Research Article

Craniometric Analysis of a Cat and Clinical Significance in Performing Dental Nerve Blocks

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Abstract | Dental nerve blocks represent an important segment of pain management during dental procedures in veterinary medicine due to their rapid onset of action, affordability and simple execution. Four different dental nerve blocks have been described in cats: infraorbital, maxillary, inferior alveolar (mandibular) and middle mental block. Considering the size of a cat's head and location of important anatomical structures, iatrogenic trauma can happen very easily while performing dental nerve blocks. This study aimed to investigate morphometric details of the skull and mandible nerve foramina as crucial structures for the precise administration of local anesthetics. The research included skulls and mandibles of 12 domestic shorthair cats. The morphometric analysis was performed on 20 parameters. Our study revealed smaller values (6.25 ± 0.31 mm) for the distance from the infraorbital canal to the root of premolar compared to Persian and Australian domestic cats. The present study provided a valuable information about the location of the cranial nerves on the skull and mandible of the domestic shorthair cats, which can be useful during dental procedures.

Keywords | Morphometry, Cats, Dental procedures, Nerve blocks

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INTRODUCTION

Pain represents a welfare issue that causes distress and affects the life quality in both humans and animals (Watanabe et al., 2019). The pain that accompanies dental procedures is mostly somatic and not visceral, which is an important fact to consider when choosing appropriate analgesics (Woodward, 2008). The modern approach to pain management in small animal dentistry involves the use of multimodal and preemptive analgesia, which implies a combination of opioids, alpha-2 agonists, nonsteroidal anti-inflammatory drugs (NSAIDs) and local/regional anesthesia (Beckman, 2006). Many advantages of using regional anesthesia for the patient include: lowering the level of general anesthesia; offering analgesia in the initial hours following the procedure; collaborating with opioids, alpha-2 agonists, and NSAIDs; and serving as an additional means of pain relief (Woodward, 2008). Although the pharmacologic agents employed for regional anesthesia vary depending on the practice, lidocaine, bupivacaine, and mepivacaine are the most often utilized local anesthetics (Rochette, 2005). Infraorbital, maxillary, inferior alveolar (mandibular), and middle mental blocks are the four dental nerve blocks that have been reported in cats (Shilo-Benjamini et al., 2022).

The caudal, middle and rostral maxillary alveolar nerves and the infraorbital nerve are all desensitized by performing the infraorbital nerve block. This block anesthetizes the maxillary molar teeth, premolars, the canine and incisor teeth and their associated buccal gingivae and buccal mucosas, as well as cutaneous structures of the rostral maxilla and upper lip on one side (O'Morrow, 2010). Given that cats' globes are relatively large, their orbits are close to their mouth cavities, and there is no bone barrier between them, extra caution must be used when executing this block. Globe perforation usually leads to endophtalmitis which, in most cases, results in palliative enucleation (Volk et al., 2018).

The maxillary nerve block is performed when major pain control is desired, and it desensitizes the major and minor palatine nerves. It provides anesthesia for dentition, bone and soft tissues of the entire hemimaxilla (Rochette, 2005; O'Morrow, 2010).

The inferior alveolar/mandibular block desensitizes the mandibular nerve which provides sensation to the mandibular teeth to the midline. It can be performed both intraorally and extraorally (Rochette, 2005).

The middle mental block desensitizes the mental nerve which exits the middle mental foramen located between the third premolar and the canine tooth, midway down the lateral aspect of the mandible in the cat (Woodward, 2008). Structures that are anesthetized by performing the middle mental block are incisors, cuspids and first three premolars, as well as adjacent bone and soft tissues. The mental foramen can be hard to palpate in small cats, which is why the mandibular block is an alternative in that kind of situation (Rochette, 2005).

Performing dental nerve blocks is not a risk-free procedure. Several complications are possible, including physical trauma to nerves and blood vessels which could lead to neuropathies and bleeding/hematoma. Intravascular administration of the local anaesthetic may cause dysrhythmia and bronchospasm (Hale 2007; Woodward, 2008). Iatrogenic trauma can happen very easily while performing regional blocks on a cat's head because of the size and location of important anatomical structures (Pumphrey et al., 2021). With the aim of safe administration and better distribution of local anesthetics, morphometric measurements of infraorbital, mandibular and mental foramina are of essential value. Even though some data on the morphometry of individual foramina of the cats are present in the available literature, the aim of this study is to present the morphometry of all the foramina that are essential for regional anaesthesia in one place.

MATERIALS AND METHODS

The skulls and mandibles of 12 domestic shorthair cats were used in the study. The study materials were obtained from euthanized animals due to terminal illnesses. The muscles and the fasciae were dissected, boiled and macerated to remove the fat, and finally the skulls were bleached with 3% hydrogen peroxide solution. The morphometric analysis of the infraorbital, mandibular and mental foramina was performed on twenty metric parameters and the mean value and standard deviation were calculated for each parameter (Figures 1-4). These parameters were measured using an electronic digital caliper with a precision of 0.01 mm. The following measurements were made following data suggested by a series of authors (Barosso et al., 2009; Avdić et al., 2013; Saber et al., 2016; Magalhães et al., 2019) with some adaptations:

1 – Length of the sagittal axis of the infraorbital foramen
2 – Distance between the ventral end of the caudal margin of the infraorbital foramen and the alveolar margin of the maxilla
3 – Distance between the ventral end of the caudal margin of the infraorbital foramen and the orbital margin in the level of the lacrimal foramen
4 – Distance between the ventral end of the caudal margin of the infraorbital foramen and the dorsal end of the frontal process of the zygomatic bone
5 – Distance between the ventral end of the caudal margin of the infraorbital foramen and the rostral end of the alveolar margin of the incisive bone in the level of the first upper incisor tooth
6 – Distance between the ventral end of the caudal margin of the infraorbital foramen and the caudal end of the nuchal crest at the level of the median sagittal plane
7 – Length of the mandible from the condylar process to the oral margin of the mandibular symphysis
8 – Width of the mandible at the height of PM4
9 – Distance between the mandibular foramen and the ventral margin of the mandible
10 – Distance between the mandibular foramen and the angular process of the mandible
11 – Distance between the mandibular foramen and the condylar process of the mandible
12 – Distance between the mandibular foramen and the coronoid process of the mandible
13 – Distance between the caudal mental foramen and the caudal border of the mandible
14 - Distance between the middle and caudal mental foramina
15 – Distance between the middle mental foramen and the

canine alveolus
16 - Diastema (C – PM3)
17 – Distance between the dorsal limit of the caudal mental foramen and the alveolar margin of the mandibular body
18 – Distance between the ventral limit of the caudal mental foramen and the ventral margin of the mandibular body
19 – Distance between the middle mental foramen and the alveolar margin of the mandibular body
20 – Distance between the ventral margin of the middle mental foramen and the ventral margin of the mandibular body

Figure 1: Measurements of the infraorbital foramen.
1. Length of the sagittal axis of the infraorbital foramen; 2. Distance between the ventral end of the caudal margin of the infraorbital foramen and the alveolar margin of the maxilla

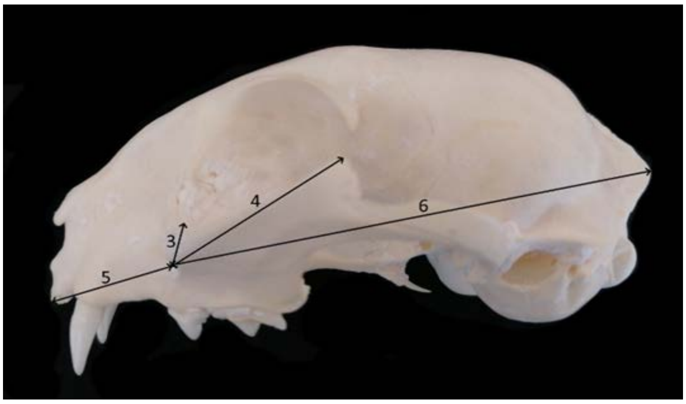

Figure 2: Measurements of the infraorbital foramen.
3. Distance between the ventral end of the caudal margin of the infraorbital foramen and the orbital margin in the level of the lacrimal foramen; 4. Distance between the ventral end of the caudal margin of the infraorbital foramen and the dorsal end of the frontal process of the zygomatic bone; 5. Distance between the ventral end of the caudal margin of the infraorbital foramen and the rostral end of the alveolar margin of the incisive bone in the level of the first upper incisor tooth; 6. Distance between the ventral end of the caudal margin of the infraorbital foramen and the caudal end of the nuchal crest at the level of the median sagittal plane

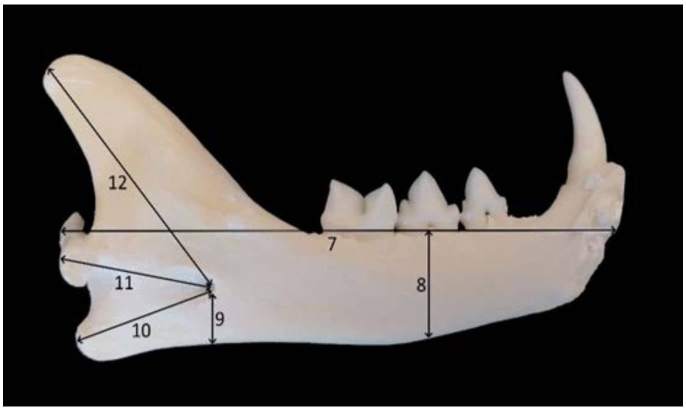

Figure 3: Measurements of the mandibular and mental foramina (medial aspect).
7. Length of the mandible from the condylar process to the oral margin of the mandibular symphysis; 8. Width of the mandible at the height of PM4; 9. Distance between the mandibular foramen and the ventral margin of the mandible; 10. Distance between the mandibular foramen and the angular process of the mandible; 11. Distance between the mandibular foramen and the condylar process of the mandible; 12. Distance between the mandibular foramen and the coronoid process of the mandible

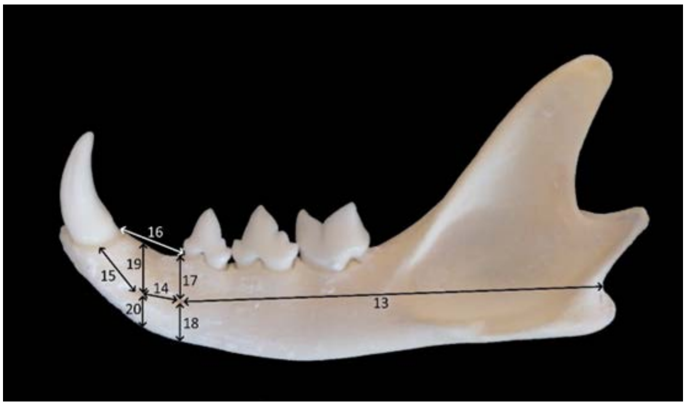

Figure 4: Measurements of the mandibular and mental foramina (lateral aspect).
13. Distance between the caudal mental foramen and the caudal border of the mandible; 14. Distance between the middle and caudal mental foramina; 15. Distance between the middle mental foramen and the canine alveolus; 16. Diastema (C – PM3); 17. Distance between the dorsal limit of the caudal mental foramen and the alveolar margin of the mandibular body; 18. Distance between the ventral limit of the caudal mental foramen and the ventral margin of the mandibular body; 19. Distance between the middle mental foramen and the alveolar margin of the mandibular body; 20. Distance between the ventral margin of the middle mental foramen and the ventral margin of the mandibular body

RESULTS AND DISCUSSION

Anatomical measurements are essential for improving our understanding of the anatomy of the organs and for developing more effective treatment plans for them. Foramina,

Table 1: Skull and mandible measurements

Parameters	Domestic shorthair Mean ± SD (mm)	Australian cat Mean ± SD (cm)	No defined breed Mean ± SD (mm)	Persian cat Mean ± SD (cm)
1	4.17 ± 0.63			
2	6.25 ± 0.31	0.7 ± 0.2		0.94 ± 0.08
3	3.27 ± 0.27			
4	28.52 ± 1.34			
5	22.81 ± 1.95			
6	74.01 ± 2.34			
7	54.51 ± 5.45	6 ± 0.6	51.47 ± 4.01	8.3 ± 1.03
8	9.87 ± 1.12		8.6 ± 1.07	
9	3.99 ± 0.90	0.7 ± 0.2	4.17 ± 1.21	0.8 ± 0.66
10	12.86 ± 2.51	1.5 ± 0.2	12.37 ± 1.47	
11	13.50 ± 1.63		21.93 ± 1.98	
12	23.34 ± 3.67		11.00 ± 1.72	
13	42.36 ± 4.25	4.3 ± 1.3		6.9 ± 1.48
14	3.67 ± 0.73	0.4 ± 0.1		
15	6.14 ± 0.82	0.9 ± 0.1		
16	6.33 ± 1.12	0.9 ± 0.3		
17	4.72 ± 0.66			
18	4.80 ± 0.54			
19	3.32 ± 0.44			
20	5.65 ± 0.91			

which are tiny apertures found in many anatomical locations, are essential features for accurately delivering local anesthetic during dental block procedures. However, given the size of cats, this procedure can be quite difficult and requires a thorough study of feline cranium anatomy and related components. The morphometric details of the skull and mandibular nerve foramina and cranium have been revealed by the present investigation. Table 1 provides a summary of these results by displaying the mean values and the accompanying standard deviations.

The infraorbital foramen, serving as the oral aperture of the canal, encompasses the *n. infraorbitalis* and its associated vascular structures. Positioned dorsally relative to the second maxillary premolar tooth, the distance between the infraorbital foramen and the alveolar margin of the maxilla was 6.25 ± 0.31 mm, while the average length along the sagittal axis of the infraorbital foramen measured 4.17 ± 0.63 mm. The orbital margin was situated approximately 3.27 mm away from the infraorbital foramen. These measurements yield useful information that can improve the accuracy and safety of infraorbital block operations.

The mandible is composed of right and left halves, that are joined medially through oral parts by fibrocartilaginous symphysis. This joint permits some movement, thus it's not very rigid. The total length of the mandible from the condylar process to the oral margin of the mandibular symphysis was 54.51 ± 5.45 mm. Two parts of the mandible, a horizontal body (*corpus mandibulae*) and vertical part (*ramus mandibulae*) form the canal (*canalis mandibulae*) which carries the nerve that can be used for both mandibular and mental nerve blocks. The *n. alveolaris inferior* enters from the mandibular foramen on the lingual side of the ramus. The foramen was situated 13.50 ± 1.63 mm from the condylar process of the mandible. The rough angular process projects backwards from the posterior border and serves as an orientation point during the administration of a mandibular nerve block. The measured distance between angular process and mandibular foramen was found to be 12.86 ± 2.51 mm. The ventral border of the mandible positioned almost 4 mm away from the foramen.

Two mental foramina for the branches of the mental nerve are located on the buccal surface of the mandible. The prominent middle mental foramen was positioned approximately at the midpoint of the diastema and maintained a distance of 3.32 mm from the alveolar margin. Furthermore, a significant measurement was derived from the canine alveolus, yielding a distance of 6.14 ± 0.82 mm. The distance between the middle and caudal mental foramina was 3.67 ± 0.73 mm.

The anatomy of a cat's skull is very different from that of a dog. Although cats have a reduced number of teeth in both maxilla and mandible, the teeth along with their roots and the associated neurovascular supply, occupy over 70% of the mandibular body, which makes surgical procedures quite challenging (Lombardero et al., 2021). The morphometric studies of the skull and mandible are often used in taxonomy and sex determination (Szara et al., 2022; Gundemir et al., 2023).

Numerous morphometric studies have been published on the osteometric analysis of cat skulls and mandibles. These studies aim to provide comprehensive topographical information, facilitating more precise and effective application of regional anaesthesia (Barroso et al., 2009; Monfared, 2013; Saber et al., 2016). Most of these studies focused on specific cat breeds providing valuable anatomical references for future morphometric research in this field. The study performed on Persian cats, showed that the distance from the infraorbital canal to the root of premolar was 0.94 ± 0.08 cm, and similar result was reported in the Australian domestic cat 0.7 ± 0.2 cm (Monfared, 2013; Saber et al., 2016). The same measurement reported in other carnivores such as the hoary fox was 4.19 ± 0.10 mm (Magalhaes et al., 2020). Our study revealed smaller values compared to other cat breeds (6.25 ± 0.31 mm). The inferior alveolar (mandibular) nerve block provides regional anaesthesia for all soft tissues and dentition on that side of the mouth (Rochette, 2005). According to Barroso et al. (2008) the mandibular foramen has been remote from the angular process 12.37 ± 1.47 mm and from the mandible ventral margin 4.17 ± 1.20 mm. For Persian cats, the distance between the foramen and the ventral margin was 0.8 ± 0.66 cm (Monfared, 2013). Similar values were reported for the Australian domestic cat, between foramen and angular process 0.9 ± 0.3 cm, and from foramen and ventral margin 0.4 ± 0.1 cm (Saber et al., 2016). Our findings were in accordance with the previous study on cats, the distance for angular process was 12.86 ± 2.51 mm, and for ventral margin of the mandible 3.99 ± 0.90 mm.

In the study by Saber et al. (2016), it was noted that there is a greater distance between the middle mental foramen and the canine alveolus in Australian cats, measuring 0.9 ± 0.1 cm, compared to our findings, which measured 6.14 ± 0.82 mm. Additionally, a prior investigation reported that Persian cats have the longest mandibles at 8.3 ± 1.03 cm, surpassing Australian cats at 6 ± 0.6 cm, while domestic shorthairs exhibited the shortest mandibles at 54.51 ± 5.45 mm (Monfared, 2013; Saber et al., 2016). In contrast, wild carnivores displayed significantly larger and more robust mandibles. The jackal's total mandible length was recorded at 113.2 ± 3.6 mm, the hoary fox 107.58 ± 1.63 mm and the red fox exhibited a length of 98.3 ± 4.8 mm (Magalhaes et al., 2019; Hadžiomerović et al., 2022).

CONCLUSIONS AND RECOMMENDATIONS

The osteometric measurement plays an important role in the study of the foramina in cats and its application in regional anaesthesia for dental nerve blocks. An understanding of the location and dimensions of the foramina in the feline head is essential for successful administration of regional anaesthesia. Veterinarians can use this knowledge to minimize pain and discomfort during dental procedures, thus improving the overall welfare of cats.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

NOVELTY STATEMENT

The obtained results provide a valuable information about the position of the cranial nerves on the skull and mandible of the domestic shorthair cats, which can be useful during dental procedures.

AUTHOR'S CONTRIBUTION

All authors have equally contributed to this manuscript.

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