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CLINICAL RESEARCH

Anterior loop of the inferior alveolar nerve: Averages and prevalence based on CT scans

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ABSTRACT

Statement of problem. The treatment of edentulous patients by using a complete implant-supported fixed prosthetic with distal extension has been widely studied; success is mainly dependent upon the placement of the distal implants. The location of the inferior alveolar nerve determines implant placement, but the length, prevalence, and symmetry between the left and right side of the anterior loop of the alveolar nerve are unknown.

Purpose. The purpose of this clinical study was to measure the anterior loop of the inferior alveolar nerve, which determines the placement of distal implants, in a group of 55 Mexican participants. The study expected to ascertain the average length, prevalence, and symmetry between left and right side and any sex differences. To differentiate the inferior alveolar nerve path, a new technique was applied using Hounsfield unit (HU) thresholds. The null hypothesis was that no significant differences would be found between the left and right sides or between men and women for the anterior loop of the inferior alveolar nerve.

Material and methods. Fifty-five computed tomography (CT) scans were made (Somatom Sensation 16; Siemens Healthcare) and were visualized with InVesalius software. Anterior loop measurements were made on 3-dimensional surfaces. To determine statistical differences between the left and right side and between the sexes, the *t* test was used. The interclass correlation coefficient test was also applied to verify the reliability of the measurements.

Results. Ninety percent of participants showed the anterior loop of the inferior alveolar nerve. The length of the anterior loop ranged between 0 and 6.68 mm, with a mean of 2.19 mm. No significant differences were found between the left and right sides or between men and women.

Conclusions. The mean length for the anterior loop in the sample was 2.19 mm. As the anterior loop length shows a high degree of variability, these findings suggest that a CT scan for each patient is recommended in order to visualize a safety zone before placing implants close to the mental foramen. (J Prosthet Dent 2016;115:156-160)

Treatment of edentulous patients with a complete implant-supported fixed prosthesis with distal extension has a high success rate.[1] This prosthesis is commonly supported by 3 to 6 implants placed in the mandible in the interforaminal space. Placement of these implants is limited by the mental foramen and, in particular, by the anterior loop of the inferior alveolar nerve.[2] The position of the posterior implants is crucial because it determines the length of the extension of the distal prosthesis and the number of implants that are biomechanically appropriate.[3,4]

Postoperative trauma, either temporary or permanent, has been described.[5,6] Several studies have demonstrated alterations of the inferior alveolar nerve, ranging from 8.5% to 24% of patients for periods of between 3 and 16 months.[7-10] The length of the anterior loop showed a range from 0.5 mm to 10 mm.[11,12] Various techniques, such as measuring during surgery, measuring in dry mandibles,[13-17] panoramic images,[18,19] computerized tomography (CT),[20-26] or a combination of these[27,28] have been used to measure this curvature. Accurate image measurement depends on several factors, the most important of which are voxel size and Hounsfield units (HU) because images can alter significantly in size if these values are changed.[29,30]

The purpose of this study was to measure the anterior loop of the inferior alveolar nerve to determine the mean, prevalence, and symmetry between the left and right

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Clinical Implications

A computed tomography scan for each patient is recommended to visualize a safety zone before placing implants adjacent to the mental foramen. The inferior dental nerve's path must be marked correctly to avoid injury, using the HU threshold values.

sides and any sex differences. Measurements were made directly on 3-dimensional (3D) images as the accuracy of this method has been established.[31-33] Rather than tracing the nerve by hand, which can lead to a margin in error of 1.7 mm, the nerve path was established with graphical tools for soft tissue intervals within the Hounsfield scale.[34]

MATERIAL AND METHODS

Fifty-five head and neck CT scans were selected from a series of previous studies of participants who had implants placed in the maxilla and mandible. All images were made with software (SOMATOM Sensation 16; Siemens Healthcare). The slices were between 0.625 mm and 0.4 mm, and the voxel size was 0.4 mm.

Digital Imaging and Communications in Medicine (DICOM) files were imported into a software program (InVesalius) (Fig. 1). The bone was then isolated by marking the structures that were in the range of 226 to 3071 HU. This generated a green mask to demarcate the bone (Fig. 2). In the toolbar for the advanced edition, the mandible was isolated by using the brush (create/erase mode) to eliminate all points and areas of the anatomy that did not belong to the mandible. This was done carefully, slice by slice, to leave a clean tomogram (Fig. 3).

The 3D image was generated with the command "create new 3D surface." However, this resulted in many points because of the presence of voxels within a density range of 226 to 3071 HU (Fig. 4). These points were eliminated with the tool "select largest surfaces," which isolated the jaw in a new 3D surface (Fig. 5).

A new mask was created to visualize the nerve by selecting the soft tissue option, which included the inferior alveolar nerve along with the other soft tissue (Fig. 6). In the toolbar for the advanced edition, the brush was then used to isolate the nerve, slice by slice, eliminating the rest of the soft tissue (Figs. 7-9). The measurement command tool was used to measure the distance between the anterior wall of the mental foramen and the loop (measurement 1) (Fig. 10). This measurement was not ideal because of the diagonal trajectory (Fig. 11). To obtain the mesiodistal measurement, the mandible was observed frontally, and the measurement

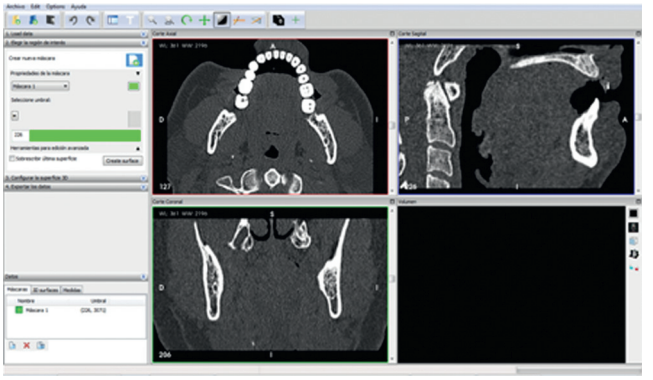

Figure 1. Images visualized in program, observed in 3 planes.

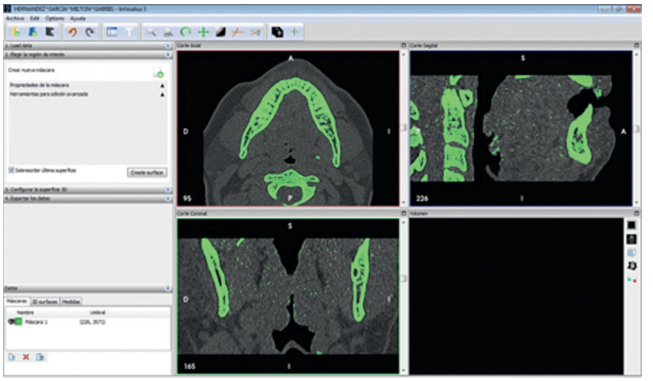

Figure 2. Bone shown in green (green mask).

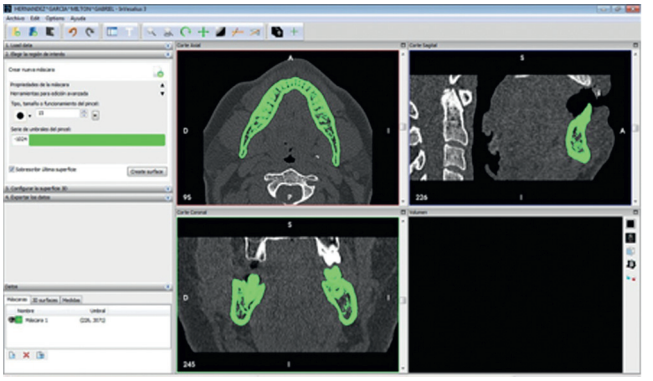

Figure 3. Isolation of mandible.

was made from the anterior wall of the mental foramen to the mesial point of measure 1; therefore, measurement 2 was correct in the present study (Fig. 12).

The prevalence of the anterior loop and its length were recorded and collated by sex. All data were processed with software (SPSS statistics v21.0; IBM Corp). The *t* test was used (α=.05) to compare differences in the mean values of nerve lengths between the sexes and between the left and right sides. The intraclass coefficient test was used to determine the reliability of the measurements.

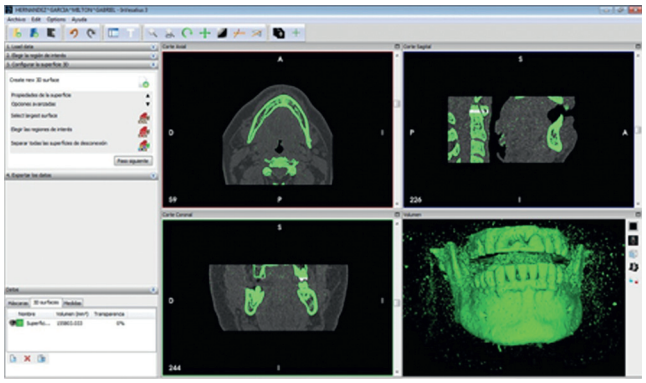

Figure 4. Three-dimensional images showing pixels within threshold of 226 to 3 071 HU (green spots). HU, Hounsfield units.

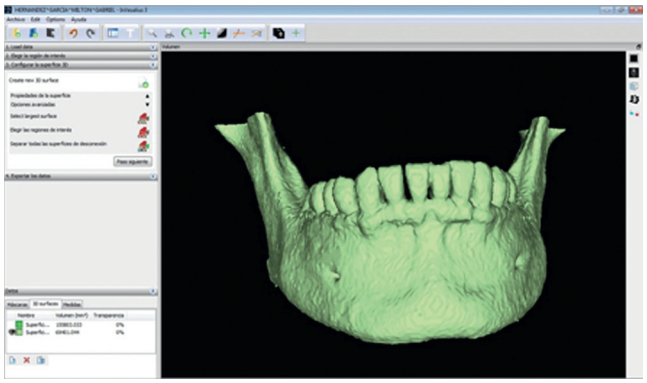

Figure 5. New surface 3-dimensional view after elimination of pixels within 226 to 3 071 HU. HU, Hounsfield units.

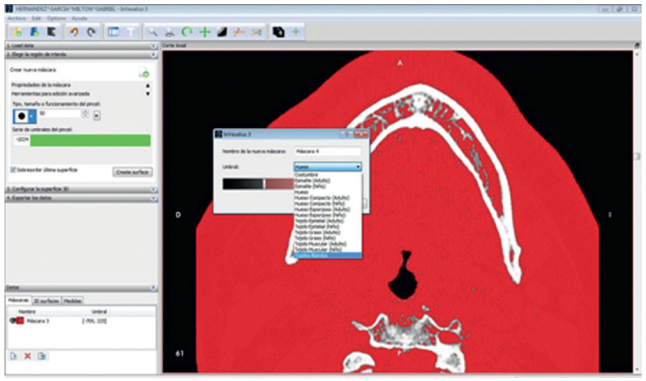

Figure 6. Soft tissues including nerves visualized.

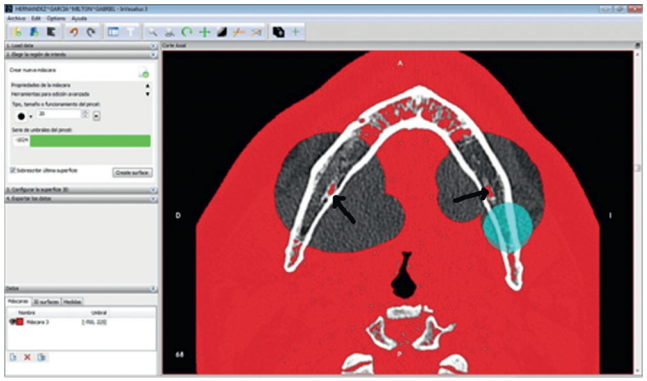

Figure 7. Elimination of all soft tissue, leaving only nerve (black arrows).

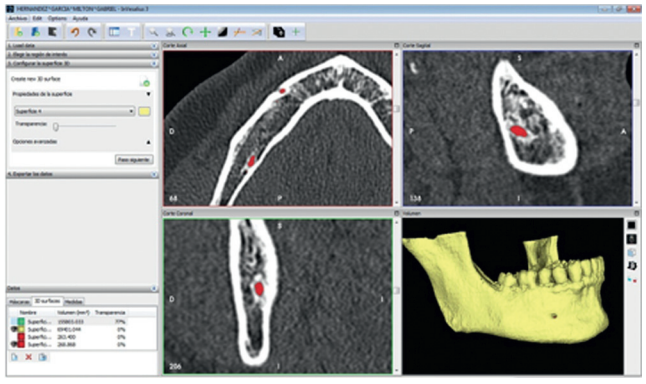

Figure 8. Demarcation of nerve.

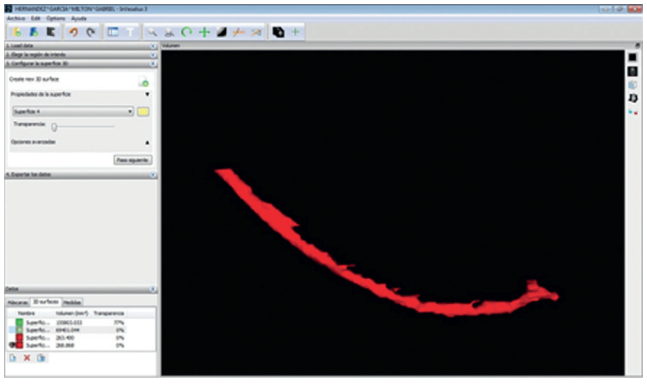

Figure 9. Three-dimensional image generated once nerve was isolated.

RESULTS

Ninety percent of participants showed the anterior loop. The length of the anterior loop ranged between 0 and 6.68 mm; the mean length was 2.19 mm.

The mean lengths on the left and right sides of the mandible were not significantly different (P=.381). Differences in length between the sexes also were not significantly different (P=.485). The intraclass coefficient test determined the reliability of measurements (rI: 0.894).

DISCUSSION

The anterior loop of the inferior alveolar nerve was measured from CT scans with 3D-generated images to determine any length differences between the left and right sides, between men and women, the mean length of the anterior loop, and its prevalence among the population. The mean anterior loop length of 2.19 mm was similar to that reported by Uchida et al,[13,27] Mardinger et al,[19] Apostolakis et al,[22] Rosa et al,[24] and Ritter et al.[25] However, Neiva et al[16] and Hwang et al[6] reported greater

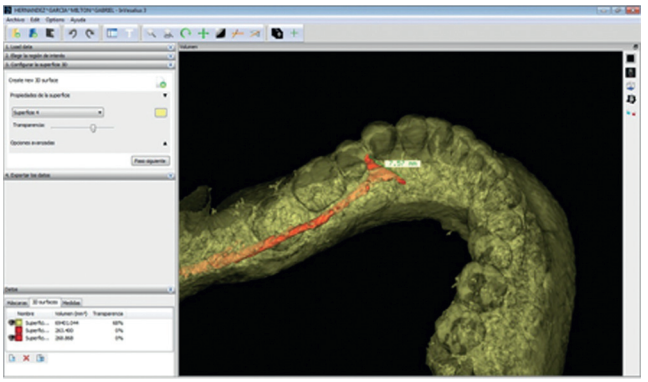

Figure 10. Measurement 1.

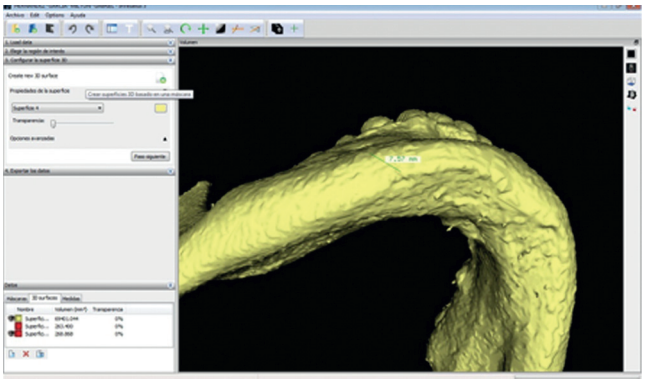

Figure 11. Measurement 1 in diagonal trajectory.

anterior loop lengths. These discrepancies can be attributed to different measurement techniques: Neiva et al[16] measured anterior loops with a periodontal probe that could have entered the incisive nerve canal, leading to greater reported lengths, whereas Uchida et al[27] measured the anterior loops directly after removing bone from the mandible's buccal wall, providing a more accurate measurement.

The present study found no significant differences between the length of the anterior loop on the left and right sides in accordance with studies by Rosa et al,[24] de Oliveira-Santos et al,[23] and Uchida et al.[13] Therefore, it can be concluded that the loop is symmetrical.

The present study did not find any significant differences in anterior loop length between the sexes in accordance with Oliveira-Santos et al[23]; however, Uchida et al[13] reported a difference. More studies into this issue are required before a conclusion can be drawn.

Several factors can affect the measurements of soft tissues, including voxel size and HU. Previous studies have established that with a voxel greater than 0.4 mm, a significant deviation may be obtained from an object with real dimensions[26,29]; however, other studies have also established that a 0.4-mm voxel does not generate a significant difference.[26,30,32] In those studies in which many differences were found with a 0.4-mm voxel, the researchers were trying to measure volumes related to hard tissues, so, in the present study, lineal measurements were performed to avoid any distortions. Also, in previous studies, the accuracy of anterior loop measurements has been compared with real measurements in the jaw.[26-28]

Another factor to take into account is the HU threshold, which may increase or decrease the size of the images. In the present study, the threshold was established with standards set by Ye et al[31] and Damstra et al[32], to minimize variance due to equipment variables, the same CT scanner, with a 0.4 mm voxel, was used each time.

In the present study, the first point of measurement was the anterior wall of the mental foramen, and the

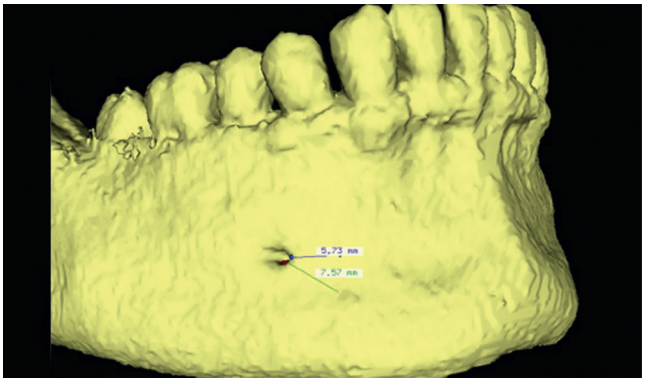

Figure 12. Measurement 2 made from anterior wall of mental foramen to front point of measurement 1.

second point was the front of the mandibular loop, in accordance with Uchida et al[13,27] and Santana et al.[28] The tomographic view for anterior loop measurement was not described by Watanabe et al,[20] while Jacobs et al[21] used the cross-section view, Apostolakis et al[22] used an axial view, and Oliveira-Santos et al[23] used a cross-section view and panoramic reconstruction images with no discernable differences between either. Rosa et al[24] used only panoramic reconstructions, Uchida et al[13,27] used mandibles from cadavers and compared them with their tomography's 3D reconstruction view, revealing no discernable differences in the measurements. Santana et al[28] used dry mandibles, which were compared with their respective tomography view and stereolithography models, revealing no distortions in measurement with tomography views but distortions with stereolithographic modeling. Gerlach et al[34] stated that marking the nerve manually results in a margin of error, even by combining multiple tomography views as in the previous studies. The technique described in the present study successfully shows the nerve path, as the rest of the tissues have been disabled; however, more research is needed to determine the benefits of using this technique for measurements on images.

CONCLUSIONS

The mean length for the anterior loop of the inferior alveolar nerve in the sample was 2.19 mm. As the anterior loop length shows a high degree of variability, these findings suggest that a CT scan for each patient is recommended to visualize a safety zone before placing implants close to the mental foramen. The inferior alveolar nerve path must be marked with the technique described in the present study to avoid injury.

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