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Original Article

Enhancing Prosthetic Rehabilitation with Metal-Free Restorations for Dental Tissue Preservation

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ABSTRACT

Ceramic and metal materials are commonly used to restore tooth tissue. However, metal-free alternatives offer superior aesthetics and adaptability. In recent years, there has been a significant increase in patients' preference for non-metallic restorations, often due to concerns about metal hypersensitivity or aesthetic preferences. This study aims to increase the effectiveness of treating patients with dental tissue defects through the use of ceramic restorations. A total of 60 patients were treated using metal-free restorations fabricated through pressing and milling techniques, with each method applied to a group of 30 patients. Several evaluation criteria were used to evaluate the results, including restoration fit accuracy, color compatibility, cementation stability, and the presence of chipping within the oral cavity. Statistical analysis was performed to compare both groups. The findings showed that milled restorations demonstrated superior adhesion to dental tissues and better color matching. Therefore, metal-free restorations are highly recommended for prosthetic rehabilitation of hard dental tissues.

Keywords: Pressing, Milling, Metal-free restorations, Dentition aesthetics

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Introduction

Metal-ceramic crowns have demonstrated a 94% success rate over a decade. However, despite their durability, restorations with metal frameworks do not achieve the highest level of aesthetic appeal or precision [1, 2] when compared to all ceramic alternatives [3]. Additionally, biocompatibility and interaction with soft tissues are key factors contributing to the growing clinical preference for all-ceramic restorations, particularly in the anterior teeth region [4-9]. The long-term performance of these restorations heavily relies on the accuracy of their fit, both at the margins and within the restoration itself [10]. Any increase in the marginal gap accelerates cement degradation and microleakage, which may lead to hypersensitivity, secondary caries, pulp inflammation, and discoloration along the transition line. Furthermore, improper fit can contribute to periodontal inflammation because of the accumulation of subgingival microbial biofilm and alterations in its composition [11].

Among the widely used ceramic restoration techniques, pressed ceramics have gained significant popularity due to their ease of fabrication and superior marginal adaptation. This method offers advantages such as enhanced translucency, robust mechanical properties, minimal shrinkage, reduced porosity, and lower brittleness compared to traditional feldspar ceramics [12]. The initial generation of heat-pressed ceramics featured IPS Empress, which was later replaced by IPS e.max Press— a lithium disilicate glass-ceramic optimized for pressing techniques. This updated material overcomes the shortcomings of its predecessor [13].

One of the most significant benefits of lithium disilicate (LS2) is its exceptional interaction with soft tissues. Laboratory studies have demonstrated that LS2 exhibits high biocompatibility, attributed not only to its low plaque retention but also to its ability to support the adhesion and growth of human epithelial cells [14] and gingival fibroblasts [15], especially when polished [1]. Even in cases where the endodontic prognosis is poor, all-ceramic restorations still show excellent adaptation [16]. A three-year randomized clinical trial further validated that LS2 partial crowns offer a reliable treatment option for posterior teeth, including premolars and molars, with or without fiber post-reinforcement [17].

Lithium disilicate blocks are designed for use in clinical CAD/CAM systems, enabling same-day fabrication of restorations through intraoral digital scanning and in-office milling. This approach eliminates dimensional distortions in the denture base, making milling one of the most reliable and reproducible techniques [18]. Following the milling process, the pre-crystallized crowns should undergo a high-temperature crystallization phase to attain their final mechanical strength [19]. Studies have demonstrated that CAD-fabricated crowns possess excellent fracture resistance, making them a suitable choice for monolithic posterior restorations [20]. Additionally, they have shown greater durability under cyclic loading compared to veneered zirconia, which is more susceptible to chipping [20, 21].

This study focuses on optimizing prosthetic treatment for patients with hard tissue defects using metal-free restorations. It also aims to develop a systematic approach for selecting the most appropriate fabrication technique based on clinical conditions while evaluating its impact on the marginal gap of the final restoration.

Materials and Methods

This study was conducted between 2018 and 2021 at the Department of Prosthetic Dentistry at Sechenov University and the private clinic “Nanostom.” A total of 60 patients underwent examination and treatment, including 40 women and 20 men, aged between 25 and 45 years, with an average age of 34.5 ± 5.6 years. The primary diagnosis among participants was K02.1, “Caries extending into dentin.” Many of the patients presented with failed dental fillings in the affected area, necessitating restoration with an onlay, crown, or endocrown.

Patients were randomly divided into two groups, each consisting of 30 individuals. The first group comprised 20 women and 10 men who received metal-free restorations fabricated using the pressing technique. The second group, also composed of 20 women and 10 men, underwent restoration using metal-free restorations created through the milling technique.

A variety of research methods were employed in the study to assess the effectiveness of the restorations. The accuracy of fit was determined by measuring the thickness of fit checkers, while the replica (copy) technique was utilized for additional evaluation. Radiographic examination using direct bite images provided further insight, and dental photographs were analyzed to support the findings.

To evaluate the restorations, several key criteria were considered, some of which were assigned numerical values for ease of comparison. The accuracy of fit was measured in microns, with a satisfactory result defined as a marginal gap of less than 80 microns. Color matching was assessed using the Vita scale, with scores assigned as follows: 0 for complete conformity, 1 for partial conformity, and 2 for inconsistency. The probability of cement connection loss was recorded as either 0 (no loss) or 1 (loss present). The presence of chips in the restoration was also noted, with 0 indicating no chipping and 1 signifying minor chips in the oral cavity.

Results and Discussion

The findings of this study, based on an analysis of evaluation criteria, revealed a statistically significant difference in the degree of adhesion between the restorations and the tooth tissues. Milled onlays, crowns, and endocrowns demonstrated superior adaptation to dental structures, with an advantage of approximately 10 microns over their pressed counterparts.

In terms of color accuracy, milled metal-free restorations exhibited significantly better shade matching compared to pressed restorations ($P < 0.05$). This suggests that milling technology offers improved aesthetic outcomes in prosthetic restorations.

Regarding the durability of the cement connection, pressed metal-free restorations showed a higher likelihood of cement loss than milled restorations. However, the difference was not statistically significant ($P > 0.05$), as confirmed by the analysis of four-field tables and the chi-square test.

Chipping was evaluated at different stages—during the manufacturing process, as well as after fixation and mastication in the cavity. While pressed metal-free restorations initially exhibited greater strength during fabrication, milled restorations demonstrated a lower incidence of chipping after placement and during chewing ($P < 0.05$). Despite this trend, statistical analysis did not confirm the significance of these findings.

Preserving the integrity of dental structures through minimally invasive preparation is widely recognized as the gold standard in restorative dentistry. The extent of tooth preparation directly correlates with the risk of restoration fractures, making conservative approaches preferable [22]. Endocrowns have gained popularity due to their ability to restore extensively damaged teeth while maintaining a significant portion of the hard dental tissues. Unlike conventional crowns, they require minimal retention geometry, reducing both treatment time and financial costs. Furthermore, advancements in CAD/CAM technology have introduced efficient in-office fabrication methods, allowing for the automated production of ceramic restorations. This is particularly beneficial for ceramic endocrowns, which integrate the crown and core into a single restoration, enhancing both functionality and durability.

A systematic review conducted by Al-Dabbagh [23] compared endocrowns and traditional crowns across seven studies, analyzing their fracture resistance and the occurrence of catastrophic failures. These studies focused on different tooth groups, with one examining incisors, four investigating premolars, and two assessing molars. Additionally, an initial study on the marginal adaptation of endocrowns to premolars was conducted [24]. According to the results, the fracture strength of polymeric ceramic endocrowns and traditional crowns did not exhibit significant differences (869 ± 247.8 N vs. 580.0 ± 295.4 N). But, the frequency of catastrophic failure reached 100% for endocrowns, while traditional crowns demonstrated no such failures [25]. A similar pattern was observed when comparing lithium disilicate ceramic endocrowns and traditional crowns, where fracture resistance remained statistically comparable (915.9 ± 182.1 N vs. 646.8 N). However, catastrophic failures occurred in 85% of endocrowns, whereas no such failures were reported for traditional crowns.

Our findings indicate that the rate of catastrophic failures did not exceed 10% for any type of restoration, regardless of the fabrication technique used. Additionally, no significant discrepancies were observed between the two manufacturing methods in terms of marginal fit or mechanical durability (MD) [26-28]. Both CAD/CAM milling and hot-press techniques for monolithic lithium disilicate crowns produced MD values below 120 μm, which falls within the clinically acceptable range [26].

The long-term clinical performance of all-ceramic restorations has been debated. A study by Becker *et al*. [29] reported a high failure rate in clinical applications. However, contrasting evidence from another study [30] demonstrated that chairside lithium disilicate glass-ceramic restorations achieved a high survival rate, with promising performance even after four years of function, making them a dependable choice for posterior tooth restoration [31].

While our study confirmed that milled ceramic restorations exhibit greater precision and superior aesthetics, previous research suggests that pressed ceramic restorations may provide better overall adaptation [32]. Additionally, pressed lithium disilicate monolithic crowns have been shown to outperform CAD/CAM-milled crowns in fatigue resistance and internal fit [33], particularly when treated with self-etching ceramic primer [34].

Conversely, other studies suggest that milling technology produces a smoother, more homogenous tooth surface topography ($P < 0.05$), compared to the pressing technique [35]. This finding underscores the advantages of CAD/CAM systems in achieving enhanced surface quality and overall restoration accuracy.

Conclusion

For restoring hard tooth tissues with an onlay, crown, or endocrown, metal-free restorations are strongly recommended to ensure both functional integrity and superior aesthetics.

The findings of this clinical study highlight notable advantages of metal-free restorations fabricated using the milling technique over those produced through pressing. Milled restorations demonstrated stronger adhesion to dental tissues, more accurate color matching, and overall superior structural quality within the oral environment. These benefits support the recommendation of using milled metal-free restorations when the preparation area has well-defined margins. However, in cases where the preparation boundaries are irregular or "torn," pressed metal-free restorations are the preferable choice for achieving optimal results.

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