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Original article

Reliability of cone beam computed tomography in locating and measuring the mandibular canal for planning of surgical techniques in the mandibular body[☆]



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ABSTRACT

Aim: The aim of this study was to determine the reliability of cone beam computed tomography to locate and take measurements of the mandibular canal, as well as the vestibular bone wall, in the planning of the bone graft surgery in the mandibular body.

Material and methods: A total of 11 mandibles from fresh cadavers were studied (22 hemimandibles, half of them with teeth). A CBTC and a surgical procedure for the lateralization of the lower dental nerve were performed with the aim of measuring the thickness of the vestibular table and the mandibular canal (MC) or lower dental nerve at 5, 15, and 25 mm from the most posterior position of the mentonian hole.

Results: The results obtained in the study indicate that CBTC, being the best diagnostic tool currently available, still appears to be unreliable when compared to actual results. This discrepancy is a mean of 1.15 mm as regards the thickness of the vestibular bone wall that covers the MC, and a mean of 0.3 mm in relation to the thickness of the lower dental nerve.

Discussion: It is important to know and assess these discrepancies in view of the multitude of surgical procedures that can be performed in this area, and in the vicinity of the lower dental nerve.

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Fiabilidad del uso de la tomografía computarizada de haz cónico en la localización y medida del conducto mandibular en la planificación de técnicas quirúrgicas en el cuerpo mandibular

R E S U M E N

Palabras clave:

Nervio dentario inferior
Anatomía
Tomografía computarizada de haz cónico
Injerto de cuerpo mandibular

Objetivo: El objetivo de nuestro estudio fue determinar la fiabilidad del estudio tomográfico para localizar el conducto mandibular y tomar mediciones exactas del diámetro de dicho conducto y de la pared ósea vestibular, como mediciones principales en la planificación de la toma de injerto óseo de cuerpo mandibular.

Material y método: Se estudiaron 11 mandíbulas (22 hemimandíbulas) de cadáver fresco, lamitad de ellas dentadas, a las cuales se les realizaron una CBCT y un procedimiento quirúrgico de lateralización del nervio dentario inferior con el objetivo de medir el grosor de la tabla vestibular y el grosor del conducto mandibular o dentario inferior (CDI) a los 5, 15 y 25 mm de la parte más posterior del agujero mentoniano.

Resultados: Los resultados obtenidos por nuestro estudio indican que el CBCT, siendo el mejor método diagnóstico disponible en la actualidad, aún presenta diferencias respecto a la realidad. Esta discrepancia es de 1,15 mm de media con relación al grosor de la tabla ósea vestibular que lo recubre y de 0,3 mm de media con relación al grosor del CDI.

Discusión: Conocer y valorar estas discrepancias es importante dada la multitud de procedimientos quirúrgicos que se pueden realizar en esta zona, y la vecindad con el nervio dentario inferior.

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Introduction

Currently, the advances in implantology and its recognition as one of the most important therapeutic weapons in the field of Odontology have led to the need to use bone graft techniques for the provision of this tissue in certain areas for adequate implant rehabilitation.¹⁻³

There is a wide range of techniques, some of which are performed in the anatomical area of the mandible. For the latter, the mandibular ramus and body grafts have been frequently mentioned in publications in recent years.^{4,5}

The main noble structure in this area that must be carefully handled at all times is the intraosseous trajectory of the inferior dental nerve (IDN), located in the inferior dental canal (IDC).⁴

Thus, determining the location of this structure before surgery to avoid damage is essential for the planning of a mandibular body bone graft. Therefore, it is important to understand the reliability of the techniques that surgeons may implement.⁶

In some patients, the IDC cannot be identified using a panoramic X-ray.^{7,8} Besides, this technique does not allow for a three-dimensional assessment of the mandible. Towards the end of the last century, the development of IT software together with computed tomographies (CT scans) introduced a major breakthrough for clinicians. Currently, the CT scan technique provides the largest amount of data compared to other diagnostic techniques in relation to the planning of bone tissue surgery.⁶

Previous studies on the reliability of CT scans and cone beam computed tomographies (CBCT) for the planning and selection of mandibular dental implants of adequate diameter

and length, specifically about their reliability for the correct measurement of the distance between the upper rim of the mandibular canal and the upper rim of the mandible, have indicated that some anatomical points and accidents (such as the mental foramen) are essential and may not be seen clearly.⁹⁻¹¹

Based on this approach, the studies conducted present contradictory results.^{12,13} Our study was centred on the same area. However, instead of focusing on the coronal area of the IDC, we focused on the vestibular area. In this area, measurements must be based on a lower number and smaller anatomical accidents than those in the alveolar area. However, the potential consequences of an incorrect measurement are more serious in bone grafting surgery than in implant insertion surgery.⁴

The objective of our study was to determine the reliability of the tomography study (CBCT) to locate the IDC and take precise measurements of its diameter and of the vestibular bone wall, which are the main measurements for the planning of a mandibular body bone grafting surgery or any other kind of surgery in this area.

Material and method

The study involved 11 mandibles (8 male subjects and 3 female subjects), 22 mandibular hemiarches, half of which had teeth, obtained from fresh corpses. The mandibles were requested, under due authorisation, by the Lavante Centre, which had been authorised by the Board of Andalucía. Before conducting the clinical study for the obtaining of actual measurements, these underwent a CBCT (GE Locus Ultra, GE Healthcare, United Kingdom). The images obtained were based on the

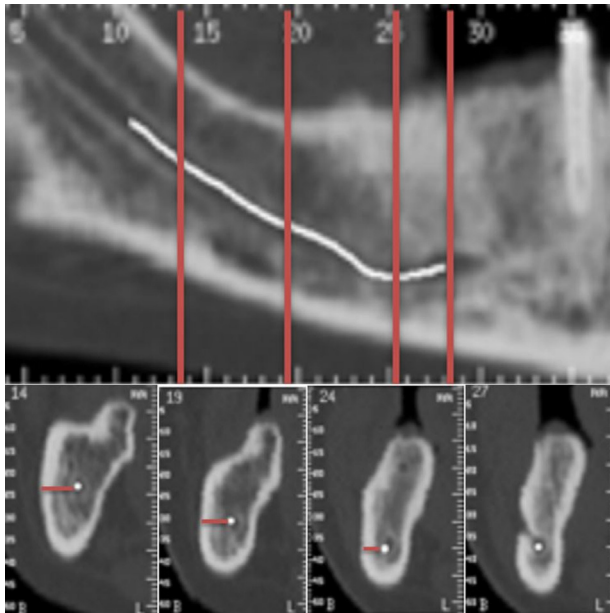


Fig. 1 – Radiological measurements performed on the head of the corpse.

following parameters: 120 kV, 20 mA, exposure time of 16 s, and incisions of 154 μm thick. Images were subject to a three-dimensional treatment, visualisation and measurement using the software Romexis Viewer (Planmeca OY, Finland) (Fig. 1).

The buccal distance was measured from the most lateral area of the IDC towards the vestibular area up to the bone buccal margin. This measurement was based on an incision perpendicular to the basal plane of the mandible in the following points: at 5, 15 and 25 mm from the most rear part of the mandibular mental foramen (Fig. 1). The distance was always measured by the same person. The coronal-caudal diameter of the inferior dental canal was measured in the same way.

After the radiological measurement, the following protocol was carried out on the heads of the corpses to obtain the actual measurement of the distances between the most outer part of the IDC and the limit of the vestibular cortical bone of the mandible. After a surgical approach to this anatomical location, the mental foramen was identified and, on its rear part, at 5, 15 and 25 mm, subsequent osteotomies were conducted (with a handpiece and a fissure drill under irrigation) to access the area to be measured (a fenestration was performed until nerve exposure, and the walls and the canal were subsequently measured using a gauge). Measurements were taken using a manual gauge, and one tenth of a millimetre was established as the base unit (Figs. 2 and 3).

As happened with the radiological measurements, only one independent observer, after the surgical preparation, measured each of the distances: the width of the vestibular bone wall of the IDC and the coronal-caudal diameter of the IDC.

Apart from these main measurements or variables, other measurements were collected in relation to the part of the mandible from which measurements were taken (right or left) and to the gender of the patient.

Finally, the data collected were included in a spreadsheet that was exported to SPSS v.14 (IBM Corp., USA) for their



Fig. 2 – Actual measurements performed on the head of the corpse (conducted lateralisation).

statistical analysis. The Mann-Whitney U statistical test was applied.

Results

The thickness of the vestibular wall of the IDC amounted to 4.73 ± 0.95 mm when radiographically measured and to 3.91 ± 1.62 mm when directly measured, at 5 mm from the mental foramen. At 15 and 25 mm from this point, on a radiographic level, the measurements were 7.17 ± 1.18 and 6.72 ± 2.04 mm, respectively. When directly measured, these amounted to 5.13 ± 2.50 and 6.09 ± 3.42 mm, respectively. The differences were statistically significant both at 15 and at 25 mm from the mental foramen (Table 1).

The data used for the comparison of anatomical measurements based on gender or location, as well as the data used for the comparison of radiological measurements, present no statistically significant differences (Table 1).

The diameter of the interior dental canal radiographically measured amounted to 3.94 ± 1.05 , 4.06 ± 1.10 and 4.02 ± 1.14 mm, respectively, at 5, 15 and 25 mm from the mental foramen. When directly measured, these presented the following results at 5, 15 and 25 mm from the mental foramen,



Fig. 3 – Actual measurements performed on the head of the corpse (gauge).

Table 1 – Measurements related to the vestibular wall of the inferior dental canal, distal to MF in mm.

	Radiographic measurements	Anatomical measurements	p
<i>Comparison between radiographic and anatomical measurements</i>			
5	4.73 ± 0.95	3.91 ± 1.62	NS
15	7.17 ± 1.18	5.13 ± 2.50	0.004
25	6.72 ± 2.04	6.09 ± 3.42	0.0001
	Male subject	Female subject	p
Comparison between radiographic measurements by group			
<i>Gender</i>			
5	4.77 ± 1.03	4.60 ± 0.75	NS
15	7.30 ± 1.30	6.76 ± 0.68	NS
25	6.78 ± 2.35	6.55 ± 1.30	NS
	Right	Left	p
<i>Hemimandible</i>			
5	4.89 ± 0.96	4.56 ± 0.96	NS
15	7.48 ± 1.37	6.86 ± 0.89	NS
25	7.28 ± 2.49	6.16 ± 1.50	NS
	Male subject	Female subject	p
Comparison between anatomical measurements by group			
<i>Gender</i>			
5	4.03 ± 1.72	3.56 ± 1.36	NS
15	5.18 ± 2.98	5.00 ± 1.00	NS
25	6.16 ± 3.98	5.88 ± 1.23	NS
	Right	Left	p
<i>Hemimandible</i>			
5	4.11 mm ± 1.91	3.70 mm ± 1.31	NS
15	5.53 mm ± 3.81	4.72 mm ± 1.63	NS
25	6.50 mm ± 4.21	5.67 mm ± 2.54	NS

NS: not statistically significant difference; MF: mental foramen.

respectively: 3.86 ± 1.10 , 3.81 ± 1.11 and 4.45 ± 2.16 mm. All the differences were statistically significant (Table 2).

The data used for the comparison of anatomical measurements based on location did not present significant differences. However, in comparisons based on gender, female subjects did present a significantly smaller diameter of the IDC than male subjects, on both a radiological and an anatomical level (Table 2).

Discussion

Although the IDN presents only one sensible component, patients and clinicians consider its damage as a failure in the planning of a treatment.⁴ Therefore, it is necessary to conduct a precise assessment of its anatomy and location to prevent any damage.

Several surgical procedures, such as the placement of implants, mandibular ramus or body block grafts, embedded third-molar exodontia, ramus sagittal osteotomy, nerve transposition and the placement of miniscrews for orthodontics, pose a risk of damage to the IDN.¹⁴⁻¹⁷

Currently, the planning of these surgical procedures greatly benefits from the use of CT scans, which have been applied to the anatomical study of these areas.¹⁸

However, given the importance of preserving noble structures and the aggressiveness of some of these techniques, it is essential to understand the correlation between radiological measurements and actual measurements, so as to avoid planning errors.

In relation to the vestibular wall of the IDC, its radiological thickness ranged from 4.75–5 mm from the mental foramen to 7–25 mm from said point. When measured directly from the corpse, said thickness ranged from 4 to 6 mm under the same conditions. The mean difference between radiological measurements and anatomical measurements amounted to 1.15 mm. This difference must be taken into account upon planning surgical interventions on this area when performing a CBCT.

Our results from the radiological measurements were slightly higher than those obtained in the study conducted by Massey et al.,¹⁹ although it is rare that, in that study, radiographic measurements were lower than anatomical measurements in the rear areas but higher than the latter in the areas surrounding the mental foramen. It would seem

Table 2 – Measurements related to the diameter of the inferior dental canal, distal to MF in mm.

Radiographic measurements		Anatomical measurements		p
<i>Comparison between radiographic and anatomical measurements</i>				
5	3.94 ± 1.05		3.86 ± 1.10	0.0001
15	4.06 ± 1.10		3.81 ± 1.11	0.0001
25	4.02 ± 1.14		4.45 ± 2.16	0.004
	Male subject		Female subject	p
<i>Comparison between radiographic measurements by group</i>				
<i>Gender</i>				
5	4.20 ± 1.09		3.23 ± 0.43	0.007
15	4.33 ± 1.16		3.35 ± 0.46	0.01
25	4.35 ± 1.17		3.13 ± 0.17	0.001
	Right		Left	p
<i>Hemimandible</i>				
5	4.02 ± 1.07		3.85 ± 1.06	NS
15	3.92 ± 1.15		4.20 ± 1.08	NS
25	4.02 ± 1.22		4.00 ± 1.10	NS
	Male subject		Female subject	p
<i>Comparison between anatomical measurements by group</i>				
<i>Gender</i>				
5	3.38 ± 1.13		2.18 ± 0.24	0.01
15	3.60 ± 1.16		2.93 ± 0.12	0.003
25	4.22 ± 1.35		3.10 ± 0.49	0.01
	Right		Left	p
<i>Hemimandible</i>				
5	3.26 ± 1.32		2.84 ± 0.86	NS
15	3.56 ± 1.17		3.27 ± 0.89	NS
25	4.00 ± 1.16		3.83 ± 1.43	NS

NS: not statistically significant difference; MF: mental foramen.

that the magnification of the CBCT varies from one area to the other until it disappears and turns into a negative value. This effect was not observed in our study, where radiological measurements were higher than anatomical ones in all cases, regardless of their statistical significance in some situations.

In the work conducted by Kamburoglu et al.,¹² which was focused on this same area, it was observed that anatomical measurements were somewhat higher than radiological ones, but almost practically the same.

The study conducted by Leong et al.⁴ was focused on the thickness of the buccal cortical bone. The data collected showed that the thickness of this structure ranged from 2.53 to 2.81 mm in the buccal area. Based on these data and on the mean thickness of the vestibular mandibular cortical bone measured in our study (6.20 mm when radiographically measured/5.05 mm when anatomically measured), there would be a space of 2–2.5 mm of trabecular bone over the IDC on a buccal level.

The mean thickness of our measurements was similar to that obtained in other studies, such as the one performed by Levine et al. in 2007 and by Yashar et al. in 2002 (4.9 mm).^{20–22}

The results related to the thickness of the IDC demonstrated that, in all locations, the radiologically measured thickness was greater than the anatomically measured one (mean value of 0.3 mm).

Several articles indicate that the thickness of the vestibular table is reduced if the analysed individuals are Caucasian or older in the area of the furca of the first molar.^{20–22}

In our study, we did not find differences in relation to the thickness of the vestibular table based on gender or location. However, the thickness of the IDC is lower for female subjects (for both anatomical and radiological measurements) than for male subjects.

In conclusion, the results obtained in our study indicate that the CBCT still presents differences when compared to actual measurements, despite being the best diagnostic method currently available. This difference amounts to a mean value of 1.15 mm in relation to the thickness of the surrounding vestibular bone table and a mean value of 0.3 mm in relation to the thickness of the IDC.

It is essential to understand and assess these differences, given the wide range of surgical procedures that may be performed in this area and its closeness to the IDN.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Conflict of interest

The authors declare that there are no conflicts of interest.

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