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Is buccolingual angulation of maxillary anterior implants associated with the crestal labial soft tissue thickness?

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B. T. Le, W. Pluemsakunthai: Is buccolingual angulation of maxillary anterior implants associated with the crestal labial soft tissue thickness?. Int. J. Oral Maxillofac. Surg. 2014; xxx: xxx–xxx.

Abstract. We aimed to examine the relationship between crestal labial soft tissue thickness (CLSTT, measured with a digital calliper at the crestal level of casts) and implant buccolingual angulation (IBLA). The records of 22 females and 10 males treated with two bone-level implants (3.3–4.6 mm) between the maxillary canines were evaluated. IBLA was recorded as cingulum, incisal, or labial based on the screw access hole position on provisional restorations. Postoperative implant labial bone thickness (ILBT) at the crestal (2 mm from crest) and mid-implant levels were measured on sectional cone beam computed tomography scans. The mean (SD) ridge width at the crestal level was 6.81 (0.98) mm. Mean (SD) CLSTT for implants with cingulum, incisal, and labial angulations were 2.98 (0.84), 2.24 (0.51), and 1.71 (0.72) mm, respectively. Significant differences were detected between CLSTT of implants with cingulum and incisal, as well as cingulum and labial angulations ($P < 0.01$). Of implants with cingulum, incisal, and labial angulations, 3.4%, 20%, and 53.3%, respectively, had a CLSTT $<$ 2 mm. Overall, 74.2% of CLSTT variance could be predicted by IBLA and ILBT at the crestal and mid-implant levels. A significant association between CLSTT and IBLA was noted when ILBT (crestal level) was $<$2 mm ($P < 0.01$). Implants with labial angulations carry a higher risk of soft tissue complications when the crestal implant labial bone thickness is $<$2 mm.

Key words: buccolingual implant angulation; labial bone thickness; maxillary anterior; crestal labial soft tissue thickness; soft tissue biotype.

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The morphological assessment of mucogingival soft tissue dimensions around implants is of great interest to patients and clinicians. It has been reported that thinner gingival tissue thickness around a dental implant is more friable, less vascularized, and more prone to gingival recession.[1–3] Thinner crestal gingival thickness has been associated with increased marginal bone loss around dental implants.[4,5] In addition, crestal gingival thickness is also a crucial factor in abutment material selection, with thinner gingival thickness exhibiting more discoloration.[6]

Implant position and angulation can have a significant effect on the aesthetic outcome. Therefore implants must be accurately placed in a three-dimensional (mesiodistal, labiolingual, and apico-coronal) position with the goal of achieving a proper emergence profile for the final

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restoration. When the implant position is not accurate, the aesthetic result is often compromised. Implants placed too deep in an apico-coronal position or too labial often result is an unnaturally long restoration.[7] The design of the prosthetic restoration should be planned to achieve appropriate implant location with adequate thickness of bone around the implant.[8] However, a lack of adequate bone volume may necessitate implant placement in non-ideal locations and with various angulations. So far, the effect of various buccolingual implant angulations on the crestal labial soft tissue thickness (CLSTT) in aesthetic areas has not been investigated. Therefore, the objective of this study was to assess the relationship between the CLSTT and the buccolingual angulations of maxillary anterior implants.

The null hypothesis for this study was that there would be no differences in the CLSTT of implants with three different buccolingual angulations.

Materials and methods

Institutional Review Board Services approval was granted for the present study. The material for the study was kept anonymous so that patients could not be identified. The inclusion criteria for this study included consecutive patients who received single-unit implants in the anterior maxillary area (central or lateral incisor areas) and had complete data sets (clinical data, intraoral photographs, radiographs, and study casts). All implants were placed at the bone level and had screw-retained provisionals placed to guide soft tissue formation prior to delivery of the final restoration. The records of 32 patients were selected and used for this retrospective study. One operator (BTL) placed the implants under investigation in this study; they were 20 Astra, 18 Straumann, 12 BHZ, 6 Zimmer, 6 Biomet, and 2 Lifecore implants.

Assessment of implant angulation and labial bone thickness

The implant position was determined using a sectional cone beam computed tomography (CBCT) scan. The CLSTT was measured using a digital calliper (Mitutoyo Corporation) at the crestal level of study casts (Fig. 1). CLSTT measurements were performed directly on the final study casts, made after the provisional stage, approximately 4 months after implant placement. The buccolingual angulation of implants was determined

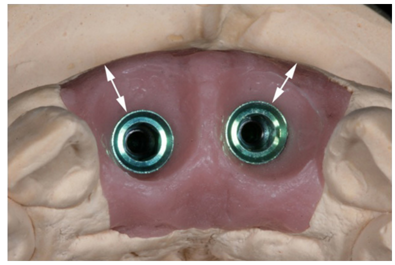

Fig. 1. Crestal labial soft tissue thickness measurements performed on the final study casts, made after the provisional stage, approximately 4 months after implant placement.

by the position of the screw access hole in the provisional restoration, and was recorded as cingulum, incisal, or labial position (Fig. 2). Considering the low amount of radiation, the first author performed sectional CBCT scans to assess the bone volume and implant conditions at the time of provisionalization. From the post-operative sectional CBCT scans, the implant labial bone thickness at the crestal (2 mm from the bone crest) and mid-implant levels were also measured and recorded.[9]

Statistical analysis

CLSTT data were compared by sex (independent t-test), and the different implant angulations were compared using descriptive analysis and one-way analysis of variance (ANOVA). CLSTT records for the three implant angulation groups were exposed to the test of homogeneity of variances (Levene statistic) before performing the one-way ANOVA test. Multiple

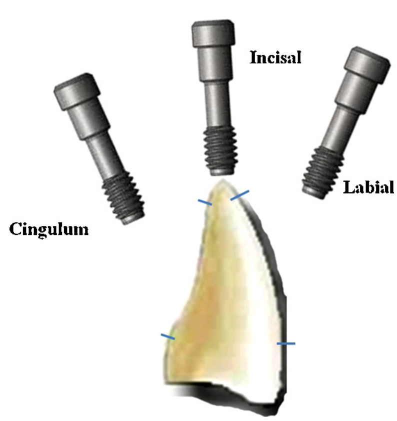

Fig. 2. Different implant angulations. Implant angulation was classified as cingulum, incisal, or labial based on the screw access hole position on the provisional restoration. By convention incisal angulation was determined only if the access to the screw hole involved reduction of the incisal edge.

comparisons of CLSTT in the three implant angulation groups were performed using post hoc tests and Bonferroni corrections. The percentages of implants with a thick CLSTT ($\geq$2 mm) were calculated for the different implant angulations. A contingency table was produced, and data for CLSTT were exposed to the χ^2 test to identify any significant differences among the implant angulation groups. Multiple regression analysis was also used to assess the predictability of variables such as implant labial bone thickness at the crestal and mid-implant levels, as well as implant angulation, for the outcome variable of CLSTT. The fit of the model was also assessed.

To further assess the relationship between the CLSTT and implant angulation, data were split into two categories based on the thickness of labial bone at the crestal level: <2 mm and $\geq$2 mm. Subsequently, the χ^2 test was performed in each group to determine whether there was any difference between groups with adequate ($\geq$2 mm) and less than adequate (<2 mm) labial bone thickness. A P-value of <0.05 was considered as statistically significant.

Results

Patients for this study were 22 females and 10 males. These patients had two implants placed in the maxillary arch between permanent canines in either the maxillary lateral incisor (7 and 10) or central incisor (8 and 9) region. Overall, 64 implants were placed. The diameters of implants ranged from 3.3 to 4.6 mm.

The mean (SD) ridge width at crestal level was 6.81 (0.98) mm. The independent t-test revealed no significant difference for the CLSTT with regard to sex ($P > 0.05$). The mean (SD) CLSTT for female patients was 2.46 (0.88) and for male patients was 2.43 (0.90) mm. There were 29 implants with a cingulum buccolingual angulation, 20 with an incisal angulation, and 15 with a labial angulation. The mean (SD) CLSTT for implants with cingulum, incisal, and labial angulations were 2.98 (0.84), 2.24 (0.51), and 1.71 (0.72) mm, respectively. One-way ANOVA tests revealed significant differences in CLSTT among the implant angulation groups ($F = 16.67$, $P = 0.000$) (Table 1). There were statistically significant differences between the CLSTT of implants with cingulum and incisal, as well as cingulum and labial angulations ($P < 0.05$). Therefore, the null hypothesis for this study was partially rejected.

A thick CLSTT was seen in 80% of implants placed. Of implants with cingulum,

Table 1. Multiple comparisons of crestal labial soft tissue thicknesses (CLSTT) for the three implant angulation groups.

Implant buccolingual angulation			95% CI of mean difference (mm)	*P*-value
Group I[a]	Group II[a]	CLSTT mean difference (mm)		
Incisal	Labial	0.53	−0.07 to 1.14	0.105
Cingulum	Labial	1.27	0.71–1.84	0.000
Cingulum	Incisal	0.74	0.23–1.26	0.002

CI, confidence interval.
[a] ANOVA test ($F = 16.67$, $P = 0.000$) and multiple comparisons of CLSTT in the three implant angulation groups using the post hoc tests and Bonferroni corrections.

Table 2. Implant buccolingual angulations according to the crestal labial soft tissue thickness.

Implant angulation[a]	Crestal labial soft tissue thickness, *n* (%)		Total
	Thick (≥2 mm)	Thin (<2 mm)	
Labial	7 (46.7)	8 (53.3)	15
Incisal	16 (80)	4 (20)	20
Cingulum	28 (96.6)	1 (3.4)	29
Total	51 (79.7)	13 (20.3)	64

[a] $\chi^2 = 15.201$, df = 2, $P = 0.001$.

incisal, and labial angulations, 3.4%, 20%, and 53.3%, respectively, had a thin (<2 mm thickness) CLSTT (Table 2). The χ^2 test revealed a significant difference in CLSTT among implant angulation groups ($\chi^2 = 15.201$, df = 2, $P = 0.001$).

Multiple regression analysis revealed a significant association between the three predictor variables and the CLSTT (adjusted $R^2 = 0.742$). Overall, 74.2% of the variance in CLSTT could be predicted by the three variables of the implant labial bone thickness at the crestal and mid-implant levels and the implant angulation. Analysis showed that the fit of the model was good ($F = 61.286$, $P = 0.000$). Every unit increase in implant angulation and implant labial bone thickness at the crestal and mid-implant levels was shown to add 0.27 mm ($P = 0.003$, 95% confidence interval (CI) 0.10–0.44), 0.73 mm ($P = 0.000$, 95% CI 0.50–0.96), and 0.18 mm ($P = 0.039$, 95% CI 0.01–0.35), respectively, to the CLSTT. Table 3 and Fig. 3 show the relationships between the CLSTT and implant angulations when the data were split into two categories based on the thickness of labial bone at the crestal level. It can be seen that the implant angulation was only related to the CLSTT when the thickness of labial bone at the crestal level was less than 2 mm ($\chi^2 = 15.029$, df = 2, $P = 0.001$) (Table 3).

Discussion

The present study investigated the relationship between the CLSTT and the buccolingual angulation of implants approximately 4 months after placement. Conducting a prospective clinical trial to assess this relationship would be difficult because it would not be ethically right to place implants with various angulations and assess the changes in the crestal soft tissue profile. Thus, we reviewed the retrospective data that were gathered from 32 patients and assumed that variations in the buccolingual angulation of their implants would allow assessment of the relationship between CLSTT and implant angulation.

Various methods have been used to measure the soft tissue thickness or assess the gingival biotype. Using a periodontal probe is probably the easiest way of determining the soft tissue biotype.[10–12] Put simply, the gingival biotype is either thin, if the outline of the probe inside the gingival sulcus can be seen through the gingiva, or thick (outline of the probe cannot be seen).[11] In addition, other methods can be used to evaluate the soft tissue biotype, such as transgingival probing,[13] ultrasonic determination,[14] using a transformer probe,[15] and radiographic soft tissue determination.[16,17] For the present study, the thickness of the crestal labial soft tissue was measured non-invasively using a digital calliper. This was done by direct measurement of the soft tissue moulage on the laboratory cast made during the final impression process for the final restoration.

Ideally, the screw access holes in a fixed screw-retained prosthetic crown should

Table 3. Relationship between the crestal labial soft tissue thickness and implant angulation according to the thickness of labial bone at the crestal level.

Thickness of labial bone at the crestal level for implants with different angulation	Crestal labial soft tissue thickness		Total
	Thick (≥2 mm)	Thin (<2 mm)	
<2 mm[a]			
Angulation			
Labial	1	8	9
Incisal	10	4	14
Cingulum	11	1	12
Total	22	13	35
≥2 mm			
Angulation			
Labial	6	0	6
Incisal	6	0	6
Cingulum	17	0	17
Total	29	0	29

[a] $\chi^2 = 15.029$, df = 2, $P = 0.001$.

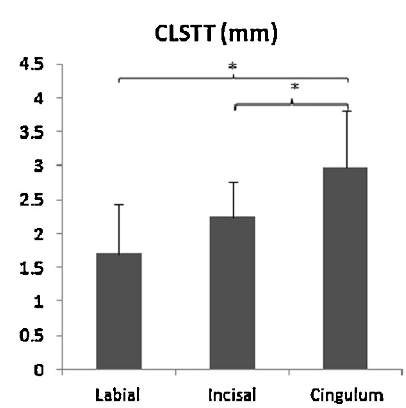

Fig. 3. Crestal labial soft tissue thickness measurements in the different implant angulation groups.

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follow the implant's long axis, which is in the cingulum or central fossa area. This is to achieve axial implant loading and optimal aesthetics.[8,18] Achieving this goal is not always possible, and subsequently, heavy loads can generate bending moments that are transferred to the supporting bone.[8,18] Available evidence, however, states that a direct relationship between heavy occlusal loads and marginal bone loss without bacteria and inflammation has not been established yet.[8]

Several factors can affect the soft tissue profile around implants, such as crestal labial bone thickness,[9] the distance between the contact points to the interproximal crestal bone,[19–23] and inter-implant as well as the implant–tooth distances.[23–26] The present implant angulation protocol divided the implant into three groups of cingulum, incisal, or labial angulation. This method is easy to use and can be used in a clinical setting. The null hypothesis for this study was partially rejected. According to our findings, implants with a cingulum type of angulation presented with the thickest CLSTT of almost 3 mm.

Gingival biotype plays a critical role in influencing tissue levels achieved around dental implants. The ideal amount of soft tissue thickness and width of keratinized mucosa around a dental implant has been debated in the literature for many years.[27–29] Although the importance of soft tissue thickness for the prevention of gingival recession around dental implants has been questioned,[30,31] soft tissue <2 mm has been associated with increased marginal bone loss,[6] thinner underlying bone,[9] angular bone defects, and increased susceptibility to papilla loss after immediate implant placement, and has been found to be more prone to recession in response to trauma and bacteria than a thicker biotype.[3] Consequently, a thinner soft tissue biotype may be more prone to recession and affect the final aesthetic result of the restoration. This is particularly more evident when immediate placement is the treatment of choice.[32] As a result, the use of connective tissue grafts to convert a thin gingival biotype into a thick gingiva has been recommended to enhance the long-term gingival marginal stability.[33]

According to the present study, 3.4%, 20%, and 53.3% of implants with cingulum, incisal, and labial angulations, respectively, had a thin (<2 mm thickness) CLSTT. There was also a significant difference in CLSTT among implants with different buccolingual angulations. These findings are clinically important, as according to this study, the placement of an implant with a labial angulation can affect the implant's labial soft tissue profile adversely.

Previous studies have reported a mean labial gingival recession of 0.5–1 mm around single implants, and this appears to be a common finding subsequent to implant restorations.[34–39] Over 1 year between single implant placement and the second-stage surgery, mean reductions in facial bone thickness and facial bone height of 0.4 mm and 0.7 mm, respectively, in the peri-implant tissues of the anterior maxillary region have also been reported, which resulted in a mean apical displacement of 0.6 mm for the labial soft tissue margins.[37] Thus, a possible limitation of this study is the lack of long-term data on changes in CLSTT. Although we found a higher incidence of thin soft tissue profiles in implants with labial or incisal angulations, it was not clear if the implant angulation was the major determinant of CLSTT, or if other factors, such as bone volume, also play a part in this equation. To answer this question we performed the multiple regression analysis. It appeared that the three variables of the implant labial bone thickness at the crestal and mid-implant levels and the implant angulation, determined nearly 75% of variation in CLSTT, but not all of it. Considering the level of significance, it seems that among the three variables mentioned, the implant labial bone thickness at the crestal level was the strongest determinant of the soft tissue thickness.

When data were split, it appeared that implant angulation was a confounding variable, and the labial bone thickness was the dominating factor that was associated with the soft tissue thickness. Perhaps buccal angulation is more associated with thinner soft tissue because cases with buccal angulation may have a decreased labial crestal bone thickness. In other words, buccal angulation can be accompanied by thick soft tissue ($\geq$2 mm) if there is an adequate labial bone thickness ($\geq$2 mm). This study showed that at 4 months post-implant placement, even if the implant was placed with incisal or labial angulation, provided that the thickness of bone was $\geq$2 mm, then the labial soft tissue at the crestal level was quite thick ($\geq$2 mm). Future studies can examine other determinants of the CLSTT at longer time intervals, or assess the long-term effect of labial bone thickness on bone resorption around the implant.

In conclusion, within the limitations of this study, it can be concluded that implants with labial angulations carry a higher risk of soft tissue complications when implant labial bone thickness (crestal level) is less than 2 mm.

Funding

None.

Competing interest

None declared.

Ethical approval

Ethical approval for the study was obtained from the Institutional Review Board Services (FL IRB: IRB00006338); it was exempted due to its retrospective nature.

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