated the L* and a* colour coordinates were affected by ceramic thickness in two all-ceramic systems [12].

Since the thickness of porcelain has a great effect on the overall colour of completed veneer restoration, clinician should consider whether tooth anatomy and shade permit for thin or moderately thick veneers to be prepared [7,8].

In a laboratory, the use of spectrophotometric techniques allows for reliable and repeatable measurements of the colour of porcelain [13,14]. Spectrophotometers measure CIE-LAB values [15] to give a digital value of 3D colour (E*) which can then be used to assess colour difference (ΔE*) [16]. A scale of perceptible colour difference has also been suggested with a $\Delta E^* < 1$ regarded as not perceived by the human eye [17]. Additionally, it has also been claimed that the average ΔE* between teeth assessed to be a colour match intra-orally is 3.7 [18]. It follows, therefore, that if different shades of resin cement produce a ΔE*ab by that threshold, then a clinically significant difference in the colour of the restoration has been obtained.

## Aim of the Study

The purpose of this study is to assess how different shades of try-in pastes and resin cements affect the overall colour of porcelain veneer restorations of two different thicknesses.

## Materials and Methods

### Study design

A total of 135 bovine teeth were collected, prepared and bleached to standardise colour before random division into 3 groups. Ceramic veneers were produced to a standardised shade and thicknesses of 1 mm.

Colour was measured with the veneers placed on the prepared surfaces of the teeth with Aquagel acting as a medium between the veneer and tooth (Aquagel is a commercially lubricating water gel: Aquagel® - Adams Healthcare, UK).

One group had veneers bonded with Calibra (Dentsply International), the second with Nexus-3 (Kerr Corporation), and the third with Rely-X (3M-ESPE). Each of the bonded groups was further subdivided into three groups (15 per group) with a light, a dark and a translucent resin selected from those provided by each manufacturer. The veneers were applied to the teeth using the try-in pastes and the colour measured. The veneers were then loaded with resin cement and placed on the prepared tooth surface. Colour was measured pre- and post-curing of the resin. Colour was measured using a spectrophotometer and analysed to determine any differences in the colour of the restorations achieved by the different shades and products produced by each manufacturer.

### Preparation of tooth samples

Bovine central incisor teeth were used in the study. The teeth had been stored in Thymol solution. Soft tissue was removed manually and then by soaking in 2% sodium hypochlorite (Milton's solution) for 2 hours. Buccal surfaces were prepared using a circular abrasive lathe in order to produce flattened enamel surfaces of at least 8mm diameter. The flattened surface was then polished using fine abrasive paper. The teeth were bleached in 33% hydrogen peroxide for 1 hour in order to standardise the colour by reducing staining. A single operator then recorded a colour reading for all teeth. A specific area of the prepared surface of each tooth were noted as a circular line just larger than 8 mm diameter (The diameter of the porcelain veneers used in this study), and colour measurement were performed on this area throughout the whole study to determine standardisation. The teeth were then randomly assigned to the groups and analysed statistically to confirm that there was no significant variation within or between groups.

### Preparation of veneers

Vitadur Alpha porcelain veneers of shade 1M1 VM7 (Vita, Zahnfabrik, Bad Sackigen, Germany) were produced by a single operator as such light shades is the most desirable and used shades to fabricate porcelain veneers. Veneers were produced using a Teflon mould with a diameter of 10 mm and a depth of 1.2 mm. The porcelain and modelling liquid were mixed, packed and dried and then placed onto platinum foil and fired according to manufacturer's instructions. Both surfaces of the veneers were finished using abrasive paper to give a finished thickness of 1.0 mm +/- 0.025 mm (measured with digital callipers and rejected if outside given range). A single operator then recorded a colour reading for all veneers to determine standardisation. The veneers were then randomly assigned to the groups.

The bonding surface of each veneer was then prepared by sandblasting and etched with hydrofluoric acid (Vita Ceramic Etch) for 1 minute.

### Resin cements

Resin cements in the following shades from each stated manufacturer were chosen: Calibra - light, dark, and transparent shades; Nexus-3 Universal Luting system - light, dark and neutral shades; RelyX- Unicem Veneer cement - white opaque, A3 opaque/dark and translucent shades. These shades represent the broadest colour variation available within the shades produced by each manufacturer along with a neutral or translucent resin. The corresponding try-in pastes of each of the above shades were also used.

### Bonding

Measurements of colour were taken with each of the control [Commercially available lubricating water gel (Aquagel, Adams Healthcare, UK)] and test substances (Try-in pastes, resin cements before curing and resin cements after curing) in place. The tooth and veneer were cleaned and dried before the application of each substance. The try-in paste and resin cements were applied according to the manufacturers' instructions. Teeth surfaces were etched using the phosphoric acid that came with the resin cement kit for 15 - 20 seconds as instructed by the resin cement's manufacturer. The resin cement, as instructed, was applied to the etched surfaces of the veneers and then the veneers were applied to the determined area of the teeth surfaces using a gentle figure pressure to allow presenting the excess cement at the borders. The resin was then cured with a light-curing unit (Curing light XL3000, 3M ESPE, U.S.A) for 80 seconds to insure complete curing of the cement under such 1 mm porcelain veneers (Linden., *et al.* 1991 and O'Keefe., *et al.* 1991). A measurement of colour was made before and after the resin was cured.

### Porcelain thickness

The exact same materials and methods mentioned above were redone again using 0.6mm porcelain disc thickness.

### Colour measurement

Colour measurements were made using an 'Easy shade' Vita probe spectrophotometer (Vita Easy shade, Vita, Germany). Spectrophotometers measure CIE-LAB values giving a numerical representation of a 3D measure of colour. These measurements have been previously used in studies assessing shades of both teeth and porcelain. Readings of L*, a* and b* were performed three times against the same background (black) and the mean value used.

Bovine teeth through the whole study, with or without the porcelain veneers, were stabilized against the gray background by hand-holding their roots entirely on the background.

### Data analysis

Data was entered into a Microsoft Excel (Microsoft Corp., Redmond, USA) spreadsheet and analysed using SPSS 15 (SPSS inc., Chicago, USA).

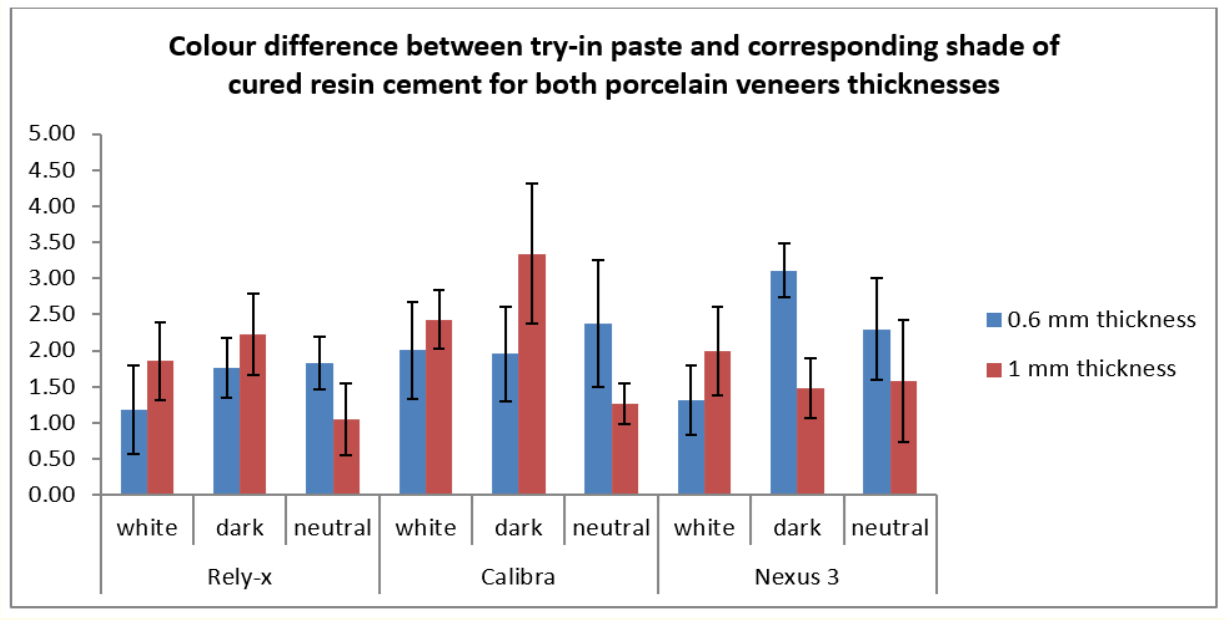
The ΔE* values were calculated for the different shades of cured resin and try-in paste and were also calculated for each resin on curing using the following equation:

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

The ΔE* values were entered into SPSS 15 and analysed using analysis of variance ($p < 0.05$ and 95% confidence intervals) and Tukey test for multiple comparisons. An assessment was also made of the clinical significance of colour differences values by comparing them to the perceptibility (1 ΔE* unit) and acceptability (3.7 ΔE* units) thresholds.

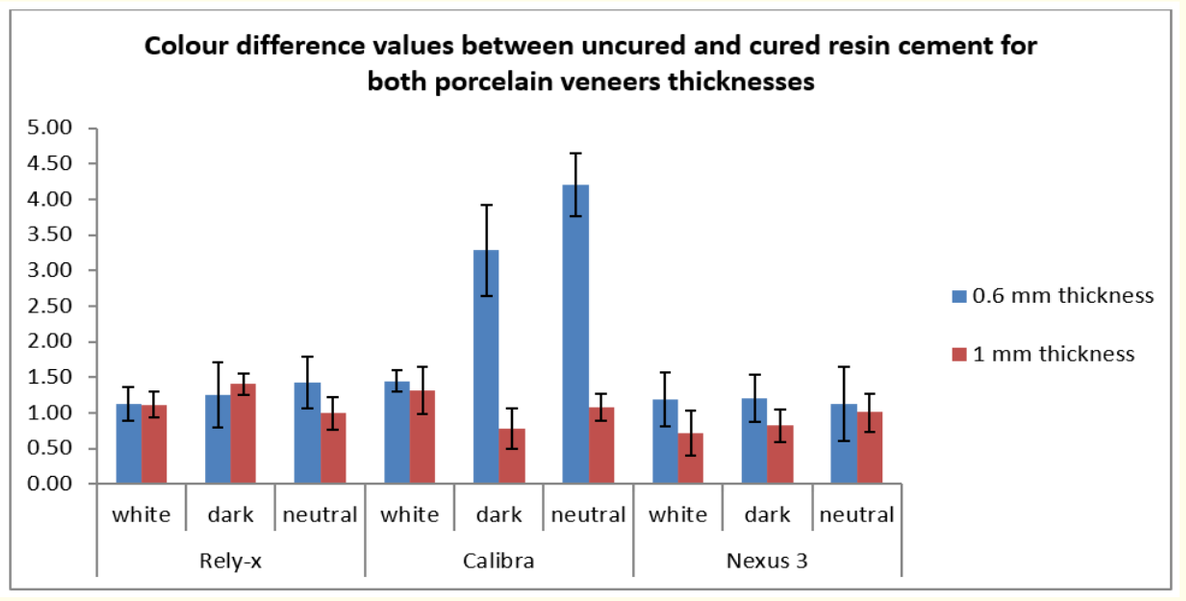
## Results

The colour difference values found between try in paste and the corresponding shade of cured resin cement in case of 1 mm thick veneers were not perceptibly different from those found in case of 0.6 mm thick veneers for all shades and manufacturers (Graph 1).



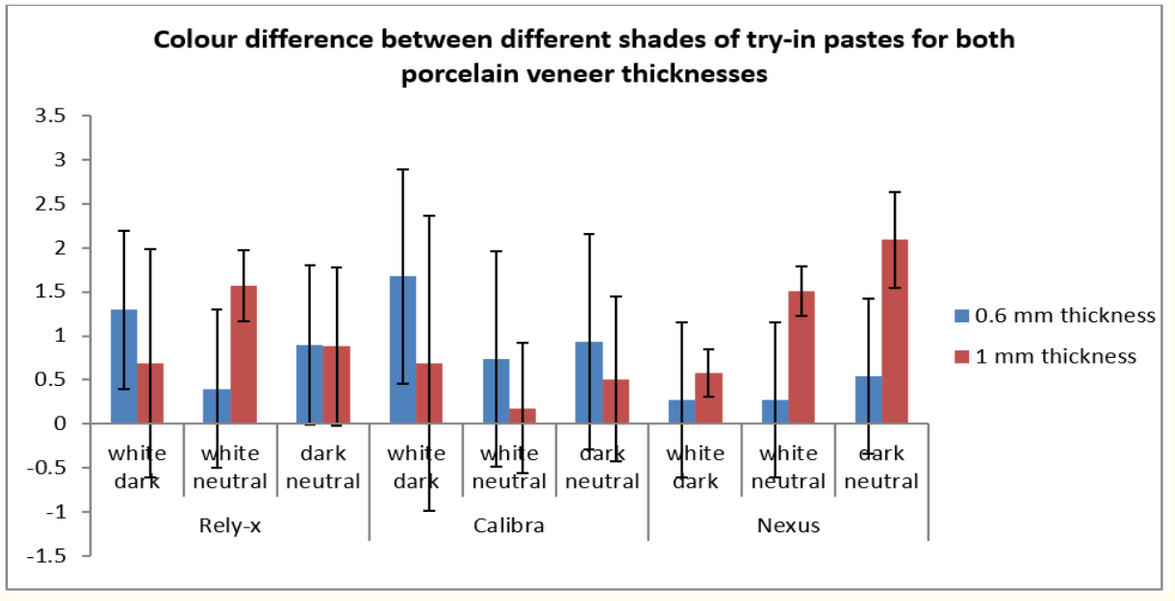

***Graph 1:*** *Demonstrates the colour difference values between try-in paste and corresponding shade of resin cement for both porcelain veneers thicknesses.*

The colour difference values found between uncured resin cement and the corresponding shade of cured resin cement in case of 1 mm thick veneers were not perceptibly different from those found in case of 0.6mm thick veneers for all shades and manufacturers, except in case of neutral and dark shades of Calibra cement, the colour differences caused by polymerization of resin cement in case of 1mm thickness were very different from those noticed in case of 0.6 mm thickness graph 2.



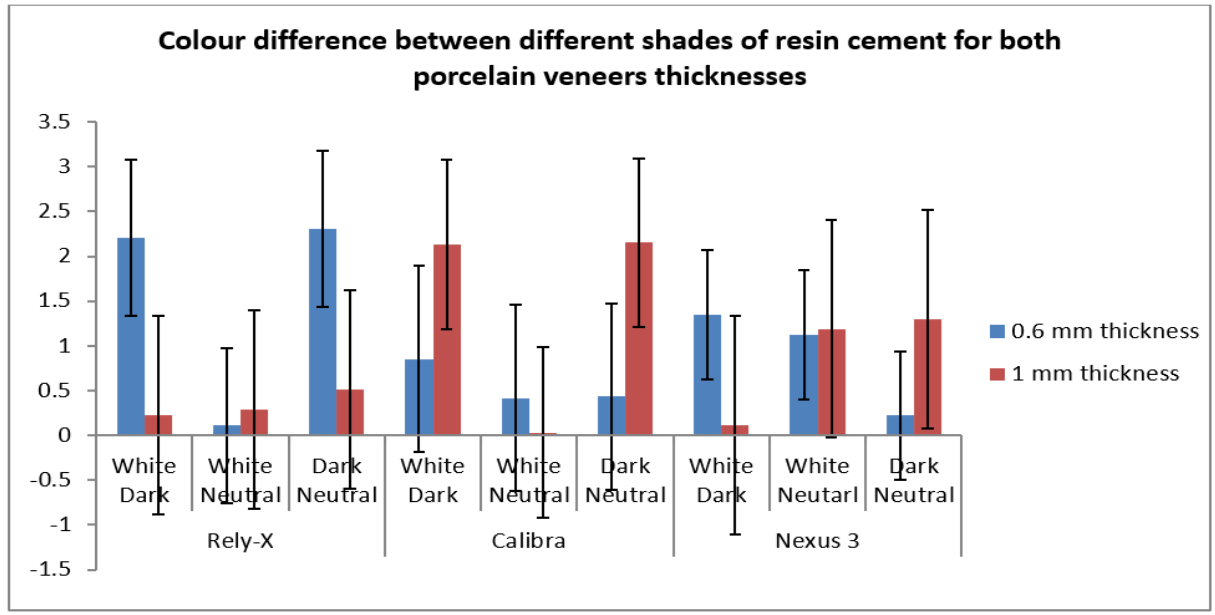

***Graph 2:*** *Demonstrates the colour changes values of different shades and manufacturers of resin cement on curing for both porcelain veneers thicknesses.*

For assessing the colour difference between different shades of try-in pastes within each manufacturer, significant differences were noticed in case of 0.6 mm thick veneers between white/dark shades of RelyX cement and between white/dark shades of calibra cement. On the other hand, significant differences in case of 1 mm thick veneers were found between white/neutral shades of RelyX cement and between neutral/dark and neutral/white shades of Nexus graph 3.




***Graph 3:*** *Demonstrates the colour difference values between different shades within each manufacturer of try-in pastes for both porcelain veneers thicknesses.*

For assessing the colour difference between different shades of resin cements within each manufacturer, significant differences were noticed in case of 0.6 mm thick veneers between white/dark and dark/neutral shades of RelyX cement and between white/neutral shades of Nexus cement. On the other hand, significant differences in case of 1 mm thick veneers were found between white/dark and neutral/dark shades of Calibra cement and between neutral/dark shades of Nexus graph 4.




***Graph 4:*** *Demonstrates the colour difference values between different shades within each manufacturer of resin cements for both porcelain veneers thicknesses.*

## Discussion

Luting agents in combination with the background shade have influenced the outcome colour of porcelain restorations. In our study, the final colour of porcelain veneers was significantly affected by the resin cement and porcelain thickness used.

The colour shift from the aquagel baseline to the porcelain restoration in place (with cured resin cement) were influenced by the shade and brand of resin cement and by the thickness of the porcelain veneers.

The thickness of porcelain veneer has no significant effect neither on the colour difference values between try-in paste and resin cement of the same shade, nor on the colour changes of porcelain veneers caused by different shades of try-in pastes. Therefore, using try-in pastes of different shades and brands as a guide to approach the shade of resin cement required to achieve shade match can be performed wherever needed regardless of the thickness of porcelain veneer, especially with neutral and dark shades of Calibra where the uncured resin cement is not recommended to act as a guide in 0.6 mm thick porcelain veneers.

Moreover, different shades of resin cements produce different levels of colour changes, and these changes were significant when changing the porcelain thickness. Therefore, different shades of resin cements can help changing the colour of the overall veneer to achieve an acceptable colour match in any porcelain thickness used.

Final colours achieved by a specific shade of try in paste was significantly different when using the corresponding shade of resin cement in both veneers thickness used. This lead to more caution to be taken when using try in pastes as an indicator of the final colour of the porcelain veneers.

A general protocol was suggested by the author for cementing porcelain veneer restorations (Alghazali's protocol):

1. Porcelain veneers can firstly be tried on prepared teeth using any shade of resin cement before preparing the teeth and veneers surfaces for cementing process.
2. If that used shade did not give an acceptable colour match, then, it is advised to change the shade of resin cement until attaining a clinically acceptable colour match between the veneers and the adjacent teeth. Moreover, using any of solvent material produced for oral use (for instance, Acetone, ethanol and methanol) may be used to insure a complete removal of the residuals of the resin cement and such procedures will not affect the bond strength of the teeth -veneers complex.
3. Once a certain shade of resin cement was chosen, preparing the teeth and veneer surfaces are accomplished and that shade of resin cement is used for cementing. It is recommended to use the light cured cements rather than dual cured ones since there are several advantages of doing so: light cured cements give a longer working time that enables to remove excess resin properly, light cured cements are easy to remove when they are used for trying-on, and colour stability of light cured cements is superior to dual cured ones. When using dual cured cements for trying-on, it is advised turning the operatory light off to insure adequate working time.
4. As recommended, the veneers will be gently pressed to place using a light to medium finger pressure allowing excess resin cement to be presenting at the margins. Moreover, it has been revealed that the cement thickness can be controlled to a certain extent by the clinician, and therefore, it may not be considered as a significant procedure influencing the colour matching process. Moreover, when using the uncured resin cement for trying on of veneers and the same finger pressure will be used in each trial, which in turn will minimize to a large extent even the minor effects of cement thickness on the colour match as this variable will be kept the same throughout the whole trying-on and cementing process.

## Conclusion

Clinically unacceptable differences were found between try-in pastes and the cured resin of the same shade, however, there were relatively imperceptible changes measured between un-cured and cured resins for both ceramic thickness used. Therefore, colour match achieved by the try-in paste should be treated with caution and further assessment of the restoration made with the resin in place before curing regardless of the thickness of the ceramic veneers used.

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