Archives of Oral Biology 79 (2017) 1–6

Contents lists available at ScienceDirect

Archives of Oral Biology

journal homepage: www.elsevier.com/locate/aob

Assessment of gingival biotype and facial hard/soft tissue dimensions in the maxillary anterior teeth region using cone beam computed tomography

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ARTICLE INFO

Article history:
Received 20 May 2016
Received in revised form 18 January 2017
Accepted 27 February 2017

Keywords:
Dentogingival complex
Gingival thickness
Bone thickness
Gingival biotype
Cone beam computed tomography
Periodontal biotype

ABSTRACT

Objective: This study sought to assess the relationship between facial gingival and bone dimensions in maxillary anterior teeth region using cone beam computed tomography (CBCT).
Design: This study assessed 621 maxillary anterior teeth in 144 patients. In the sagittal plane, facial bone thickness (BT) and gingival thickness (GT) were measured at the crestal level and at 2, 4 and 6 mm apical to the cementoenamel junction (CEJ). The dentogingival complex (DGC) dimensions and the distance from the CEJ to bone crest were also measured on CBCT scans. To determine the gingival biotype, GT at 2 mm apical to the gingival margin was measured and GT <1.5 mm was categorized as thin while GT ≥1.5 mm was categorized as thick. The data were analyzed using SPSS version 21 via repeated measures ANOVA and the Cochrane's Q, chi-square and independent samples *t*-tests.
Results: The BT around the maxillary central and lateral incisors and canine teeth at 4 and 6 mm apical to the CEJ was significantly different in thick and thin gingival biotypes ($P < 0.05$). The mean GT at 2 and 4 mm apical to the CEJ was significantly different around central and lateral incisors ($P < 0.05$). Thickness of crestal bone was significantly different between the two gingival biotypes around central and lateral incisors ($P < 0.05$).
Conclusion: The two gingival biotypes had significantly different mean BT; different biotypes and their relationship to BT varied around anterior maxillary teeth.
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1. Introduction

Gingival biotype is an important parameter, which may affect the success and esthetic results of periodontal plastic surgery and implant treatment in the esthetic zone (De Rouck, Eghbali, Collys, De Bruyn, & Cosyn, 2009; La Rocca et al., 2012) Several classifications have been proposed for gingival biotypes. According to Ochsenbein and Ross (1973), gingiva follows the contour of the underlying bone and tooth shape; accordingly, they described two gingival anatomies namely (I) thin scalloped, which refers to triangular-shaped teeth with scalloped gingival margins and (II) thick flat, which refers to square-shaped teeth with flat gingival margins (Ochsenbein & Ross, 1973). Seibert and Lindhe (1989) described the differences in tooth shapes and heights in relation to the morphology of periodontium and introduced a classification for periodontal biotypes (Seibert & Lindhe, 1989). Kois (1996) categorized two biotypes of thin and thick, depending on the distance from the CEJ to bone crest. The thick biotype referred to cases where the distance from the CEJ to crestal bone was less than 3 mm (Kois, 1996). Later in 1997, Müller and Eger (1997) in their study on 42 individuals described periodontal phenotypes for different shapes of teeth and gingiva as follows: (I) Keratinized gingiva with normal thickness and width in teeth with normal length and width (two-thirds of the subjects); (II) Square-shaped incisors with thick and wide gingiva (21% of the subjects); and (III)

Abbreviations: BT, bone thickness; CEJ, cementoenamel junction; CBCT, cone beam computed tomography; DGC, dentogingival complex; GT, gingival thickness.

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http://dx.doi.org/10.1016/j.archoralbio.2017.02.021
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Square-shaped incisors with normal GT and minimal width of keratinized tissue (12% of the subjects) (Müller & Eger, 1997).

De Rouck et al. (2009) revisited gingival biotype in their study and assessed the transparency of the periodontal probe through the gingival margin as a method to differentiate thin from thick gingival biotypes. They evaluated 100 subjects (50 males and 50 females) and reported that approximately one-third of the subjects in their study had clearly thin gingiva associated with slender teeth, a thin band of keratinized tissue and highly scalloped gingival margins previously referred to as thin-scalloped biotype. Approximately two-thirds of the subjects had clearly thick gingiva; half of which had quadratic teeth, wide keratinized tissue and flat gingival margins previously referred to as thick-flat biotype. The other half had thick gingiva along with slender teeth, a thin band of keratinized tissue and highly scalloped gingival margins (De Rouck et al., 2009).

In addition to different classifications, various methods are available to determine the gingival biotype such as visual inspection (Ochsenbein & Ross, 1969; Seibert & Lindhe, 1989) and assessment of the transparency of the periodontal probe through the gingival margin (Y. Kan, Rungcharassaeng, Morimoto, & Lozada, 2009). Eghbali, De Rouck, De Bruyn, and Cosyn (2009) discussed that visual inspection may not be a valuable method to determine the gingival biotype since this. method is associated with misclassification of approximately half of the thin-scalloped cases (Eghbali et al., 2009).

Assessment of gingival biotype is critical prior to restorative and implant treatment planning (Buser, Martin, & Belser, 2003). In addition to optimal function, dental implants must provide favorable esthetics (Stimmelmayr, Allen, Reichert, & Iglhaut, 2010). Achieving maximum esthetics following immediate implant placement depends on three main factors, namely the proper location of implant (Buser et al., 2003), adequate facial bone (Ferrus et al., 2010) and peri-implant soft tissue status (Kan, Rungcharassaeng, Umezu, & Kois, 2003).

Soft tissue recession is a common problem associated with implant treatment in the anterior region (Goodacre, Kan, & Rungcharassaeng, 1999). Immediate implant placement in patients with thick gingival biotype often yields predictable results and long clinical service (Nagaraj et al., 2010). Evidence shows that in patients with thick-flat gingival biotype, papillary height (PH) around implant remains unchanged (Romeo et al., 2008), and this biotype is more favorable for implant placement and yields optimal esthetic results (Nagaraj et al., 2010).

Cone Beam Computed tomography can be used as a non-invasive modality for assessment of gingival biotype and determination of thickness of cortical bone and facial gingiva prior to implant treatment and flap elevation in periodontal surgery. This study sought to assess the relationship between facial gingival biotype and hard/soft tissue dimensions in maxillary anterior teeth using CBCT in patients presenting to a private oral and maxillofacial radiology clinic in 2015.

2. Materials and methods

This descriptive cross-sectional study was conducted on 144 patients who were candidates for dental implants referred to a radiology clinic for CBCT scans. The study protocol was approved by the Ethics Committee of Research Department of Shahid Beheshti Dental School. Patients with a minimum of three maxillary anterior teeth were selected using convenience sampling and written informed consent was obtained from them. Exclusion criteria were:

- Gingival enlargement in the anterior maxilla (Frost, Mealey, Jones, & Huynh-Ba, 2015)
- Gingival recession in the anterior maxilla (Stein et al., 2013)
- Previous or current orthodontic treatment (Ramírez, García-Rodríguez, Murillo-Arocho, Fernández-López, & Elías-Boneta, 2013)
- Crowding in the anterior maxilla (Fischer, Richter, Kebschull, Petersen, & Fickl, 2015)
- History of periodontal surgery in the anterior maxilla (Borges, Ruiz, Alencar, Porto, & Estrela, 2015)
- Teeth with prosthetic crowns or restorations (Jin et al., 2012; Sin et al., 2013), bridge abutments or implants in the anterior maxilla
- Missing (Jin et al., 2012), impacted, broken, endodontically treated (Nahass & Naiem, 2015) or decayed (Jin et al., 2012) teeth and teeth with root resorption (Nahass & Naiem, 2015), rotation or malposition (La Rocca et al., 2012)
- Skeletal descrepancies (Rossell, Puigdollers, & Girabent-Farrés, 2015), cleft lip or palate
- History of trauma to the anterior maxilla
- Smoking (Arora, Narula, Sharma, & Tewari, 2013), pregnancy (Sin et al., 2013), nursing (Sin et al., 2013) or systemic diseases (Arora et al., 2013)

The lips and cheeks were retracted by a sterile plastic retractor. The CBCT scans were obtained using Soredex dental X-ray system (Soredex, Helsinki, Finland) with 12 × 8 cm field of view and 200 μ voxel size. All measurements were made by the same observer. The BT and GT in the sagittal plane were measured at the bone crest and at 2, 4 and 6 mm apical to the CEJ. The DGC dimensions and the distance from the CEJ to bone crest were also measured on CBCT scans (Fig. 1). To determine the gingival biotype, GT at 2 mm apical

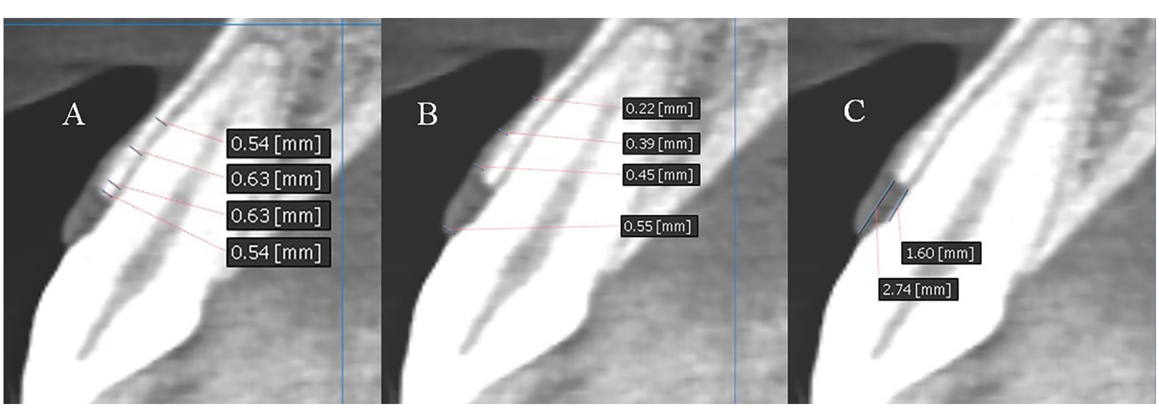

Fig 1. (A) Measurement of BT at the level of bone crest and at 2, 4 and 6 mm apical to the CEJ; (B) GT at the level of bone crest and at 2, 4 and 6 mm apical to the CEJ; (C) DGC dimensions and the distance from the CEJ to bone crest.

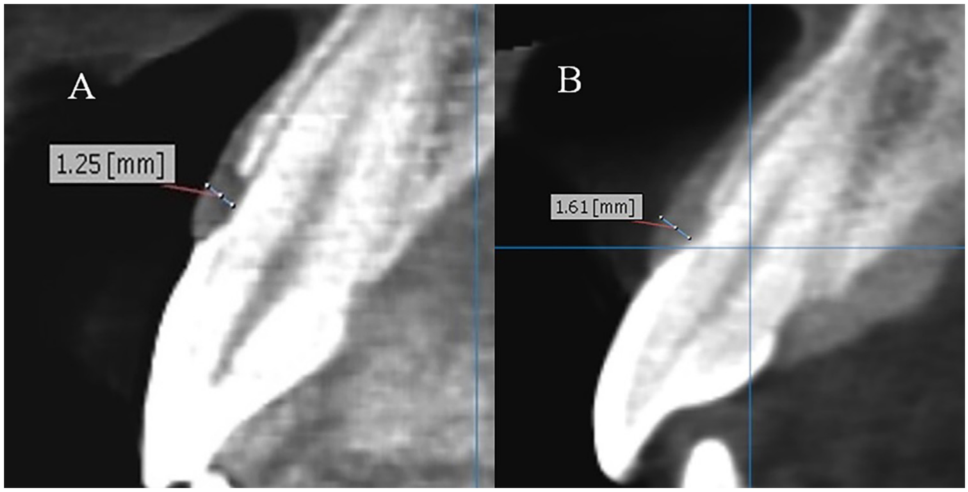

Fig. 2. Determination of gingival biotype by measuring gingival thickness at 2 mm apical to the gingival margin: (A) Thin biotype (B) Thick.

to the gingival margin was measured on CBCT scans (Fig. 2). At this level, GT < 1.5 mm was categorized as thin biotype while GT ≥ 1.5 mm was categorized as thick biotype (Claffey & Shanley, 1986)

The data were analyzed using SPSS version 21 (SPSS Inc., Chicago, IL, USA). To assess the intraobserver agreement (intra-examiner error), CBCT scans of 10 randomly selected patients were analyzed twice by the same observer with a 2-week interval and the intraclass correlation coefficient (ICC) was calculated. The mean and standard deviation (SD) of BT and GT were calculated at each level. Repeated measures ANOVA, Cochrane's Q test, chi-square test, independent samples *t*-test and the Spearman's correlation coefficient were used for statistical analysis of the data and comparisons. P < 0.05 was considered statistically significant.

3. Results

CBCT scans of 144 patients (58.3% females and 41.7% males) with a mean age of 44.62 ± 13.71 years were assessed. A total of 621 maxillary anterior teeth, including 244 central incisors, 216 lateral incisors and 161 canine teeth were evaluated.

The minimum, maximum and mean ICC for assessment of the agreement for 11 factors measured by the same observer were found to be 0.88, 0.99 and 0.9672, respectively, for central incisors. These values were 0.95, 0.99 and 0.9754, respectively for lateral incisors and 0.84, 0.99 and 0.96, respectively for canine teeth.

The results of independent samples *t*-test revealed that the mean age of subjects with different gingival biotypes around central and lateral incisors and canine teeth was not significantly different (P > 0.05).

The mean and SD of GT at 2 mm apical to the gingival margin (gingival biotype) was 1.35 ± 0.29 mm for central incisors, 1.23 ± 0.29 mm for lateral incisors and 1.15 ± 0.27 mm for canine teeth. Repeated measures ANOVA showed that these values were significantly different among the teeth, and the mean GT of central incisors was significantly greater than that of lateral incisors and canine teeth (P < 0.0005). Moreover, this value in lateral incisors was significantly greater than that in canine teeth (P = 0.013). Fig. 3 shows the frequency of thin and thick biotypes in maxillary anterior teeth and the significant difference is highlighted. Cochrane's Q test showed that the frequency percentage of gingival biotypes was significantly different between canine and central incisor teeth areas (P < 0.0005) and also between central and lateral incisors (P = 0.039).

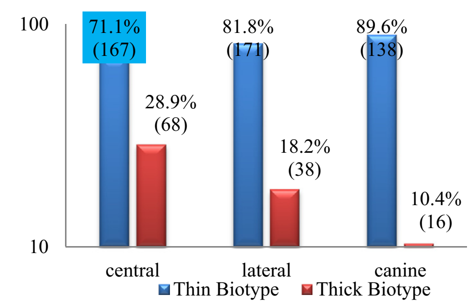

Fig. 3. The frequency percentage of thin and thick biotypes in maxillary anterior teeth.

Using chi-square test, The frequency percentage of thin and thick biotypes in maxillary anterior teeth showed no significantly different parameters between males and females (P > 0.05, Fig. 4).

Using independent samples *t*-test, the mean and SD of BT and GT were calculated at 2, 4 and 6 mm below the CEJ for each gingival biotype around maxillary anterior teeth. The P values for the comparisons of these parameters between the two gingival biotypes are shown in Table 1.

Using independent samples *t*-test, the mean and SD of GT and crestal BT, the distance from the CEJ to bone crest and DGC dimensions were calculated and compared between the two gingival biotypes for maxillary anterior teeth. The results are presented in Table 2.

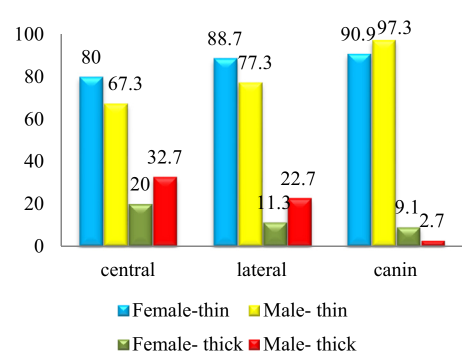

Fig. 4. The frequency percentage of thin and thick biotypes in maxillary anterior teeth of males and females.

Table 1
The mean and standard deviation (SD) of bone thickcness and gingival thickness at 2, 4 and 6 mm below the CEJ in the two gingival biotypes of maxillary anterior teeth.

Level		Gingival biotype	Central incisors mean ± SD (mm)	Lateral incisors mean ± SD (mm)	Canine mean ± SD (mm)
At 2 mm below the CEJ	Bone	Thin	0.35 ± 0.40	0.29 ± 0.39	0.36 ± 0.44
		Thick	0.52 ± 0.52	0.47 ± 0.53	0.56 ± 0.71
		P value	0.010	0.065	0.291
	Gingiva	Thin	0.99 ± 0.33	0.97 ± 0.32	0.92 ± 0.35
		Thick	1.24 ± 0.46	1.24 ± 0.47	1.14 ± 0.48
		P value	0.00	0.002	0.089
At 4 mm below the CEJ	Bone	Thin	0.77 ± 0.25	0.78 ± 0.36	0.76 ± 0.36
		Thick	0.94 ± 0.40	1.02 ± 0.49	1.09 ± 0.55
		P value	0.001	0.007	0.002
	Gingiva	Thin	0.63 ± 0.25	0.65 ± 0.25	0.60 ± 0.25
		Thick	0.77 ± 0.27	0.85 ± 0.42	0.72 ± 0.28
		P value	0.00	0.006	0.101
At 6 mm below the CEJ	Bone	Thin	0.75 ± 0.23	0.75 ± 0.31	0.79 ± 0.33
		Thick	0.89 ± 0.38	1.03 ± 0.45	1.10 ± 0.53
		P value	0.006	0.001	0.001
	Gingiva	Thin	0.65 ± 0.27	0.74 ± 0.26	0.58 ± 0.21
		Thick	0.69 ± 0.23	0.84 ± 0.39	0.65 ± 0.16
		P value	0.320	0.144	0.232

4. Discussion

The results of our study showed that BT around central and lateral incisors and canine teeth at 4 and 6 mm apical to the CEJ was significantly different when the two gingival biotypes were compared; the mean BT at all levels was greater in patients with thick biotype compared to those with thin biotype; although this difference at 2 mm below the CEJ of lateral incisors and canine teeth was not significant. The mean GT of the central and lateral incisors and canine teeth was greater in thick biotype compared to the thin biotype group; although only at 2 and 4 mm levels below the CEJ of the central and lateral incisors was statistically significant. This difference in canine teeth was not significant at any level. The gingival margin thickness around central and lateral incisors and canine teeth was greater in thick biotype compared to the thin biotype group; although this difference was statistically significant only for lateral incisors. Crestal BT of central and lateral incisors and canine teeth in the thick biotype group was greater than that in the thin biotype group; although this difference was only significant for central and lateral incisors. In central and lateral incisors and canine teeth area, the distance from the CEJ to bone crest and DGC dimensions were not significantly different between the two gingival biotypes.

The relationship between soft and hard tissue thickness in periodontal and peri-implant tissues has been evaluated in several studies. Kheur et al. (2015) showed that GT of 65% of maxillary central incisors was 1 mm or more (Kheur et al., 2015). They also found a significant correlation between GT and BT at 3 mm apical to the CEJ ($P < 0.001$, $r = 0.4955$). A significant relationship was also reported by Le and Borzabadi-Farahani (2012) between soft/hard tissue thickness around 64 implants inserted in the anterior maxilla ($P = 0.000$) (Le & Borzabadi-Farahani, 2012).

Zweers, Thomas, Slot, Weisgold, and Van der Weijden (2014) in a review study stated that gingival phenotype and periodontal biotype are interchangeable terms and some authors have classified gingival biotypes merely based on GT irrespective of other factors (Zweers et al., 2014). Kan, Morimoto, Rungcharassaeng, Roe, and Smith (2010) stated that the term gingival biotype is commonly used to describe facial and palatal GT (Kan et al., 2010). Fischer et al. (2015) evaluated the relationship of gingival biotype (determined by evaluating the transparency of periodontal probe through gingival margin) with GT (measured by a digital caliper). They found significant differences between the thin and thick biotypes with regard to GT, PH and gingival width (GW). Afterwards, they subdivided the thin group into very thin and thin and the thick group into very thick and thick subgroups. After applying these classifications, comparison of GW and PH among the four biotype groups revealed no significant differences; GT was not significantly different between the thin and thick groups while comparison of GT among other subgroups yielded significant differences. Therefore, they suggested that instead of classifying the gingival biotype into two groups of thin and thick, gingival biotype should be classified into three groups of very thick, moderate and very thin (Fischer et al., 2015). Fischer et al. (2014) showed that the mean supra-crestal gingival height and the crown width/crown length ratio were not significantly different between different gingival biotypes (Fischer et al., 2014). Moreover, De Rouck et al. (2009) showed that the crown width/crown length

Table 2
The mean and standard deviation (SD) of gingival margin and crestal bone thickness, the distance from the cementoenamel junction (CEJ) to bone crest and the dentogingival complex dimensions in the two gingival biotypes of maxillary anterior teeth.

Gingival biotype		Central incisors mean ± SD (mm)	Lateral incisors mean ± SD (mm)	Canine mean ± SD (mm)
Gingival margin thickness	Thin	0.49 ± 0.15	0.48 ± 0.13	0.56 ± 0.17
	Thick	0.52 ± 0.15	0.56 ± 0.20	0.63 ± 0.19
	P value	0.220	0.002	0.104
Crestal bone thickness	Thin	0.49 ± 0.13	0.50 ± 0.13	0.51 ± 0.14
	Thick	0.56 ± 0.19	0.57 ± 0.19	0.65 ± 0.33
	P value	0.010	0.018	0.113
Distance from the CEJ to bone crest	Thin	2.23 ± 0.99	2.42 ± 1.00	2.51 ± 1.02
	Thick	2.00 ± 0.90	2.39 ± 1.15	2.15 ± 1.11
	P value	0.110	0.867	0.194
Dentogingival complex	Thin	3.16 ± 0.74	3.52 ± 0.80	3.17 ± 0.80
	Thick	3.29 ± 0.66	3.60 ± 0.87	3.06 ± 0.74
	P value	0.229	0.593	0.609

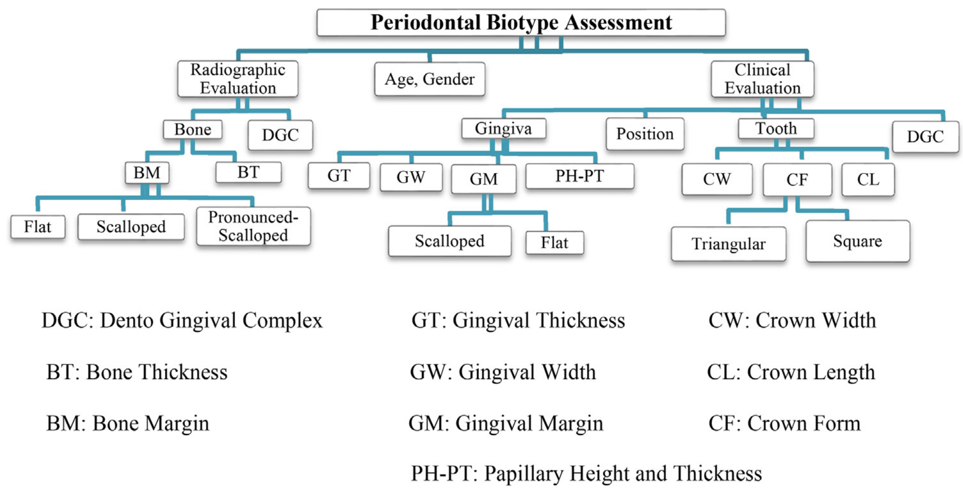

Fig. 5. Factors affecting periodontal biotype determination.

ratio, GW and PH were not significantly different between the thin-scalloped and thick-flat biotypes; but GT was significantly different between the two biotypes (De Rouck et al., 2009). Therefore, it can be stated that precisely determined gingival biotype has a stronger correlation with GT than with GW and PH; this is probably the reason behind selection of GT as the only determinant of gingival biotype in some studies.

In our study, GT at 2 mm level below the gingival margin was used for determination of gingival biotype. Stein et al. (2013) demonstrated that a negative correlation existed between BT and GT assessed by the transparency of periodontal probe through the gingival margin. A moderate positive correlation existed between BT and GT with GW and a positive association existed between BT and GT (Stein et al., 2013). Fu et al. (2010) demonstrated that facial GT had a significant correlation with thickness of the underlying bone (Fu et al., 2010). Cook et al. (2010) found that periodontal biotype was significantly correlated with BT, crestal bone level, GW and gingival texture (Cook et al., 2010). Similarly, in our study, the mean BT at all levels (crestal and 2,4, 6 mm apical to CEJ) was greater in thick biotype than in thin biotype group and this difference at 4 and 6 mm below the CEJ was statistically significant for all maxillary anterior teeth. Moreover, in our study, the mean GT at all levels was greater in thick than in thin biotype of Maxillary Anterior Teeth.

Moreover, the distance from the CEJ to bone crest was not significantly different between the two gingival biotypes although the mean distance in the thin biotype group was greater than that in the thick biotype group. Arora et al. (2013) evaluated 322 maxillary teeth and showed that the mean DGC dimensions in thick-flat gingival biotype group were significantly greater than those in thin-scalloped biotype group (Arora et al., 2013). Ramírez et al. (2013) showed that DGC dimensions were smaller in thick biotype compared to mixed and thin periodontium (Ramírez et al., 2013). We found that although differences existed between thin and thick biotypes, the mean DGC dimensions were not significantly different between the two main biotypes.

Comparison of the above-mentioned studies revealed that GT followed by the thickness of underlying bone had the greatest correlation with gingival biotype compared to DGC dimensions and the distance from the CEJ to bone crest. Since the transparency of periodontal probe through the gingival margin determines the gingival biotype based on GT, it would be more accurate to use GT instead of gingival biotype; GT is the most important factor determining gingival biotype and GT (biotype) can be considered as a subgroup of periodontal biotype since some other factors such as the morphology of the underlying bone and tooth dimensions must also be taken into account for assessment of periodontal biotype. Since gingiva is part of the periodontal tissue, using the term periodontal biotype seems to be more appropriate because it is a more general term that covers the morphology of all periodontal components such as teeth, bone and gingiva. Different factors affecting periodontal biotypes are shown in Fig. 5. We analyzed the relationship between soft tissue thickness and some of these factors including age, sex, BT, DGC and GT while some other authors evaluated other criteria such as GW, crown form, crown length, crown width, GT, papillary height, DGC, age, sex and maxillary/mandibular arch (Arora et al., 2013; De Rouck et al., 2009; Fischer et al., 2014; Stein et al., 2013; Vandana & Savitha, 2005).

Decreased GT is one of the factors that can result in periodontal attachment loss and marginal recession (Januario, Barriviera, & Duarte, 2008). It seems that patients with a thin biotype are at higher risk of gingival recession after periodontal therapy and implant surgery. Although the gingival biotype is genetically predetermined, a case report by Polack and Mahn (2013) showed that gingival biotype can be changed by a combination of orthodontic, restorative and periodontal treatments (Polack & Mahn, 2013).

5. Conclusion

Since CBCT scans are taken routinely prior to implant treatment for bone assessment, soft tissue assessment can also be done simultaneously and non-invasively by using a retractor or asking the patients to pucker their lips and blow out their cheeks during scanning. The current study results demonstrated that some bone and gingival dimensions were significantly different between patients with thin and thick gingival biotypes. Some of these dimensions such as the mean BT and GT were significantly lower in the thin compared to the thick biotype group but the mean distance from the CEJ to bone crest and DGC dimensions were not significantly different between the two gingival biotypes.

Clinical recommendation

The results of the present study clearly showed that the available classifications for tissue biotype as thin/thick are not Sufficient for clinical judgment. Individual analysis of each site using soft tissue CBCT may be helpful for a treatment plan based on soft/hard tissue thickness and tooth positioning.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgement

The authors kindly appreciate Dr. Mojdeh Kalantar Motamedi for collaboration in scientific writing.

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