The midline mandibular lingual canal: importance in implant surgery

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Running title: Implants near the midline mandibular lingual canal

Abstract

Purpose: To determine the position and occurrence of the midline mandibular canal (MLC) in the various age, sex, population and dentition groups. The average distances from the MLC to a planned mandibular midline implant and the inferior mandibular border were measured. **Materials and methods:** Cone beam computed tomography (CBCT) was used to scan 122 mandibles (31 black males; 28 black females; 32 white males and 31 white females). Midsagittal sections in the reconstructed images of edentulous mandibles or sagittal sections through the socket of the 41 tooth (FDI nomenclature) in dentate mandibles were made. A measurement of 6 mm across bucco-lingually (BL) was delineated with the caliper tool indicating the minimum dimensions for placement of an implant. In dentate cases where the BL distance was in excess of 6 mm, the caliper was placed across the deepest part of the socket as a marker to determine the bone dimension available below the socket for implant placement. From these markers a vertical line was dropped to the MLC to measure the available bone. **Results:** The MLC was a consistent finding within the anterior mandible. A statistical significant difference in bone availability amongst the sexes and with dentition pattern was found indicating that edentulous female patients were particularly at risk of injury to the vessels of the midline lingual canal during implants in that area. **Conclusion:** Immediate implants in the position of lower central incisors are regarded as a safe procedure as is the placement of inter-foraminal implants in the anterior mandible. Clinicians should however take note of the position of the midline mandibular lingual canal and approach this area with caution, especially if the alveolar ridge is to be reduced before implant placement.

Key words: Near-fatal bleeding; lingual foramen; edentulous; sublingual artery; submental artery

Introduction

The midline lingual canal (MLC) of the mandible contains a blood vessel that may hemorrhage if perforated and should be considered when dental implants are planned.[1] The consequences of the perforation of this blood vessel may be serious as it may lead to a near fatal bleeding incident due to the obstruction of the airway (Fig 1).[2-4]

The proximity of any planned implant site to the MLC is therefore pivotal. This study was done to determine whether the average distance from the midline lingual canal to the 31/41 (FDI nomenclature) or midline planned implant site, was clinically significant. This distance is especially important when an immediate implant is planned to replace the 31 or 41 tooth or when the anterior mandibular alveolar ridge is reduced to create a platform for inter-foraminal implants. Immediate implants are often placed deeper than the pre-existing socket to obtain primary stability, which could damage the MLC and its blood vessel. Reduction of the anterior mandible to create a platform for implant placement has become an accepted procedure which may also lead to damage to the MLC position. Previous studies focused on the distance of the inferior border of the mandible to the lingual foramen or canal.[1,5-15]

The midline lingual foramen leading into the MLC is a constant feature of the anterior mandible as 81-100% of patients have at least one such foramen.[5-11,13,14,16-22] Some authors refer to this foramen as the midline lingual foramen; to distinguish it from the more laterally situated lingual foramen.[6,19] We prefer the term midline lingual canal as it describes the anatomic structure containing the artery and not just the entry point. It is more likely that a clinician will damage the artery just inside the mandibular body, rather than at the site of the foramen.

The foramen is found superior to or at the level of the mental spines or genial tubercles in the midline of the mandible.[5,7,9,13,14,18] There may be two or more foramina present in the midline and their locations and dimensions are variable.[11]

The contents of the MLC have not been clarified and are under debate.[18] Some researchers suggest that a neurovascular bundle enters through the foramen[11,23] while others have found that the canal contains an artery only.[8,24]

Lustig et al, (2003) found the average diameter of the artery to be 1.41mm ± 0.34mm with an average blood flow of 2.92 ± 3.19 ml/min*,* while Jaju and Jaju reported a mean diameter of 0.31 mm ± 0.7 mm with the largest diameter being 1.6 mm.[21,24] It is therefore clear that the artery entering the lingual foramen is of sufficient size to cause hemorrhage intra-osseous or in the floor of the mouth when the lingual cortex is perforated.[2,4,19,24-26] Should the artery be perforated close to the lingual border of the mandible, it is conceivable that the bleeding will spread into the floor of the mouth, with the risk of obstructing the airway as has previously been described.[2,4,9]

Successful implant surgery is dependent on sufficient bone quantity and quality.[27-29] Convention dictates that a border of at least 1 mm on both the lingual and buccal sides should surround the implant osteotomy site. Standard sized implants are +/- 4 mm in diameter, implying that a minimum bone dimension of 6 mm is required for successful implant placement.[29-31]

Implant placement in thin ridges is often abandoned as the implant strength and surface area for load distribution is greatly reduced.[32] On the other hand, reducing the thin alveolar ridge to obtain a width of 6 mm in such cases decreases the vertical dimension of the implant site.[28] Vertical reduction may also be required to establish sufficient vertical restorative space, especially in cases where the anterior mandibular segment has over-erupted in response to loss of maxillary teeth. The reduction of the alveolar bone in such a manner may pose a risk if a midline implant is considered, as it will encroach on the MLC position.

Trauma to the artery within the MLC may lead to serious hemorrhage if the size of the artery exceeds 1 mm.[4,22] The main hazard of such hemorrhage is airway obstruction caused by hematoma formation in the floor of the mouth which results in swelling that pushes the tongue against the palate.[9] This may lead to near fatal bleeding incidents.[3,4,25,33-49] The risk of hemorrhage is further increased in edentulous patients having atrophic mandibles with resorption of the alveolar ridge.[7]

It is difficult to visualize the lingual foramen with conventional radiographs.[12] Natekar et al (2011) observed the lingual foramen in only 28% of cases.[23] Computer-assisted imaging systems such as cone beam computed tomography (CBCT) is recommended as almost all lingual foramina can be visualized, the correct implant size can be calculated and surgical complications reduced.[1,10,12,22] It further has the benefit of a lower radiation dose than medical multi-slice computed tomography.[10]

In the literature search no studies could be found that compare different population groups with regards to the position and occurrence of the lingual canal and only a few that compared sexes and populations.[20,21,50]

The purpose of the study was to determine the position and occurrence of the midline mandibular canal in the various age, sex, population and dentition groups. The average distance from the midline lingual canal (MLC) to a planned implant site in the midline of the mandible was measured to determine the feasibility of such a midline implant.

Materials and methods

Materials

The study sample consisted of 122 dried mandibles belonging to two South African population groups and both sexes: 31 black males; 28 black females; 32 white males and 31 white females. Representatives of three dentition pattern subgroups are included in each sex- and population group. Dentition patterns were introduced to distinguish between the degree of tooth loss which has functional implications for mastication and the forces exerted on the mandible and therefore potentially for the distances measured. The three dentition pattern subgroups are the following: edentulous (dentition pattern 0); those with fewer than two occlusions of molars or premolars and fewer than one occlusion of canines or incisors on either side (dentition pattern 1) and those with at least two occlusions of molars and premolars or at least one occlusion of canines and incisors on either side (dentition pattern 2).

Methods

Dried mandibles were scanned at Necsa (South African Nuclear Energy Corporation Ltd) which hosts the South African Neutron Radiography (SANRAD) and tomography facility capable of producing CBCT.[51] The reconstruction of 370 X-rays per section was performed through Octopus® software, a commercial tomography reconstruction package for CBCT, which first converts the raw projections into tiff image stacks of two-dimensional cross- sections through the sample.

The slices were stacked to produce a virtual voxel volume representing the sample in three-dimensions in a software package. The VG Studio MAX-2.1 software from Volume-Graphics was used for the three-dimensional rendering, segmentation and visualization of the reconstructed volume data (Volume Graphics, 2010). The distances were measured by integrating the information provided by the three-dimensional image together with the axial, sagittal and frontal views.

If no teeth were present, a midsagittal section of the 3D-reconstructed mandible was made to enable measurements. When teeth were present the sagittal section was made through the deeper part of the socket of tooth 41 and inspected for the presence of midline lingual canal/s. If a canal was not immediately obvious the images were scrolled sequentially until such a canal could be found near the midline.

If the mandible was wide enough to allow a measurement of 6 mm bucco-lingually (BL) it was delineated with the caliper tool in VG studio max (Figs. 3, 4a and b). In six cases (four white females, one black male and one white male) the section was not wide enough to allow a measurement of 6 mm BL and the superior distance was indicated as zero, as no distance was considered available for placing a 4mm implant safely. In dentate cases where the BL distance was in excess of 6 mm, the caliper was placed across the deepest part of the socket to simulate reduction of the alveolar bone in order to obtain primary stability for immediate implant placement. From this marker a vertical line was dropped into the medullary bone to measure the closest distance to the midline lingual canal: the superior distance (Fig 5).

A second measurement was taken from the superior midline lingual canal to the inferior border of the mandible: the inferior distance (Figs. 3, 4a and b). Very small canals even if superior to a main canal were not taken into account as were canals that pierced the cortex but did not reach the medulla of the bone.

The mean and standard deviations were calculated for each of the four sex, population and dentition groups for the superior and inferior distance. Statistical comparisons between groups were done using analysis of covariance (ANCOVA) correcting for age if it was found to be a significant covariate.

Ethics considerations

Ethics approval was obtained from the Ethics Committee of the Faculty of Health Sciences of the University of Pretoria (Protocol no: 120/2010).

Results

Inferior distance

Basic descriptive analysis for the inferior distance was performed and is presented in Tables 1 to 3.

ANCOVA showed no statistical difference according to sex ($p = 0.13$), age ($p = 0.27$) population group ($p = 0.61$) or dentition pattern ($p = 0.79$) for inferior distances.

Superior distance

Basic descriptive analysis for the superior distance was performed and is presented in Tables 4 to 6.

ANCOVA for the superior distance exhibited a significant difference amongst the sexes ($p = 0.0044$) and dentition patterns ($p = 0.0006$). As evident from Tables 4 to 6, the superior distance was significantly shorter in females and edentulous individuals. The difference between populations was not significant ($p = 0.5337$). Age was not a significant covariate and none of the interactions between the main factors (sex; dentition pattern or population) were significant.

Course of the MLC

It was found that the midline lingual canals situated more superior, progressed in an antero-inferior direction while those canals located inferior showed an antero-superior direction. In some instances the canals anastomosed to form one continuous canal connecting the superior lingual foramen with the inferior lingual foramen (Fig 6). In other cases the canals of the lingual foramen seemed to bifurcate (Fig 7).

Discussion

The direction of the canals described in this study is similar to that described by other researchers.[1,5,6,20] It has been reported that the artery of the MLC anastomoses with the incisive artery. [5,13,16] Others describe the course of the MLC as extending from the lingual side towards the buccal or vestibular side, thereby connecting the lingual and labial plates.[16,20] No reports however have described an anastomosis between the canals of the more superiorly located lingual foramina and the more inferiorly located canals as seen in this study. One can postulate that the lingual canals follow this circular pathway to run towards a capillary bed contained within the cancellous bone of the mandible providing nutrients to the mandible. Such an area might explain excessive bleeding during implant drilling or harvesting of bone blocks from the chin.

The bifurcation of the lingual canals as seen in this study may pose an additional risk for injury as the bifurcation may be in the path of the implant preparation site.

In some cases where hemorrhage has been reported, a drilling depth of 15 mm was used.[7] This depth would have posed a risk to the individuals in this study (Tables 4-6). The risk of hemorrhage is further increased in edentulous patients with atrophic mandibles[7] or where the alveolar ridge is reduced for immediate implant placement and loading. Reduction of the mandible is often done to obtain primary stability for the dental implant which is not always possible within a tooth socket and also to flatten the anterior alveolar ridge in the mandible for prosthetic purposes. A maximum implant length of 14mm has been proposed in the anterior mandible to lessen the chances of complications.[36]

No statistical variation was found for the inferior distance with a mean distance ranging from 10.83 to 12.874 for all groups.

The statistical variation noted in the superior distance between sexes and dentition groups necessitates the need to consider these factors when planning implants in the midline of the mandible. Some clinical protocols require 5 implants inter-foraminal, where limited space between the mental foramina might force the clinician into a midline position. Other clinical protocols require the reduction of the anterior mandible in order to do immediate placement and loading of implants. Such a reduction might encroach on the midline lingual canal amongst others, and may lead to a near fatal bleeding incident if the MLC is perforated close to the lingual foramen. The replacement of teeth 41 and 31 with dental implants should also be approached with caution, for both immediate and late placement protocols. The proximity of the root apex of these teeth to the MLC might pose a risk for vascular injury.

If 8 mm is considered the minimum implant length required below a BL width of 6 mm the mean value of edentulous females and some with variable number of teeth will not qualify for implantation in the midline without endangering the vessels in the midline lingual canals. Furthermore, the suggested safety margin of 2 mm between a dental implant and neurovascular structures would not be maintained. In males, some edentulous individuals will also not qualify although the mean value is adequate in this group. Dentate males seem as a group to have adequate height of alveolar bone needed for dental implants in the midline without endangering the vessels of the midline lingual canals.

Conclusion

The MLC is a consistent finding within the anterior mandible. It is of surgical significance as it contains a blood vessel that may lead to hemorrhage and life-threatening conditions when perforated. Clinicians should take note of its presence and approach the area with caution. Panoramic radiographs are often the only diagnostic aid used in the anterior mandible and does not show the lingual canal. We therefore recommend the use of computed tomography in pre-operative assessment of implants in the midline mandibular area as the standard of care.

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Figures:

Figure 1: Near fatal bleeding incident after perforation of a blood vessel in the anterior floor of the mouth during routine implant placement in the anterior mandible (Photo courtesy of Joe Niamtu III)

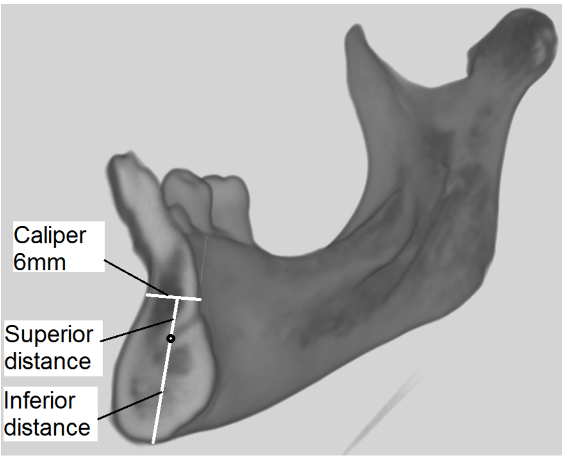

Figure 2: Midsagittal section of a reconstructed Cone Beam Computed Tomography (CBCT) image of the mandible demonstrating the midline lingual canal

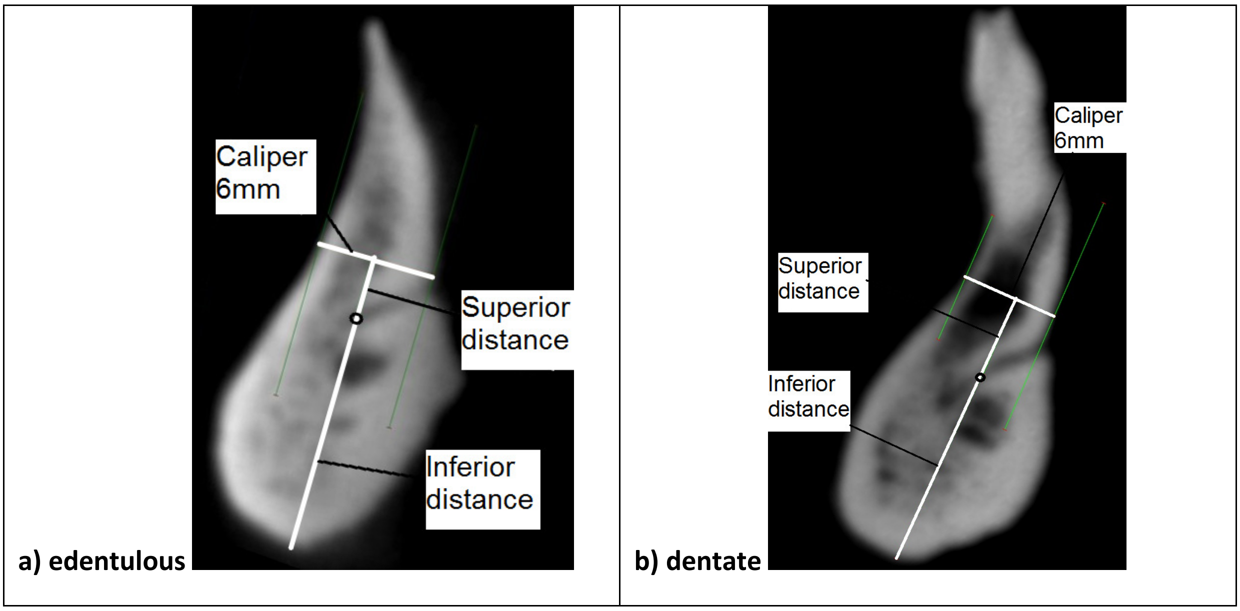

Figure 3: Midsagittal section of a reconstructed image showing the superior and inferior measurements

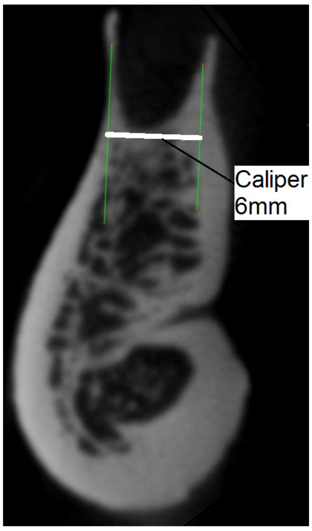

Figure 4: Calliper position across the deepest part of the extraction cavity coinciding with root apex

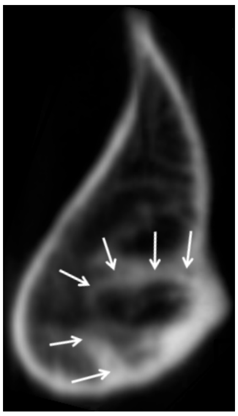

Figure 5: Continuity between superior and inferior lingual foramen

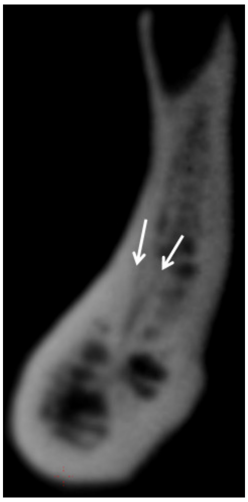

Figure 6: Bifurcation of lingual canal

Tables:

Table 1: The inferior distance amongst the sexes and dentition patterns measured in mm

Sex → Dentition pattern ↓	Female	Male	Total
0 edentulous	N = 20 10.83 +/-3.17	N = 20 12.87 +/- 2.68	N = 40 11.85 +/- 3.08
1 fewer than two occlusions of molars or premolars and fewer than one occlusion of canines or incisors on either side	N = 25 11.05 +/- 2.15	N = 14 11.71 +/- 2.95	N = 39 11.29 +/- 2.45
2 at least two occlusions of molars and premolars or at least one occlusion of canines and incisors on either side	N = 14 12.27 +/- 2.52	N = 27 11.53 +/- 1.83	N = 41 11.79 +/-2.09
Total	N=59 11.27 +/-2.64	N=61 12.01 +/-2.45	N=120 11.65 +/- 2.56

Table 2: The inferior distance amongst the sexes and population groups measured in mm

Sex → Population groups ↓	Female	Male	Total
Black	N = 30 11.40 +/- 2. 58	N = 26 11.87 +/- 2.6	N = 56 11.62 +/- 2. 58
White	N = 29 11.13 +/- 2.74	N = 35 12.12 +/- 2.36	N = 64 11.67 +/- 2.57
Total	N=59 11.27 +/- 2.64	N=61 12.01 +/- 2.45	N=120 11.65 +/- 2.56

Table 3: The inferior distance amongst the dentition patterns and population groups measured in mm

Population groups → Dentition pattern ↓	Black	White	Total
0 edentulous	N = 13 11.45 (2.64)	N = 27 12.04 (3.3)	N = 40 11.85 (3.08)
1 fewer than two occlusions of molars or premolars and fewer than one occlusion of canines or incisors on either side	N = 19 11.58 (2.82)	N = 20 11.01 (2.08)	N = 39 11.29 (2.45)
2 at least two occlusions of molars and premolars or at least one occlusion of canines and incisors on either side	N = 24 11.74 (2.49)	N = 17 11.85 (1.52)	N = 41 11.79 (2.09)
Total	N=56 11.62 (2.58)	N=64 11.67 (2.57)	N=120 11.65 (2.56)

Table 4: The superior distance amongst the sexes and dentition patterns measured in mm

Sex → Dentition pattern ↓	Female	Male	Total
0 edentulous	N = 20 6.02 +/-4.88	N = 20 8.18 +/-5.06	N = 40 7.10 +/- 5.03
1 fewer than two occlusions of molars or premolars and fewer than one occlusion of canines or incisors on either side	N = 25 9.39 +/- 3.45	N = 14 11.28 +/- 5.30	N = 39 10.05 +/- 4.23
2 at least two occlusions of molars and premolars or at least one occlusion of canines and incisors on either side	N = 14 9.22 +/- 2.85	N = 27 12.17 +/- 4.14	N = 41 11.16 +/- 3.98
Total	N=59 8.21 +/- 4.13	N=61 10.65 +/- 4.98	N=120 9.45 +/- 4.72

Table 5: The superior distance amongst the sexes and population groups measured in mm

Sex → Population groups ↓	Female	Male	Total
Black	N = 30 9.09 +/- 3.78	N = 26 10.99 +/- 4.65	N = 56 9.97 +/- 4.27
White	N = 29 7.30 +/- 4.35	N = 35 10.4 +/- 5.27	N = 64 8.99 +/- 5.08
Total	N=59 8.20 +/- 4.13	N=61 10.65 +/- 4.98	N=120 9.45 +/- 4.72

Table 6: The superior distance amongst the dentition patterns and population groups measured in mm

Populations → Dentition pattern ↓	Black	White	Total
0 edentulous	N = 13 8.45 +/- 4.37	N = 27 6.46 +/- 5.27	N = 40 7.10 +/- 5.03
1 fewer than two occlusions of molars or premolars and fewer than one occlusion of canines or incisors on either side	N = 19 9.17 +/- 4.18	N = 20 10.89 +/- 4.22	N = 39 10.05 +/- 4.23
2 at least two occlusions of molars and premolars or at least one occlusion of canines and incisors on either side	N = 24 11.43 +/- 4.00	N = 17 10.79 +/- 4.04	N = 41 11.16 +/- 3.98
Total	N=56 9.97 +/- 4.27	N=64 8.99 +/- 5.08	N=120 9.45 +/- 4.72

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