https://africanjournalofbiomedicalresearch.com/index.php/AJBR
Afr. J. Biomed. Res. Vol. 27(4s) (November 2024); 2209 - 2213
Research Article

"Evaluation Of Wear Among Two Different Clasps Designs And Different Abutment Materials By Repetitive Insertions And Removal Of Rpd Underocclusal Loading"

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Received: 09/11/2024, Acceptance 15/11/2024

DOI: https://doi.org/10.53555/AJBR.v27i4S.3671

Introduction

Removable partial dentures (RPDs) are a well-established solution for managing partially edentulous conditions, from the loss of a single tooth to the presence of only one remaining tooth within the dental arch. Designing and fabricating RPDs require a holistic approach, addressing aesthetics, periodontal health, and retention to meet functional demands. The RPD design process is intricate, involving components like rests, rest seats, major connectors, minor connectors, denture bases, and both direct and indirect retainers. This comprehensive design framework aims to balance occlusal pressure distribution while minimizing periodontal complications, thus enhancing the prosthesis's aesthetic and functional performance.

Retention in RPDs is crucial, defined as the ability of the denture to resist dislodging forces. According to Johanson et al. (1983), retention results from a combination of mechanical means, such as clasps engaging undercuts on abutment teeth, and the patient's muscular control. Davenport et al. (2000) expanded on this by highlighting the role of mucosal coverage. Phoenix et al. (2003) and Boucher and Renner (1982) emphasized the importance of the clasp assembly in opposing dislodging forces and stabilizing the RPD. The Academy of Prosthodontics (2005) further defined the direct retainer as the element specifically responsible for holding the RPD in place.

Effective retention relies on precise clasp placement within natural or artificially created undercuts on abutment teeth. Clasp designs are tailored to fit undercuts of varying depths—0.25 mm, 0.50 mm, and 0.75 mm—adjusted to near and far zones. When natural undercuts are insufficient, techniques like crowns, enamel recontouring, or composite resin application can create artificial undercuts. Studies by Davenport et al.

(2000) and Tietge et al. (2021) demonstrate that composite resin recontouring can effectively produce durable undercuts with minimal tooth structure removal. However, choice of resin composite is crucial, as certain composites exhibit varying wear characteristics, impacting retention.

Full-coverage crowns, such as porcelain-fused-to-metal (PFM) or zirconia crowns, provide robust alternatives to enamel and composite, with less wear under clasp stress. Research indicates that full-coverage crowns offer better retention and durability compared to enamel or composite resin surfaces. Despite advancements in materials, such as titanium and polyamide, which offer aesthetic and functional advantages, these materials also pose challenges like potential deformation under repeated stress.

The Akers clasp, a commonly used supra-bulge retainer, relies on its design for retention, involving elastic deformation to fit precisely with the abutment tooth. The I-bar clasp, favored in Kennedy Class I and II cases, is noted for its lower stress transfer and reduced food debris accumulation. Both clasps offer distinct advantages, but their effectiveness can diminish over time due to wear and repeated use.

The scientific literature does not clarify the gradual decline in the retention of C clasps and I-bar clasp on different abutments surfaces. The study aims to compare the wear resistance among cobalt chrome clasps against different abutment surfaces under repetitive insertion and removal of RPD.

Materials and Methods

Fabrication of Tooth Models

This study aimed to evaluate the wear resistance of two clasp designs—C-clasp and I-bar clasp—across various abutment crown materials, including metal crowns, porcelain-fused-to-metal (PFM) crowns, and zirconia crowns. The experimental setup simulated approximately three years of clinical usage. Previous studies (Hebel et al. 1984; Tannous et al. 2012) suggest that this period corresponds to around 4000 cycles of insertion and removal for a removable partial denture (RPD) detached four times daily.

Naturally extracted premolar teeth were embedded in epoxy resin models, ensuring the crown preparation reached the cementoenamel junction (CEJ) and was aligned parallel to the surveyor table. This setup replicated typical clinical preparations for RPD components, allowing for an accurate assessment of wear resistance and performance of the crowns and clasps.

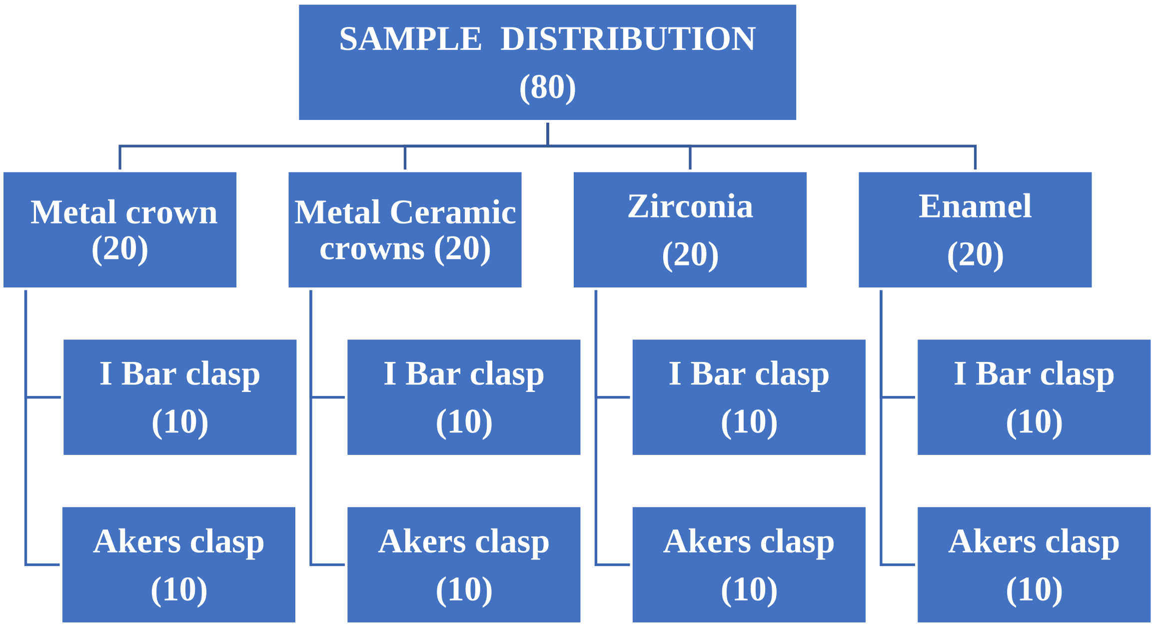
Grouping and Crown Fabrication

The study divided the models into four groups with two subgroups each:

1. **Group I (GI):** Metal crowns
2. **Group II (G2):** PFM crowns
3. **Group III (G3):** Zirconia crowns
4. **Group IV (G4):** Natural teeth for enamel wear resistance

Each group was further subdivided into:

- **Subgroup S1:** Aker clasp
- **Subgroup S2:** I-bar clasp



Each subgroup contained 10 models, totalling 80 models for the study. The tooth preparations followed Schillingburg's principles, ensuring consistency in preparation across all crown types.

Preparation of Metal and PFM crowns

For metal and PFM crowns, a wax pattern was created on gypsum dies, using a 30 µm spacer applied in two layers. The wax patterns included a 0.25-mm undercut on the distobuccal surface and a rest seat prepared to a depth of 2 mm. The patterns were cast using the lost wax technique, invested in phosphate-bonded material, and cast with cobalt-chromium alloy. The resulting crowns were polished, and porcelain was layered onto metal copings for PFM crowns.

Zirconia Crown Fabrication

Zirconia crowns were fabricated using CAD software (Exocad) to design the crown, with a 40 µm cement space. Zirconia blanks were milled using a Ceramil motion machine and sintered according to the manufacturer's guidelines.

Clasp Fabrication

Aker and I-bar clasp patterns were designed using pattern wax, ensuring proper fit and engagement with the undercut areas. Standardization was achieved using veneer calipers. The clasps were cast in Co-Cr alloy, adjusted minimally, and polished to preserve their as-cast state.

Testing Procedure

RPD insertion and removal were simulated using a universal testing device, cycling through 250, 500, 1000, 2000, and 4000 cycles. Wear was analyzed using a scanning electron microscope (SEM), where samples were coated with a thin layer of conductive material and examined for wear patterns on both the clasps and abutment materials.

Statistical Analysis

Wear data from the abutment materials and clasps were collected at each cycle interval and analyzed using two-way ANOVA to determine the significance of the results.

Table 1A: Wear Measurements (in micrometers) for Akers Clasp Against Different Abutment Materials

Cycles	Enamel	Zirconia	Metal Ceramics	Metal	Row Total (xr)
250	2.658	2.658	4.225	3.525	17.748
500	3.015	3.015	4.725	3.625	14.380
1000	3.525	3.625	5.219	3.700	16.069
2000	4.025	4.025	5.725	4.825	18.600
4000	4.525	4.525	6.225	4.925	20.200
Col Total (xc)	13.066	17.848	26.119	20.600	82.315

Statistical Analysis

The statistical analysis was performed to assess the significance of wear differences among materials.

Source of Variation

Source of Variation	Sum of Squares (SS)	df	Mean Squares (MS)	F	p-value
Between Rows	SSR = 9.233	r-1=3	MS = 3.0777	F = 123.2227	p = 0.012
Error (Residual)	SSE = 0.2997	(r-1)(c-1)=12	MS = 0.025		
Total	SST = 18.1741	rc-1=19			

The F-statistic for between materials (rows) is significantly high (F = 123.2227), with a p-value of 0.012, indicating significant differences in the wear of the Akers clasp across different abutment materials.

Results: Wear of I Bar Clasp Against Different Abutment Materials

Table 1B: Wear Measurements (in micrometers) for I Bar Clasp Against Different Abutment Materials

Cycles	Enamel	Zirconia	Metal Ceramics	Metal
250	1.625	1.673	3.075	3.275
500	1.755	1.800	3.560	3.390
1000	2.425	2.475	3.895	3.575
2000	2.925	2.975	4.075	3.875
4000	3.425	3.475	4.275	4.075

Statistical Analysis for I Bar Clasp
Source of Variation

Source of Variation	Sum of Squares (SS)	df	Mean Squares (MS)	F	p-value
Between Rows	SSR =7 .8873	r-1=3	MS =2 .6291	F =46 .2636	
Error (Residual)		SSE=0 .6819		MS=0 .0568	
Total		SST=13 .9097		rc-1=19	

Discussion

Removable partial dentures (RPDs) require support, stability, and retention, achieved through clasps positioned in specific undercuts on abutment teeth surfaces. (9) The Akers clasp and I Bar clasp are commonly used for RPDs, with the Akers clasp originating from the occlusal rest and extending past the contour to engage the undercut region. I-bar clasps provide effective retention with minimal interference in aesthetics and are suitable for canines and premolars with adequate bone support. (10) The Akers clasp is preferred in tooth-borne cases due to its simplicity and versatility. Retention force is crucial, and factors such as clasp dimensions, flexibility, and engagement with the undercut should be considered when evaluating a clasp material's suitability. The retentive force of Akers clasps decreases after repeated insertion and removal cycles from the abutment tooth. This reduction is influenced by the shape and material of both the clasp and abutment tooth. The study investigates the effects of long-term simulated clasp attachment/detachment analysis wear on different abutment material surfaces, ranging from 250 to 4000 cycles. The results reveal notable variations in wear among the abutment materials across different cycle ranges, highlighting the importance of understanding the wear properties of clasps. (10,11)

The study analyzed the wear of various abutment materials under various cycles, revealing significant differences in wear levels. The Akers clasp showed the highest wear in metal-ceramic abutments, while the I-bar clasp showed maximum wear in metal-ceramic abutments. The metal crown showed intermediate wear levels between metal ceramics and enamel. The Akers clasp showed greater wear than the I-bar clasp, with the lowest wear observed in enamel and zirconia. The frictional forces between the materials and the force holding surfaces together were also significant. The Akers clasp exhibited higher wear rates than the I-bar clasp, possibly due to the similar coefficient of friction between cobalt and chrome materials.

Studies show that the Akers clasp, with an undercut of 0.25 mm, has a mean retentive force of 4.77 N, less than the I bar clap. The pullout location and clasp type significantly affect the retention force of the clasp. The pull force acting on the Akers clasp, especially in different environments, plays a crucial role in determining its effectiveness. A study comparing the wear of different abutment materials and enamel against the Akers clasp and I bar revealed a significant difference in wear areas. The metal ceramics showed the highest wear, while zirconia and metal ceramics had the least wear.(12)

The wear of different abutment materials changes with the number of cycles, with some materials showing little change and others experiencing significant wear. (13)The surface hardness of materials plays a crucial role in enhancing wear resistance. Enamel, zirconia, and metal ceramics have different surface hardness values, with enamel being harder than dentin and zirconia having higher wear resistance. Metal ceramics have the maximum wear due to the least surface hardness, which is influenced by specific material and fabrication techniques.(14)

The friction coefficient between abutment teeth and the clasp can also contribute to wear. Higher friction coefficients can lead to increased wear, while cyclic insertion and removal of the clasp can decrease retentive force. The number of insertion/removal cycles can also affect the retentive force of the clasp. The choice of clasp type, abutment material, and the number of insertion/removal cycles can all contribute to the wear observed in the Akers clasp compared to the I-bar clasp.(15)

The I bar clasp is best in terms of withstanding wear, while enamel is most wear-resistant and can withstand wear resulting from the clasp during insertion and removal. Zirconia can be advocated for the abutment when the abutment needs to be prepared for crown preparation or for correction of the plane of occlusion.