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EVALUATION OF CRAZING CAUSED BY REPEATED STERILIZATION CYCLES ON STAINLESS STEEL, ZIRCONIA, BIOFLX CROWNS

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ABSTRACT

Background: Preformed crowns are widely used in pediatric dentistry for restoring primary teeth with extensive caries or after pulp therapy. During crown selection, multiple crowns may need to be tried-in, potentially leading to microbial contamination. Therefore, sterilization before reuse is essential; however, repeated autoclave cycles may alter the crown surface, causing crazing or micro-structural changes. With increasing clinical preference for esthetic crowns such as Zirconia and BioFlx, it is necessary to evaluate their sterilization tolerance.

Aim: To evaluate the effect of repeated steam sterilization cycles on surface crazing of Stainless steel, Zirconia, and BioFlx crowns under stereomicroscopy.

Materials and Methods: An in-vitro study was conducted using fifteen preformed pediatric crowns, divided into three groups (n=5): stainless steel (Shin-Hung), zirconia (Kids-e-Dental), and BioFlx (Kids-e-Dental). Crowns were examined initially using an explorer and stereomicroscope at 40x magnification. Sterilization was performed in an autoclave at 121°C, 15 psi for 20 minutes. Each crown underwent three sterilization cycles, followed by stereomicroscopic evaluation after each cycle. Crazing was assessed using Wickersham's criteria.

Results: No visible surface defects were observed with the naked eye. Stainless steel and zirconia crowns demonstrated isolated micro-cracks after repeated sterilization, while BioFlx crowns showed no noticeable crazing. Stainless steel crowns exhibited the highest surface change scores, followed by zirconia, whereas BioFlx crowns remained unaffected.

Conclusion: Repeated autoclave sterilization results in mild crazing in stainless steel and zirconia crowns, with stainless steel crowns being more susceptible. BioFlx crowns demonstrated the highest resistance to sterilization-induced surface alterations, indicating better suitability for repeated try-in and sterilization cycles.

KEYWORDS: Stainless steel crowns, Zirconia crowns, BioFlx crowns, Sterilization, Crazing, Stereomicroscope, Pediatric dentistry, Autoclave

I. INTRODUCTION

Dental caries is the most prevalent condition affecting the primary teeth of children. Following pulp therapy, these teeth often become more susceptible to fracture; therefore, those that have received pulpal treatment should be restored using full coronal restorations.[1] Since the mid-20th century, preformed crowns have become a vital component of pediatric dental practice.

Preformed crowns are used to restore teeth affected by caries, enamel developmental defects, or those that have received pulp therapy. Stainless steel crowns (SSCs) have long been regarded as the gold standard for full coverage restorations in primary dentition owing to their strength, longevity, and cost-effectiveness. However, increasing esthetic demands have led to the development of alternative materials such as zirconia and newer resin-based crowns, including BioFlx, which offer improved appearance while maintaining adequate mechanical properties.[2] Despite these advancements, all preformed crowns share a common clinical challenge during crown selection, which often involves a trial-and-error process. Because these crowns come in various sizes, clinicians must perform a try-in on the prepared tooth to determine the most suitable fit.[3] However, while preformed crowns cannot be reused once they have been cemented, it remains uncertain what should be done with crowns that have been tried in the mouth but found to be an improper size.

Because preformed crowns are expensive, discarding those that become contaminated during try-in procedures is not economically viable. To minimize this issue, some manufacturers provide special try-in replicas. However, any attempt to reuse preformed crowns that have been tested in a patient's mouth must carefully address the risk of cross-contamination from saliva or blood, which could potentially spread infections.[4]
It is crucial to establish evidence-based protocols for the appropriate reprocessing of preformed crowns, along with detailed documentation of decontamination steps within patient records. Moreover, standardized guidelines should specify the maximum number of times a crown can be safely reprocessed. Steam sterilization (autoclaving) has been shown to cause crazing and cracking in preformed crowns, which can result in surface defects such as pitting corrosion. Therefore, any decontamination procedure must be compatible with the alloy composition of the crown material. While earlier research has explored crazing in stainless steel crowns, comparative studies involving stainless steel and esthetic crowns remain limited. Thus, this in vitro study aimed to evaluate the degree of crazing induced by repeated sterilization cycles on Stainless Steel, Zirconia, and BioFlx crowns.

II. MATERIALS AND METHODS

Before the study was carried out, the institutional ethical committee reviewed and approved the research protocol (343/IRB-IBSEC/SIST Dated 18 October 2023). The sample size was determined using GPOWER software (Version 3.0.10) based on previous study done by Sowkarthicaa P et al considering a 5% level of significance, a study power of 0.8, a total of 15 Crowns were estimated.[5]
For this study total of 15 crowns (n – 15) of three different types were used.
1. Group 1- Stainless steel crown (Shin Hung)
2. Group 2- Zirconia crowns (Kids-e-Dental)
3. Group 3- BioFlx crowns (Kids-e-Dental)

This current study consisted of five crowns randomly chosen from each crown type. Firstly examination of the crowns with an explorer was done and subjected to 40x magnification stereomicroscope (Leica) evaluation to check for any deformities. Then first cycle of sterilization (Unique Clave C- 79 B) of crowns was carried out. Sterilization was done using autoclave with the temperature being set at 121 ^{0}C at 15 pounds pressure for 20 minutes and then the crowns was evaluated under stereomicroscope. For microscopic examination, vestibular surface of each crown from all the groups has been examined from occlusal to cervical portion of the crowns to check for any crazing. In the all crowns, crazing was evaluated using the criteria of Wickersham, followed by 2nd and 3rd cycles of sterilization of crowns was done and then followed by evaluation of crowns under stereomicroscope to check for any crazing.
In the all 15 crowns, crazing was evaluated using the criteria of Wickersham 1998[6].

Score	Crazing criteria
1	A few isolated cracks involving less than one-third of the surface
2	Cracks involving one-third to one-half of the surface
3	Cracks involving greater than one-half of the surface

III. RESULTS

The study sample consisted of 15 crowns 5 in each group

	Group 1 (Stainless steel crown)	**Group 2 (Zirconia)**	**Group 3 (Bioflx)**
Crazing (Mean)	**2**	**1**	**No crazing**

No noticeable crazing was observed in any of the group when examined with naked eye. In stainless steel group, after repeated sterilization the surface of the crown was relatively smooth with few isolated cracks when examined under stereomicroscope. In Zirconia group, after repeated sterilization the surface of the crown was relatively smooth with few isolated cracks when examined under stereomicroscope. In BioFlx crowns no noticeable crazing was observed.


Fig 1: Examination of Group 1- Stainless steel crown under stereomicroscope for crazing post sterilization.


Fig 2: Examination of Group 2- Zirconia crowns under stereomicroscope for crazing post sterilization.


Fig 3: Examination of Group 3- BioFlx crowns under stereomicroscope for crazing post sterilization.

IV. DISCUSSION

Preformed crowns are commonly used for full coronal restoration in cases of severely decayed, malformed, or fractured primary anterior teeth, developmental enamel and dentin defects, and as abutments for space maintainers.[7,8] Preformed crowns are used in such cases due to their durability, ease of placement, and ability to provide complete coverage.

Stainless steel crown (SSC) is a strong, less technique sensitive, durable, economical full coverage restoration. Composed of Iron, Chromium 18%, Nickel 8%, Carbon. It has a disadvantage of unaesthetic metallic appearance which demanded for introduction of esthetic crowns.[9] Zirconia is a crystal-like dioxide of zirconium with metal like mechanical properties and is tooth coloured. Composed of Yttria-stabilized tetragonal zirconia polycrystal, Zirconium dioxide stabilized with yttrium oxide. Zirconia crown has advantages of full coverage, less technique sensitivity, premium esthetics, undetachable material and adequate strength. BioFlx composed of High-impact composite resin matrix**,**Reinforcing fibers, Bis-GMA or UDMA-based resin systems, Fillers to enhance strength and flexibility.

Crown selection can be done either by measuring the mesiodistal width of the tooth or through a trial and error approach.[10] During the latter, multiple crowns may need to be tested to achieve a proper fit. These trial crowns can become contaminated with blood and saliva, posing a risk of transmitting infections such as hepatitis B (HBV), hepatitis C (HCV), and human immunodeficiency virus (HIV). Therefore, all contaminated or surplus crowns must be properly sterilized before being reused on another patient.[11] According to the universal precaution of sterilization to rule out the cross infection control, all patients are considered as if they are infectious. In comparison with the adults, children are more prone to diseases and may exhibit prolonged transmission.[12]

Even though with the availability of many disinfection methods like sodium hypochlorite, glutaraldehyde, glass bead sterilizer, isopropyl alcohol, ultraviolet chamber, and quaternary ammonium compounds, the most commonly and widely accepted method of sterilization is an autoclave.[3] Steam sterilization chamber temperatures are below the parameters required to affect the properties of stainless steel. However, these crowns have prominent tooling marks that could potentially serve as sites for pitting corrosion, if there was a very large number of reprocessing cycles.[13] The manufacturer's instruction recommends cold sterilization.[14] But the amount of microbial elimination cannot be justified by this method.

Crazing refers to the presence of internal microcracks that can be identified under ×10 magnification, without any detectable surface roughness when examined using an explorer. In the present study, stainless steel crowns exhibited the

highest degree of crazing, whereas BioFlx crowns showed the least. Zirconia crowns demonstrated minimal surface changes and exhibited the least amount of crazing. This may be attributed to their dense crystalline structure, high strength, and superior resistance to thermal and mechanical stress. Similar findings of increased crazing in stainless steel crowns have been reported by Padmanabh SK and Shital DP Kiran, as well as by Yilmaz Y in studies evaluating preformed crowns.[15,16,3] The surface quality of dental restorations is clinically important, as rough or altered surfaces promote greater plaque retention. Increased plaque accumulation on crown surfaces may predispose to inflammatory changes in the surrounding periodontal tissues. Previous investigations by Kopel and Batterman[17] demonstrated an association between crazing and plaque retention, and comparable observations were made by Van Dijken et al., who reported increased dental plaque accumulation on rough restorative surfaces.[18] Sterilization methods using the autoclave caused surface changes of the stainless steel crown when examined by stereomicroscopy. This crazing may be due to higher temperature and pressure during sterilization process.

Overall, the results of this study emphasize the importance of selecting appropriate crown materials and sterilization protocols in pediatric dentistry. While stainless steel crowns continue to be a reliable and economical restorative option, zirconia crowns may offer superior resistance to surface changes following sterilization, along with enhanced esthetics and biocompatibility. Further long-term clinical studies are recommended to evaluate the effects of repeated sterilization cycles on the surface integrity and clinical performance of preformed crowns.

V. CONCLUSION

The results of this study demonstrate that repeated sterilization can affect the surface integrity of preformed crowns used in pediatric dentistry. Stainless steel crowns showed the highest degree of crazing following autoclave sterilization, whereas zirconia crowns exhibited minimal surface changes, likely due to their superior thermal and mechanical stability. BioFlx crowns demonstrated fewer surface alterations than stainless steel crowns. Although crazing may not be clinically visible, it is significant as it can increase plaque retention and predispose to gingival inflammation. Given the routine trial fitting and reuse of preformed crowns in pediatric practice, appropriate selection of crown material and sterilization protocol is essential to preserve surface integrity and maintain periodontal health.

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