Research, Society and Development, v. 11, n. 5, e46411528472, 2022
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v11i5.28472

Analysis of buccal gingival thickness in maxillary implants and its relation to gingival biotype

Análise da espessura gengival vestibular em implantes na maxila anterior e sua relação com o biotipo gengival

Análisis del espesor gingival vestibular en implantes en el maxilar anterior y su relación con el biotipo gingival

Received: 03/24/2022 | Reviewed: 04/03/2022 | Accept: 04/07/2022 | Published: 04/18/2022

Fernando Rodrigo Policarpo Matosinhos
ORCID: https://orcid.org/0000-0003-1785-1373
Faculdade São Leopoldo Mandic, Brazil
E-mail: matosinhos@gmail.com
Frederico Nigro
ORCID: https://orcid.org/0000-0002-7562-7276
Faculdade São Leopoldo Mandic, Brazil
E-mail: institutonigro@gmail.com
Bruno Aiello Barbosa
ORCID: https://orcid.org/0000-0002-4664-8780
Faculdade São Leopoldo Mandic, Brazil
E-mail: drbrunoaiello@gmail.com
Amanda Gonçalves Franco
ORCID: https://orcid.org/0000-0003-0983-7539
Universidade de Itaúna, Brasil
E-mail: amandagfranco38@gmail.com
Bruno Salles Sotto-Maior
ORCID: https://orcid.org/0000-0002-9462-0299
Faculdade São Leopoldo Mandic, Brazil
E-mail: bruno.sotto@ufjf.br
Carlos Eduardo Francischone
ORCID: https://orcid.org/0000-0003-2627-5646
Faculdade São Leopoldo Mandic, Brazil
E-mail: drfrancischone@yahoo.com.br

Abstract
Objectives: This study aimed to evaluate vestibular gingival thickness in unitary implants located in the anterior maxilla through a cone beam tomography. Material and methods: After visual classification of the gingival biotype of the 32 patients selected for this study (16 patients with thin biotype and 16 patients with thick biotype) measurements of the vestibular tissue thickness were made at 2, 4 and 6 mm from the gingival margin in the apical direction in the most longitudinal transverse cut of the implant and the contralateral tooth through tomographic cone beam examination for soft tissue. The data of age and gender of the patients, mean buccal wall thickness of the implants and contralateral natural teeth, and the use of connective tissue graft (CTG) were tabulated for descriptive analysis. Results: For thin gingival biotype, mean vestibular gingival thickness varied between 1.26 ± 0.31 mm (teeth) and 2.65 ± 0.93 mm (implant), and for thick biotype varied from 1.77 ± 0.58 mm (teeth) and 3.01 ± 0.96 mm (implant). The use of CTG increased the buccal thickness of thick biotype when compared to thin biotype without CTG. Conclusions: It was not possible to establish a direct relationship between the classification of the gingival biotype of the contralateral teeth and the gingival biotype of the implants installed in the anterior region of the maxilla, but CTG was shown to be efficient in increasing gingival tissue thickness.
Keywords: Dental implant; Gingival phenotype; Gum.

Resumo
A identificação do biotipo gengival é importante e deve ser levada em consideração durante o plano de tratamento, para que estratégias de manipulação tecidual possam ser previstas, a fim de melhorar os resultados estéticos.Este estudo objetivou avaliar a espessura gengival vestibular em implantes unitários localizados na maxila anterior, através de exame tomográfico cone beam para tecido mole. Após classificação visual do biotipo gengival dos 32 pacientes selecionados para este estudo (sendo 16 pacientes de biotipo fino e 16 pacientes de biotipo espesso), foram feitas medidas da espessura tecidualvestibular a2, 4 e 6 mm a partir da margem gengival em direção apical no corte

transversal mais longitudinal do implante e do dente contralateral, através de exame tomográfico cone beam para tecido mole. Os resultados apresentaram medidas médias de espessura gengival vestibular aos dentes de 1,26 ± 0,31mm em pacientes de biotipo gengival fino e de 1,77 ± 0,58mm em pacientes de biotipo gengival espesso; e medidas médias 2,65 ± 0,93mm e de 3,01 ± 0,96mm de espessura gengival na vestibular dos implantes analisados, para o biotipo fino e biotipo espesso, respectivamente. Além disso, evidenciou-se a importância da utilização do enxerto de tecido conjuntivo, que quando utilizado, os pacientes apresentaram uma média de espessura tecidual vestibular de 2,85 ± 0,93 mm e de 3,19 ± 1,08 mm para biotipo fino e espesso. Não foi possível estabelecer uma relação direta entre a classificação do biotipo gengival dos dentes contralaterais com o biotipo gengival dos implantes instalados na região anterior da maxila.
Palavras-chave: Implante dentário; Fenótipo gengival; Gengiva.

Resumen

La identificación del biotipo gingival es importante y debe ser tenida en cuenta durante el plan de tratamiento, de manera que se puedan predecir estrategias de manipulación tisular para mejorar los resultados estéticos. Este estudio tuvo como objetivo evaluar el espesor gingival vestibular en implantes unitarios ubicados en la maxilar anterior, mediante examen tomográfico de haz cónico para tejidos blandos. Después de la clasificación visual del biotipo gingival de los 32 pacientes seleccionados para este estudio (16 pacientes con biotipo delgado y 16 pacientes con biotipo grueso), se realizaron mediciones del espesor del tejido bucal a 2, 4 y 6 mm del margen gingival. en dirección apical en el corte transversal longitudinal del implante y el diente contralateral, mediante examen tomográfico de haz cónico para tejidos blandos. Los resultados mostraron medidas promedio de espesor gingival bucal a los dientes de 1,26 ± 0,31 mm en pacientes con biotipo gingival delgado y 1,77 ± 0,58 mm en pacientes con biotipo gingival grueso; y medidas promedio de 2,65 ± 0,93 mm y 3,01 ± 0,96 mm de espesor gingival en vestibular de los implantes analizados, para el biotipo delgado y biotipo grueso, respectivamente. Además, se destacó la importancia de utilizar un injerto de tejido conectivo, el cual, al ser utilizado, los pacientes presentaban un espesor de tejido vestibular promedio de 2,85 ± 0,93 mm y de 3,19 ± 1,08 mm para biotipo delgado y grueso. No fue posible establecer una relación directa entre la clasificación del biotipo gingival de los dientes contralaterales y el biotipo gingival de los implantes instalados en la región anterior del maxilar.
Palabras clave: Implante dental; Fenotipo gingival; Encía.

1. Introduction

The concept of osseointegration was introduced by Branemark focused on rehabilitation, and a wide variety of concepts, treatment protocols and implant evolutions resulted in a successful implant therapy from the functional point of view (Teughels et al., 2009). This success can be evaluated by parameters such as marginal bone loss, depth of groove and mobility of the implant. In addition, the favorable aesthetic result of implant treatment is also related to soft tissue thickness, which may influence the level of the gingival margin and the presence of the papilla around the implant (Spray et al., 2000). Thus, the understanding of the remodeling of the hard and soft tissues contributes to achieve greater aesthetic predictability and consequent success in the treatment (Lee et al., 2011).

The ideal three-dimensional positioning of the implant within available bone dimensions, and proper maintenance of the buccal bone on the surface of the implant are related to the degree of bone remodeling that occurs after implant implantation, which may negatively influence the soft tissue topography and the aesthetic result of the implant therapy. In order to establish the positioning criteria, bone augmentation techniques, orthodontics, ameloplasty or restorative materials have been recommended (Buser et al., 2004; Cardaropoli et al., 2006; Grunder, 20011).

For evaluation of the gingival tissues can be used the periodontal probing (Cardaropoli et al., 2006; Kan et al., 2003; Müller HP & Eger T, 2002; Muller et al., 2000), considered more invasive, or image exams, like soft-tissue cone-beam computed tomography (Januário et al., 2008). This technique allows accurate visualization and measurement of hard and soft tissues of the tooth-gingival complex, such as the distances between the gingival margin and vestibular bone crest, gingival margin and cement-enamel junction, cement-enamel junction and vestibular bone crest, width of the vestibular or palatine/lingual bone and the width of the vestibular or palatine/lingual gingiva.

Extrapolating the observations of soft tissue behavior around natural teeth, peri-implant soft tissues can be classified into thin and thick biotype (Lee et al., 2011). A thin biotype is one where the contour of the periodontal probe can be seen through the tissue margin when probed, whereas in the thicker biotype the probe is camouflaged by the marginal tissue (Kan et al., 2003). The soft tissue thickness is often corresponding to the thickness of the underlying bone. These two gingival biotypes respond differently to inflammation, restorative traumas and parafunctional habits (Kao et al., 2008; Nagaraj et al., 2010). Thinner bone tissues are more prone to gingival recession in response to a trauma or plaque when compared to thicker ones (Nisapakultorn et al., 2010). Thus, the distinction between them influences the treatment plan and implant installation (Kao et al., 2008; Nagaraj et al., 2010). When these biotypes are carefully considered, some periodontal and surgical strategies may be employed to optimize treatment outcome, minimize alveolar resorption or even improve the tissue environment for implant installation (Kao et al., 2008; Nagaraj et al., 2010; Müller HP & Eger T, 2002).

The objective of this study was to analyze the vestibular gingival thickness of implants installed in the anterior maxilla, by means of cone-beam tomographic examination for soft tissues, establishing a relation with the gingival biotype.

2. Methods

This study was approved by the Research Ethics Committee of the São Leopoldo Mandic School, and all patients received guidelines about work and signed a Consent Form (Approval Number: 795.579)

Patients from the Implant Dentistry clinics of the São Leopoldo Mandic School were evaluated during the return of the treatment, and were included in the study patients that had implants installed in a correct position in the anterior maxillary arch, in healed alveolus, and those already had the implant-supported prosthetic crown for at least 6 months, located between natural teeth, and having the contralateral natural tooth. The following exclusion criteria were adopted in the study: patients who received a bone graft in the upper anterior region prior to implantation, patients who presented a history or presence of periodontal disease, patients with anterior maxillary teeth poorly aligned, patients undergoing orthodontic treatment, smokers, patients with systemic diseases, pregnancy or lactation and patients who were using drugs that could alter soft tissue thickness (cyclosporins A, calcium channel blockers or phenytoins).

The selected patients were clinically evaluated and had their gingival biotype classified as thin or thick by two independent and previously calibrated periodontists, according to the following parameters: a periodontal millimeter probe (North Carolina millimeter probe #15, HuFriedy, Chicago, USA) was introduced into the buccal face of the natural tooth and when this probe presented a shadow through the gingiva, the patient was classified as a thin biotype (Figure 1). When the periodontal probe could not be visualized, the biotype was classified as thick (Figure 2). With the sample already defined equal for both biotypes, a specialist in Implantology, who did not have access to the classification of the first specialist, made the same evaluation with the periodontal probe to confirm the classification of the gingival biotypes. The interobserver reliability was confirmed by a Kappa index at 95%, with $p < 0.001$.

Figure 1 – Thin biotype.

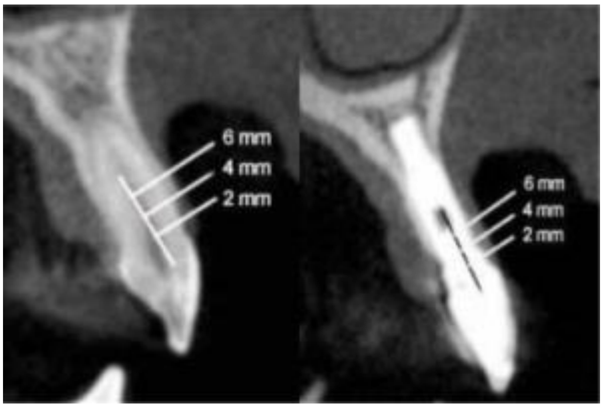
Source: Authors.

Figure 2 – Thick biotype.

Source: Authors.

After the determination of the gingival biotype, patients were submitted to a cone-beam type computed tomography, using a labial retractor during the examination, to visualize the soft and hard tissues located buccaly to the anterior implant. The exams were done using the i-Cat Next Generation (ImagingSciences, Hatfield, PA, USA) equipment with acquisition time of 26 sec and voxel of 0.2 mm. For each implant and contralateral tooth, 1 mm sections/images were obtained. Buccal measurements of gingival thickness, located at the most median longitudinal cut perpendicular to the implant and the tooth, were performed in three different positions in relation to the gingival margin: 2 (#1), 4 (#2) and 6 (#3) mm of the free marginal gingiva in the apical direction (Figure 3). Measurements were made using the image processing software Dental Slice (Bioparts, Brasília, Brazil), by a radiologist.

Figure 3 - Three different positions in relation to the gingival margin: 2 (#1), 4 (#2) and 6 (#3) mm of the free marginal gingiva in the apical direction.



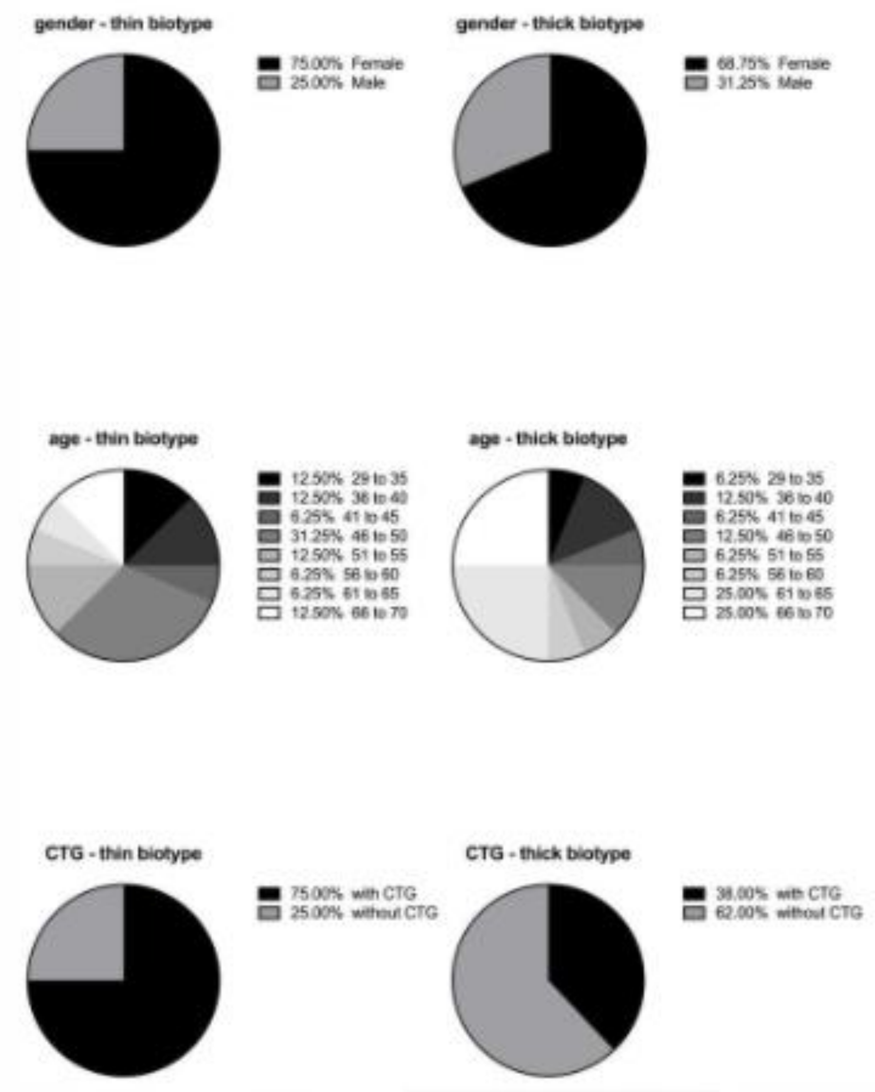
Source: Authors.

The data of age and gender of the patients, mean buccal wall thickness of the implants and contralateral natural teeth, and the use of connective tissue graft (CTG) were tabulated for descriptive analysis, the respective percentages were calculated and (Microsoft Excel for Mac 15.29.1, Microsoft, Redmond, Washington, USA) and the graphs were obtained (Prism 7.0, GraphPad, La Jolla, California, USA). Afterwards, the inferential statistical analysis of the buccal mean thickness of the implants and contralateral teeth, and the use of CTG or not, was performed by Prism 6.0 software (GraphPad, La Jolla, California, USA). Once the distribution normality and the homogeneity of the data were confirmed by the Kolmogorov-Smirnov test, the vestibular wall thickness data of the contralateral teeth were analyzed by 2-way ANOVA, followed by Tukey's test with single effects for the biotype and local factors (all with 5% significance). Due to the unequal size of the number of occurrences for each condition assessed and its distribution, buccal wall thickness data on implants and the comparison between the use of CTG did not obey the assumptions of normality and homogeneity of the variances, and were evaluated by Kruskal-Wallis non-parametric test with significance of 5%. Differences, when they occurred, were analyzed by Dunn test with significance of 5%.

3. Results

Thirty-two patients were evaluated in this study, equally distributed between gingival biotypes (thin and thick), presenting a mean age of 51.5 years, between 29 and 70 years of age, with age groups distributed according to Figure 4. Most of the patients were females, who represented 75% and 68.25%, in the thin and thicker biotypes, respectively, as shown in Figure 3.

Figure 4 – Distribution of gengival biotypes.



Source: Authors.

In this study, 32 contralateral teeth were also evaluated, represented by 14 central incisors, 16 lateral incisors and 2 canines, which presented a tissue thickness in the buccal face between 0.99 and 1.44 mm for the thin biotype and between 1.56 and 1.94 mm for the thick biotype (Table 1).

Table 1 - Means and standard deviation of the buccal thickness data, in mm, of the natural teeth of the patients included in this study as a function of the gingival biotype.

	Thin biotype	Thick biotype
# 1	0.99 ± 0.18^{Aa}	1.56 ± 0.34^{Ba}
# 2	1.36 ± 0.26^{Ab}	1.81 ± 0.29^{Bab}
# 3	1.44 ± 0.26^{Ab}	1.94 ± 0.58^{Bb}
Total	1.26 ± 0.31	1.77 ± 0.58

Caption: Measure # 1 performed at 2 mm from the free marginal gingiva in the apical direction; Measure # 2 performed at 4 mm from the free marginal gingival in the apical direction; Measure # 3 performed at 6 mm of the free marginal gingival in the apical direction.
Identical upper case letters represent absence of statistically significant difference in the same line (measurement site). Source: Authors.

Identical lower case letters represent absence of statistically significant difference in the same column (biotype).

2-way ANOVA test found that biotype and measurement points isolated factors influenced the mean buccal wall thickness for natural teeth ($p<0.0001$ for both), but their interaction did not influence the buccal wall thickness ($p=0.7707$). All measurement sites had lower buccal wall thickness values for the thin biotype compared to the thicker one. For the thin biotype, Tukey's test detected the lowest thickness occurred for the measurement point #1, while for the thick biotype the highest thicknesses were observed at the measurement points #2 and #3, and the measurement point #2 also presented buccal thickness similar to the measurement point #1.

In the evaluation of the implanted area, the averages of tissue thickness of the vestibular face varied between 2.24 and 2.99 mm for the thin biotype, and between 2.63 and 3.13 mm for the thick biotype (Table 2). Kruskall Wallis test did not detect a statistical difference between groups for the implants (KW=9.074; gl=5; p-value=0.1061).

Table 2 - Means and standard deviation of the buccal wall thickness data, in mm, of the implants of the patients included in this study as a function of the gingival biotype.

	Thin biotype	Thick biotype
# 1	2.24 ± 0.65	2.63 ± 0.85
# 2	2.72 ± 0.86	3.12 ± 0.90
# 3	2.99 ± 1.11	3.27 ± 1.06
Total	2.65 ± 0.93	3.01 ± 0.96

Caption: Measure # 1 performed at 2 mm from the free marginal gingiva in the apical direction; Measure # 2 performed at 4 mm from the free marginal gingival in the apical direction; Measure # 3 performed at 6 mm of the free marginal gingival in the apical direction. Source: Authors.

In thin biotype, it was observed that 75% of the patients received CTG, whereas 38% of patients of thick biotype underwent soft tissue regeneration therapy. Figure 4 shows the distribution of CTG in the patients included in this study, according to the biotypes. Table 3 shows the mean tissue thickness of the buccal face at the three points of the longitudinal axis was 2.04 ± 0.64 mm (thin biotype) and 2.90 ± 0.88 mm (thick biotype) for patients did not receive CTG, while patients with CTG varied from 2.85 ± 0.93 (thin biotype) to 3.19 ± 1.08 mm (thick biotype) (Table 3). Kruskall Wallis test detected a statistical difference between the mean wall thickness data for the implants (KW=20.40, gl=11, p-value=0.0401) and Dunn's test found that only the thicker biotype with CTG at measurement point #3 presented different thickness of the thin biotype without CTG at measurement point #1, but these conditions were similar in thickness to the others.

Table 3 - Means and standard deviation of buccal wall thickness data, in mm, of implants that received CTG or not, as a function of the gingival biotype.

	with CTG		without CTG	
Biotype	thin	thick	thin	thick
# 1	2.41 ± 0.56^{AB}	2.60 ± 0.92^{AB}	1.71 ± 0.66^{B}	2.65 ± 0.86^{AB}
# 2	2.95 ± 0.83^{AB}	3.25 ± 0.92^{AB}	2.03 ± 0.57^{AB}	3.04 ± 0.92^{AB}
# 3	3.20 ± 1.17^{AB}	3.73 ± 1.24^{A}	2.38 ± 0.66^{AB}	3.00 ± 0.89^{AB}
Total	2.85 ± 0.93	3.19 ± 1.08	2.04 ± 0.64	2.90 ± 0.88

Caption: Measure # 1 performed at 2 mm from the free marginal gingiva in the apical direction; Measure # 2 performed at 4 mm from the free marginal gingival in the apical direction; Measure # 3 performed at 6 mm of the free marginal gingival in the apical direction.
Source: Authors.

Identical upper case letters represent absence of statistically significant difference.

4. Discussion

The method of soft tissue evaluation by means of cone-beam computed tomography proposed showed to be quite feasible in the clear visualization of the soft tissues buccally located to the implants in the present research (Januário et al., 2008)

The average thickness of the tissue at 2 mm from gingival margin obtained corroborated with the classification proposed, where the thin biotype was associated with thicknesses less than or equal to 1mm, and thicknesses greater than 1 mm were classified as thick biotype (Kan et al., 2010). It is important to emphasize that the classification of the gingival biotype of the present study was performed by analyzing the soft vestibular tissue of the contralateral natural teeth (Kan et al., 2010; Nisapakultorn et al., 2010; Yoshino et al., 2014) and not only of the implanted areas (Kan et al., 2003). The evaluation was carried out in 3 points, and the biotypes classified with the periodontal probe as thick in fact presented higher mean thickness compared to the fine biotypes. In addition, these values, for both biotypes, increased apically, agreeing with the results presented that indicated an increase in the value in the apical direction in the evaluated points in the vestibular mucosa of the natural teeth for both biotypes (Cook et al., 2011). The inverse relationship can be observed for measurements of hard tissues, with values of the buccal bone plate decreasing apically towards the bone crest (Januário et al., 2011).

It is possible to consider that the correct planning and positioning of the implant contributed to a considerable increase in the mean vestibular tissue thickness compared to the measurements presented by the contralateral teeth in the present study (thin biotype: 2.65 ± 0.93 mm; thick biotype: 3.01 ± 0.96 mm). The observed values were higher than previous studies (mean of 1.2 ± 0.6 mm for the buccal bone board at 0.5 mm of bone crest), that did not evaluate the thickness of the soft tissue suprajacent to the implant (Nisapakultorn et al., 2010). Cardaropoli et al., 2006 obtained results of 1.6 ± 0.7 mm of soft tissue and 0.8 ± 0.3 mm of hard tissue, which added together, are similar to the findings of the present study, although they did not classify the gingival biotypes. Results similar to ours were also observed by Myamoto & Obama, 2011 (2.76 ± 0.74 mm of buccal bone board at 5 mm of the implant platform). The study by Merheb et al. 2017 found lower values of mean thickness (between 0.85 ± 0.71 mm and 1.81 ± 0.93 mm) but did not consider the location of the implants, besides using other instruments for measurement.

The use of a connective tissue graft and bone grafting immediately upon implantation of the implant in the aesthetic areas are an effective treatment option to compensate for the expected volume loss of vestibular soft tissue and to guarantee good aesthetic results (Chu et., 2015; Grunder et al., 2011; Yoshino et al., 2014; Atieh et al., 2020). With respect to CTG, the present study observed that only at the most apical measuring point (#3) the presence of CTG in the thick biotype resulted in a greater thickness compared to the most cervical measurement point (#1) in the thin biotype without CTG, but both were similar to the other conditions compared. However, when comparing the mean vestibular gingival thickness of the fine biotype in the contralateral teeth (1.26 ± 0.31 mm) with the data after the use of CTG (2.85 ± 0.93 mm), it could be observed the possibility of alteration of a thin gingival biotype into a thick gingival biotype using CTG, as previously discussed, considering that a thick gingival tissue is one that presents 2 mm or more of thickness (Kao et al., 2008; Linkevicius et al., 2009).

Vestibular gingival thickness in patients who received a connective tissue graft in the rehabilitation therapy with dental implants in aesthetic area (mean value of 2.61 ± 0.57 mm) was similar to that found in the present study. (Rungcharassaeng et al., 2012). But guided bone regeneration contributes more to the volume increase than the CTG, which in its study failed to increase the tissue volume in almost 1/3 of the patients. (Schneider et al., 2011).

5. Conclusion

The present study observed that the technique of connective tissue grafting was most often used in patients with fine biotype and it was shown to be efficient in increasing gingival tissue thickness. In spite of the statistical difference between the mean thickness of the vestibular wall for implants when the use of CTG was compared, it was not possible to establish a direct relationship between the classification of the gingival biotype of the contralateral teeth and the gingival biotype of the implants for the anterior region of the maxilla.

For future studies, as important as the assessment of the gingival biotype is the need for further studies to assess the stability of the gingival margin around implants after receiving a soft tissue graft.

References

Atieh, M. A., et al. (2020). Soft issue changes after connective tissue grafts around immediately placed and restored dental implants in the esthetic zone: A systematic review and meta-analysis. *J Esthet Restor Dent*, 32, 280–290.

Buser, D., et al. (2004). Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations. *Int J Oral Maxillofac Implants*,19, 43-61.

Cardaropoli, G., et al. (2006). Tissue alterations at implant-supported single-tooth replacements: a 1-year prospective clinical study. *Clin Oral Implants Res*, 17, 165-171.

Chu, S., et al. (2015). Flapless Postextraction Socket Implant Placement, Part 2: The Effects of Bone Grafting and Provisional Restoration on Peri-implant Soft Tissue Height and Thickness — A Retrospective Study. *Int J Periodontics Restorative Dent*, 35, 803-809.

Cook, R., et al. (2011). Relationship between clinical periodontal biotype and labial plate thickness: an in vivo study. *Int J Periodontics Restorative Dent*, 31, 345-354.

Grunder U. (2011). Crestal ridge width changes when placing implants at the time of tooth extraction with and without soft tissue augmentation after a healing period of 6 months: report of 24 consecutive cases. *Int J Periodontics Restorative Dent* 31, 9-17.

Januário, A. L., et al. (2008). Soft Tissue Cone-Beam computed tomography: a novel method for the measurement of gingival tissue and the dimensions of the dentogingival unit. *J Esthet Restor Dent*, 20, 366-373.

Januário, A. L., et al. (2011). Dimension of the facial bone wall in the anterior maxilla: a cone-beam computed tomography study. *Clin Oral Implants Res*,10, 1-4.

Kan, J. Y. K., et al. (2010). Gingival biotype assessment in the esthetic zone: visual versus direct measurement. *Int J Periodontics Restorative Dent*, 30, 237-243.

Kan, J. Y. K., et al. (2003). Dimensions of peri-implant mucosa: an evaluation of maxillary anterior single implants in humans. *J Periodontol*, 74, 557-562.

Kao, R. T., et al. (2008). Thick vs. thin gingival biotypes: a key determinant in treatment planning for dental implants. *J Calif Dent Assoc*, 36, 193-198.

Lee, A., et al. (2011). Soft tissue biotype affects implant success. *Implant Dent*, 20, 38-47.

Linkevicius, T., et al. (2009). The influence of soft tissue thickness on crestal bone changes around implants: a 1-year prospective controlled clinical trial. *Int J Oral Maxillofac Implants*, 24, 712-719.

Merheb, J., et al. (2017). The fate of buccal bone around dental implants. A 12-month postloading follow-up study. *Clin Oral Implants Res* 28, 103-108.

Müller, H. P. & Eger, T. (2002). Masticatory Mucosa and Periodontal Phenotype: A Review. *Int J Periodontics Restorative Dent* 22, 173-183.

Müller, H. P., et al. (2000). Thickness of masticatory mucosa. *J Clin Periodontol*, 27, 431-36.

Miyamoto, Y., et al. (2011). Dental cone beam computed tomography analyses of postoperative labial bone thickness in maxillary anterior implants: comparing immediate and delayed implant placement. *Int J Periodontics Restorative Dent*, 31, 215-225.

Nagaraj, K. R., et al. (2010). Gingival biotype – prosthodontic perspective. *J Indian Prosthodont Soc*, 10, 27-30.

Nisapakultorn, K., et al. (2010). Factors affecting soft tissue level around anterior maxillary single-tooth implants. *Clin Oral Implants Res,* 21, 662-670.

Rungcharassaeng, K., et al.. (2012). Immediate implant placement and provisionalization with or without a connective tissue graft: an analysis of facial gingival tissue thickness. *Int J Periodontics Restorative Dent*, 32, 657-663.

Schneider, D., et al. (2011). Volume gain and stability of peri-implant tissue following bone and soft tissue augmentation: 1-year results from a prospective cohort study. *Clin Oral Implants Res,* 22, 28-37.

Spray, J. R., et al. (2000). The influence of bone thickness on facial marginal bone response: stage 1 placement through stage 2 uncovering. *Ann Periodontol*, 5, 163-172.

Teughels W., et al. (2009). Critical horizontal dimensions of interproximal and buccal bone around implants for optimal aesthetic outcomes: a systematic review. *Clin Oral Implants Res,* 20, 134-145.

Yoshino, S., et al. (2014). Effects of connective tissue on the facial gingival level following single immediate implant placement and provisionalization in the esthetic zone: a 1-year randomized controlled prospective study. *Int J Oral Maxillofac Implants* 2014: 29:432-440.