Assessment of prevalence and measurement of mandibular lingual concavities using Cone-Beam Computerized Tomography (CBCT) among patients in Jeddah: a cross-sectional study

A.A. ALMARGHLANI[1], B.A. ALSHAHRANI[2], B.T. FAYYAD[3], M.K. SHAMI[2], M.H. ALSAEGH[2], F.S. ALADWANI[4], A.S. ALGHAMDI[1]

[1]Department of Periodontics, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
[2]Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia
[3]Private practice, Unidents, Jeddah, Saudi Arabia
[4]Private practice, Myclinic, Jeddah, Saudi Arabia

Abstract. – OBJECTIVE: Dental implant procedure is the most common way to restore missing teeth but also comes with several complications. Success rates for dental implants are expected to be good when proper diagnosis and planning, study of bone morphology and closeness of implant with vital structures, such as nerves and blood vessels, are made pre-surgery.

PATIENTS AND METHODS: This cross-sectional study involved 636 adult patients, aged 18-80 years old, that came for dental implants in screening clinics or referred to specialty clinics in Jeddah, Saudi Arabia for the year 2019 to 2020. Instead of conventional Computed Tomography (CT), Cone Beam Computed Tomography (CBCT) X-Rays have been used to evaluate mandibular lingual concavities.

RESULTS: Prevalence and measurement of lingual concavities were determined. Type U mandibles with a lingual concavity, were found to have a higher chance of lingual cortical plate but this may still vary on factors such as type of population and ethnicity. The typical finding in the mandibular posterior region is the lingual undercut.

CONCLUSIONS: CBCT is a great tool used to study mandibular lingual concavities and it is essential prior the installation of dental implant to prevent life-threatening complications.

Key Words:
Cone Beam Computed Tomography, Dental implant, Lingual concavity.

Abbreviations

CT: Computed Tomography; CBCT: Cone Beam Computed Tomography; ANOVA: Analysis of Variance; IAN: Inferior Alveolar Nerve; USA: United States of America; IBM SPPS: International Business Machines Corporation Statistical Product and Service Solutions; NY, USA: New York, United States of America; CA, USA: California, United States of America; CM-REC: College of Medicine – Research Ethics Committee; SD: Standard Deviation; Partially ED: Partially Edentulous; RPD: Removable prosthodontics; LCP: Lingual Cortical Plate; P Type: Parallel ridge type; C type: Convergent ridge type; U type: Undercut ridge type.

Introduction

Nowadays, advancements in technology have contributed to the improvements in dental implants and have made the replacement of missing teeth a more convenient procedure. The dental implant procedure is the most common technique but also comes with several complications. Complications may occur during surgery, after surgery or the recovery phase, or even after loading. With that, it is important to conduct an accurate clinical examination of the dimensions and bone morphology at the implant placement location. To determine the exact positioning of drill and implant fixtures, evaluation of the implant placement site must be done *via* palpation of the alveolar ridge, use of an osteometer, and diagnostic casts. These methods successfully assess intermaxillary relations and use advanced imaging modalities[1]. Ideally, there are 97% success rates for dental implants when proper diagnosis and planning, including the morphology of the bone and implant link with important structures namely blood vessels and nerves, are conducted[2]. The compressive forces on the mandibular cortex from the sub-lingual and sub-mandibular area of the salivary glands are causing Lingual mandibular bone concavities[3].

Corresponding Author: Ammar Abdulbasit Almarghlani, MD; e-mail: ammar.marg@live.com

In the mandible, the lingual side is described to be much vascularized. This composes 2 arteries that act as support for blood in the area. These arteries are namely sublingual and submental arteries[4,5]. Ignoring the undercut may result in perforation of the lingual cortex, stress in highly vascularized and neurological structures in the area, and severe bleeding that can be fatal if it leads to upper airway obstruction[1]. Cross-sectional work showed that perforation in the lingual plate or mandibular canal was the result of a parapharyngeal infection upon attachment of the implant leading to an injury in the inferior part of the alveolar nerve (IAN) and irreversible neurologic defects (e.g., chin numbness, loss of teeth vitality)[2].

The position of IAN can be easily identified through the utilization of panoramic radiographs (with vertical magnification factor). However, buccolingual dimensions cannot be provided using this method. Aside from that, alveolar ridge clinical palpation can only provide few details concerning the lingual concavity. Thus, three-dimensional imaging is introduced to better understand and prevent further occurrence of complications. Computed tomography (CT) is a three-dimensional radiological technique that analyzes the mandible and maxilla morphologies. It provides cross-sectional analysis and soft and hard tissues 3D reconstruction. However, regular CT scan equates to higher exposure to radiation, leading to increased risk in the organ's damage as well as cancer formation. Thus, Cone Beam Computed Tomography (CBCT) is introduced as a better option for the conventional CT. This cross-sectional CT provides a better view of the hard tissue around the maxillofacial area with the use of lower dose radiation, higher accessibility, and accuracy[2].

The primary complications are described to be inferior alveolar nerve- and lingual cortical plate lesions-related in the posterior area. There are low known cases of implant placement on the outer bony housing of the posterior mandibular area reported, but higher perforation rate is suspected as some were left unnoticed or unreported[6]. During implant placement in undercut types, the lingual cortical plate may cause severe-type hemorrhage, including continued infection or inflammation, which could perforate the lingual oral mucosa, exposing it to the oral environment[7]. The infection could go further in the retropharyngeal and parapharyngeal areas and can further result to worse consequences namely mediastinitis, internal jugular vein thrombosis, and mycotic aneurysm with potential tear of the internal carotid artery. These complications do not occur immediately so more careful planning is needed when touching this area[6]. Moreover, by applying strong finger pressure in the bleeding point, the hemorrhage of the artery – particularly in the lingual mandibular posterior area – can be controlled. This is enough, rather than attempting to subject the artery to ligation or conducting artery's dissection that may further complicate the condition[4]. Hemorrhage brought about by arterial trauma may happen after the inactivity period, leading to airway obstruction and death[7].

This research aimed to determine the prevalence of mandibular lingual concavities and perform measurements using CBCT on patients. Specifically, this work aimed to examine mandibular lingual concavities of patients who came for dental implants in clinics in Jeddah, Saudi Arabia.

Patients and Methods

This cross-sectional research involved 636 adult patients, aged 18-80 years old, who went for dental implants in screening clinics or referred to specialty clinics in Jeddah, Saudi Arabia, for the year 2019 to 2020. Validated Cone Beam Computed Tomography (CBCT) X-Rays were used to evaluate by Kodak CT machines and Sidex software system.

Before the start of the investigation, the patients were educated that their cooperation was voluntary with no penalties for non-participation. Aside from written informed consents, patient anonymity was observed. Ethical approval was obtained from the Research Ethics Committee (CM-REC). Evaluation of CBCT scans was done for pre-implant planning purposes. Inclusion criteria included patients having partial or total dental implant treatment. Exclusion criteria included: patients unable to provide essential information or patients providing incomplete, confusing, and inconsistent data; CBCT scans with artifacts having reference points that were hard to measure, and those pathologies that have potential life-endangering to the alveolar bone (e.g., jaw disorders) related to inflammatory, developmental, or metabolic factors; fracture of the jaw; and those who underwent orthognathic surgery.

Through sagittal slices, the most obvious points (inferior and superior) of the sub-mandibular and sub-lingual concavities were determined. Between the 2 points, a 1st line was drawn, for the purpose of defining the length of concavity. The length was automatically calculated using Kodak CT machines and Sidex software system. The 2nd line was drawn perpendicularly (extending to the deepest point of concavity) for measurement of the concavity depth. In representing the maximum concavity depth, the slice having the deepest concavity was chosen.

Statistical Analysis

This study was analyzed using IBM SPSS ver. 23 (IBM Corp., Armonk, NY, USA) and GraphPad Prism v. 8 (GraphPad Software, Inc., San Diego, CA, USA). Descriptive statistics was utilized to present categorical and nominal variables in the form of counts and percentages, while continuous variables in the form of mean and standard deviations. Chi-square test was used to establish relationship between categorical variables. One-way ANOVA analysis was utilized to compared >2 group means with Games Howell test as a post hoc test. These tests were performed assuming that there is normal distribution. The p-value <0.05 was the criteria used to reject the null hypothesis.

Results

This study reported data of 636 patients aged 18-80 years old that came for dental implants in screening clinics or referred to specialty clinics in Jeddah, Saudi Arabia for the year 2019-2020. CBCT x-rays were used to evaluate using Kodak CT machines and Sidex software systems. Sagittal slices were used to identify most obvious points (inferior and superior) in the sub-lingual and sub-mandibular concavities.

For C point, the maximum value was 15.30 having a mean of 7.55 ± 2.6. D point showed a maximum value of 16.50, with a mean of 11.17, and SD of 2.8. E point had a max value of 7.90 mm, with a mean of 3.31 and SD of 1.3. B point in mm had a maximum value of 15, mean of 10.27 and SD of 2.9. From point F to D, the maximum value is 15.40 mm, with a mean of 8.27 and SD of 3.0. Fromm D-G, the highest value was 28.00 mm, with a mean of 16.08 and SD of 5.0. Lastly from F-G, there is 31.00 mm maximum length, 24.01 mm average and 6.0. Angle was also determined, and the maximum angle was 82 degrees, with a mean of 61.56 ± 16.4.

Among the group, there were 58 patients with full dentition (9.1%), 565 or majority of the patients were partially ED (88.8%), while there were 13 patients or 2.0% with missing all posteriors. Ridge type code was also identified. There were 321 patients (50.5%) that were C shape, 88 or 13.8% were P shape, and 207 or 32.5% were U shape. Meanwhile, there were 2 or 0.3% patient data that encountered CT error, and 15 or 2.4% were not clear. One patient has CT after drilling and 2 patients have CT after bone augmentation.

Angle was also determined. There were 40 patients or 6.3% that have less than 45 degrees (< 45°). On the other hand, there were 151 patients or 23.7% with 45°- 60° and 445 or 70.0% with > 60°.

Correlation of points, angle, and ridge type code with type of RPDs was also determined. C point was 9.99 ± 3.7A, 7.36 ± 2.4B, 4.94 ± 2.7C, for full dentition, partially ED and missing all posteriors, respectively, and was found to be significant with p-value of < 0.001 using One-way ANOVA at <0.05 level. D point was 9.82 ± 3.3A, 11.37 ± 2.6B, 8.35 ± 4.5AB, for full dentition, partially ED and missing all posteriors, respectively, and has shown significance with < 0.001 p-value. E point was 2.46 ± 1.7A, 3.44 ± 1.2B, 1.42 ± 1.7A, for full dentition, partially ED and missing all posteriors, respectively, and exhibited significance with < 0.001 p-value. B point was 8.64 ± 4.5A, 10.47 ± 2.6B, 8.56 ± 4.4AB, for full dentition, partially ED and missing all posteriors, respectively, and was found to revealed significance with < 0.001 p-value. F-D point in mm was 8.54 ± 5.0A, 8.34 ± 2.7A, 3.96 ± 2.8B, for full dentition, partially ED and missing all posteriors, respectively, and was found to show significance with < 0.001 p-value. D-G point in mm was 8.90 ± 6.0A, 16.90 ± 4.2B, 12.25 ± 6.3AB, for full dentition, partially ED and missing all posteriors, respectively, and exhibited significance with < 0.001 p-value. F-G point in mm was 17.48 ± 10.3A, 24.86 ± 4.7B, 16.16 ± 8.8A, for full dentition, partially ED and missing all posteriors, respectively, and was found to be significant with p-value of < 0.001. Angle was 47.45 ± 27.6A, 63.71 ± 12.4B, 31.00 ± 35.0A, for full dentition, partially ED and missing all posteriors, respectively, and was found to reveal significance with < 0.001 p-value.

Ridge type code was also correlated with full dentition *vs.* partially ED *vs.* missing all posteriors according to Chi-square test at <0.05 level. C shape was observed on 18 patients (5.6%) with full dentition, 294 (91.6%) with partially ED, and 9 (2.8%) with missing all posteriors. P shape was observed on 17 patients (19.3%) with full dentition, 69 (78.4%) with partially ED, and 2 (2.3%) with missing all posteriors. U shape was observed on 18 patients (8.7%) with full dentition, 189 (91.3%) with partially ED, and 0 (0%) with missing all posteriors. Ridge type code showed significance with < 0.001 *p*-value.

Relationship of angle with classification of RPDs was also determined according to Chi-square test at < 0.05 level. For angle < 45°, there were 18 patients (45.0%) with full dentition, 15 (37.5%) partially ED, and 7 (17.5%) missing all posteriors. For angle 45° - 60°, there were 8 patients (5.3%) with full dentition, 143 (94.7%) partially ED, and 0 (0.0%) missing all posteriors. For angle > 60°, there were 32 patients (7.2%) with full dentition, 407 (91.5%) partially ED, and 6 (1.3%) missing all posteriors. Angle is significantly correlated to classification of RPDs with *p*-value of < 0.001.

Figures 1-4 show trends and relationships between points in mm *vs*. RPDs, degree of angle *vs*. RPDs, percentages of ridge type codes *vs*. RPDs, and percentages of angles *vs*. RPDs, respectively.

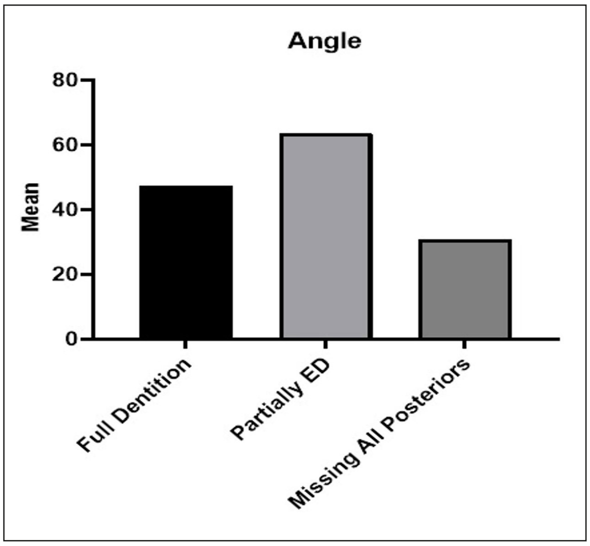

Figure 2. Mean degree of angle *vs*. classification of RPDs.

Discussion

The first part of the study was able to identify length of mandibular concavity at different points. It was found that the highest was from point D with maximum value of 16.50 and mean value of 11.17. Meanwhile, F-G point has the highest value for length in 31.00 mm and a mean of 24.01. The highest degree of angle of concavity was found to be 82° with a mean of 61.56°. Lingual concavity that is greater than 2 mm can pose a risk for lingual plate perforation and complications as well. The data shown above reflect that pre-assessment must be done correctly as this is a very delicate procedure that can lead to worse effects[1]. An oral surgeon should identify the mandible shape and size to accurately pick the size of implant, and of course for complication prevention purposes. In a work mentioned by Herranz-Aparicio et al[8], using CBCT, it was identified a higher prevalence of U shape mandible compared to P and C types. Although 32.5% of the patients having U shape

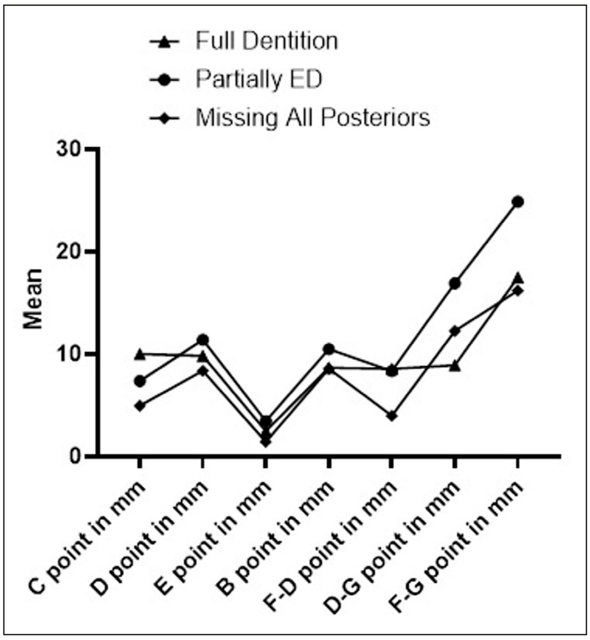

Figure 1. Trends in points in mm *vs*. classification of RPDs.

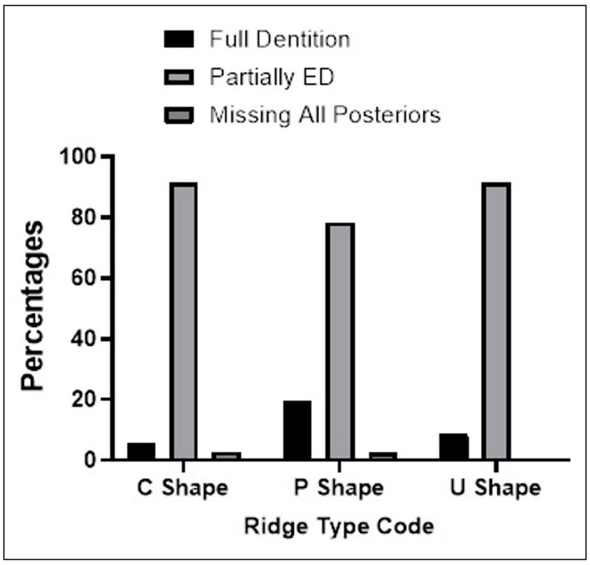

Figure 3. Percentages of Ridge Type Code *vs*. Classification of RPDs.

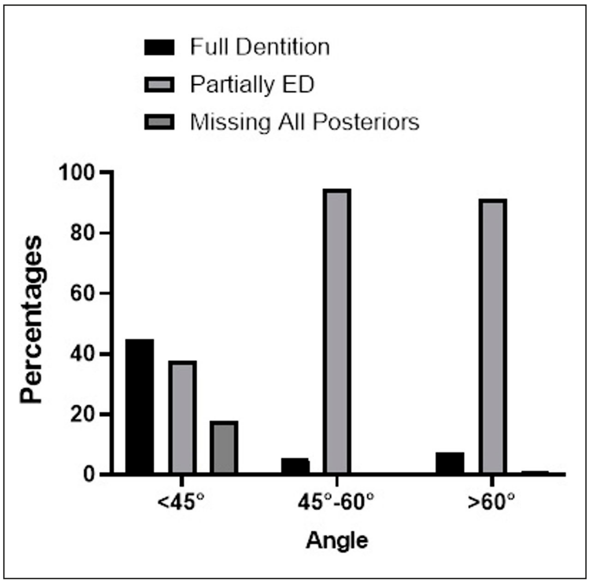

Figure 4. Percentages of angles *vs.* classification of RPDs.

mandible, the most prevalent one is the C shape at 50.5%. Meanwhile, the least prevalent ridge type code was the P shape. Type U mandibles with a lingual concavity, were found to have a higher chance of LCP. This may not be consistent among other studies due to utilization of varying classification and population ethnicity. CBCT was able to provide a better picture of submandibular fossa anatomy and jaw dental defects, as well as the bone morphology and quality. Thus, it is great for posterior mandible assessment (preoperative) in dental implant surgeries[8].

Patient group was determined. The majority of the patients have partially ED at 88.8%, followed by full dentition at 9.1% and missing all posteriors at 2.0%. Angle less than 85 degrees of posterior mandibular region is classified as concave. On the other hand, if it is larger than 95 degrees, it is convex. For anterior region, a lingual undercut with angulation of less than 60 degrees was classified as concave. Between 60 to 70 degrees, it is parallel, and more than 70 degrees, the image is classified as convex. In this study, results showed that prevalent angle was more than 60°, composed of 445 patients or 70.0%. Such points relative to the lingual concavity must be analyzed by utilizing CBCT to avoid life-threatening complications.

Correlation was also determined in this study. Correlation of types of RPDs was found significantly correlated with different points of concavity. Moreover, angulation of concavity was also significant with RPDs. Among three ridge type codes, U shape was the most predominant type and was also most prevalent among partially EDs. In a study by Ren et al[9], the prevalence of C-shaped canals in mandibular second molars was found to have no significant correlation between gender. This was also supported by another study by Zheng et al[10]. The high prevalence of C-shaped canals may also vary in terms of genetic influence and ethnic variations. C-shaped root canals have low prevalence among ancient Saudi according to another study[9,11].

Prevalence on partially ED group was also consistent in different ridge-type codes, and they were all found to be significant. Lastly, the most prevalent angulation of concavity was greater than 60 degrees and it was also most prevalent in partially ED. This was also consistent for all angulation, and all were found significant.

In a study by Huang et al[15] in 2015 in line with other studies[12-14], they found that there was a significantly higher frequency of lingual concavities in the second molar region than the first molar or second premolar. This would support the requirement of series of evaluation using CBCT in the second molar region with LC.

Ridge-type codes may also vary depending on bone density and anatomy. Also, changes in the volume of alveolar bone at edentulism may develop reduction in depth of a sublingual concavity[1]. Lingual undercuts were found to be most frequent in edentulous mandible according to data from CBCT. Lingual undercut is typically found in mandible posterior region. It is important to considered this before installation of dental implant[2].

The lesions of the IAN and LCP can be interrelated to some main complications in the posterior region. Although there were only a few cases of implant installation outside the posterior mandibular region, a higher perforation rate is still considered due to this negative effect that, when left undetected, can lead to serious problems[6,8]. LCP upon implant procedure can also cause severe hemorrhage, perpetual inflammation, or infection from the dental implant that perforates the lingual oral mucosa and is then uncovered to the oral environment. Infection from this may then lead to other worse complications such as mediastinitis, mycotic aneurysm that could trigger rupture of the internal carotid artery, internal jugular vein thrombosis with septic pulmonary embolism or obstruction of the upper airway. Thus, this procedure requires ample attention and planning[6,8].

Aside from that, arterial hemorrhage in the posterior, lingual, and mandibular region can be stopped using strong finger pressure at the point of bleeding.

If trauma occurs in this region of cavity, hemorrhage may follow after remission, and can further lead to airway obstruction, then death[7,8].

Two-dimensional radiography may be still relevant, although evaluation and assessment of the posterior mandible region in some complicated analyses, like localization and amount of bone volume in buccolingual direction, can only be done with an imaging modality with three-dimensional capability such as the CBCT.

Limitations

This study had limited data and age could also be a factor on the prevalence of lingual concavity. Other limitations included the fact that CBCT scans were retrieved from archives, thus oral status of patients was not monitored from the start, including data on extraction/loss of the first molars. Other factors, such as metabolic disorders in patients, may also have affected data on this study.

Conclusions

A proper CBCT image analysis of concavity morphology must be done as a part of pre-operative implant planning. With it, the operator will be at ease in identifying the mandible shape and size to accurately choose the size of the implant to avoid primary complications, such as Inferior Alveolar Nerve- and Lingual Cortical Plate perforations in the posterior area.

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Conflict of Interest

None declared.

Funding

None declared.

Ethics Approval

Ethical approval was granted by the Research Ethics Committee (Approval No. 103-10-20). Before doing the survey, the participants were informed about the study purpose and steps. Participation in this research was voluntary. Each volunteer was given enough time to ask any question about the research and verbal consent was taken from them in the presence of a witness.

Informed Consent

After the participant agreed on the verbal consent, then, the data collector and the witness signed the written consent. The consent participants' privacy and confidentiality were assured: no identification was collected. All data collected was kept in a secure place. All hard and soft copies of the data could only be accessed by the research team.

ORCID ID

Ammar Almarghlani: 0000-0003-2259-3401.

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