

Morphometric Study of Incisive, Greater and Lesser Palatine Foramina: A Novel Point of Maxillary Nerve Block in a Thai Population

Estudio Morfométrico del Foramen Palatino Incisivo, Mayor y Menor: Un Punto Novedoso de Bloqueo del Nervio Maxilar en una Población Tailandesa

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SUMMARY: To study the morphometric location of the incisive, greater, and lesser palatine foramina for maxillary nerve block. Two hundred Thai dry skulls were randomly organized from the Forensic Osteology Research Center. The distances of the parameters were measured via Vernier caliper. The distances from the incisive foramen to the incisive margin of the premaxilla were 10.93 ± 2.42 mm in males and 10.98 ± 2.06 mm in females. From the left side, the incisive foramen to the greater palatine foramen (GPF) was 39.07 ± 2.23 mm in males and 38.57 ± 2.41 mm in females, and from the right side were 39.81 ± 2.37 mm in males and 38.62 ± 2.53 mm in females. From the left side, the incisive foramen to the lesser palatine foramen (LPF) was 43.16 ± 2.23 mm in males and 41.84 ± 2.42 mm in females and from the right side were 42.93 ± 2.14 mm in males and 41.76 ± 2.61 mm in females. The GPF found at medial to the maxillary third molar were 94-95 % in males and 84 % in females. These findings suggest that the medial position to the third molar teeth be used as a landmark for a palatine nerve block in Thais. These findings will help dentists to perform local anesthetic procedures, especially the nasopalatine and greater palatine nerve blocks, more effectively.

KEY WORDS: Greater palatine foramen; Incisive foramen; Lesser palatine foramen; Maxillary nerve block.

INTRODUCTION

The incisive foramen (IF) or canal is an upper aperture located at the medial exterior of the maxilla and located at the rear of the incisive teeth. Incisive foramen is an important path of the incisive conduit which encompasses the neurovascular structures for example the nasopalatine nerve. The nasopalatine nerve block is one procedure for blocking the maxillary branch of the trigeminal nerve for the anterior soft tissue at the hard palate and six anterior teeth (incisive and canine teeth). The insertion route of the needle is alongside and posterior to the central incisor approximately but this is an uncertain position for determining the incisive foramen.

Interiorly, the greater and lesser palatine foramina around molar teeth have an extensive implication in dental operations, especially for anesthesia in diverse maxillofacial

surgical procedures. The greater palatine nerve passes through the greater palatine foramen or GPF structure. In addition, the lesser palatine nerve administers a transition for the lesser palatine foramina or LPF, which are located posteriorly to the greater palatine foramen. The greater and lesser palatine foramina have an essential significance in dental surgery, especially in the anesthesia in various maxillofacial surgical procedures (Kang *et al.*, 2012). Clinically, the transverse distance of the greater palatine foramina is not statistically significant in sex determination (Kamath *et al.*, 2016). Accuracy in localizing the greater and lesser palatine foramen is appropriate for a regional block. Thus, anesthetic or surgical procedures recommend a specific position to hinder the procedure deterioration and misapprehension, found mostly because of anatomical variation. Therefore, knowing the exact position of greater palatine foramen position could lead to precise and proper anesthesia. The molar teeth are one of the applicable choices for estimating the position.

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The maxillary nerve block is an anesthetic operation aimed to anesthetize the hemi-maxilla part that affects the maxillary premolar and molars and the adjacent soft and hard tissues. Dentists with a lack of experience and uncertainty of the anatomy are restricted from utilizing the maxillary nerve block. Several previous studies have revealed that the position of the GPF is medially placed at the position of the third molar teeth. Awareness of the definite anatomical position of the GPF is crucial for dentists to perform a maxillary nerve block and achieve precise local anesthesia (Methathrathip *et al.*, 2005). However, no investigation of the anatomical localization of the incisive foramen, greater and lesser palatine foramen of the maxilla has been reported in Thais before. Therefore, the present study aimed to fill this research gap by investigating these anatomical structures which are essential for the greater palatine and nasopalatine nerve blocks in a Thai population. Knowing the exact locations of the incisive foramen, the greater and lesser palatine foramen in the maxilla will be beneficial for better dental procedures for Thai patients.

MATERIAL AND METHOD

Samples: The sampling was conducted randomly in a Thai population with 100 dry male skulls and 100 dry female skulls. This investigation conducted a cross-sectional descriptive study to research maxilla of human skull from the Forensic Osteology Research Center (FORC), Department of Anatomy, Faculty of Medicine, Chiang Mai University, Thailand. Collected maxilla samples were from adult cadavers (more than 20 years of age). The impaired bones or pathological bone for example traumatic fracture, osteoporosis, congenital anomalies, bone cancer were excluded in this investigation. The morphological structure of incisive foramen, greater and lesser palatine foramen was completed and obvious. We achieved approval from the Research Ethics Committee of Chiang Mai University (CODE: ANA-2563-07308).

Measurements: Morphometric location of the incisive foramen, greater and lesser palatine foramen in the maxilla bone from various anatomical landmarks were considered and studied.

To locate the foramen, various parameters were measured on the specific landmarks of the hard palate by 0.02 mm accuracy Digital Vernier Caliper on the maxilla both sides as in Figure 1:

1. IF-MI: linearly with distance from the midpoint of the incisive foramen to the incisive margin of the premaxilla.

2. IF-GPF: linearly with distance from the midpoint of the incisive foramen to the greater palatine foramen.
3. IF-LPF: linearly with distance from the midpoint of the incisive foramen to the largest position of the lesser palatine foramen.

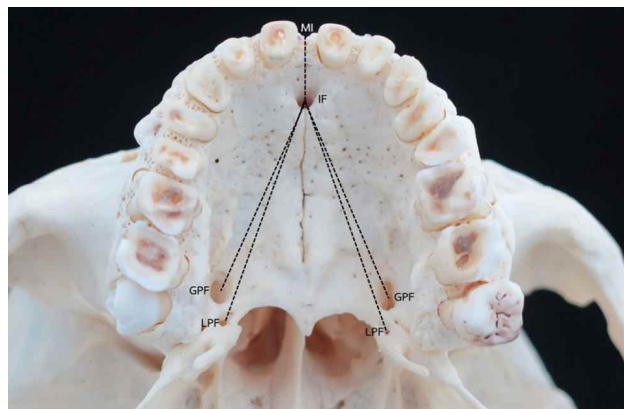


Fig. 1. Parameters measurements from various anatomical landmarks to maxilla foramen, IF-MI: distance from the midpoint of the incisive foramen to the incisive margin of the premaxilla, IF-GPF: distance from the midpoint of the incisive foramen to the greater palatine foramen, IF-LPF: distance from the midpoint of the incisive foramen to the largest of the lesser palatine foramen.

If the third molar was missing, its position was predicted by using the association with the left over molars. Also, some landmarks like the palatal midline could be estimated (Srisopark & Rodsudhi, 1982). Further study, the position of the GPF was explored with the position of the molar teeth relationship by normal visual observation as Figure 2.

Statistical Analysis: The total parameters of the maxilla foramen were analyzed to figure out the central tendency (mean) and dispersion of data (S.D). The maxilla parameters were calculated and compared the foramina of maxilla in different sexes. Further, the maxilla parameters were analyzed and compared both sides of the maxilla among all the group of samples.

The position of greater palatine foramen observations was determined by frequency and percentage and classified by the third molar teeth, second and third molar teeth, second molar teeth, and post (retro) the third molar teeth. All the previous parameters were conscientiously calculated and analyzed via Microsoft Excel 2016 (Microsoft Corp., Redmond, WA, USA) and the program SPSS version 26 (SPSS Inc., Chicago, IL, USA). The descriptive statistical analysis of this study was applied for illustrating the central tendency (mean) and dispersion of data (S.D) and an independent sample t-test was applied to test of significance under p-value < 0.05 and p-value < 0.05 were considered as statistical significance.

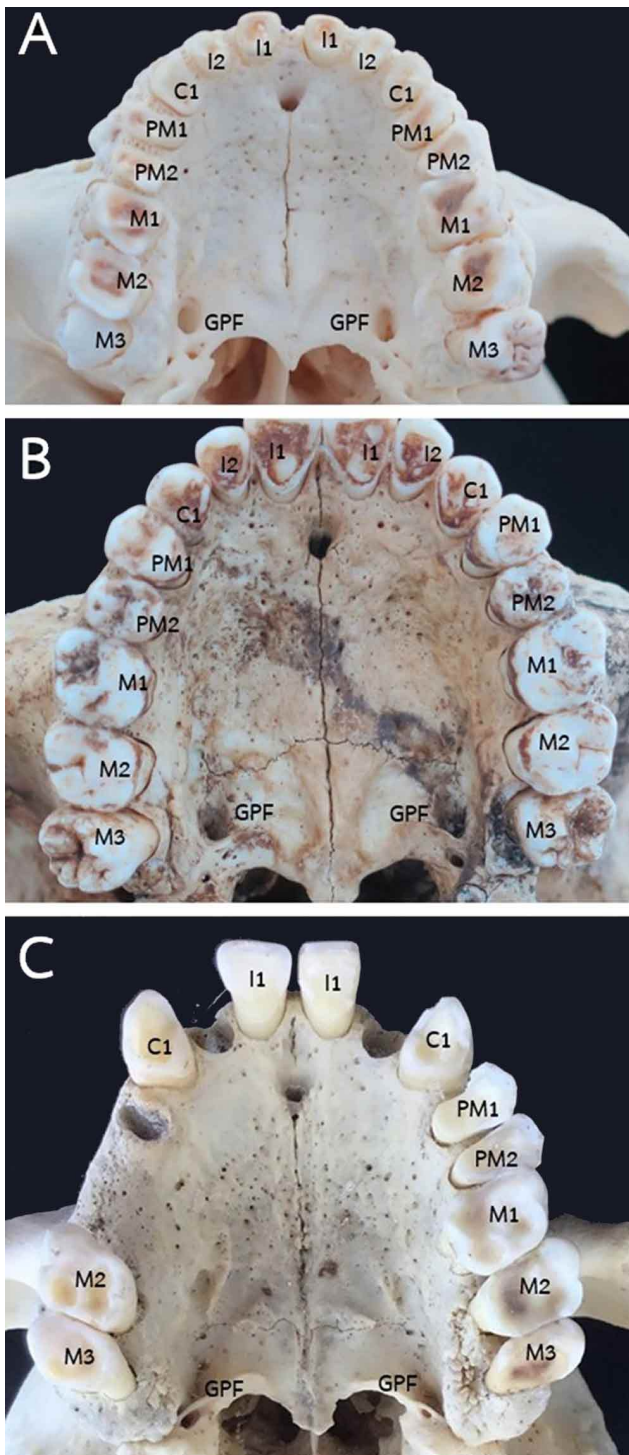


Fig. 2. Greater palatine foramen localization explored with the position of the molar teeth relationship by normal visual observation, A = Localization of the greater palatine foramen is located between the second and the third molar teeth, B = Localization of the greater palatine foramen is located near the third molar teeth, C = Localization of the greater palatine foramen is located behind the third molar teeth.

RESULTS

The distance of the Incisive foramen (IF) from different maxilla landmarks on the left and right sides in the different sexes. The maxilla foramina were assorted by sex difference; the central tendency (mean) and dispersion of data (S.D) of various parameters between sexes. Table I elucidated the several maxilla parameters. In addition, the comparison between different sexes have statistically considerable differences in the IF-GPF of the left maxilla, IF-LPF of the left maxilla, IF-GPF of the right maxilla, and IF-LPF of the right maxilla parameters ($p < 0.01$). Nevertheless, the IF-MI parameter was not statistically different with $p > 0.05$.

In males, the distance from the IF-MI averaged 10.92 ± 2.42 mm (Range = 5.51-17.625 mm). Meanwhile, the distance between IF-GPF averaged 39.70 ± 2.23 mm (Range = 35.135-46.58 mm) at left maxilla and 39.81 ± 2.37 mm (Range = 34.37-46.58mm) at the right maxilla. The distance from the IF-LPF averaged 43.16 ± 2.23 mm (Range = 37.48-50.04 mm) at the left maxilla and 42.93 ± 2.14 mm (Range = 38.145-48.85 mm) at the right maxilla.

In contrast, the female data elucidate the distance between IF-MI averaged 10.98 ± 2.06 mm (Range = 6.24-15.935 mm). Simultaneously, the distance between the IF-GPF averaged 38.59 ± 2.41 mm (Range = 32.19-46.32 mm) at the left maxilla and 38.62 ± 2.53 mm (Range = 33.02-45.68 mm) at right maxilla. The distance between the IF-LPF averaged 41.84 ± 2.42 mm (Range = 36.48-48.48 mm) at left maxilla and 41.76 ± 2.61 mm (Range = 35.795-49.04 mm) at the right maxilla.

Prevalence of the Localization of the Greater Palatine Foramen (GPF). Distinguished, in male samples, the morphological position of GPF close to the second molar could not be found on both sides. The location of GPF adheres to the second to the third molar was found 1 % on both the left and right sides. The location of the GPF adheres to the third molar was found 94 % and 95 % in the left and right side, respectively. Also, the location of the GPF is behind the third molar was presented 5 %, 4 % on the left and right side, respectively.

Contrary to the female sample, the anatomical position of GPF close to the second molar could not be found on both the left and right sides also. The position of GPF close to the second and third molar was found 8 % on both the left and right sides, respectively. The position of GPF close to the third molar was found 84 % on both the left and right sides, respectively. Also, the position of the GPF is

behind the third molar was found 8 % on both the left and right sides, respectively. The numbers and percentages of

the prevalence of the greater palatine foramen or GPF are shown in Table II.

Table I. The distance of incisive foramen (IF) from different maxilla landmarks on the left and right sides (mean±S.D. (mm)).

| Sex and Parameters | IF-MI | IF-GPF of left maxilla | IF -LPF of left maxilla | IF -GPF of right maxilla | IF -LPF of right maxilla |
|--------------------|------------|------------------------|-------------------------|--------------------------|--------------------------|
| Male | 10.93±2.42 | 39.07±2.23 | 43.16±2.23 | 39.81±2.37 | 42.93±2.14 |
| Female | 10.98±2.06 | 38.57±2.41 | 41.84±2.42 | 38.62±2.53 | 41.76±2.61 |

Table II. The numbers and percentages of the prevalence of greater palatine foramen.

| Source | Localization | Right | | Left | |
|---------------|---|-------|--------|------|--------|
| | | Male | Female | Male | Female |
| Present study | Medial to the 2 nd molar | 0 % | 0 % | 0 % | 0 % |
| | Between the 2 nd and 3 rd molar | 1 % | 8 % | 1 % | 8 % |
| | Medial to the 3 rd molar | 95 % | 84 % | 94 % | 84 % |
| | Behind the 3 rd molar | 4 % | 8 % | 5 % | 8 % |

DISCUSSION

In the present study, the morphometric location of the incisive foramen, the greater and lesser palatine foramen in a Thai population showed different results from other previous studies in the central tendency (mean) and dispersion of data (S.D.), and statistically significant differences between sexes (Table III). The distance of each foramen assists dentists in determining the approximate position of the foramen. We found that left IF-GPF in males is 39.70±2.23 mm, left IF-GPF in females is 38.59±2.41 mm, right IF-GPF in males is 39.81±2.37 mm, right IF-GPF in females is 38.62±2.53 mm, left IF-LPF in males is 43.16±2.23 mm, left IF-LPF in females is 41.84±2.42 mm, right IF-LPF in males is 42.93±2.14 mm, right IF-LPF in females is 41.76±2.61 mm. The means of all parameters (except IF-MI parameter) from males and females have statistically significant differences at p<0.01. Likewise, the parameter values of the Thai population are similar to the Indian population (Sharma *et al.*, 2014) that reflect the effects of geographic factors influencing these structures.

Previous studies have shown that the locations of the GPF and LPF were varied. Bahşi *et al.* (2019) studied the IF and GPF locations in a Turkish population and presented the statistic variations from anatomical landmarks: the left IF-GPF in males is 32.70±2.99 mm, left IF-GPF in females is 31.65±2.5 mm, the right IF-GPF in males is 32.43±2.70 mm, right IF-GPF in females is 31.45±2.26 mm. There is no significant difference. Kim *et al.* (2012) studied the IF and GPF locations in a Korean population and found the statistic variations from the perpendicular length in the coronal plane between the IF and GPF was 32.04±3.31 mm. Gibelli *et al.* (2017) investigated the incisive IF and GPF locations in an

Italy population and found the statistic variations from diverse anatomical features: the left IF-GPF in males is 40.4±2.5 mm, left IF-GPF in females is 38.8±2.6 mm, right IF-GPF in males is 40.5±2.6 mm, right IF-GPF in females is 38.8±2.4 mm and means from males and females present statistically significant differences at p<0.0001 but no statistically significant difference inside comparisons. Sharma *et al.* studied the IF and GPF locations in the Indian population and showed the statistic variations from various anatomical features. No significant difference was observed at p = 0.68 from males and female with the left IF-GPF is 37.89±2.83 mm, right IF-GPF is 37.74±2.39 mm. Saralaya & Nayak (2007) inspected the IF and GPF locations in a Southern India population and declared the statistic variations from various landmarks: the left IF-GPF is 37.4±0.301 mm, right IF-GPF is 37.2±0.292 mm. There were no statistically significant differences in the parameters with p = 0.466. Sharma & Garud (2013) considered the IF and GPF locations in an Indian population and showed the statistic variations from various anatomical landmarks: the left IF-GPF is 35.66 ± 2.61 mm, right IF-GPF is 35.42 ± 2.75 mm. It manifests there is no statistically significant difference between the left and right side of maxilla with p = 0.23.

Moreover, the practical analysis of the GPF can be estimated via the localized relationship of molar teeth according to (Table IV). The parameters of distance and position relationship of molars ensure the position of the foramen. The palatine nerve block mostly observes the medial third molar for applying the anesthesia into the palatine foramen. The position of the GPF in association

Table III. The location of incisive foramen, greater and lesser palatine foramen in previous and recent studies.

| Source | Sex | I-MI | Left I-GP | Left I-LP | Right I-GP | Right I-LP |
|---|------------------|------------|--------------|-------------|--------------|------------|
| Bahsi <i>et al.</i> (2019) | Male | - | 32.70±2.99 | - | 32.43±2.70 | - |
| | Female | - | 31.65±2.5 | - | 31.45±2.26 | - |
| Kang <i>et al.</i> (2012) | Male | - | - | - | - | - |
| | Female | - | - | - | - | - |
| This studying show the perpendicular distance between the incisive foramen to the greater palatine foramen in the coronal plane was 32.04±3.31 mm | | | | | | |
| Gibelli <i>et al.</i> (2017) | Male | - | 40.4±2.5 | - | 40.5±2.6 | - |
| | Female | - | 38.8±2.6 | - | 38.8±2.4 | - |
| Sharma <i>et al.</i> (2014) | Total population | - | 37.89±2.83 | - | 37.74±2.39 | - |
| Saralaya & Nayak (2007) | Total population | 14.7±0.155 | 37.4±0.301 | - | 37.2±0.292 | - |
| Sharma & Garud (2013) | Total population | - | 35.66 ± 2.61 | - | 35.42 ± 2.75 | - |
| Present study | Male | 10.92±2.42 | 39.70±2.23* | 43.16±2.23* | 39.81±2.37* | 42.93±2.14 |
| | Female | 10.98±2.06 | 38.59±2.41* | 41.84±2.42* | 38.62±2.53* | 41.76±2.61 |

(mean±S.D. (mm)). * = Statistically significant at p <0.01

Table IV. Localization of greater palatine foramen with the molar relationship.

| Source | Localization | Right | | Left | |
|------------------------------------|--|---------|---------|--------|---------|
| | | Male | Female | Male | Female |
| Bahsi <i>et al.</i> (2019) | Medial to the 2 nd molar | 5.33 % | 6.66 % | 5.33 % | 6 % |
| | Between the 2 nd and 3 rd molar | 18.66 % | 22.66 % | 10 % | 20.66 % |
| | Medial to the 3 rd molar | 69.33 % | 65.33 % | 33.3 % | 66 % |
| | Behind the 3 rd molar | 6.66 % | 5.33 % | 8 % | 7.33 % |
| Methathrathip <i>et al.</i> (2005) | Palatal to the 2 nd molar | 4.8 % | 7 % | - | - |
| | Interproximal to the 2 nd and 3 rd molar | 28.2 % | 14.1 % | - | - |
| | Palatal to the 3 rd molar | 60.2 % | 71.9 % | - | - |
| | Distal the 3 rd molar | 6.8 % | 7 % | - | - |
| Sharma <i>et al.</i> (2014) | Opposite to 2 nd molar | | 0 % | | 0 % |
| | Between 2 nd and 3 rd molar | | 25 % | | 24 % |
| | Opposite to 3 rd molar | | 72 % | | 69 % |
| | Behind 3 rd molar | | 3 % | | 5 % |
| Saralaya & Nayak (2007) | Second molar | | 0.8 % | | 0 % |
| | Between 2 nd and 3 rd molars | | 25 % | | 23.5 % |
| | Third molar | | 73.5 % | | 75.8 % |
| | Behind third molar | | 0.8 % | | 0.8 % |
| Sharma & Garud (2013) | Opposite 2 nd molar | | 8.63 % | | |
| | Between 2 ^{na} and 3 rd molar | | 0 % | | |
| | Opposite 3 rd molar | | 73.38 % | | |
| | Distal to 3 rd molar | | 17.99 % | | |
| Present study | Medial to the 2 nd molar | 1 % | 1 % | 1 % | 1 % |
| | Between the 2 ^{na} and 3 rd molar | 0 % | 7 % | 0 % | 7 % |
| | Medial to the 3 rd molar | 95 % | 84 % | 94 % | 84 % |
| | Behind the 3 rd molar | 4 % | 8 % | 5 % | 8 % |

with the molar teeth is mentioned to be opposite the second molar, the third molar, or between the second and third molars. Most of the GPF in the present study was determined at the palatal area of the upper third molar which agreed with prior reports in Thais (Srisopark & Rodsudhi). Tomaszewska *et al.* (2014) claimed that the maxillary mo-

lar teeth were the best landmarks for indicating the position of the GPF. In this recent study, the location of the GPF on the right side of males existed 95 % medial to the third molar, 4 % behind the third molar position, 1 % medial to the second molar. The location of the GPF in the right side of females existed 84 % medial to the third molar, 8 % behind

the third molar position, 7 % between the 2nd and second and third molar medial to the second molar, 1 % medial to the second molar. The location of the LPF on the left side of males is presented 94 % medial to the third molar, 5 % behind the third molar position, 1 % medial to the second molar. The location of the LPF on the left side of females is presented 84 % medial to the third molar, 8 % behind the third molar position, 7 % between the second and third molar medial to the second molar, 1 % medial to the second molar. In summary, the side of the maxilla has no difference for the palatine foramen position but in males has the position of palatine foramen medially to the third molar 94-95 % which is more than in females (84 % medially to the third molar.)

Nevertheless, several data are required from different populations to verify variability among ethnic groups. Geographical distribution and ethnic variations are also some considerations that determine the location of palatine foramen according to molars (Saralaya & Nayak).

Methathrathip *et al.* show the frequency of the location of the greater palatine foramen in relationship to upper molars with sex comparison but no side data. The table of Methathrathip *et al.* will elucidate the total parameter of both sides.

To achieve a maxillary nerve block in Thais, we suggest that a medial position to the third molar teeth can be used as a landmark for nerve block procedures. Our study found that the distance from the incisive foramen to the palatine foramen was approximately 39.70 ± 2.23 mm on the left side, and 39.81 ± 2.37 mm on the right side in males, and 38.59 ± 2.41 mm on the left side, and 38.62 ± 2.53 mm on the right side in females. This implication of localization of the incisive foramen, greater and lesser palatine foramen in the Thai population can be applied in several dental surgeries, dental operations and also anesthetic procedures. The location of the greater and lesser palatine foramen may be obtained from anatomical landmarks especially the position of molar teeth which are important for maxillary nerve blocks. Some data corroborated that the most frequently 2 foramina on lesser palatine foramina on each sides (Cagimmi *et al.*, 2017). According the statistical analysis, it presented the significance of the IF-GPF and IF-LPF parameters between males and females on both sides. Remarkably, the assessment of the location of the maxilla foramen differently in sexes must occur before any operation. Regarding morphometric location, no significant difference was determined between the left and right sides of each sex.

Our study focuses on the innovative data regarding the anatomical localization of the IF and the palatine

foramina on the maxillary bone in a Thai population. Statistical differences between sexes were found. The distances from the IF to the left GPF were 39.07 ± 2.23 mm in males and 38.59 ± 2.41 mm in females. The distances from the IF to the right GPF were 39.81 ± 2.37 mm in males and 38.62 ± 2.53 mm in females. The distance between the IF to the GPF in males was significantly greater than in females. Taken together, these parameters may be useful for sex determination in forensic cases (Kasikam *et al.*, 2019).

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THUNYACHAROEN, S.; IAMAROON, A. & MAHAKKANUKRAUH, P. Estudio morfológico del foramen palatino incisivo, mayor y menor: Un punto novedoso de bloqueo del nervio maxilar en una población tailandesa. *Int. J. Morphol.*, 39(4):994-1000, 2021.

RESUMEN: El objetivo de este trabajo fue estudiar la localización morfológica de los forámenes palatinos incisivos, mayores y menores para el bloqueo del nervio maxilar. Se organizaron al azar doscientos cráneos secos tailandeses del Centro de Investigación de Osteología Forense. Las distancias de los parámetros se midieron mediante un calibre Vernier. Las distancias desde el foramen incisivo hasta el margen incisivo de la premaxila fueron $10,93 \pm 2,42$ mm en hombres y $10,98 \pm 2,06$ mm en mujeres. Desde el lado izquierdo, el foramen incisivo al foramen palatino mayor (FPM) fue de $39,07 \pm 2,23$ mm en los hombres y $38,57 \pm 2,41$ mm en las mujeres, y del lado derecho fue de $39,81 \pm 2,37$ mm en los hombres y $38,62 \pm 2,53$ mm en las mujeres. Del lado izquierdo, el foramen incisivo al foramen palatino menor (LPF) fue de $43,16 \pm 2,23$ mm en hombres y $41,84 \pm 2,42$ mm en mujeres y del lado derecho $42,93 \pm 2,14$ mm en hombres y $41,76 \pm 2,61$ mm en mujeres. El FPM encontrado medial al tercer molar maxilar fue 94-95 % en hombres y 84 % en mujeres. Estos hallazgos sugieren que la posición medial de los terceros molares se utilice como punto de referencia para un bloqueo del nervio palatino en individuos tailandeses. Estos hallazgos ayudarán, de manera más eficaz, a los dentistas a realizar procedimientos anestésicos locales, especialmente los bloqueos nasopalatinos y del nervio palatino mayor.

PALABRAS CLAVE: Foramen palatino mayor; Foramen incisivo; Foramen palatino menor; Bloqueo del nervio maxilar.

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