

Comparison of three regional anaesthetic techniques for infraorbital or maxillary nerve block in cats: a cadaveric study

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Abstract

Objectives The maxillary nerve courses very close to the globe, rendering cats – with their large eyes – at risk of globe penetration during infraorbital or maxillary nerve blocks. Therefore, the goals of the study were to compare the distribution and potential complications of three infraorbital or maxillary regional injection techniques.

Methods Twenty-three bilateral maxillae of cat cadavers were used in a randomised blinded trial. Each maxilla was injected with a 0.2 ml 1:1 mixture of lidocaine 2% and a contrast medium by one of three injection techniques: infraorbital foramen (IOF; $n = 14$); infraorbital canal (IOC; $n = 16$); or maxillary foramen (MF; transpalpebral approach; $n = 16$) using a 25 G 1.6 cm needle. CT imaging of each cadaver head was performed before and after injections. A radiologist scored injectate distribution (none [0], mild [1], moderate [2], large [3]) in four locations: rostral, central and caudal IOC, and at the MF, for which the distribution side was also determined. Comparisons were performed with ordinal logistic mixed effects ($P < 0.05$).

Results The median (range) total distribution score of the IOC and MF technique were significantly higher compared with the IOF technique (6.5 [4–12], 4 [2–8] and 0 [0–10], respectively). The total IOC score was also significantly higher compared with the MF technique. Injectate distribution at the MF was significantly more central following IOC injection compared with MF injection, which distributed centrolaterally. None of the techniques resulted in intraocular injection.

Conclusions and relevance The IOC and MF techniques produced a satisfactory spread of the mixture that could result in effective maxillary anaesthesia in cats. Further studies are required to determine the effectiveness and safety of these techniques.

Keywords: Dental nerve block; infraorbital canal; infraorbital nerve; maxillary nerve; regional anaesthesia

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Introduction

Dental nerve blocks provide excellent perioperative analgesia and have been used successfully for many years in humans and in horses under sedation.^{1–3} Administration of dental blocks have also been reported as adjuvants to general anaesthesia during dental procedures in cats.^{4–7} Four primarily dental nerve blocks have been described in cats: maxillary and infraorbital, which supply the caudal and rostral maxillae, respectively, and inferior alveolar and middle mental, which supply the caudal and rostral mandible, respectively. Blocking both the maxillary and inferior alveolar nerves results in desensitisation of the entire oral cavity.^{7,8}

The maxillary nerve courses on the orbital floor ventral to the globe, in the pterygopalatine fossa, before

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entering the infraorbital canal (IOC) via the maxillary foramen (MF). Cats have large prominent eyes, and their IOC is only a few millimetres in length,^{9,10} which is much shorter than in dogs. Thus, cats are at increased risk of globe penetration while performing the maxillary nerve block via commonly used techniques. Recently, a case report described a globe penetration with catastrophic outcome (vision loss, glaucoma and eventually enucleation) following a maxillary nerve block in a cat.⁹ In order to avoid this potential complication, some authors recommend injecting outside the infraorbital foramen (IOF).¹¹

To our knowledge, no studies have investigated the local anaesthetic distribution, and potential complications of the current local anaesthetic techniques prior to maxillary dental procedures or oral surgery in cats, despite these being widely used. In this study we suggest the use of a new maxillary nerve block via the MF, using the transpalpebral approach. The objectives of this study were to evaluate injectate distribution and potential complications with three different infraorbital and maxillary nerve block techniques in cats: outside the IOC; inside the IOC; and at the MF. Our hypotheses were that injection at the MF would produce a comparable or better distribution of injectate with fewer complications compared with the infraorbital injection technique, and that both techniques would provide better distribution than an injection outside the IOC.

Materials and methods

Twenty-three cadavers of cats that died or were euthanased due to terminal illness not related to this study, and were donated for unrestricted use by their owners, were used in this study. Three injection techniques and the maxillary side to be treated (right or left) were randomly

assigned using a computer-generated random list (<https://www.random.org/lists/>). The IOF injection was performed at the IOF opening and digital pressure was applied on the injection site (n = 14). The IOC injection was performed by advancing the needle 3–4 mm into the IOC (n = 16). The MF injection via the transpalpebral approach was performed by inserting the needle through the lower conjunctiva at the mid-inferior orbital rim, advancing it ventrally 4–5 mm to approach the MF opening, while gently pressing the globe caudally (n = 16; Figure 1). A board-certified veterinary anaesthesiologist experienced with these techniques performed all injections.

Cadavers were positioned in sternal recumbency with the head levelled on a plastic surface at a height of 8–10 cm. A 25 G, 5/8 inch (1.6 cm) needle (Kendall Monoject; Covidien) was used for all techniques to inject 0.2 ml of a 1:1 volume ratio mixture of lidocaine 2% (Lidocaine 2%; B Braun) and a contrast agent (iohexol 300 mg/ml [Omnipaque; GE Healthcare]).

CT imaging (MX8000 IDT, 16-slice multidetector CT; Philips) was performed on all cadaver heads, prior to injections and 10 mins after injections, in order to establish the distribution of the combined anaesthetic–contrast mixture. All CT scans were performed using 0.8 mm thick contiguous transverse slices, which were acquired with a soft tissue reconstruction algorithm. Images were reviewed on a dedicated viewing software (Fujifilm Synapse) in bone and soft tissue windows. A radiologist, masked as to the injection techniques, scored the injectate distribution at four transverse planes: rostral, central and caudal of the IOC, and at the MF. The scoring was according to injectate volume of distribution in the IOC/MF in percentage of the canal/foramen size and was scored on a scale of 0–3, where 0 = no contrast

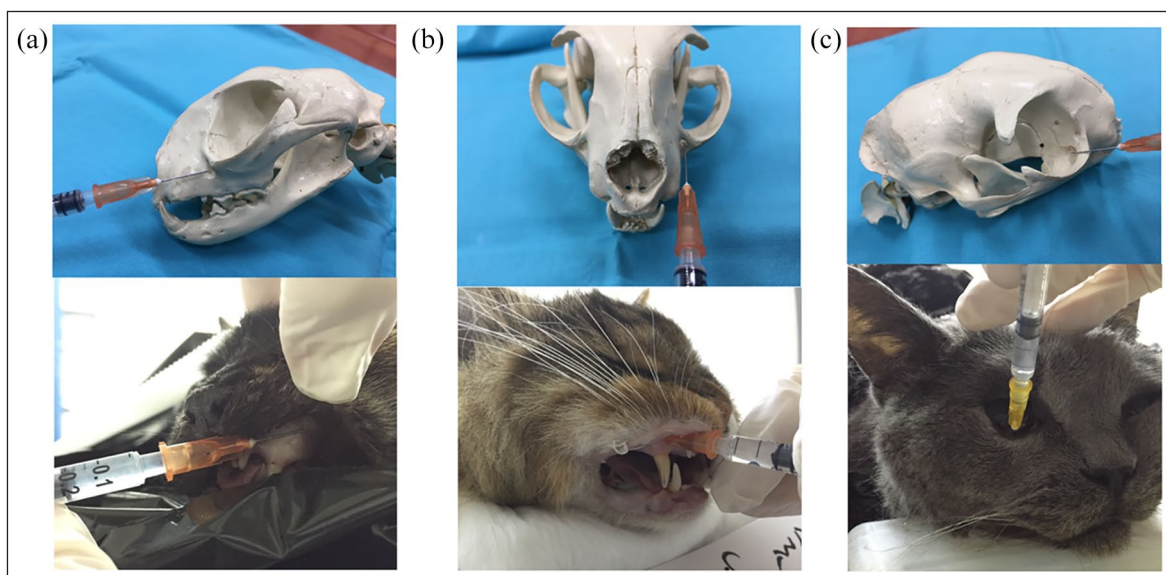


Figure 1 Needle insertion approaches to the infraorbital or maxillary nerve injection presented on a cat skull and cat cadavers: (a) infraorbital foramen; (b) infraorbital canal; and (c) maxillary foramen

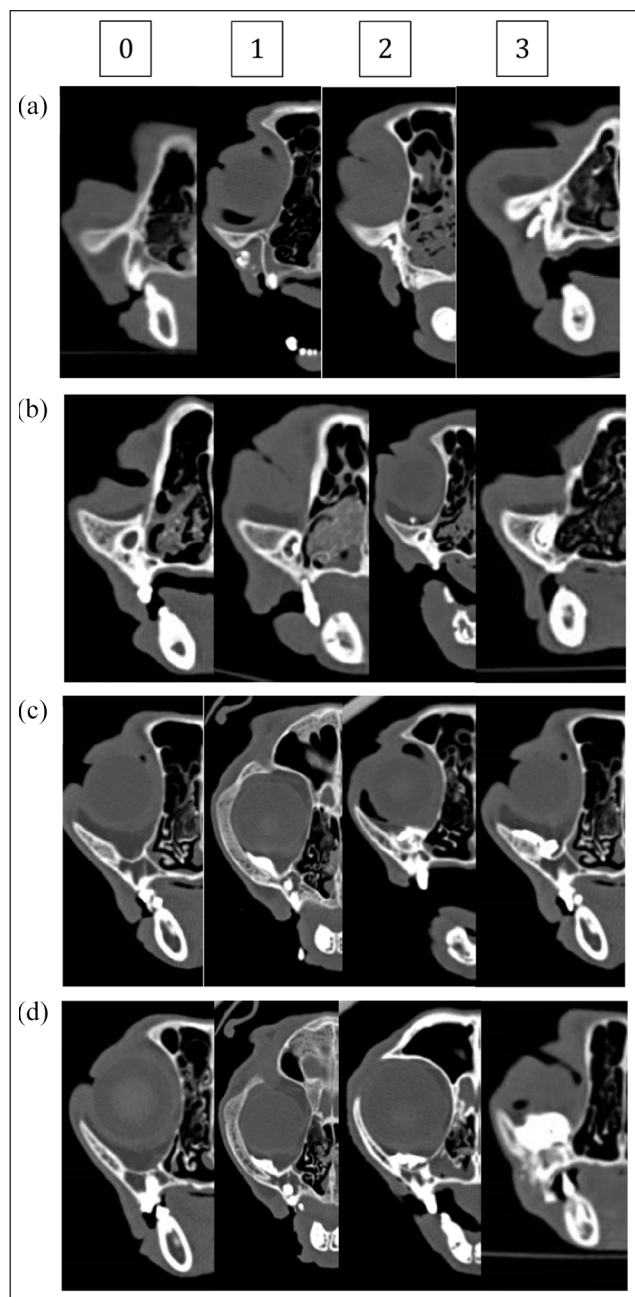


Figure 2 Injectate distribution scoring guidelines on a scale of 0–3 (0 = none, 1 = mild distribution, 2 = moderate distribution, 3 = large distribution), at the (a) rostral, (b) central and (c) caudal infraorbital canal, and (d) at the maxillary foramen

distribution noted; 1 = mild distribution noted (10–30%); 2 = moderate distribution noted (40–70%); and 3 = large distribution noted (80–100%) (Figure 2). A total score of distribution throughout the IOC and MF was calculated by addition of all scores. The side of contrast agent distribution at the MF was also determined and scored on a scale of 0–5, where 0 = no contrast noted; 1 = lateral distribution; 2 = centrolateral distribution; 3 = central distribution; 4 = centromedial distribution; and 5 = medial distribution.

Statistical analysis

The cat data are presented as mean \pm SD. The scoring data are categorical and, as such, are presented as median (range). Ordinal logistic mixed effects was used to model the potential effect of injection approach on volume of distribution scores. Maximum likelihood estimation was used to compare the total scoring of each approach. For all analyses, $P < 0.05$ was considered significant. Data analyses were performed using Stata version 15.0.

Results

Forty-six maxilla of 23 cat cadavers (12 males and 11 females) were used in this study. Injections were performed 36 ± 32.4 h (range 0.6–96) after euthanasia (cadavers were kept at 2–4°C until use). The age and body weight of the cat cadavers were 7.8 ± 5.3 years (range 0.5–19) and 3.7 ± 1.2 kg (range 1.9–6.5). Seven cats were considered cachectic and one cat was brachycephalic.

The scoring distribution of the three techniques along the IOC and MF based upon imaging data are presented in Figure 3. Injectate distribution at the rostral aspect of the IOC was significantly higher with the IOC approach compared with the IOF and MF approaches (2 [0–3], 0 [0–3] and 0 [0–1]; $P = 0.005$ and $P = 0.03$, respectively). Injectate distribution at the central aspect of the IOC was significantly higher with the IOC approach compared with the IOF approach (1.5 [1–3] and 0 [0–3]; $P = 0.005$). The distribution score following the MF approach at the central canal was not different than with the other two techniques (0.5 [0–2]). Injectate distribution at the caudal aspect of the IOC was significantly higher with the IOC and MF approaches compared with the IOF approach (2 [1–3], 1 [0–3] and 0 [0–3]; $P < 0.001$ and $P = 0.002$, respectively). Injectate distribution at the MF was significantly higher with the IOC and MF approaches compared with the IOF approach (1 [0–3], 2 [1–3] and 0 [0–1]; $P = 0.003$ and $P < 0.003$, respectively). The total distribution score with the IOC and MF techniques were significantly higher compared with the IOF approach (6.5 [4–12], 4 [2–8] and 0 [0–10]; $P < 0.001$ and $P = 0.038$, respectively). The total IOC score was also significantly higher compared with the MF approach ($P = 0.028$).

During the IOF technique, the needle was inadvertently inserted into the canal in 2/14 maxillae sides (14%), and the distribution was excellent (the total score of these sides was 7 and 10, respectively). One of these cats was brachycephalic.

Injectate distribution at the MF was significantly more central following IOC injection compared with MF injection, which gave centrolateral distribution ($P = 0.022$). Both were significantly different compared with the IOF injection, which gave no distribution at the MF ($P < 0.001$ for both). None of the approaches resulted in intraocular injection or any other noted complication.

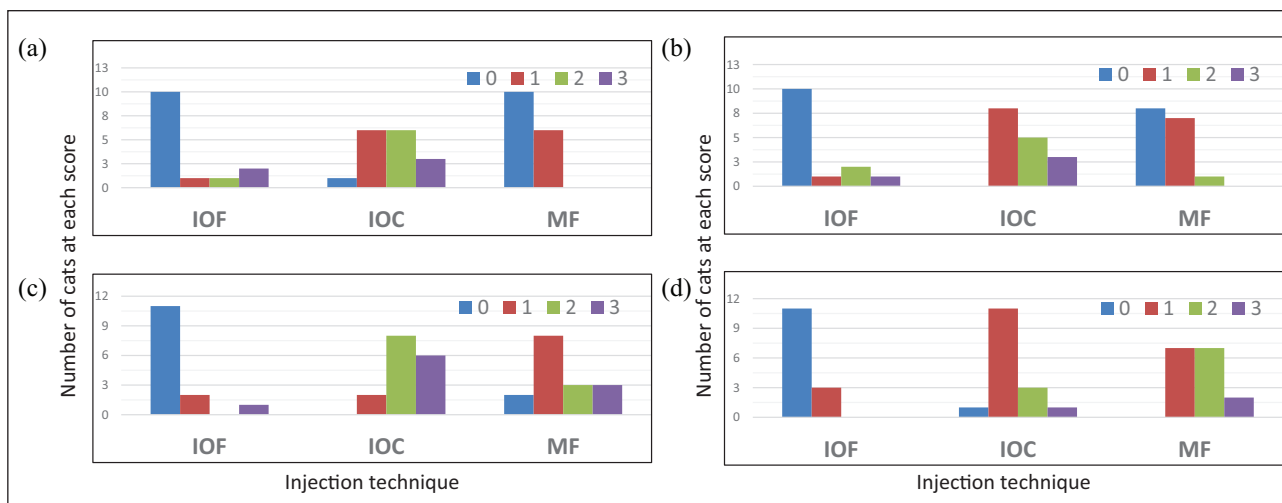


Figure 3 Number of cats according to distribution scores (see Figure 2 for scoring guidelines) at each location: (a) rostral; (b) centre and (c) caudal infraorbital canal; and (d) at the maxillary foramen. Three injection techniques were compared in 23 cat cadavers (46 maxillae): infraorbital foramen (IOF; n = 14), infraorbital canal (IOC; n = 16) and at the maxillary foramen (MF; transpalpebral approach; n = 16)

Discussion

The results of this study suggest that the IOC technique provides the best overall distribution of injectate to the IOC and the MF, and that the MF technique via the transpalpebral approach provided better injectate distribution at the IOC and at the MF than the IOF technique. In order to achieve a wider anaesthetised area, the local anaesthetics should reach the caudal part of the IOC and preferably distribute further caudally to the MF to desensitise the maxillary nerve and the complete maxilla.^{6,12}

The IOF technique, also called a 'cranial infraorbital block', has been described in the veterinary literature as a deposition of local anaesthetic at the entrance to the IOC, and then applying digital pressure to encourage caudal spread of the local anaesthetic into the canal.^{5,6} This technique is specifically recommended for use in cats and brachycephalic dogs, because it is considered to be safer than inserting a needle into the canal and risking globe puncture in animals with short-length IOCs.^{6,11} It has been suggested that because of the very short length of the canal in cats, deposition of the local anaesthetic at the rostral entrance of the canal facilitates caudal spread, and therefore it is not necessary to insert the needle into the canal in cats.¹¹ However, others object to this practice, and suggest that, at this level, the sensory innervation supplies only the nose and upper lip, and does not provide dental analgesia.^{9,13} Although the present study did not use live cats, which may have affected injectate distribution, it was very clear from the results that injecting at the canal entrance does not encourage caudal spread of the injectate into the canal, and therefore this technique is not appropriate for achieving a maxillary nerve block. However, it had a good distribution around the IOF, and therefore it can be used safely for rostral procedures of the

soft tissue. In the present study, 2/14 IOF injections were accidentally inserted inside the IOC, one of them being in a brachycephalic cat. Thus, in breeds with a brachycephalic conformation it is important to be extra cautious when applying the IOF or IOC techniques in order to avoid globe penetration.

The IOC technique is referred to in the veterinary literature as the 'caudal' or 'deep infraorbital block', and has been described as insertion of the needle into the IOC, up to the medial canthus.^{5,6,11} This approach offers several advantages over other techniques used to block the maxillary nerve. First, it ensures that the needle is advanced accurately to the desired location, as was reported in a canine study;¹⁴ and, secondly, the tip of the needle advances parallel to nerves and blood vessels, potentially avoiding perpendicular contact, thus decreasing the risk of damage to these structures. A disadvantage of the infraorbital approach is the fact that it may not consistently anaesthetise the maxillary molar area if, for example, the anaesthetic agent is deposited in the IOC and does not distribute to the pterygopalatine fossa.¹³ In the present study, the overall best distribution score was attributed to the IOC technique and therefore these results support the use of this technique, although a further effectiveness study is advocated.

The IOC technique is frequently described in dogs, as they have a longer IOC and therefore it is safer to insert the needle without the risk of globe penetration. In the present study, there was no evidence of injury to the globe following any of the techniques. It seems that as long as the needle insertion into the canal is performed correctly (ie, only several millimetres deep), the globe should be protected. Another precaution was suggested in a study of dog cadavers, where needle insertion into the IOC was

replaced with an intravenous catheter (20–22 G; 25–48 mm length).¹⁴ However, to our knowledge, this technique has not been reported in cats.

The MF technique was first described anecdotally for dogs in a veterinary dentistry book as an 'extraoral dorsal approach',¹³ and recently it was investigated in 17 dog cadavers as a 'transorbital approach'.¹⁵ The transorbital approach was performed by retropulsing the globe and inserting the needle directed ventrally through the conjunctiva approximately 5 mm lateral to the medial canthus, advancing until it contacted the bone and injecting. Nerve staining length was compared between the transorbital approach and the IOC (percutaneous approach) following methylene blue (1 ml) injection. The transorbital approach provided effective stain distribution as the traditional IOC approach, with both techniques providing 82–88% nerves stained over a length of 6 mm.¹⁵ In the present study, distribution scoring with the MF approach was similar to the IOC approach at the caudal aspect of the IOC and at the MF. Therefore, it is likely that application of local anaesthetics via this technique in feline patients will provide a similar effective local analgesia.

As the maxillary nerve passes medially at the pterygopalatine fossa before entering into the MF and the IOC,¹³ determination of injectate distribution at that area was important. In the present study, the IOC approach provided a more central distribution at the MF than the MF approach. This is attributed to needle placement inside the canal, which keeps the needle centrally positioned. During the MF approach needle insertion was performed at the middle of the lower eyelid, achieving a centrolateral distribution at the MF. In the transorbital dog cadaver study, needle insertion was performed closer to the medial canthus.¹⁵ In retrospect, needle placement should have been directed more medially, at the medial third of the eyelid, in order to achieve a more central distribution at the MF.

Another approach to the maxillary nerve commonly used in cats is referred to in the veterinary literature as the 'intraoral' or 'transoral' technique. The needle is inserted through the mucosa caudal to the last molar tooth and directed dorsally towards the MF. The needle should be inserted no more than 2–4 mm into the tissue.^{9,11,13} A bend of 45° to the needle was described as assisting with directing the tip towards the MF.⁹ Although this technique seems to be commonly used in cats,^{9,11,16} to our knowledge there are no published prospective studies reporting its efficacy and complications.

Globe perforation, which is one of the complications described in the literature,^{9,16} and can be easily detected with CT imaging, was not observed in the present study with any of the approaches. However, owing to the small number of maxillae used for each approach, the probability of globe perforation cannot be completely ruled out. Previous reports of globe penetration include a case in a cat following intraoral/transoral approach to the

caudal maxillary nerve block,⁹ and a case in a brachycephalic dog following an extraoral approach to the caudal maxillary nerve block.¹⁷ The primary disadvantage of both of these approaches is the blind insertion of a needle into the bulbar space in the direction of the globe. A case series from 2019 reported 13 cats with ocular complications (14 eyes) following dental procedures.¹⁶ Maxillary regional anaesthesia was used in 8/13 cats (9/14 eyes), all performed via the transoral approach. Histopathological reports were available only for six enucleated globes, and the site of needle penetration was clearly identified in three of these globes. Although a poor tooth extraction technique may also result in inadvertent penetration of the globe, the authors concluded that the transoral maxillary nerve block should probably not be used further, or only used with extreme caution, in cats.¹⁶ An advantage of the MF approach is that the needle is directed away from the globe and is advanced in close proximity to the orbital wall, therefore reducing the risk of perforation. The reason that the intraoral/transoral approach was correlated with a high incidence of globe penetration could be attributed to the frequent use of this technique in cats, although we are not aware of any study or survey that has investigated the frequency of use of these techniques. It is also important to emphasise that the risk of globe perforation can potentially occur with all the techniques presented in the current study and that caution should be taken with all techniques.

Other risks associated with all regional anaesthesia techniques are intravascular or intraneural injections. It is therefore recommended that negative pressure is applied to the syringe plunger prior to injection, in order to avoid intravascular administration, and to stop injecting if resistance to injection occurs, in order to avoid intraneural injection.¹³ Additionally, when using the MF transpalpebral approach, it is always important to be cautious near the cornea, as accidental corneal scratching may be a potential complication.

The limitations of this study include the relatively small sample size for each approach, and extrapolation of the results from cadavers to live animals. Factors such as blood flow, temperature and other physiological mechanisms are absent in cadavers and may affect the distribution of the mixture solution. In dogs, although methylene blue distribution around the maxillary nerve following IOC seemed adequate in one study,¹⁵ the same technique was inadequate in producing complete block to the caudal teeth in a different experimental setting.¹⁸ In addition, many complications can occur in live animals but not in cadavers (eg, injection into blood vessels, globe penetration or significant haematoma). Distribution could also be affected by physical properties of the injectate that was used. The contrast agent has a very high density, and although lidocaine was added in order to imitate the consistency of local anaesthetics, the distribution may have been reduced.

There are at least five different approaches to the maxillary nerve.¹³ It would have been interesting to compare injectate distribution following the intraoral/transoral and extraoral injection techniques to the IOF, IOC and MF techniques, and to evaluate their complications. Unfortunately, these comparisons were not performed in the present study owing to budget constraints and cadaver specimen availability. Another limitation is that CT resolution is not sufficient to detect small nerves, such as the maxillary and infraorbital nerves in cats. Therefore, it is only assumed that if there is more injected material in the IOC and at the MF, then the injectate had a better diffusion around the nerves and will most likely provide better local anaesthetic effect.

Conclusions

According to the findings of the present study, injection at the IOF, without entering the canal (IOF), did not seem to be effective with regard to caudal injectate distribution, and is probably less likely to produce a good local anaesthetic effect at the maxillary nerve. The mid-IOC will most likely produce the best distribution of injectate to the maxillary nerve and therefore is estimated to achieve a regional anaesthetic effect in live cats; although this technique should be used with caution in order not to accidentally insert the needle too deep and penetrate the globe. The transpalpebral approach (MF) might be a good alternative to the IOC approach in cases where ocular penetration is a concern, such as in brachycephalic cats. The clinical use of these approaches requires further investigation in live cats to determine their safety and efficacy.

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Conflict of interest The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical approval The work described in this manuscript involved the use of non-experimental (owned or unowned) animals. Established internationally recognised high standards ('best practice') of veterinary clinical care for the individual patient were always followed and/or this work involved the use of cadavers. Ethical approval from a committee was therefore not specifically required for publication in *JFMS*.

Informed consent Informed consent (verbal or written) was obtained from the owner or legal custodian of all animal(s) described in this work (experimental or non-experimental animals, including cadavers) for all procedure(s) undertaken (prospective or retrospective studies). No animals or people are identifiable within this publication, and therefore additional informed consent for publication was not required.

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