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Original Research Article

Positional Anatomy of the Mandibular Foramen and Canal: A Scan Study in the Melanoderma Living in Bénin

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ABSTRACT

Background: The mandibular canal is an intrabone sheltering the inferior alveolar nerve, and the mandibular foramen serves as a site for performing nerve block. Their positions vary according to populations and ages.

Objectives: Determine through a scan study the position of the mandibular canal and its foramen in the melanoderma living in Benin.

Methods: A retrospective, descriptive and analytical study was conducted over two years based on the exploitation of 60 digital files of facial scans. The determination of the position of the canal and the mandibular foramen was made from measurements of distances separating the canal from certain points of reference on the mandible.

Results: The mandibular foramen, the position of which varies according to age, was situated in children under 10 years of age, in the vicinity of the union of the preceding third and lower half; between 10 and 20 years, it would be around the meeting of the 2/3 before and the lower half then around the 2/3 before and 2/3 below the mandibular ramus. Compared to the alveolar ridges, the mandibular canal was closer to the root of the third molar than it is to the other molars. It appeared more lateral at the level of the second and third molars.

Conclusion: The position of the mandibular foramen and canal varies according to age in the beninese population. A preoperative CT (computed tomography) scan is desirable to avoid iatrogenic lesions to the inferior alveolar nerve.

KEY WORDS: Canal, Foramen, Mandibular, Position, Beninese melanoderma.

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INTRODUCTION

The mandibular canal (MC) is an intrabone tunnel that transmits the lower alveolar neurovascularization. The anatomical points of reference of this canal and its foramen are known for their positional variations according to ages and populations, with implications in the approaches and results of orthognathic surgery [1, 2]. The appearance of the third mandibular molars or wisdom teeth is usually a source of pain for some individuals and in the majority of cases, its nursing is based on the surgical removal of these teeth. The intimacy of anatomical relations between the roots of the wisdom teeth and the mandibular canal (MC) sheltering the lower alveolar

nerve is a difficulty for the dental surgeon during the extraction. The proximal opening of the mandibular canal (MC) or the mandibular foramen (MF) through which the lower alveolar nerve enters, serves as a common site for the administration of the mandibular nerve blocks. The pitfalls and failures in the practice of this nerve block range from 15% to 25% [3,4], and remain partly due to the absence of fixed points of reference and anatomical variations. The aim of this work was to determine through a CT scan study the position of the mandibular canal and its foramen in relation to the accurate points of reference of the mandibular bone in the melanoderma living in Benin.

MATERIALS AND METHODS

A retrospective, descriptive and analytical study over two years (January 2019 to December 2021) was conducted jointly in the anatomy laboratory and the National Hospital and University Centre of Cotonou (Benin) medical imaging department. The study material consisted of digital files of facial scans with no mandibular lesions. The position of the mandibular canal and foramen was determined from measurements of distances separating the canal from certain points of reference on the mandible. Three examiners made the measurements; the measure retained was the average sum of the three values. The measurement was compared (right and left) in the three slice planes with the DICOM 2021 RadiAnt software. For the mandibular foramen position analysis, points of reference have been identified and marked with a ruler in the software, and measurements are shown in figure 1. Determining the mandibular canal's position in its path used measurements of distances between the canal and the edges of the mandible at the reference points located in the extension of the dental faces on the canal (figure 2). At each of these points, the measured distances are shown in figure 3.

The statistical analysis of the data was done with the R software; the quantitative variations were expressed as an average plus or minus standard deviation. The averages or medians were compared using parametric and non-parametric tests. Comparison tests carried out the correlation between two qualitative variables with a significance level p lower than 0.05. The ethical considerations in force were scrupulously respected.

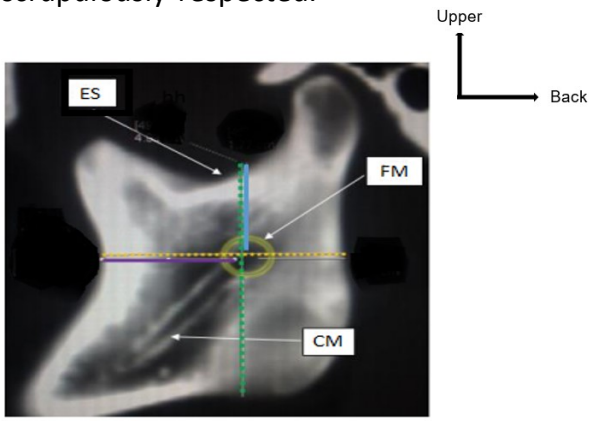

Fig. 1: Sagittal section of the left mandibular ramus showing the mandibular foramen, the mandibular canal and the sigmoid notch.

SN: Sigmoid notch, **MC:** Mandibular canal, **MF:** Mandibular foramen

In blue: The distance from the deepest point of the sigmoid notch to the upper edge of the mandibular foramen (A)

In purple: The distance from the anterior edge of the mandibular ramus to the anterior edge of the mandibular foramen (B)

In yellow dotted lines: The width of the mandibular ramus at the height of the MF (C)

Green dotted lines: The height of the mandibular ramus through the MF and the deepest point of the SN (D).

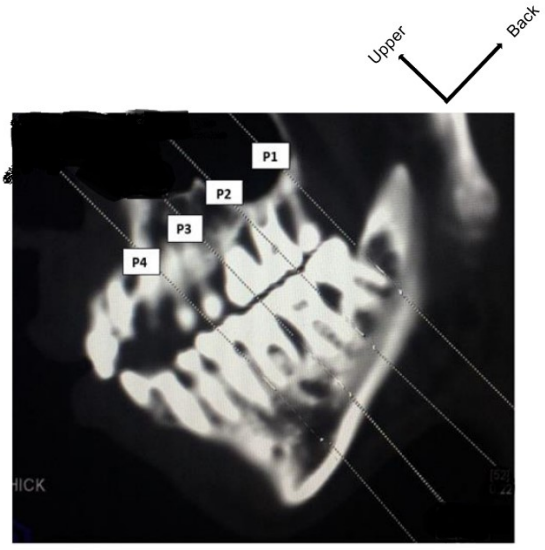

Fig. 2: Left sagittal scan showing the points of reference of the measurements made on the mandibular canal.

P1: point of the mandibular canal located on the tangent to the distal surface at the 3rd molar.

P2: point of the mandibular canal located on the tangent to the mesial surface of the 3rd molar.

P3: point in the mandibular canal located on the tangent to the mesial surface of the 2nd molar.

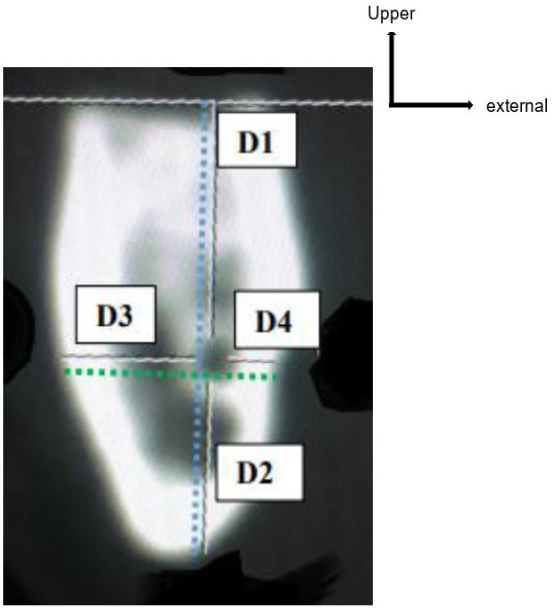

Fig. 3: Coronal scan of the mandibular body showing measurements taken to locate the position of the mandibular canal.

D1: distance from the mandibular canal to the upper edge of the alveolar ridge
D2: distance from the mandibular canal to the lower edge of the mandible
D3: distance from the mandibular canal to the external mouth plate
D4: distance from the mandibular canal to the external lingual plate
Blue dotted lines (E): vertical height of the mandibular body
Green dotted lines (F): horizontal width of the mandibular body

RESULTS

General data: Of the 60 digital files of facial scanners, 29 belonged to female individuals. The average age of the individuals was 39.0 ± 21.8 years, with extremes of 7 and 86 years.

Data on the topography of the mandibular foramen: The mandibular foramen (MF) was located at an average distance of 1.906 ±0.400 cm and 2.361 ±0.858 cm, respectively from the sigmoid notch and the anterior edge of the mandibular ramus (table 1). Furthermore, considering the ratios of the average distances A/D and B/C, the foramen was located globally at the union of the anterior 2/3 and inferior 2/3 of the mandibular ramus. Neither side nor gender had a statistically significant influence on the position of the foramen (p >0.05) on the mandibular ramus.

Age is the factor that statistically influenced the position of the foramen in our study. The different distance ratios in table 2 show the following: in children under 10 years of age, the foramen was located around the union of the anterior third and the inferior half; between 10 and 20 years of age, it would be around the union of the anterior 2/3 and the inferior half and then around the anterior 2/3 and the inferior 2/3 of the mandibular ramus.

Data on the topography of the mandibular canal:

Compared to the alveolar ridges, the mandibular canal (MC) was closer to the third molar's root than the other molars. It appeared more lateral in the second and third molars (table 3). These positional findings of the canal were influenced neither by side nor gender.

Like the mandibular foramen's position, the canal's position was also influenced by age. According to statistics, the distance between the canal and the third molar decreases significantly with age (table 4).

Table 1: Distribution of the average measurements of the mandibular foramen according to the sides.

	Right	Left	Average of both sides	p-value
A	1,902 ±0,390	1,911 ±0,413	1,906 ±0,400	>0,9
B	2,342 ±0,746	2,380 ±0,963	2,361 ±0,858	0,9
C	3,542 ±0,685	3,506 ±0,683	3,524 ±0,681	0,8
D	3,189 ±0,614	3,076 ±0,571	3,133 ±0,593	0,5

Table 2: Distribution of the mandibular foramen's averages of distances – points of reference, according to age group.

	A	B	C	D
0 -9	1,255 ±0,283	1,665 ±0,387	3,385 ±0,445	2,717 ±0,286
10 – 19	1,758 ±0,384	2,441 ±1,237	3,485 ±0,613	3,175 ±0,729
20 – 29	1,901 ±0,374	2,442 ±0,566	3,491 ±0,802	3,130 ±0,339
30 – 39	1,778 ±0,217	2,114 ±0,483	3,584 ±0,672	3,134 ±0,551
40 – 49	2,066 ±0,295	2,830 ±0,888	3,561 ±0,63	3,114 ±0,361
50 – 69	1,870 ±0,400	2,037 ±0,856	3,471 ±0,577	2,669 ±0,898
70 – 79	2,441 ±0,477	2,585 ±0,419	4,093 ±0,688	3,545 ±0,260
≥ 80	1,956 ±0,230	2,089 ±0,935	3,046 ±0,661	3,483 ±0,499
p-value	<0.001	0.02	0.12	0.001

Table 3: distribution of the averages of distances between the mandibular canal and the edges of the mandible at different points of reference.

	Sample	Right	Left	p-value
D1 in P1	0,633 ±0,250	0,637 ±0,258	0,629 ±0,244	>0,9
D1 in P2	0,591 ±0,209	0,591 ±0,213	0,590 ±0,208	>0,9
D1 in P3	0,625 ±0,237	0,626 ±0,241	0,623 ±0,234	>0,9
D1 in P4	0,662 ±0,228	0,660 ±0,231	0,664 ±0,226	0,9
D2 in P1	1 ±0,363	1,002 ±0,352	0,998 ±0,375	0,8
D2 in P2	0,973 ±0,323	0,985 ±0,313	0,962 ±0,334	0,7
D2 in P3	0,941 ±0,308	0,943 ±0,305	0,938 ±0,313	0,9
D2 in P4	0,896 ±0,381	0,893 ±0,388	0,898 ±0,377	>0,9
D3 in P1	0,433 ±0,271	0,441 ±0,306	0,425 ±0,234	0,9
D3 in P2	0,405 ±0,208	0,403 ±0,210	0,407 ±0,207	>0,9
D3 in P3	0,41 ±0,251	0,409 ±0,245	0,410 ±0,259	0,8
D3 in P4	0,376 ±0,241	0,373 ±0,233	0,380 ±0,250	>0,9
D4 in P1	0,339 ±0,440	0,305 ±0,521	0,372 ±0,341	0,5
D4 in P2	0,362 ±0,313	0,361 ±0,315	0,364 ±0,313	>0,9
D4 in P3	0,399 ±0,398	0,400 ±0,402	0,398 ±0,397	>0,9
D4 in P4	1,7 ±12,932	2,855 ±18,278	0,544 ±0,726	>0,9

Table 4: distribution of the averages of distances between the mandibular canal and the edges of the mandible at different points of reference, according to age group.

	0 - 9	10 - 19	20 - 29	30 - 39	40 - 49	50 - 69	70 - 79	≥ 80	p-value
D1 in P1	0,962± 0,414	0,635 ±0,226	0,635 ±0,177)	0,759 ±0,287	0,741 ±0,240)	0,509 ±0,129	0,415 ±0,059	0,416 ±0,146	<0,001
D1 in P2	1,004±0,018	0,620 ±0,230	0,673 ±0,158)	0,653 ±0,184	0,599 ±0,185)	0,514 ±0,163	0,392 ±0,028	0,359 ±0,064	<0,001
D1 in P3	0,968 ±0,061	0,632 ±0,269	0,691 ±0,195)	0,689 ±0,199	0,651 ±0,247)	0,620 ±0,232	0,370 ±0,055	0,421 ±0,074	<0,001
D1 in P4	0,777 ±0,098	0,644 ±0,248	0,715 ±0,160)	0,719 ±0,202	0,709 ±0,236)	0,689 ±0,288	0,483 ±0,210	0,488 ±0,145	0,001
D2 in P1	0,677 ±0,385	0,893 ±0,300	1,163 ±0,324)	0,969 ±0,335	1,096 ±0,390)	1,066 ±0,536	0,891 ±0,255	0,931 ±0,196	0,14
D2 in P2	0,756 ±0,340	0,856 ±0,245	1,168 ±0,303)	0,971 ±0,348	1,066 ±0,250)	1,068 ±0,466	0,823 ±0,209	0,767 ±0,127	<0,001
D2 in P3	0,594 ±0,252	0,869 ±0,297	1,109 ±0,333)	0,949 ±0,257	1,093 ±0,314)	0,894 ±0,342	0,763 ±0,135	0,820 ±0,150	0,001
D2 in P4	0,510 ±0,221	0,763 ±0,436	1,058 ±0,387)	0,971 ±0,326	0,965 ±0,397)	0,969 ±0,376	0,719 ±0,085	0,803 ±0,356	0,007
D3 in P1	0,691 ±0,438	0,564 ±0,330	0,338 ±0,078)	0,368 ±0,168	0,540 ±0,383)	0,322 ±0,115	0,424 ±0,261	0,308 ±0,144	0,007
D3 in P2	0,710 ±0,410	0,564 ±0,259	0,350 ±0,072)	0,380 ±0,118	0,446 ±0,196)	0,335 ±0,147	0,313 ±0,153	0,200 ±0,054	<0,001
D3 in P3	0,687 ±0,448	0,580 ±0,349	0,372 ±0,085)	0,427 ±0,169	0,460 ±0,276)	0,282 ±0,126	0,253 ±0,059	0,199 ±0,065	<0,001
D3 in P4	0,643 ±0,495	0,478 ±0,326	0,359 ±0,108)	0,381 ±0,153	0,423 ±0,319)	0,278 ±0,141	0,248 ±0,062	0,245 ±0,020	0,008
D4 in P1	0,513 ±0,346	0,362 ±0,865	0,364 ±0,266)	0,232 ±0,194	0,412 ±0,385)	0,405 ±0,318	0,233 ±0,026	0,245 ±0,021	0,001
D4 in P2	0,519 ±0,275	0,447 ±0,343	0,439 ±0,465)	0,373 ±0,232	0,418 ±0,353)	0,231 ±0,103	0,187 ±0,033	0,190±0,018	<0,001
D4 in P3	0,491 ±0,249	0,565 ±0,596	0,489 ±0,527)	0,333 ±0,191	0,457 ±0,393)	0,285 ±0,142	0,184 ±0,057	0,202 ±0,058	<0,001
D4 in P4	0,492 ±0,252	0,562 ±0,652	0,693 ±0,757)	0,676 ±1,020	0,632 ±0,640)	0,289 ±0,175	14,351 ±44,851	0,206 ±0,082	<0,001

COMMENTS

The choice of the indirect CT scan method for this study is justified on the one hand by the absence of anatomical subjects and dry mandibular specimens in our anatomy laboratory, and on the other hand by the advantages in terms of accuracy and safety that CT scan offers in comparison to standard radiography.

The study of the anatomy of the MF and the MC has aroused the curiosity of a number of researchers and has led to a variety of edifying conclusions that can be compared with the results of this study.

The distance between the MF and the sigmoid notch on the one hand and the anterior edge of the mandibular ramus on the other hand has been commonly used to locate the MF.

The average distance between the MF and the sigmoid notch, which was 1.906 ±0.400 cm, varies from one study to another and from one region to another; in Turkey, Von Arx and Lozanoff put it at 1.41 ±2.52 cm [5]. The differences in values found are attributable to the materials used in these different studies, which consist of dry skulls or orthopantomograms [6, 7]. The common denominator of the studies with ours was the absence of statistically significant variations neither with sex nor with side. The only determining factor in the change of the MF's position in the vertical direction was age (p=0.056). In this work, the average distances between the MF and the notch increased overall with age (p<0.001) so much that our results are in line with the concept that the mandibular foramen has previously been described as occupying a low position with increasing age, with children having the mandibular foramen above the occlusal plane, adolescents at the occlusal plane and adults below the occlusal plane [8]. This is therefore an anatomical reality that justifies the adaptation of the level of the mandibular ramus cuts to age in osteotomies.

Compared to the anterior edge of the mandibular ramus, the average distances were 2.361 ±0.858 cm; 1.90 ±0.41 cm; 1.86 ± 0.24 cm in our work and those of Yoshioka and Kilic [7 9,] respectively. There is a statistically significant correlation between the increase in this pre-foraminal distance and the one in age-related to the anterior remodeling of the bone. As the MF is located in the vicinity of a repeated point at the 2/3 anterior -1/3 posterior union, our results are in line with those of Trost, who suggests that the sector located in the posterior-superior third of the mandibular ramus is the zone free of all pitfalls and complications in surgical procedures as it guarantees the eviction of the lower alveolar vacuole-nervous bundle from the entrance of the MF [8].

The mandibular canal was the closest to the distal alveolar ridge of the third molar. It then gradually moved away from the alveolar ridge as it approached the mesial margin of the first molar. Bokindo and Coll. [10] reported the proximity of the mandibular canal to the root tips of the third molars, the impacted teeth having the shortest distance. The progressive decrease in distance was observed in the different age groups, with differences at P4 (mesial to the first molar) being statistically significant (p = 0.024). This high location of the mandibular canal in the posterior region should be considered when performing dental procedures such as dental de-impaction. Analysis of the results indicated that the mandibular canal descends from the distal to the third molar and reaches its lowest point at the mesial margin of the same tooth before ascending to the mesial of the first molar.

It has moved from its lingual entry point in the mandibular ramus to a more buccal position distal to the third molar. It then crossed lingually from distal to mesial of the third molar, and then changed its course to cross buccally as it approached the mesial side of the first molar. These changes in mandibular canal position were observed in all age groups. The MC has previously been observed to lie closer to the lingual surface of the mandible in the posterior part of the mandibular body, and gradually becomes more superficial to the buccal surface of the mandible where it terminates in the mental foramen [11,12].

In the current study, the MC showed the same pattern by gradually moving away from the

lingual plate and being furthest from it mesially, in comparision to the first molar near its termination. The average distance between the four points was 0.455 cm. This value is in the range of 0.210 to 0.580 cm, as reported in the review of von Arx and Lozanoff [5]. Ozturk and coll. [13] reported that the bucco-lingual location of the canal becomes more important when the vertical dimension of the ridge is impeded due to bone resorption.

In short, based on our measurements, horizontally, the mandibular canal crosses the distal side of the third molar and then changes its trajectory to go laterally to the mesial side of the first molar. This forms an S-shaped curve. Vertically, the canal displays a cartenal curve with the lowest point at the third molar's mesial edge.

CONCLUSION

In the Beninese population, the mandibular foramen and canal occupy variable positions in the mandible. The area of the posterior-superior third is the safe zone to avoid lesions to the inferior alveolar nerve. The safest place for the placement of cuts in ascending branch osteotomies is the second molar region due to the thickness of the buccal cortex.

A preoperative CT scan is suggested to avoid iatrogenic lesions to the inferior alveolar neurovascular bundle during surgical procedures involving the mandible.

Conflicts of Interests: None

Author Contributions

Laleye Christel Marie, Sogan Ananivi, Murhabazi Emmanuel Mulume made substantial contributions in conception and design of the work, analysed the results, have been involved in drafting the manuscript, revised critically for important intellectual content, and have given final approval of the manuscript version to be published.

Toni Kochami Wilfried, Houmenou Yahouédéou Espérance contributed in the conception and design of the work and acquisition of data.

Hounnou Martial Gervais, Agossou - Voyeme Augustin Karl have revised critically for important intellectual content, and have given final approval of the manuscript version to be published.

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