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COMPARATIVE EVALUATION OF INTERNAL FIT AND AMOUNT OF TOOTH REDUCTION REQUIRED IN BIOFLEX CROWNS WITH STAINLESS STEEL CROWNS ON DECIDUOUS MOLARS: AN IN- VITRO STUDY.

Paediatric Dentistry

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ABSTRACT

Introduction: Primary molars hold significant importance, not only in mastication but also in the development of a child's occlusion and in maintaining space for permanent teeth. Thus, crowns are often recommended to restore these teeth, with molars being given special consideration for their crucial role in oral function and arch stability. Stainless Steel Crowns (SSCs) have a long-standing history in pediatric dentistry and have been integral to restorative procedures for primary teeth. In light of the need for more aesthetic restorations, BioFlex crowns have emerged as a promising alternative to SSCs while maintaining clinical functionality. **Aim:** To compare the internal fit and the amount of tooth reduction required for BioFlex crowns and Stainless Steel Crowns (SSCs) when used on deciduous molars in an in-vitro setting. **Material & Method:** This experimental in-vitro trial consisted of total of 60 freshly extracted deciduous mandibular first molars allocated in two groups: Group A (n=30) – Bioflex Crowns (Experimental group) and Group B (n=30) – Stainless Steel Crowns (Control group). Teeth were weighed using digital weighing scale before and after tooth preparation according to standard guidelines by manufacturer to determine the amount of tooth reduction. After crown adaptation and sectioning, the internal fit and marginal fit was assessed using stereomicroscope. **Result:** Stainless steel crowns demonstrate superior clinical performance compared to BioFlex crowns in terms of internal fit, marginal adaptation, and overall retention. They require significantly less tooth reduction than Bioflex crowns. **Conclusion:** Although Bioflex crowns offer aesthetic benefits, their clinical limitations, including excessive tooth reduction, inadequate internal adaptation, and weak cement retention, need to be addressed before they can be recommended as a viable alternative to stainless steel crowns.

KEYWORDS

bioflex crowns, primary molar crowns, ssc, esthetic crowns, marginal fit, tooth preparation

INTRODUCTION:

Dental caries is a predominant health issue affecting oral well-being across various age groups, with children being particularly vulnerable. Providing effective and durable restorations in primary teeth can significantly improve the oral health-related quality of life of an individual throughout their life.[1] Primary molars hold significant importance, not only in mastication but also in the development of a child's occlusion and in maintaining space for permanent teeth.[2] Thus, crowns are often recommended to restore these teeth, with molars being given special consideration for their crucial role in oral function and arch stability.[3]

Stainless Steel Crowns (SSCs) have a long-standing history in pediatric dentistry and have been integral to restorative procedures for primary teeth.[4] Introduced to the field in 1947 by the Rocky Mountain Company, SSCs quickly became the gold standard for pediatric full-coverage restorations due to their exceptional durability, ease of placement, and reliability in children at high risk for caries.[5] SSCs have consistently outperformed other materials and resisted the test of time, heat and chemicals. Their resilience and capacity to withstand the forces of mastication make SSCs particularly suitable for restoring posterior primary teeth.[6]

When adapted properly, SSCs cover the entire coronal surface, providing a seal that minimizes the risk of marginal leakage and secondary caries, thus enhancing the longevity of the restoration.[7] SSCs are especially favored in cases of severe early childhood caries (ECC), where extensive tooth decay requires a full-coverage approach for protection and durability.[8]

However, despite their benefits, SSCs have a notable disadvantage in aesthetics. Their metallic appearance can be visually unappealing, leading to concerns among parents who may prefer restorations that blend more naturally with the child's dentition.[9] In response, studies have explored the use of tooth-colored facings on SSCs to improve aesthetics, though these modifications often fall short in terms of durability.

In light of the need for more aesthetic restorations, Bioflex crowns have emerged as a promising alternative to SSCs while maintaining clinical functionality.[10] Constructed from hybrid resin polymers, Bioflex crowns are free from both metal and Bis-GMA, making them a biocompatible, aesthetic choice for pediatric restorations.[11] These crowns provide a natural, tooth-colored appearance, meeting the increasing demand for aesthetically pleasing options that blend with the natural dentition.

Although they have not yet undergone the same extensive long-term studies as SSCs, Bioflex crowns show promise for their potential to match the durability of SSCs while offering superior aesthetics. Due to their recent incorporation into pediatric dentistry, it is essential to further evaluate Bioflex crowns' properties, including their internal fit and the necessary tooth preparation when used in clinical practice. Understanding these factors is critical for clinicians seeking to balance aesthetics with effective, durable restorative care for primary molars.

In this context, the present study aims to provide evidence regarding the effectiveness of Bioflex crowns relative to SSCs, particularly in terms of internal fit and conservation of natural tooth structure. Through this comparison, the study will identify the most conservative approach to restoring primary molars, ultimately enhancing both the functional and aesthetic outcomes in pediatric dental care.

MATERIALS AND METHODS:

The present study was conducted as an experimental in-vitro trial in the Department of Pediatric and Preventive Dentistry of the institution during the period of March 2023-March 2025. A total of 60 freshly extracted deciduous mandibular first molars were collected and stored in distilled water at room temperature to prevent dehydration. The study employed a simple random sampling technique to allocate the extracted teeth into two groups:

- Group A (n=30) – Bioflex Crowns (Experimental group)
- Group B (n=30) – Stainless Steel Crowns (Control group)

Ethical Considerations

The study adhered to the ethical principles outlined in the Declaration of Helsinki and the guidelines of the Occupational Safety and Health Administration (OSHA). The study protocol was approved by the Institutional Ethical Review Board.

Sample Size Determination:

A power analysis was conducted using G*Power version 3.0.1. The parameters for the analysis included: Level of significance (α): 5%, Power ($1-\beta$): 80%, Effect size (d): 0.8, Test type: Two-sided independent means t-test. Based on these parameters, a total of 52 samples was determined to be required. To account for potential procedural errors, the sample size was rounded up to 60 (n=30 per group). These 60 teeth were used for both the amount of tooth reduction analysis and internal fit evaluation.

Selection Criteria:

Inclusion Criteria:

1. Extracted healthy deciduous mandibular first molars obtained for orthodontic reasons.
2. Extracted deciduous molars with occlusal caries only (no proximal, buccal, or lingual caries involvement).

Exclusion Criteria:

1. Teeth with extensive carious involvement on buccal, lingual, or proximal surfaces.
2. Teeth with developmental anomalies such as hypoplasia, fusion, or gemination.

Procedure:

Step 1: Preliminary Preparation

1. The collected teeth were cleaned of residual organic tissues using an ultrasonic scaler and polished with abrasive rubber cups.
2. The teeth were stored in distilled water until further processing.
3. Each tooth was weighed three consecutive times on a digital weighing scale to ensure accuracy in recording the initial weight.

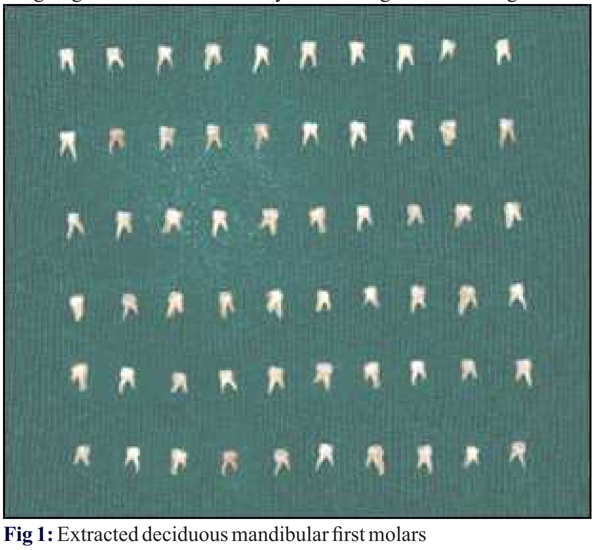

Fig 1: Extracted deciduous mandibular first molars

Step 2: Tooth Preparation

1. The teeth were embedded in self-cure acrylic resin blocks, ensuring they were positioned 2 mm below the cementoenamel junction (CEJ).
2. The teeth were then randomly divided into two study groups:
Group A: Bioflex Crowns (n=30)
Group B: Stainless Steel Crowns (n=30)
3. In both groups, n=16 primary mandibular left first molars and n=14 primary mandibular right first molars were included each.
4. Tooth preparation was carried out following the manufacturer's guidelines for Bioflex Crowns and AAPD (American Academy of Pediatric Dentistry) guidelines for Stainless Steel Crowns
5. After preparation, each tooth was re-weighed using the same procedure to calculate the amount of tooth reduction.

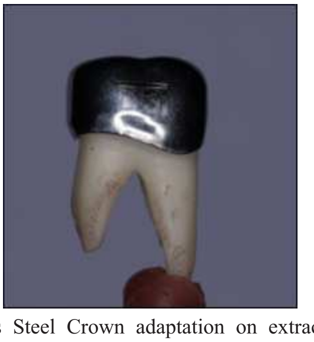

Fig 2: Stainless Steel Crown adaptation on extracted deciduous mandibular first molar.

Fig 3: Bioflex Crown adaptation on extracted deciduous mandibular first molar.

Step 3: Internal Fit Assessment

1. The mesiodistal dimension of each prepared tooth was measured using a Vernier Caliper to select the appropriately sized Bioflex or Stainless Steel crown.
2. Luting cement was applied to three-fourths of the internal surface of the selected crown, and the crown was seated over the prepared tooth.
3. The embedded teeth were then sectioned buccolingually using a diamond disk.
4. A digital photograph of each section was obtained using a stereomicroscope at 20× magnification.
5. Thirteen different points were considered for the measurement. Points A and M represented the corner points indicative of marginal fit, while points B to L represented middle points indicative of the internal fit.
6. The internal fit was measured as the perpendicular distance from the internal surface of the crown to the axial wall of the tooth preparation using a stereomicroscope under 45x magnification and using compatible software (MegaVision).
7. The recorded measurements were compared between the two groups.

Fig 4: Internal fit assessment using stereomicroscope

Fig 5: Cross section of tooth with Stainless steel crown for assessing the marginal fit at various points

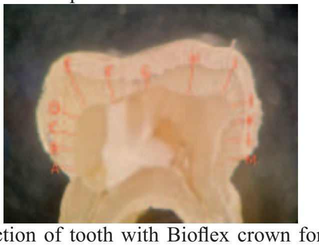

Fig 6: Cross section of tooth with Bioflex crown for assessing the marginal fit at various points

Statistical Analysis:

Data was analysed using SPSS Computer Software (IBM SPSS

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Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp), R (Version 4.4.1) and Excel. Data normality was assessed using the Shapiro–Wilk test. An independent two-sample t-test and Welch's T-test were used for intragroup and intergroup comparison respectively. Data was represented in the form of bar charts and boxplots.

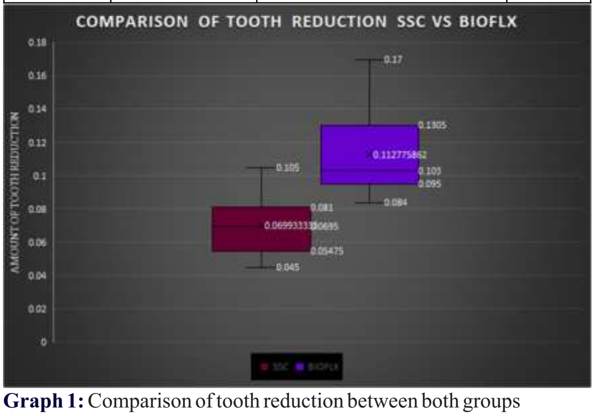
RESULTS:

Amount of tooth reduction:

A statistically significant difference was noted between the mean tooth reduction in both groups. The t-statistic (-8.002933238), which is a negative value, indicates that Bioflex, i.e. Group B, requires significantly more tooth reduction in comparison to SSC. The findings align with the expectation based on material properties, where SSC's malleability allows for less invasive fitting, whereas the thickness of Bioflex necessitates greater reduction.

Table 1: Inter-group Comparisons For The Amount Of Tooth Reduction

Material		Mean Standard Deviation	Range
SSC	Before Cutting	0.58 ± 0.062	0.28
	After Cutting	0.51 ± 0.062	0.27
	Difference	0.07 ± 0.016	0.06
Bioflex	Before Cutting	0.61 ± 0.045	0.2
	After Cutting	0.5 ± 0.052	0.23
	Difference	0.11 ± 0.025	0.086



Graph 1: Comparison of tooth reduction between both groups

Internal Fit:

A significant difference between means of Internal Fit of SSC and Bioflex crowns. The mean internal fit value for Bioflex (1.477) is higher than SSC (1.021). A higher internal fit value generally indicates a looser fit, meaning that Bioflex crowns may not fit as snugly as SSC crowns. Conversely, the lower internal fit value for SSC suggests that it adapts more tightly to the internal structure, possibly leading to better retention and stability.

Table 2: Inter-group Comparisons For Marginal And Internal Fit

Material	Gap	Min	Max	Mean Sd	Range
SSC	Marginal	0.28	0.56	0.43 ± 0.054	0.28
	Internal	0.79	1.45	1.02 ± 0.029	0.66
Bioflex	Marginal	0.78	0.9	0.85 ± 0.023	1.12
	Internal	1.25	1.89	1.48 ± 0.021	0.64

Marginal Fit:

A significant difference between means of marginal Fit of SSC and Bioflex crowns. The mean marginal fit for SSC (0.4263) is significantly lower than for Bioflex (0.8463). The large negative t-statistic value indicates a strong and statistically significant difference. Since a lower marginal fit value indicates a better fit, SSC adapts more precisely to the tooth margins than Bioflex.

DISCUSSION:

The present study was conducted as an experimental in-vitro trial to comparatively evaluate the internal fit and the amount of tooth reduction required for Bioflex crowns and stainless steel crowns on deciduous mandibular first molars. By maintaining uniform preparation procedures and controlled experimental conditions, this study aimed to achieve consistency in baseline variables and allow for valid intergroup comparisons. The decision to choose an in-vitro model facilitated the control of confounding clinical variables such as salivary contamination, patient cooperation, and masticatory forces, thus allowing the isolation and accurate evaluation of specific parameters like internal fit and tooth reduction.

The methodology employed in the present study was deliberately selected to ensure precision, reproducibility, and clinical relevance. Digital weighing was utilized to measure the amount of tooth reduction, as it provides highly accurate, sensitive, and Stereomicroscopy was employed for internal fit evaluation because of its ability to offer magnified, high-resolution, three-dimensional visualization of interfaces that are otherwise difficult to assess through conventional inspection. Stereomicroscopy has been widely validated as a reliable technique for marginal and internal fit studies, offering significant advantages over naked eye or low-magnification assessments that may lead to inconsistent observations.[12]

The findings of the present study revealed that Bioflex crowns required a significantly greater amount of tooth reduction compared to stainless steel crowns. The internal fit assessment in this study demonstrated that stainless steel crowns exhibited significantly better adaptation to the prepared tooth surface compared to Bioflex crowns. These findings can be scientifically explained by the fundamental material differences between the two crowns. Stainless steel crowns are thin, ductile, and highly malleable, allowing for passive adaptation to the prepared tooth without necessitating extensive removal of tooth structure.[13] The ability to crimp and contour stainless steel crowns chairside ensures intimate adaptation with minimal invasion. In contrast, Bioflex crowns are composed of a high-impact hybrid resin polymer material which, although durable and flexible to some extent, is inherently thicker and less accommodating.[14] To ensure an adequate passive fit of Bioflex crowns, greater circumferential and occlusal reduction is inevitably required, leading to unnecessary sacrifice of healthy enamel and dentin, which can potentially weaken the structural integrity of primary teeth.

Clinically, this greater tooth reduction associated with Bioflex crowns carries important implications. In primary teeth, the pulp chamber is relatively large and the enamel-dentin thickness is considerably thinner than permanent teeth. Therefore, any increase in tooth preparation depth inherently increases the risk of pulp exposure, postoperative sensitivity, and compromise of pulpal health.[15] Excessive removal of dentin may also reduce the ability of the remaining tooth structure to withstand masticatory loads, leading to higher susceptibility to fractures.[16]. Thus, while Bioflex crowns offer aesthetic advantages, the need for substantial tooth reduction must be carefully weighed.

Although the manufacturer claims that Bioflex crowns are capable of adapting over time to the underlying tooth structure, the present in-vitro study did not observe any such property within the experimental timeframe. Bioflex crowns retained their original shape and dimensions after placement, with no measurable evidence of enhanced conformity to the tooth surfaces. This could be explained by the intrinsic material characteristics of Bioflex, which, despite its designation as a flexible resin-based polymer, lacks the true viscoelastic behavior required for active post-placement adaptation.[9,17] In clinical scenarios, adaptation over time would rely on the material responding plastically to functional masticatory forces; however, in the absence of significant intraoral mechanical loading under controlled experimental conditions, no adaptive changes were evident. This observation suggests that the adaptation claims by the manufacturer might be overly optimistic and not reliably achievable in realistic clinical practice, especially in the immediate to short-term period following crown placement.

Crowns that fail to closely conform to the underlying tooth can compromise the longevity of the restoration by allowing microleakage, ultimately leading to early restoration failure.[18] A tighter internal fit of stainless steel crowns results in greater mechanical retention and reduces the microgap available for bacterial colonization, thus decreasing the risk of recurrent caries and crown failure.[19] Bioflex crowns, on the other hand, do not permit chairside manipulation, making it challenging to modify their fit to individual tooth contours, particularly in cases of slight anatomic variations.[17]

Another important factor influencing the clinical performance of crowns is the bond between the crown material and the luting cement. In this study, the bonding of the luting cement to Bioflex crowns was found to be inferior compared to stainless steel crowns. This is most likely attributed to the differences in surface characteristics. Stainless steel crowns have a slightly roughened surface that facilitates mechanical interlocking with glass ionomer cements, enhancing retention.[20] In contrast, the smoother, less retentive surface of Bioflex crowns impairs the mechanical retention of the cement. Kameli et al. (2021) highlighted the critical influence of material surface properties on cement adhesion, noting that roughness and surface energy play key roles in achieving optimal bond strength.[21] Furthermore, resin-modified glass ionomer cements have been shown to outperform conventional cements in terms of bonding to smooth surfaces, yet even with their improved properties, Bioflex crowns still demonstrated poor adhesion in this study.[22]

A crucial observation was the frequent dislodgement of Bioflex crowns during the process of cross-sectioning for internal fit assessment. This observation is of clinical significance as it directly reflects the mechanical retention capacity of the crowns under shear forces. In real-world conditions, crowns are subjected to complex stresses including tensile, compressive, and shear forces during mastication and parafunctional habits.[23] The inability of Bioflex crowns to resist dislodgement during experimental handling suggests that they may be at risk for clinical debonding under functional loading. Patil et al. (2023) also reported lower retention rates for preformed esthetic crowns compared to traditional stainless steel crowns, corroborating the findings of the present study.[24] The interplay of poor marginal adaptation, weaker cement bonding, and lack of malleability likely acts synergistically to compromise the overall retention and stability of Bioflex crowns in clinical use. Thus, the lack of sufficient mechanical and adhesive retention of Bioflex crowns may limit their application primarily to low-load anterior teeth or cases where aesthetic demands outweigh functional priorities, rather than their routine use in high-stress posterior regions.[25]

Marginal fit assessment in this study further reinforced the superiority of stainless steel crowns over Bioflex crowns. The inferior internal fit and poor marginal adaptation observed with Bioflex crowns suggest a greater susceptibility to microleakage compared to stainless steel crowns, raising concerns regarding their long-term effectiveness in maintaining pulpal health.

Patient-centered outcomes such as comfort, functional longevity, gingival response, and esthetic satisfaction, which are critical for the real-world success of pediatric crowns, were not evaluated due to the in-vitro design. Looking ahead, future research must address these gaps through well-designed clinical trials. Moreover, development of thinner yet durable versions of Bioflex crowns could reduce the need for aggressive tooth reduction, preserving more natural tooth structure. Further studies in this area should be encouraged.

CONCLUSION:

The findings of this study indicate that stainless steel crowns demonstrate superior clinical performance compared to Bioflex crowns in terms of internal fit, marginal adaptation, and overall retention. These findings raise concerns about the reliability of Bioflex crowns as a full-coverage restorative option, particularly in pediatric patients where long-term durability and adaptation are critical. Although Bioflex crowns offer aesthetic benefits, their clinical limitations, including excessive tooth reduction, inadequate internal adaptation, and weak cement retention, need to be addressed before they can be recommended as a viable alternative to stainless steel crowns.

Future research should focus on improving the material properties of Bioflex crowns to enhance their adaptability, bonding strength, and overall clinical performance. Additionally, long-term clinical trials are necessary to assess their effectiveness in real-world conditions, considering factors such as mastication forces, patient comfort, and parental satisfaction. Until then, stainless steel crowns remain the preferred choice for full-coverage restorations in primary molars due to their superior mechanical and clinical properties.

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