Proximal Contact Areas of the Maxillary Anterior Dentition

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The goal of this study was to quantify the apicoincisal extent of the proximal contact area (PCA) between the eight maxillary anterior teeth. A total of 140 PCA sites and 160 crown lengths were measured in 20 healthy patients. The percentage ratio of PCA to clinical crown length was computed and defined as the proximal contact area proportion (PCAP). Mean PCA dimensions between central incisors (CI/CI), central and lateral incisors (CI/LI), lateral incisors and canines (LI/CA), and canines and first premolars (CA/PM) were 4.2, 2.9, 2.0, and 1.5 mm, respectively. Mesial mean PCAPs were 41%, 32%, 20%, and 18%, respectively. The paired sample t test demonstrated significant differences between all PCAs (P < .0001), except for CA/PM sites (P = .24). Contact areas, not contact points, were observed between neighboring maxillary anterior teeth. Natural PCAPs emerged as well defined in the maxillary anterior dentition bilaterally. Therefore, PCAPs should be taken into consideration for clinical anterior restorations since they determine the papillary and incisal embrasures. (Int J Periodontics Restorative Dent 2010;30:471–477.)

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Literature regarding dental anatomy and morphology have identified the location of contact points between the maxillary anterior dentition in an apicoincisal direction and have used the terms contact *point* and contact *area* interchangeably.[1–3] The importance of the contact *point* is that it defines the gingival embrasure and the height of the interdental papilla,[4–6] as well as the incisal embrasure, which widens coronally from the area of contact. Incisal embrasures are relevant for efficient mastication and give individuality to the anterior dentition.[3]

True *point* contacts appear when the contacting surfaces demonstrate nearly perfect curvatures, which have been observed in only young patients with newly erupted teeth, specifically at the canines and first premolars.[3] In adults, proximal contact *areas* (PCAs) are common in the anterior dentition and vary in size in relation to the shape of the contacting tooth surfaces and wear.[3]

Reference books attentive to esthetic dentistry have illustrated contact points or areas with differing locations[7–9] and dimensions.[10,11] Several authors have agreed that the contact

area of the central incisors is located at the coronal incisal third, whereas the contact areas of the lateral incisors, canines, and premolars become more apical from anterior to posterior teeth from a frontal perspective. The gingival relocation of the contact area means that the gingival embrasure, which correlates with the height of the interdental papilla, and the incisal embrasure move more apically from anterior to posterior teeth. Yet, guidelines for contact area extensions and dimensions in the anterior dentition remain undefined.

Sulikowski[12] stated that the PCA lies between the incisal and gingival embrasures. Therefore, the PCA can be defined as the distance between the most apical and incisal points of the contact area. Morley and Eubank[13] were the first to describe the connector space or zone between teeth as the places in which the anterior teeth appear to touch. This zone is defined as a larger, broader area than a contact point or area, which is usually 2 mm × 2 mm in dimension. Morley[14] further described a relationship in the connector zone between the maxillary anterior teeth as a percentage of the maxillary central incisor tooth length or height, referred to as the 50-40-30 rule. The rule states that the connector zone between the maxillary central incisors is 50% of the height of the central incisor. The connector zone between the central and lateral incisors is 40% of the length of the central incisor, with the zone between the lateral incisor and canine being 30%. This rule is a descriptive visual perception of the contact area between the anterior teeth and no quantitative research has supported these percentage values, though the concept has raised the question as to what the dimensions are.

To date, no investigation has resolved the location of the apical and incisal points in relation to the PCA of the maxillary anterior dentition, the representative apicoincisal dimensions of the contact area between the maxillary anterior teeth from right first premolar to the contralateral left first premolar. There are currently no studies that have evaluated these parameters under healthy conditions. Therefore, the purpose of this study was to *(1)* define the most apical and incisal points of the PCA defining the gingival embrasure of the interdental papilla and incisal embrasure, respectively, and *(2)* quantify the apicoincisal dimensions of the PCA of the maxillary anterior dentition as a percentage of individual tooth length.

Method and materials

Twenty patients (13 women, 7 men; mean age: 27.7 years) participated in this study. Patients demonstrated good systemic health and absence of periodontal disease. Exclusion criteria were the presence of restorations or fillings in the anterior dentition, crowding or spacing of the maxillary anterior teeth, loss of interdental papillae, gingival recession or inflammation, and incisal attrition.

Impressions were taken of the anterior dentition of each patient using irreversible hydrocolloid impression material (Jeltrate, Dentsply Caulk) and poured immediately with dental stone (Resin Rock, Whip Mix). Measurements of the PCA were performed on master casts in the range of the maxillary right to left first premolar by one investigator. Control measurements were performed by a second operator. Seven PCA locations were defined: central incisor to central incisor (CI/CI), central incisor to lateral incisor (CI/LI; ×2), lateral incisor to canine (LI/CA; ×2), and canine to first premolar (CA/PM; ×2). PCAs were measured using a digital caliper with a light-emitting diode display (Avenger Measuring Tools) in an apicoincisal direction from the apical point (AP) of the contact area, corresponding to the peak of the interdental papilla, to the incisal point (IP) of the contact area, equivalent to the initiation of the incisal embrasure (Figs 1 and 2). The height of the mesial AP and the mesial IP in reference to the gingival zenith of each tooth were recorded.[6] Additionally, the lengths of clinical crowns were measured from the gingival zenith to the incisal edge of each tooth group (CIs, LIs, CAs, and PMs; n = 160).[6,15] The caliper was calibrated prior to each measurement. In total, 140 PCAs were observed using 2.5× magnification optical loupes (SurgiTel, General Scientific) and contact area dimensions were recorded. The following mathematic equation was used to calculate a percentage ratio referred to as the proximal contact area proportion (PCAP):

$$PCAP = \frac{\text{height of PCA}}{\text{crown length}} \times 100\%$$

Descriptive statistics were calculated for each contact area location and paired sample *t* tests were
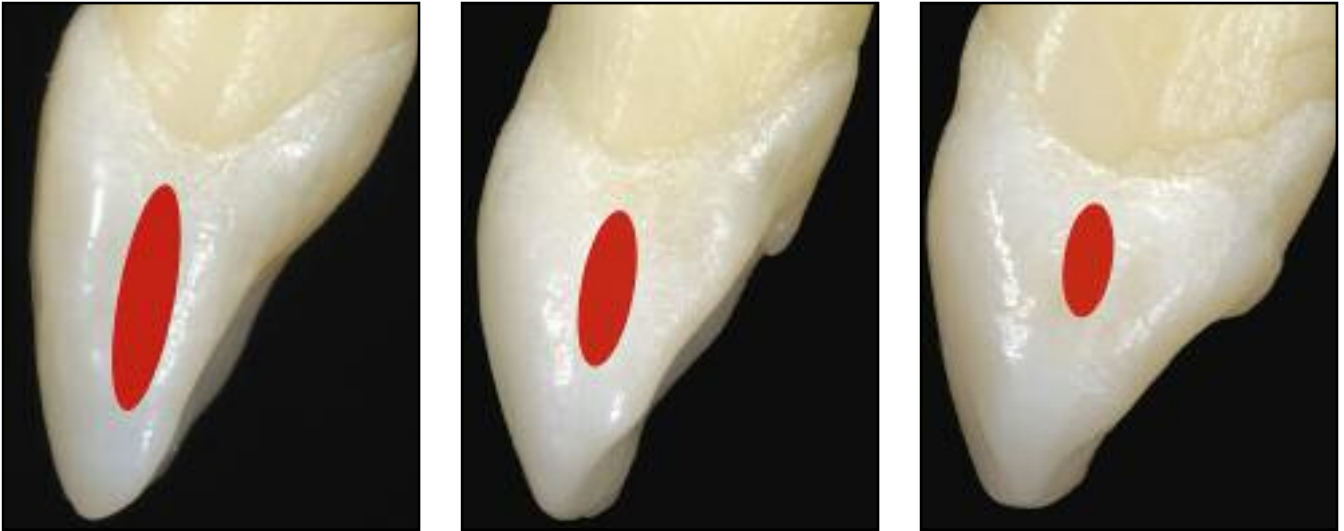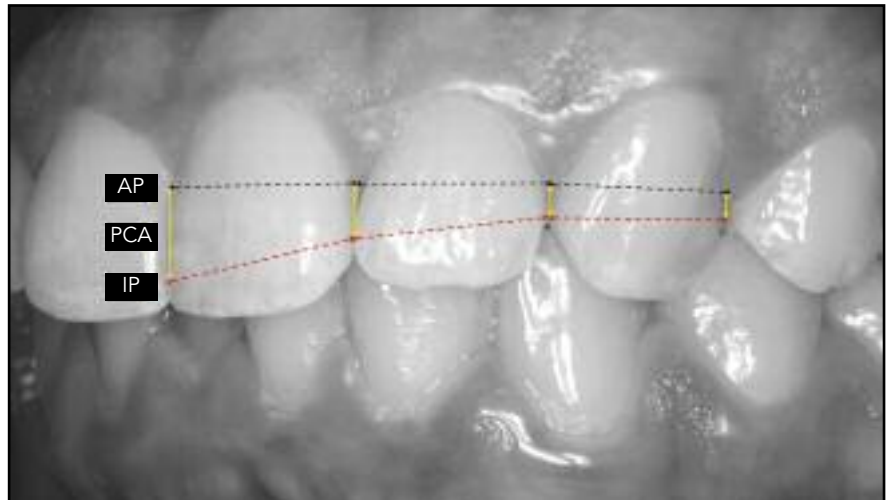
Fig 1 *PCAs between the maxillary anterior teeth in an apicoincisal direction. Measurements reflect the distance from the apical point (papilla height) to the incisal point (incisal embrasure) of the PCA. (left) Left central incisor, (center) left lateral incisor, and (right) left canine.*

Fig 2 *Clinical case reevaluation of the PCA rule based on absolute mesial PCA values and the PCAP rule in relation to individual crown lengths. AP = apical point, PCA = proximal contact area, IP = incisal point.*

performed for comparisons (α = .05). This study was conducted according to the Declaration of Helsinki for clinical investigations.

Results

Table 1 shows the descriptive values of PCAs measured in an apicoincisal direction. The greatest PCA heights were recorded between central incisors (CI/CI) and the lowest between canines and first premolars (CA/PM).

Mean PCA dimensions decreased from mesial to distal sites in the maxillary anterior dentition bilaterally. Table 2 demonstrates the descriptive data of the PCA, defined by the AP and the IP of the PCA in relation to crown length, resulting in the PCAP. The mean (standard deviation) PCA dimensions

Table 1	Absolute values (mm) of PCAs between maxillary anterior teeth			
PCA (tooth)*	**N**	**Mean ± SD**	**Minimum**	**Maximum**
PM/CA (14/13)	20	1.4 ± 0.5	0.7	2.6
CA/LI (13/12)	20	1.9 ± 0.5	1.0	2.8
LI/CI (12/11)	20	2.9 ± 0.7	1.0	3.9
CI/CI (11/21)	20	4.2 ± 0.9	2.4	5.9
CI/LI (21/22)	20	2.8 ± 0.8	1.0	4.3
LI/CA (22/23)	20	2.0 ± 0.6	0.9	2.8
CA/PM (23/24)	20	1.5 ± 0.5	0.9	2.8

PCA = proximal contact area; SD = standard deviation; PM = premolar; CA = canine;
LI = lateral incisor; CI = central incisor.
*FDI tooth-numbering system.

Table 2	Descriptive values for crown length and PCA							
	Group (tooth)*							
	PM (14)	**CA (13)**	**LI (12)**	**CI (11)**	**CI (21)**	**LI (22)**	**CA (23)**	**PM (24)**
Crown length (mm)	8.1 ± 0.6	9.7 ± 0.9	8.8 ± 0.9	10.3 ± 0.8	10.4 ± 0.7	9.0 ± 0.8	9.9 ± 0.7	8.2 ± 0.7
Apical point (mm)	2.9 ± 0.5	4.2 ± 0.9	3.5 ± 0.7	4.3 ± 0.7	4.2 ± 0.8	3.8 ± 0.8	4.3 ± 0.3	3.1 ± 0.5
Incisal point (mm)	4.3 ± 0.5	6.1 ± 0.7	6.4 ± 0.7	8.5 ± 0.8	8.4 ± 0.9	6.6 ± 0.8	6.3 ± 0.5	4.6 ± 0.5
PCA (mm)	1.4 ± 0.5	1.9 ± 0.5	2.9 ± 0.7	4.2 ± 0.9	4.2 ± 0.9	2.8 ± 0.8	2.0 ± 0.6	1.5 ± 0.5
PCAP (%)	17.6 ± 5.6	19.5 ± 4.8	32.8 ± 8.2	40.8 ± 8.3	40.6 ± 8.0	31.7 ± 8.1	19.7 ± 5.0	18.4 ± 5.4

PCA = proximal contact area; PCAP = proximal contact area proportion.
*FDI tooth-numbering system.

Table 3	PCAP (%) sorted by tooth sequence			
PCA	**N**	**Mean ± SD**	**Minimum**	**Maximum**
CI/CI	20	40.7 ± 8.0	23.7	52.7
CI/LI	40	32.3 ± 8.0	12.4	47.6
LI/CA	40	19.6 ± 4.3	11.1	28.0
CA/PM	40	18.0 ± 5.3	10.0	30.0

PCA = proximal contact area; SD = standard deviation; CI = central incisor; LI = lateral incisor;
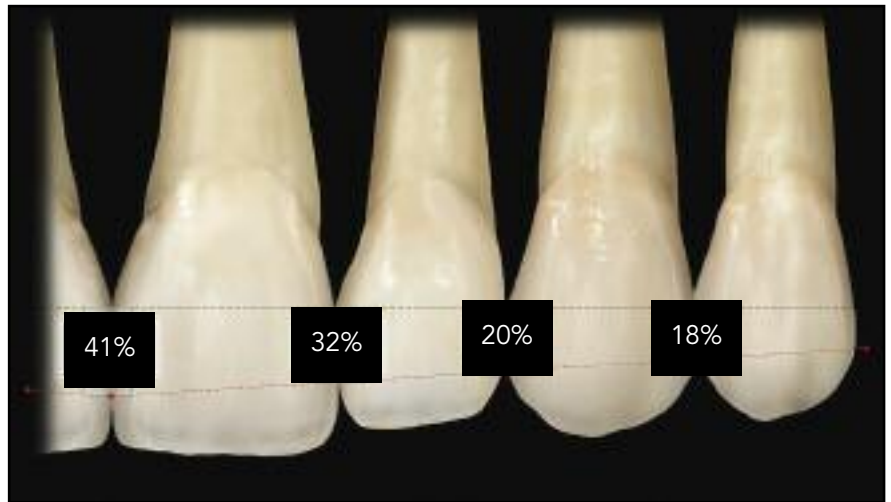CA = canine; PM = premolar.

between central incisors (CI/CI), central and lateral incisors (CI/LI), lateral incisors and canines (LI/CA), and canines and first premolars (CA/PM) were 4.2 (± 0.86), 2.9 (± 0.72), 1.9 (± 0.47), and 1.5 mm (± 0.46), respectively. Table 3 shows PCAPs sorted by tooth sequence [CI > LI > CA > PM] of 41%, 32%, 20%, and 18%, respectively.

Figures 3 and 4 illustrate the absolute PCA dimensions and the PCAPs in relation to clinical crown lengths. The paired sample t test demonstrated significant differences between all PCAs ($P < .0001$), except for CA/PM sites ($P = .24$).

Fig 3 *Bilateral mean dimensions of the PCA area between the maxillary anterior teeth (n = 140). The PCA dimensions result in a bilateral triangle based on a line of cervical embrasure initiation points. The PCA dimensions can be simplified to a 4-3-2-1.5 mm rule.*

Fig 4 *PCAP as a percentage ratio of mesial PCA to individual crown length. The PCAPs can be simplified to a 40-30-20-20 percentage rule.*

Discussion

Several published esthetic guidelines address the importance of adequate PCA locations to restore maxillary anterior esthetics[10,11,16,17] but fall short of defining the contact area dimensions in relation to reproducible anatomical reference points. The position of the contact point in relation to the level of the bone crest gained interest in maintaining and reconstructing the interdental papilla.[4,18,19] Tarnow et al[18] and Cho et al[19] measured the distance between the bone crest and facial aspect of the apical contact area by sounding the soft tissue. The papilla embrasure measurements were reevaluated on teeth that underwent surgical reflections of the facial gingiva.[18,19] Martegani et al[4] performed similar clinical measurements by tissue sounding but reevaluated the data using periapical radiographs. The most apical portion of the contact area was identified using a copper electrical line fixed

within the interdental embrasure. In healthy conditions, the apical contact of the PCA corresponded with the peak of the interdental papilla.[4,18,19] Kurth and Kokich[20] reported that, on average, the interproximal contact in patients with open gingival embrasures was shorter or located 1 mm more incisal than in patients with normal gingival embrasures.[20]

Although the cervical gingival margin was not used as a vertical reference point, the authors, based on previous results,[21] concluded that in an ideal esthetic situation, the interproximal contact should be about halfway between the cervical gingival margin and the incisal edge in patients with normal gingival embrasures.[20] Unfortunately, no actual measurements of the interproximal contact area were presented.[20]

Chu et al[6] suggested the gingival zenith in relation to the cementoenamel junction as a reference point to measure the proximal papilla height of maxillary anterior teeth, since the cementoenamel junction appeared to be more approachable for the restorative clinician than the alveolar bone crest. The investigators demonstrated that no difference was eminent between the height of the mesial and distal papilla of each maxillary anterior tooth, nor did the papilla height decrease (become more apical) from anterior to posterior teeth. The apical point of the contact area, defined by the height of the interdental papilla, remained relatively constant as a percentage of individual tooth length.[6] Therefore, the demonstration of decreasing PCAs in the anterior dentition seems to be responsible for the illusion of the interdental papillae

becoming shorter (more apical) bilaterally.[12] It was verified in the present study that the incisal points of the contact areas are more apical (moving anteroposteriorly), resulting in a reduction of the PCA distances. The reduction of distal contact area height in comparison to the mesial contact area of each tooth results in an increasing depth of the incisal embrasures from central incisor to canine.[22] The increase of the incisal embrasure angles anteroposteriorly from maxillary incisors to canines occurs soon after eruption. Wear resulting from aging can shorten the anterior teeth and cover this effect.[23]

Mathematic analysis of PCAs relative to crown lengths challenges the 50-40-30 rule of the connector space or zone.[13,14] Another concept, introduced by Spear, stated that 50% of the overall crown length (11 mm) of an unworn central incisor is considered the contact area (5 to 5.5 mm) and the remaining 50% is papilla height (5 to 5.5 mm).[24,25] This appears improbable since it does not account for incisal embrasure height. Numerically, the mesial PCAP was a 40-30-20-20 percentage of the mean individual tooth height dimensions for the maxillary central incisors, lateral incisors, canines, and first premolar teeth, respectively (Table 3, Fig 4). The PCA measurements demonstrated a normal distribution, which accounted for about 68% of the data for one standard deviation from the mean. The given minimum and maximum values do not reflect the data distribution but represent isolated data at the boundaries. Future investigations with additional patients will be useful to verify these initial results.

In planning the treatment of a smile, the guidelines for PCAPs should be corrected to a 40-30-20 percentage rule for maxillary central incisors, lateral incisors, and canines.[17,26] The corresponding PCA dimensions can be estimated according to a 4-3-2 mm rule. The apical point of the contact area does not move gingivally from anterior to posterior maxillary teeth; however, the incisal point of the contact area does move more apical.

Conclusion

The current literature on maxillary anterior esthetics refers mainly to contact points between neighboring teeth. The present results imply that PCAs are given, not contact points. The PCA dimensions decrease anteroposteriorly between maxillary central incisors to first premolars bilaterally, from 4 to 3 to 2 to 1.5 mm, respectively. The position of the apical point of the gingival embrasure is almost maintained, whereas the incisal point marking the incisal embrasure moves apically towards the distal maxillary anterior dentition. The dimensions of anterior PCAs should be taken into consideration when restoring teeth indirectly in the lab or directly in a clinical setting.

Acknowledgment

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