Gingival Zenith of the Maxillary Anterior and Premolar Teeth in Normal Gingiva

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บทคัดย่อ: การศึกษาตำแหน่งและระดับจุดสูงสุดของขอบเหงือกบริเวณฟันหน้าบนในสภาวะเหงือกปกติ

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**ภาควิชาปริทันตวิทยา คณะทันตแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย เขตปทุมวัน กรุงเทพมหานคร 10330

ภูมิหลัง: จิงไจวอลซีนิท (gingival zenith) หรือ จุดสูงสุดในแนวโค้งบนขอบเหงือกอิสระ เป็นตัวแปรทางคลินิกที่มีความสำคัญด้านความสวยงามกับการรักษาทางทันตกรรม **วัตถุประสงค์:** เพื่อหาตำแหน่งจิงไจวอลซีนิท (gingival zenith position; GZP) และระดับจิงไจวอลซีนิท (gingival zenith level; GZL) ของฟันหน้าบนและฟันกรามน้อยบน ในผู้ใหญ่ สุขภาพเหงือกปกติ **วิธีการ:** พิมพ์ปากอาสาสมัครอายุ 18-35 ปี จำนวน 60 ราย เพื่อทำแบบจำลองฟันในขากรรไกรบน วัดค่า GZP และ GZL โดยใช้ดิจิตอลเวอเนียร์-คาลิปเปอร์ **ผล:** พบค่า GZP จากจำนวนฟันที่ศึกษาชนิดละ 120 ซี่ ในฟันตัดบนซี่กลาง ฟันตัดบนซี่ข้าง ฟันเขี้ยวบน ฟันกรามน้อยบนซี่ที่หนึ่ง และฟันกรามน้อยบนซี่ที่สอง อยู่ค่อนไปทางด้านไกลกลางจาก VBM เท่ากับ 0.41 ± 0.24, 0.22 ± 0.22, 0.13 ± 0.23, 0.18 ± 0.17 และ 0.17 ± 0.16 มิลลิเมตร GZL ในฟันตัดบนซี่ข้าง เท่ากับ 0.60 ± 0.28 มิลลิเมตร ค่อนไปทางด้านตัวฟัน และ GZL ในฟันกรามน้อยบนซี่ที่หนึ่งและฟันกรามน้อยบนซี่ที่สอง เท่ากับ 1.04 ± 0.41 และ 1.56 ± 0.59 มิลลิเมตร ค่อนไปทางด้านตัวฟัน เมื่อเทียบกับเส้นอ้างอิง **สรุป:** จากการศึกษานี้ พบ GZP ของฟันหน้าบนและฟันกรามน้อยบนอยู่ค่อนไปด้านไกลกลางจาก VBM เป็นระยะ 0.2-0.5 มิลลิเมตร GZP ของฟันเขี้ยวบนอยู่ตรงกันกับ VBM GZL ในฟันตัดบนซี่ข้าง อยู่ค่อนไปทางด้านตัวฟันประมาณ 0.5 มิลลิเมตร และ GZL ในฟันกรามน้อยบน อยู่ค่อนไปทางด้านตัวฟันประมาณ 1 - 2 มิลลิเมตร

คำสำคัญ: จิงไจวา (gingiva) จิงไจวอล ซีนิท (gingival zenith) มอร์ฟอสโลจี (morphology) เอสเธททิคซ (esthetics)

Abstract

Background: The gingival zenith is an essential clinical parameter to consider during esthetic dental treatment. **Objective:** To estimate the gingival zenith position (GZP) and gingival zenith level (GZL) of maxillary anterior teeth and premolar in adults with normal gingiva. **Methods:** Sixty healthy volunteers age range of 18-35 years were enrolled. All participants were taken an impression on the upper arch with alginate and pour with Velmix die stone. Indirect measurements on study casts performed by calibrated digital. The GZP of central incisor, lateral incisor, canine, first and second premolar were measured in a medial-lateral direction from the vertical bisecting midline (VBM). The GZL of the lateral incisor was measured in an apical-coronal direction related to the line joining the tangents of the GZP of the ipsilateral central incisor and canine. While the GZL of first and second premolar were recorded by referencing with the perpendicular line to VBM of the ipsilateral canine. **Result:** The mean of GZP from 120 teeth per each tooth group in the upper central incisors, lateral incisors, canine, first and second premolars were distally from VBM at 0.41 ± 0.24, 0.22 ± 0.22, 0.13 ± 0.23, 0.18 ± 0.17 and 0.17 ± 0.16 mm, respectively. The mean distance of the GZL for the

lateral incisors was 0.60 ± 0.28 mm, in the first premolar and the second premolar were 1.04 ± 0.41 and 1.56 ± 0.59 mm. **Conclusion:** This study demonstrated that the mesio-distal positions of gingival zenith on maxillary anterior and premolar teeth were distal to VBM around 0.2-0.5 mm, except canine, which GZP were approximately at VBM. The GZL of the lateral incisors were coronal about 0.5 mm, and the level of the gingival zenith of premolars was coronal approximately 1-2 mm to the perpendicular line of VBM of adjacent canine.

Keywords: Gingiva, Gingival zenith, Morphology, Esthetics

Introduction

The smile is an essential component of personal attractiveness and social interaction. Developing a pleasing smile is related to a comprehensive and multidisciplinary approach to create the proper relationship between the lips, teeth, and gingiva.[1] The gingival zenith is defined as the highest point of the gingival marginal scalloped.[2] It is the important reference of the apical gingival margin outline. Establishing the proper location for zenith points is a critical step in the alteration of the teeth dimensions to achieve predictable esthetic treatment outcome. Taking certain clinical parameters into account during treatment planning may be helpful for the clinician to better perform treatment procedures

Most of previous studies described the location of gingival zenith by two-axis, i.e., gingival zenith position (GZP) and gingival zenith level (GZL). The GZP is the mesio-distal deviation from the vertical bisecting midline (VBM) of each individual tooth[3]. While, GZL represents its apico-coronal level. Variations of GZP and GZL were presented in previous studies. Rufenacht[4] suggested that GZP of the central incisor and canine were distally displaced from the long axis of the tooth but was coincident with the long axis in the lateral incisor. Chu[3] found that the gingival zenith of the central incisor and lateral incisor were distally displaced from the VBM 1.0 and 0.4 mm, respectively, and the canine placed coincident with VBM. However, Magne and Belser[5] indicated that the gingival zenith in all maxillary anterior teeth was located distally to the long axis. Moreover, 74% of young adults displayed gingiva extended to the second premolar during a maximum smile.[6] However, the references for GZP and GZL in the maxillary premolar and the studies of GZP and GZL in Thai population have been limited.

Therefore, the aim of this study was to evaluate the GZP and GZL of maxillary anterior teeth and premolar in Thai young adults with normal periodontium. Theses information could be clinically applied to re-establish the proper GZPs of the maxillary anterior teeth and maxillary premolar during periodontal crown lengthening or used as the additional reference points during esthetic anterior oral rehabilitation. However, the mean average of the GZPs and GZLs from this study may not directly related to patient satisfaction.

Materials and Methods

Participants were included with the convenience sampling method from the outpatient department at the Institute of Dentistry, Nonthaburi province, Thailand. Participants gave their written informed consent, and the study was approved by the Institute of Dentistry's ethics committee. The calculation of the sample size was used ($N = 4Z_{\alpha}^{2} S^{2}/ W^{2}$)[7] based on the results of 50 subjects in a previous study [2](an α = 0.05, desired total width of confidence interval (W) = 0.25, standard deviation of the variable (S) = 0.49) revealed that 59 subjects needed in this study and 1 subject added for practical.

Sixty healthy volunteers (52 females, 8 males) aging between 18-35 years who met the inclusion criteria were enrolled between December 2017 to March 2018. Inclusion criteria were the presence of completed maxillary anterior and premolar dentition (left and right maxillary central incisor, lateral incisor, canine, first premolar and second premolar) without any restoration, healthy gingiva (gingival index; GI < 1)[8], normal alignment (no crowding or spacing) and no gingival recession. Participants with a fixed prosthesis, abutment for a removable partial denture, orthodontic appliances, gingival hyperplasia, altered passive eruption, smoking and previous history of orthodontic treatment or periodontal surgery at the premaxilla area were excluded.

All included subjects were undergone periodontal examination. Periodontal probing depth, gingival recession and GI were recorded on the buccal aspect in all maxillary anterior teeth and premolars. Moreover, the tissue biotype

was assessed by the Probe Transparency (TRAN) method with periodontal probe (PCPUNC 15, Hu-Friedy, Chicago, US). All measurements were performed by a single calibrated examiner.

The gingival zenith measurement

Impressions of the maxillary arch were made using irreversible hydrocolloid impression material (Millennium, Lascod Spa, Florence, Italy) with stock tray and immediately poured with Vel-mix™; type IV Die-stone (Kromotypo 4, Lascod Spa, Florence, Italy). Indirect measurement was performed by calibrated digital caliper (Mitutoyo 500-196-30; six-inch digital calipers with LCD display, resolution: 0.01 mm, accuracy: ±0.02 mm, repeatability: 0.01 mm). The GZP of the central incisor, lateral incisor, canine, first and second premolars were measured in a medial-lateral direction from the vertical bisecting midline (VBM). The GZL of the lateral incisor was measured in an apical-coronal direction related to the line joining the tangents of the GZP of the ipsilateral central incisor and canine. The GZL of the first and second premolars were recorded by referencing with the perpendicular line to the VBM of the ipsilateral canine. Steps to measure GZP and GZL were conducted as follows:

1) To determine the VBM of each clinical crown, established the two reference points by measurement of the proximal incisal contact area position (ICAP) and the apical contact area position (ACAP) (Figure 1a).

2) Each width was divided in half and the center point marked (Figure 1b).

3) Joining the center point together toward the gingival aspect of the clinical crown to define the VBM (Figure 1c)

4) The gingival zenith was the highest point of free gingival margin marked on each tooth (Figure 1d).

5) The gingival zenith positions (GZP) of the central incisor, lateral incisor, canine, first and second premolars were the distance measured in a medial-lateral direction from the gingival zenith to the vertical bisecting midline (VBM) (Figure 1e).

6) The GZL of the lateral incisor was measured in an apical-coronal direction related to the line joining the tangents of the gingival zenith for the ipsilateral central incisor and canine (Figure 2a).

7) The GZL of the first and second premolars were recorded by referencing with the perpendicular line to VBM of the ipsilateral canine (Figure 2b).

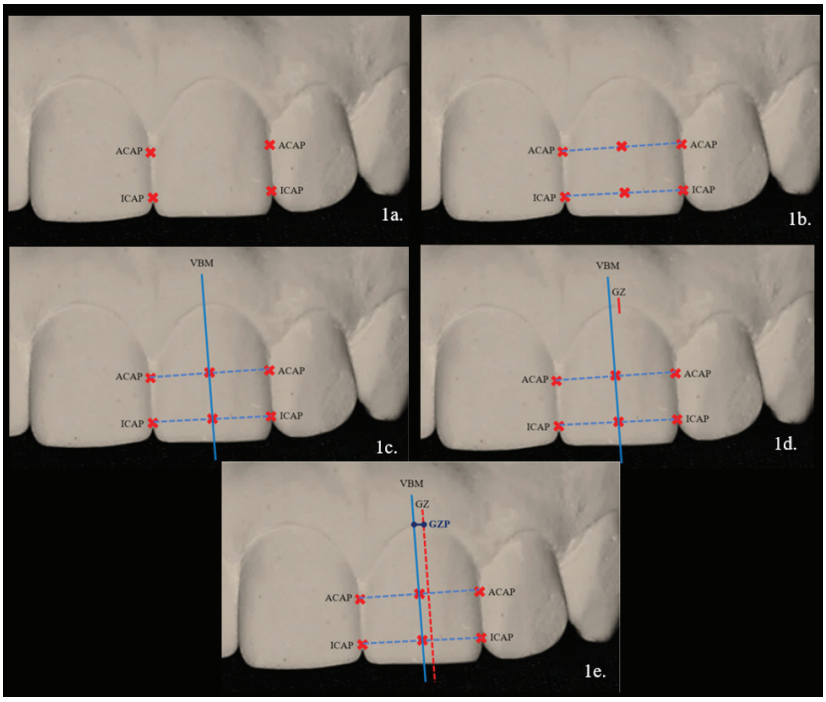

Figure 1 The gingival zenith position (GZP) measurement

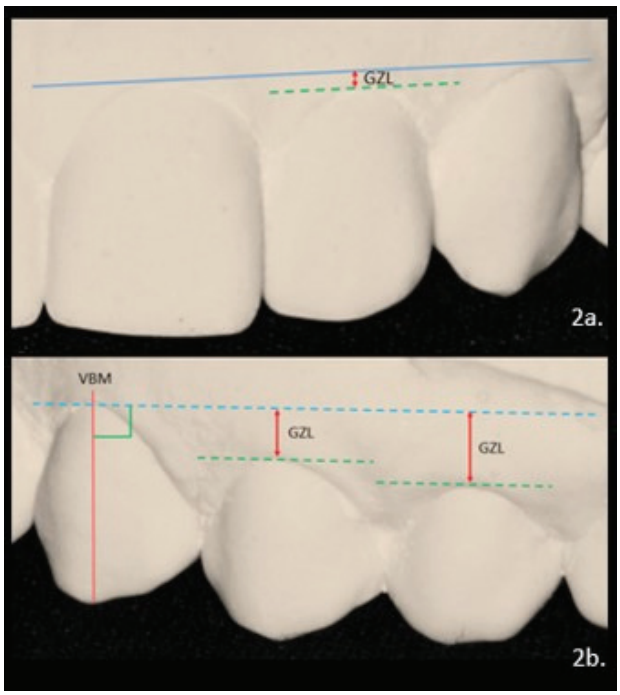

Figure 2 The gingival zenith level (GZL) measurement

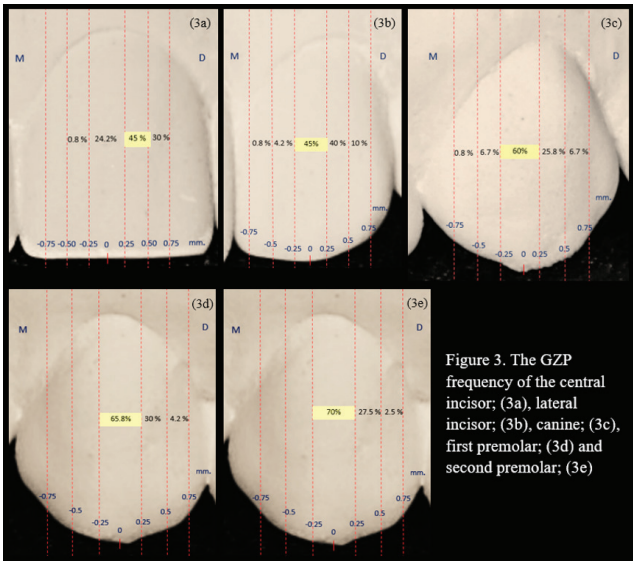

Figure 3 The frequency of gingival zenith position along the long axis of the tooth

Statistical analysis

The GZP and GZL were measured and reported for each tooth separately. In addition, the prevalence of GZP deviations from the long axis (< 0.25 mm, 0.25 - 0.50 mm, > 0.50 mm) also were reported. The paired t-test or the Wilcoxon signed rank test were performed to investigate the left and right symmetry of gingival zenith. Then, the differences of gingival zenith among males and females, thin and thick biotypes were identified by the Mann-Whitney U test or the Independent Sample t-test. Statistical analyses were performed using STATA 14.2 software. A p-value < 0.05 was considered statistically significant.

Results

Included subjects consisted of 60 healthy patients (52 females, 8 males) aging from 18-35 years (mean 26.9 years) with healthy gingival tissue (28 thick and 32 thin gingival biotypes).

The mean distance of GZP and GZL (Table 1)

The mean distances for the GZP from the VBM of clinical crown for maxillary central incisors, lateral incisors, canines, first premolars, and second premolars were 0.41 ± 0.24, 0.22 ± 0.22, 0.13 ± 0.23, 0.18 ± 0.17 and 0.17 ± 0.16 mm, respectively.

Table 1 The gingival zenith position (GZP) and the gingival zenith level (GZL) of maxillary anterior and premolar dentition

	N	Mean ± SD	Median	Minimum	Maximum
Gingival zenith position*					
Central incisor	120	0.41 ± 0.24	0.39	-0.26	1.24
Lateral incisor	120	0.22 ± 0.22	0.25	-0.50	0.66
Canine	120	0.13 ± 0.23	0.09	-0.61	0.61
First premolar	120	0.18 ± 0.17	0.15	-0.18	0.80
Second premolar	120	0.17 ± 0.16	0.13	-0.13	0.70
Gingival zenith level**					
Lateral incisor	120	0.60 ± 0.28	0.58	-0.06	1.40
First premolar	120	1.04 ± 0.41	0.99	0.21	2.40
Second premolar	120	1.56 ± 0.59	1.56	0.30	2.88

** (+) GZP was distal from VBM (-) GZP was mesial from VBM*
*** (+) GZL was coronal to the reference line (-) GZL was apical to the reference line*

The mean distance of the GZL of the lateral incisors was 0.60 ± 0.28 mm coronally to the line joining the tangents of the GZP of the ipsilateral central incisor and canine. Meanwhile, the GZL of the first premolars and the second premolars were 1.04 ± 0.41 and 1.56 ± 0.59 mm, coronally to the line perpendicular to VBM of the ipsilateral canine

The frequency of gingival zenith position along the long axis of the tooth (Figure 3)

Roughly 75% of central incisors displayed distal displacement of GZP from VBM 0.25-0.75 mm. 45% of lateral incisor had gingival zenith which were approximately with VBM. The GZP of canines, first premolars, and second premolar coincide with VBM 60%, 66% and 70%, respectively.

The gingival zenith symmetry (Table 2)

Mesio-distal deviations of all teeth showed no statistically significant between the left and the right sides, assuming the symmetry of GZP. Similarly, the GZL of lateral incisor and first premolar also presented. However, the GZL of the second premolar were statistically different.

Table 2 The results of contralateral comparison of the GZP and GZL of maxillary anterior teeth and premolar dentition

Tooth	Right side		Left side		Mean Difference (95% CI)	P-value
	Median	Min, Max	Median	Min, Max		
Gingival zenith position*						
Central incisor	0.39	-0.26, 1.01	0.40	0.00, 1.24	-0.01 (-0.06, 0.04)	0.89
Lateral incisor	0.24	-0.50, 0.66	0.26	-0.42, 0.61	0.02 (-0.04, 0.08)	0.33
Canine	0.08	-0.61, 0.60	0.12	-0.36, 0.61	-0.02 (-0.09, 0.04)	0.50
First premolar	0.18	-0.14, 0.80	0.12	-0.18, 0.59	0.03 (-0.03, 0.09)	0.39
Second premolar	0.16	0.00, 0.61	0.12	-0.13, 0.70	0.03 (-0.01, 0.08)	0.17
Gingival zenith level**						
Lateral incisor	0.62 ± 0.28		0.59 ± 0.28		0.02 (-0.04, 0.09)	0.46
First premolar	1.01 ± 0.39		1.06 ± 0.43		-0.04 (-0.13, 0.05)	0.35
Second premolar	1.59 ± 0.60		1.65 ± 0.62		-0.14 (-0.23, -0.05)	0.03

**Wilcoxon Signed Rank Test*
***Student's t-test: Paired samples*

Comparing gingival zenith between Male Versus Female, and Thick Versus Thin biotype

The results of comparison of the GZP and GZL between male and female, as well as thick and thin biotype showed in Table 3. Results found that only the difference of central incisor s' GZP between male and female were statistically significant. The GZP of central incisor in male (0.51 ± 0.33) were more distally-positioned than in female (0.39 ± 0.21). While, there was no significant difference of the GZP and GZL between thick and thin biotype.

Table 3 Comparing GZ in male and female; thick and thin biotype

	Female (n = 52)			Male (n = 8)			Mean Difference (95% CI)	p-value#
	Mean±SD	Median	Min, Max	Mean±SD	Median	Min, Max		
Gingival zenith position*								
Central incisor	0.39±0.21	0.35	0.00, 1.24	0.51±0.33	0.55	-0.26, 1.01	0.12 (-0.06, 0.30)	0.03
Lateral incisor	0.22 ±0.22	0.25	-0.50, 0.66	0.20±0.27	0.23	-0.34, 0.62	-0.03 (-0.15, 0.09)	0.78
Canine	0.13±0.22	0.10	-0.36, 0.61	0.11±0.26	0.08	-0.61, 0.52	-0.02 (-0.14, 0.10)	0.85

Table 3 Comparing GZ in male and female; thick and thin biotype (Continue)

	Female (n = 52)			Male (n = 8)			Mean Difference (95% CI)	p-value#
	Mean±SD	Median	Min, Max	Mean±SD	Median	Min, Max		
First premolar	0.18±0.18	0.15	-0.18, 0.80	0.15±0.15	0.16	0.00, 0.50	-0.03 (-0.12,0.06)	0.53
Second premolar	0.17±0.16	0.13	-0.13, 0.70	0.14±0.15	0.12	0.00, 0.45	-0.03 (-0.11, 0.06)	0.54
Gingival zenith level**								
Lateral incisor	0.61±0.28	0.59	-0.06, 1.40	0.57±0.27	0.54	0.22, 1.04	-0.04 (-0.19, 0.11)	0.61
First premolar	1.04±0.42	1.01	0.21, 2.40	1.03±0.32	0.98	0.43, 1.73	-0.01 (-0.22, 0.21)	0.19
Second premolar	1.55±0.59	1.54	0.30, 2.88	1.62±0.61	1.61	0.77, 2.62	0.07 (-0.25, 0.38)	0.83
	Thick biotype (n = 28)			*Thin biotype (n = 32)*				
Gingival zenith position*								
Central incisor	0.42±0.21	0.42	-0.26, 0.84	0.40±0.26	0.35	0.00, 1.24	0.03 (-0.06, 0.11)	0.16
Lateral incisor	0.22±0.23	0.27	-0.50, 0.60	0.22±0.22	0.24	-0.42, 0.66	0.01 (-0.08, 0.09)	0.83
Canine	0.10±0.24	0.03	-0.36, 0.60	0.16±0.21	0.11	-0.61, 0.61	-0.06 (-0.14, 0.02)	0.09
First premolar	0.17±0.18	0.15	-0.18, 0.59	0.19±0.17	0.15	-0.14, 0.80	-0.02 (-0.08, 0.04)	0.59
Second premolar	0.17±0.18	0.13	-0.13, 0.70	0.16±0.14	0.13	0.00, 0.61	0.01 (-0.05, 0.06)	0.86
Gingival zenith level**								
Lateral incisor	0.60±0.27	0.60	-0.06, 1.15	0.60±0.29	0.57	0.16, 1.40	0.00, (-0.10, 0.10)	0.94
First premolar	0.99±0.35	1.00	0.21, 1.86	1.08±0.45	0.99	0.36, 2.40	-0.09 (-0.23, 0.06)	0.23
Second premolar	1.56±0.55	1.56	0.37, 2.81	1.57±0.63	1.54	0.30, 2.88	-0.01 (-0.23, 0.20)	0.90

** (+) GZP was distal from VBM (-) GZP was mesial from VBM*

*** (+) GZL was coronal to the reference line (-) GZL was apical to the reference line*

 # GZP: Mann–Whitney U test; GZL: Student's t-test

Discussion

The gingival zenith is apical border of the gingival margin, which directly influences the facial esthetic. This study presented the average of gingival zenith location of maxillary anterior teeth and premolar in both mesio-distal and apico-coronal axis. Mean distances of GZP for maxillary central incisor, lateral incisor and canine were distal to the VBM of 0.50, 0.22 and 0.09 mm, respectively. The GZL of the lateral incisors were 0.5 mm coronally to the central incisor and canine.

Distal deviation of GZP of all anterior teeth was corresponded with previous studies[2, 3, 9]. These deviations were greatest distally positioned at central incisors, then reduced at lateral incisors, and approximated with VBM at canines. However, the degree of divergence was varied among studies[2, 3, 9-12]. The average distance of GZP distal

from the VBM in our study was 0.5 and 0.2 mm in central and lateral incisors, respectively. These mesio-distal deviations of central and lateral incisors were found less distally located comparing with others[2, 3, 9-12] which indicated the mean distance of GZP of 1.0 mm and 0.5 mm in central and lateral incisors.

Most of gingival zenith were distally displaced or approximated with VBM. Interestingly, the mesial displacement of GZP could be found, but it was very rare. It was found only 0.8% in the central incisors, 5% in the lateral incisors and 7.5% in the canines.

The apico-coronal relationship of gingival margin or GZL for anterior teeth was quite consistent among the literature[2, 3, 9-11, 13]. This study also found that the GZL of the lateral incisor was about 1 mm coronally to the gingival zenith of adjacent central incisor and canine. Additionally, there was no significant difference between right and left sides.

Three-fourths of young adults displayed gingiva extended to the second premolar during a maximum smile[6], and more pronounced in females and younger subjects. Our study provided the information of gingival zenith of premolars and indicated that the GZP of maxillary first and second premolar were slightly distal to the VBM by approximately 0.2 mm. The GZL of premolars were 1-2 mm coronal to the perpendicular line of VBM of the adjacent canine. Previous study[14] investigated the GZL of first and second premolars using the line draw connecting ipsilateral canine and central incisor as the reference, and reported that the mean apico-coronal distances from the gingival zenith to the reference were approximately 1-2 mm.

Gingival margin, height of clinical crown, and tooth shape are the intrinsic characteristics which are components of an attractive smile. They can be modified by periodontal and restorative treatment. To re-establish these proper dento-gingival components by esthetic crown lengthening or oral rehabilitation, the appropriate gingival zenith is needed. It is essential to consider symmetrical gingival morphology. Next, the GZP in maxillary anterior teeth is mostly distally displaced from the VBM ranging from 0 to 1 mm. The mesial placement should be avoided. In apico-coronal direction, the gingival zenith of lateral incisors and premolars should be place coronally to adjacent canines.

Besides the validity of our inclusion criteria, our study has other strengths. The indirect measurement was carefully taken to eliminate measurement error. An impression was taken with qualified impression material, and an indirect measurement was performed by standardized calibrated digital vernier caliper and measured by one calibrated examiner. However, our results were identified from the average of gingival zenith form samples, which may not directly relate to patient satisfaction. Keys to achieve a pleasant esthetic outcome are the robust treatment planning and mutual communication between clinicians and patients.

Conclusion

The mesio-distal positions of gingival zenith on maxillary anterior and premolar teeth were distal to the VBM by around 0.2 - 0.5 mm, except canine, which GZP were approximately at VBM. Moreover, the GZL were coronal to the adjacent canines about 0.5 mm for lateral incisors, and 1-2 mm for premolars.This information could be used as references point in conjunction with other esthetic parameters in treatment planning procedure for esthetic anterior oral rehabilitation or periodontal surgery.

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