Anatomical description of the trigeminal nerve [v] and its branching in mongrel dogs

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Abstract

For this study we had 10 (ten) dead bodies of dogs bearing different constitutional types. The following procedure for fixation was done in each animal: on both sides, the common carotid artery was cannulated and a 10% formaldehyde solution was then stilled. After fixation, the heads were separated from the bodies and the dissection of the target-region was performed according to classical dissection protocols, which included the removal of the skin and muscle and nerve exposition plus a further magnifying glass-aided dissection of the trigeminal nerve [V]. This study aimed to describe the anatomy of the main trunk and branching of the trigeminal nerve [V] on mongrel dogs, compare its characterization to those described in human beings and to obtain, data that conclude whether structural or branching differences of this nerve are closely related to different constitutional types of mongrel dogs.

Keywords: anatomical, trigeminal, nerve, dogs, branching.

1 Introduction

Perhaps the human being was aware of the similarity involving his own body organization to that of other animals, especially mammals, and could not deny that the spirit of life (anima) is also seen on both. The morphofunctional organization of neural structures on men and animals has a common model, and that is one of the reasons why experiments in animals are accepted in neurosciences (PRADA, 1997).

The trigeminal palsy (Bell's palsy) induced by tumors, nerve fiber degenerative diseases of the trigeminal nerve and its branching (PALMER, 2007; SCHULTZ, TUCKER, GAVIN et al. 2007), functional impairment of the trigeminal (SCATENA, 2008), tongue or mouth cancer (NIEMIEC, 2005), and also dental pathologies (endodontitis and periodontitis) triggered by unbalanced diet on dogs and cats (DEBOWES, 2005; LYON, 2005; ROCHETTE, 2005; LORENZ and KORNEGAY, 2006) are more and more recurrent in vet offices and hospitals. Based on these facts, we describe anatomically the trigeminal nerve and its branching on mongrel dogs and compare their characterization to that described in human beings in order to obtain data that conclude whether structural or branching differences of this nerve are closely related to different constitutional types of mongrel dogs and to aid in diagnostic accuracy, surgical procedures, and dental treatment that require regional anesthesia in trigeminal innervated areas.

2 Material and methods

This study used 10 (ten) mongrel dogs bearing different constitutional types legally granted by the county ZCC (Zoonosis Control Center) of Alfenas, MG, Brazil, and was performed at the Laboratory of Anatomy of the Federal University of Alfenas-MG (UNIFAL) according to ethical principles in animal experimentation and approved by the Ethical Committee (225/2009).

In each animal, the common carotid artery was cannulated on both sides and a 10% formaldehyde solution was then stilled. After fixation, the heads were separated from the bodies and the dissection of the target-region was performed according to classical dissection protocols, which included the removal of the skin and muscle and nerve exposition (EVANS and DELAHUNTA, 2001) with a further magnifying glass-aided dissection of the trigeminal nerve [V] for the recognition of the origin, pathway, and branching of the nerve.

3 Results

The trigeminal nerve is the fifth cranial nerve and it is distributed only in the head (Figure 1). Its apparent origin is in the brainstem through two roots: a greater, thicker, and sensitive root and a lesser, thinner, and motor root. Further its emergence, the two roots of the trigeminal nerve pass anteriorly to end in the trigeminal ganglion, which is located in the anterior surface of the petrous part of the temporal bone in the trigeminal impression. From this ganglion, arise the three main branches of the trigeminal nerve: ophthalmic nerve, maxillary nerve, and mandibular nerve. Respectively, they leave the cranial cavity through the superior orbital fissure, foramen rotundum and foramen ovale (Figures 2 and 3). In order to be more didactical, we will describe these three main branches and branching founded in separated subtitles.

3.1 Ophthalmic nerve [V1]

It is the most medial branch and arises from the anterior margin of the trigeminal ganglion. It passes anteriorly to



Figure 1. Left lateral view showing the average distribution pattern of the trigeminal nerve.



Figure 3. Trigeminal ganglion (white arrow) and its branches: ophthalmic nerve (light gray arrow), maxillary nerve (dark gray arrow) and mandibular nerve (black arrow). Sensitive root (1) arising from the pons (2).



Figure 2. Right lateral view showing the mandibular nerve leaving the cranial cavity through the foramen ovale (white arrow) and the maxillary nerve leaving it through the foramen rotundum (gray arrow).

reach the orbital cavity through the superior orbital fissure, where it eventually branches (Figure 4).

3.2 Maxillary nerve [V2]

It arises from the median part of the anterior margin of the trigeminal ganglion. After emerging, it passes anteriorly and leaves the cranial cavity through the foramen rotundum. Reaching and crossing the pterygopalatine fossa, it comes to the orbital cavity and passes anteriorly as the infra-orbital nerve. Passing along the infra-orbital canal, it becomes superficial in the face through the infra-orbital foramen (Figure 5).

Because of its relatively long pathway, the maxillary nerve has many branches that spread to all areas it passes by. Thus, there are branches within the cranial cavity and branches in the pterygopalatine fossa within the infra-orbital canal and in the face. The former are after the nerve and passes through the infra-orbital foramen.



Figure 4. Ophthalmic nerve pathway and its branches: frontal nerve (light gray arrow), with its medial supratrochlear (dark gray arrow) and lateral supraorbital (white arrow) branches and the lacrimal nerve (black arrow).

- A Branches arising within the cranial cavity.
- A1 Meningeal branch: responsible for the sensitive innervation of the cranial dura-mater.
- B Branches arising in the pterygopalatine fossa.
- B1 Zygomatic nerve: it arises in the pterygopalatine fossa and passes to the orbital cavity. It sends the zygomaticotemporal branch, that reaches the lateral part of the forehead, and the zygomaticofacial branch, which supplies the skin over the facial prominence.
- B2 Ganglionic branches to the pterygopalatine ganglion: there are two or three tiny branches that join the maxillary nerve to the pterygopalatine ganglion (functionally related to the facial nerve). These tiny branches pass through the ganglion without synapsing and then divide into four distinguished groups:



Figure 5. Maxillary nerve pathway in the pterygopalatine fossa, piercing the infra-orbital canal. Posterior superior alveolar branches (white arrow).



Figure 7. Greater palatine nerve pathway after piercing the greater palatine foramen (white arrow) through the greater palatine groove (black arrow).



Figure 6. Greater palatine nerve passing over the greater palatine canal (black arrow) and sending the posterior inferior nasal nerves (white arrow).

3.3 Orbital group

Here we find the orbital branches which are responsible for the sensitive supply of the orbital cavity periosteum and mucous membrane of the frontal and sphenoidal sinuses and ethmoidal cells.

3.4 Palatine group

a) Greater palatine nerve: it leaves the pterygopalatine fossa to pierce along the greater palatine canal. It reaches the hard palate through the greater palatine foramen (Figure 6). Then, it passes in the greater palatine groove anteriorly to the hard palate and at the level of the superior canine tooth it apparently joins the nasopalatine nerve (Figure 7). The greater palatine nerve provides sensitive innervation to the mucous membrane and palatine gingiva in the superior molar and premolar teeth regions. It also has branches that supplies part of the mucous membrane of the nasal cavity, the so-called caudal nasal nerve (Figure 8).



Figure 8. Posterior superior and inferior nasal branches within the nasal cavity. White arrow indicates the nasopalatine nerve pathway.

b) Lesser palatine nerves: they leave the pterygopalatine fossa through the greater palatine canal, together with the greater palatine nerve. More inferiorly, they leave this canal and pierce the pyramidal process of palatine bone to reach the soft palate. They supply the mucous membrane of the soft palate and send a tonsillar branch to the palatine tonsil.

3.5 Nasal group

In this group, stand out the posterior superior nasal branches. They leave the pterygopalatine fossa and enter the nasal cavity through the sphenopalatine foramen. They supply the majority part of the mucous membrane. Their larger branch is the nasopalatine branch (Figure 8). It descends close to the nasal septum, passes anteriorly to pierce the incisive canal and reach the anterior region of the hard palate through the incisive foramen. The nasopalatine branch supplies the mucous membrane and palatine gingiva in the superior incisive and canine teeth region.

3.6 Posterior superior alveolar branches

These are the ultimate branches in the pterygopalatine fossa. They pass inferiorly beneath the maxillary tuberosity and send branches that supply the vestibular gingiva in the superior molar and premolar teeth regions and the cheek mucous membrane close to molar teeth region (Figure 5). Afterwards, they pierce the alveolar foramina in the level of the maxillary tuberosity and send branches to the mucous membrane of the maxillary sinus, periodontium, alveolar processes and pulp cavity of the superior molar teeth (dental branches).

- C Branches arising in the infra-orbital canal: within this canal two branches can emerge.
- C1 Middle superior alveolar branch: it travels all over the anterior wall the maxillary sinus and supplies its mucous membrane, periodontium, alveolar process and pulp cavity of the superior premolar teeth.
- C2 Anterior superior alveolar branches: they also arise within the infra-orbital canal. They travel all over the anterior wall of the maxillary sinus and supply its mucous membrane, vestibular gingiva in the superior incisive and canine teeth region, periodontium and the alveolar process and pulp cavity of the superior incisive and canine teeth (dental branches).
- D Branches arising in the face: these branches become superficial after the emergence of the infraorbital nerve through the infra-orbital foramen. They are: inferior palpebral branches which supply the skin and the conjunctiva of the lower eyelid; external and internal nasal branches that supply the mucous membrane of the nasal septum and ala of nose; and superior labial branches supplying the skin and mucous membrane of the upper lip, labial glandulae, vestibular gingiva of superior teeth and vibrissae of the upper lip and snout (Figure 9).

3.7 Mandibular nerve [V3]

It is the third division of the trigeminal nerve [V]. It arises from the lateral part of the anterior margin of the trigeminal

ganglion and leaves the cranial cavity through the foramen ovale (Figure 2). At the level of this foramen or just out of it, the mandibular nerve joins the motor root of the trigeminal nerve and forms the main trunk of the mandibular nerve (Figure 10). After a 1-2 mm short pathway this main trunk divides into an anterior division (lesser) and a posterior division (greater).

• *A - Branches of anterior division:* this division presents a larger amount of motor nerve fibers than sensitive ones. The following branches were observed:

3.8 Masseteric nerve

It is responsible for the motor innervation of the masseter and probably for sending tiny branches that supply the temporomandibular joint (TMJ).

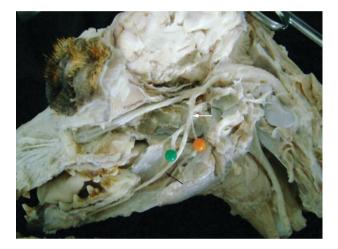


Figure 10. Posterior division of the main trunk (white arrow) of the mandibular nerve showing its branches: nerve to mylohyoid (orange arrow), inferior alveolar nerve (black arrow) and lingual nerve (Green arrow).



Figure 9. Ending branches of the infra-orbital nerve externally to the infra-orbital foramen (white arrow indicates superior labial branches and black arrow indicates nasal branches).



Figure 11. Left lateral view showing the inferior alveolar nerve traveling along the mandibular canal (white arrow) and sending dental branches to inferior premolar and molar teeth (black arrows).

3.9 Nerves to lateral and medial pterygoid

We observed that these nerves arise from the anterior division of the mandibular nerve and they supply the motor innervation of these muscles (Figure 11).

3.10 Deep temporal nerves

In number of two, one anterior and one posterior, they supply the anterior and posterior parts of the temporal muscle, respectively.

3.11 Buccal nerve

Although pertaining to the anterior division, it bears sensitive nerve fibers (Figure 11). It supplies the cheek skin and mucous membrane, except that of the region supplied by the posterior superior alveolar branches from the maxillary nerve.

• *B* - *Branches of posterior division:* this division has a larger amount of sensitive nerve fibers than the motor ones. From the posterior division of the mandibular nerve of the dissected dogs, arise the branches that are described as follows.

3.12 Auriculotemporal nerve

It descends laterally to the middle meningeal artery and after that passes posteriorly to the TMJ and reaches the temporal region (Figure 11). In its long posterior pathway, it crosses the parotid gland and the zygomatic arch and ends in the lateral region of the head as superficial temporal branches which supply the skin of this area, ear, TMJ, and parotid gland.

3.13 Lingual nerve

It is a sensitive-predominant nerve. From its origin in the posterior division of the mandibular nerve, it passes inferiorly between the lateral and medial pterygoids and reaches the pterygomandibular space (space between the medial surface of the ramus of mandible and the superior part of the lateral surface of the medial pterygoid), anterior and medial to the inferior alveolar nerve and to the nerve to mylohyoid (Figure 10). The lingual nerve leaves the pterygomandibular space in an oblique anterior and inferior pathway and passes between the styloglossus and mylohyoid muscles ending in the anterior part of the mucous membrane of the floor of the mouth. The following branches were observed:

- a) Branches to isthmus of fauces: supply the homonymous structure.
- b) Sublingual nerve: sensitive supply of the submandibular and sublingual glands.
- c) Lingual branches: general-sensitive supply of the anterior two thirds of the tongue (Figure 10).
- d) Gingival branches: supply the lingual gingiva of all inferior teeth.

3.14 Inferior alveolar nerve

After its emergence, it descends between the lingual nerve and the nerve to mylohyoid (Figure 10), passes between the pterygoid muscles, and pierces into the pterygomandibular space. Afterwards, it leaves this space and pierces the mandibular foramen with the inferior alveolar vessels. It travels along the mandibular canal and divides into a mental nerve and an incisive nerve at the level of the inferior premolar teeth (Figure 12). The mental nerve leaves the mandibular canal through the middle mental foramen, but before its emergence it sends a branch that leaves the mandibular canal through the caudal mental foramen. The mental branches supply the skin and mucous membrane of the lower lip, skin of the chin and vestibular gingiva of the inferior incisive and canine teeth. The incisive nerve travels within the mandibular canal and ends at the level of the mandibular symphysis. There is a tiny branch that pierces through the rostral mental foramen and supplies the neighboring region.

The inferior alveolar nerve supplies the alveolar process in the inferior premolar and molar teeth region (bony branches) and the periosteum of the mandible body in the same region; vestibular gingiva of the inferior premolar and molar teeth (gingival branches) and the pulp cavity of the same teeth (dental branches). The incisive nerve, a prolongation of the inferior alveolar nerve, supplies the same structures listed above but in the incisive and canine teeth regions.

3.15 Nerve to mylobyoid

It is probably a mixed nerve that reaches the anterior margin of the mandible and sends a branch to the anterior belly of the digastric and to the mylohyoid. It provides motor nerve fibers to these muscles and sensitive nerve fibers to the neighboring skin (Figures 10 and 11).

4 Discussion

The anterior superior alveolar branches arise within the infra-orbital canal. They pass over the anterior wall of the maxillary sinus and supply the mucous membrane of the maxillary sinus, vestibular gingiva of superior incisive, and canine teeth, periodontium and alveolar process in the superior incisive and canine teeth region; the dental branches supply the pulp cavity of the superior incisive and canine teeth. Getty (1986), Evans and DeLahunta (2001) assert that the branches arising from the infra-orbital canal are the facial branches only and the middle superior alveolar branch but not the anterior superior alveolar branch.



Figure 12. Distribution of the branches from the anterior division of the mandibular nerve: buccal nerve (1), nerve to medial pterygoid (2), and from the posterior division: lingual nerve (3), inferior alveolar nerve (4), nerve to mylohyoid (5) and auriculotemporal nerve (6).

The ophthalmic nerve is the branch that arises more medially from the anterior margin of the trigeminal ganglion. It travels anteriorly to pierce the orbital cavity through the superior orbital fissure, and then it branches. Nevertheless, none of the branches has a direct relationship with structures within the oral cavity. According to Getty 1986 and Dyce, Sack and Wensing (2004), the ophthalmic nerve still divides into lacrimal, nasociliary, and frontal branches. The last one presents itself with two branches: one medial, the supratrochlear, and one lateral, the supra-orbital.

We observed that the nerves to lateral and medial pterygoids arise from the anterior division of the mandibular nerve and they send motor nerve fibers to these muscles. According to Getty 1986, the nerves to lateral and medial pterygoids arise from a nerve to pterygoids (common trunk), which emerges from the anterior margin of the mandibular nerve. This was not found in our samples.

In our study, we also observed that the deep temporal nerves are generally a pair, one anterior and one posterior that supply the respective parts of the temporal muscle and arise directly from the mandibular nerve. In a different way, Getty 1986 finds that the deep temporal nerves arise directly from the masseteric nerve.

According to Dyce, Sack and Wensing (2004), after leaving the foramen ovale, the mandibular nerve sends the auriculotemporal masseteric buccal nerves and the nerve to pterygoids. In our study we observed further that the mandibular nerve through its posterior division still sends the lingual, inferior alveolar nerves and the nerve to mylohyoid besides the auriculotemporal nerve.

The buccal nerve, which for us arises from the anterior division, has sensitive nerve fibers that supply the cheek skin and mucous membrane, except that of the region supplied by the posterior superior alveolar branches from the maxillary nerve and superior molar teeth region, but to Getty 1986 the buccal nerve arises from a common trunk joining the masseteric nerve.

According to many other authors (DYCE et al., 2004; KONIG and LIEBICK, 2004; ROSA, ESCOBAR and BRUSCO 2007; EVANS and MILLER, 1993), the nerve to mylohyoid is a caudal branch of the inferior alveolar nerve, but in our samples this nerve presents itself as a branch of the posterior division of the main trunk, so as the inferior alveolar and lingual nerves.

As formerly asserted, the buccal nerve although being a part of the anterior division has sensitive nerve fibers that supply the cheek skin and mucous membrane, except that of the region supplied by the posterior superior alveolar branches from the maxillary nerve and superior molar teeth region, but to Getty 1986 the buccal nerve arise from a common trunk joining the masseteric nerve.

According to our study, the anterior superior alveolar branches arise within the infra-orbital canal, pass over the anterior wall of the maxillary sinus, and supply its mucous membrane, vestibular gingival of the superior incisive and canine teeth, periodontium, alveolar process of the superior incisive and canine teeth region (bony branches), and the pulp cavity of the superior incisive and canine teeth (dental branches). Getty 1986 describes that the branches arising within the infra-orbital canal are the facial branches only and the middle superior alveolar branch, but not the anterior superior alveolar branch. As far as we are concerned, the lingual and gingival branches described in this paper were not considered in any literature.

5 Conclusion

From what was asserted above, we conclude that the following data is worthy: the pattern of pathway and branching of the trigeminal nerve in mongrel dogs suggest a great similarity to those described in human beings presenting only slight differences of pathway due to constitutional type and anatomical structures found exclusively in flesh-eating mammals.

On further studies, we intend to accomplish quantitative and functional studies on the trigeminal nerve and its branches in order to clarify some functional aspects of this nerve.

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