

A Comparative Shade Evaluation of Two Different All-Ceramic Materials over Three Core Build-up Materials: An *in vitro* Study

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ABSTRACT

Aim: To evaluate and compare the shade of zirconia and alumina crowns over composite, all-ceramic and metal core material.

Objectives: (1) To evaluate the influence of composite core build-up material on the shade of zirconia and alumina crowns. (2) To evaluate the influence of all-ceramic core material on the shade of zirconia and alumina crowns. (3) To evaluate the influence of metal core material on the shade of zirconia and alumina crowns. (4) To compare the influence of composite, all-ceramic and metal core material on the shade of zirconia and alumina crowns.

Materials and methods: The all-ceramic materials used for fabrication of crowns were zirconia (LAVA) and alumina (PROCERA). They were evaluated spectrophotometrically for the change in shade when placed over three core build-up materials.

Results: The observations obtained were statistically analyzed by analysis of variance. Zirconia crowns when compared with alumina crowns showed the least shade change when placed on the three core materials. Among the three core materials used, composite core build-up material showed the least change in the shade.

Conclusion: Zirconia crowns showed least shade change when placed on the three core materials.

Keywords: Zirconia crowns, Alumina crowns, All-ceramic core material.

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INTRODUCTION

A clinically successful esthetic restoration offers a positive effect on once self-esteem.¹ Increasing patient expectation regarding the appearance of restorations test the skill of a clinician but total patient satisfaction is still a challenge.²

The ceramometal crowns have been the predominant restorations for the past three to four decades.³ They have a proven record of success and being versatile they can provide superior strength, marginal integrity, excellent durability and most predictable service in term of clinical longevity. But, one of the shortcomings of these restorations

was esthetics, which was not up to the mark, due to the metal substructure which blocked the transmission of light.⁴ Hence, in the pursuit of perfecting esthetic and to fulfill the exacting demands of the patients, all-ceramic restorations were substantially used in which the light blocking metal was eliminated. Even though all-ceramics date back to the 19th century, rapid improvement and developments with sophisticated innovative technologies have been seen in recent years.⁵ The introduction of improved all-ceramic systems makes it possible to achieve optimal esthetics along with the necessary mechanical properties to withstand functional stresses.

Endodontic therapy has transversed a meandering course, and in the present day scenario a nonvital tooth is used very effectively to support a restoration and return to function, esthetic and psychological comfort for the patient. Special techniques and considerations are needed to restore such mutilated teeth to have a good prognosis.⁶

When there is extensive loss of coronal tooth structure in an endodontically treated tooth, a post and core reconstruction for retention of crown is commonly required.⁷ Various materials for posts and core have been introduced and to achieve the best results, material should have physical properties similar to dentin, it should bond to the tooth structure and be biologically compatible.⁸ Metal posts and cores are commonly used because of their superior physical properties. But with the growing demand for esthetic restorations, it has led to the development of tooth colored, metal free posts and cores.⁹ The esthetic post could be used with composite built-ups to achieve good esthetic results but the phase between the post and core always remains a weak link.

With the development of zirconia it could be used as a one piece post and core to enhance the strength and esthetics. It would be as good as using a one piece metal post and core which has the strength but may have poor esthetic when an all-ceramic restoration is placed over it. The zirconia post and core could be an alternative approach that contributes to a better light transmission and reflectance through an all-ceramic restoration or thin gingival tissue, thereby giving a natural appearance to the restoration.¹⁰

It was therefore planned to carry out the study to compare and evaluate what effect the core build-up material would have on the shade of the overlying all-ceramic crown.

MATERIALS AND METHODS

The study was divided in the following steps:

- Selection of the extracted teeth
- Preparation of the extracted teeth
- Fabrication of the cores
- Fabrication of all-ceramic crowns
- Spectrophotometric analysis.

Selection of the Extracted Teeth

Three extracted maxillary central incisors of approximately the same size and shape were selected for the study and were disinfected by storing under 10% neutral buffered formalin solution. They were cleaned with ultrasonic scaler and each of the tooth were mounted on a block of dental stone leaving the crown portion and cemento-enamel junction (CEJ) exposed (Fig. 1). The labial and palatal surfaces were marked on the mounting block.

Preparation of the Extracted Teeth

All the three extracted teeth were sectioned 2 mm coronal to the CEJ with a wheel-shaped diamond point on an airrotor handpiece with water spray. The teeth were prepared using a torpedo-shaped diamond point above the CEJ, in such a way, to achieve a 2 mm ferrule,¹¹ and a 1.5 mm deep chamfer finish margin¹² (Fig. 2). Post space of 2 mm was also prepared using peso reamer for the retention of the core.

Fabrication of Core

After preparation of the teeth they were divided into three groups:

- *Group A:* Composite core (Luxacore)
- *Group B:* All-ceramic zirconia core (Cercon)
- *Group C:* Metal core (Wiron 99).

Group A: Composite Core (Luxacore)

Luxacore which is a dual cure composite resin core build-up material was used to fabricate the core on the prepared tooth. Equal amount of base and catalyst was dispensed from the mixing tip directly onto the prepared tooth surface and was manipulated using composite instrument. The build-up was then light cured for 40 seconds, this was done incrementally (Figs 3 and 4). The core preparation was done after a time interval of 10 minutes. It was prepared and contoured to form the core replicating a prepared tooth to receive all-ceramic core. A silicon putty index was then prepared over the composite core (Fig. 5). The index was used for fabricating all-ceramic zirconia core and metal core to standardize the size of the core.

Group B: All-ceramic Zirconia Core (Cercon)

On the prepared tooth, wax separator was applied and wax pattern was prepared using the silicon putty index. On completion of the wax pattern it was scanned in the cercon

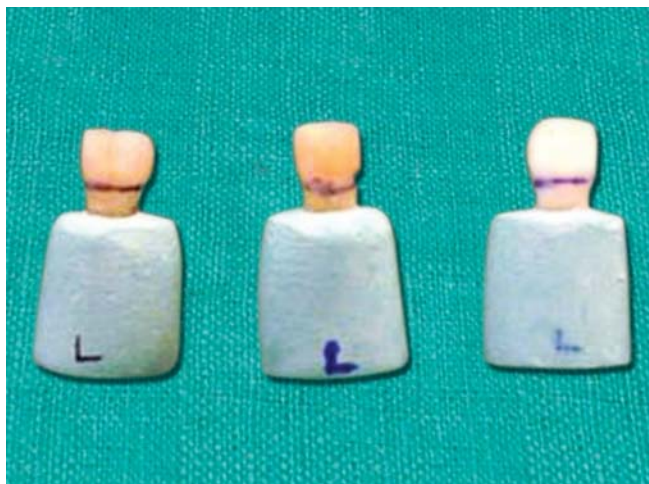


Fig. 1: Teeth mounted for preparation



Fig. 2: Prepared tooth sample



Fig. 3: Material, instruments and equipment used for fabricating composite core

milling machine and then the machine milled the cercon zirconia block of natural shade. The core was milled from presintered zirconia block in an enlarged size. The enlargement factor compensated for the sintering shrinkage (18% linear). The milled sample was sintered in the cercon heat furnace at 1,350°C for 6 hours. The core was then finished and polished using diamond points on an air rotor with water spray. The core was cemented on the tooth using resin cement (Varolink II; Figs 6 and 7).¹³

Group C: Metal Core (Wiron 99)

Wax separator was applied over the prepared tooth and using the silicon putty index, a wax pattern for the core was prepared. On completion of the wax pattern, it was sprued and invested in the rubber casting ring. The investment material was allowed to set for 1 hour after which it was placed in wax burnout furnace until the temperature of 950°C was achieved. The casting was done with NiCr alloy to get a metal core. It was finished and polished to fit onto the prepared tooth. The core was then cemented on the

prepared tooth using zinc phosphate cement (Figs 8 and 9).¹⁴

Fabrication of All-ceramic Crowns

After the core was cemented in place on the prepared tooth, all-ceramic crowns were fabricated. All-ceramic crowns were divided according to the material used:

- *Group I:* Zirconia crowns (Lava)
- *Group II:* Alumina crowns (Procera)

Group I: Zirconia Crowns (Lava)

The tooth along with the ceramic core was mounted on a rotating platform in an optical scanning device Lava scan that was attached to a computer. After scanning the tooth with the core, the three-dimensional (3D) image got displayed on the computer screen. The next step was to decide the thickness of the coping, which was kept at 0.4 mm as advised by the company for anterior restorations. After designing of the coping, the 3D shape was milled from a presintered zirconia oxide blank using hard metal tools.

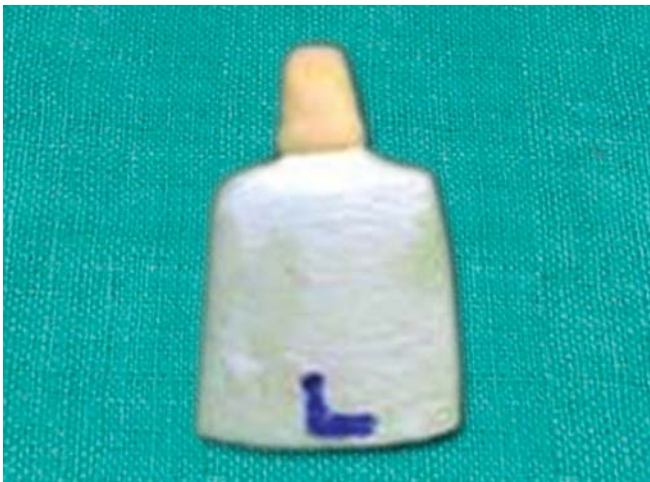


Fig. 4: Tooth with composite core (LuxaCore)



Fig. 6: Tooth with all-ceramic zirconia core (Cercon)



Fig. 5: Tooth with silicon putty index



Fig. 7: Tooth with all-ceramic zirconia core (Cercon)

The milling time for the crown was 35 minutes. After the milling process got completed the manual finishing was carried out before sintering takes place. The coloring of the framework was also done before sintering process. The framework was colored using FS2 shade which corresponds to B2 shade of Vita classic shade guide. Then fully automated, monitored sintering process was done with no manual handling in a special furnace, the Lava Therm for 11 hours including heating and cooling phase at 1,500°C. Five copings of zirconia oxide (Lava) all ceramic system were prepared.

The copings were then evaluated for their fit and also thickness was verified with gauge to be 0.4 mm. Later on ceramic build-up was carried out using Lava Ceram ceramic material and layering of 1.1 mm thickness was done to attain the desired 1.5 mm thickness of the restoration. Firing of the layering ceramic was carried out at the program set in the ceramic furnace Programat P200. On completion of firing procedure the crowns were finished, polished and glazed.



Fig. 8: Material used for fabricating metal core



Fig. 9: Tooth with metal core (Wiron 99)

Group II: Alumina Crowns (Procera)

Scanning procedure in dental laboratory: The tooth along with the ceramic core was mounted on a rotating platform in a digital scanning device that was attached to a computer and the entire preparation was digitalized. After scanning the tooth, the two-dimensional image got displayed on the computer screen. The next step was to decide the thickness of the coping, which was kept at 0.4 mm as advised by the company for anterior restorations. After designing of the coping, a file was saved in computer and was sent via e-mail to the production station in Sweden. Five copings of alumina (Procera) all ceramic system were ordered from Sweden.

Manufacturing procedure at Sweden work station: The copings were manufactured with advanced powder technology by sintering high purity alumina powder with CAD-CAM technique. This process takes into account the sintering shrinkage of approximately 20%. It was compensated by enlarging the tooth to a 20% larger refractory die, on which the alumina powder is sintered. Five densely sintered high purity aluminum oxide copings were manufactured in the similar manner. The copings were examined for quality control and sent by courier to the dental laboratory.

In the laboratory: The copings were then evaluated over for their fit and also thickness was verified with gauge to be 0.4 mm. Later on ceramic build-up was carried out using Nobel Rondo alumina ceramic material and layering of 1.1 mm thickness was done to attain the desired 1.5 mm thickness of the restoration. Firing of the layering ceramic was carried out at the program set in the ceramic furnace Programat P200. On completion of firing procedure the crowns were finished, polished and glazed.

Spectrophotometric Analysis ($L^*a^*b^*$)

Spectrophotometric analysis ($L^*a^*b^*$) of (Figs 10 and 11):

- All-ceramic crowns
- Zirconia crowns over three core build-up materials
- Alumina crowns over three core build-up materials.

All-ceramic Crowns

The groups I and II crowns were ready to be subjected to spectrophotometric analysis. They were placed on the tooth without the core build-up material on it and were placed on the modeling clay, to get the labial surface of the crown parallel to the beam of spectrophotometer. The middle third surface was evaluated and readings for each crown were recorded in the CIELAB system in the form of $L^*a^*b^*$ values.

Zirconia Crowns Over Three Core Materials

Each crown of group I were placed over the three core material and were positioned on the modeling clay and subjected to spectrophotometric analysis as stated earlier. L*a*b* values were obtained for each crown.

Alumina Crowns Over Three Core Materials

Each crown of group II were placed over the three core material and were positioned on the modeling clay and subjected to spectrophotometric analysis as stated earlier. L*a*b* values were obtained for each crown and dE* values for each combination were calculated.

RESULTS

The observations were statistically analyzed to comparatively evaluate the dE* values obtained. The one-way analysis of variance (ANOVA) was applied to the data to determine differences and decide whether the comparisons between the crowns for their shade reproducibility were statistically significant. The mean dE*

values for groups IA, IB and IC crowns was 0.62, 0.64 and 2.08 respectively. The mean dE* values for groups IIA, IIB and IIC crowns was 0.83, 0.86 and 2.44 respectively. There was a significant difference statistically in the shade reproducibility of groups I and II crowns when placed over the three core build-up materials and group I crowns being better. Among the core build-up materials used group A showed the least change in shade of the crowns (Graph 1, Tables 1 and 2).

DISCUSSION

The dental profession for ages has continually sought the 'perfect replica' of a natural tooth. The most commonly encountered conditions with anterior teeth are fracture and discoloration but it has been observed, that in clinical practice a single maxillary central incisor being in the esthetic zone poses the greatest restorative challenge.

Several decades of clinical experience has proved metal-ceramics to be the most extensively advocated restoration. But in this new millennium, television and media have promoted the importance of dental esthetics which has resulted in a heightened level of perception among the people while seeking esthetic treatment. The ceramometal restorations though stronger than the ceramic, did have the drawback of light transmission due to underlying metal coping. This lead to research in ceramic material science to emerge with the new generation of ceramic materials which would have the required esthetics and strength.

When there is excessive loss of tooth structure, retention for the artificial crown is required. This can be achieved by using post and core. But the type of the crown material affects the post selection. When all-ceramic crowns are used, tooth colored nonmetallic post and core material should be used.¹⁵

This study was planned to compare and evaluate the influence of three different core materials on the shade of two all ceramic system (Lava and Procera). In this study, the shade reproducibility was analyzed with help of a spectrophotometer (Datacolor 650) as it is capable of quantifying color values more precisely.¹⁶ Three extracted maxillary central incisors were chosen for the study. The three selected central incisor were sectioned with an air rotor 2 mm coronal to the CEJ, and a finish line of 1.5 mm deep chamfer was prepared. After preparation of the teeth they were divided into three groups. In group A, the core build-up was done with composite (Luxacore), in group B, the core build-up was done with all-ceramic zirconia core (Cercon) and in group C, the core build was done with metal (Wiron 99). After core build-up was completed, the all-ceramic crowns were fabricated. The all-ceramic crowns were divided into two groups according to the material used:

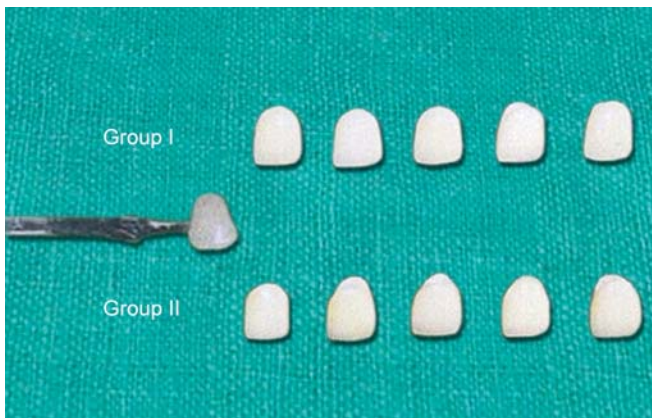


Fig. 10: Groups I and II crowns ready for spectrophotometric analysis

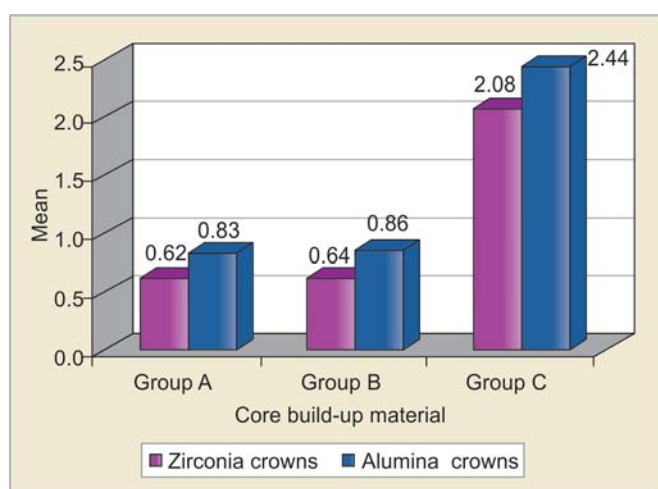


Fig. 11: Spectrophotometric analysis

Group I—Zirconia Crowns (Lava) and Group II—Alumina Crowns (Procera)

The manufacturers instructions were strictly followed while fabricating all the crowns. It was important to get even thickness of the ceramic over the ceramic copings so that the thickness of the crowns was maintained as 1.5 mm. The thickness of the copings for groups I and II was kept as 0.4 mm.

After the fabrication of the crowns was completed, they were subjected to spectrophotometric analysis where the $L^*a^*b^*$ and dE^* values of all the crowns in groups I and II were obtained. The dE^* values were indicative of the color change and showed the difference between the color values obtained for the B2 shade tab and color values obtained for the crowns after fabrication.



Graph 1: Mean dE^* between group IA, group IIA and group IB, group IIB, and group IC, group IIC

Table 1: Comparative evaluation of mean dE^* values between groups and within groups for group I, when placed over groups A, B and C

Source of variation	Sum of squares	Degrees of freedom	Mean square	F	p-value
Between groups	7.856	2	3.928	400.124	0.000
Within groups	0.118	12	0.010		

Table 2: Comparative evaluation of mean dE^* values between groups and within groups for group II, when placed over groups A, B and C

Source of variation	Sum of squares	Degrees of freedom	Mean square	F	p-value
Between groups	11.795	2	5.898	510.470	0.000
Within groups	0.139	12	0.012		

The crowns of groups I and II were placed over three core materials and were subjected to spectrophotometric analysis where the $L^*a^*b^*$ and dE^* values were obtained.

Various studies¹⁷ have concluded that when dE values <1 , the difference was not perceptible, when dE was between 1 and 2, it was considered as good color match and when dE values were between 2 and less than 3.3 to 3.7, it was considered clinically acceptable in oral environment. But when the dE values >3.7 it was considered a poor match.

From the results of the study, it was seen that when the crowns of group I (zirconia) and group II (alumina) were placed on core material of group A (composite), group B (all-ceramic zirconia) and group C (metal), shade changes were seen in the crowns. The results revealed that the shade of group II crowns was significantly influenced as compare to group I crowns. This finding may have been owing to the fact that group I crowns fabricated with zirconia substructure are more opaque when compared to group II crowns fabricated with alumina substructure, so group I crowns could mask the underlying core materials and showed better results. Though spectrophotometrically there was significant difference in the shade values of the two groups of crowns fabricated in zirconia and alumina but the dE^* values were below the specific threshold meaning that the color difference between the groups were not visually perceivable.

LIMITATION OF THE STUDY

This study was limited by the fact that the luting agent was not considered for cementation of crowns which could bring about a change in the shade of all-ceramic restorations and may even mask the underlying core material.

CONCLUSION

The study conducted evaluated the shade of two different all-ceramic materials over three core build-up materials. Within the limitation of the *in vitro* study, the following conclusions were drawn:

1. Zirconia and alumina crowns when placed over the composite core build-up material showed the least change in the shade.
2. Zirconia and alumina crowns when placed over the all-ceramic zirconia core material showed less change as compared to metal core but more than the composite core build-up material.
3. Zirconia and alumina crowns when placed over the metal core material showed the highest shade change as compared to the composite and all-ceramic zirconia core materials.
4. Zirconia crowns when compared to the alumina crowns showed the least shade change when placed on the three core materials.

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