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THE EFFECT OF ABUTMENT AND CROWN DESIGN ON FRACTURE STRENGTH AND FRACTURE MODE OF IMPLANT-SUPPORTED PROSTHESIS (ISP)

AMMAR YASEER BIN ABDUL HAKIM @ ABDUL KHAKIN

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ABSTRACT

Aim: This in-vitro study aimed to evaluate the fracture strength and fractographic characteristics of CAD/CAM cement-retained (CR) and screw-retrievable cement-retained (SRCR) implant-supported molar crowns bonded to different titanium-based abutments. **Material and methods:** Sixty implant crowns, comprising monolithic zirconia and bilayer crowns, were assigned into control and test groups. The control group included monolithic cemented crowns bonded to Variobase (MCV, n=10) and NiTium abutments (MCN, n=10). The test groups consisted of monolithic screw-retained crowns bonded to Variobase (MSV, n=10) and NiTium abutments (MSN, n=10), as well as bilayer screw-retained crowns with reinforced access hole bonded to Variobase (BSV, n=10) and NiTium abutments (BSN, n=10). All crowns were cemented onto prefabricated titanium-based abutments. Samples underwent thermal cycling to simulate oral conditions, followed by a single-load fracture test. Fracture modes were examined using Scanning Electron Microscopy (SEM). Fracture strength values were statistically analyzed using the Mann-Whitney U test, with significance set at $P < .05$. **Results:** There was no significant difference in fracture strength between NiTium and Variobase abutments for both cement-retained ($p = 0.096$) and screw-retrievable cement-retained crowns ($p = 0.650$). Similarly, no significant difference was observed between abutments for bilayer crowns (BSV vs. BSN, $p = 0.520$). However, crown design significantly influenced fracture strength (Kruskal-Walli's test, $p < 0.001$). Bilayer crowns demonstrated significantly lower fracture strength compared to monolithic crowns (both CR and SRCR groups, $p < 0.001$), while no significant difference was noted between monolithic CR and SRCR crowns ($p = 1.000$). Fractographic analysis revealed catastrophic failure for MSV and MSN, while other groups showed complex failure patterns. **Conclusion:** No significant difference in fracture strength was found between NiTium and Variobase abutments, indicating both effectively support implant crowns under the tested conditions. Bilayer crowns exhibited lower fracture strength primarily due to lithium disilicate chipping and delamination. Retention type (CR vs. SRCR) did not significantly affect monolithic crown fracture strength. The SEM analysis highlight significant differences in fracture behavior among the three groups. While monolithic SRCR crowns demonstrated superior mechanical strength, they predominantly failed through catastrophic cohesive bulk fractures. In contrast, bilayer crowns exhibited more repairable adhesive failures, typically occurring at the veneer-core interface. The findings highlight the superior mechanical strength of monolithic crowns for posterior load-bearing applications, whereas bilayer crowns may be better suited to anterior regions, where aesthetic considerations are of primary concern.

Keywords: Dental implant; Implant abutment; Cement retained; Screw-retained; Zirconia crown

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Dental implants have revolutionized restorative dentistry, providing predictable success rates attributed to factors such as osseointegration, prosthesis stability, peri-mucosal health, and bone preservation. However, complications often arise post-loading, emphasizing the importance of effective prosthetic design and retention methods to ensure long-term outcomes (Pjetursson et al., 2018; Misch, 2020). Among these, the retention interface between the crown, abutment, and implant fixture plays a critical role in determining the mechanical and clinical success of implant-supported restorations (Affendi et al., 2024).

Implant-supported restorations are traditionally categorized as cement-retained or screw-retained, each with distinct benefits and limitations. Cement-retained restorations are lauded for their aesthetics, simplified fabrication, and passive fit. However, residual cement from placement often contributes to biological complications such as peri-implantitis, while their lack of retrievability poses challenges during maintenance or repair (Levine et al., 2014; Linkevicius et al., 2013). Conversely, screw-retained systems eliminate the risks of cement-related complications and allow easier retrievability, but their visible screw access channels may compromise esthetics, and the disruption of the crown's structural integrity due to the channel often reduces fracture strength (Rajan & Gunaseelan, 2004; Kotsakis et al., 2016).

To address these shortcomings, screw-retrievable cement-retained (SRCR) restorations have been developed as a hybrid solution, combining the advantages of both systems. This design minimizes the risks of residual cement by allowing extra-oral cementation while retaining the retrievability of screw-retained systems. Moreover, the cement layer in SRCR restorations serves as a stress absorber, potentially enhancing fracture strength under functional loads. However, the screw access channels themselves introduce structural challenges, with factors such as channel diameter, placement, and