Evaluation of compressive strength, microleakage and amount of primary tooth reduction required for posterior zirconia and stainless steel crowns-an invitro study

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Abstract
Aim: The aim of this analysis is to compare and contrast the compressive power, microleakage, and amount of primary tooth reduction needed for posterior zirconia crowns versus stainless steel crowns.
Design of Study: Sixty removed primary molar teeth with developmental defects and no reconstruction is collected and reconstructed with stainless steel crowns (30) and zirconia crowns (30). Micro leakage, compressive power, and the amount of tooth reduction needed for crowns were all measured on 15 teeth with crowns in each category. The data was tallied and analyzed. Mann-Whitney U test and t-test are two statistical tests.
Results: Stainless steel crowns had a slightly higher compressive strength (783.94 + 24.16 N) than zirconia crowns (545.68 + 27.42 N) (p= 0.001). In both classes, minimal microleakage values were observed. Zirconia crowns allowed more tooth reduction (0.260 + 0.055 gms) than stainless steel crowns (0.136 + 0.050 gms), which was statistically important (p= 0.050).
Conclusion: Both zirconia and stainless steel crowns were good options for full coronal restorations.

Index Terms- Extracted pimary teeth - zirconia crowns - stainless steel crowns.

I. Introduction

Dental decay particularly early childhood caries and severe-early childhood caries are the most common cause for partial or complete loss of coronal tooth structure in primary teeth.[1] Rehabilitation and restoration of the primary teeth damaged due to decay or trauma is a challenging task to the pedodontist to meet the clinical parameters and parental demands.

Commonly used full coverage restoration for the primary dentition include composites, stainless steel crowns and its modifications polycarbonate crowns and strip crowns,[2&3]PedoJacket crowns[4] and New Millennium crowns. The PedoJacket are similar to celluloid crowns with only the "jacket" made of tooth colored copolyster material which is filled with resin material and left on the tooth after polymerisation instead of being removed as the celluloid crown form. These crowns are available as single shade which makes it difficult to match with adjacent natural teeth. The Millennium crowns [5] are similar in form to the PedoJacket and strip crowns except that it is made of laboratory-enhanced composite resin material. These crown forms are very brittle, however can crack or fracture if forced down onto a preparation that has not been adequately reduced. With objections to its color and material loss at the interface in the case of veneered stainless steel crowns, stainless steel crowns were used as effective complete coronal restorations on both anterior and posterior primary teeth..

The search for alternate crown options in which durability, ease of placement and esthetics resulted in the development of "ZIRCONIA CROWNS"[1]. They are esthetic with better strength but require massive tooth preparation.

The materials and technical variations in each crown systems can result in difference in the strength and marginal fit which ultimately influences the outcome of the final restorations. Increase in marginal gap results in an increase in cement dissolution, thus growing the risk of micro-leakage which ultimately leads to secondary caries and also have impact on gingival health and crown retention. Keeping the above facts in mind, the present in vitro study was done to evaluate the compressive strength, microleakage, amount of tooth reduction using zirconia crowns and compare it with that of stainless steel crowns.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

Materials:

- Extracted primary maxillay & mandibular first & second molars.
- Digital weighing machine.
- High speed airotor handpiece with water coolant
- Crown cutting burs
- Zirconia crowns- Kinder Krowns
- Stainless steel crowns- 3M company
- Luting cement- Rely X cement
- Instron universal testing machine (3382).
- 2% basic fuschin dye solution
- Diamond disc with the thickness of 0.01mm.
- Stereomicroscope (50X microscope)

Methods:

The study design was approved by the Institutional Review Board of Ragas Dental College and Hospital, Chennai, India.

Sixty freshly extracted human primary first and second molars- without restoration and developmental defects and cracks and with root structure more than 1/3rd – were selected after examining under transillumination and teeth were washed and stored in saline water.

Prior to tooth preparation, each tooth was pre weighed three consecutive times to the ten thousandths of a gram using digital weighing machine and the measured weights were recorded. Tooth preparations were performed separately for both the stainless steel (n=30) and zirconia crowns by (n=30) following the manufacturer's guidelines and the weights of the prepared teeth were done following the same procedure.

Using a robotic measuring unit, the volume of tooth reduction was determined by subtracting the post-weigh from the pre-weigh [6].

The prepared teeth's compressive strength was measured by inserting each tooth-crown into a custom-made holder on the Instron Testing Machine (3382) and increasing the loading until the crown fractured. (Fig.1 & 2). The force was delivered through a stainless steel ball fixature, set in a uniaxial lever intended to replicate a cusp contact. Testing was performed in a single cycle, with the speed of the crosshead maintained at 1mm/ min; until fractured. The maximum force to produce fracture was recorded in Newtons (N), which was calculated by the formula load/ area [7].

Microleakage was assessed for 15 each of the experimental samples which were stored in distilled water at 37°C for 24 hrs and were subjected to500 thermal cycles between 5° and 55°C using dwell time of 30 seconds. The samples were painted with nail varnish to 1mm below the finish line to avoid dye penetration from the root surface. The samples were immersed for 24 hrs in 2% basic fuchsin dye solution and kept in the incubator at 37°C temperature. Subsequently, the samples were washed, dried and teeth were embedded in a slow-setting clear epoxy resin to prepare resin block of 1x1x1.5cm. Each tooth-crown unit was longitudinally cut into four pieces using microtome (MT-4 Diamond cut-off saw) with a disc thickness of 0.01mm cutting at high speed with water coolant in mesiodistal and buccolingual directions. Under a Stereomicroscope 50X magnification, each surface was examined for dye penetration at the margins along the tooth-cement interface. [8]

The degree of dye penetration inside each surface of the sections was scored (0 = No leakage, 1 = Leakage up to one-third of the axial wall, 2 = Leakage up to two-thirds of the axial wall, 3 = Leakage along the full length of the axial wall, 4 = Leakage extending into the occlusal aspect) (Fig. 3 & 4).

The results of compressive strength, microleakage and tooth reduction were recorded, tabulated and statistically analysed by't' test and Mann Whitney 'U' test using IBM SPSS statistics 24 version software.

III. WRITE DOWN YOUR STUDIES AND FINDINGS

Compressive strength

The mean compressive strength of stainless steel crown was 783.94 + 24.16 and for Zirconia crowns 545.68 + 27.42 which was highly significant (p= 0.001) (Table 1).

Microleakage

Minimal microleakage was observed with both zirconia and stainless steel crowns using Mann Whitney "U" test which shows 0.1667 + 0.379.

There was no significant difference in the microleakage between the Zirconia crowns and stainless steel crowns (p= 0.130) (Table 2).

Table 1 Mean + S.D of compressive strength of zirconia and stainless steel crowns

Crowns	Number	Mean + s.d
Zirconia	15	545.68 + 27.42
Stainless steel	15	783.94 +24.16
p value		0.001*

*Highly significant (P ≤0.05)

Table 2 Mean+ S.D of microleakage of zirconia and stainless steel crowns

Descriptive statistics

Groups	Number	Mean + S.D
1	15	0.1667 +0.379
2	15	0.1667 + 0.379

Table 3 Mean+ S.D of tooth reduction of zirconia and stainless steel crowns

Crowns	Number	Mean + s.d
Zirconia	15	0.260+0.055
Stainless steel	15	0.136 +0.050
P value		0.001*

*Highly significant (P <0.05)

Tooth reduction

For stainless steel crowns, the amount of reduction needed was (0.136 + 0.050) and for Zirconia crowns, it was (0.260+ 0.055), which is extremely important (p= 0.001). (Table 3).

The results showed that Stainless steel crowns exhibited better compressive strength and lesser amount of tooth reduction required compared to Zirconia crowns. There was no difference in microleakage score of both the crowns. Even though Zirconia crowns have lesser compressive strength (583.4N), it is found to be five times greater to the normal biting force exhibited by the children (106N)[9]

Figure 1: Zirconia Tooth Specimen Under Compressive Load

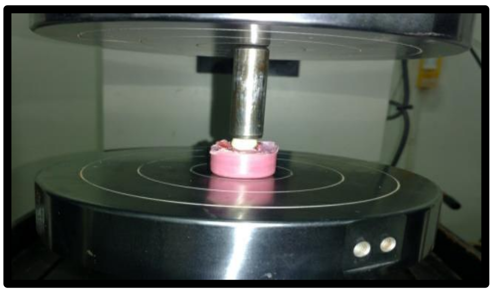

Figure 2: Stainless Steel Crown Tooth Specimen Under

Compressive Load

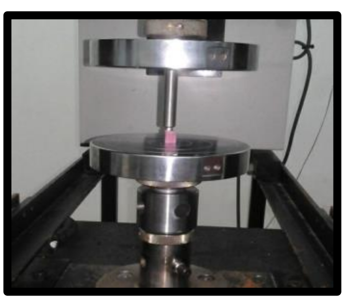

Figure 3: Microleakage Score 0 – Zirconia Crowns

Figure 4: Microleakage Score 1 – Zirconia Crowns.

Discussion:

Increasing parental desire for esthetic restoration for their children and search for metal-free, tooth- colored restorations lead to the development of Zirconia crowns which are available as prefabricated crowns for primary molars. The performance of these crowns depends on its chemical and mechanical properties.

Keeping the above facts in mind, the present in vitro study was done to evaluate the compressive strength, microleakage, amount of primary tooth reduction required for posterior zirconia crowns and compare it with that of stainless steel crowns.

Zirconia crown (Kinder Krowns) system used in the present study has internal retention system to lock the restoration after cementation and also they have retention bands to provide additional surface for bonding. Fine feathered margin of these crowns makes the emergence profile for the crown as natural as possible. (Tote et al 20151).

The present study results showed that the compressive strength of stainless steel crown (783.94 + 24.16),the values were lower than the preveneered stainless steel crowns (1826+339N)(Beattie et al ,2011[9])

The compressive strength of the zirconia crowns (545.68 + 27.42) was in similar to the findings of study done by Townsend et al 2014[10] (576 +132.3).

Results showed that the compressive strength of stainless steel crown (783.94 + 24.16) was higher than the zirconia crowns (545.68 + 27.42) which was found to be similar with findings of (Townsend et al 2014[10]) (576 +132.3) who concluded that the fracture resistance of zirconia crowns was lower than the fracture resistance of preveneered stainless steel crowns(1937N). But EZ Pedo crowns showed higher strength (1091N) than other systems. Even though, zirconia crowns showed lower fracture resistance compared to that of stainless steel crowns but it was (545N) higher than the biting forces exhibited by children.(Braun et al, 1996, Gaviaoet al 2007[9,11])

The present study observed microleakage in one sample (6.66%) each in both the groups. It shows good adaptability (93.3%) of the crowns to the prepared tooth and the sealing ability of the luting cement. This was in accordance with other studies done by MahtabMemarpour, MahkamehMirkarimi[12, 13].

IV. CONCLUSION

Based on the results of the present study, it can be conclude that both the zirconia and stainless steel crowns were good options for full coronal restorations. Stainless steel crowns are better option in terms of compressive strength, when the esthetics is of prime concern, zirconia crowns are good alternative.

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