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Original Article

Measurement of Distance Between the Mental Foramina using Cone-Beam Computed Tomography: A Pilot Study with a Possible Method for Planning Mandibular Implants

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Abstract

Objective: To identify the average number of dental implants that can be placed in the lower anterior region to support a fixed mandibular prosthesis based on the distance between the mental foramina, using a cone beam computed tomography (CBCT) scan through a new method of measurement. **Material and Methods:** Eighty-two CT scans from a total sample of 1,465 exams were selected. The method to measure the space between the foramina was developed using the BlueSky Plan3 software in Dicom format and the axial reconstruction views were chosen for measurements. Descriptive analysis of data was conducted categorical variables were compared using the $\chi 2$ test ($p < 0.05$). **Results:** The mean age of individuals who underwent the scans was 63.51 ± 9.49 years old with a minimum and maximum age of 40 and 86 years old, respectively. The mean linear measurement between the foramina was 40.52 ± 3.92mm. In males the mean distance was 41.93 ± 3.98 mm, and for females it was 39.99 ± 3.80mm, with a significant difference between the means ($p = 0.043$). There was no positive association between the presence of the anterior loop and gender ($p = 0.719$). The results showed that the vast majority of subjects ($n = 80$) could be rehabilitated using a protocol with 4 implants of 3.3mm diameters. **Conclusion:** Seventy-seven patients would be able to receive protocols of 4 implants with diameters of 3.75 or 4.0mm, and only 4 subjects would be able to be rehabilitated with 6 implants with diameters of 3.75 mm according to the protocol originally described by Brånemark.

Keywords: Tomography; Dental Prosthesis; Surgery, Oral.

Introduction

Tooth decay remains the main problem of oral health of Brazilians. Gingival alterations such as gingivitis and periodontitis are absent in only 17% of adults 35-44 years old and only 1.8% of those aged 65-74 years old. Consequently, there is a great demand for dental prostheses in both public and private dental practices. In elderly people 65-74 years old, 23% need full-arch dentures in at least one arch and 15% need dentures in both arches [1].

There is a strong trend in the professional environment to select implant-supported prostheses as the model of rehabilitation [2]. Prior knowledge of the surgical anatomy is a key to the surgical protocol for implant placement in the anterior mandible region, allowing surgery with less trauma, less sensory complications and with a spatial distribution that favors the biomechanics. The correct demarcation of the bilateral mental emergence paths using the surgical guide allows the distal implants to be positioned at a minimum distance of 3.5 mm from the mental foramina [3].

Previously, such analysis and planning were carried out by periapical and panoramic radiographs leading to not so satisfactory results due to the distortions that are common in such techniques. Nowadays, there are more accurate techniques such as CT scans, especially the cone-beam type that provides a three dimensional (3D) image showing maximum details and using low exposure doses [4,5].

Surgical planning procedures, such as the placement of endosseous implants in the interforaminal area to carry out Brånemark protocol-type rehabilitations, can be better achieved with CBCT. The original Brånemark technique used fixed prostheses screwed onto six implants with diameters of 3.75 mm each and they were empirically distributed in this space [6].

Thus, the aim of this study was to retrospectively determine the distance between mental foramina of a Brazilian population and define the number of implants that could be placed in the interforaminal region using CBCT scans. Moreover, this pilot study developed and presents a method to measure the space available for the installation of the implants between the mental foramina.

Material and Methods

Ethical Aspects

This study was approved by the Ethics Committee of the Veiga de Almeida University (UVA) under resolution No. 1,197,645.

Study Design and Data Collection

CBCT scans were selected retrospectively. The scans were taken between 2012 and 2014 at two private oral radiology clinics, located in Rio de Janeiro and Niteroi (Brazil).

The inclusion criteria for these scans were: CBCT of the jaw with high quality and without any significant distortions, CBCT scans of edentulous or partially edentulous patients, examinations of patients more than 30 years old (end of growth period) [7], files in the DICOM language [8] and

CBCT scans performed by iCAT tomography (Imaging Sciences International Inc). The exclusion criteria were: CBCT scans of patients with intraosseous lesions involving the mental foramina region.

The method to measure the space between the foramina was developed using the BlueSky Plan3 software in Dicom format and the axial reconstruction views were chosen for measurements. The presence of the anterior loop, when visible in the examination was recorded. Figure 1 shows the innovative technique used to measure the distance between the interforamina. Based on the linear measures between the foramina, the number of implants that could be placed was defined according to their diameters: 3.35mm, 3.75 mm and 4.0 mm. The total space required was calculated by the sum of the minimum safety distance between the mental foramina bilaterally [3], the minumum distance between implants [9] and the diameter of the implants' bodies.

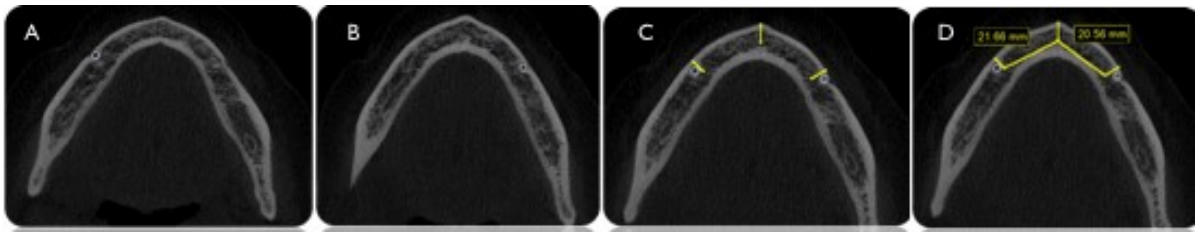

Figure 1. Technique to measure the interforaminal spaces: (A) and (B) select the axial section in which the anatomical structure of the mental foramen is visible and load an implant (applicative tool) on the medial border of the foramen, (C) mark three lines perpendicular to the buccal and lingual cortical plate: medial tangent to the left foramen, in the middle of the jaw line and tangent to the medial right foramen, (D) Mark the midpoints of these lines and add the length of the two lines found = linear measure of the distance between the foramina.

Statistical Analysis

Statistical data analysis was performed using the SPSS - 21.0 program for the chi-square test, with a significance level of 5% ($p < 0.05$). The normality of the sample was confirmed by the Kolmogorov-Smirnov Test. The Student's t-test was used to compare the means analyzed.

Results

A total of 82 exams were selected from 1,465 exams for this work. Of these, 60 (73.2%) examinations were from females and 22 (26.8%) were from males. The anterior loop was absent in most of the CBCT scans (86.6%). The average age of the patients who underwent the scans was 63.51 ± 9.49 years old; the minimum was 40 and the maximum 86 years old. The average linear measurement between the foramina was 40.52 ± 3.92mm. The mean for male patients was 41.93 ± 3.98 mm, and for female patients was 39.99 ± 3.80mm, with a significant difference between the means ($p = 0.043$). The data of the sample are shown in Table 1. There was no positive association between the presence of the anterior loop and gender of the patient whose tomography scans was studied ($p = 0.719$). The linear measurements between the foramina were classified into three groups.

Table 1. Data collected from the tomographic exams (N=82).

Variables	N (%)
Gender	
Female	60 (73.2)
Male	22 (26.8)
Loop anterior	
Present	11 (13.4)
Absent	71 (86.6)

Table 2 shows the frequencies of the groups in absolute numbers and percentages and average numbers of implants that could be installed based on the different measurements presented. Most of the patients (n = 80) whose CTs were analyzed could be rehabilitated using a protocol of four 3.3mm diameter implants.

Table 2. Distribution of dental implants according to the groups G1, G2 and G3.

Groups	Dental Implants				Total
		Implant 3.3 mm			
	0	4	5	6	
G1	2	22	22	0	46
G2	0	0	26	8	34
G3	0	0	0	2	2
Total	2	22	48	10	82
		Implant 3.75 mm			
	0	4	5	6	
G1	5	38	3	0	46
G2	0	0	32	2	34
G3	0	0	0	2	2
Total	5	38	35	4	82
		Implant 4.0mm			
	0	4	5	6	
G1	5	41	0	0	46
G2	0	6	28	0	34
G3	0	0	0	2	2
Total	5	47	28	2	82

Note: G1: linear measure 30 to 40 mm; G2: linear measure 41 to 50 mm; G3: linear measure 51 to 60 mm.

Seventy-seven patients could receive protocols of 4 implants with diameters of 3.75 or 4.0 mm, according to Table 3.

Table 3. Distribution of number of dental implants possible in the patients according to their diameters.

	Implants		
Diameter	3.3mm	3.75mm	4.0mm
Insufficient space	2	5	5
Protocol with 4 implants	80	77	77
Protocol with 5 implants	57	40	30
Protocol with 6 implants	10	4	2

Discussion

The aim of this study was to measure the distance between foramina in CBCT scans of a population in the state of Rio de Janeiro and to predict the number of possible implants that could be installed in edentulous and partially edentulous jaws. The importance of this study was the measurement methodology using CBCT scan images in the Dicom file format. The CBCT scan produces images compatible with the reality of the object, providing precise analysis, and with superior identification compared to panoramic radiographs [10].

In this study there was a significant difference between the male and female linear foramina measurements. According to a previous study there are significant differences between the genders for mandibular length. The authors revealed also significant differences between the genders for mandibular width [11].

Also the CBCT scans showed that the majority of the patients (n = 80) could be rehabilitated using a protocol of four 3.3mm diameter implants; and 77 patients could receive protocols of 4 implants with diameters of 3.75 or 4.0mm. These results contradict the preliminary results of Brånemark, who taking into account the biological space between the implants, recommended the use of 6 implants in the region between the foramina. In the exams of the 82 patients analyzed, only 4 patients would be able to receive a protocol of 6 implants with 3.75mm diameters, as originally described by Brånemark. Even reducing the diameter of the implants to 3.3mm, only 10 (12.19%) of the patients would be able to receive the protocol of 6 implants.

The security measures for the minimum clearances required for each type of protocol that were used in this study should also be emphasized. The distance measured from more distal implants to the mental foramen is not a consensus in the literature. Although some authors recommmend a minimum distance of 5.0mm [12], we chose to base our measurements by a previous report (3.5mm) [3] in the attempt to allow the placement of more implants. The distance between implants is largely described and should be of 3mm respecting the biological width formation around the fixtures [9]. These measures are necessary to ensure the integrity of the mandibular nerve that emerges from the mental foramen, and thus avoid any postoperative complications such as the paresthesia of the lower lip, pain and loss of the installed implant. These measures allow the formation of a biological space and maintenance of the crestal bone between the implants; an important factor for peri-implant health.

It is important to highlight that this preliminary study has limitations. We suggested a simple and innovative practice to straight-line measurement, instead of a curved line, to estimate the interforaminal length. Only one operator examined a small number of tomography. We believe that this method needs to be validated and compared with a gold standard, such as human dry skulls measurements.

The absence of these security measures in the Brånemark study may be in part due to the lack of biological and technological information at that time related to the idea that a larger number of implants with longer lengths favor the osseous integration process [6]. Thus, based on the results of this preliminary study, the installation of 6 implants would be unrealistic for most of the

individuals studied in the pilot sample. However, further studies with representative samples of the population and validation of the methodology are needed.

Conclusion

Four implants of 3.75 mm could be installed in the majority of the sample (93.9%) analyzed here. Only 4.87% of the analyzed patients would be able to receive 6 implants of the same diameter as used by Brånemark. Even reducing the diameter of the implants to 3.3mm, only 12.19% (10) of the patients would be able to receive a protocol with 6 implants.

Disclosure

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

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