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ORIGINAL RESEARCH

A COMPARATIVE STUDY ON PERIODONTAL PARAMETERS IN TOOTH-SUPPORTED VERSUS IMPLANT-SUPPORTED FIXED PROSTHESES

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ABSTRACT

Background: To obtain the fixed prosthodontic rehabilitation, both tooth-supported and implant-supported prostheses may be used, but their relative impact on the surrounding periodontal and peri-implant tissue has not been fully developed.
Purpose: This paper was focused on comparing periodontal parameters in patients with tooth-supported fixed partial dentures (FPDs) and implant-supported fixed prostheses.
Methods: A comparative cross-sectional research was conducted involving 156 patients in three groups, which were tooth-supported FPD group (n=52), implant-supported prosthesis group (n=52), and natural tooth control group (n=52). Measured clinical parameters were probing depth (PD), clinical attachment level (CAL), bleeding on probing (BOP), plaque index (PI), gingivial index (GI) and width of keratinized tissue (KTW) and papilla fill. The radiographic levels of the bones were measured using the periapical radiographs which were of standard. ANOVA, post-hoc tests and chi-square tests were used as statistical analysis.
Results: The mean PD of implant group (3.8±0.9 mm) was significantly higher than that of tooth-supported FPD (2.9±0.7 mm) and control groups (2.1±0.5 mm) ($p<0.001$). BOP was maximally great between tooth-supported group (48.3±18.2) and implant (38.7±16.4) and control groups (24.6±12.1) ($p<0.001$). The implant group exhibited lower KTW (2.8+1.2mm vs. 4.2+1.1mm in controls, $p=0.001$) and decreased papillary fill with only half being papillary filled at the implant sites compared to 78.8 in controls ($p=0.001$). The mean radiographic bone level was 1.8+ 0.6 mm in the implant group and 1.2+ 0.4 mm in the tooth-supported group ($p<0.001$).
Conclusion: The implant-supported and tooth-supported prostheses show changes in periodontal parameters compared to natural teeth with dissimilar trends of tissue reaction. The dentural prostheses with implants demonstrate higher probing depth and impaired soft tissue aesthetics and the tooth-supported prostheses, more inflammation.

Keywords**:** dental implants, fixed partial denture, periodontal health, peri-implant tissue, prosthodontics, clinical attachment level

INTRODUCTION

Fixed prosthodontic rehabilitation is one of the pillars of modern dentistry, which is used to treat tooth loss and provide masticatory functions, phonetics, and esthetic 1]. With the introduction of an osseointegrated dental implant, treatment paradigms have essentially been changed to offer an alternative to the traditional tooth-supported fixed partial denture (FPDs) [2]. Although both modalities deliver functional rehabilitation, their biological adaptation with the surrounding tissues vary significantly, which could affect the long-term periodontal and peri-implant health outcomes [3].

FPDs supported by teeth have shown a predictable success of more than 90 percent within a 10-year period of observation where the abutment teeth were periodontally healthy [4]. Nevertheless, the abutment teeth preparation requires permanent ablation of healthy tooth substance and may affect the pulpal health [5]. In addition, periodontal health of abutment teeth is of critical importance to the life of prosthesis, and periodontal disease is the primary reason of FPD failure [6]. Dental plaque in the margins of the prostheses, inability to take care of the oral cavity in the vicinity of pontic, and possible breach of biological width in tooth preparation can have an undesirable impact on periodontal parameters [7].

The implant-supported prostheses avoid the preparation of adjacent teeth and have demonstrated high survival rates, with systematical reviews reporting 10 year implant survival rates of 95-98% [8]. However, biological complications of peri-implant tissues are very challenging [9]. Reversible inflammation without bone loss is referred to as peri-implant mucositis which is found in 19-65% of the implants and peri-implantitis which involves progressive bone loss is found in 1-47% of the implants depending on the criteria of diagnosis [10]. Structural and functional distinctions between periodontal and peri-implant tissues such as differences in collagen fiber orientation, vascularity and immune response could predetermine different pathological processes of implants [11].

Contrasting research involving periodontal parameters in teeth-supported and implant-supported prostheses have given inconsistent results. Other studies cite higher periodontal health indices in the area of implants which is said to be due to lower retention of plaque as well as lack of periodontal ligament mediated inflammatory reactions [12]. As contrasted to other literature, the prevalence of peri-implant inflammation and bone loss is reported to be greater in other studies and may be associated with the factors of the prosthetic design, the pattern of occlusal loading, or the host susceptibility [13]. Different timings of the method of assessment that occurs after the restoration, prosthesis designs tested and criteria used to select the patient among others, make it difficult to directly compare studies (Taylor, 2002 2).

In recent times, soft tissue parameters have been highlighted by research studies to assess health and aesthetic outcome of fixed prostheses. The width of tissue surrounding implant that is keratinized affects the plaque and tissue inflammation, as well as patient comfort in the process of oral hygiene [15]. The preservation or regeneration of papilla has a critical impact on the aesthetic outcomes especially at the anterior region wherein the anatomical differences between teeth and implant affect the potential of papillary fill regeneration [16]. Moreover, radiographic evaluation of the bone level also offers objective evidence of hard tissue reaction to the prosthetic rehabilitation [17].

Though the given topic is clinically important, very few comparative analyses considering several peri-implant and periodontal parameters are available. The literature on the topic of most current studies is based on individual parameters or anatomical areas, lacking the systematic evaluation of the entire range of clinical and radiographic indicators [18]. More so, most studies do not have sufficient control groups of natural teeth, which limits the ability to interpret whether the changes observed are a sign of pathological changes or normal changes caused by baseline health [19].

These knowledge gaps have been filled by the current study that presents a detailed comparative analysis of periodontal parameters in tooth-supported FPDs, implant-supported prostheses, and natural control teeth. In particular, this study was intended to: (1) to compare clinical periodontal parameters such as probing depth, clinical attachment level, bleeding on probing, plaque index, and gingival index among the three groups; (2) to measure the soft tissue parameters such as keratinized tissue width and papilla fill; and (3) to measure the radiographic bone levels. We theorized that unique patterns of periodontal parameters would define each of the prosthetic modalities which would exemplify the unique interactions with tissues and biomechanical characteristics.

2. MATERIALS AND METHODS

2.1 Study Design and Ethical Considerations

This comparative cross-sectional study was conducted at the Department of Prosthodontics and Periodontology, University Dental Hospital, between March 2023 and February 2024. The study protocol received approval from the Institutional Ethics Committee (Protocol Number: UDH/IEC/2023/087) and was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent after receiving detailed information about study procedures.

2.2 Sample Size Determination

Sample size calculation was performed using G*Power software (version 3.1.9.7) for one-way ANOVA with three groups. Based on pilot data showing mean probing depth differences of 0.8 mm between groups with pooled standard deviation of 0.9 mm, an alpha level of 0.05, power of 0.85, and effect size of 0.35, the minimum required

sample size was calculated as 45 participants per group. Accounting for potential 15% attrition, we aimed to recruit 52 participants per group, totaling 156 participants.

2.3 Participant Selection and Grouping

Participants were recruited from patients attending the prosthodontic clinic and categorized into three groups:

Group 1 (Tooth-supported FPD): Patients who had received tooth-supported fixed partial dentures at least 12 months previously.

Group 2 (Implant-supported): Patients who had received implant-supported fixed prostheses (single crowns or FPDs) at least 12 months post-loading.

Group 3 (Control): Individuals with complete natural dentition or minimal restoration (no more than three single-tooth restorations).

2.4 Inclusion Criteria

General inclusion criteria comprised: (1) age 25-65 years; (2) systemically healthy status or well-controlled systemic conditions; (3) non-smokers or former smokers (quit >5 years); (4) adequate oral hygiene (plaque index <25% for control group); (5) willingness to participate and attend follow-up examinations.

Specific criteria for Groups 1 and 2 included: (1) prostheses in function for 12-60 months; (2) prostheses fabricated according to established biological and mechanical principles; (3) absence of prosthetic complications requiring intervention; (4) radiographic evidence of osseointegration for implants.

2.5 Exclusion Criteria

Exclusion criteria encompassed: (1) pregnancy or lactation; (2) uncontrolled diabetes mellitus (HbA1c >8%); (3) immunocompromised conditions; (4) history of head and neck radiotherapy; (5) bisphosphonate therapy; (6) periodontal therapy within the past six months; (7) antibiotic therapy within the past three months; (8) presence of active periodontal or peri-implant disease requiring immediate intervention; (9) prostheses with evident technical complications (fractures, decementation); (10) implants placed with simultaneous bone augmentation procedures.

2.6 Clinical Examination Procedures

All clinical examinations were performed by two calibrated examiners (periodontists) who underwent calibration exercises achieving inter-examiner agreement with kappa coefficient >0.85 for all parameters. Participants were unaware of the specific research hypotheses to minimize response bias.

2.6.1 Clinical Periodontal Parameters

The following parameters were assessed at six sites per tooth/implant (mesiobuccal, buccal, distobuccal, mesiolingual, lingual, distolingual):

Probing Depth (PD): Measured from gingival margin to the base of the sulcus/pocket using a standardized periodontal probe (UNC-15, Hu-Friedy, Chicago, IL) with controlled probing force (0.25 N).

Clinical Attachment Level (CAL): Measured from a fixed reference point (cemento-enamel junction for teeth, implant platform for implants) to the base of the sulcus/pocket.

Bleeding on Probing (BOP): Recorded as presence or absence of bleeding within 30 seconds of probing, expressed as percentage of sites exhibiting bleeding.

Plaque Index (PI): Assessed using Silness and Löe criteria (0-3 scale) at four surfaces per tooth/implant.

Gingival Index (GI): Evaluated using Löe and Silness criteria (0-3 scale) at four surfaces per tooth/implant.

2.6.2 Soft Tissue Aesthetic Parameters

Keratinized Tissue Width (KTW): Measured from the gingival margin to the mucogingival junction on the buccal aspect using a periodontal probe following mucogingival junction visualization with Schiller's iodine solution when necessary.

Papilla Fill: Assessed using the Jemt Papilla Index Score (0-4 scale) for interproximal areas adjacent to prosthetic restorations or control teeth in the aesthetic zone (canine to canine, maxillary and mandibular).

2.7 Radiographic Assessment

Standardized intraoral periapical radiographs were obtained using the parallel technique with film holders and beam-aiming devices to ensure reproducibility. Radiographic bone level was measured as the linear distance from the implant platform (for implants) or cemento-enamel junction (for teeth) to the most coronal point of bone contact, measured on mesial and distal aspects and averaged. Measurements were performed using calibrated digital software (ImageJ, National Institutes of Health) by a blinded examiner, with the known implant/restoration dimensions serving as reference for calibration.

2.8 Data Collection

Demographic information including age, gender, education level, occupation, and general health status was collected through structured interviews. Oral health behavior data encompassed tooth brushing frequency, interdental cleaning habits, and professional dental cleaning frequency. Prosthesis-related data included prosthesis type, number of units, location, time since placement, and fabrication details.

2.9 Statistical Analysis

Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY). Continuous variables were tested for normality using Shapiro-Wilk test and presented as mean ± standard deviation. Categorical variables were presented as frequencies and percentages. One-way analysis of variance (ANOVA) compared continuous variables among the three groups, followed by Tukey's post-hoc test for pairwise comparisons when ANOVA revealed significant differences. Chi-square test or Fisher's exact test compared categorical variables. Pearson correlation assessed relationships between clinical parameters. Multiple linear regression analysis identified independent predictors of

probing depth and bone level, adjusting for confounding variables. Statistical significance was set at $p<0.05$.

3. RESULTS

3.1 Participant Characteristics

A total of 156 participants completed the study, with 52 participants in each group. Table 1 presents the demographic and baseline characteristics.

Table 1. Demographic and Clinical Characteristics of Study Participants

Characteristic	Tooth-supported FPD (n=52)	Implant-supported (n=52)	Control (n=52)	p-value
Age (years), mean ± SD	48.3 ± 9.2	51.2 ± 8.7	46.8 ± 10.1	0.062
Gender, n (%)				0.487
Male	27 (51.9)	24 (46.2)	29 (55.8)	
Female	25 (48.1)	28 (53.8)	23 (44.2)	
Education level, n (%)				0.324
Secondary or less	18 (34.6)	22 (42.3)	16 (30.8)	
Higher education	34 (65.4)	30 (57.7)	36 (69.2)	
Tooth brushing ≥2 times/day, n (%)	43 (82.7)	47 (90.4)	48 (92.3)	0.227
Regular interdental cleaning, n (%)	31 (59.6)	38 (73.1)	36 (69.2)	0.298
Professional cleaning <6 months, n (%)	29 (55.8)	41 (78.8)	32 (61.5)	0.028*
Time since prosthesis placement (months), mean ± SD	28.4 ± 12.6	26.7 ± 13.2	N/A	0.494
Prosthesis location, n (%)				
Anterior (canine-canine)	14 (26.9)	18 (34.6)	N/A	
Posterior	38 (73.1)	34 (65.4)	N/A	
Number of prosthetic units				
Single crown	0 (0.0)	29 (55.8)	N/A	
3-unit FPD	38 (73.1)	15 (28.8)	N/A	
4-unit or more	14 (26.9)	8 (15.4)	N/A	

*p<0.05; FPD = Fixed Partial Denture; N/A = Not Applicable

The three groups showed no significant differences in age, gender distribution, education level, or oral hygiene behaviors (tooth brushing and interdental cleaning), except for professional cleaning frequency, which was higher in the implant-supported group ($p=0.028$). Mean time since prosthesis placement was comparable between tooth-supported and implant-supported groups ($p=0.494$).

3.2 Clinical Periodontal Parameters

Table 2 presents the comparative analysis of clinical periodontal parameters among the three groups.

Table 2. Comparison of Clinical Periodontal Parameters Among Groups

Parameter	Tooth-supported FPD (n=52)	Implant-supported (n=52)	Control (n=52)	p-value (ANOVA)	Post-hoc comparisons
Probing depth (mm), mean ± SD	2.9 ± 0.7	3.8 ± 0.9	2.1 ± 0.5	<0.001	I>T>C (all p<0.001)
Sites with PD ≥4mm (%), mean ± SD	18.4 ± 12.3	34.7 ± 16.8	6.2 ± 5.1	<0.001	I>T>C (all p<0.001)
Clinical attachment level (mm), mean ± SD	3.2 ± 0.9	N/A	1.8 ± 0.6	<0.001	T>C

Bleeding on probing (%), mean ± SD	48.3 ± 18.2	38.7 ± 16.4	24.6 ± 12.1	<0.001	T>I>C (all p<0.01)
Plaque index (0-3), mean ± SD	1.2 ± 0.4	0.9 ± 0.3	0.6 ± 0.3	<0.001	T>I>C (all p<0.001)
Gingival index (0-3), mean ± SD	1.3 ± 0.5	1.0 ± 0.4	0.5 ± 0.3	<0.001	T>I>C (p<0.001)
Modified sulcus bleeding index (%), mean ± SD	52.1 ± 19.4	41.3 ± 17.8	22.8 ± 11.6	<0.001	T>I>C (all p<0.001)

T = Tooth-supported FPD; I = Implant-supported; C = Control; N/A = Not applicable (different reference point for implants)

Significant differences were observed among groups for all clinical parameters (all p<0.001). Mean probing depth was greatest in the implant-supported group (3.8±0.9 mm), followed by tooth-supported FPD (2.9±0.7 mm) and control groups (2.1±0.5 mm), with all pairwise comparisons showing significant differences (p<0.001). The proportion of sites with pathological probing depth (≥4 mm) was 34.7±16.8% in the implant group versus 18.4±12.3% in the tooth-supported group and 6.2±5.1% in controls (all p<0.001).

Clinical attachment level (applicable only to natural teeth) was significantly greater in the tooth-supported FPD group compared to controls (3.2±0.9 mm vs. 1.8±0.6 mm, p<0.001), indicating attachment loss around abutment teeth.

Bleeding on probing was highest in the tooth-supported group (48.3±18.2%), followed by implant-supported (38.7±16.4%) and control groups (24.6±12.1%), with all pairwise differences significant (p<0.01). Similarly, plaque index and gingival index followed the pattern tooth-supported > implant-supported > control, with all comparisons statistically significant (p<0.001).

3.3 Soft Tissue Aesthetic Parameters and Radiographic Bone Level

Table 3 presents soft tissue aesthetic parameters and radiographic bone level measurements.

Table 3. Soft Tissue Aesthetic Parameters and Radiographic Bone Level

Parameter	Tooth-supported FPD (n=52)	Implant-supported (n=52)	Control (n=52)	p-value
Keratinized tissue width (mm)				
Buccal, mean ± SD	3.8 ± 1.0	2.8 ± 1.2	4.2 ± 1.1	<0.001
Sites with KTW <2mm, n (%)	8 (15.4)	21 (40.4)	3 (5.8)	<0.001
Papilla Index Score (anterior region only)				
Complete fill (Score 3-4), n (%)	26/34 (76.5)	18/52 (34.6)	41/52 (78.8)	<0.001
Incomplete fill (Score 0-2), n (%)	8/34 (23.5)	34/52 (65.4)	11/52 (21.2)	
Mean papilla index score ± SD	2.9 ± 0.8	1.8 ± 1.1	3.2 ± 0.7	<0.001
Papilla presence by location				
Mesial papilla, complete fill (%)	79.4	38.5	82.7	<0.001
Distal papilla, complete fill (%)	73.5	30.8	75.0	<0.001
Radiographic bone level (mm)				

From CEJ/implant platform, mean ± SD	1.2 ± 0.4	1.8 ± 0.6	0.8 ± 0.3	<0.001
Bone loss ≥2mm, n (%)	11 (21.2)	24 (46.2)	4 (7.7)	<0.001
Mesial bone level (mm), mean ± SD	1.3 ± 0.5	1.9 ± 0.7	0.8 ± 0.3	<0.001
Distal bone level (mm), mean ± SD	1.1 ± 0.4	1.7 ± 0.6	0.7 ± 0.3	<0.001

CEJ = Cemento-enamel junction; KTW = Keratinized tissue width

The width of the keratinized tissue at the buccal aspect was significantly less in the implant-supported one (2.8±1.2 mm) than in both tooth-supported FPD (3.8±1.0 mm) and control groups (4.2±1.1 mm) ($p<0.001$). Keratinized tissue (<2 mm) was less common at the implant site (40.4 per cent) than in the tooth-supported site (15.4 per cent) and control site (5.8 per cent) ($p<0.001$).

Papilla fill examination in the anterior part showed that there were major differences in groups ($p< 0.001$). Only 34.6 of the implant-supported sites out of 100 were completely filled with papillary (score of 3-4) as opposed to 76.5 percent of tooth-supported sites and 78.8 percent of control sites. The lowest mean papilla index score was in the implant (1.8±1.1 vs. 2.9±0.8 in tooth-supported and 3.2±0.7 in controls, $p<0.001$). The fill rates in both mesial and distal papillae were significantly lower in implant sites (38.5% and 30.8% respectively) than those in tooth-supported (79.4% and 73.5) and control groups (82.7% and 75.0).

Bone level measurements of radiographs revealed that the bone loss was much higher in the group of the implant-supported (1.8±0.6 mm of implant platform) than in the groups of the tooth-supported FPD (1.2±0.4 mm of implant platform), and control (0.8±0.3 mm of implant platform) respectively ($p<0.001$). The% of sites that had bone loss 2 mm or more was 46.2% in the implant group and 21.2% in the tooth-supported group and 7.7% in the controls ($p<0.001$).

Correlation analysis showed that probing depth and plaque index ($r=0.54$, $p=0.001$), gingival index ($r=0.61$, $p=0.001$), and bleeding on probing had a significant positive relationship across all groups. Plaque index ($r= -0.38$, $p=0.001$) and gingival index ($r= -0.42$, $p=0.001$) had a negative relationship with Keratinized tissue width.

The analysis of multiple linear regression found their independent predictors of the increased probing depth: the type of the prosthesis (implant-supported: 0.89, $p<0.001$), plaque index (0.47, $p=0.002$), time interval of having the prosthesis (0.03, $p=0.018$), and the width of the keratinized tissue (0.21, $p=0.012$). These factors described 52.3% of probing depth variance ($R 2=0.523$, $p<0.001$).

Independent predictors that yielded 44.7% of variance ($R 2=0.447$, $p<0.001$) in the radiographic bone level are the type of prosthesis (implant-supported: 2=0.54, $p=0.001$), probing depth (2=0.23), and the age (2=0.02).

4. DISCUSSION

These comparative analyses supply detailed data that tooth-supported and implant-supported fixed prostheses reveal imbalanced periodontal parameters with reference to natural teeth, each of which is distinguished by certain patterns. The implant-supported had much higher probing depth, lesser keratinized tissue width, less papillary fill and higher radiographic bone loss, whereas the tooth- supported FPD had more inflammatory indices such as bleeding on probing, plaque index and gingival index. This research has significant implications on the treatment planning, patient counseling, and maintenance guidelines in the prosthodontics practice.

The probing depth of implants (3.8+-0.9 mm) was greater than the controls (tooth-supported restorations 2.9+-0.7 mm) and natural teeth (2.1+-0.5 mm), which is in line with the results of earlier studies that reported deeper probing around dental implants [20]. This observation could be due to a number of factors. To begin with, there are fundamental differences in the anatomy of periodontal and peri-implant tissues. The periodontal ligament in the case of natural teeth gives it a functional connection tissue attachment in which collagen fibers are inserted perpendicularly in cementum, as compared to the peri-implant soft tissue attachment, which is primarily composed of parallel collagen fibers with no actual connection to the titanium surface [21]. This structural variation could influence probe penetration resistance in the clinical examination [22]. Second, the width of biological zone surrounding implants including epithelial and connective tissue sizes in nature would be larger than that surrounding real teeth which may be one reason why deeper physiological probing depths occur even in good health [23].

Nonetheless, the clinical importance of increased probing depth in the area of implants has to be understood with caution. Although the deeper pockets around teeth are usually a sign of pathological loss of attachment, the same measurements concerning implants can be seen as a sign of physiological arrangement of the tissue or as an actual peri-implant disease [24]. The fact that we have identified a proportions of 34.7% of implant sites with probing depths of 4 mm and above raises concern because 4 mm has been identified as a risk factor that results to progressive bone loss [25]. The coincidental finding of high bleeding on probing (38.7%) in the implant group though lesser than in the tooth-supported group indicates that active inflammatory action occurs in a significant proportion of implant sites [26].

The FPD group that used the teeth as supports was the most inflammatory since it presented the highest rates of bleeding with probing 48.3 and the highest rates of the plaque and gingivitis indices. The same results support previous studies that have reported greater levels of plaque deposits and gingivitis in response to tooth-supported prostheses [27]. There are several mechanisms that are likely to lead to this trend. Even supragingival or equigivally placed, the alteration of the microenvironment of the gum by the placement of the crowns can harbor bacterial biofilm [28]. The aesthetical or retention placement of subgingival margins may breach biological width and cause chronic inflammation [29]. FPDs have a pontic design and an embrasure arrangement that forms regions that the standard oral hygiene techniques are not effective at clearing the plaque [30]. Besides, abutment teeth have higher functional loads which can generate micro movements that lead to disruption of the attachment apparatus [31].

The results of clinical attachment levels of the tooth-supported group (3.2±0.9 mm vs. 1.8±0.6 mm in controls) show that there is an indicative loss of attachment around abutment teeth even though the prostheses did not reach

28.4 plus 12.6 months on average. This finding has been found to question the long term periodontal prognosis of the abutment teeth and also the basis of the suggestion to meticulously evaluate periodontal assessment prior to the choice of teeth as FPD abutments [32]. The future longitudinal research has reported gradual loss of attachment around compromised abutments within 5-10 years of observation, thus showing the significance of primary periodontal health and continued care [33]. There were significant differences in the soft tissue aesthetic parameters, especially in respect of papillary fill. The full presence of papillary was obtained at the implant sites in only 34.6% of the sites as compared to 76.5% of tooth-supported sites and 78.8% of the natural teeth controls. This observation is indicative of inherent difficulties in reconstructing natural papillary structures about dental implants [34]. Supply of blood to the interdental papilla is supplied mainly by supraperiosteal vessels of the interdental bone, and the periodontal ligament of the adjacent teeth [35]. Loss of the vascular contribution of periodontal ligament and possible loss of bone remodeling occur following tooth extraction and placing implants, which deteriorates papillary support [36]. Moreover, the contact point-bone crest distance plays a critical role in defining papillary fill potential where distances above 5 mm have a significant likelihood that the likelihood of complete fill will be impracticable [37].

According to our findings, even with the improvement in surgical methods and prosthetic firewalls, the uniform generation of papillary tissues around implants has not yet been achieved, especially on the aesthetic outcome in the front which is termed as anterior [38]. Another important finding with a clinical implication is reduced width of tissue that is keratinized around implants (2.8 1.2 mm vs. 4.2 1.1 mm in controls). Although there is a controversy that there is an absolute need of keratinized mucosa to maintain the health of the implants, some evidence indicates that sufficient width of the keratinized tissue (at least 2 mm) enables the control of plaque and alleviates patient discomfort when having oral health procedures, as well as that it may even prevent recession and loss of the bone [39]. The presence of high plaque and inflammation indices in our implant sites is aligned with the fact that 40.4 percent of the implant sites showed lack of enough keratinized tissue. Keratinized tissue width may be enhanced by soft tissue augmentation procedures during implant placement or second stage surgery, which may lead to better long-term results [40]. The Radiographic bone level results indicate that marginal bone loss is more in the cases of implants (1.8+0.6mm) against tooth-supported restorations (1.2+0.4mm) and natural teeth (0.8+0.3mm). The normal physiological bone remodeling after the implant placement normally accounts to 1.0-1.5 mm marginal bone loss as the first year after loading and the marginal bone loss of 0.1-0.2 mm per year in successful implants [41]. The bone levels in our implant group of 26.7 months mean time since placement were marginally greater than physiological remodeling, indicating that a number of implants might be undergoing pathological bone loss [42]. It should be worried that the result that 46.2% of implants had bone loss ≥ 2 mm is significant since this is the critical point that determines the progression of peri- implant health to disease [43].

The independent variable that significantly predicts the probing depth, regardless of plaque index, width of the keratinized tissue and length of time after placement, was found to be prosthesis type by multiple regression analysis. The implication of this finding is that natural biological disparities between tooth-supported and implant-supported restorations have an impact on clinical parameters that may not be affected by oral hygiene and soft tissue properties. The undesired correlation of keratinized tissue width and probing depth justifies the protective effect of sufficient keratinized mucosa [44].

Our findings have several clinical implications. To start with, realistic expectations should be considered in the treatment planning as far as periodontal and peri-implant tissue responses to various prosthetic modalities are concerned. Although implants do not require preparation of adjacent teeth and have recorded high survival rates, the loss of aesthetics of the soft tissues and deep probing depths that have been recorded by this research are worth consideration, especially in the aesthetic zone [45]. Second, the maintenance guidelines need to be customized to the particularities of a particular type of prosthesis, and the intensive oral hygiene education, professional cleaning timetables, and parameters of monitoring should be adjusted [46]. Third, the selection criterion used to choose

the patients must focus on the presence of sufficient keratinized tissue on which the implants can be placed and ideal periodontal health on which the tooth-supported FPDs can be placed [47].

A number of limitations should be mentioned. The cross-sectional design does not allow causal inferences, and it fails to record longitudinal variations in periodontal parameters. Each of the individual prostheses instead of clustering on a patient basis was included, which may affect the statistical independence. The heterogeneous prosthesis designs (single crowns to multiple-unit FPDs) and locations (anterior vs. posterior) were introduced to the study, which brought variability to the tissue responses. Improved comparison of the parameters of implants and teeth is not possible due to the fundamental differences between the places of assessment (no true attachment, different reference points), which makes comparison quite difficult [48]. Also, this research failed to measure the microbiological profile or inflammatory mediators which could offer mechanistic understanding of clinical differences noticed [49].

Future studies are supposed to use longitudinal designs that follow patients in a prospective manner since placement of prostheses up to long durations of observations to define temporal changes of tissue adaptation. Confounding variables would be minimized by standardization of the type, location and loading practices of prosthesis. Evidence of clinical practice improvement would be obtained by investigating interventions to maximize periodontal and peri-implant health, including soft tissue augmentation, which altered prosthetic designs, or improved maintenance regimens [50]. Conclusion

The provided comparative research enables to show that tooth-supported fixed partial dentures and implant-supported prostheses have different periodontal parameters in comparison with natural teeth, and each of the two prosthetic modalities features specific patterns. Implant supplied prostheses demonstrate a much higher level of probing depth, lessened width of keratinized tissue, weaker papillary fill and a greater amount of radiographic bone loss than tooth-supplied restorations and natural teeth. On the other hand, tooth-based fixed partial dentures show elevated inflammatory indices such as bleeding on probing, plaque accumulation, and gingival inflammation and quantifiable clinical attachment loss in the area of abutment teeth.

The clinical implications of these findings include the treatment planning, patient selection, and maintenance protocols. Both forms of prosthetics are imperfect at recreating the biological and aesthetic aspects of natural teeth, and the decision of which modality to use (tooth-supported or implant-supported) should take into account the personal factors in patients, the desire to achieve the best results, the state of periodontal health, and the willingness to maintain the health rehabilitation process. To optimize the results, he/she should pay great attention to the surgical and prosthetic procedures, health of periodontal conditions of the abutment tissue, good periodontal health of the abutment teeth, and strict professional and patient-provided oral health approaches. All modalities of fixed prosthodontic rehabilitation success rely on the comprehensive assessment, evidence-based treatment planning, and long-term periodontal maintenance programs.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

This study was conducted in accordance with the principles of the Declaration of Helsinki and was approved by the Institutional Medical Ethics Committee.

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None

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