ORIGINAL RESEARCH

Comparative Evaluation on the Wear of Opposing Primary Teeth against Commonly Preferred Crown Materials: An *In Vitro* Study

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Abstract

Aim: This investigation aims to compare and evaluate the effect of stainless steel, zirconia, and acrylic materials on antagonistic primary teeth.

Materials and methods: Fifteen primary canine teeth that were naturally lost during the transition to permanent dentition and had no cusp wear were gathered and stored in saline. They were split up into three groups of five at random. After the collected teeth were set in acrylic resin, around 5 mm of the teeth's cusp was visible. For the wear test, group I—stainless steel, group II—zirconia, and group III—acrylic disks were utilized. In two body wear tester machines, tooth samples and a disk were positioned on the top and lower members, respectively. For every sample, pin-on-disk test was performed with a steady load. The Design Web Format (DWF) file format was used to record the readings. The highest readings were taken into consideration. Statistical analysis was done using one-way analysis of variance (ANOVA) and *post hoc* test with p-value < 0.001.

Results: Zirconia shows higher amounts of primary teeth wear with the mean of 448.40 ± 60.88. The following is a descending sequence of opposing tooth wear: zirconia, acrylic, and stainless steel, showing statistically significant differences with the p-value of 0.000.

Conclusion: Zirconia disks cause considerable tooth wear compared to the acrylic and stainless steel disks.

Clinical significance: We can optimize the advantages of zirconia crowns in pediatric patients while reducing any potential drawbacks against the opposing natural dentition by progressively integrating safe restorative approaches. Zirconia is often preferred for its strength and esthetics, but its potential for increased tooth wear should be weighed against the benefits of using alternative materials such as stainless steel or acrylic.

Keywords: Crown, Opposing tooth, Wear, Zirconia.

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Introduction

Early childhood caries in its nature is severe, widespread, and progressive. Serious local, systemic, esthetic, psychological, and social issues are possible if the caries condition's advancement is not halted.[1] The American Academy of Pediatric Dentistry recommends that we restore teeth with excessive tissue loss, developmental defects, pulpotomy, or pulpectomy with crowns for restoration of better masticatory function.[2]

Since Humphrey first implemented stainless steel crowns (SSCs) on pediatric patients in 1950, they have been one of the most effective and economical ways to restore teeth in pediatric dentistry. SSCs are frequently the first option for treating caries-related defects in primary dentition.[3] SSCs fail to fulfill the esthetic needs of parents, patients, and pediatric dentists, despite high qualities such as longevity, durability, and a low incidence of recurrent caries.[4]

Since the past decade, zirconia crowns—also described as "ceramic steel"—have promised satisfactory results for the repair of primary and permanent teeth. They have exceptional esthetic results, high flexural strength, biocompatibility, smooth and glossy surface, superior corrosion resistance, unique ability to resist crack propagation, good mechanical qualities, and satisfaction among patients, parents, and the dental fraternity. However, they hold certain disadvantages that include subgingival preparation, brittleness, and greater tooth reduction; unlike SSCs, they cannot be crimped or contoured, and they have limited shade options.[5,6]

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Acrylic crowns are regarded as a great way to restore a child's smile and self-esteem when used as a treatment modality for cosmetic management in permanent teeth for pediatric patients. Permanent teeth that have undergone endodontic treatment can be restored with

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acrylic crowns. They are composed of polycarbonate resin shells with microglass fibers, which have the advantages of being tooth-colored, somewhat translucent, and easily manipulable. In situations such as bruxism, deep bite, and significant abrasion, they are contraindicated.[7,8]

Tooth wear is a complex clinical phenomenon and is multifaceted in occurrence, inclusive of biological, mechanical, and chemical element interactions within the oral environment. When antagonistic natural teeth and/or restorations slip over one another, tooth wear is an unavoidable process. The restoration materials' resistance to wear should ideally be closer to that of enamel. The wear characteristics of the prosthetic materials and the natural tooth appear to differ. The quantity of tooth wear is influenced by the type of dental restorative material, chewing force, and eating habits.[9,10]

There are only a small number of studies assessing the characteristics of various restorative crown materials against natural teeth wear, and hence this *in vitro* study aims to evaluate and compare the effects of stainless steel, zirconia, and acrylic materials on antagonistic primary teeth.

Materials and Methods

This is an *in vitro* study conducted in the Department of Pedodontics at Vivekanandha Dental College for Women, Tiruchengode, Tamil Nadu from October 2022 to November 2022. Fifteen primary canines that were obtained due to natural transition from primary to permanent dentition were included in the study. Teeth with attrition, caries, fracture, and developmental anomalies of any concern were excluded from the study.

A sample size of 15 was determined, whereas experimental disk groups consisted of a sample size of 5 in each group: group I—stainless steel, group II—zirconia, group III—acrylic disks. All the disks were made with 5 mm in height and 5 mm in diameter.

After teeth collection, they were stored in saline until experimentation and were mounted on an acrylic resin mold measuring about 2 cm in diameter and 1 cm in height, with approximately 5 mm of cusp exposed. Tooth samples and disks were placed on the upper and lower members, respectively, in a pin-on-disk (two-body wear) tester machine (DUCOM, USA, Model: TR 20 LE). Testing was carried out under a constant load of 50 N and 1,00,000 cycles for each sample. Readings were recorded in DWF file format. The highest value was taken into consideration. The wear of primary canines was obtained against the study groups in micrometers.

Descriptive statistics were calculated using the Statistical Package for the Social Sciences (SPSS) version 22.0 (SPSS Inc., IBM Co., Somers, NY, USA). After the positive evidence of normality assessment, one-way analysis of variance (ANOVA) was performed for comparison of three groups followed by *post hoc* Bonferroni test for pairwise comparison among the three groups. The statistical significance of the mean difference in each parameter was tested at the level of $p < 0.001$.

Results

Table 1 depicts a summary of mean and standard deviation of wear values of primary canines antagonized against stainless steel as 97.6 ± 11.10, zirconia as 448.40 ± 60.88, and acrylic as 250.8 ± 44.61. One-way ANOVA was performed after establishment of normality, and *p*-values were found to be statistically significant for three groups (Fig. 1).

A subsequent *post hoc* Bonferroni test was employed for the intergroup comparison. Table 2 shows that the highest mean difference (–350.80) was seen between the stainless steel and zirconia with a *p*-value of 0.000.

Figure 2 picturizes the percentage of wear exhibited by the three groups against primary canines as zirconia (56%), followed by acrylic (32%) and stainless steel (12%).

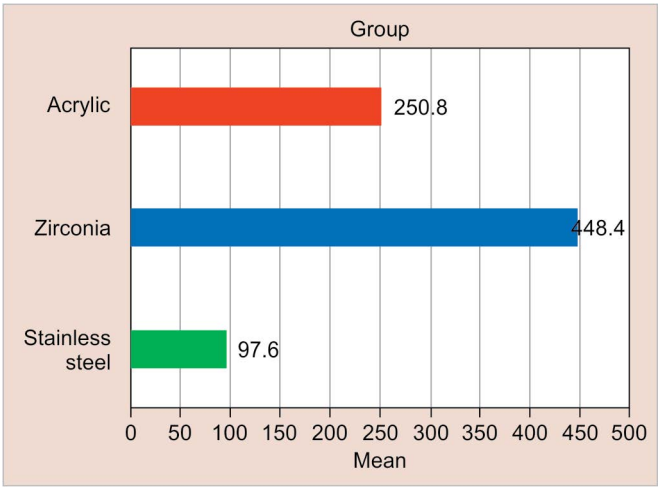


Fig. 1: Bar graph showing comparison of wear values of primary canines against each study groups

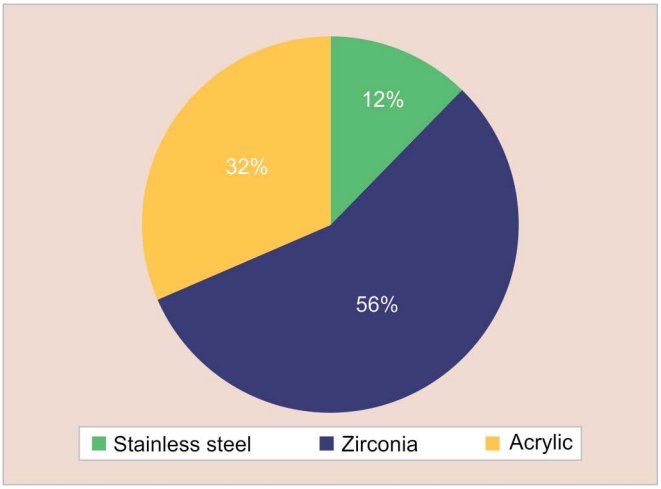


Fig. 2: Percentage of wear experienced by primary canines opposed by three experimental groups

Table 1: Comparison of wear values of primary canines against each study group exhibiting statistical significance

Group	*N*	*Mean ± SD*	*p-value*
Stainless steel	5	97.6 ± 11.10	0.000*
Zirconia	5	448.40 ± 60.88	
Acrylic	5	250.8 ± 44.61	

* Highly statistically significant

Table 2: Pairwise comparison by *post hoc* Bonferroni test indicates higher amount of tooth wear in group II

(I) Group	*(J) Group*	*Mean difference (I – J)*	*p-value*
Stainless steel	*Zirconia*	–350.80	0.000*
Stainless steel	*Acrylic*	–153.20	0.000*
Zirconia	*Acrylic*	197.600	0.000*

* Highly statistically significant

The results of the current study abridge that group II—zirconia exhibited higher amounts of natural tooth wear among all the other experimental groups.

Discussion

The phenomenon of progressive loss of surface material from a specimen as a result of mechanical activity is known as occlusal wear.[11] Although severe wear can result in clinical problems such as dentin hypersensitivity, loss of vertical dimension, poor masticatory performance, and esthetic difficulties that affect overall dental health and function, it is imperative to check the wear on teeth that oppose crowns.

Among various factors ensuring the longevity of restorative choices, the importance of studying antagonistic tooth wear was stated in a systematic review as dental restoration materials' wearing capability differs from those of natural teeth and can quickly affect the opposing tooth, thus demanding to take into account the enamel wear brought on by restorations.[12]

The assessment of tooth wear studies is mostly limited to primary teeth. Clinical tooth wear investigation is expensive and time-consuming. Furthermore, because elements such as chewing forces and environmental influences are difficult to fully control, precise measurements are difficult.[13] Thus, an *in vitro* study was followed to assess the antagonistic teeth wear.

Preclinical testing can assess the antiwear processes of different restoration materials, and simple movements such as tooth grinding and clenching can be replicated, despite the limitations of *in vitro* studies in accurately simulating mastication in the oral cavity.[14]

It is debatable whether or not the enamel surface of natural teeth should be standardized for the wear test.[15] The most suitable opponent, according to Krejci et al.[16] is the nonstandardized enamel cusp of genuine teeth. According to Kunzelmann et al.,[17] polished enamel may exhibit variations in its wear characteristics in contrast to untreated enamel. Therefore, the primary canine teeth's enamel surfaces that were spontaneously lost during the transition to permanent dentition were used as antagonist teeth in this investigation.

Magne et al.[18] proposed that, since height loss measurements are easily calculated and linked to clinical vertical assessments of occlusion, they offer a practical way to measure wear. However, because values vary linearly over time, volumetric loss offers a more sensitive mean than weight loss.[19]

Numerous mastication simulators that replicate the wear process in the oral environment have been created as a result of the benefits of *in vitro* research.[20,21] The wear performance of dental materials may be examined using a variety of tests (such as pin-on-block, pin-on-disk, three-body wear, and toothbrush simulation), and antagonist wear has been shown to be directly related to the types of ceramic materials and testing parameters. The pin-on-disk test device employed in this study has been widely utilized since it is useful, long-lasting, and reasonably priced.[22]

The masticatory force in this study was 50 N, which was the median value between the lowest and highest masticatory forces employed in earlier research. Each chamber was loaded with 5 kg in order to meet the 50 N condition.[23]

In the present study, the antagonistic teeth wear was investigated against stainless steel, zirconia, and acrylic disks and was found that zirconia shows higher amounts of primary teeth wear. This is in accordance with a study conducted by Tang et al. that concludes that monolithic zirconia crowns cause wear on antagonistic teeth and adds that it undergoes abrasive and fatigue types of wear.[24] According to Solá-Ruíz et al., monolithic zirconia crowns' opposing tooth gradually experiences maximum wear that surpasses the maximum wear experienced by the crown. An objective and quantitative objection to metal-ceramic crowns or natural enamel wear cannot be established.[25]

Choi et al. proposed that leucite glass-ceramic and lithium disilicate glass-ceramic cause more primary tooth wear than stainless steel or zirconia, which is in contrast to the current findings.[22] Results of the *in vitro* investigation by Bolaca et al. concluded that zirconia caused less wear on primary tooth enamel than lithium disilicate, resin nanoceramic, and nanohybrid composite resin.[25]

Our results showed an upward trend toward a positive relationship between the quantities of wear on opposed primary teeth and restoration materials. This study's occlusal force, masticatory motion, and instances are different from those found in the oral environment. Moreover, this study assessed two-body wear results from three-body wear testing may differ. An *in vitro* test methodology that can accurately predict clinical wear in primary teeth and its association with 1- or 4-year clinical studies must be developed since *in vitro* studies provide faster results and are less expensive than clinical trials.

Therefore, in order to examine the clinical consequences of different ceramic materials in primary teeth, we suggest undertaking more long-term studies that mimic the oral environment.

Conclusion

Within the limitations of this *in vitro* study, the current study concludes that zirconia blocks exhibited an increased amount of antagonist tooth wear among the acrylic and stainless-steel groups. In conclusion, while the benefits of esthetics are essential in the current era of recuperation, it is crucial to address the potential concerns to the existing oral environment.

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