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Evaluation of Wear Resistance Of Commercially Available Stainless Steel Pedodontics Crown And Nano Zirconia Coated Stainless Steel Pedodontics Crown- In-Vitro Study

Research Article

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Abstract

Introduction: The treatment of carious primary molars has always been a problem for dentists. SSCs are exposed to the oral environment for many years and are influenced by physical and chemical factors such as saliva secretion, chewing, brushing, acidic drinks, abrasion, and biofilm composition. To counteract the effects of SSCs, they are coated with nano zirconia particles.
Materials and Methods: This in vitro study was carried out at the saveetha institute of medical and technical science, and the zirconia coating was performed at University of Madras, Chennai. Total of 20 preformed stainless-steel crowns of the second primary mandibular molar from 3M (3M India Ltd) were evaluated in this study. One group had SSC (N=10) and the other group had of SCC were coated with nano-zirconia (N=10) and these crowns were evaluated for wear resistance
Results: The microhardnesstest (VHN) assessed showed a higher range of indentation in nano zirconia coated SSCs than the preformed SSCs. In the wear test, the wear was more in nano zirconia coated SSCs than the preformed SSCs.
Conclusion: To conclude, based on the present study, Nano zirconia coated on SSCs technique has high wear resistance and lower microhardness compared to SSCs. But the zirconia coated crowns are more esthetic when compared to SSCs.

Keywords: Pediatric Stainless-Steel Crowns; Wear Resistance; Nano Zirconia Coating; Pre-Formed SSCs.

Introduction

The treatment of carious primary molars has always been a problem for dentists [1]. Several materials have been used to rebuild such teeth over the years, with varying degrees of success. Rocky Mountain Company introduced stainless steel crowns (SSCs) into dentistry in 1947 [2], and they were first identified by Engel and popularized by Humphrey in 1950. SSCs have been used to recover carious teeth in patients with high caries risk after pulpal therapy [3], teeth with developmental defects, and brittle teeth that are vulnerable to fracture over the past 70 years in dental practice. In terms of toughness and longevity, SSCs have recently outperformed other materials such as amalgam and composite [4]. Where interim full-coronal coverage is needed, no restorative material has previously provided the benefits of low cost, longevity, and reliability. Despite these advantages, the SSC has a conspicuous flaw: its metallic appearance, which has been met with disapproval by patients, parents, and even practitioners. Prevented SSC was introduced in response to the growing demand for aesthetics among parents [5]. These crowns have a resin or ceramic facing that has been bonded to the SSCs' metal surface. Though the aesthetics were acceptable to parents, these crowns had some

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disadvantages, such as being heavy, poor gingival health, and the possibility of veneer fracturing, all of which made them unattractive. As a result, dentists found a crown that would combine the SSC's resilience and endurance while still being aesthetically appealing.

Because of its aesthetics, biocompatibility, and excellent mechanical properties, zirconia crowns have been used in permanent dentition for over two decades with high acceptability [6]. The first commercially available pediatric zirconia crown was launched by EZ Pedo (formerly EZ Pedo, now EZ crown by Sprig) in 2008. Then, as a new full-coverage restoration, zirconia crowns were launched by different companies as a new full-coverage restoration that blends aesthetics with excellent and superior mechanical properties. Despite rising parental expectations, a recent review found that no studies on parental satisfaction with zirconia crowns in primary molars have been conducted. Hardness refers to the resistance to penetration or permanent indentation of the surface; it affects the ease of finishing, cutting, and polishing of materials, as well as scratch resistance. When two surfaces are rubbed together, wear is characterized as the process of removing material from the surface. The occlusal surface of the SSCs shows a lot of wear and can even be pierced due to excessive chewing forces in children with bruxism. The most common cause of occlusal surface perforation and SSC failure is occlusal wear [7]. Fatigue in metals occurs when the metal is subjected to repetitive or swinging stress, causing SSCs to crack or deform. The compressive strength of a metal is the maximum pressure it can withstand before deforming [8]. According to some reports, children aged 5 to 10 have a chewing force of 375 N. SSCs are very durable restorative materials for children's deciduous teeth, but they can be weakened or deformed over time if they are subjected to forces greater than the normal chewing force. A galvanic bond is formed by two separate metals in the electrolyte solution. Ion migration is aided by the electrolyte solution, and corrosion occurs almost instantly. In this form of corrosion, the metals' contact surface is critical. In this step, the weaker metal (anode) corrodes [9].

SSCs are exposed to the oral environment for many years and are influenced by physical and chemical factors such as saliva secretion, chewing, brushing, acidic drinks, abrasion, and biofilm composition [10, 11]. To counteract the effects of SSCs, they are coated with nano zirconia particles. The null hypothesis of study is that there is significance difference in the wear resistance between pre-formed SSCs and Nano zirconia coated SSCs and hence the aim of this study was to compare the wear resistance of commercially available stainless steel pedodontics crowns to those coated with nano zirconia.

Materials And Methodology

Study design: In-vitro study

Study setting: Saveetha institute of medical and technical science (SIMATS), Chennai.

This in vitro study was carried out at the saveetha institute of medical and technical science, and the zirconia coating was performed at University of Madras, Chennai. Total of 20 preformed stainless-steel crowns of the second primary mandibular molar from 3M (3M India Ltd) were evaluated in this study. One group had SSC (N=10) and the other group had of SCC were coated with nano-zirconia (N=10) and these crowns were evaluated for wear resistance. Ethical approval for the study was provided by the Institutional Review Board, Saveetha University.

Deposition of zirconia nanoparticles

ZrO2 films were deposited using an electron beam evaporator (M/S PLASSYS (MEB 600)) method. ZrO2 powder (Itasco, 99.8%) was pelletized and sintered for 5 hours at 1400 °C before deposition. 316L SS substrates and ZrO2 pellets were placed into a substrate holder and a tungsten carbide crucible, respectively, after sintering. The chamber was then evacuated to give 2 10-6 m base and working pressures.

Assessment of Microhardness

Stainless steel crowns and nano zirconia coated SSC were tested for 15 seconds on a Vickers microhardness tester with a load of 200 g. The crowns were mounted horizontally to give the indenter the best possible smooth level. The effect of the indenter on the specimen was calculated after it was placed under the microscope. The produced impact was calculated with a magnification of 20 after the force was applied. The machine determined the specimen's hardness number based on the diameter and depth of the effect. The hardness of each specimen was measured three times at the mesial area and the average was published. (Table 1)

Wear assessment

An abrasive machine was used to inspect 10 stainless steel crowns and 10 nano zirconia coated SSCs of 3M brand. The specimens were measured on an electronic scale before being abraded at 5000, 10000, 20000, 40000, 80000, and 120000 under a load of 20 N, respectively, on the abrasion unit. The specimens were carefully evacuated from water at the end of each abrading cycle, and the wear rate at the mesial surface of the crowns was examined. Finally, the specimens were weighed again, and the weight difference between them was determined. (Table 2)

Statistical analysis

For statistical analysis, first the data is transferred to excel sheet and SPSS software version 23 (IBM). To compare differences between SSC and nano zirconia coated SSC Mann Whitney U test is performed where p value is <0.001 was considered as significant with 95% confidence interval.

Results

The mean microhardness values among both the groups measured using Vickersmicrohardness test is presented in table 1. The microhardnesstest (VHN) assessed showed a higher range of indentation in nano zirconia coated SSCs than the preformed SSCs. The Mean ± SD of 3M pre-formed SSC was 284.48 ± 26.22 and Mean ± SD of Nano zirconia coated SSC was 321.34 ± 36.52. There was a significant difference in the mean microhardness value between both the crown group tested in our study (P<0.05). The results for wear resistance of SSCs and nano zirconia coated SSCs are mentioned in table 2. In the wear test, the wear was more in nano zirconia coated SSCs than the preformed SSCs. The

Table 1. Vickers Microhardness test for SSCs and nano zirconia coated SSCs.

Microhardness test	316L SSC (Mean ± SD)	Nano zirconia coated 316 SSC (Mean ± SD)	P value
VHN	284.48 ± 26.22	321.34 ± 36.52	<0.001

(VHN- Vickers hardness number, SD- Standard Deviation)

Table 2. Wear assessment of SSCs and nano zirconia coated SSCs.

Wear cycle	316L SSC (Mean ± SD)	Nano zirconia coated 316 SSC (Mean ± SD)	P value
5000	0.00035 ± 0.00032	0.00195 ± 0.00052	< 0.001
10000	0.00018 ± 0.00006	0.00171 ± 0.00065	< 0.001
20000	0.00031 ± 0.00043	0.00097 ± 0.00066	< 0.001
40000	0.0004 ± 0.00067	0.00057 ± 0.00031	< 0.001
80000	0.00018 ± 0.00012	0.0005 ± 0.00033	< 0.001
120000	0.00015 ± 0.00011	0.0007 ± 0.00032	< 0.001

(SD- Standard Deviation)

Mean ± SD of 3M pre-formed SSC was at 5000 for 316L pre-formed SSCs (0.00035 ± 0.00032) and for nano zirconia coated SSCs (0.00195 ± 0.00052), at 10000 for 316L pre-formed SSCs (0.00018 ± 0.00006) and for nano zirconia coated SSCs (0.00171 ± 0.00065), at 20000 for 316L pre-formed SSCs (0.00031 ± 0.00043) and for nano zirconia coated SSCs (0.00097 ± 0.00066), at 40000 for 316L pre-formed SSCs (0.0004 ± 0.00067) and for nano zirconia coated SSCs (0.00057 ± 0.00031), at 80000 for 316L pre-formed SSCs (0.00018 ± 0.00012) and for nano zirconia coated SSCs (0.0005 ± 0.00033), at 120000 for 316L pre-formed SSCs (0.00015 ± 0.00011) and for nano zirconia coated SSCs (0.0007 ± 0.00032). There was a significant difference in the mean wear value between both the crown group tested in our study (P<0.05).

Discussion

The results of the present study showed that the SSCs are stronger and are more resistant to wear. The microhardness test on a Vickersmicrohardness tester with a load of 200 g, the highest microhardness seen in nano zirconia coated SSCs (321.34 ± 36.52) compared to SSCs (284.48 ± 26.22) with statistical significance p<0.001. The wear resistance was assessed by abrading machine in the form of Mean ± SD (Table 2) with significant p value where, p<0.001.

Currently, the success and reliability of SSCs is known. Even if SCCs are recommended in the treatment of serious tooth decay in infants, few dental practitioners adopt their use in clinical practice; one of the reasons for this is their poor aesthetic appearance. ZCs are an enticing alternative to SSCs. If the evidence shows that their success rate is comparable to that of SCCs, they will be more generally accepted by clinicians and policymakers [12]. Just a few credible studies testing ZCs' efficacy and reliability back them up. Just a few case studies focusing on PM restoration with ZCs have been published to date; these find that they function well. The establishment of a sufficiently powered clinical trial comparing SSCs and ZCs is needed, as is an assessment of ZCs' long-term performance compared to SCCs [13]. This trial, which includes nine centers across the country and the potential recruitment of a large sample of 101 patients, may be able to help solve this problem. Furthermore, the inclusion criteria are large, resulting in variation in the patients included, particularly in terms of individual caries risk. As a consequence, the data's external validity should be enhanced. Gallagher et al., found that the placement of an SSC disrupted maximum intercuspation role in seven of twenty cases examined, with most cases returning to preoperative status within four weeks of crown placement [14]. The technique for preparing the buccal surface for both open windows and buccal grooves is similar to Yilmaz and Kocogullari's method [15], but with the following changes: First, in this research, the window was prepared in the second visit, while in Yilmaz and Kocogullari's technique, the window preparation was done in the first visit and then covered with a temporary restorative material. Second, in our research, buccal grooves and veneering were done intraorally on the cemented SSC in the second visit, as opposed to Yilmaz and Kocogullari'sextraoral preparation of the buccal surface of the SSC [16]. Furthermore, instead of using a diamond round bur no. 12, the present study used tapering fissure diamond bur ISO 160/012 and diamond straight fissure diamond bur ISO 111/012, respectively, to prepare the window and buccal grooves. Buccal grooves, on the other hand, should be properly prepared with a bur to avoid crown perforation. Another in vitro research conducted by Khatri et al., [17] for the evaluation of bonded conventional and nanocomposite resin on sandblasted anterior SSCs using the bonding Prime and Bond NT revealed that the fracture site distribution observed in the conventional composite community was adhesive failure 6 (40%), cohesive failure 6 (40%), and combined failure 3 (20%), and I (33.34 percent). In an in vitro analysis, Salama and elMallakh discovered that sandblasted SSC bonded to Dyract (a compomer resin material) had a mean shear bond strength of 9.518 MPa when compared to compomer bonded directly to the metal surface (shear bond strength of 2.998 MPa) [18]. Yew et al., who tested the color stability of a resin composite after exposure to three spices: turmeric, paprika,

and tamarind, discovered that the turmeric category had the largest color variance. Another cause for the visible yellow staining is poor oral hygiene, which leads to plaque accumulation.

The limitations of the current in vitro study are questionable relevance to final in-vivo use of the material, lack of inflammatory and other tissue protective mechanisms in the *in vivo* environment. Further studies have to be carried out to evaluate the zirconia coated in different methods of coating zirconia to increase its strength and wear resistance.

Conclusion

To conclude, based on the present study, the null hypothesis was proved where the Nano zirconia coated on SSCs technique has high wear resistance and lower microhardness compared to SSCs. But the zirconia coated crowns are more esthetic when compared to SSCs where esthetic is of concern in the future.

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