Influence of Four Different Cements on the Colour of Zirconia Structures of Varying Ceramic Thickness

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Abstract

Objectives: The aim of this study was to investigate the influence of four different cements on the final colour of LAVA® restorations with variations of core thickness, staining, veneering thickness and shade.

Materials and Methods: A combination of four cements, four shades of Core material and three shades of veneering porcelain were tested for colour using a laboratory spectrophotometer. A total of 25 cylindrical disks, 15mm in diameter were prepared. To simulate the clinical situation, discs were made from LAVA® core and veneering porcelain in three different thicknesses of 0.3, 0.5 and 0.7mmm and 0.5, 1.0, and 1.5mm respectively. Overlapping the disks on a neutral background enabled ΔE calculations of the various thickness and shades combinations.

Results: The collected data showed statistically significant colour differences for zinc phosphate cement compared to resin modified glass-ionomer and resin cements. Veneering porcelain thickness influenced the colour more notably than porcelain shade, core thickness or staining.

Conclusions: It was concluded that where porcelain thickness is reduced due to limited restorative space, opaque cements should be avoided due to the translucency of LAVA® restorations. Other factors such core staining or thickness could not compensate for such colour changes.

Clinical significance: Opaque cements such as zinc phosphate cement may affect the final colour of LAVA® all ceramic restorations, especially when restorative space is limited.

Key words: Dental cements, LAVA®, Spectrophotometer, All-ceramic crowns.

Introduction

Achieving optimal aesthetics in the anterior region by means of full coverage restorations still represents a difficult task in dentistry.[1]

Many different all-ceramic systems have been developed over the past forty years to overcome the aesthetic deficiencies of metal ceramic crowns.[2] The main limitations of the majority of the systems were poor marginal fit and poor physical properties. In recent years the use of zirconia core has significantly improved the strength of the restorations [3]. CAD-CAM systems have advanced to reach levels comparable to metal-ceramic crowns, in terms of marginal fit [4]. Although long-term clinical studies are not yet available, zirconia CAD-CAM crowns appear to be a promising metal-free alternative for highly aesthetic anterior restorations.[5]

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One of the advantages of zirconia CAD-CAM crowns is the option for the clinician to utilize conventional cements without compromising the strength of the restoration, as was often the case with older generation all-ceramic crowns.[6] However, the effect of conventional cements on the final shade of the restorations has yet to be investigated. Nor has it been established what the minimal thickness of both core and veneering porcelain should be in order to avoid any colour distortion through cementation, should any occur.

The purpose of this study was to evaluate the influence of four different cements on the final colour of LAVA™ specimens of varying thickness, core material staining and thickness of veneering porcelain.

Materials and Methods

This study used the LAVA™ system (3M ESPE, Seefeld, Germany), consisting of a core made of partially yttria-stabilized zirconia ceramic and a compatible veneering

Figure 1: Custom made cylindrical device employed for cement disks fabrication.

feldspathic porcelain.[7]

Disks of LAVA™ Frame and LAVA™ Ceram of different thicknesses were combined in order to simulate different thicknesses of cores and veneering ceramics. Each combination was tested on four different cements by means of a spectrophotometer.

Preparation of the specimens

Disks of core material with thicknesses of 0.3mm, 0.5mm, 0.7mm were obtained by cutting a cylinder of LAVA™ Frame (Lot. 210136) with a low speed, water cooled, precision saw (IsoMet®, Buehler, Lake Bluff., USA). The disks were then sintered, with the addition of 3 different colour modifiers of the core material FS1, FS3, FS4. These colour modifiers are part of the Lava™ Ceram system and can be applied to the core before sintering. Core disks without any colour modifiers were fabricated as well, making a total of 12 disks (4 colours x 3 thickness). The core disks were not polished.

Veneering porcelain LAVA™ Ceram disks were also obtained by cutting fired-ceramic of three different shades (A1, A3, A4) in three thicknesses (0.5mm, 1.00 mm, 1.5 mm) for a total of 9 disks (3 shades x 3 thickness). None of the porcelain disks were glazed or polished to avoid variations in surface texture.

Four different cements were involved in the study: a Zinc-Phosphate cement (Heraeus Kulzer, Dormagen, Germany), a Resin modified glass-ionomer cement (Fuji PLUS, (GC Co, Tokyo, Japan), two resin cements RelyX™ Unicem (3M ESPE, Seefeld, Germany) and Maxcem (Kerr, Orange, CA, USA). were compared.

A disk of 15mm in diameter and 0.1 mm in thickness was fabricated for each cement using a custom-made cylindrical device (Figure 1).[8] The mould was filled with the unset cement and pressed against a glass slab, producing disks of 15mm diameter 0.1mm thickness .

The thickness of all the disks was measured with a 50 µ resolution caliper. Samples that were within this resolution range were involved in the study and those with significant voids were discarded.

Colour measurements

For colour measurements, a spectrophotometer (PSD1000, Ocean Optics, FL, USA) equipped with an integrating sphere (ISP-REF, Ocean Optics, FL, USA) with a 10 mm opening was used. The spectrophotometer was connected to a computer running OOILab 1.0 software (Ocean Optics, FL, USA) in Lab* system as colour measurement software. D65 illumination and a 10° standard observation angle were selected. A 50% gray card (Kodak Co, Rochester, USA) was used as a neutral background.[8]

Colour measurements were taken by overlapping three disks, made of veneering porcelain, core and cement respectively, on the neutral background. No disc interface media was used as, in a pilot study, no differences were found whether either water or demineralised water was used, as opposed to no interface media.. ΔE calculations were made for all the combinations of core, veneering porcelain and cements.

Colour difference (ΔE) was determined by comparing the differences between respective coordinate values for each coordinate as expressed by the following equation[9]:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

ΔE represents the total colour difference where ΔL is “light”,

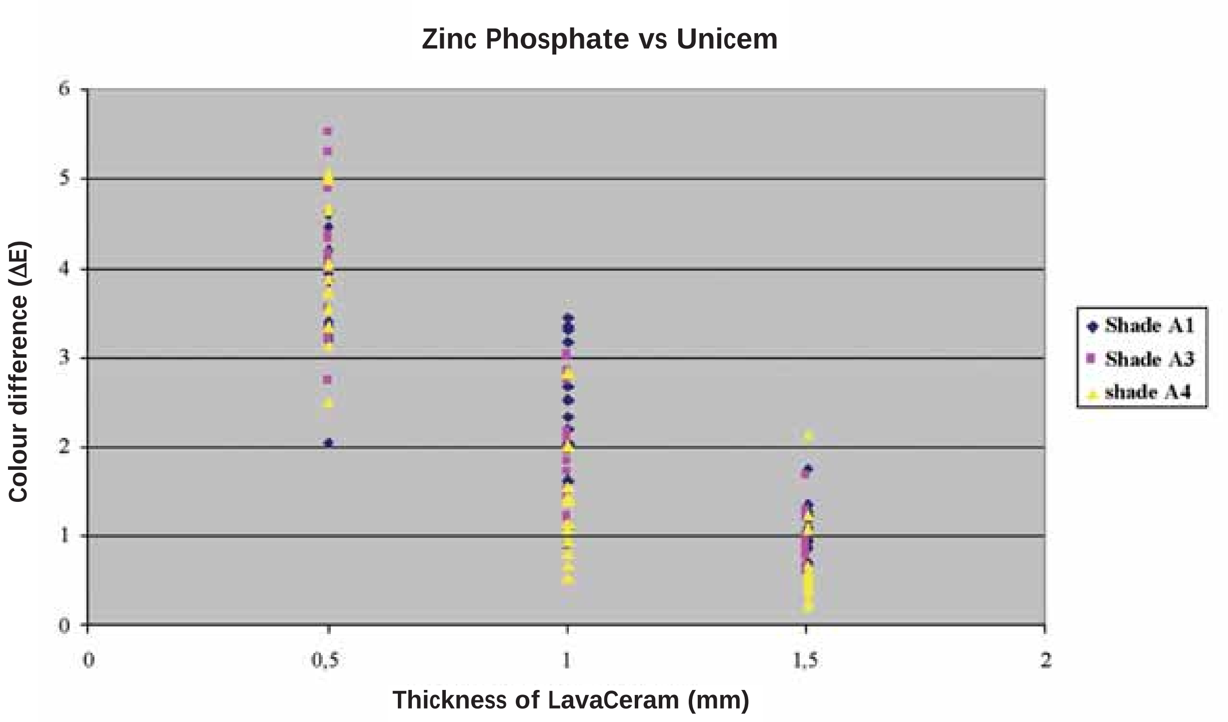

Figure 2: Colour differences (ΔE) between Zinc-Phosphate cement and RelyX™ Unicem for samples of LavaCeram of different thickness (0,3-0,7mm) in shades A1, A3 and A4 on Lava cores of different thickness (0,3-0,7mm) and core modifiers. Clinically significant colour variations(ΔE) are observed when 0,5mm porcelain is used.

Δa "red-green" and Δb "yellow-blue".

Several studies provide information regarding clinical colour-matching tolerance.[10-13] Values of ΔE < 1 were regarded as invisible to the naked eye. Values 1< ΔE< 3.3 were considered perceptible by skilled operators, but considered clinically acceptable. Values ΔE >3.3 were considered perceptible by non-skilled persons as well and for that reason are clinically unacceptable.

The recorded data was analyzed by a linear regression analysis at the 0.05 level of significance.

Results

Zinc phosphate cement showed a different behaviour when compared to the other cements in terms of colour changes.

Table 1.

Linear regression analysis of the comparison between Zinc phosphate and Unicem. In the first section it is reported the overall significance of the statistical model. In the second section are reported all the variables introduced. Among them veneering porcelain thickness was the only to exhibit a statistically significant influence on ΔE variations.

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
,883(a)	,780	,771	,686360016	,780	91,116	4	103	,000

a Predictors: (Constant), core thickness, core stain, porcelain shade, porcelain thickness
b Dependent Variable: ΔE

Non-standardized Coefficients			Standardized Coefficients	t	Sig.	Correlations		
Predictors	B	Std. Error	Beta			Zero-order	Partial	Part
(Constant)	5,271	,304		17,340	,000			
Porcelain thickness	-1,208	,064	-,869	-18,797	,000	-,869	-,880	-,869
Porcelain shade	-,223	,081	-,127	-2,753	,007	-,127	-,262	-,127
Core Stain	-,108	,059	-,084	-1,827	,071	-,084	-,177	-,084
Core thickness	-,037	,081	-,021	-,455	,650	-,021	-,045	-,021

a Dependent Variable: ΔE

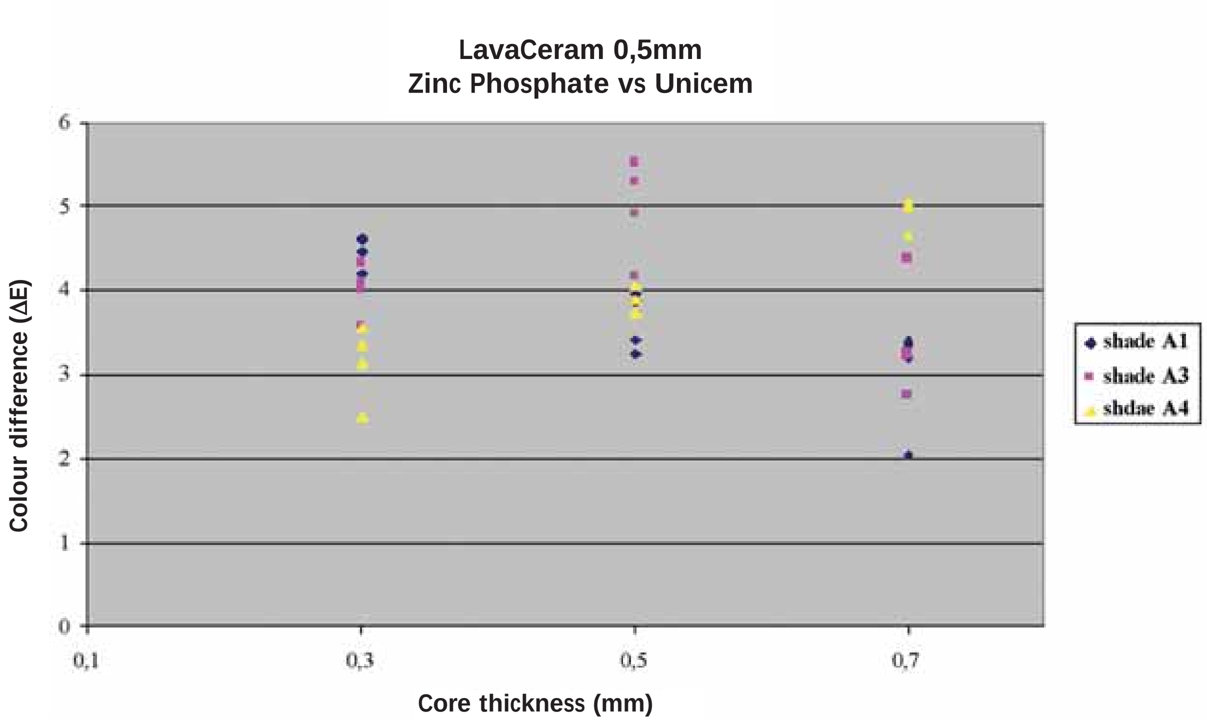

***Figure 3:** Colour differences (ΔE) between Zinc-Phosphate cement and Unicem for samples of LavaCeram 0,5mm of shades A1, A3 and A4 on Lava cores of different thickness.*

Figure 2 reports the graphical distribution of ΔE values of the comparison between Zinc phosphate cement and RelyX™ Unicem cement. ΔE values >3.3 were observed when veneering porcelain of thickness 0,5mm and 1,0mm were used, and are therefore clinically unacceptable. Linear Regression analysis showed a statistically significant effect for the porcelain thickness factor, with a regression score (R) = -0.869 at a 0,05 level of significance. (Table. I)

As most of ΔE values above 3,3 where found in the group of 0,5mm thick porcelain samples, further analysis was conducted in order to establish whether other factors could play a role in the colour shift. Figure 3 presents data restricted to the samples with veneering porcelain of 0,5mm. None of the other factors such as core stain, core thickness and shade of porcelain showed any significant effect on total colour changes (R=0,208).

Both resin cements and resin modified GI cements showed similar behaviour in terms of total colour changes. Figure 4 shows ΔE values for samples of RelyX™ Unicem and Maxcem for all the possible combinations of veneering porcelain disks and core disks. The regression analysis did not reveal significant correlation for any of the factors investigated reporting an R = 0,282..

The same data are shown in Figure 5 for the comparison between Fuji PLUS and Unicem cements. The linear regression analysis did not show significant differences among all the factors (R=0,275).

Discussion

This study simulated three major elements of an all-ceramic restoration such as veneering porcelain, core and luting agent. This was obtained by assembling disks of the same diameter (1,5mm) for each individual element of the system which is the object of the investigation. This methodology, presented previously in the literature [14,15], allows a great number of measures with a reduced number of specimens.

Cement disks were fabricated at a predetermined thickness of 0,1mm. In another study[16] cement was applied with arbitrary pressure directly to the specimens, producing varying thicknesses of luting agents, ranging from 0,08 to 0,18mm. While the latter methodology may better simulate a clinical simulation, a predetermined measure was preferred in order to reduce the already large number of variables.

From the calculation of ΔL, Zinc-Phosphate cement was found to be the most opaque cement and showed poor light transmittance in comparison to the other three cements..

Zinc phosphate presented the greatest variations of ΔE as can be seen in Figure 2. This could be expected given the degree of translucency of the all-ceramic restoration and concurs with previous reports.[17, 18] .

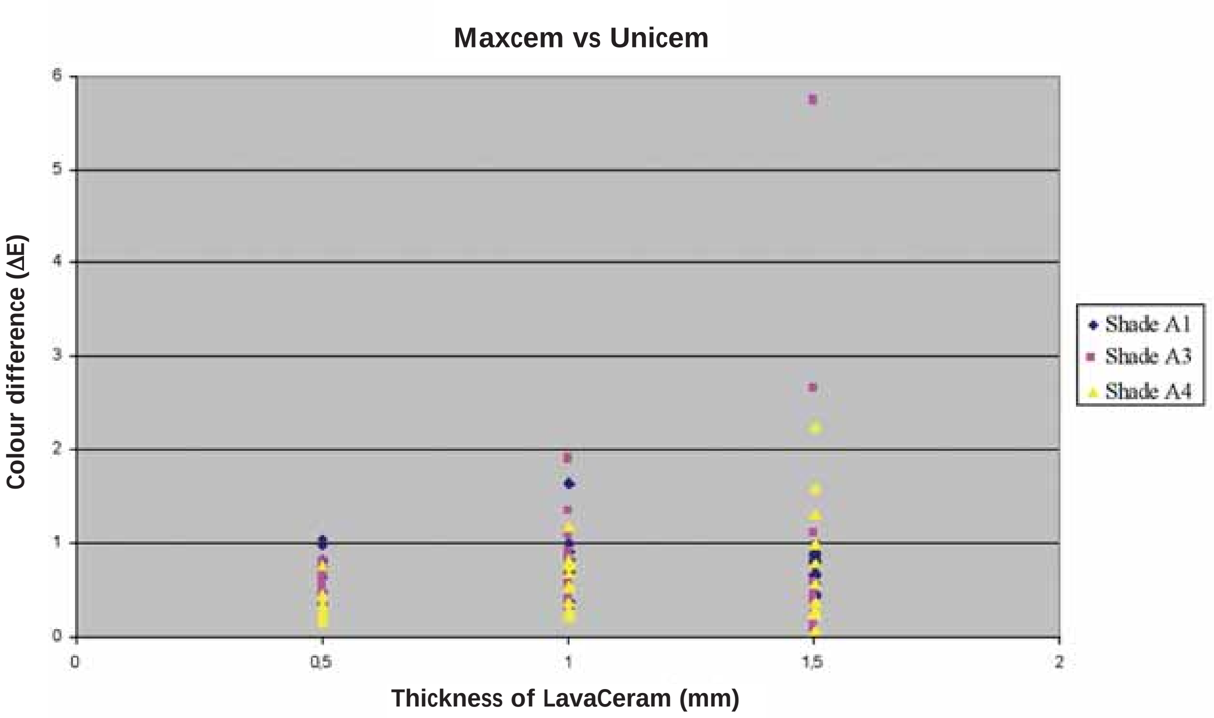

Figure 4: Colour differences (ΔE) between Maxcem and Unicem for samples of LavaCeram of different thickness (0,3-0,7) in shades A1, A3 and A4 on Lava cores of different thickness (0,3-0,7) and stain.

In the comparison between Zinc phosphate cement and RelyX™ Unicem, veneering porcelain thickness was found to have statistically significant effects on ΔE. As expected, the highest values of ΔE were attributed to thin veneering porcelain (0,5mm).

A further statistical analysis in the group of 0,5mm veneering porcelain (Figure 3) revealed that no other factors such as core thickness, core stain or shade had significant effects on ΔE. This was surprising as a masking effect of a thicker core on cement influence aws expected. Further studies should confirm this data and establish what the minimal core thickness should be in order to minimize tooth background interferences on the final colour of the restoration.

Figures 4 and 5 show that all the other cements presented limited variations of ΔE when compared one another. All the recorded ΔE where well below the limit of clinical acceptance and not statistically significant.

Although clinical data are needed to confirm our findings, the data of the present study suggest that significant colour changes may occur after cementation of a zirconia restoration by mean of a conventional luting agent such as zinc phosphate cement, particularly when the thickness of the porcelain is limited.

Conclusions

Within the limitation of this study the following conclusions were drawn.

- Zinc Phosphate cement behaves differently in terms of light transmittance compared to resin cements (RelyX™ Unicem and Maxcem) and resin modified glass ionomer cement (Fuji PLUS)
- Colour changes seen in this laboratory model of a LAVA® restoration are significantly dependent on the thickness of veneering porcelain
- When the thickness of veneering porcelain is limited to 0,5mm other factors, such as core thickness or core staining, cannot compensate sufficiently to prevent colour shift due to opaque luting agents

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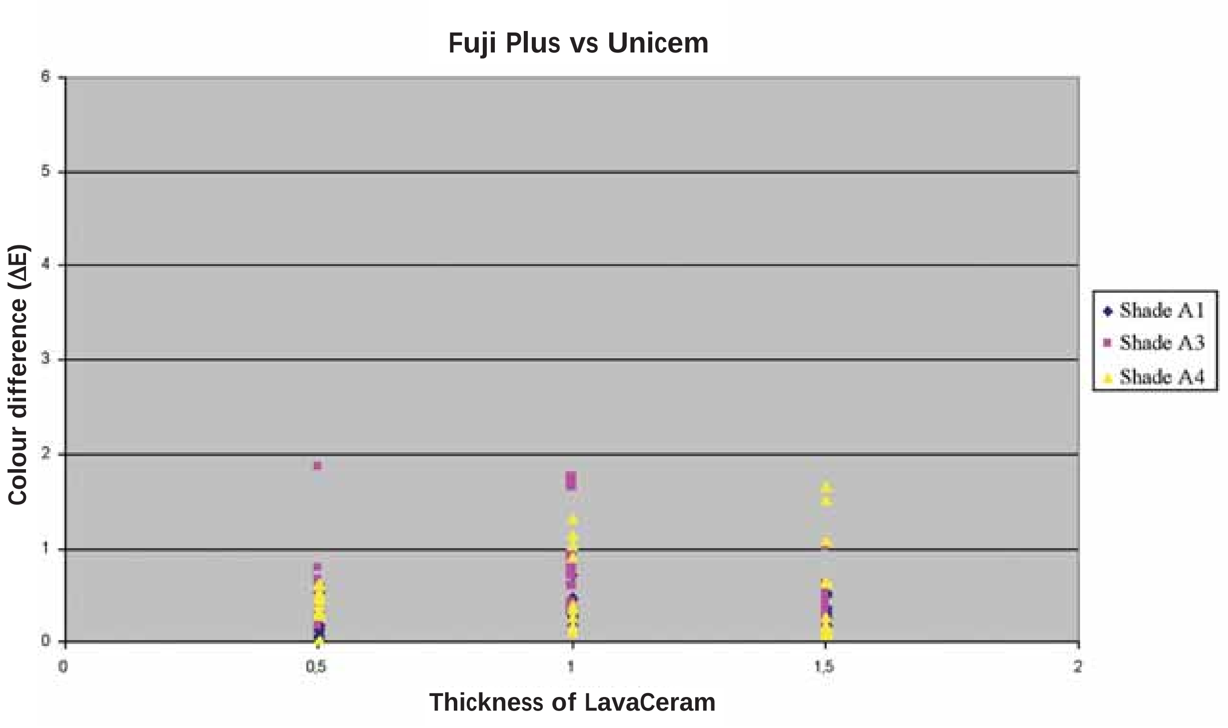

Figure 5: Colour differences (ΔE) between Fuji plus and Unicem for samples of LavaCeram of different thickness (0,3-0,7) in shades A1, A3 and A4 on Lava cores of different thickness (0,3-0,7) and stain. All the colour differences (ΔE) observed are below the value 2.

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