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RESEARCH PAPER

Ultrasound guided trigeminal nerve approach at the level of the pterygopalatine fossa in cat cadavers

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Abstract

Objective To describe an ultrasound-guided suprazygomatic approach to the trigeminal nerve block in cat cadavers.

Study design Prospective descriptive study.

Animals Ten feline cadaver heads.

Methods A 25:75 methylene blue—iopamidol mixture (0.1 mL cm^{-1} cranium length) was injected into 10 cadaver heads using an ultrasound-guided suprazygomatic approach. A computed tomography (CT) scan was performed to identify contrast presence at the orbital ssure, foramen rotundum and ovale, followed by anatomical dissection to identify staining of the pterygopalatine fossa (PPF), extraconal retrobulbar area, mandibular and maxillary nerves. Descriptive statistics were used to summarize results.

Results A total of 20 injections were performed. Of these, 1/20 misinjection occurred and excluded from further reporting. The volume of injectate was 0.9 (0.9—1.1) mL [median (range)]. Staining of the PPF, extraconal space, maxillary and mandibular nerves over more than 6 mm was achieved in 19/19 (100), 18/19 (95), 17/19 (89) and 19/19 (100) of injections, respectively. CT showed presence of contrast within 5 mm of the orbital ssure, foramen rotundum and ovale in 18/19 (95), 19/19 (100) and 19/19 (100) of the injections, respectively. No intracranial migration was observed.

Conclusions and clinical relevance This cadaver study illustrates that the suprazygomatic ultrasound-guided trigeminal nerve injection technique can successfully stain the PPF, retrobulbar cone extraconally, mandibular and maxillary nerves. Consequently, this technique has the potential to be used *in vivo* in cats to desensitize areas innervated by the trigeminal nerve.

eywords feline, locoregional analgesia, pain, pterygopalatine fossa, trigeminal nerve, ultrasound-guided block.

Introduction

The trigeminal nerve (TN) divides into three main branches before leaving the cranium: the ophthalmic, maxillary and mandibular nerves. These nerves emerge in the pterygopalatine fossa (PPF) through the orbital ssure (OF), foramen rotundum (FR) and foramen ovale (FO), from rostral to caudal, respectively (Jennings Reighard 1901; Hudson Hamilton 2010; Lee et al. 2022). Sensory innervation provided by the TN includes maxillary and mandibular bone, teeth and associated soft tissues including the palate, lower and upper lip, tongue, masseter muscle, skin and oral mucosa, nose, the entire eyeball and orbit, lacrimal gland, upper and lower eyelids (Whalen Kitchell 1983a; Campoy Read 2013; Hudson Hamilton 2010; Lombardero et al. 2021). Branches of the TN also contribute to innervation of the external acoustic meatus, tympanic membrane, parotid salivary gland and pinna, alongside the auricular branches of the facial nerve, great auricular nerve and caudal auricular nerve (Whalen Kitchell 1983b).

The trigeminal nerve block (TNB) aims to desensitize the structures innervated by the maxillary, mandibular and ophthalmic nerves. In human medicine, this block is used to treat migraine, trigeminal neuralgia and orbital pain and to provide analgesia in orthognathic surgery and total parotidectomy (Kendall 2013; Blumenfeld et al. 2015; Gong et al. 2021; Wang et al. 2021; Lee et al. 2022). In veterinary medicine, the use of TNB has been reported in one dog

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undergoing exenteration, excision of the zygomatic arch and caudal maxillectomy (Viscasillas Ter Haar 2017). In dog cadavers, Viscasillas et al. (2019) also described an ultrasound-guided block of the ophthalmic nerve using an approach similar to that used to perform TNB.

The TNB is performed by depositing local anesthetic (LA) in the vicinity of PPF. PPF is a small, fat- lled space that serves as a major neurovascular crossroad and conduit between the oral cavity, nasal cavity, nasopharynx, orbit, masticator space, and the middle cranial fossa. Intracranial migration of the injectate placed in close proximity of the OF has been described in dog cadavers when targeting the ophthalmic branch of the TN (Mahler et al. 2020; Foster et al. 2021) and could potentially lead to central nervous system toxicity. Other mechanisms possibly responsible for central nervous system toxicity include inadvertent intraarterial injection or systemic absorption of the solution owing to the vascularity of the injected area, as described for other locoregional technique of the head in cats and humans (Hamilton, 1985; Nicoll et al. 1987; Dettoraki et al. 2015; Tolesa Gebreal 2016; Oliver and Bradbrook, 2013). The safety of ultrasound-guided suprazygomatic TNBs performed via PPF injections has been recently evaluated in humans (Smith et al. 2022).

Minor oozing from the injection site was the only reported adverse effect in one subject, and this technique is considered a safe and well-tolerated pain management strategy (Smith et al. 2022).

From a search of the literature, a technique to perform an ultrasound-guided block of the TN has not been described in cats. Therefore, the aim of this study was to describe an ultrasound-guided injection technique to stain the TN branches in the PPF in cat cadavers, adapting a technique previously described in dogs, and to report if intracranial migration of injectate occurs (Viscasillas Ter Haar 2017; Otero Portela 2019).

Material and methods

Fifteen frozen heads of adult Domestic Short Hair (DSH) cat cadavers were purchased from an authorized vendor (Skulls Unlimited, OK, USA) and included in this prospective descriptive study. This vendor makes an explicit commitment to obtaining specimens legally and ethically for educational, medical and research communities. Heads were thawed to room temperature for 24 hours before the study day. Heads were positioned in ventral recumbency, and the length of the cranium measured with a pachymeter (Drinyoung Electromechanical Ltd., Zhejiang, China) from the inion to the nasion, to calculate the total volume of injectate to perform the TNB in mL cm^{-1} cranium length, as suggested in dogs (Otero Portela 2019). Five heads were used in a pilot study and 10 in the main study.

Rete mirabile depth calculation

The maxillary artery is used as the landmark to deposit LA in the PPF when performing a TNB in dogs (Viscasillas Ter Haar 2017; Otero Portela 2019). In cats, cerebral blood supply is provided by the maxillary artery via a complex plexus called the rete mirabile (Gillilan Markesbery 1963; Kier et al. 2019). Because this structure cannot be visualized in cadavers, prior to the pilot study, ultrasound Doppler was used in 10 anesthetized adult DSH cats to measure *in vivo* its distance from the skin. These cats were assigned an American Society of Anesthesiologists physical status classi cation of I–II/V and had no evidence of muscle wasting that could have affected the measurements. Ultrasonography was performed using a 5-8 MHz microconvex probe attached to an ultrasound machine (SonoSite Edge II, Fuji lm, WA, USA). The probe was positioned on the temporal area, caudal to the zygomatic process of the frontal bone and the frontal process of the zygomatic bone, with the marker orientated medially. The probe was then rotated rostrodorsally to caudoventrally creating an angle of approximately 45 degrees to the zygomatic bone to obtain a transverse view of the caudal portion of the PPF (Fig. 1). The probe was tilted cranially until the lateral aspect of the frontal bone and the coronoid process of the mandible were visualized, and the vessels of the rete mirabile were identi ed with color Doppler, as similarly described in dogs (Viscasillas Ter Haar 2017; Otero Portela 2019). The distance (in mm) between the rete mirabile and skin was measured in each side of each head and averaged to be used as a reference point to perform the TNB in cadavers. This distance was found to be approximately 20.1 ± 1.6 mm (unpublished data).

Cadaveric pilot study

The pilot study was designed to identify the volume of methylene blue–iopamidol mixture to be used to perform TNBs in the main study. In the pilot study, head length was measured and TNBs performed as described above. After visualization of the lateral aspect of the frontal bone and coronoid process of the mandible with ultrasonography, using the above-described approach, a 22 gauge, 30 degree angle atraumatic short bevel 3.81 cm spinal needle (Avanos Medical, GA USA) connected to a 3 mL syringe was advanced in-plane in a ventromedial direction, with the tip orientated towards the mandible. Based on the data collected in live cats to estimate the depth of the rete mirabile, the needle was advanced to a depth of 20 mm, measured with the ultrasound machine depth ruler (Fig. 1). A predetermined volume of 0.15 mL cm^{-1} cranium length of a room temperature 25:75 methylene blue 1 (Thomas Scienti c, NJ, USA) and iopamidol (Isovue-370; Bracco Diagnostic Inc., Germany) mixture was used (de Miguel Garcia et al. 2020). The rst injection was performed on the left side of the head, as determined by random selection, and all

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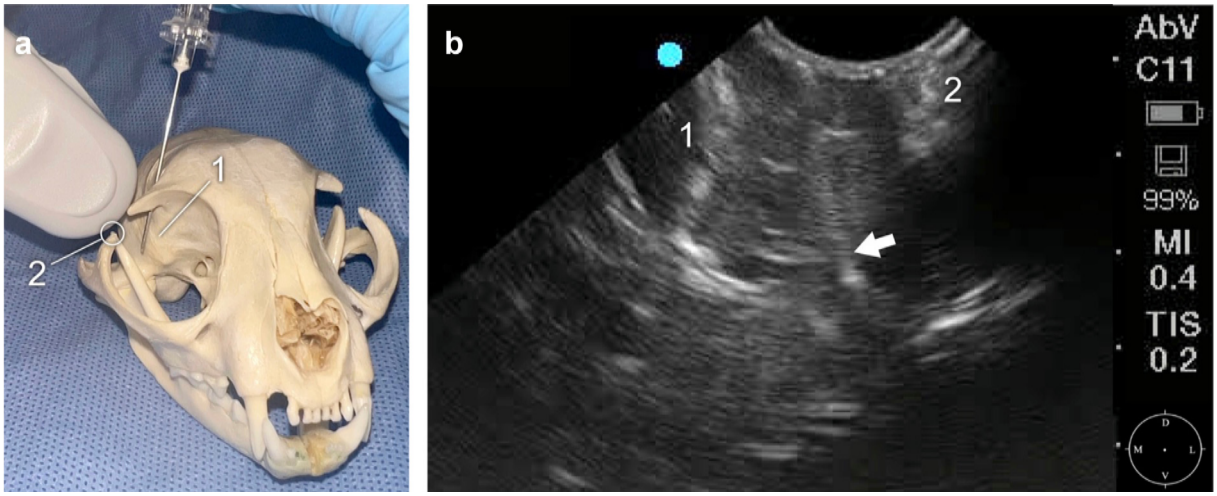

Figure (a) Pterygopalatine fossa in a cat skull and its relation to the position of the ultrasound probe and the needle during trigeminal nerve block execution. (b) Ultrasound image of the caudal portion of the pterygopalatine fossa and the needle during trigeminal nerve block execution in a cat cadaver. White arrow indicates needle. 1, frontal bone; 2, coronoid process of the mandible.

subsequent heads (pilot and main study) were also injected on the left side rst. The spread of the injectate solution in the PPF was observed under ultrasound guidance.

Anatomical dissection was performed immediately after the TNB to con rm the spread of methylene blue in the PPF and along the three branches of the TN over at least 6 mm of nerve length (Raymond et al. 1989). First, a zygomectomy and partial orbitectomy were performed to con rm the staining of the PPF, retrobulbar cone and maxillary nerve (Fig. 2). Next, a 10 cm metal rod was inserted through the infraorbital foramen exiting in a retrograde direction through the maxillary foramen, to locate the maxillary nerve. An additional incision was then made on the ventral aspect of the mandible, medial to its horizontal ramus, to evaluate if staining of the inferior alveolar nerve branch of the mandibular nerve also occurred at this level (Fig. 2). Because of dif culties in consistently isolating the ophthalmic nerve, this branch was considered stained if extraconal staining of the retrobulbar cone occurred, as this nerve travels alongside the extraocular muscles on this structure (Ozudogru Aksoy 2005). The retrobulbar cone was considered stained if methylene blue was present on the entire length of the dorsolateral aspect of the retrobulbar cone, which was exposed after zygomectomy (Fig. 2).

The injectate volume used for subsequent injections was repeated, increased or decreased by 0.05 mL cm^{-1} cranium length as follows: the same volume was repeated if staining of the PPF, retrobulbar cone and maxillary and mandibular nerve for more than 6 mm occurred; the volume was increased if the staining was deemed insuf cient (none, one or two branches stained); the volume was decreased if subjective excessive staining of tissues surrounding the PPF occurred upon visual inspection of the area after anatomical dissection. The injectate

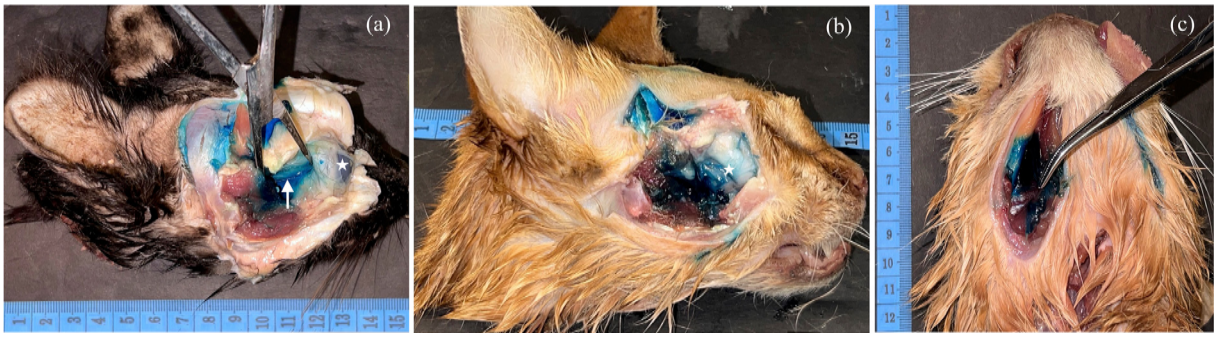

Figure 2 Dissection of a cadaver after trigeminal nerve block execution showing distribution of methylene blue on the retrobulbar cone (a), in the pterygopalatine fossa (b) and at the ventral aspect of the mandible (c). White arrow points at the ophthalmic nerve, and white star marks the ocular globe.

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volume (in mL cm^{-1} cranium length) most consistently associated with staining of the PPF, retrobulbar cone and mandibular and maxillary nerve for at least 6 mm without subjective excessive spread to tissues surrounding the PPF was selected for the main study.

Cadaveric main study

A volume of 0.1 mL cm^{-1} cranium length of a mixture of room temperature 25:75 methylene blue 1 and iopamidol was injected at this level for the TNB using the same technique as described in the pilot study (Fig. 1).

With the head positioned in ventral recumbency, a computed tomography (CT) scan, obtained using a 16 slice multidetector CT scanner (*Lightspeed16; GE Medical Systems, WI, USA), was performed before each TNB. A second CT scan was performed as soon as each TNB was completed. For each CT scan, images were obtained as follows: helical acquisition, 0.5625 spiral pitch factor, 0.625 mm slice thickness, 120 kVp, 120–150 mAs, 96 mm eld of view and 512 512 matrix with bone and soft tissue algorithm reconstructions. The scans extended from the external nares to the occipital crest.

All CT scan data were stored in DICOM format in a picture archiving and communication system (AGFA Healthcare Enterprise Imaging version 8.1, Belgium) and later analyzed by a third year veterinary radiology resident (CSB). Images were reviewed using a window level of 500 HU and width of 2000 HU for the bone algorithm reconstructions and a window level of 50 HU and width of 350 HU for the soft tissue algorithm reconstructions, with widening of the window width as necessary for visualization of contrast media margination. The distance (in mm) between contrast media and the nearest osseous margin of the OF, FR and FO was assessed using multiplanar reconstructions. Oblique planes were applied when the margins of the contrast media and foramina were out of plane from one another in the traditional sagittal, transverse and dorsal planes. Images were evaluated for the presence of iopamidol contrast intracranially and intraconally in the retrobulbar cone.

Each CT scan performed post-TNB was immediately followed by anatomical dissection of the injected side to con rm the spread of methylene blue in the PPF and along the three branches of the TN for at least 6 mm of nerve length (Raymond et al. 1989). Anatomical dissections were performed as described in the pilot study.

Once anatomical dissection of the left side was completed, the pre-TNB CT scan, TNB injection, post-TNB CT scan and anatomical dissection were performed on the right side of the same head, as described for the left side, until all 10 heads were studied, for a total of 20 TNB injections.

The same operator (MFB) performed all TNBs. All anatomical dissections were performed by the same operators (MFB, AC), after being trained by a board-certi ed veterinary dentist (BA). Operators were not blinded.

Statistical analyses

As only one study group was included, a power analysis could not be performed and sample size was chosen based on previously published cadaveric studies (Monticelli et al. 2017; Viscasillas et al. 2019; Foster et al. 2021; Dos-Santos et al. 2021, 2022). Descriptive statistics were used to summarize results. A Shapiro–Wilk test was used to assess data for normality.

Head length (in cm) from the nasion to the inion, total volume (in mL) of methylene blue–iopamidol mixture injected, time (in minutes) between TNBs and post-TNB CT scans and between TNBs and beginning of anatomical dissections, and distance (in mm) between iopamidol contrast and the nearest osseous margin of the OF, FR and FO are reported as either mean and standard deviation (mean ± SD) or median and range (minimum–maximum), if they were normally or not normally distributed, respectively.

The following are reported as fraction (n/n) and percentage ( ) of the total number of injections performed: presence of dye solution in the PPF, presence of dye solution along the retrobulbar cone and mandibular and maxillary nerve for at least 6 mm of nerve length, presence of contrast media intraconally in the retrobulbar cone and intracranially.

Results

The depth of the rete mirabile measured in alive cats while recovering from general anesthesia was 20.1 ± 1.6 mm.

Cadaveric pilot study

A total of 10 TNBs were performed in the pilot study and three volumes were tested (Table S1). The highest volume tested, 0.15 mL cm^{-1} cranium length, was assessed as spreading excessively to the tissues surrounding the PPF. A volume of 0.1 mL cm^{-1} cranium length consistently stained the PPF, retrobulbar area, maxillary and mandibular nerve for a length of at least 6 mm without subjective excessive spread to surrounding areas. The lowest volume tested, 0.05 mL cm^{-1} cranium length, did not achieve consistent staining. For these reasons, an injectate volume of 0.1 mL cm^{-1} cranium length was chosen for the main study.

Cadaveric main study

A total of 10 thawed heads were included in the main study and 20 TNBs performed (10 on the left side and 10 on the right side). For one TNB injection (head number 10, left side), the needle was improperly positioned between the coronoid process of the mandible and the zygomatic arch. This was the

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largest of the heads included in this study, and it is speculated that this might have led to improper identi cation of the bony landmarks in the absence of blood flow in the rete mirabile (an important landmark *in vivo*). The spread of the methylene blue–iopamidol outside of the targeted area was visible on ultrasound during the injection, and improper position of the needle noticed at the end of the injection. Spread of the mixture outside the PPF was con rmed via CT scan and anatomical dissection. Results from this injection were excluded from further reporting as the technique was known to be inaccurate, and remaining results are reported as n/n and of a total of 19 TNB injections correctly performed. Head length was 8.1 (7.9–9.6) cm. The volume of methylene blue–iopamidol mixture used was 0.9 (0.9–1.1) mL. The time between TNBs and post-TNB CT scans and the time between TNBs and the beginning of anatomical dissections was 1 (0.5–2) and 3 (3–5) minutes, respectively.

Based on the CT scan results, iopamidol contrast was almost always found near the nearest osseus margin of the OF, FR and FO assessed in all the planes (Fig. 3). Distances (in mm) between iopamidol contrast and the OF, FR and FO are summarized in Table 1. No contrast was found intraconally in the retrobulbar cone or intracranially. In 1/19 (5) of injections, contrast was found intranasally as a result of migration via the sphenopalatine foramen. Results from the anatomical dissection showed staining of the PPF in 19/19 (100), retrobulbar cone in 18/19 (95), maxillary and mandibular nerves for at least 6 mm length in 17/19 (89) and 19/19 (100) of injections, respectively (Fig. 2).

Discussion

These results suggest that the ultrasound-guided suprazygomatic approach to the TNB tested here could be a suitable option when intending to block the three branches of the TN in dolichocephalic cats. It remains to be determined if the same is true for brachycephalic cats. The volume chosen for this study was selected based on results of the pilot study. In previous studies conducted in canine cadavers, injectate volumes between 0.05 and 0.2 mL cm^{-1} cranium length were used to target branches of the TN (Viscasillas et al. 2019; Mahler et al. 2020; Foster et al. 2021). Intracranial spread via injectate migration through the OF has been reported in 50 of cases when a 0.2 mL cm^{-1} cranium length volume was used to block the ophthalmic branch of the TN in thawed canine cadavers using an injection technique similar to the one tested in the present study (Foster et al. 2021).

In a previous study in thawed dog cadavers, a total of 0.5 mL of a mixture of 50:50 iohexol and methylene blue was injected in the vicinity of the OF to block the ophthalmic branch of the TN, and injections were considered successful if contrast was visualized via CT scan within 5 mm of this foramen (Viscasillas et al. 2019). CT scan results in the present study showed injectate to be within 5 mm from the nearest osseous margin of the OF, FR and FO, except for a single exception (1/19, 5 mm from the OF). Based on Viscasillas et al. (2019), if a successful TNB block is de ned as the presence of injectate within 5 mm of the OF, FR and FO, this yields a successful injection rate of 95 (18/19 injections) in the present study.

For a nerve block to be effective, the nerve length and the number of Ranvier nodes exposed to the LA plays a signi cant role (Raymond et al. 1989). In frogs, when this length is less than 5 mm, an effective local blockade cannot always be achieved (Raymond et al. 1989), but whether this applies to cats is unknown. For this reason, the presence of injectate along the course of the maxillary and mandibular nerves for at least 6 mm in length was used as an indicator of successful staining. Based on these results, it can be speculated that the

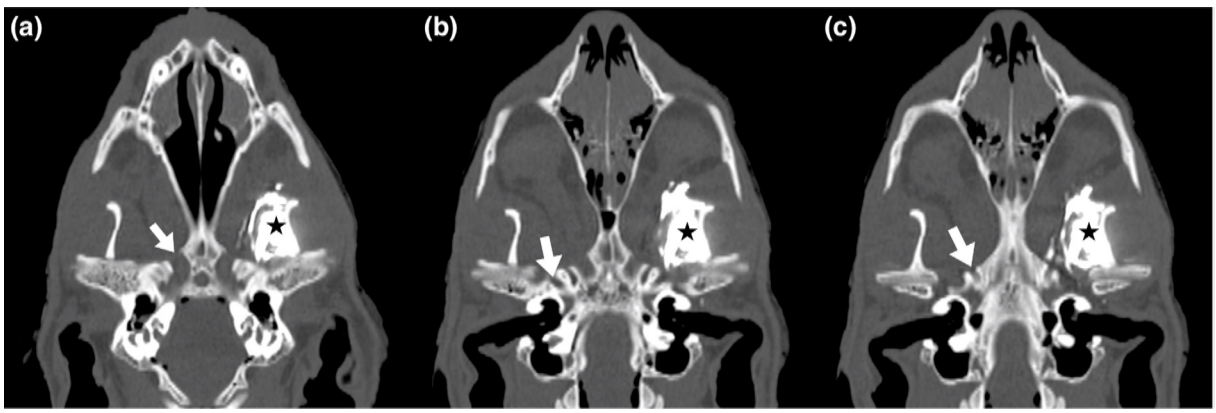

Figure 3 Computed tomography scan images taken after trigeminal nerve block execution showing the distribution of iopamidol in the caudal portion of the pterygopalatine fossa (indicated by black star) and close to the orbital ssure, foramen ovale and foramen rotundum (indicated by white arrow in panel a, b and c, respectively).

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Table 1 Distances (in mm) between iodinated contrast and the nearest osseus margin of the infraorbital ssure (OF), foramen rotundum (FR) and foramen ovale (FO) in 10 thawed feline head cadavers measured in different planes on computed tomography scans after performing trigeminal nerve blocks (TNBs). Data from 19 TNB injections, after excluding one erroneously performed injection (head 10 left side), are shown. Data are presented as mean and standard deviation (mean ± SD).

Head number	Side	TNB number	OF	FR	FO
1	Left	1	4 1	3 4	1
	Right	2	3 7	3 2	2 8
2	Left	3	3	3 3	3 4
	Right	4	3 9	3 4	3 1
3	Left	5	1 6	0 9	1 3
	Right	6	3 5	4 1	3 8
4	Left	7	1 3	0 4	1 8
	Right	8	2 5	2 5	0
5	Left	9	2 1	2 6	2 9
	Right	10	7 5	5	2 8
6	Left	11	1 1	0 7	1 4
	Right	12	3 3	1 8	1 3
7	Left	13	0 8	0 7	0
	Right	14	0 7	0 9	1 4
8	Left	15	1 2	2 1	2 8
	Right	16	2 9	1 6	3 5
9	Left	17	3 5	2 8	3 2
	Right	18	3 1	2 3	2 7
10	Right	19	4 7	3 8	3 4
19 19 TNB injections			2 9 ± 1 6	2 4 ± 1 3	2 2 ± 1 1

technique tested here could be used to effectively desensitize the maxillary and mandibular nerves.

Limitations

Staining of the ophthalmic nerve was assumed to be successful if the dorsolateral aspect of the retrobulbar cone was completely stained, as it was not possible to consistently identify this nerve during anatomical dissections. Consequently, it is unknown if the ophthalmic nerve was consistently stained for at least 6 mm in length and if the TNB technique tested here could be used to effectively desensitize this branch of the TN.

TNBs were performed in thawed cadavers using a mixture of methylene blue and CT contrast, hence distribution of the injected solution may not adequately reflect the spread of a LA when a TNB is performed *in vivo*. Tissue blood flow, compliance and temperature, and drug pharmacokinetics can affect the spread of any solution used for locoregional anesthesia *in vivo* differently than in cadavers. Further to this point, the use of fresh cadavers would have been a better option than thawed cadavers, to limit the impact of autolysis on distribution of the injectate. Thawed cadaveric heads were used because of the unavailability of fresh cadavers. Viscosity, density and temperature of solutions can as well affect migration in the injected area (de Miguel Garcia et al. 2020). The 25:75 solution of 1 methylene blue—iopamidol contrast used (de Miguel Garcia et al. 2020) was kept at room temperature and its density was 1.3 g cm^{-3}, which is higher than the density of room temperature bupivacaine 0.5 and lidocaine 2 , which are commonly used to perform locoregional anesthesia *in vivo* (Paliwal et al. 2024). Moreover, the viscosity of our mixture was not measured. Therefore, it is unknown if the spread of a similar volume of LA in live cats will mimic the spread observed in the results.

If intraneural injection occurs, complications such as paresthesia and anesthesia dolorosa may manifest (Waldman 2015). Although ultrasound guidance was used to avoid this complication, its occurrence could not be assessed in this study. The occurrence of hematoma formation, intravascular injection or systemic absorption could not be assessed in cadavers, and their incidence when this block is performed remains unknown in this species. In this cadaveric study, the correct injection site for the TNB was identi ed solely based on bony landmarks owing to the absence of blood flow in the rete mirabile, which is main landmark when performing this block *in vivo*. This could explain the single misinjection. Accuracy in performing this locoregional technique *in vivo* might increase when the vessels of the rete mirabile can be properly identi ed.

Anatomical dissections and CT scans were performed almost immediately after completing each TNB. In previous studies investigating different locoregional techniques in cadavers, CT scans were run approximately 10 minutes after performing blocks, to allow time for the injected solution to spread (Dos-

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Santos et al. 2021, 2022; Shilo-Benjamini et al. 2022). This means that in the present study, the spread of the injectate to the targeted structures might have been limited by lack of time, and it cannot be ruled out that, if more time had been allowed to pass between each TNB and post-TNB CT scan, injectate might have migrated both closer to the foramina and intraconally into the retrobulbar cone. If so, it may be argued that intracranial migration could have occurred, as previously reported in studies in dog cadavers that aimed to block the ophthalmic branch of the TN by injectate delivery in the PPF (Mahler et al. 2020; Foster et al. 2021). In the studies of Foster et al. (2021) and Viscasillas et al. (2019), the ophthalmic branch of the TN was targeted in thawed dog cadavers with the same injection technique tested here, using a 50:50 methylene blue–CT contrast mixture. Foster et al. (2021) used a volume of 0.2 mL cm^{-1} of cranial length of mixture, and intracranial spread was reported in 50 of cases when CT scans were run upon completion of the injections (the actual time between injection and CT scan was not reported). In the study by Viscasillas et al. (2019), a smaller volume (0.5 mL) of mixture was used and intracranial migration was never observed, even when CT scans were run hours after performing the injections.

In a study by Mahler et al. (2020), the needle was introduced with a subzygomatic approach and directed medially and dorsocaudally towards the OF. A total volume of 0.1 mL kg^{-1} of a 50:50 mixture of CT contrast and 0.9 saline was used in fresh dog cadavers weighing 10.8 ± 1.1 kg in order to target the ophthalmic branch of the TN. Intracranial migration of contrast was seen in 100 of cases via rostral alar foramen migration (Mahler et al. 2020). It could be speculated that orientation of the needle towards the OF, rather than perpendicular to it, as in the present study, increased the risk of intracranial migration.

From the literature and the present study, it remains unclear to what extent the following factors, in isolation or by interaction, affect solution spread and potential for intracranial migration: time elapsed between injections and CT scans, the injection technique, the direction and orientation of the needle, and the volume and mixture of injectate. *In vivo*, if intracranial migration of LA occurs, clinical signs vary and may include brainstem anesthesia, seizures and transient contralateral hemiparesis. Although usually transient, permanent damage may occur in some cases and cardiopulmonary arrest is also possible (Hamilton 1985; Nicoll et al., 1987; Tolesa Gebreal 2016; Benumo, 2000).

Conclusions

In thawed cat cadavers, a suprazygomatic ultrasound-guided TNB with 0.1 mL cm^{-1} cranium length methylene blue 1 –iopamidol delivered via PPF injection resulted in successful deposition of the mixture in close proximity to the OF, FO and FR. Staining of the PPF, retrobulbar cone, maxillary and mandibular nerve was achieved without intracranial spread. Further studies *in vivo* are needed to determine if the same volume of LA can be safely and effectively used in cats to desensitize the structures innervated by the three branches of the TN using the technique tested here.

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Authors' contributions

MFB, AC and CB: study design, data collection, interpretation and analysis, manuscript preparation and revision. BA: study design, data collection, manuscript revision. EW: helped with a proof-of-concept development prior to the pilot study, manuscript revision. BP: study design, data interpretation, manuscript revision. All authors approved the nal manuscript for publication.

Con ict of interest statement

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Additional Supporting Information may be found in the online version of this article: https://doi.org/10.1016/j.vaa.2024.08.003.

Table S . Pilot cadaveric study.

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