J Oral Res
research in oral sciences

ORIGINAL ARTICLE

CHARACTERISTICS OF THE BUCCAL SHELF FOR THE INSTALLATION OF MINISCREWS IN CHILEAN INDIVIDUALS AGED 15-45 YEARS: A DESCRIPTIVE STUDY

Características del Buccal Shelf para la instalación de microtornillos en individuos chilenos de 15-45 años: Estudio descriptivo

Lourdes Wang,[1] Rodrigo Oyonarte,[1] Raimundo Carmona,[1] Carolina Bidart,[1] Gianfranco Battaglia.[1]

1. Facultad de Odontología, Universidad de Los Andes, Santiago, Chile.

ABSTRACT

Introduction: Orthodontic mini-screws allow complex therapeutic objectives to be achieved conservatively, so their use in clinical practice has increased considerably in recent years. The most important aspect to consider is the stability when installing it, related to the thickness of the cortical bone in the area where it is implanted. In the mandible, it has been seen that the area with the highest success rate is that of the buccal shelf (BS). Several studies have proposed variation in its location and bone thickness according to the characteristics of each patient. **Objective:** To describe the characteristics of the mandibular vestibular balcony (Buccal Shelf or BS) through the study of CBCT in individuals between 15-45 years of age in the Metropolitan Region of Santiago de Chile.

Materials and Methods: Full-head CBCT images of 159 patients aged 15 to 45 years were analyzed, categorized into 3 groups classified according to age between 15-24 years; 25-34 years; 35-45 years. The patients' facial pattern was measured based on Steiner's S-N-Go-Gn angle, where it was classified into three ranges; less than 30 degrees, between 30 and 34 degrees, greater than 34 degrees and were analyzed with BlueSkyPlan software4. For the statistical tests, the normality in the distribution of the data was first analyzed through the Shapiro-Wilk test. For the comparison between variables, the Kruskal Wallis test was used with Bonferroni's multiple comparisons test. The Horos v.3.3.5 program was used for measurements of alveolar cortical thickness and the angle formed by the cortical contour of the BS in relation to the axial axis of the respective molar. All images were obtained with a KODAK 9500 CT scanner and stored in DICOM files.

Results: The distance from the cortical to the tooth root increases from mesial to distal and as depth increases. When assessing the distance from the cortical to the inferior alveolar nerve, it also increases from mesial to distal, but decreases as the depth of the site increases. The greatest distance is from the vestibular cortical of the distal site of the second mandibular molar at 7mm depth to the root of the same tooth and, also, the vestibular cortical of the distal site of the second mandibular molar at 5 mm depth to the alveolar nerve.

Conclusion: From mesial to distal in this area, the slope of the vestibular balcony increases, becoming flatter; likewise, the distance to the molar root and mandibular alveolar nerve measured from the alveolar cortical also increases. This may be due to the principle of mandibular growth and physiological characteristics of the posterior mandibular area. Different facial patterns show differences in the anatomy of the vestibular balcony, mainly in the angle of the vestibular balcony, but not in the thickness of the alveolar cortical bone in this area. It is important to consider that the variations found in other studies may be due primarily to racial differences.

Keywords: Mandibular vestibular shelf; Bone screws; Orthodontic anchorage procedures; Cortical bone; Mandible; Orthodontics.

RESUMEN

Introducción: Los minitornillos de uso ortodóncico permiten lograr objetivos terapéuticos complejos de forma conservadora, por lo que su uso en la práctica clínica ha aumentado considerablemente en los últimos años. El aspecto más importante por considerar es la estabilidad al instalarlo, relacionada al espesor del hueso cortical de la zona donde se implanta. En la mandíbula, se ha visto que el área de mayor tasa de éxito es la del balcón vestibular o buccal shelf (BS). Diversos estudios han propuesto variación de su ubicación y espesor óseo según características de cada paciente. **Objetivo:** Describir las características del balcón vestibular mandibular (buccal shelf o BS) a través de estudio de CBCT en individuos entre 15-45 años de la Región Metropolitana de Santiago de Chile.

Materiales y métodos: Se analizaron imágenes de CBCT de cabeza completa de 159 pacientes de entre 15 a 45 años, categorizados en 3 grupos clasificados según edad entre 15-24 años; 25-34 años; 35-45 años. El patrón facial de los pacientes fue medido en base al ángulo S-N-Go-Gn de Steiner, donde se clasificó en tres rangos; menor a 30 grados, entre 30 y 34 grados, mayor a 34 grados y se analizaron con el software BlueSkyPlan4. Para las pruebas estadísticas primero se analizó la normalidad en la distribución de los datos a través de la prueba Shapiro-Wilk. Para la comparación entre variables se utilizó el test de Kruskal Wallis con la prueba de comparaciones múltiples de Bonferroni. Se utilizó el programa Horos v.3.3.5 para mediciones de espesor cortical alveolar y el ángulo formado por el contorno cortical del BS en relación con el eje axial del molar respectivo. Todas las imágenes fueron obtenidas con un equipo radiológico Tomógrafo KODAK 9500, almacenadas en archivos con formato DICOM.

Resultado: La distancia desde la cortical a la raíz dentaria aumenta desde mesial a distal y a medida que aumenta la profundidad. Al evaluar la distancia desde la cortical hasta el nervio alveolar inferior, también aumenta de mesial a distal, pero disminuye a medida que aumenta la profundidad del sitio. Siendo los lugares de mayor distancia desde la cortical vestibular del sitio distal del segundo molar mandibular a los 7 mm de profundidad hasta la raíz del mismo diente y, también, la cortical vestibular del sitio distal del segundo molar mandibular a los 5mm de profundidad hasta el nervio alveolar.

Conclusión: A medida que nos desplazamos de mesial a distal en esta área aumenta tanto la pendiente del balcón vestibular, haciéndose más plana, así como la distancia a la raíz molar y nervio alveolar mandibular medidos desde la cortical alveolar, esto puede responder al principio de crecimiento mandibular y a características fisiológicas de la zona mandibular posterior. Diferentes patrones faciales presentan diferencias en la anatomía del balcón vestibular, principalmente en el ángulo de esta, no así en el espesor de hueso cortical alveolar de esta zona. Es importante considerar que las variaciones encontradas en otros estudios pueden deberse a diferencias raciales principalmente.

Palabras Clave: Balcón Vestibular Mandibular; Tornillos óseos; Métodos de anclaje en ortodoncia; Hueso cortical; Mandíbula; Ortodoncia.

CORRESPONDING AUTHOR: Lourdes Wang and Rodrigo Oyonarte. Facultad de Odontología, Universidad de Los Andes, Santiago, Chile. **E-mail:** lourdes.wang@miuandes.cl - royonarte@miuandes.cl.

CITE AS: Wang L, Oyonarte R, Carmona R, Bidart C, Bataglia G. Characteristics of the mandibular vestibular balcony for the installation of miniscrews in Chilean individuals aged 15-45 years: A descriptive study. J Oral Res. 2024; 13(1):222-233. doi:10.17126/joralres.2024.020

Received: June 27, 2023.
Accepted: May 2, 2024.
Published online: October 4, 2024.

ISSN Print 0719-2460
ISSN Online 0719-2479

INTRODUCTION

Currently, mini screws for orthodontic use have become widely used in clinical practice, allowing the achievement of complex therapeutic objectives and maximizing the excellence of orthodontic treatments with conservative clinical strategies.[1] In addition, they offer advantages over other skeletal anchoring systems; such as its low cost and ease of surgical insertion and removal.[2,3]

One of the most important aspects to consider when installing mini screws in orthodontics is their primary stability, that is, immediately after their insertion and secondary, which is related to the maintenance of the implant in its place after healing; which can be altered by factors such as insertion torque, the design of the mini screw, and especially the characteristics of the implant insertion site.[4,5] These characteristics include thickness, soft tissue properties, proximity to specific dental or neurovascular anatomical structures, and the intra- or extra-alveolar nature of the insertion site.[2,6] This gives rise to variations in the failure rate of the mini-screws according to the anatomical area where they are located, obtaining results from 1.3% in the midpalatal area to 16.4% in the infrazygomatic crest.[7]

It has been proposed that cortical bone thickness is mainly responsible for the mechanical retention of the microscrew,[4] achieving greater stability as bone cortical thickness increases.[8,9] Thus, it is accepted that the achievement of such primary stability would require a cortical bone thickness equal to or greater than 1 millimeter.[6] On the other hand, previous studies have stated that a vestibular total bone larger than 5 mm is sufficiently suitable for the placement of temporal anchoring devices (TADs) that are inserted perpendicular to the occlusal plane.[2]

In the literature, the total width of the vestibular balcony bone has been evaluated and it was determined that the total bone is generally thinner at the level of the distovestibular cusp of the first mandibular molar and thicker at the distovestibular cusp of the mandibular second molar.[4] Specifically, the overall failure rate of monitors installed in the mandibular vestibular area ranges from 13.5% to 14.3%.[5,6,8,9]

The mandibular vestibular balcony area (*"Buccal Shelf"* or BS) is located bilaterally at the back of the mandibular body, next to the roots of the lower molars and anterior to the external oblique line of the mandibular ramus.[2] It is made up of a thick cortical extending towards the vestibular of the mandibular alveolar process, so it allows microscrews to be installed parallel to the major axis of the teeth. Regarding their clinical utility, it has been reported that microscrews inserted into the BS are an effective form of extraalveolar anchorage. Reporting high clinical success rates of over 90%.[25]

The microscrews located in the BS allow the retraction of the mandibular arch conservatively for the correction of severe malocclusions, mainly in class III and vertical occlusions. Its use allows for an anti-clockwise rotation of the mandibular, reducing the need for extractions and orthognathic surgery.[6,9,10,11]

Although it is true that the success rates of the installation of mini-screws in the BS are among the most favorable,[13] their anatomical location as well as their thickness apparently vary between individuals of different races.[3,4,6] This is relevant, as clinical site management varies according to cortical thickness, and the risk of infection decreases when using more mesial insertion sites. To date, there is no agreement on which site is indicated to be used as an insertion of TADs, in addition to the individual and ethnic variation in this area and the lack of related studies.[2,6,9]

Currently, the question remains as to which is the optimal site for the installation of mini-screws. At the same time, there are no Chilean data describing the anatomical characteristics of BS

in the national population, which would be of utmost relevance for the planning of orthodontic treatments with TADs for professionals in Chile.
The aim of this study was to describe the characteristics of the mandibular vestibular balcony through the study of CBCT in individuals between 15-45 years of age from the Metropolitan Region of Santiago de Chile.

MATERIALS AND METHODS

An intra-examiner calibration was performed based on a previously published method.[4] Measurements were made on 10 randomly selected images, which were repeated after 30 days. An intraclass correlation coefficient of 0.96 was obtained, demonstrating a high concordance. The measurements were made by a calibrated blind examiner, using a computer with a high-definition screen in a dark room.

Radiological records of whole-head CBCT images from an anonymized database were analyzed. The images were performed between 2016 and 2020 for medical and dental purposes, either for diagnosis or treatment. The project was approved by the research ethics committee of the Faculty of Dentistry of the Universidad de los Andes. For this cross-sectional study, full-head CBCT images from a total of 356 patients were analyzed. According to the established inclusion criteria, 159 CBCTs were selected from patients between 15 and 45 years of age, who were categorized into 3 age groups; group A from 15 to 24 years old, group B from 25 to 34 years old, and group C from 34 to 45 years old, all with a gender distribution of 79 men and 80 women.

Regarding the inclusion and exclusion criteria of this study, all full-head images of patients between 15 and 45 years of age with erupted and normal mandibular first and second molars were included. Images of individuals with craniofacial abnormalities or artifacts that affected the evaluation of bone corticals, or patients with bone loss in the areas of interest, were excluded.
All images were obtained with a KODAK 9500 by Carestream Health CT scanner according to standard protocol, with a minimum field of view of 20x18cm, exposure time of 10s with alternating radiation of 20s rotation, spatial resolution of 1.7 lp/mm, voxel size of 300um, 90kV(p) and 15mA.

The images were stored in files with DICOM (Digital Imaging and Communications in Medicine) format and analyzed with BlueSky Plan4 software for angular measurements of the vertical facial pattern (S-N-Go-Gn angle) and Horos v.3.3.5 software for measurements of alveolar cortical thickness, and the angle formed by the vestibular balcony cortical contour with the axial axis of the respective molar. The images were not distorted or enlarged, and were displayed simultaneously with their coronal, axial, and sagittal slices, so that the dental regions could be accurately measured in all 3 dimensions.

To determine the bone availability in the different sites of the mandibular vestibular balcony, the measurement was protocolized, defining that the orientation of the head should correspond to the natural position of the head in the 3 planes of the space, either verified or corrected. For this, the position indicator of the analysis software was located in the mid-sagittal plane of the patient, both in the coronal view and in the axial view. For the sagittal view, the patient's head was adjusted by positioning the anteroposterior axis of the palate parallel to the horizontal. In addition, the images were standardized in the three planes of space according to the method proposed in the literature.[2]
Within the protocol, the measurement of the fa-cial pattern was made based on the S-N-

ISSN Print 0719-2460 - ISSN Online 0719-2479.

Go-Gn angle through the Blue Sky Plan[4] program, and was classified into three ranges according to the value of the angle; that is, angle less than 30 degrees, between 30 and 34 degrees and greater than 34 degrees; being defined as hypodivergent, normodivergent and hyperdivergent respectively.

Different areas of measurement of the thickness of the bone cortex were determined, which were coded based on previous studies,[4,6] these areas are the mesial cusp of the first molar (6M), the distal cusp of the first molar (6D), the mesial cusp of the second molar (7M), the middle surface of the second molar (7Middle or 7Md) and the distal cusp of the second molar (7D) (Figure 1).

Cortical thickness was assessed according to the distance of the perpendicular from the alveolar ridge and the dental axis, measured at 3mm, 5mm, and 7mm (Figure 2). In turn, the angle formed by the cortical contour of the mandibular vestibular balcony in relation to the axial axis of the respective molar was calculated; This provides a qualitative characteristic of the area.[6] For the statistical tests, the normality in the distribution of the data was first analyzed through the Shapiro-Wilk test. The data do not follow the normal distribution, so non-parametric tests were used. For the comparison between variables, the Kruskal Wallis test was used with Bonferroni's multiple comparisons test.

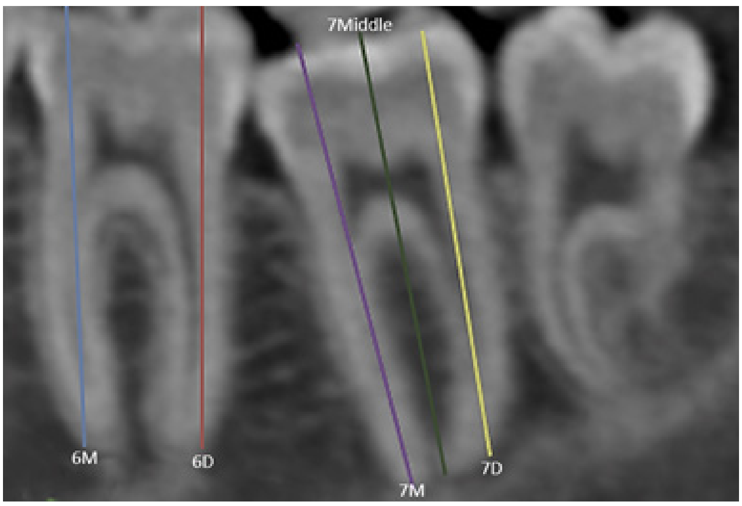
RESULTS

CBCT examinations of 159 patients, ranging from 15 to 45 years, were analyzed. Descriptive statistics and division according to facial type are reported, as well as the analysis of inferential statistics with a 95% confidence interval. (Figure 3) (Table 1).

In terms of cortical thickness values measured at each site, as well as slope angles of each mandibular vestibular balcony site, the highest mean per site was relative to site 7Md (Figure 1 and Table 2) and the highest mean according to site and depth was observed at site 7Md at 7mm depth. The lowest mean was found at site 6M, at a depth of 3 mm. On the other hand, in relation to angles, the highest average value was observed in relation to site 7D (47.2°) and the lowest in relation to site 6M (24.2°), (Figure 2).

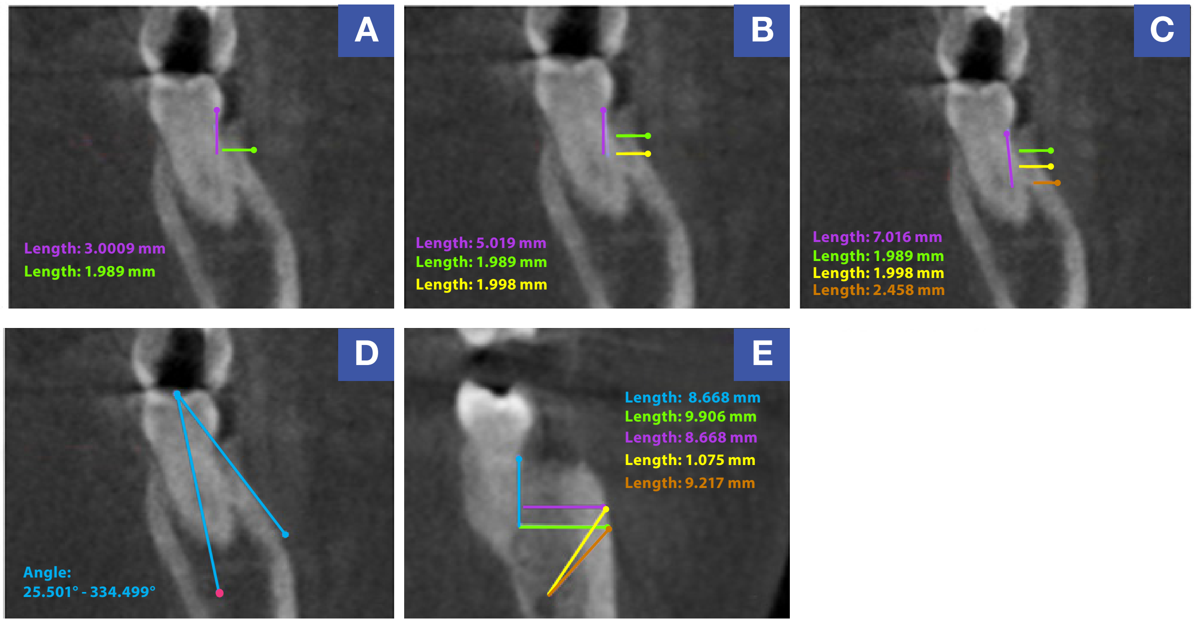
When evaluating whether there were significant differences between the different depths (3mm, 5mm and 7mm), regardless of the site, significant

Figure 1. Areas of bone cortical thickness measurement. It is shown from mesial to distal.



Blue line: (6M - mesial cusp first molar).
Red line: (6D - distal cusp first molar).
Purple line: (7M - mesial cusp second molar).
Green line: (7Middle - middle second molar)
Yelow line: (7D - distal to second molar).

Figure 2. Cortical thickness according to the distance of the perpendicular from the alveolar ridge and the dental axis.



A, B, and C: Process of measuring cortical bone thickness at 3, 5, and 7 mm from the alveolar bone crest.
D: Angle formed by the cortical contour of the mandibular vestibular balcony in relation to the axial axis of the respective molar.
E: Process of measuring the distance to the mesial and distal tooth root of the second molar (7M and 7D), as well as to the alveolar nerve at 5 and 7 mm depth.
Purple line: distance to the root at 5mm. **Green line:** distance to the root at 7mm. **Yellow line:** distance to the upper outer point of the nerve at 5mm. **Orange line:** distance to the upper outer point of the nerve at 7mm.

Figure 3. Distribution by age group (15-24 years, 25-34 years, 35-44 years).

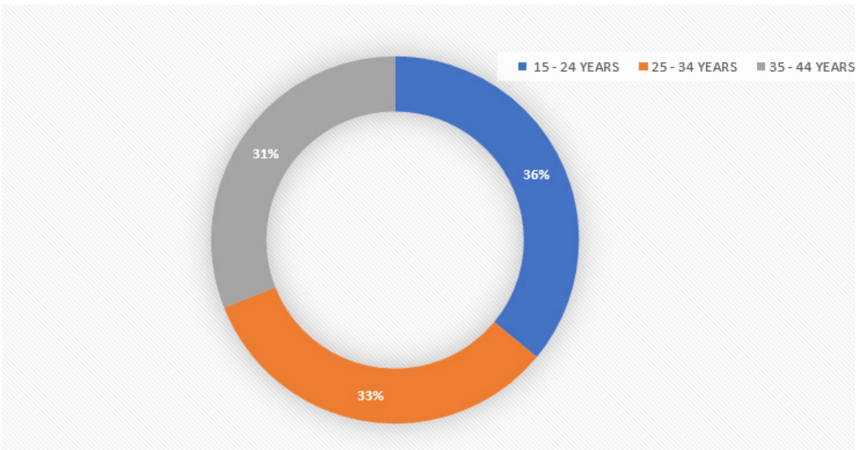


Table 1. ROBINS-E tool for risk of bias of observational studies.

	FREQUENCY	PERCENTAGE	VALID(%)	ACCUMULATED(%)
Sn-GoGn angle	55	34.6	34.6	34.6
	54	34	34	68.6
	50	31.4	31.4	100
	159	100	100	

ISSN Print 0719-2460 - ISSN Online 0719-2479.

Table 2. Bone cortical thickness values and slope angles at each site.

	N	RANGE	MINIMUM	MAXIMUM	AVERAGE	DEVIATION
6M 3MM	159	0.6	2.3	2.9	1.388	0.4548
6M 5MM	159	3.2	0.5	3.7	1.745	0.639
6M 7MM	159	3.5	0.6	4.1	2.169	0.7675
ÁNGLE 6M	159	2.7	1.0	3.7	24.26	5.972
6D 3MM	159	3.6	0.6	4.2	1.684	0.556
6D 5MM	159	4.6	0.6	5.2	2.164	0.7999
6D 7MM	159	4.2	0.8	5.0	2.592	0.8611
ÁNGLE 6M	159	3.8	1.1	4.9	29.14	7.798
7M 3MM	159	4.8	0.6	5.4	2.552	1.0096
7M 5MM	159	4.6	1.2	5.8	3.154	0.9184
7M 7MM	159	3.8	1.2	5.0	3.324	0.7105
ÁNGLE 7M	159	3.9	1.6	5.5	35.99	7.794
7M 3MM	159	5.3	1.0	6.3	3.031	1.0368
7M 5MM	159	4.1	1.2	5.3	3.321	0.7806
7M 7MM	159	3.6	1.2	4.8	3.309	0.623
ÁNGLE 7M	159	4.3	1.8	6.1	41.12	8.885
7M 3MM	159	7.0	0.7	7.7	2.906	0.9723
7M 5MM	159	3.7	1.0	4.7	3.117	0.6562
7M 7MM	159	3.5	1.0	4.5	3.124	0.5802
ÁNGLE 7M	159	5.8	1.7	7.5	47.2	10.391

Table 3 . Bone thickness by age group.

	OVERALL THICKNESS *VERSUS* AGE		
KRUSKAL-WALLIS *P*=0.001	SIGNIFICANT	P-VALUE	SIGNIFICANT
15-24	25-34	0.002	*
15-24	35-44	0.011	*
25-34	35-44	1	

Table 4. Average cortical thickness and slope angle by site according to facial pattern groups.

	OVERALL THICKNESS *VERSUS* AGE	
Angle Sn-Go Gn	Average Cortical Thickness	Averaget Slope Angle
Less than 30°	2.68	36.714°
30-34°	2.60	35.314°

Table 5. Distance to the mesial and distal root in mm, and to the nerve of the mandibular second molar at 5 and 7 mm from the alveolar crest.

Descriptive Statistics	Minimum	Maximum	Media	Dev. Deviation
DR at 5mm site 7M	2	11.8	6.107	1.98
DR at 7 mm site 7M	2.2	13.1	7.04	1.9654
DN 5mm site 7M	4.8	16.1	11.417	1.7673
DN 7mm site 7M	3.4	15.6	10.237	1.7716
DR at 5mm site7D	2	13.3	7.556	2.0627
DR at 7mm site7D	2.5	13.4	8.08	1.9132
DN at 5mm site7D	7.8	19.3	11.934	1.7859
DN at 7mm 7D	6.7	17.5	10.,604	1.8176

Table 6. Distance to the mesial and distal root in mm, and to the nerve of the mandibular second molar at 5 and 7 mm from the alveolar crest.

Author	Thickness average First Molar	Thickness average Second Molar
Park (2002)[23]	2.4mm	3.17mm
Deguchi (2006)[24]	1.8mm at apical level (mesial) 1.8mm at apical level (distal)	1.9mm at apical level (distal)
Chang (2015)[25]	2.8mm to 7mm from the bone crest (mesial) 2.5mm to 7mm from the bone crest (distal)	3.2 to 7mm from the bone crest. (mesial) 3.3 to 7mm from the bone crest. (mid) 3.4 to 7mm from the bone crest. (distal)
Tarek (2018)	2.0 +- 0.71mm (distal)	3.52 +- 0.54mm (mesial) 3.96 +-0.57mm (distal)
Current study	1.7mm (mesial) 2.15mm (distal)	3.01mm (mesial) 3.22mm (mid) 3.05mm (distal)

differences were found between most of the groups, with the thickness being greater as the depth is increased. In the 7M groups between 5mm and 7mm, 7Md in the 3mm, 5mm and 7mm, and 7D groups, no significant differences were found according to depth. When comparing thicknesses in the different groups, significant differences were only found between the group of young patients (15-24 years) and the group of young adults (25-34 years) (p=0.002) and the group of young patients (15-24 years) with the group of adults (35-44 years) (p= 0.011) (Table 3). The other groups, compared with each other, did not show significant differences in thickness.

Regarding the analysis of the relationship between cortical thickness and sex, the results indicate that there are no significant differences between the different groups. When analyzing whether there were significant differences in overall cortical thickness and by sites, according to facial pattern groups, no significant differences were found in any mean cortical thickness or by site between the different groups. When comparing whether there were significant differences in slope angles according to different facial patterns, a significant difference was observed between the >34° group and the other groups (p=0.004). (Table 4).

The distance from the cortical to the tooth root (RD) increases from mesial to distal and as depth increases. In turn, when assessing the distance from the cortical to the inferior alveolar nerve, it also increases from mesial to distal, but decreases as the depth of the site increases. The sites are the farthest from the cortical of the 7D site at 7mm to the root of the second molar and also the cortical from the 7D site at 5mm depth to the alveolar nerve (Table 5).
Regarding cortical bone thickness, this study found significant differences in cortical bone thickness at the different sites analyzed. The mean thicknesses were 1.7 and 2.15 mm (mesial and distal respectively) in relation to the first molar and 3.01, 3.22 and 3.05 mm (mesial, middle and distal respectively) in relation to the second molar. The mean thickness per site is highest relative to site 7Md and lowest relative to site 6M.

DISCUSSION

The present study was carried out with the aim of describing the cortical thickness of the Mandibular Buccal Shelf and its relationship with the facial pattern in Chilean adolescent and adult patients, using a sample of 159 patients. A lower bone thickness was observed in the younger

 ISSN Print 0719-2460 - ISSN Online 0719-2479.

group of individuals. This result is consistent with other studies[5,19,25] that have compared the different success rates at mini-screw placement sites according to age, and concluded that, in the mandibular vestibular area, in children under 15 years of age, the success rate decreases due to the presence of thin and less dense cortical bone. Like the age variable, sex could be a determinant when evaluating cortical bone thickness in different individuals.[20,31,33]
However, in the present study, no differences in bone thickness according to sex were observed, which coincides with previous research.[8,24] When analyzing the mean thickness according to site and depth, the highest means were observed at sites 7M and 7Md between 5 and 7 mm depth, and the lowest values were found in the mesial aspect of the first molar. These results are consistent with those reported in previous studies[6,9,22,23] with similar values of bone thickness in the region between the first and second molars (Table 6).

The results obtained suggest that different sites may present significant differences in cortical bone thickness. The average cortical thickness of the first molar is about 1-2 mm, and of the second molar greater than 3 mm. Therefore, sites in relation to the second molar consistently have sufficient bone thickness to achieve stability in the insertion of a microscrew. It is worth mentioning that previous research suggests pilot milling in places where the cortical is greater than 1.5 mm thick.[5] Considering the above, it is reasonable to consider pilot milling in the second molar area prior to the installation of BS mini screws. Similar to the observed pattern of increased cortical thickness towards the distal BS, this thickness also increases significantly towards the apical side, with the exception of the vestibular sites at the second molar, for which there was no significant difference in thickness between 5 and 7 mm depth. These findings are partially consistent with those reported by others[4,6,7] regarding the increase in thickness with the depth of measurement.

In the same way, at the level of the second molars, no significant differences were found in the thickness of the vestibular cortical bone associated with variations in the measurement height in the Japanese population in those who used the same DICOM format for the CBCT images, but the cortical thickness was measured with the Cybermed V-works program.[24] It is important to mention that this study was carried out on 10 people, 5 men and 5 women of Asian race, so the data obtained may not be representative of the Chilean population. These data may be clinically relevant, offering good mini-screw receptor sites.

Another aspect evaluated in this study was the distance between the vestibular aspect of the bone cortex and the root of the second molar, which is important if a distalization of the mandibular arch located by lingual of the insertion site of a BS miniscrew is intended. It has been suggested that a distance of 1.5 mm from the molar root to the TADs would be safe to maintain root integrity during orthodontic treatment.[7] In the present study, the distance from the cortical to the tooth root (RD) increased from mesial to distal and as depth increased, with results that are consistent with the findings of 4 others.
A possible hypothesis for this phenomenon is that the V-shaped growth of the mandibular bone is followed in a certain way, reinforcing the cortical in the vestibular wall of the posterior pieces, in addition, considering that the molars are made to receive greater occlusal loads, the increased thickness of the bone may be a physiological response to this function.

Therefore, we can observe that there is an average distance to the distal root of the second molar of 8 mm measured from the alveolar cortical to the root, being the greatest distance found in the mandibular vestibular balcony. This allows us to have a margin of safety on which length of screw we should choose so as not to damage this tooth structure.

There is controversy regarding the perpendicular or angled insertion of the microscrews in the BS area. It has been suggested that placing the implants at an angle to the surface increases contact with the bone.[6,23] However, it has also been proposed that, in the mandibular arch, a TAD inserted in the vestibular balcony area should be placed lateral to the molar roots and as perpendicular to the occlusal plane as possible.[24] It is often not possible to insert the mini screws perpendicular to the bone surface, especially when the teeth are located. Previous studies have assessed that the angle of the mandibular vestibular balcony to the long axis of the molars increases progressively between the mesial planes at the first molar and distal to the second molar.[25] The results of the present study show a clear increase in the angle of the slope from mesial to distal. Making the slope flatter from front to back would make it easier to insert a temporary anchoring device into the area.

However, the degree of this slope shows inter-individual variation, which is reflected in the presence of significant differences according to different groups of facial patterns, with the hyperdivergent group varying with a greater slope with respect to the other groups.[8] Although these results contrast with those of others that did not identify significant differences between hyperdivergent and normodivergent patients,[7] it is reasonable to consider this anatomical variation when planning the installation of microscrews in the BS, since a flat slope is preferred to facilitate insertion and obtain positive results in the short and long term.

Different vertical patterns appear to play a role in cortical bone thickness.[25-29] However, in this study, when analyzing whether there were significant differences in thickness according to facial pattern groups, no significant differences in cortical thickness or site were found between the different groups. On the other hand, multiple studies have found that vestibular cortical bone thickness varies significantly between patients of different facial heights.[11,17,26] This difference in studies may be due to different measurements of facial patterns, as well as the use of different criteria, such as the SN-mandibular plane, FMA and goniac angle.[7]

CONCLUSION

Some of the important variations found are that the facial pattern causes variation in the angulation of the BS between hyper, normal and hypodivergent patients, but not with the thickness of the cortical in this area, which did not have significant differences. On the other hand, the sex of the patient had no differences between thicknesses or angulation of the same area.

In addition, it is important to consider the age of the patient, because several studies show that thickness increases with age until approximately 24 years of age. It can be concluded that the characteristics of BS vary mainly depending on the race of the patient, which could explain the discordant results with other studies mentioned, and a thorough analysis is necessary prior to the placement of a miniscrew in this area.

 ISSN Print 0719-2460 - **ISSN Online** 0719-2479.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

ETHICS APPROVAL

The project was approved by the research ethics committee of the Faculty of Dentistry of the Universidad de Los Andes

FUNDING

Self-funded.

AUTHORS' CONTRIBUTIONS

Carmona R: Writing and editing, investigation.
Wang L: Review and editing, conceptualization.
Bidart C: Original draft, data curation.
Battaglia G: Data analysis.
Oyonarte R: Supervision, validation.

ACKNOWLEDGEMENTS

The authors aknowledge Dr. Daniela Vicuña for the statistical treatment of the data.

ORCID

Raimundo Carmona
0009-0005-3940-7718
Lourdes Wang
0009-0003-9728-8118
Carolina Bidart
No Orcid
Gianfranco Battaglia
No Orcid
Rodrigo Oyonarte
0000-0003-4517-6950

PUBLISHER'S NOTE

All statements expressed in this article are those of the authors alone and do not necessarily represent those of the publisher, editors, and reviewers.

PEER REVIEW

This manuscript was evaluated by the editors of the journal and reviewed by at least two peers in a double-blind process.

PLAGIARISM SOFTWARE

This manuscript was analyzed Compilatio plagiarism detector software. Analysis report of document ID. e0adcd6609789aa3b0440d8518 f2658db3abbbb2

ISSN Print 0719-2460 - ISSN Online 0719-2479.
https://www.joralres.com/index.php/JOralRes/issue/archive

REFERENCES

1. Monnerat C, Restle L, Mucha JN. Tomographic mapping of mandibular interradicular spaces for placement of orthodontic mini-implants. Am J Orthod Dentofac Orthop [Internet]. 2009; 135(4):428–9. doi.10.1016/j.ajodo.2008.12.003

2. Nucera R, Lo Giudice A, Bellocchio AM, Spinuzza P, Caprioglio A, Perillo L, Matarese G, Cordasco G. Bone and cortical bone thickness of mandibular buccal shelf for mini-screw insertion in adults. Angle Orthod. 2017 Sep;87(5):745-751. doi: 10.2319/011117-34.1. Epub 2017 Jun 9. PMID: 28598220; PMCID: PMC8357207.

3. Nucera R, Bellocchio AM, Oteri G, Farah AJ, Rosalia L, Giancarlo C, Portelli M. Bone and cortical bone characteristics of mandibular retromolar trigone and anterior ramus region for miniscrew insertion in adults. Am J Orthod Dentofacial Orthop. 2019 Mar;155(3):330-338. doi: 10.1016/j.ajodo.2018.04.025. PMID: 30826035.

4. Elshebiny T, Palomo JM, Baumgaertel S. Anatomic assessment of the mandibular buccal shelf for miniscrew insertion in white patients. Am J Orthod Dentofac Orthop. 2018; 153(4):505–11.

5. Baumgaertel S, Jones CL, Unal M. Miniscrew biomechanics: Guidelines for the use of rigid indirect anchorage mechanics. Am J Orthod Dentofac Orthop [Internet]. 2017; 152(3):413–9. http://doi.org/10.1016/j.ajodo.2017.04.020

6. Huang C, Chang C, WE. R. 3D Cortical Bone Anatomy of the Mandibular Buccal Shelf: a CBCT study to define sites for extra-alveolar bone screws to treat Class III malocclusion. Int J Orthod Implant. 2016; 41:74–82.

7. Mohammed H, Wafaie K, Rizk MZ, Almuzian M, Sosly R, Bearn DR. Role of anatomical sites and correlated risk factors on the survival of orthodontic miniscrew implants: a systematic review and meta-analysis. Prog Orthod. 2018 Sep 24;19(1):36. doi: 10.1186/s40510-018-0225-1. PMID: 30246217; PMCID: PMC6151309.

8. Parinyachaiphun S, Petdachai S, Chuenchompoonut V. Considerations for placement of mandibular buccal shelf orthodontic anchoring screw in Class III hyperdivergent and normodivergent subjects – A cone beam computed tomography study. Orthod Waves. 2018; 77(1):44–56.

9. Alharbi F, Almuzian M, Bearn D. Miniscrews failure rate in orthodontics: systematic review and meta-analysis. Eur J Orthod. 2018 Sep 28;40(5):519-530. doi: 10.1093/ejo/cjx093. PMID: 29315365.

10. Baumgaertel S. Cortical bone thickness and bone depth of the posterior palatal alveolar process for mini-implant insertion in adults. Am J Orthod Dentofacial Orthop. 2011 Dec;140(6):806-11. doi: 10.1016/j.ajodo.2011.05.020. PMID: 22133945.

11. Vargas EOA, Lopes de Lima R, Nojima LI. Mandibular buccal shelf and infrazygomatic crest thicknesses in patients with different vertical facial heights. Am J Orthod Dentofacial Orthop. 2020 Sep;158(3):349-356. doi: 10.1016/j.ajodo.2019.08.016. PMID: 32862936.

12. Papadopoulos MA, Tarawneh F. The use of miniscrew implants for temporary skeletal anchorage in orthodontics: a comprehensive review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007 May;103(5):e6-15. doi: 10.1016/j.tripleo.2006.11.022. Epub 2007 Feb 21. PMID: 17317235.

13. Rajesh R. Bone mapping of the mandibular buccal shelf - a CBCT study. 2017;137.

14. Poggio PM, Incorvati C, Velo S, Carano A. "Safe zones": a guide for miniscrew positioning in the maxillary and mandibular arch. Angle Orthod. 2006 Mar;76(2):191-7. doi: 10.1043/0003-3219(2006)076[0191:SZAGFM]2.0.CO;2. PMID: 16539541.

15. Timock AM, Cook V, McDonald T, Leo MC, Crow J, Benninger BL, Covell DA. Accuracy and reliability of buccal bone height and thickness measurements from cone-beam computed tomography imaging. American Journal of Orthodontics and Dentofacial Orthopedics. 2011 Nov;140(5):734-744. doi: 10.1016/j.ajodo.2011.06.021

16. Fayed MM, Pazera P, Katsaros C. Optimal sites for orthodontic mini-implant placement assessed by cone beam computed tomography. Angle Orthod. 2010 Sep;80(5):939-51. doi: 10.2319/121009-709.1. PMID: 20578867; PMCID: PMC8939012.

17. Ozdemir F, Tozlu M, Germec-Cakan D. Cortical bone thickness of the alveolar process measured with cone-beam computed tomography in patients with different facial types. Am J Orthod Dentofacial Orthop. 2013 Feb;143(2):190-6. doi: 10.1016/j.ajodo.2012.09.013. PMID: 23374925.

18. Almuzian M, Alharbi F, White J, McIntyre G. Distalizing maxillary molars – how do you do it? Orthod Updat. 2016; 9(2):42–50.

19. Jing Y, Han X, Guo Y, Li J, Bai D. Nonsurgical correction of a Class III malocclusion in an adult by miniscrew-assisted mandibular dentition distalization. Am J Orthod Dentofacial Orthop. 2013 Jun;143(6):877-87. doi: 10.1016/j.ajodo.2012.05.021. PMID: 23726338.

20. Moon CH, Lee DG, Lee HS, Im JS, Baek SH. Factors associated with the success rate of orthodontic miniscrews placed in the

 ISSN Print 0719-2460 - **ISSN Online** 0719-2479.

upper and lower posterior buccal region. Angle Orthod. 2008 Jan;78(1):101-6. doi: 10.2319/121706-515.1. PMID: 18193973.

21. Baumgaertel S, Razavi MR, Hans MG. Mini-implant anchorage for the orthodontic practitioner. Am J Orthod Dentofacial Orthop. 2008 Apr;133(4):621-7. doi: 10.1016/j.ajodo.2007.03.022. PMID: 18405827.

22. Kim YB, Bayome M, Park JH, Lim HJ, Mo SS, Lee NK, Kook YA. Displacement of mandibular dentition during total arch distalization according to locations and types of TSADs: 3D Finite element analysis. Orthod Craniofac Res. 2019 Feb;22(1):46-52. doi: 10.1111/ocr.12256. Epub 2018 Dec 10. PMID: 30466181.

23. Park HS. An anatomical study using CT images for the implantation of micro-implants. Korean J Orthod 2002;32:435-441.

24. Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. Am J Orthod Dentofacial Orthop. 2006 Jun;129(6):721.e7-12. doi: 10.1016/j.ajodo.2006.02.026. PMID: 16769488.

25. Chang C, Liu SS, Roberts WE. Primary failure rate for 1680 extra-alveolar mandibular buccal shelf mini-screws placed in movable mucosa or attached gingiva. Angle Orthod. 2015 Nov;85(6):905-10. doi: 10.2319/092714.695.1. Epub 2015 Jan 20. PMID: 25603272; PMCID: PMC8612035.

26. Cassetta M, Sofan AA, Altieri F, Barbato E. Evaluation of alveolar cortical bone thickness and density for orthodontic mini-implant placement. J Clin Exp Dent. 2013 Dec 1;5(5):e245-52. doi: 10.4317/jced.51228. PMID: 24455090; PMCID: PMC3892271.

27. Motoyoshi M, Yoshida T, Ono A, Shimizu N. Effect of cortical bone thickness and implant placement torque on stability of orthodontic mini-implants. Int J Oral Maxillofac Implants. 2007 Sep-Oct;22(5):779-84. PMID: 17974113.

28. Veli I, Uysal T, Baysal A, Karadede I. Buccal cortical bone thickness at miniscrew placement sites in patients with different vertical skeletal patterns. J Orofac Orthop. 2014 Nov;75(6):417-29. doi: 10.1007/s00056-014-0235-7. Epub 2014 Oct 26. PMID: 25344123.

29. Masumoto T, Hayashi I, Kawamura A, Tanaka K, Kasai K. Relationships among facial type, buccolingual molar inclination, and cortical bone thickness of the mandible. Eur J Orthod. 2001 Feb;23(1):15-23. doi: 10.1093/ejo/23.1.15. PMID: 11296507.

30. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthop. 2003 Oct;124(4):373-8. doi: 10.1016/s0889-5406(03)00565-1. PMID: 14560266.

31. Temporary anchorage devices in orthodontics: a paradigm shift. Cope JB. Semin Orthod. 2005;11:3–9.

32. Devlin H, Horner K, Ledgerton D. A comparison of maxillary and mandibular bone mineral densities. J Prosthet Dent. 1998 Mar;79(3):323-7. doi: 10.1016/s0022-3913(98)70245-8. PMID: 9553887.

33. Kim JH, Park YC. Evaluation of mandibular cortical bone thickness for placement of temporary anchorage devices (TADs). Korean J Orthod. 2012 Jun;42(3):110-7. doi: 10.4041/kjod.2012.42.3.110. Epub 2012 Jun 28. PMID: 23112941; PMCID: PMC3481976.