CURRICULUM VITAE

I. NAME

Elizabeth Marie Alston Ottey
ealston@umaryland.edu

II. EDUCATION

University of Maryland School of Dentistry
Baltimore, MD
Certificate in Orthodontics and Master of Science in Biomedical Sciences, Expected Graduation May 2020
University of Maryland School of Dentistry
Baltimore, MD

Doctor of Dental Surgery, May 2017
Meharry Medical College
Nashville, TN

Bachelor of Arts in Biology, May 2010
University of North Carolina at Charlotte
Charlotte, NC

III. PROFESSIONAL EXPERIENCE

Research
University of Maryland School of Dentistry Department of Orthodontics
Baltimore, MD
Variation in Accessory Branches of the Mylohyoid Nerve in the Posterior Mandible: An Anatomic Study
March 2018- Present

Research
Meharry Medical College School of Dentistry
Nashville, TN
Xerostomia in the African American Compared to Other Ethnicities and its Effects on Dental Health: A Pilot Study. Administered patient survey's and collected saliva samples
June 2015- May 2017

Case Report Paper Co-Author
University of Maryland School of Dentistry Department of Orthodontics
Baltimore, MD
Orthodontic Retreatment Minimizing Financial Resources
October 2019

Professional Conferences
AAO, MASO, MSSO
Aug 2017- Present

Office Visit
Harmon Orthodontics
Mitchellville, MD
April 2018, Oct 2019

Office Visit
Maryland Orthodontic Specialist
Catonsville, MD
Sept 2018

Andrew's Six Elements by Tim Tremont
Charleston, SC
Learned the Andrew's Six Elements and Surgical planning
Oct 2018

Orthodontic Program Visit
Howard University Department of Orthodontics
District of Columbia, VA
March 2016

IV. PROFESSIONAL MEMBERSHIP

American Association of Orthodontists
Fall 2017- Present
Middle Atlantic Society of Orthodontists
Fall 2017- Present
American Dental Association
Fall 2017- Present
Omicron Kappa Upsilon National Honor Society
Spring 2017- Present

V. HONORS & AWARDS

Dean's List
Meharry Medical College School of Dentistry
Aug 2013- May 2017

VI. COMMUNITY ACTIVITIES

Unified Efforts Inc- Mentor
July 2018- Present

Abstract

Title of Thesis: Variation in Accessory Branches of the Mylohyoid Nerve in the Posterior Mandible: An Anatomic Study

Candidate: Elizabeth Marie Alston Ottey, Master of Biomedical Science, 2020

Thesis Directed by: Dr. Maureen Stone, Professor, Department of Neural and Pain Sciences, Department of Orthodontics and Pediatrics

The purpose of the present study was to examine the courses and branching patterns of the mylohyoid nerve in adult cadavers in order to determine if there are accessory branches, which insert on the posterior mandible. 25 cadavers preserved in 10% formalin were dissected in the gross anatomy dissection lab at the University of Maryland. The mylohyoid and any varying branches were dissected and preserved as far as possible. The dissected cadaver's data sets were analyzed using Image J software. 12 out 25 (48%) cadavers had at least one accessory branch present that attached to the posterior mandible. The accessory branch identified was located an average of 2.3 cm from the posterior mandible. Accessory branches of the mylohyoid exist in the posterior mandible. Our next step is testing the identified branches to confirm if they are nerve fibers.

Variation in Accessory Branches of the Mylohyoid Nerve in the Posterior Mandible: An Anatomic Study

by
Elizabeth Marie Alston Ottey

Thesis submitted to the faculty of the Graduate School of the
University of Maryland, Baltimore in partial fulfillment
of the requirements for the degree of
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2020

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Table of Contents

List of Tables

List of Figures

1. Introduction and Literature Review

Many dental clinicians have noted anesthetic failures in mandibular molars after administering an inferior alveolar nerve block. This may be due to the various neural branching patterns of the involved nerves. Anatomical variations such as length, location, and number can all affect proper anesthesia. The nerve responsible for the sensation and perception of pain in the mandible is the trigeminal nerve. The trigeminal nerve is the fifth cranial nerve (CNV) and the largest among all 12 cranial nerves. It has three divisions as follows: opthalmic (V1), maxillary (V2), and mandibular (V3). Sensory innervation to the head and neck is primarily provided by the Trigeminal nerve (Huff, 2018). However, a very minor portion of the nerve contributes to motor function innervating fibers responsible for mastication also known as the muscles of mastication. Therefore, the trigeminal nerve is identified as a mixed nerve (Basit, 2019). The division in which is of particular interest for this study is the mandibular branch V3.

The mandibular nerve is the largest of the three branches of the trigeminal nerve. The mandibular nerve contains sensory and motor axons. Once the mandibular branch has emerged from the cranium it passes through the infratemporal fossa branching in to four tributaries, Auriculotemporal, Buccal, Inferior Alveolar, and Lingual nerves (DeSantis, 1996). The inferior alveolar nerve is a branch of the posterior division of the mandibular nerve. Before traversing the mandibular foramen, it first gives rise to the nerve to the mylohyoid (MN), a motor nerve supplying the mylohyoid and the anterior belly of the digastric muscles (see Figure1, DeSantis, 1996). The remaining sensory fibers enter the mandibular canal, a tunnel running through the mandible bone. Within in the canal these fibers give rise to branches that innervate the mandibular teeth. The nerve emerges through the mental foramen as the mental nerve providing sensory innervation to the lower lip and chin (DeSantis, 1996). It has been suggested that accessory branches from the mylohyoid nerve (MN) may contribute to sensory innervation of the posterior mandibular teeth. However, such branches have not previously been identified and that is what we are going to do.

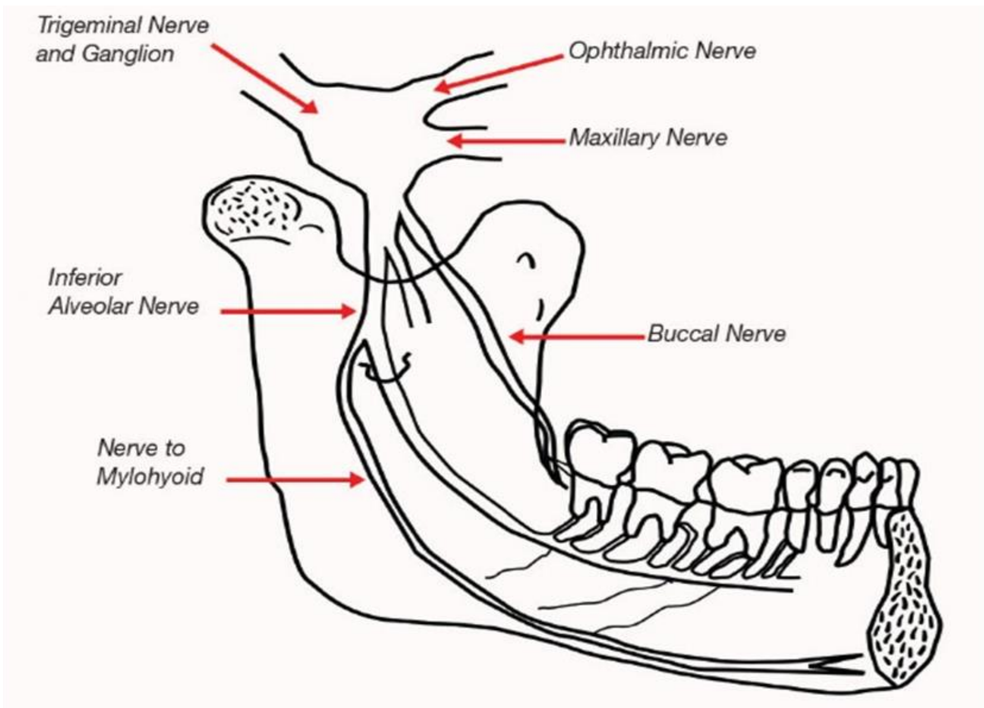

Figure 1: Illustration of the Interior border of the mandible and associated nerves

Expression of the dual role of the MN has been evidenced by micro-dissection studies of the diameters of the neurons composing the nerve with results of one study indicating the presence of both motor and sensory neurons (Frommer, 1972). Because of this afferent innervation, a conventional inferior alveolar block may be ineffective in achieving mandibular anesthesia of the posterior teeth. Studies have shown that the MN is often implicated in unsuccessful anesthesia of the first mandibular molar (Altug, 2012).

In a study conducted by Sillanpää and coworkers a local anesthetic solution was injected (1.8 milliliters of 3 percent prilocaine with felypressin) into the area directly below the mylohyoid muscle, posterior to the distal root of the first molar, inducing partial anesthesia of that tooth in 21 percent of the subjects tested (Sillanpää, 1988).

Variant branching patterns of the mandibular nerve are of great clinical importance since these variations may cause failure to obtain adequate local anesthesia in oral and dental procedures. Wilson and colleagues found that the mylohyoid nerve branched an average of 14.7 millimeters from the entry of the inferior alveolar nerve into the mandibular canal (Wilson, 1984). This distance could be beyond the area of diffusion of the deposited anesthetic in a conventional mandibular block, thus allowing any accessory nervous supply to continue to transmit pain signals. These authors also presented evidence of a traceable continuation of branches of the mylohyoid nerve into small foramina located on the anterior lingual aspect of the mandible. Sixteen of the 37 cadavers (43 percent) studied had this anatomical distinction, indicating entry of the nerve’s fibers into the mandible (Wilson, 1984). Pulpal innervation of mandibular anterior teeth was also demonstrated to be provided by the mylohyoid nerve in a few studies (Sutton, 1974 and Hwang, 2005).

Madeira and colleagues demonstrated that 13 of 26 (50%) cadavers studied possessed a supplementary branch of the mylohyoid nerve. With the aid of a dissecting microscope, they showed contiguity of the nerve with both the incisor teeth and gingivae, or the incisive nerve proper (Madeira, 1978). The evidence presented demonstrates that an accessory innervation of the mandibular teeth by the mylohyoid nerve may exist. This should lead the clinician to evaluate the possible role of this type of innervation in patients who report pain during dental surgery after receiving a conventional mandibular block. The purpose of the present study is to examine the courses and branching patterns of the mylohyoid nerve in adult cadavers in order to determine if there are accessory branches which insert on the posterior mandible that may contribute to sensory innervation of the posterior teeth.

2. Materials and Methods

25 cadavers (14 females and 11 males) preserved in 10% formalin were dissected in the gross anatomy dissection lab of the Medical School at University of Maryland Baltimore. A scalpel was used to make an incision lateral to the tongue to remove its connecting fibers from the mandible. Another incision was made on the alveolar ridge. Connective tissue was reflected down to the body of the ramus. The mylohyoid and medial pterygoid muscles were carefully removed from the inferior border, and angle of the mandible respectively. The dissection exposed the emergence of the mylohyoid nerve free from surrounding tissue so that its course through the mylohyoid groove could be observed. The mylohyoid and any varying branches were dissected and preserved as far as possible. The mylohyoid nerve was also traced back to its origin above the lingula reflecting all surrounding tissue. The ascending ramus was then sectioned about mid-ramus with a striker. Lack of measurability due distortion, dryness, and other reasons, 13 cadavers could not be used in the study. The 12 dissectible mandibles were removed from the head and placed on a table. This allowed for the mandible to be examined closer for further documentation.

<u>Measuring:</u>

A ruler was placed on a white piece of paper with the cadaver table number in the corner to measure the length of the mandible. Each sectioned mandible was placed above the ruler with the centimeter side facing the inferior border of the mandible. Pictures were taken of the internal and external sides of the mandible with an iPhone X. This was repeated for each side whenever present.

Software Analysis: Image J

Each hemi-mandible was saved as a Jpeg image and imported into Image J software. Seven points were extracted from each hemi-mandible picture (see Figure 2) in the following order:

Internal mandibular surface
Point 1: 0 cm on the ruler
Point 2: 1 cm on the ruler
Point 3: Most anterior point
Point 4: Most posterior point
Point 5: Point of divergence of the accessory branch
Point 6: inner most superior edge of the accessory branch
Point 7: inner most inferior edge of the continuation of the mylohyoid nerve

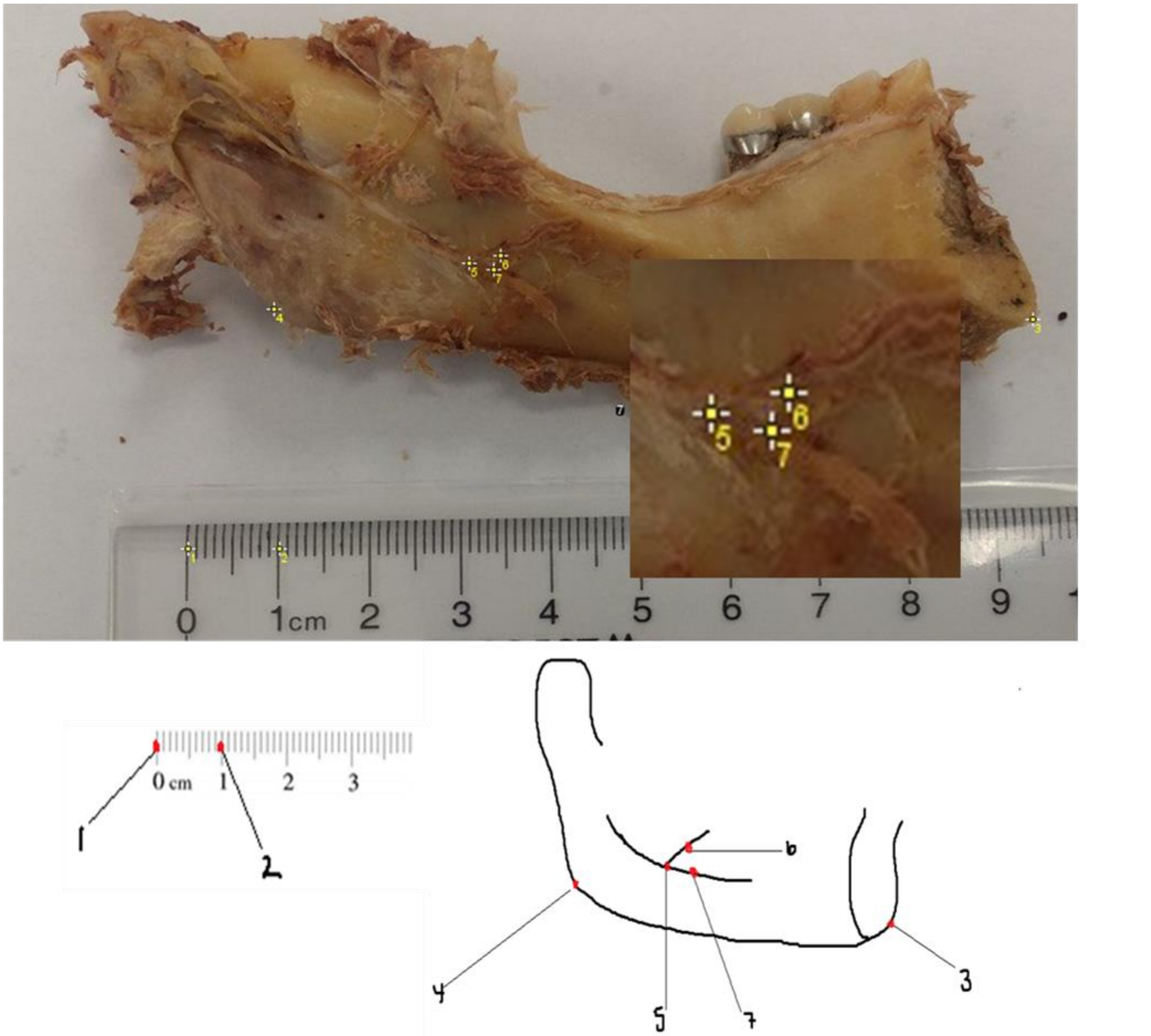

Figure 2: Inner mandible with all the identified points 1-7 used to determine the length, accessory branch point and angle of divergence of the accessory branch

The multipoint feature (Figure 3) was selected and each point was selected.

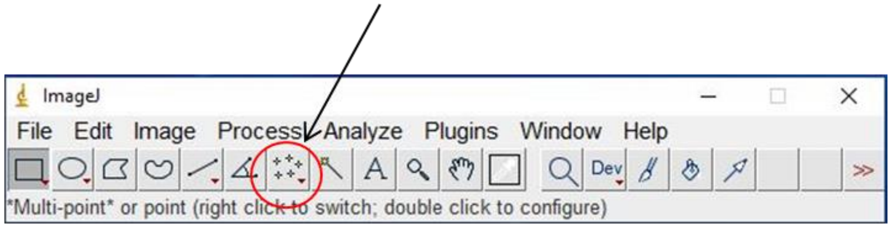

Figure 3: Multi-point feature in the Image J software

After each point was noted the analyze tab was selected and from the drop down the measure feature (see Figure 4) was selected and it displayed X and Y coordinates (see Table 1)

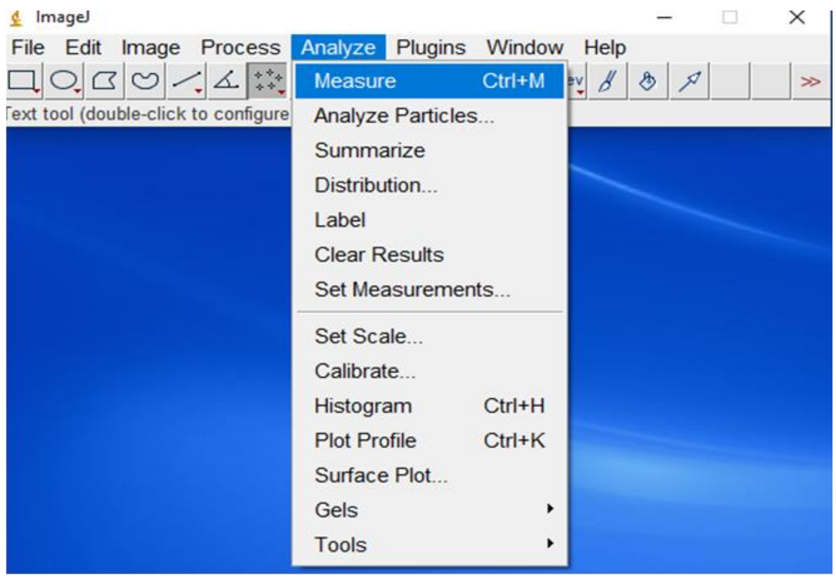

Figure 4: Analyze and Measure feature in Image J software used to generate the x and y values for each picture

Table 1: Example of X and Y values for points 1-7 on each image

Results

File Edit Font Results

Label	X	Y
33LI.jpg	307.000	520.000
33LI.jpg	374.000	520.000
33LI.jpg	926.667	340.000
33LI.jpg	370.000	332.333
33LI.jpg	513.667	296.333
33LI.jpg	536.333	290.333
33LI.jpg	531.000	301.667

<u>Calculating length and divergence point:</u>

To calculate the length of the mandible and the distance where the accessory branch diverged (if any), seven points were identified in Image J (Figure 2). The x and y values of the points were transferred into an excel sheet (Table 2). Points 1 and 2 (zero and one cm on the ruler) were used to calibrate the scale of each hemi-mandible as follows. Image J provided the number of pixels between points 1 and 2 (see Table 2). The Pythagorean theorem was used to calculate this 1 cm distance in pixels. The pixel-length distances between the hemi-mandible measurements were divided by this value, converting them to cm.

Table 2: Excel file showing calculations for one subject cadaver 21

Point No.	Point Name	x value	y value	Distance value (pixels)	Distance value (cm)	Name of calculation		
Point 1:	0 cm on the ruler	260	602	61	1	1 cm scale multiplier (1-2)		
Point 2:	1 cm on the ruler	374	520					
Point 3:	Most anterior point	817	494	536	8.7	jaw length (3 to 5) anterior to posterior		
Point 4:	Most posterior point	281	513	182	3	post jaw to divergence (4 to 5)		
Point 5:	Point of divergence of the accessory branch	459	474					
Point 6:	Inner most superior edge of the accessory branch	467	463					
Point 7:	Inner most inferior edge of the continuation of the mylohyoid nerve	478	479					

The Pythagorean equation was also used to determine the length of the mandible. Point 3 represented the most anterior point of the mandible. Point 4 represented the most posterior point of the mandible. The distance between the posterior mandible and the point where the accessory branch diverged, point 5, was also calculated using the Pythagorean equation. Once the distances were calculated, they were converted to cm, as mentioned above, for each picture individually. Point six represented the inner most superior edge of the accessory branch and point seven represented the inner most inferior edge continuation of the mylohyoid nerve. These two points were not used in this thesis, because the angle was not considered crucial to this study. Observation shows that all were acute angles. These data were collected for use in the future if this information should be needed.

3. Results

Twenty- five cadavers were dissected for the current study; a total of fifty hemi-mandibles (hm) were available from the gross dissection lab. Of the 50 hm, 10 hm were not dissectible due to various reasons such as being dried out, ripped from the mandible, and not cut appropriately. Of the forty hemi-mandibles available for dissection only fourteen had one accessory nerve branch that attached to the mandible, 2 had branches present on the left and right sides, and 23 had no accessory nerve branches.

Of the twenty-five cadavers 14 were women and 6 (43%) had the nerve present on one side. Eleven were men and 6 (55%) had the nerve present on at least one side; two of them had it on both sides. The average age was 80 years old (SD= 12.8) see Table: 3.

Table 3: Hemi-mandibles with at least one Accessory Nerve Branch

Cadaver #	Hemi Mand #	Left	Right	M/F	Age
1	1	1*	0	F	95
2	2	1	-	M	49
3	3	0	0	F	85
4	4	1	1	F	100
5	5	0	1	M	68
6	6	0	0	F	89
7	7	0	-	M	93
8	8	0	-	F	71
9	9	0	-	M	62
10	10	0	0	F	87
11	11	1	-	F	98
12	12	0	0	F	79
13	13	0	0	M	60
14	14 & 15	1	1	M	78
15	16	0	-	F	88
16	17	0	0	F	72
17	18 & 19	1	1	M	75
18	20	0	-	F	91
19	21	1	0	F	67
20	22	1	-	M	67
21	23	1	0	F	87
22	24	0	0	M	88
23	25	-	0	M	79
24	26	1	0	F	83
25	27	1	-	M	81

* present (1), not present (0), not dissected (-)

The average accessory branch location along the mandible was on average 2.3 cm from the posterior border (Figure 5). The shortest distance was 1.4 cm, and the longest was 3.0 cm. The average percentage the mylohyoid accessory nerve branched along the mandible was 26% (Figure 6). In the present study many of the cadavers have visual accessory branches accompanied by blood vessels (see Figure 7). However, 23 hemi- mandibles did not have any accessory branches identified (see Figure 8).

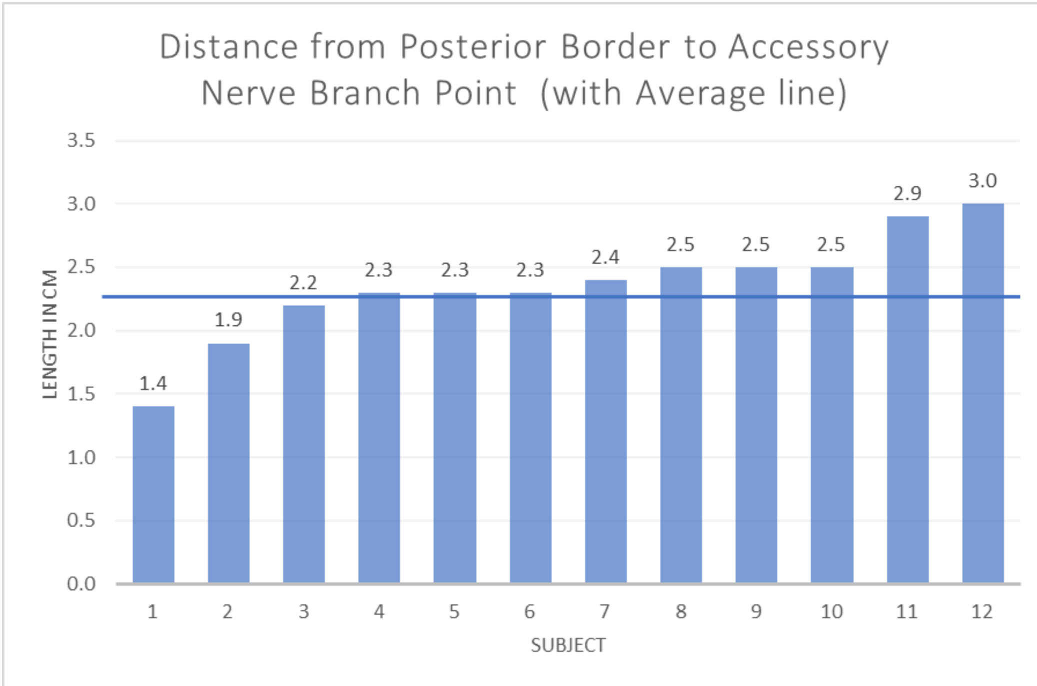

Figure 5: Average Accessory branch Location along the Mandible. Mean distance is indicated by blue bar.

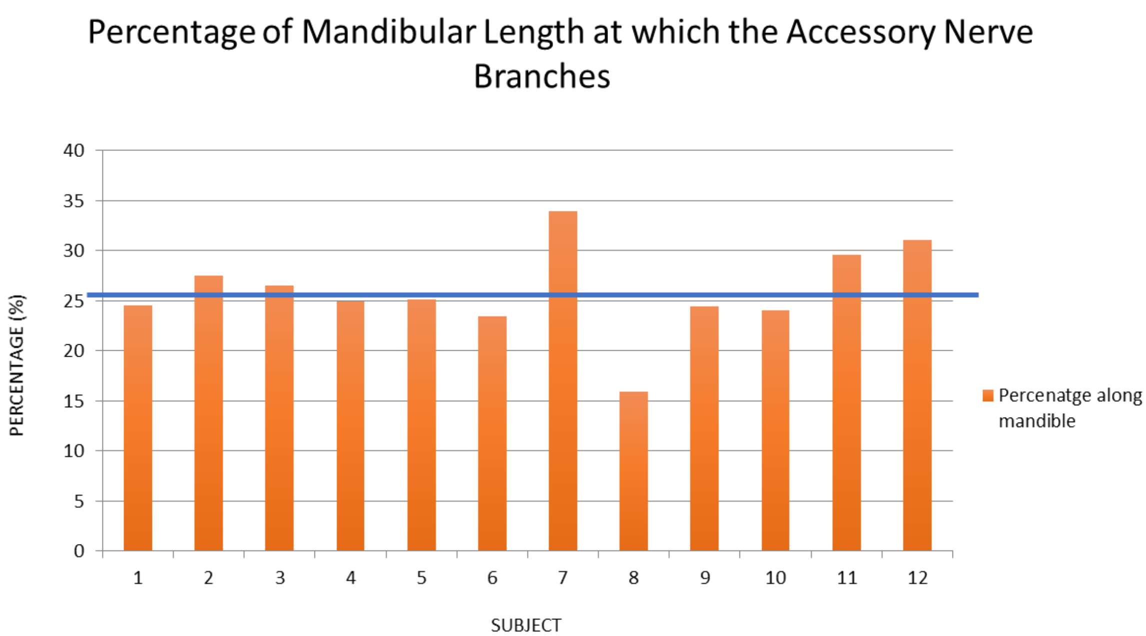

Figure 6: Percentage of mandible in which the Accessory never branches. Mean percentage is indicated by the blue bar.

Figure 7: Shows the divergence of the accessory branch of the MH nerve (white) coursing together with a blood vessel (red). The arrows point to these items. Arrow 1- blood vessel (red), Arrow 2-accessory nerve (white)

Figure 8: Accessory branch of mylohyoid not present on right side of subject 16. Black line tracks the mylohyoid nerve, which does not have an accessory branch.

4. Discussion

The use of cadavers in the present study had its advantages and disadvantages. Many of the cadavers were partially dissected and hemisected prior to the study. There was a slight uncertainty about the integrity and consistency of the nerve tissue sections. Some were thrown out of the study due to inadequate preservation, that is, dried out and butchering of the nerve's origin or anywhere along its path. Others did not have sufficient image quality and therefore, could not be analyzed and measured. However, those cadavers with intact mandibles were dissected for the mylohyoid nerve and preserved as far as possible.

If accessory foramina exist in the posterior mandible, it is quite possible that accessory nerves travel through these foramina. Traditionally, blood vessels and nerves are branched structures that travel together. A number of anatomic studies have shown that accessory foramina exist on the inner surface of the mandible. In one study conducted by Shiller et al (1954), 68% of mandibles showed lingual bilateral foramens in the posterior mandible. A second study demonstrated this by using 100 dried adult human mandibles, which had no nerves available (Goyal, 2017). Accessory foramina were observed in 97% of their cases and 26% of these were found unilaterally, similar to the present study (Goyal, 2017). Knowledge of the position and location of these foramina in the mandible is very helpful for dental surgeons in procedures for implants, orthognathic surgery, or for routine fillings. These Foramina contain neurovascular bundles. Therefore, they contain blood vessels and nerves. In the present study many of the cadavers have visual accessory branches accompanied by blood vessels. (Figure 7)

Shiller et al. (1954) also demonstrated that the mylohyoid is a mixed nerve based on its fiber composition ranging from 1micron to 20 microns. Pain sensation has been associated with unmyelinated or lightly myelinated fibers with diameters of 4 microns and less. 20% of the mylohyoid nerve fibers in Shiller’s study were of this caliber. In other words the cadavers studied in Shiller’s research supported the presence of small fibers between the proximal and distal segments of the mylohyoid. They concluded that there is a correlation between the mylohyoid nerve and posterior tooth innervation. These same small fibers have also been previously documented in tooth pulp (Windle, 1927).

All of this evidence supports the notion that there are additional fibers that contribute to posterior tooth innervation and the mylohyoid is strongly associated.

In, the present study posterior accessory branches of the mylohyoid may be considered fairly frequent. Of the 40 hemi-mandibles there was an average incidence of 37.5%. Of the 25 cadavers that had at least one measurable side, 12 had the nerve present, 43 % and 55% of the time in women and men respectively. Madeira and colleagues (1978) demonstrated that 13 of 26 (50%) cadavers possessed a supplementary (accessory) branch of the mylohyoid nerve that entered the mandible through accessory foramina in the lingual side of the mandibular symphysis. It generally arose from the right side 76.9%. The mylohyoid nerve branch either ended directly in the incisor teeth and the gingiva or joined the ipsilateral or contralateral incisve nerve (Madeira, 1978). When we consider the whole cadaver, the percent of accessory branches goes up, because it includes those with only one accessory branch.

The present study is just the beginning. Future studies would need to use local anesthetic injections to include the conventional Inferior alveolar nerve (INA) block and document those patients who have failed blocks first. Of those individuals with failed blocks administering a block in the posterior area where the proposed accessory branches of the mylohyoid are located could help confirm that this nerve is the contributing factor. Sillanpää and colleagues (1988) have already shown that local anesthetic injected below the mylohyoid, posterior to the distal root of the first molar induced partial anesthesia in 21 percent of the subjects tested. The results of this study provide support to the notion that the mylohyoid nerve has a dual role including sensory innervation to mandibular teeth. .With the aid of a dissecting microscope, they showed contiguity of the nerve with both the incisor teeth and gingivae, or the incisive nerve proper (Sillanpää, 1988).

For patients that have this nerve, it would give them additional innervation for tooth sensation. This would make them more sensitive to pain and might require additional anesthetic blocks. Traditionally, the mylohyoid has been known to be a motor nerve only. The presence of an accessory nerve branch, confirmed in the present study, suggests that there may be some sensory fibers associated with the mylohyoid nerve Sillanpää et al. suggested that there is some association with anterior teeth, gingiva and the mylohyoid. This result also is consistent with the idea that sensory fibers course through the accessory branch to the anterior mandible.

5. Conclusion

This is the first study of its kind to anatomically demonstrate the presence of accessory branches of the mylohyoid nerve that may contribute to sensory innervation of posterior mandibular teeth. Accessory branches of the mylohyoid exist in the posterior mandible in 50% of the 25 cadavers measured. Of these, 40 hemi-mandibles could be measured, and 17 of them contained accessory nerves**.** The existence of an accessory nerve should be considered when an INA block fails to provide adequate anesthesia to the posterior teeth. Our next step will be to test the identified branches to confirm that they are nerve fiber tissue with a diameter appropriate for sensory nerve, not connective tissue.

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