Papilla Proportions in the Maxillary Anterior Dentition

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Two hundred forty interdental papilla sites in 20 healthy patients were investigated. Interdental papilla heights of maxillary anterior teeth were measured from the gingival zenith, along with clinical crown lengths. Percentages of papilla height to crown length were computed and defined as papilla proportion, mesial papilla proportion (MPP), and distal papilla proportion (DPP). Mean interdental papilla heights of maxillary anterior teeth were 4 mm mesially and 4.1 mm distally. Mean MPP was 42% (n = 120), and mean DPP was 43% (n = 120). No significant differences were found between MPP and DPP for maxillary incisors (P ≥ .5). Canines demonstrated a trend toward increased distal papilla heights. Papilla proportions were approximately 40% for all tooth groups. A more apical position of distal papilla heights from anterior to posterior teeth, mentioned in the literature, was not confirmed by the present data. (Int J Periodontics Restorative Dent 2009;29:385–393.)

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An interdisciplinary team approach to multidisciplinary therapies in esthetic restorative treatment has become commonplace in the dental profession. The perception of dental esthetics, however, varies significantly among dental professionals, although substantial efforts have been made to establish common standards. Several textbooks have sought to help guide clinicians in optimizing esthetic results. Rufenacht,[1,2] for example, discussed the fundamentals of esthetics and described procedures for integrating dental restorations into the individual facial composition with respect to biologic and functional requirements, not merely esthetics. Goldstein[3] attempted to establish principles to help practitioners achieve esthetic results and develop a rationale for esthetic dental treatment. Fradeani[4] described a systematic approach to esthetic analysis, evaluation, and treatment based on general principles and illustrated that the height of the interdental papillae decreased from anterior to posterior teeth. Despite these efforts, there is still little consistency among clinicians' perspectives of what constitutes an esthetic smile.[5–11] With an increased

awareness and understanding of esthetic dentistry, patients today require natural-looking teeth and gingival architecture in the esthetic zone.

It is the interdental appearance of the papillae in an apicocoronal location that is critical during smiling that results in positive gingival architecture esthetics,[12,13] although the supracoronal tissues might not always be visible in patients with a low smile line. LaVacca et al[14] conducted a study to evaluate the impact of symmetric alterations in interdental papilla length on esthetic perceptions. The authors reviewed the importance of interdental papilla location for optimal esthetics and its assessment by dental professionals and patients. Although dental specialists were more consistent than patients in their evaluation of the impact of interdental papilla length on the perception of esthetics, this study demonstrated that there is still a need to enhance communication and standardize evaluation among dental specialists to achieve consistent treatment planning goals.

There is no universal guideline for clinicians to follow in creating greater conformity and a predictable esthetic smile, including ideal papilla heights. It may be possible to mathematically quantify certain esthetic components to establish a standard that is satisfying to both patients and clinicians.

Chu[15] suggested that a mathematical correlation exists between the clinical crown widths of maxillary anterior teeth. The investigation unveiled that variations of tooth width existed more frequently (~68%) than mean averages (~32%). It was concluded that individual clinical crown size must

be identified prior to treatment to promote a more esthetic result. Accordingly, it may be feasible to quantify the heights of the interdental papillae of the maxillary anterior teeth as measured from the level of the zenith of the labial free gingival margin (gingival zenith).

Several investigators have attempted to establish guidelines for proper papillae form to enhance denture esthetics, optimize soft tissue position, improve surgical and nonsurgical techniques to treat soft tissue deformities, and to better manage interproximal spaces following tooth extraction or implant placement.[16–20] Spear[17] presented a clinical technique for maintaining papilla height and form following anterior tooth removal. He believed that the presence of adjacent tooth attachment and the size of the gingival embrasure formed by these teeth were responsible for papilla presence and height. Tarnow et al[21] examined the distance from the base of the contact area to the crest of bone in 288 sites and determined that, at 5 mm, 6 mm, and 7 mm, the papilla was present 98%, 56%, and 27% of the time, respectively. Cho et al[22] and Martegani et al[23] found that the interradicular distance and the distance between the contact point and the alveolar crest have independent and combined effects on the presence or absence of the interdental papilla. Based on this information, clinicians are able to influence and maintain papilla development more effectively, but they must rely on the alveolar crest as a reference point.

The height of the interdental papillae between the maxillary anterior

teeth, with reference to the crest of the gingival zenith, remains undefined. To date, no investigation has determined what the representative value of the anatomical location of the interdental papilla should be from the gingival zenith. There are currently no studies designed to evaluate or quantify this location. Therefore, the purpose of this pilot study was to quantify the interdental papilla location mathematically as a percentage ratio of clinical crown length, thereby establishing a useful parameter for treatment.

Method and materials

A sample population of 20 patients (13 women, 7 men) was studied. The patients, who ranged in age from 20 to 47 years (mean, 27.7 years), were in good systemic health. The sample population were included on the basis of nonrestored maxillary anterior teeth, no loss of interdental papillae, no anterior crowding or spacing, no incisal attrition, no periodontal disease, and no gingival recession (Fig 1).

Alginate impressions of the study subjects were made using irreversible hydrocolloid impression material (Jeltrate, Dentsply Caulk) and immediately poured with stone (Resin Rock, Whip Mix Corp). A digital caliper with a lighted display (SAE/Metric) was used to measure the 240 papilla sites of the anterior maxillary teeth, from canine to canine (Avenger Measuring Tools). Each cast was measured by one operator using 2.5× optical loupes. Control measurements were performed by a second investigator. The caliper was calibrated prior to each measurement.

Fig 1   *Healthy patient with sound maxillary anterior dentition and interdental papillae between central and lateral incisors as well as canines.*
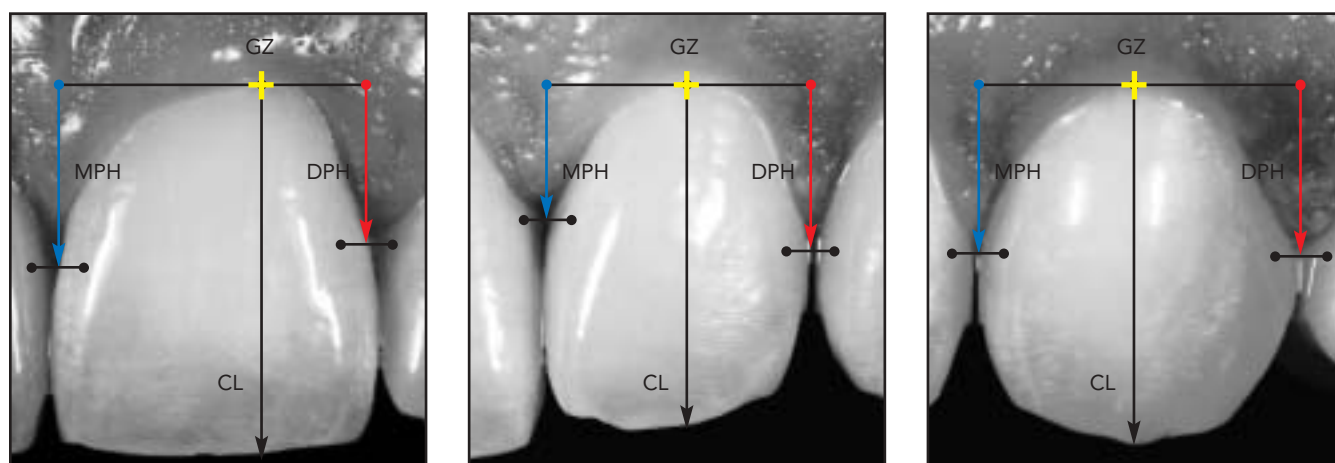

Fig 2   *Height measurements were made from the level of the gingival zenith (GZ) to the tip of the mesial papilla (MPH) and distal papilla (DPH) for (left) the central incisor, (center) the lateral incisor, and (right) the canine, as well as for clinical crown length (CL).*

The mesial and distal interdental papilla heights in the maxillary anterior dentition, including the central incisors (CI), lateral incisors (LI), and canines (CA), were measured from the level of the gingival zenith of the corresponding tooth to the tip of the papilla (n = 240) (Fig 2). Additionally, the lengths and widths of clinical crowns were recorded for each tooth group: CI, LI, and CA (n = 120). Each papilla height measurement was divided by the clinical crown length of the corresponding tooth. Therefore a percentage ratio was calculated of the papilla height related to the clinical crown length. The percentage ratio accounted for variations in crown lengths and papilla heights and was not predicated upon absolute values.

The following mathematical equation was used to calculate a percentage ratio, termed papilla proportion (PP): PP = papilla height/crown length × 100%. Mesial papilla proportions (MPP) and distal papilla proportions (DPP) were calculated separately: MPP = mesial papilla height/crown length × 100%, and DPP = distal papilla height/crown length × 100%.

This study was conducted according to the Declaration of Helsinki for clinical investigations. Statistical analysis was performed by independent-sample *t* tests and binomial tests (α = .05).
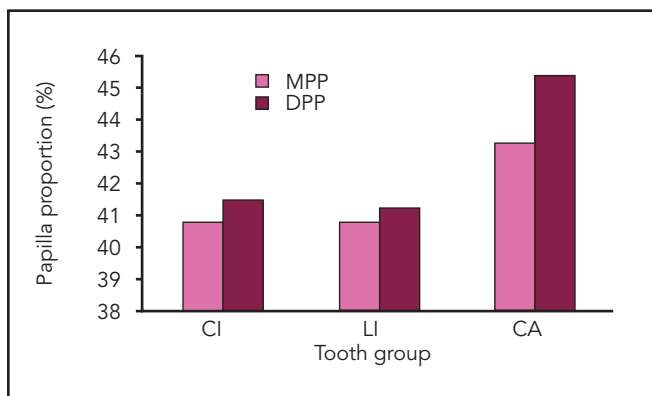
Fig 3 *Percentage ratio of papilla height to crown length sorted by tooth group and divided into mesial papilla proportion (MPP) and distal papilla proportion (DPP). CI = central incisors; LI = lateral incisors; CA = canines.*

Table 1	Absolute values of papilla heights (in mm) sorted by tooth position and divided into mesial (MPH) and distal (DPH) groups				
Tooth position	**n**	**Group**	**Mean ± SD**	**Min**	**Max**
Right CA	20	MPH	4.2 ± 0.87	2.9	6.2
Right CA	20	DPH	4.5 ± 0.74	3.3	6.0
Right LI	20	MPH	3.5 ± 0.69	2.4	5.0
Right LI	20	DPH	3.6 ± 0.98	2.0	5.1
Right CI	20	MPH	4.3 ± 0.71	3.1	5.8
Right CI	20	DPH	4.3 ± 0.62	3.4	5.8
Left CI	20	MPH	4.2 ± 0.82	2.9	5.7
Left CI	20	DPH	4.2 ± 0.60	3.3	5.6
Left LI	20	MPH	3.8 ± 0.78	2.4	5.7
Left LI	20	DPH	3.8 ± 0.83	2.4	5.7
Left CA	20	MPH	4.3 ± 0.33	3.7	5.0
Left CA	20	DPH	4.4 ± 0.73	3.3	5.7

CI = central incisor; LI = lateral incisor; CA = canine.

Results

The mean absolute values (± SDs) for the interdental papilla heights of maxillary anterior teeth measured from the level of the gingival zenith were 4.0 ± 0.8 mm mesially and 4.1 ± 0.8 mm distally. The mean absolute interdental papilla heights (± SDs) by tooth of CI, LI, and CA were 4.3 ± 0.7 mm, 3.7 ± 0.8 mm, and 4.4 ± 0.7 mm, respectively. Taking into account all measured sites, the mean MPP (± SD) was 42% ± 6% (n = 120), and the mean DPP was 43% ± 7% (n = 120). The measurements demonstrated a normal distribution, which accounted for about 68% of the data for one standard deviation from the mean (± SD). The MPP for the CI, LI, and CA were 40.8%, 40.8%, and 43.3%, respectively. The DPP of the CI, LI, and CA were 41.5%, 41.1%, and 45.4%, respectively (Fig 3). Table 1 demonstrates the absolute

Fig 4 *Absolute values of papilla heights (lengths) by tooth position and divided into mesial papilla height (MPH) and distal papilla height (DPH). FDI tooth-numbering system used.*
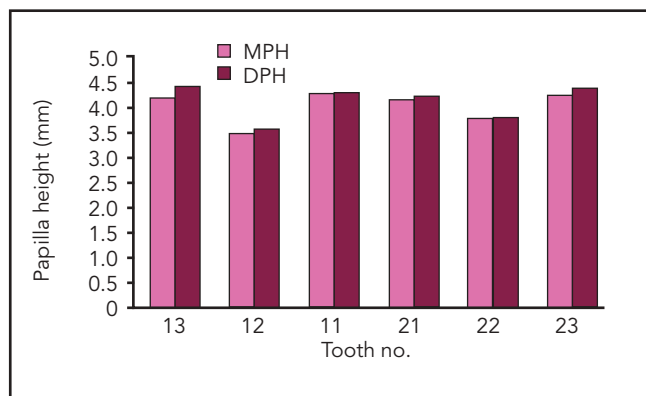

Tooth position	n	Group	Mean ± SD	Min	Max
Table 2		**Clinical crown lengths (CL) and widths (CW) (in mm) measured in the maxillary anterior dentition, sorted by tooth position**			
Right CA	20	CL	9.7 ± 0.9	8.3	11.1
Right CA	20	CW	7.8 ± 0.62	6.8	9.4
Right LI	20	CL	8.8 ± 0.9	7.2	10.5
Right LI	20	CW	6.8 ± 0.68	5.3	8.2
Right CI	20	CL	10.3 ± 0.8	8.7	11.9
Right CI	20	CW	8.8 ± 0.55	7.7	9.6
Left CI	20	CL	10.3 ± 0.71	8.9	11.8
Left CI	20	CW	8.8 ± 0.56	7.7	9.7
Left LI	20	CL	9.0 ± 0.83	6.8	10.4
Left LI	20	CW	6.9 ± 0.68	5.6	8.2
Left CA	20	CL	9.9 ± 0.73	8.8	11.4
Left CA	20	CW	7.9 ± 0.49	6.9	8.8

CI = central incisor; LI = lateral incisor; CA = canine.

values of interdental papilla heights sorted by tooth position (Fig 4). Table 2 shows the descriptive data of clinical crown lengths and crown widths accordingly. MPP and DPP values are given in Table 3 (Fig 5). No significant differences were found between MPP and DPP for the maxillary incisors (groups CI and LI) ($P \geq .51$). The canines demonstrated a trend toward greater distal papilla lengths and higher DPP; this difference was significant for the right canine ($P = .04$) and was not significant for the left canine ($P = .24$). The mean difference between MPP and DPP for all values (n = 240) was 1%, but not significant ($P = .06$). The mean difference between distal and mesial measures aggregated over all teeth was 0.1 mm ($P = .054$). Because of the canine measures, the difference was nearly significant.
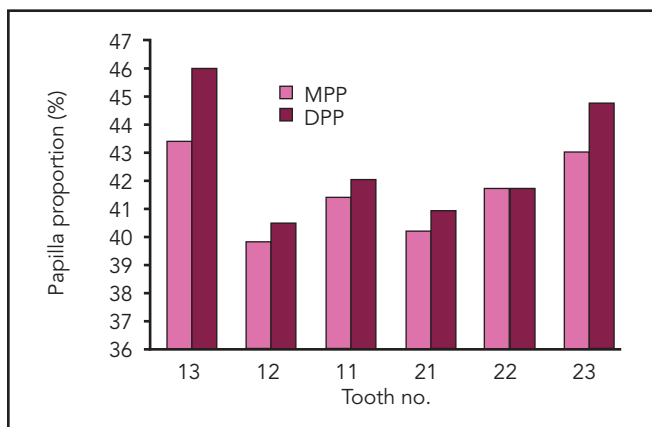
Fig 5 *Percentage ratio of papilla height to crown length sorted by tooth position and divided in mesial papilla proportion (MPP) and distal papilla proportion (DPP). FDI tooth-numbering system used.*

Table 3	Percentage ratio of papilla height to crown length sorted by tooth position and divided into mesial (MPP) and distal (DPP) groups				
Tooth position	**n**	**Group**	**Mean ± SD**	**Min**	**Max**
Right CA	20	MPP	43 ± 7	31	56
Right CA	20	DPP	46 ± 6	34	55
Right LI	20	MPP	40 ± 6	29	48
Right LI	20	DPP	41 ± 8	27	55
Right CI	20	MPP	41 ± 5	32	49
Right CI	20	DPP	42 ± 5	32	53
Left CI	20	MPP	40 ± 6	29	53
Left CI	20	DPP	41 ± 5	30	50
Left LI	20	MPP	42 ± 7	25	57
Left LI	20	DPP	42 ± 8	25	58
Left CA	20	MPP	43 ± 4	35	50
Left CA	20	DPP	45 ± 7	30	58

CI = central incisor; LI = lateral incisor; CA = canine.

Discussion

The goal of this study was to determine a representative value for interdental papilla height of the maxillary anterior dentition as a percentage ratio of clinical crown length, as measured from the level of the gingival zenith. Ideally, this figure would be relevant and clinically applicable for practitioners striving to achieve a more esthetic smile.

Furthermore, this value could be helpful for periodontists and implant dentists in validating and planning surgeries concerning desired vertical soft tissue height in the esthetic zone.[20] The mean absolute interdental papilla heights by tooth of CI, LI, and CA were 4.3 mm, 3.7 mm, and 4.4 mm, respectively. Values of interdental papilla heights in the maxillary anterior dentition have been mentioned in the

literature. Kois[24] measured interdental papilla heights from the free gingival margin to the osseous crest with a periodontal probe. Mesial sites at the maxillary right central incisor in 100 healthy patients were observed. Kois[24] reported a range of 3 to 4.5 mm interproximal depth. No additional anterior teeth or interdental sites were measured.

Becker et al[25] evaluated human skulls and classified them into flat, scalloped, and pronounced scalloped anatomical profiles according to alveolar bone anatomy. The mean distance from the height of the interdental bone to the buccal alveolar crest was statistically significantly different when the groups were compared (flat 2.1 mm, scalloped 2.8 mm, and pronounced 4.1 mm). Spear[17] concluded that the osseous scallop from facial to interproximal averages 3 mm in height. Taking an average of 3 mm dentogingival complex height into account, Spear concluded that the facial free gingival margin height equals the interproximal aspect of bone in a healthy patient. Therefore, he estimated that the average maxillary interproximal papilla height would be 4.5 to 5.5 mm for central incisors (Spear referred to Kois[24]), also when measured from the facial zenith of the free gingival margin. Spear did not provide control measurements for this estimate but cited a study of van der Velden,[26] who reported interdental tissue recovery after surgical treatment of 4.3 mm on average and a mean sulcus depth of 2.2 mm. An estimate of interdental papilla height of 4.5 mm correlates with the current statistical findings for central incisors and canines, with mean

crown lengths of 10.3 mm and 9.8 mm, respectively. Lateral incisors demonstrated a smaller mean value of interdental papilla height of 3.7 mm, with a mean crown length of 8.9 mm. The investigation of Tarnow and coworkers[21] on the influence of the contact point position on the presence or absence of the interproximal dental papilla was reevaluated by Cho et al.[22] The authors measured anterior and posterior interdental sites. The data confirmed the findings of Tarnow et al[21] that the number of papillae that filled the interproximal space decreased with increasing distance from the contact point to the alveolar crest. The authors reported that the interdental papillae were present in 89.7% of sites when the distance from the contact point to the alveolar crest was 4 mm, 58.5% of sites when the distance was 5 mm, 35.2% of sites when the distance was 6 mm, and fewer than 7.5% of sites when the distance was > 7 mm. Their results also suggested that an increasing interproximal distance between the tooth roots has a significant decreasing influence on the papilla presence. Unfortunately, the study did not provide absolute interdental papilla height values of the anterior maxillary dentition for comparison.

It is important to note that mean absolute values are important findings but do not account for individual variations in crown lengths and papilla heights. For esthetic anterior restorations, papilla heights must be proportional to clinical crown lengths. Hence, mathematical equations were presented as proportion calculations, which accounts for variability in clinical crown length. The average MPP and

DPP of the CI, LI, and CA measured were 41% and 42%, 41% and 41%, and 43% and 45%, respectively. These proportion ratios would account for variations in clinical crown length and would not be dependent upon absolute tooth measurement values. Although 240 papilla sites were measured, the number of investigated patients (n = 20) might be a short coming of the present study. However, the calculated standard deviation of all PP measurements (n = 240) was less than 7%, which equaled an esthetic natural appearance of the papilla within a 36% to 49% PP range. The given range of data (min/max) represents isolated measurements located at the extended tails of the bell curve. Further studies are needed to verify these results.

The perception of beauty is very subjective and often influenced by societal and/or geographic factors. Nevertheless, this study may be used as a pilot reference, providing some guidance for clinicians. By mathematically quantifying the papilla length from the gingival zenith, dental professionals can communicate more efficiently and with a more uniform treatment goal. As a result, a closer-to-ideal spatial relationship between teeth and their respective papillae can be established to achieve optimized esthetics.

Conclusions

The percentage ratios of papilla heights and crown lengths demonstrated an almost equivalent papilla proportion for all tested tooth groups of approximately 40%. There were no clinically relevant differences in mesial versus distal papilla heights in the anterior maxillary dentition. A more apical position of distal papilla heights from anterior to posterior teeth as mentioned in the literature was not confirmed by the present data.

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