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Morphometry of Mental Foramina Applied to Local Anesthesia in Hoary Fox (*Lycalopex vetulus* Lund, 1842)

Morfometría de Forámenes Mentales Aplicada a la Anestesia Local en Zorro de Campo Común (*Lycalopex vetulus* Lund, 1842)

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SUMMARY: In order to perform local anaesthetic blockade of the mental nerves, it is fundamentally to determine anatomical references, including the precise identification of the mental foramina; however, the literature does not present specific data on such structures in the Hoary Fox. Therefore, the objective was describing the morphometry of the mental foramina of this specie, in order to correlate its topographies with the mandibular anatomical reference points, supporting the effective technique for mental desensitization. For this purpose, four mandibles of adult bodies of *Lycalopex vetulus* were used. Bilaterally, three mental foramina were observed located on the rostral third of the lateral margin of the mandibular body. One of them is more caudal, positioned ventrally to the lower third premolar tooth; a medium one, is located ventrally to the lower first premolar tooth; and a rostral one, placed ventrally to the lower intermediate incisor tooth. There were no statistically significant differences between the antimeres. Therefore, it is indicated that the local anaesthetic block of the mental nerves in this species should be performed by inserting the needle approximately 4.4 mm in a ventrodorsal direction. It is necessary positioning it perpendicularly to the ventral margin of the mandibular body and juxtaposed to its lateral face, using as anatomical reference the interalveolar space located between the first two lower premolar teeth. Thus, that the point established for anaesthetic injection (caudal limit of the ventral margin of the middle mental foramen), provides greater safety for its realization since, for small animals, the recommendation for blockade is represented by needle penetration on the direction of emergence of the mental nerve and artery from this foramen, which makes these structures more exposed to iatrogenic lesions resulting from the technique.

KEY WORDS: Area anaesthesia; Dentistry; Mandible; Morphology; Skull.

INTRODUCTION

In a very broad way, most of the veterinary care of wild carnivores is related to dental diseases (Pachaly & Gioso, 2001) caused, more commonly, by dental trauma, especially in animals kept in captivity. Frequently, these traumas start after dental fractures and abrasions with consequent pulp exposure or tooth loss, which leads to pulp necrosis, dentoalveolar abscesses or extra oral fistulas, caused by bacterial infection (Pachaly, 2007).

These patients clinically showed decreased appetite, weight loss, food loss during chewing, signs of pain and discomfort, facial swelling, fistulas and changes in attitude and selectivity of the diet (Wiggs & Lobprise, 1997). On serious cases, dietary changes can create a considerable risk of death (Gioso & Rossi Júnior, 2001). Therefore, procedures capable of preserving normal dentition and occlusion in these animals are extremely important for maintaining the integrity of the masticatory apparatus, ensuring an adequate food intake (Pachaly & Gioso).

For that propose, the anatomical knowledge regarding the innervation of the oral cavity and adjacent

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structures is essential, especially when the use of local anaesthetic techniques is required (Beckman & Legendre, 2002). One of the most used, responsible for desensitising the mental nerves (Lopes & Gioso, 2007), promotes ipsilateral anaesthesia of the incisor teeth, canine, first and second lower premolar teeth, adjacent tissues, lower lip and mental skin (Beckman & Legendre; Malamed, 2005), as an alternative to blocking the lower alveolar nerve in cases where treatment is limited to this region (Malamed).

In order to perform this study, it is fundamentally necessary to determine anatomical references (de Souza Júnior *et al*., 2016) and the precise identification of the location of the mental foramina (Oliveira Júnior *et al*., 2009; Guedes *et al*., 2011); however, the specialized literature does not present specific data on such structures in the Hoary Fox. Thus, the objective was to describe the morphometry of the mental foramina of this species in order to correlate its topographies with anatomical reference points in the mandible, defining a more effective local anaesthetic block of the mental nerves.

MATERIAL AND METHOD

Eight hemimandibles from four adult bodies of *Lycalopex vetulus* were used, two males and two females, items from the research collection of the Anatomy Laboratory of the School of Biological Sciences of the Federal University of Goiás (UFG), Campus Catalão, Brazil. The preparation of the mandibles was initiated by removing the skin and soft tissues from the head region, with subsequent temporomandibular dislocation. Afterwards, the material was submitted to chemical maceration with sodium hydroxide (NaOH, Lavitex®, concentration 98 % - 99 %) during 30 minutes for its cleaning, and later clarified by immersion in an aqueous solution of hydrogen peroxide (H2O2, Dinâmica®, concentration 30 % - 36 %) with dilution 1:10, during 30 minutes.

Subsequently, a single examiner performed biometrics in each hemimandible in duplicate using a Starrett® digital electronic calliper (capacity 0 - 150 mm, resolution 0.01 mm and accuracy $\pm$ 0.02 mm). Only the RFAM (Igado, 2014), DMT, DPMM, SAMF and MFVM measurements (de Souza Júnior *et al*.) were adapted from the literature. The other measurements were proposed for this study (Figs. 1 and 2): (LAM) - distance between the dorsal limit of the angular process and the rostral limit of the mandibular symphysis; (SAM) - distance between the ventral and alveolar margins of the mandibular body, taken between the first and second lower premolar teeth; (DPM) - distance between the caudal margin of the first lower premolar tooth and the rostral margin of the second lower premolar tooth, taken at the level of the alveolar margin of the mandibular body; (DPMM) - distance between the rostral margin of the first lower premolar tooth and the caudal margin of the third lower molar tooth; (DMT) - distance between the rostral margin of the first lower molar tooth and the caudal margin of the third lower molar tooth; (DPMT) - distance between the rostral margin of the first lower premolar tooth and the caudal margin of the fourth lower premolar tooth; (LACF) - length of the longitudinal axis of the caudal mental foramen; (SACF) - length of the sagittal axis of the caudal mental foramen; (CFAM) - distance between the dorsal limit of the caudal mental foramen and the alveolar margin of the mandibular body at this level; (CFVM) - distance between the ventral limit of the caudal mental foramen and the ventral margin of the mandibular body at this level; (LAMF) - length of the longitudinal axis of the middle mental foramen; (SAMF) - length of the sagittal axis of the middle mental foramen; (MFAM) - distance between the caudal limit of the dorsal margin of the middle mental foramen and the alveolar margin of the mandibular body at this level; (MFCT) - distance between the rostral limit of the dorsal margin of the middle mental foramen and the caudal limit of the alveolar margin of the lower canine tooth; (MFVM) - distance between the caudal limit of the ventral margin of the middle mental foramen and the ventral margin of the mandibular body at this level; (LARF) - length of the longitudinal axis of the rostral mental foramen; (SARF) - length of the sagittal axis of the rostral mental foramen; (RFAM) - distance between the dorsal limit of the rostral mental foramen and the alveolar margin of the mandibular body at this level; (RFVM) - distance between the ventral limit of the rostral mental foramen and the ventral margin of the mandibular body at this level; (DCM) - distance between the rostral limit of the caudal mental foramen and the caudal limit of the middle mental foramen; (DMR) - distance between the rostral limit of the middle mental foramen and the caudal limit of the rostral mental foramen.

The acquired morphometric data were submitted to descriptive statistical analysis (arithmetic mean, standard deviation and coefficient of variation) and the student's t-test with reliability of 95 %, via BioEstat® 5.3 software. The anatomical nomenclature used to describe the results was in accordance with the International Committee on Veterinary Gross Anatomical Nomenclature (International Committee on Veterinary Gross Anatomical Nomenclature, 2017), and the study was approved by the Ethics Committee for the Utilization of Animals of Federal University of Uberlândia, protocol number 81/14.

RESULTS

The hemi mandibles presented as mean biometry of their longitudinal axis 107.58 ± 1.63 mm (LAM) and sagittal axis 12.25 ± 1.03 mm (SAM), with the existing interalveolar space between the first two lower premolar teeth measuring 1.24 ± 0.24 mm (DPM). The combined longitudinal axis of the premolar and molar teeth was 54.95 ± 0.85 mm (DPMM), while when only the molar teeth (DMT) and premolar teeth (DPMT) were considered separately, the data obtained were 25.76 ± 1.57 mm and 29.45 ± 1.41 mm, respectively.

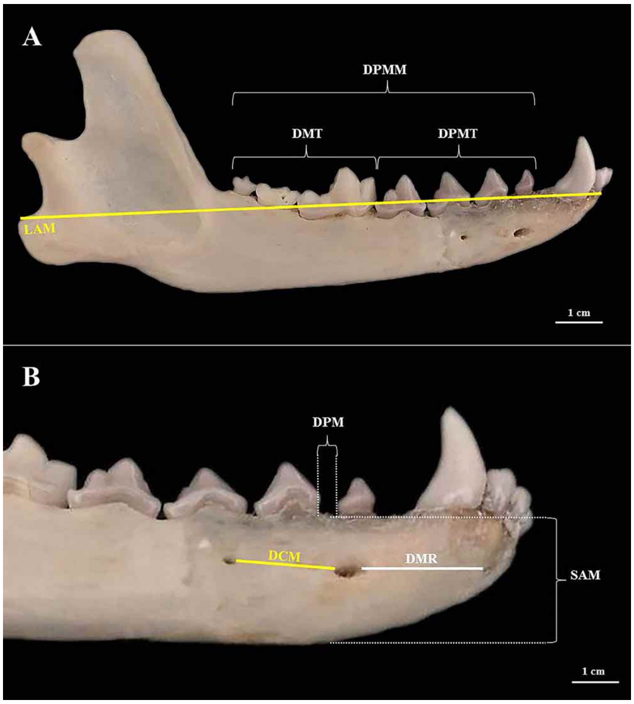

Fig. 1. Lateral face of right hemimandible of adult female of *Lycalopex vetulus*. (A) Demonstration of the measurements performed regarding the longitudinal axis of the mandible and lower premolar and molar teeth. (B) Demonstration of the measurements performed regarding the sagittal axis of the mandible, the interalveolar space between the first two lower premolar teeth, and the distance between each of the three mental foramina observed.

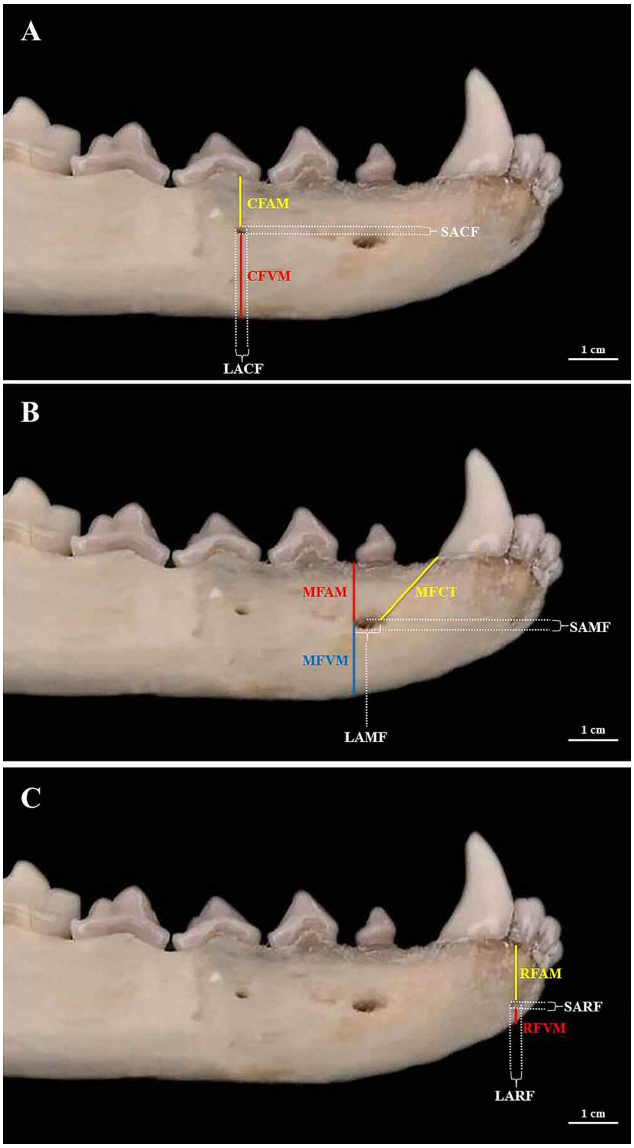

Fig. 2. Lateral face of right hemimandible of adult female of *Lycalopex vetulus*. (A) Demonstration of the measurements performed that refer to the caudal mental foramen, (B) the middle mental foramen and (C) the rostral mental foramen.

Fig. 3. Lateral face of right hemimandible of adult female of *Lycalopex vetulus*. Demonstration of the correct positioning of the needle to perform the local anaesthetic blockade of the mental nerves.

In all the hemi mandibles analyzed, three mental foramina were observed located in the rostral third of the lateral margin of the mandibular body. The most caudal, positioned ventrally to the third premolar lower tooth, presented on average 1.21 ± 0.007 mm in its longitudinal axis (LACF) and 0.98 ± 0.007 mm in its sagittal axis (SACF). Its dorsal limit was 7.03 ± 0.33 mm from the alveolar margin of the mandibular body (CFAM); its ventral limit was 6.31 ± 0.52 mm from the ventral margin of this bone structure (CFVM); and its rostral limit was 9.16 ± 1.16 mm from the caudal limit of the middle mental foramen (DCM).

On the other hand, the middle mental foramen showed, on average, longitudinal lengths of 3.51 ± 0.39 mm (LAMF) and sagittal lengths of 1.66 ± 0.39 mm (SAMF). Located ventrally to the first lower premolar tooth, the caudal limit of its dorsal margin was on average 6.18 ± 0.26 mm away from the alveolar margin of the mandibular body (MFAM); the rostral limit of its dorsal margin 8.53 ± 0.45 mm from the caudal limit of the alveolar margin of the lower canine tooth (MFCT); the caudal limit of the ventral margin 4.4 ± 0.37 mm from the ventral margin of the mandibular body (MFVM); and its rostral limit 10.26 ± 0.2 mm from the caudal limit of the rostral mental foramen (DMR).

The rostral mental foramen was ventral to the lower intermediate incisor and, on average, had a longitudinal length of 1.41 ± 0.27 mm (LARF) and a sagittal length of 0.98 ± 0.22 mm (SARF). Its dorsal limit was 4.17 ± 0.25 mm from the alveolar margin of the mandibular body (RFAM), and its ventral limit was 1.28 ± 0.39 mm from the ventral margin of the same bone structure (RFVM).

No statistically significant differences between the values obtained from the right and left hemi mandibles were observed for any of the measurements performed (Table I).

Thus, the local anaesthetic blockade of the mental nerves should be performed by introducing the needle for approximately 4.4 mm in a ventrodorsally direction, being positioned perpendicularly to the ventral margin of the mandibular body and juxtaposed to its lateral face, using as an anatomical reference the interalveolar space existing between the first two lower premolar teeth (Fig. 3).

Table I. Morphometric values of the hemi mandibles (n=8) of *Lycalopex vetulus*.

Measurements	Arithmetic mean and Standard deviation (mm)	Coefficient of variation (%)	*p*-test
LAM	107.58±1.63	1.52	0.717
SAM	12.25±1.03	8.47	0.858
DPM	1.24±0.24	19.53	0.789
DPMM	54.95±0.85	1.56	0.06
DMT	25.76±1.57	6.11	0.07
DPMT	29.45±1.41	4.81	0.697
LACF	1.21±0.007	22.15	0.11
SACF	0.98±0.007	27.04	0.08
CFAM	7.03±0.33	8.24	0.1
CFVM	6.31±0.52	8.34	0.394
LAMF	3.51±0.39	11.24	0.121
SAMF	1.66±0.39	23.71	0.058
MFAM	6.18±0.26	4.24	0.067
MFCT	8.53±0.45	5.33	0.526
MFVM	4.4±0.37	8.49	0.161
LARF	1.41±0.27	19.51	0.069
SARF	0.98±0.22	22.68	0.069
RFAM	4.17±0.25	6.22	0.208
RFVM	1.28±0.39	30.69	0.061
DCM	9.16±1.16	12.76	0.066
DMR	10.26±0.2	2.04	0.81

DISCUSSION

Among the most varied techniques for local anaesthesia, the regional nerve block consists of the most commonly used technique in animal dentistry (Beckman & Legendre). To perform this procedure at the level of the mental nerves, the determination of anatomical references (de Souza Júnior *et al.*) and the precise identification of the location of the mental foramina (Oliveira Júnior *et al.*; Guedes *et al.*) are fundamental for a more correct and efficient execution of this procedure (Oliveira Júnior *et al.*; Guedes *et al.*; de Souza Júnior *et al.*).

For the Hoary Fox, three mental foramina were bilaterally observed along the rostral third of the lateral margin of the mandibular body, being one rostral, one medium and one caudal, which corroborates in number with that reported by Beckman & Legendre for pets, Evans & deLahunta (2017) for domestic dogs and Igado for local dogs in Nigeria. Getty (1986) and König & Liebich (2016) cite that in domestic carnivores, the present number of these foramina can vary from two to three, while Budras *et al.* (2012) and Dyce *et al.* (2010) are less specific, reporting only the presence of a varied number of mental foramina, respectively, for dogs and domestic animals.

On the Maned Wolf (*Chrysocyon brachyurus*), de Souza Júnior *et al.* mentioned the existence of a wide variation in the number of mental foramina, essentially due to a variation of those considered as caudal. In total, 30 of these were counted in 22 hemimandibles, however, without demonstrating how these structures were numerically distributed by each one. Topographically, the most rostral mental foramen was located ventrally to the alveolus of the lower medial incisor tooth in three hemimandibles (13.6 %); and ventrally to the alveolus of the lower lateral incisor tooth in one hemimandibular (4.5 %). The caudal mental foramina were always ventrally between the first two lower premolar teeth in one hemimandible (3.3 %); between the second and third lower premolar teeth in 10 hemimandibles (33.3 %); the alveolus of the lower canine tooth in five hemimandibles (16.7 %); the first premolar tooth in one hemimandible (3.3 %); the second premolar tooth in three hemimandibles (10 %); and the fourth premolar tooth in two hemimandibles (6.7 %) (de Souza Júnior *et al*.).

It should be noted that in *L. vetulus*, the caudal and rostral mental foramina were ventral to the lower third premolar tooth and ventral to the lower intermediate incisor, respectively, similar to that found by de Souza Júnior *et al*. in eight (26.7 %) and 18 hemimandibles (81.9 %) of *C. brachyurus*. Noteworthy was the failure to observe morphometric data for both foramina in domestic or wild species in the literature consulted, as presented here.

On the other hand, the middle mental foramen was observed, in the Maned Wolf, ventral to the lower canine and first premolar teeth in one hemimandible (4.5 %) (de Souza Júnior *et al*.), as noted for the local dogs in Nigeria (Igado), ventral to the first two lower premolar teeth in five hemimandibles (22.8 %) (de Souza Júnior *et al*.). In domestic dogs, its position was reported to be about one third of the distance from the ventral margin to the dorsal margin of the mandible at the root level of the second lower premolar tooth, immediately caudal to the labial frenulum (Lantz, 2003). However, as noted in 16 Maned Wolf hemimandibles (72.7 %) (de Souza Júnior *et al*.), in the Hoary Fox, the middle mental foramen was ventral to the first lower premolar tooth, with a mean distance of 9.16 mm and 10.26 mm, respectively, from the caudal and rostral mental foramina.

As already evidenced by Beckman & Legendre in pets, Igado in local dogs from Nigeria and de Souza Júnior *et al*. in the Maned Wolf, it was also found that the middle mental foramen was the largest of the three mental foramina in the Hoary Fox, presenting a longitudinal axis with an average of 3.51 mm and a sagittal axis with an average of 1.66 mm. Therefore, this is also configured as the preferred anatomical reference point for performing local anaesthetic blockade of the mental nerves (Beckman & Legendre) in the Hoary Fox.

In domestic dogs, the anaesthetic injection must be performed exactly ventral to the root of the second inferior premolar tooth, advancing the needle in rostrocaudal direction from the caudal region to the labial frenulum until the opening of the middle mental foramen (Beckman & Legendre) and, depending on the size of the patient, this can still be penetrated for until four millimetres to the interior of the mandibular canal (Lantz). In domestic felines, application can be performed at the rostral margin of this same frenulum, at a mean distance between the ventral and alveolar margins of the mandibular body (Beckman & Legendre), while in the Maned Wolf, needle penetration of 10 mm from the ventral margin of the mandible was recommended, close to the mouth and at the first lower premolar tooth (de Souza Júnior *et al*.).

For the Hoary Fox, it is indicated that the procedure should be performed from the introduction of the needle for approximately 4.4 mm in ventrodorsally direction, positioning it perpendicularly to the ventral margin of the mandibular body and juxtaposed to its lateral face, using as anatomical reference the interalveolar space existing between the first two lower premolar teeth. Thus, it is believed that the established point for anaesthetic injection (caudal limit of the ventral margin of the middle mental foramen) provides greater safety for its performance since, as mentioned above for small animals, the recommendation for blocking is represented by needle penetration in the direction of the emergence of the mental nerve and artery from this foramen, which makes these structures more exposed to iatrogenic lesions resulting from the technique.

This wide variation of information on the relative positions of the mental foramina and how to proceed to a better desensitization of this site in animals of the same order reinforces the idea that, increasingly, it is necessary to develop and improve anaesthetic techniques supported by the specific morphology of each animal, giving them greater safety during clinical and surgical interventions, especially in wild animals, since most of these procedures were developed for domestic specimens (Moraes, 2016). Therefore, it is reasonable to assume that the extrapolation of anatomical references between species can further increase the rate of practical failures (de Souza Júnior *et al*.) and, in this regard, more morphometric studies involving the mental foramina can support the performance of anaesthetic manoeuvres in animals that do not yet have their anatomy fully known.

Deficiencies in technique and lack of anatomical references, in addition to endangering local structures, hinder a better regional blockade since anaesthetic deposition is easily performed in inappropriate areas. Thus, a possible and consequent pharmacological use greater than necessary would also increase the risk of systemic toxicity (Gregori &

Santos, 1996). On the other hand, if correctly performed, there is a reduction in the concentration of inhaled anaesthetic required, a faster return of the general anaesthetic plan, analgesia during part of the postoperative period, decreased central sensitivity to pain and minimized inflammatory tissue reaction (Hellyer & Gaynor, 1998). The benefits are of great interest in wild canine medicine since patients are often debilitated at the time of the surgical procedure, and there is a complexity in administering various drugs in the postoperative period (Pachaly & Gioso).

CONCLUSIONS

For the adult specimens of Hoary Fox, three mental foramina were observed located in the rostral third of the lateral margin of the mandibular body. One was more caudal, positioned ventrally to the third premolar tooth; one in the middle, located ventral to the first premolar tooth; and one rostral, placed ventrally to the lower intermediate incisor; which was similar numerically and topographically to most of the canines presented in the literature.

The local anaesthetic blockade of the mental nerves in the Hoary Fox should be performed from the introduction of the needle for approximately 4.4 mm in a ventrodorsal direction, positioning it perpendicularly to the ventral margin of the mandibular body and juxtaposed to its lateral face, using as anatomical reference the interalveolar space existing between the first two lower premolar teeth and, thus, preserving the local structures of lesions resulting from the technique itself.

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RESUMEN: Para realizar el bloqueo anestésico local de los nervios mentales, es fundamental determinar referencias anatómicas, incluida la identificación precisa de los forámenes mentales; sin embargo, la literatura no presenta datos específicos referente a estas estructuras en el zorro de campo común. Por lo tanto, el objetivo fue describir la morfometría de los forámenes mentales de esta especie, para correlacionar sus topografías con los puntos de referencia anatómicos mandibulares, apoyando la técnica efectiva para la desensibilización mental. Para este propósito, se utilizaron cuatro mandíbulas de *Lycalopex vetulus* adultos. Bilateralmente, se observaron tres resistencias mentales ubicadas en el tercio rostral del margen lateral del cuerpo mandibular. Uno de ellos es más caudal, posicionado ventralmente hacia el tercer diente premolar inferior; uno mediano, localizado ventralmente hacia el primer diente premolar inferior; y uno rostral, colocado ventralmente al diente incisivo intermedio inferior. No se observaron diferencias estadísticamente significativas entre los antímeros. Por lo tanto, el bloqueo anestésico local de los nervios mentales en esta especie debe realizarse insertando la aguja aproximadamente 4,4 mm en dirección ventrodorsal. Es necesario colocar ésta perpendicularmente al margen ventral del cuerpo mandibular y yuxtapuesto a su cara lateral, utilizando como referencia anatómica, el espacio interalveolar ubicado entre los dos primeros dientes premolares inferiores. De este modo, el punto establecido para la inyección de anestesia (límite caudal del margen ventral del foramen mental medio), proporciona una mayor seguridad para su realización ya que, para los animales pequeños, la recomendación de bloqueo está representada por la penetración de la aguja en la dirección de emergencia del nervio mental y la arteria de este foramen, lo que hace que estas estructuras estén más expuestas a las lesiones iatrogénicas resultantes de la técnica.

PALABRAS CLAVE: Anestesia del área; Odontología; Mandíbula; Morfología; Cráneo.

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