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Original Article

Association between Height of Interproximal Papilla and Different Clinical Parameters

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ABSTRACT

Objective: To assess interdental cleaning habits, demographic factors, and clinical parameters, and analyze their association with the height of the interproximal papilla over a defined study period.
Study Design: Analytical cross-sectional study.
Place and Duration of Study: Armed Forces Institute of Dentistry (AFID) Rawalpindi, Pakistan, from Apr to Sep 2024.
Methodology: A total of 29 subjects were selected for examining 202 interproximal papillae of the anterior maxillary region. Norland and Tarnow classification system was used for clinically classifying the interproximal papillae, with score range 0 to 3. By using periodontal probe transparency through the marginal gingiva, the periodontal phenotype was evaluated. Along with this, height of contact point and height of the papilla was also measured.
Results: Age positively correlated with papilla scores but negatively with papilla height (p<0.001). Height of the contact point showed a negative correlation with both papilla scores and height (p<0.001). Periodontal phenotype negatively correlated with papilla scores but positively with papilla height (p<0.001). Interdental brushing showed a non-significant negative correlation with papilla score (r = -1.82, p=0.345) but a statistically significant though weak positive correlation with papilla height (r = 0.390, p=.037). A significant positive correlation was found between flossing and height of papilla (r = 0.433, p=0.019) and a non-significant correlation with papilla score.
Conclusion: Interproximal papilla height correlated significantly with age, periodontal phenotype, and contact point height. Furthermore, interdental cleaning practices exhibited a positive, though weak correlation with papilla height.

Keywords: Gingival Recession, Papilla Height, Peridontium, Periodontal Phenotype

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INTRODUCTION

The interproximal papilla plays an important role in dental aesthetics and periodontal health. Insufficient tissue results in black triangle formation that compromises smile aesthetics and perpetuates plaque accumulation that can be contributing to both periodontal and peri-implant disease.[1] As patients expect aesthetic outcomes from dentistry to a greater degree nowadays, papillary integrity preservation has become an important restorative goal in addition to surgery.[2] Understanding the factors influencing papillary height is important for practitioners to achieve lasting and predictable esthetic results.[3]

Current research recognizes specific factors underlying papilla morphology. Tarnow *et al*., devised the fundamental "5mm rule," demonstrating that when the distance from the contact point to the alveolar crest is ≤5mm, papilla occupies the space 98% of the time, whereas at ≥7mm, this reduces to 56%.[4] Martegani *et al*., further correlated papilla height with proximal root anatomy, finding narrower embrasure spaces to have 2.1x more papilla fill (p<0.05).[5] Periodontal biotype also plays a role: Chang *et al*., showed that thick gingival phenotypes had 1.8mm taller papillae than thin biotypes (p=0.03),6 and Koori et al. associated thicker biotypes with more papilla preservation after extraction (OR = 3.2).[7] Yet, Chow *et al*., pointed out that even with optimal bone levels, 38% of implant sites showed papillary deficiencies, implying other contributing factors like soft tissue thickness or oral hygiene.[8]

In spite of these findings, significant gaps persist. Most studies center on bone levels or biotype, whereas modifiable variables—interdental cleaning habits, contact point position, and patient age—remain underinvestigated. We aimed to fill this gap by examining correlations between papilla height and clinical variables such as periodontal phenotype, oral hygiene, and proximal tooth morphology.

METHODOLOGY

This cross-sectional study was conducted in the outpatient department of Armed Forces Institute of Dentistry (AFID), Rawalpindi, Pakistan from April to

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September 2024. The ethical approval for this study was obtained from the Ethical Review Board (ERB) of AFID (vide letter no, 561/34216).

Inclusion Criteria: Patients of either gender above the age of 18 having intact anterior dentition (teeth numbered 14 to 24 in the FDI system, i.e., maxillary right first premolar to maxillary left canine) and those with no underlying pathologies, which had an impact on periodontium, periodontitis or past history of periodontitis were included.

Exclusion Criteria: Patient with previous or undergoing orthodontic treatment, diastemas, signs of high attrition of the incisal edges, gingival hypertrophy, and caries as well as pregnant or lactating women were excluded.

Sample size was calculated using the WHO calculator. The initial calculation (n = 254 sites) was adjusted for clustering using Shih's (1997) method, yielding a target of 23 participants.9 Using nonprobability convenience sampling, we included 29 patients, after taking informed consent.

Norland and Tarnow classification system was used for clinical classification of interproximal papillae. The score ranged from 0 to 3.

Score 0: the interproximal papillae cover the whole embrasure up to highest point of surface, or the point of contact.

Score 1: the top of the papillae lies between the point of contact and the upper edge of the interproximal enamel-cement junction.

Score 2: the papillae apex is located at or beneath the interproximal ECJ, but is coronal to lowest edge of the facial SCJ.

Score 3: the papillae is either at the same level or below the most apical part of the facial ECJ.

The type of periodontal phenotype was confirmed by using a periodontal probe (CPU 15 UNC; Hu-Friedys). Visibility of the probe on the edge of the gum was assessed. In the case of visible probe, it was scored 0, which indicated thin periodontal phenotype. Whereas, if the probe was not visible it was scored 1, indicating thick periodontal phenotype. The height of contact point was the distance measured through the edge of the gum tissue lying between the two teeth to an imaginary straight line that connects the highest point of the margins of the gums (gingival zeniths) of these two teeth. Information about interdental brushing and flossing was collected through binary questions asked by the examiner. The examiner inquired whether the subjects performed interdental brushing (yes or no) and whether they practiced flossing (yes or no). In order to ensure consistency, the examiner performed repetitive measurements of 5 individuals before the study. Inter-rater reliability was attained by pre-study calibration of the sole examiner, showing high agreement (κ = 0.85 for papilla scores, ICC > 0.9 for continuous measurements). To ensure statistical independence, papilla scores and heights were averaged across all measured sites for each participant prior to analysis.

Data was analyzed by Statistical Package for Social Science (SPSS) version 26. Spearman's rank correlation was used to study relationship between various parameters (age, height of contact point, and periodontal phenotype) and PSs/heights (papilla scores and height). A p value of ≤ 0.05 was considered significant.

RESULTS

From a total of 29 subjects included in the study, 202 interproximal papillae were examined. The subjects had a mean age of 34.76±8.2 years with a gender distribution of 15(51.72%) males and 14(48.27%) females. Table-I presents the clinical (papilla height, papilla score, and periodontal phenotype) and interdental cleaning (interdental brushing, and flossing) characteristics of the subjects.

Table-I. Clinical and Interdental Cleaning Characteristics of the Participants (n = 29)

Variables	Value
Papilla height	
Mean ± SD	4.21 ± 1.3
Papilla Score	
Score 0	21(72.4%)
Score 1	6(20.7%)
Score 2	2(6.9%)
Score 3	0(0%)
Periodontal Phenotype	
Thick phenotype	21(72.4%)
Thin phenotype	8(27.59%)
Interdental brushing	
Yes	19(65.52%)
No	10(34.48%)
Flossing	
Yes	9(55.17%)
No	20(68.97%)

Table-II provides a summary of the distribution of recession cases (scores of 1 or higher) based on their specific locations. The inter-incisal papilla (site 11-21) presented the greatest percentage of recession cases (Score ≥1) with 11 findings (37.93% of subjects), followed by sites 11-12 (41.38% including 4 cases Score

2) and 12-13 (37.93%). Site 23-24 presented full preservation of papillae (100% Score 0), whereas other posterior sites (13-14, 22-23) presented reduced recession percentages (10.34% and 24.14% respectively). Moderate recession (Score 2) was seen at site 11-12 (4 cases, 13.79%) alone. No severe recession (Score 3) cases were seen at any site.

Table-II: Frequency Distribution of the Papilla score based on Interproximal Papilla Location

Location	Score 0	Score 1	Score 2	Score 3
11-21	18(62.07%)	11(37.93%)	0(0%)	0(0%)
11-12	17(58.62%)	8(27.59%)	4(13.79%)	0(0%)
12-13	18(62.07%)	11(37.93%)	0(0%)	0(0%)
13-14	26(89.66%)	3(10.34%)	0(0%)	0(0%)
21-22	20(68.97%)	9(31.03%)	0(0%)	0(0%)
22-23	22(75.86%)	7(24.14%)	0(0%)	0(0%)
23-24	29(100%)	0 (0%)	0(0%)	0(0%)

Note: The scores were assigned to each papilla according to Norland and Tarnow's classification criteria

Figure-1 shows the correlation analysis showed significant associations between interproximal papilla characteristics and clinical variables. For papilla scores (PS), we found a high positive correlation with age (r = 0.785, p< 0.001), suggesting increased recession in older patients. Strong negative correlations were found between PS and contact point height (r = -0.768, p<0.001) and PS and periodontal phenotype (r = -0.990, p < 0.001), which showed higher contact points and thicker phenotypes to be correlated with reduced recession. Neither interdental brushing (r = -1.82, p = 0.345) nor flossing (r = -0.222, p = 0.246) significantly affected papilla scores.

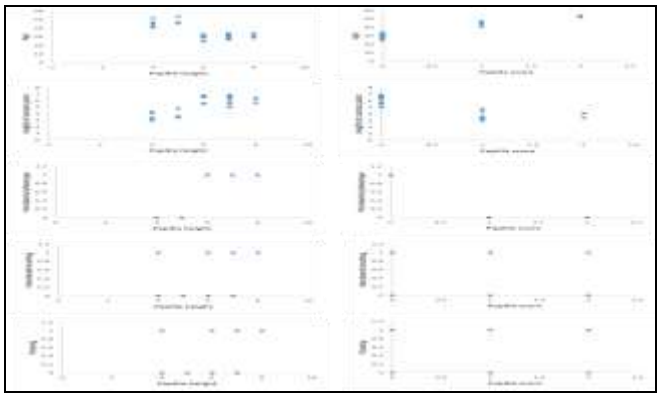

Figure-1. Correlation Analysis between Interproximal Papilla Characteristics and various Clinical Parameters.

For papilla height (HP), age had a moderate negative correlation (r = -0.591, p = 0.001), whereas contact point height had a strong negative correlation (r = -0.803, p < 0.001). Periodontal phenotype had a strong positive correlation with HP (r = 0.810, p < 0.001), affirming that thicker phenotypes support more papilla height. Flossing (r = 0.433, p = 0.019) and interdental brushing (r = 0.390, p = 0.037) had weak yet statistically significant positive correlations with papilla height.

DISCUSSION

The present study revealed strong associations between interproximal papilla morphologies with the clinical parameters. Papilla recession showed strong positive correlation with age (r = 0.785, p< 0.001) and contact points had strong inverse correlation (r = −0.786, p < 0.001) with papilla recession where higher amount of papilla recessions found, whereas thicker periodontal phenotypes (r = 0.810, p < 0.001) showed significant retention of papilla. Interdental brushing (r = 0.390, p = 0.037) and flossing (r = 0.433, p= 0.019) showed weaker but significant correlation with papilla height.

Comparison with previous studies shows consistency with the findings from international literature.[10,11] Our results are consistent with Chowdhary *et al.,* who found that increasing age is associated with papilla recession, which affects both papilla height and fill.[12] Another similar study conducted by Ahmed *et al.* in Pakistan found that an increase in age results in a higher papilla score and suggests compensatory changes in tissue appearance rather than structural elevation.[13] Similarly, a study in the Pakistani cohort by Khan *et al.* reported individuals with a thin periodontal phenotype had less papilla fill.[14] Our results confirm those of Khaireddine et al., who found similar high correlations between papilla height and periodontal phenotype (r = 0.81, p < 0.001) in their cross-sectional study of 112 patients. They also reported a similar strong age correlation (r = 0.76 compared to r = 0.79 reported in our study), studying a younger patient cohort (18-45 years).[15] The strong association between contact point location and preservation of papilla underpins Patel *et al.*'s systematic review finding that coronal contact point placement is important for preserving papilla.[16] In terms of oral hygiene effects, our findings are in partial disagreement with Barakat et al.'s review that reported data favouring interdental cleaning in the preservation of papilla.[17] Difference in results obtained in this study with Barakat could be due to our emphasis on anterior teeth as compared to their inclusion of posterior sites with poorer cleaning efficacy. Yet, significant correlations observed in this study (r = 0. 433 for flossing and r = 0. 390 for

interdental brushing) are closer to Kolte *et al.*'s report that good interdental cleaning was able to keep papilla height intact in thick biotypes ($p < 0.05$).18 Correlation between flossing and papilla height (r = 0.433) are significantly stronger than Basali *et al*. who reported (r = 0.18), [19] perhaps because we measured actual papilla height, not merely bleeding indices. The non-significant, weak correlations between interdental hygiene habits (cleaning: r = -1.32, $p = 0.495$; flossing: r = -0.170, $p = 0.377$) and papilla scores can be explained by several important factors. Even though previous research has documented the papilla recession with age, our study uniquely emphasizes the increase in papilla score simultaneously, suggesting that the changes in tissue density and volume may compensate for the reduction in height. Additionally, our findings further highlight the significance of periodontal phenotype in assessing papilla stability and thus lay a basis for individualized periodontal treatment strategies. The fact that thick periodontal phenotypes (72.4%) were dominant in our sample likely masked any potential effects of hygiene, as new evidence shows thick biotypes preserve papillary architecture independent of hygiene habits.[20] Second, our binary (yes/no) hygiene assessment lacked granularity to detect technique or frequency differences - a critical limitation given that only standardized, supervised hygiene protocols show consistent clinical impacts.[21] Early assessment of periodontal phenotype and contact point height should be given utmost priority in the assessment of patients at risk for papilla loss and the development of preventive and regenerative strategies. The preservation or regeneration of the interproximal papilla, for example, can be facilitated by periodontal treatments like in soft tissue grafting or prosthodontic contact point height adjustment.[22]

LIMITATION OF STUDY

The study had a few limitations such as the challenging nature of soft tissue such as the papilla for recording measurements can be attributed due to its ability to be deformed and easily compressed when pressure is applied. This can make it difficult to estimate the true size of the papilla which can introduce inaccuracies. First, although a calibrated examiner minimized inter-observer variation, intra-operator variation was not formally evaluated through test-retest reliability statistics. Second, we failed to adjust for confounding variables like smoking status or generalized health conditions known to affect gingival blood supply and tissue type. Third, the binary (yes/no) measurement of oral hygiene habits did not identify important subtleties such as the frequency and duration of interdental cleaning, particular instruments/techniques employed (e.g., brush versus type of floss), and regularity of practice over time.

CONCLUSION

Interproximal papilla height correlated significantly with age (older patients had shorter papillae but higher fill scores), periodontal phenotype (thicker phenotypes were related to higher papilla height but lower fill scores), and contact point height (a more apical contact point negatively affected papilla height as well as fill). Furthermore, interdental cleaning practices—especially flossing and interdental brushing—had a positive, though weak, relationship with the ability to preserve papilla height.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SAT & MS: Data acquisition, data analysis, critical review, approval of the final version to be published.

YIA & AWAK: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

NF & AA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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