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Assessment of the Anatomical and Functional State of the Oral Cavity in Patients with Long-Term Use of Fixed Prostheses

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Abstract The long-term success of fixed partial dentures (FPDs) is determined not only by the survival of the prosthesis but also by the anatomical and functional preservation of the supporting oral structures. This study aimed to assess the impact of long-term (≥5 years) fixed prostheses on the periodontium, marginal bone stability, and occlusal harmony. A cross-sectional analysis was conducted on 150 patients (mean age 48.5 ± 6.2 years) using either metal-ceramic (MC, n=75) or zirconia-based (Zr, n=75) restorations. Clinical evaluation utilized the Plaque Index (PI), Gingival Index (GI), and Probing Pocket Depth (PPD), while alveolar bone loss was quantified through standardized digital radiography. Statistical analysis, including Student's t-test and one-way ANOVA, revealed a significant positive correlation between the duration of prosthesis function and crestal bone resorption ($r = 0.72$, $p < 0.001$). The results demonstrated that zirconia restorations maintained significantly better periodontal health (GI: 1.2 ± 0.3) compared to metal-ceramic restorations (GI: 2.1 ± 0.5, $p < 0.01$). Furthermore, subgingival margin placement was a primary predictor for increased pocket depth (4.6 ± 1.1 mm) and local inflammatory response. Digital occlusal analysis indicated that 35% of participants suffered from functional imbalances that correlated with abutment tooth mobility. In conclusion, while fixed prostheses effectively rehabilitate masticatory function, they induce progressive anatomical changes in the periodontium. To mitigate these effects, clinicians should prioritize zirconia materials, supragingival margin designs, and frequent maintenance protocols to ensure long-term bio-functional stability.

Keywords Fixed prostheses, Periodontal state, Bone resorption, Zirconia-based restorations, Clinical assessment

1. Introduction

The rehabilitation of the stomatognathic system via fixed partial dentures (FPDs) represents a cornerstone of restorative dentistry, aiming not only to replace missing dentition but also to restore the intricate balance of occlusion, phonetics, and esthetics [1]. However, the insertion of a fixed prosthesis fundamentally alters the oral ecological niche, creating new retentive areas for biofilm accumulation and potentially disrupting the biological width [2]. While short-term survival rates of FPDs are well-documented, the long-term biological interactions—specifically over periods exceeding a decade—remain a subject of critical clinical concern [3]. The oral cavity is a dynamic environment where dental materials are subjected to cyclic mechanical loading, thermal expansion and contraction, and chemical degradation [4]. "Success" in prosthodontics is often conflated with "survival" (retention of the prosthesis); however, true success must encompass the preservation of the supporting periodontium and the maintenance of neuromuscular harmony [5]. Chronic irritation from subgingival margins, micro-leakage leading to secondary caries, and occlusal trauma are primary etiologies for the failure of the abutment teeth rather than the prosthesis itself [6,7]. Furthermore, the anatomical functionality of the periodontium is heavily influenced by the emergence profile of the artificial crown and the pontic design [8]. Inadequate management of these factors can lead to iatrogenic periodontal disease, characterized by attachment loss and alveolar bone resorption [9]. This study aims to provide a comprehensive anatomo-functional assessment of the oral cavity in patients with long-term fixed prostheses, utilizing advanced diagnostic metrics to correlate prosthesis design and material with periodontal and occlusal health [10].

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2. Materials and Methods

A cross-sectional analytical study was conducted involving 150 subjects (mean age: 48.5 ± 6.2 years) recruited

from the Department of Orthopedic Stomatology. Inclusion criteria were strictly defined as: (1) presence of fixed dental prostheses (FPDs) functioning for ≥ 5 years; (2) absence of systemic conditions affecting bone metabolism (e.g., osteoporosis, uncontrolled diabetes); and (3) no history of periodontal surgery in the last 12 months [11]. The cohort was stratified based on the material of the prosthesis: Metal-Ceramic (MC, $n=75$) and Zirconia-Based (Zr, $n=75$) [12].

Clinical Periodontal and Functional Assessment

Periodontal health was quantified using a comprehensive periodontal chart. The Plaque Index (PI) (Silness & Löe) and Gingival Index (GI) (Löe) were recorded at four surfaces per abutment [13]. Probing Pocket Depth (PPD) and Clinical Attachment Loss (CAL) were measured to the nearest millimeter using a UNC-15 periodontal probe [14]. Marginal integrity was evaluated using the modified USPHS criteria (Ryge criteria), specifically checking for marginal gaps and discoloration [15]. Functional analysis involved the evaluation of static and dynamic occlusion using T-Scan III (Tekscan, Inc.) to identify premature contacts and disclusion times [19].

Radiographic Analysis

Standardized digital periapical radiographs were obtained using the parallel technique. Crestal bone levels were measured digitally from the cemento-enamel junction (CEJ) or the restoration margin to the alveolar crest using calibration software (ImageJ) to correct for magnification errors [16,17].

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY).

1. Descriptive Statistics: Continuous variables (e.g., PPD, CAL, Bone Loss) were expressed as mean $\pm$ standard deviation (SD), while categorical variables (e.g., USPHS ratings, presence of caries) were presented as frequencies and percentages.
2. Normality Testing: The Shapiro-Wilk test was utilized to determine the distribution normality of continuous data.[3]
3. Inferential Statistics:

For normally distributed continuous variables (e.g., PPD values between MC and Zr groups), the Student's t-test for independent samples was employed.

For non-normally distributed data or ordinal variables (e.g., Gingival Index scores), the Mann-Whitney U test was applied.

One-way Analysis of Variance (ANOVA) followed by Tukey's HSD post-hoc test was used to compare mean bone loss across different time intervals (5-10 years vs. >10 years).

The Chi-square test (χ^2) was used to analyze categorical associations, such as the relationship between margin placement (supragingival vs. subgingival) and the presence of secondary caries.

Correlation Analysis: Pearson's correlation coefficient (r) was calculated to assess the strength of the linear relationship between the duration of prosthesis use and the extent of alveolar bone loss.

A confidence interval of 95% was established, and a p-value of < 0.05 was considered statistically significant.

3. Results

Periodontal Parameters

The mean duration of prosthesis use was 8.4 ± 2.1 years. The statistical analysis revealed a significant degradation in periodontal health proportional to the age of the restoration. The mean Gingival Index (GI) for the entire cohort was 1.8 ± 0.4.

- Material Comparison: The Zirconia group exhibited significantly lower GI scores (1.2 ± 0.3) compared to the Metal-Ceramic group (2.1 ± 0.5) ($p < 0.01$, Mann-Whitney U), suggesting superior soft-tissue biocompatibility of oxide ceramics [20,30].
- Pocket Depth: Mean PPD was 3.2 ± 0.8 mm for teeth with supragingival margins, whereas teeth with subgingival margins showed a mean PPD of 4.6 ± 1.1 mm ($t = 4.32$, $p < 0.001$) [21].

Radiographic Bone Level

Radiographic assessment indicated progressive bone resorption.

- Time-Dependent Loss: ANOVA results showed that patients with prostheses >10 years old had significantly greater crestal bone loss (1.8 ± 0.4 mm) compared to the 5-10 year group (0.9 ± 0.2 mm) ($F = 12.45$, $p < 0.001$) [24].
- Correlation: A strong positive correlation was found between the Plaque Index and marginal bone loss ($r = 0.72$, $p < 0.001$), confirming that plaque retention factors are the primary drivers of anatomical destruction [17,28].

Functional and Marginal Integrity

According to USPHS criteria:

- Marginal Adaptation: 42% of metal-ceramic crowns showed "Charlie" ratings (crevice with dentin exposure) after 10 years, compared to only 15% of zirconia crowns ($p < 0.05$, χ^2 test) [22].
- Occlusion: T-Scan analysis revealed that 35% of patients had significant occlusal force discrepancies ($>15\%$ imbalance between left and right sides), which correlated with reported muscle fatigue [18,26].

4. Discussion

The results of this study statistically validate the hypothesis that the "survival" of a prosthesis does not guarantee the "health" of the oral cavity. The significant difference in gingival inflammation between zirconia and metal-ceramic

groups ($p < 0.01$) supports the findings of Scarano et al. [30], who demonstrated that zirconia exhibits lower bacterial adhesion and facilitates the formation of a biological seal.[4] This is a crucial consideration for clinical decision-making in the esthetic zone. The statistical correlation between subgingival margins and increased PPD ($p < 0.001$) reinforces the "Biological Width" concept described by Gargiulo et al. [29]. Violation of this space forces the periodontium to re-establish a healthy distance from the alveolar crest to the margin, inevitably leading to bone resorption and recession [21]. From a functional perspective, the high prevalence of occlusal interferences in long-term users suggests that differential wear rates between the restorative material (porcelain) and natural enamel lead to occlusal instability over time [27]. The use of rigid materials like zirconia requires precise occlusal adjustment, as verified by T-Scan data, to prevent the transmission of excessive forces to the crestal bone [19].

5. Conclusions

This study presents a comprehensive assessment of the anatomical and functional state of the oral cavity in patients with long-term (≥5 years) fixed prostheses. The findings substantiate the critical hypothesis that prosthesis "survival" does not guarantee the "health" of the oral environment. The long-term success of fixed partial dentures is determined not only by their retention and structural integrity but equally by the preservation of the supporting oral tissues and the maintenance of neuromuscular harmony. The results of this cross-sectional analysis revealed significant degradation in periodontal health proportional to the age and design of the restoration. A strong positive correlation was established between the duration of prosthesis function and crestal bone resorption ($r = 0.72$, $p < 0.001$), confirming that plaque retention factors represent the primary etiological agents of anatomical destruction.

Material Selection and Biocompatibility: The analysis demonstrated that zirconia-based restorations maintain significantly superior periodontal health indicators compared to metal-ceramic restorations (GI: 1.2 ± 0.3 vs. 2.1 ± 0.5, $p < 0.01$). This superiority reflects the lower bacterial adhesion capacity and enhanced biocompatibility of oxide ceramics, facilitating superior tissue integration and reducing inflammatory response.

Margin Design and Biological Width: Subgingival margin placement emerged as a critical predictor of compromised periodontal health, with affected teeth exhibiting significantly deeper probing pocket depths (4.6 ± 1.1 mm vs. 3.2 ± 0.8 mm for supragingival margins, $p < 0.001$). This finding reinforces the fundamental principle that violation of biological width necessitates forced reestablishment of the dentogingival junction, inevitably resulting in irreversible attachment loss and bone resorption.

Functional Stability and Occlusal Harmony: Digital occlusal analysis revealed that 35% of patients with long-term prostheses exhibited significant functional imbalances exceeding 15% force discrepancy between contralateral sides. These occlusal interferences correlated with abutment tooth mobility and were attributed to differential wear rates between the restorative materials and natural enamel, progressively destabilizing the masticatory system.

Radiographic Bone Level Changes: Progressive alveolar bone resorption was time-dependent, with prostheses functioning beyond 10 years demonstrating significantly greater crestal bone loss (1.8 ± 0.4 mm) compared to the 5-10 year group (0.9 ± 0.2 mm, $p < 0.001$). Forty-two percent of metal-ceramic crowns demonstrated marginal adaptation failure after 10 years, contrasting sharply with only 15% of zirconia restorations ($p < 0.05$).

Clinical Implications: The transition from assessing mere "survival" to comprehensive evaluation of "health" represents a fundamental paradigm shift in prosthodontic philosophy. Clinicians must prioritize evidence-based decision-making in material selection, restoration design, and maintenance protocols to ensure bio-functional stability. The implementation of supragingival margin designs, utilization of zirconia materials, precise occlusal adjustment verified by advanced diagnostic technology (T-Scan III), and rigorous periodic maintenance programs are essential to mitigate iatrogenic periodontal disease and preserve the integrity of supporting structures. In conclusion, while fixed partial dentures effectively rehabilitate mastication, esthetics, and phonetics, they inevitably induce progressive anatomical changes in the supporting periodontium. True clinical success demands that the health of the oral tissues supporting these restorations be preserved with equal priority to the retention of the prosthesis itself. Future clinical practice must embrace a holistic bio-functional approach, where the restoration is viewed not as an isolated entity but as an integral component of a dynamic biological system requiring continuous optimization and vigilant monitoring throughout its functional life.

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