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Vestibular Landmarks to Minimize Injury to the Mental Nerve During Transoral Endoscopic Thyroidectomy-Vestibular Approach (TOETVA) Procedure: An Anatomical Study

Puntos de Referencia Vestibulares para Minimizar la Lesión del Nervio Mentoniano Durante el Procemiento de Abordaje Vestibular de Tiroidectomía Endoscópica Transoral (TOETVA): Un Estudio Anatómico

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SUMMARY: The aim of this study is to reveal the morphometry of the mental nerve to describe a safe zone for minimizing mental nerve damage during transoral endoscopic thyroidectomy-vestibular approach (TOETVA). This study was performed on 12 cadavers. Localization of mental foramen according to teeth, distances of buccogingival sulcus-lip (BG–L), mental foramen-midline (MF-Midline), mental foramen – buccogingival sulcus (MF – BG), commissure – branching point (Cm – Br), branching point - vertical projection of branching point on lower lip (Br – LVP), vertical projection of branching point on lower lip – commissure (LVP – Cm), commissure – midline (Cm – midline), angles of mental (AM), angular (AA) and labial branches (AL) and branching patterns were recorded. Type 1 was mostly found as branching pattern in this study (45.8 %). A new branching pattern (type 9) was found on one cadaver. Mental foramen was mostly located at level of second premolar teeth. According to morphometric results of this study; supero-lateral to course of angular branch and infero-medial to course of mental branch of mental nerve on lower lip after exiting the mental foramen were described as safe zones during surgery for preserving mental nerve and its branches.

KEY WORDS: Cadaver; Mental foramen; Mental nerve; Thyroidectomy; TOETVA; Vestibular approach.

INTRODUCTION

In traditional open thyroid surgery, there is a noticeable scar on the neck. From a cosmetic perspective, this result is not desirable for patients. With the development of surgical techniques, practicing transoral endoscopic thyroidectomy-vestibular approach (TOETVA) using the vestibular route that does not leave scar on the neck, is becoming more popular (Nakajo *et al*., 2013; Park & Sun, 2017; Anuwong *et al*., 2018a). Transoral endoscopic thyroidectomy-vestibular approach is an approach which was described in Thailand by Angkoon Anuwong (Anuwong, 2016; Anuwong *et al*., 2018b). The risk of the mental nerve damage may occur during the insertion of three oral endoscopic ports into the lower lip during TOETVA (King *et al*., 2020). The incidence of the mental nerve injury following TOETVA has been reported at the range of 0-75 % (Chai *et al*., 2017; Anuwong *et al*., 2018a; Kim *et al*., 2018). The mental nerve containing sensory fibers and being the terminal branch of the mandibular nerve -the third part of the trigeminal nerve- exits from the mandible through the mental foramen and is divided into three branches deep within the depressor anguli oris muscle and innervates the skin and the mucosa of the lower lip, the skin of the jaw and the vestibular gum of the mandibular incisor (Standring,2005). Damage to the mental nerve may cause numbness on the chin and lower lip resulting in lip biting and speech disorders (Deeb *et al*., 2000; Hu *et al*., 2007). The branching pattern of the mental nerve may differ between populations (Fabian, 2007). The mental nerve can also be injured during dental procedures such as genioplasty, mandibular osteotomy, dental implant surgery, orthodontic and endodontic treatments (Ousterhout, 1996; Babbush, 1998; Westermark *et al*., 1998; Morrison *et al*., 2002; Willy

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et al., 2004). The mental nerve is usually divided into medial and lateral inferior labial, angular and mental branches (Hu *et al*., 2007).

The aim of this study is to reveal the anatomy, morphometry, branching pattern and to identify coursing in the lower lip of the mental nerve to describe a safe zone in order to minimize the mental nerve damage while placing endoscopic port during TOETVA.

MATERIAL AND METHOD

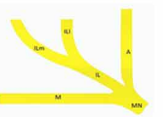
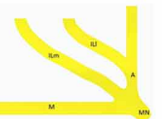
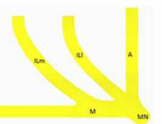
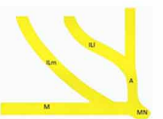
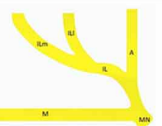
The mental nerve dissections were performed on one fresh and 11 fixed cadavers (12 right and 12 left sides). The cadavers were obtained from the authors' university, Department of Anatomy after institutional approval for study. All cadavers were male.

Dissection of the mental nerve. Before starting dissection, the midline of the mandible and lower lip, the edge of the lower lip in contact with the upper lip, "labial commissure", "buccogingival sulcus" were drawn with a marker pen to be used in measurements. Incisions were made on the skin downstream from the labial commissures to facilitate dissection and exposure. Later, the head was fixed and dissection was initiated through the mouth in a position similar to the TOETVA procedure (Anuwong *et al*., 2018b). The mucosa was cut from the buccogingival sulcus line by using a scalpel. Traction was given from the lips with the help of forceps, and dissected from the periosteum of the mandible to the mental foramen. The mental nerve root was identified and the courses of the main branches of the mental nerve on the lower lip were dissected by starting from the root of the nerve with the help of a micro clamp and a dissector up to the midline and the terminal thin branches.

Branching pattern and measurements. Branching pattern of the mental nerve was stated as in Table I classified by Hu *et al*. (2007) and King *et al*. (2020). The measurements were recorded by two authors. The landmarks, reference lines and measurements were shown in Figures 1, 2 and 3 and Table II.

The angles of the mental nerve branches were measured digitally by using the Angle Meter® (Smart Tool Factory) program. The teeth localization of the mental foramen was recorded. If there was no tooth on the cadaver, this localization could not be practiced. Dissection time was started by making the markings and stopped at the end of the dissection and finally recorded. Dissection time was expressed in minutes, angle measurements in degrees (°) and other measurements in millimeters (mm).

Tabla I. Descriptions and schematic drawings of the mental nerve types (Hu *et al*., 2007; King *et al*., 2020).

Type	Description	Schema
Type 1	Mental nerve(MN) divided into three main branches: angular (A), inferior labial (IL), and mental (M) branches. IL branch divided into medial IL (ILm) and lateral IL (ILl) branches	
Type 2	MN divided into three main branches: A, ILm, and M branches. ILl branch separated from the A branch	
Type 3	MN divided into three main branches: A, ILl, and M branches. ILm branch separated from the M branch	
Type 4	MN divided into two main branches: A and M branches. ILl branch separated from the A and ILm branch separated from the M	
Type 5	MN divided into two main branches: A and M branches. IL branch separated from the A branch and then divided into the ILm and ILl branches.	

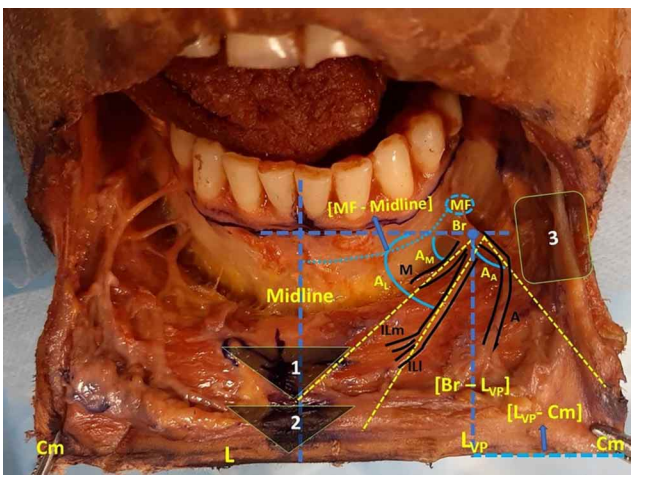


Fig. 1. External view of landmarks for the mental nerve and mental foramen identification. Cm: commissure, L: lip, MF: mental foramen Br: branching point, LVP: the vertical projection of branching point on the lower lip, [Cm – midline]: Commissure - midline, [LVP – Cm]: The vertical projection of branching point on the lower lip – commissure, [Br – LVP]: Branching point - the vertical projection of branching point on the lower lip, [Cm-Br]: Commissure – branching point, [MF-Midline]: Mental foramen-midline.

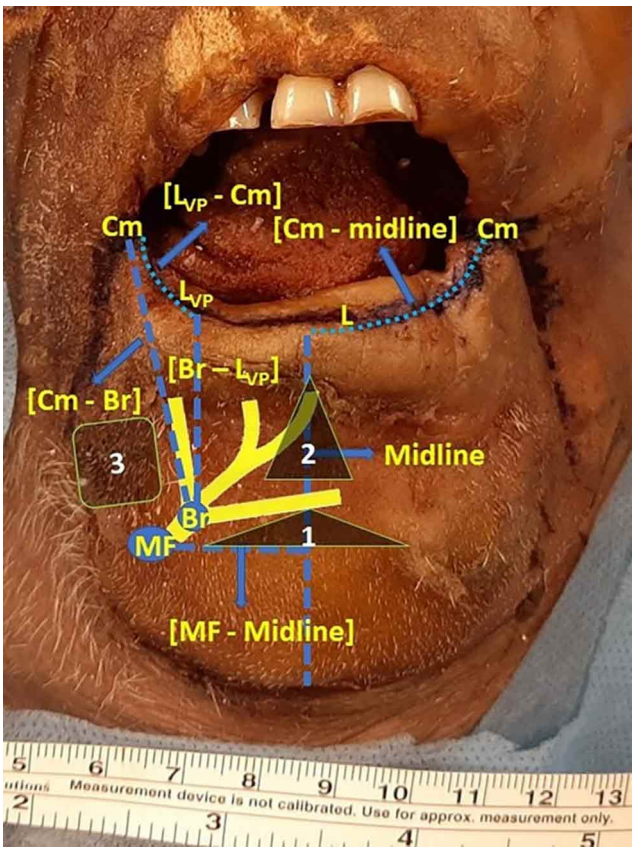


Fig. 2. Demonstration of the landmarks, reference lines and angles after dissection of the mental nerve. Cm: commissure, L: lip, MF: mental foramen, Br: branching point, LVP: the vertical projection of branching point on the lower lip, M: mental branch, A: angular branch, ILm: medial inferior labial branch, ILl: lateral inferior labial branch, AM, AA, AL: Angles of the mental branch, angular branch and labial branch, [LVP – Cm]: The vertical projection of branching point on the lower lip – commissure, [Br – LVP]: Branching point - the vertical projection of branching point on the lower lip, [MF-Midline]: Mental foramen-midline.

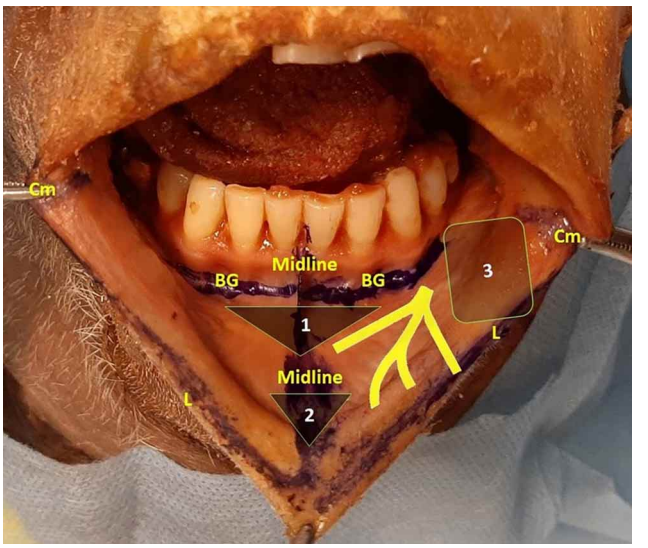


Fig. 3. Vestibular view of the lower lip. 1st zone: safe zone for the medial port that indicates the area infero-medial side of coursing of the mental branch of the mental nerve, 2nd zone: danger zone for the port placement at the midline because of the ILm and ILl branches coursing at this area, 3th zone: safe zone for the lateral port that indicates the area supero-lateral side of the coursing of the angular branch of the mental nerve.

Statistical analysis. Statistical analysis was performed using the SPSS software version 26. The variables were investigated using visual (histograms, probability plots) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk test) to determine whether or not they are normally distributed. Descriptive analysis was presented using means and standard deviations for normally distributed variables, medians and ranges for the non-normally distributed variables. Paired Student's t-test and the Wilcoxon test were used to compare right and left side measurements according to whether or not they are normally distributed. A p-value of less than 0.05 was considered to show a statistically significant result.

Table II. Descriptions of the measurements.

Buccogingival sulcus-lip distance	BG - L	The distance between highest point of lip and the inferior buccogingival sulcus at midline level
Mental foramen-midline	MF - Midline	The distance between mental foramen and midline level on each side
Mental foramen – buccogingival sulcus	MF - BG	The distance between mental foramen and buccogingival sulcus (previously cut during dissection)
Commissure – branching point	Cm - Br	The distance between the labial commissure and the first branching point of the mental nerve
Branching point - the vertical projection of branching point on the lower lip	$Br – L_{VP}$	The distance between the first branching point of the mental nerve and the vertical projection of branching point on the highest point of lower lip
The vertical projection of branching point on the lower lip - commissure	L_{VP} - Cm	The distance between the vertical projection of branching point on the highest point of lower lip and labial commissure
Commissure - midline	Cm - midline	The distance between labial commissure and the midline of the lower lip
Angles of the mental branch, angular branch and labial branch of the mental nerve	A_M, A_A, A_L	The angles between the perpendicular line to the midline and the coursing of the nerves on the lower lip

RESULTS

Mental foramen localization according to position of teeth was found on the right side on the 1. premolar, between 1.-2. premolar, 2. premolar tooth level; 20 %, 40 %, 40 % respectively. On the left side, the localizations were found on the 1. premolar, between 1.-2. premolar, 2. premolar tooth level; 11.1 %, 33.3 %, 55.6 % respectively. Totally, mental foramen was found on the 1. premolar, between 1.-2. premolar, 2. premolar teeth level; 15.8 %, 36.8 %, 47.4 % respectively (Table III).

The frequencies of the branching patterns for each side were shown in Table IV. Type 1 branching pattern was found as the most common pattern in this study. type 2, type 5, type 6 and type 8 branching patterns were not found. Type 9 branching pattern is a new pattern which has been described in this study on the right side of one cadaver (Fig. 4).

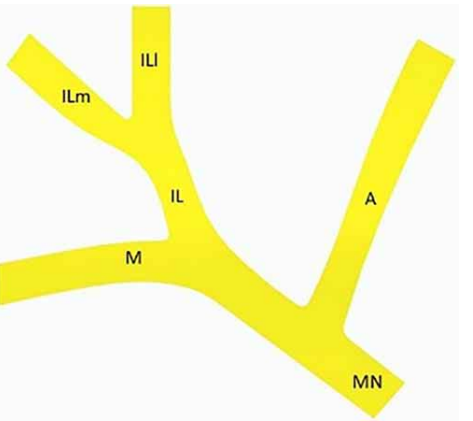


Fig. 4. Schematic drawing of the Type 9 branching pattern which was not previously described. MN: mental nerve, A: angular branch, M: mental branch, IL: inferior labial branch, ILm: medial inferior labial branch, ILl, lateral inferior labial branch. MN divided into 2 main branches: A and one main trunc. M and IL branches separated from the main trunc. ILm and ILl branches separated from IL branch.

Table III. Teeth localization of the mental foramen.

Mental foramen teeth localization	Right	Left	Total
1. premolar	2 (20 %)	1 (11.1 %)	3 (15.8 %)
Between 1.-2. premolar	4 (40 %)	3 (33.3 %)	7 (36.8 %)
2. premolar	4 (40 %)	5 (55.6 %)	9 (47.4 %)

Table IV. Frequencies of the mental nerve types.

Type	Right	Left	Total
Type 1	5 (41.7 %)	6 (50 %)	11 (45.8 %)
Type 2	-	-	-
Type 3	4 (33.3 %)	3 (25 %)	7 (29.2 %)
Type 4	1 (8.3 %)	2 (16.7 %)	3 (12.5 %)
Type 5	-	-	-
Type 6	-	-	-
Type 7	1 (8.3 %)	1 (8.3 %)	2 (8.3 %)
Type 8	-	-	-
Type 9	1 (8.3 %)	-	1 (4.2 %)

The mean values of buccogingival sulcus-lip (BG–L), mental foramen-midline (MF-Midline), mental foramen – buccogingival sulcus (MF – BG), commissure – branching point (Cm – Br), branching point - the vertical projection of branching point on the lower lip (Br – LVP), the vertical projection of branching point on the lower lip - commissure (LVP – Cm), commissure - midline (Cm – midline) distances were found 23.00±3.43 mm, 28.79±3.13 mm, 13.67±3.23 mm, 38.63±4.60 mm, 36.88±4.99 mm, 14.92±3.64 mm, 38.13±3.53 mm, respectively. Angle of the mental branch (AM), angle of the angular branch (AA), angle of the labial branch (AL) were measured as 43.68°±18.32°, 121.94°±15.29°, 76.53°±13.05°, respectively. There were no significant differences between the right and left side measurements. All measurements were summarized in Table V.

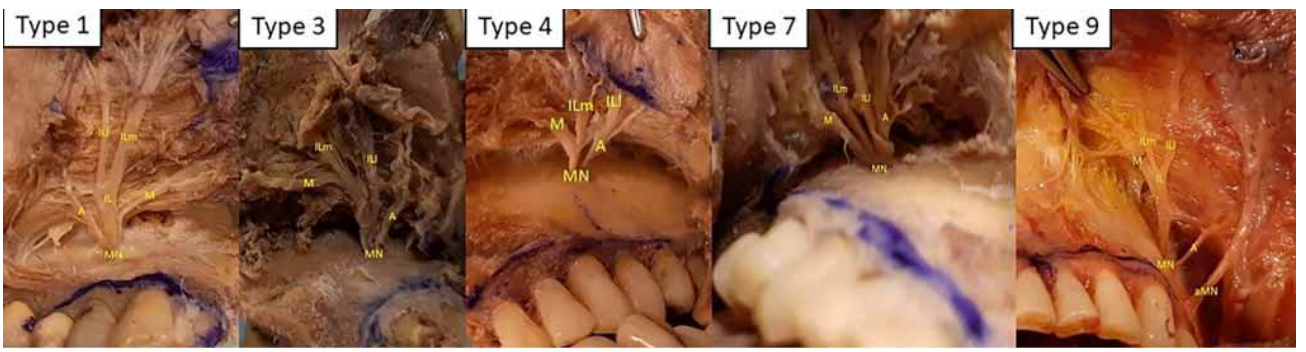


Fig. 5. Cadaveric demonstrations of the mental nerve types which were found in the present study.

Table V. Descriptive statistics of the measurements.

Parameter	Descriptive statistic	Right	Left	p value	Total
BG - L	Mean±SD	23.00±3.51	23.00±3.51	-	23.00±3.43
	Median (min-max)	22.50 (18-29)	22.50 (18-29)		22.50 (18-29)
Mental branch diameter	Mean±SD	1.50±0.67	2.25±0.62	-	1.88±0.74
	Median (min-max)	1 (1-3)	2.00 (1-3)		2.00 (1-3)
Angular branch diameter	Mean±SD	1.33±0.49	1.42±0.51	0.65	1.38±0.49
	Median (min-max)	1 (1-2)	1.00 (1-2)		1.36 (1-2)
Labial branch diameter	Mean±SD	2.17±0.40	1.83±0.40	-	2.00±0.42
	Median (min-max)	2 (2-3)	2.00 (1-2)		2.00 (1-3)
MF - Midline	Mean±SD	28.42±2.77	29.17±3.53	0.50	28.79±3.13
	Median (min-max)	29.50 (24-31)	29.50 (22-35)		29.50 (22-35)
MF - BG	Mean±SD	13.92±3.77	13.42±2.74	0.41	13.67±3.23
	Median (min-max)	14.50 (7-19)	14.00 (9-17)		14.00 (7-19)
Cm - Br	Mean±SD	38.83±3.63	38.42±5.56	0.76	38.63±4.60
	Median (min-max)	40.50 (32-43)	38.00 (30-49)		39.50 (30-49)
Br – L_{VP}	Mean±SD	37.42±3.98	36.33±5.97	0.43	36.88±4.99
	Median (min-max)	37,00 (32-45)	35.50 (28-50)		36.00 (28-50)
L_{VP} - Cm	Mean±SD	15.67±3.67	14.17±3.61	0.30	14.92±3.64
	Median (min-max)	16.00 (11-24)	13.00 (10-21)		14.50 (10-24)
Cm – midline	Mean±SD	38.50±3.31	37.75±3.84	0.43	38.13±3.53
	Median (min-max)	39.00 (32-43)	37.00 (34-45)		38.00 (32-45)
Angle of the mental branch	Mean±SD	47.408±18.29	39.96±18.36	0.12	43.688±18.32
	Median (min-max)	54.80 (16.8-67.7)	44.35 (14.3-75.4)		46.300 (14.3-75.4)
Angle of the angular branch	Mean±SD	122.35±18.52	121.52±12.07	0.90	121.942±15.29
	Median (min-max)	119.65 (90.8-161.0)	120.10 (105.5-143.4)		119.900 (90.8-161.0)
Angle of the labial branch	Mean±SD	80.25±5.47	72.08±18.53	-	76.536±13.05
	Median (min-max)	80.65 (71.8-87.0)	80.90 (41.0-85.8)		80.900 (41.0-87.0)
Dissection time (minute)	Mean±SD	26.33±18.99	25.25±18.902	0.40	25.79±18.53
	Median (min-max)	17.00 (10-63)	15.50 (9-64)		16.50 (9-64)

The mental branch diameter was found on the right side, left side and totally; 1.50±0.67 mm, 2.25±0.62 mm, 1.88±0.74 mm respectively. The angular branch diameter was found on the right side, left side and totally; 1.33±0.49 mm, 1.42±0.51 mm, 1.38±0.49 mm respectively. The labial branch diameter was found on the right side, left side and totally; 2.17±0.408 mm, 1.83±0.40 mm, 2.00±0.42 mm respectively. It was the labial branch which was the largest on the right side and the mental branch on left side in diameter.

Dissection time was found on the right side, left side and totally; 26.33±18.99 minute (min-max:10-63 minute), 25.25±18.90 minute (min-max:9-64 minute), 25.79±18.53 minute (min-max:9-64 minute) respectively.

DISCUSSION

In this study, morphometric, branching pattern of mental nerve and teeth localization of the mental foramen were defined in detail. During the port insertion, mental nerve and its branches are vulnerable (Zhang *et al*., 2019). So, knowledge of the detailed anatomy of the mental nerve and its branches are important for minimizing the nerve injury. According to the results of this study; the mean values of MF-Midline, MF – BG distances were found as 28.79±3.13 mm, 13.67±3.23 mm, respectively and the most common localization of mental foramen was found at the level of 2. premolar teeth. Angle of the mental branch (AM), angle of the angular branch (AA), angle of the labial branch (AL) were measured 43.68°±18.32°, 121.94°±15.29°, 76.53°±13.05°, respectively. As a result; we can predict the mental foramen localization and course of the mental nerve branches on the lower lip. Lower lip was divided into 3 named first, second and third zones. First zone is the area which is the infero-medial side of the course of the mental branch on the lower lip. This zone is found safe zone for the middle port insertion. Third zone is the area which is the supero-lateral side of the course of the angular branch on the lower lip. This area is found safe zone for the lateral ports. It is stated that applying of lateral and anterior displacement of the lateral ports during TOETVA is beneficial (Zhang *et al*., 2019). It is similar to safe zone 3 which was described in this study. Second zone is estimated a danger zone for the port placement because medial and lateral labial branches were found as variations in this area and it is thought to be harmful for the labial branch of the mental nerve.

It is believed that the prediction of mental foramen localization is important to prevent mental nerve injury. In a study of King *et al*. (2020) the distance from the midline to the mental foramen was found as 28.8+-3.3 mm and 29.8+-3.2 mm on the right and left sides, respectively, no significant difference was found between these measurements on the right and left sides. They defined 3-3.5 cm lateral to the midline and lateral region of mental foramen as the safe zone for lateral port placement (King *et al*., 2020). In our study, the distance of the mental foramen from the midline was found as 28.42+-2.778 on the right and 29.17+-3.538 on the left side and no significant difference was found between each sides (p=0.508). Placement of the lateral port from the third zone which is supero-lateral to the course of the angular branch after exiting the mental foramen, and the placement medial port from the first zone which is infero-medial to the course of mental branch after exiting the mental foramen were described according to the morphometric measurements which were performed in this study. Second zone was defined as the dangerous region in our study because of the variable branching pattern of the labial branch.

It is important to know the branching patterns of mental nerve due to possible injuries to each branch. There are several studies reporting different frequencies of each mental nerve branching patterns. Loyal *et al*. (2013) detected mental nerve bifurcation (39 %) mostly, followed by trifurcation (34 %) with 64 mental nerve dissections. Zhang *et al*. (2020) in their study with 20 mental nerve dissections, found four and five mental nerve branches frequently on the right side (30 %), and four mental nerve branches on the left side (40 %). Hu *et al*. (2007) detected trifurcation with 61.3 % at most, followed by the mental nerve bifurcation with 38.7 %. In our study, the mental nerve trifurcation (type 1 and type 3) was found mostly as 75 %, followed by bifurcation (type 4 and type 9) 16.7 %.

There are many important muscles and neurovascular structures which have different function in oral vestibule. During post insertion, these structures are passed through. Celik *et al*. (2020) examined the histological relationship of lateral and medial ports with the muscles and neurovascular structures in the paths they pass through in detail and found that medial ports had less damage to the mental nerve. In our study, mental nerve morphology and morphometry were studied in detail only for mental nerve damage during TOETVA procedure. The relationship of neurovascular structures and muscles other than the mental nerve with port placement can be made in future studies.

It is seen that typing the mental nerve is one of the most studied issues. Hu *et al*. (2007) in their study with 31 mental nerves, identified the mental nerve branching pattern as 5 types. They detected type 2 (35.5 %) branching pattern as the most common type. In the study of King *et al*. (2020), 120 mental nerve dissections were performed. They found three more different branching patterns in addition to mental nerve typing by Hu *et al*. (2007). King *et al*. (2020) indicated type 1 as the most common branching pattern (21 %). In our study, type 1 (45.8 %) was found as the most common branching pattern. Unlike the study of Hu *et al*. (2007) and King *et al*. (2020), type 9, which has not been defined in the literature before, was described for the first time. Only type 1, 3, 4, 7 and 9 were detected in our study (Fig. 5).

The position of the teeth is an important external landmark used to predict mental foramen localization. In previous 3 studies, teeth localization of the mental foramen was found at the level of the second premolar teeth mostly as 39 %, 61.3 %, 42.8 % on the right side respectively and 43 %, 59.3 %, 43.6 % on the left side respectively (Yes¸ilyurt *et al*., 2008; Kqiku *et al*., 2013; Voljevica *et al*., 2015). In the study of Ghimire & Gupta (2018) the mental foramen was mostly detected between the first and second premolar teeth (39.1 %). In our study, the mental foramen was identified at the level of the second premolar teeth with the rate of 40 % on the right side and 55.6 % on the left side.

Another important result of the study is that as you practice on cadavers, it becomes easier to control the dissection area and the dissection time gets noticeably shorter. In this respect, cadaver dissection training and studies are important for both anatomists and surgeons.

In conclusion detailed surgical anatomy of the mental nerve was investigated by using cadavers. This descriptive anatomical study represents important data for surgeons during clinical applications of TOETVA. The described zones may be helpful for surgeons in terms of minimizing mental nerve injury.

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CENNET, O.; ULKIR, M.; DINCER, A.; TATAR, I.; DEMIRYUREK, D. & KONAN, A. Puntos de referencia vestibulares para minimizar la lesión del nervio mentoniano durante el procedimiento de abordaje vestibular de tiroidectomía endoscópica transoral (TOETVA): Un estudio anatómico. *Int. J. Morphol., 40(4)*:1018-1024, 2022.

RESUMEN: El objetivo de este estudio fue revelar la morfometría del nervio mental o mentoniano para describir una zona segura y de esta manera, minimizar el daño de este nervio durante la tiroidectomía endoscópica transoral-abordaje vestibular (TOETVA). Este estudio se realizó en 12 cadáveres. Se realizó la localización del foramen mentoniano según los dientes, distancias surco gingival-labio (BG-L), foramen mentoniano-línea mediana (MF-Midline), foramen mentoniano-surco gingival (MF-BG), comisura-punto de ramificación (Cm-Br), punto de bifurcación - proyección vertical del punto de bifurcación en el labio inferior (Br - LVP), proyección vertical del punto de bifurcación en el labio inferior - comisura (LVP - Cm), comisura - línea mediana (Cm - línea mediana), ángulos del mentón (AM). Se registraron ramos angulares (AA) y labiales (AL) y patrones de ramificación. El tipo 1 se encontró principalmente como patrón de ramificación en el 45,8 %. Se describe un nuevo patrón de ramificación (tipo 9) encontrado en un cadáver. El foramen mentoniano se localizaba mayoritariamente a nivel de los segundos premolares. Según los resultados morfométricos, supero-lateral al curso de la rama angular e infero-medial al curso de la rama mentoniana del nervio mentoniano en el labio inferior, después de salir del foramen mentoniano, se describieron las zonas seguras, para la cirugía y preservación del nervio mentoniano y de sus ramos.

PALABRAS CLAVE: Cadáver; Foramen mental; Nervio mental; Tiroidectomía; TOETVA; Abordaje vestibular.

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