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Trigeminal Cave and Ganglion: An Anatomical Review

Cavo y Ganglio Trigeminal: Una Revisión Anatómica

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AJAYI, N. O.; LAZARUS, L. & SATYAPAL, K. S. Trigeminal cave and ganglion: an anatomical review. ***Int. J. Morphol., 31(4)***:1444-1448, 2013.

SUMMARY: The trigeminal cave (TC) is a special channel of dura mater, which extends from the posterior cranial fossa into the posteromedial portion of the middle cranial fossa at the skull base. The TC contains the motor and sensory roots of the trigeminal nerve, the trigeminal ganglion (TG) as well as the trigeminal cistern. This study aimed to review the anatomy of the TC and TG and determine some parameters of the TC. The study comprised two subsets: A) Cadaveric dissection on 30 sagitally sectioned formalin fixed heads and B) Volume injection. We found the dura associated with TC arranged in three distinct layers. TC had relations with internal carotid artery, the cavernous sinus, the superior petrosal sinus, the apex of petrous temporal bone and the endosteal dura of middle cranial fossa. The mean volume of TC was 0.14 ml. The mean length and breadth of TG were 18.3 mm and 7.9 mm, respectively, mean width and height of trigeminal porus were 7.9 mm and 4.1 mm, respectively, and mean length of terminal branches from TG to point of exit within skull was variable. An understanding of the precise formation of the TC, TG, TN and their relations is important in order to perform successful surgical procedures and localized neural block in the region of the TC.

KEY WORDS: Trigeminal cave; Trigeminal ganglion; Trigeminal nerve; Middle cranial fossa.

INTRODUCTION

The trigeminal cave (TC) is a special channel of dura mater, which extends from the posterior cranial fossa into the posteromedial portion of the middle cranial fossa at the skull base (Sabanci *et al*., 2011). It is also called Meckel's cave, after Johann Friedrich Meckel the Elder (1724–1774), who first described it in 1748 (Janjua *et al*., 2010). The TC contains the motor and sensory roots of the trigeminal nerve (TN), the trigeminal ganglion (TG) as well as the trigeminal cistern (Kapila *et al*., 1984; Daniels *et al*., 1986). The trigeminal cistern is formed by the dural-arachnoid pouch behind the trigeminal ganglion, which contains cerebrospinal fluid. This cistern communicates with the infra-tentorial basal cistern via the trigeminal porus (Chui *et al*., 1985).

The dura forming the wall of the TC is evaginated between the fibrous and endosteal dural layers of the middle cranial fossa. Therefore, above the cave lie two fused fibrous dural layers continuous with each other around the superior petrosal sinus, while inferiorly its fibrous wall is fused to the endosteal layer of dura mater (Last, 1984). It is this potential cleavage plane between the two fused layers that forms the anatomic basis for the extradural surgical approach to Meckel's cave (Al-Mefty *et al*., 2002). Due to the complexity of this small space and its proximity to many important neural and vascular structures, an understanding of its anatomy is of clinical importance in the evaluation of patients with symptoms referable to the TG and TN or with abnormalities in this region (Kapila *et al*.).

This study aimed to review the anatomy of the TC and TG and determine the following parameters of the TC: (i) dural arrangement (ii) relations (iii) volume (iv) dimensions of TG (v) dimensions of the trigeminal porus, and (vi) the length of the divisions of the TN from TG to their points of exit in the skull.

MATERIAL AND METHOD

The study comprised two subsets: A) Cadaveric dissection: Thirty sagitally sectioned formalin fixed heads were dissected at the Department of Clinical Anatomy, University of Kwa-Zulu Natal (Westville Campus) to expose the TC, the TG and the dura mater investing the TN and its branches (which are the ophthalmic (V1), maxillary (V2) and mandibular (V3) divisions). The cerebral hemispheres were carefully removed in a manner that retained the dura

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mater around the hemispheres as well as the pons uninterrupted. Dural arrangements were recorded and the pons was resected. The endosteal layer of dura mater was stripped away from the lesser wing of sphenoid bone and the lateral margin of dorsum sellae to expose the TG. B) Volume injection: Dyed gelatin was introduced into the TC through the trigeminal porus. The injection of the gelatin was stopped when it started overflowing through the trigeminal porous into the posterior cranial fossa; volumes of the injected gelatin were recorded by a calibrated syringe.

RESULTS

Dural arrangement: Three distinct layers of dura were associated with TC viz. (a) Around the TN, the dura was thin, transparent and continuous with the dura around the pons (Fig. 1); (b) Distal to the TN, the dura forming the roof of the TC was composed of two layers that were continuous with the tentorium cerebelli; (c) Distal to the TN, covering the floor of the TC: the dura was composed of two layers- continuous with endosteal dura of clivus.

Relations of TC: Medially: internal carotid artery (ICA); anteriorly: cavernous sinus; superiorly: superior petrosal sinus (Fig. 2); posteriorly: apex of petrous temporal bone; inferiorly: endosteal dura of middle cranial fossa. In 4/30 specimens; the ophthalmic division was noted to run immediately above ICA.

Mean volume of TC (ml): 0.14 (range 0.05-0.4). Mean length and breadth (mm) of TG: 18.3 (12.2-23.3); 7.9 (4.6- 9.3), respectively. Mean width and height (mm) of trigeminal porus: 7.9 (5.3-10.2); 4.1(1.9-5.8), respectively.

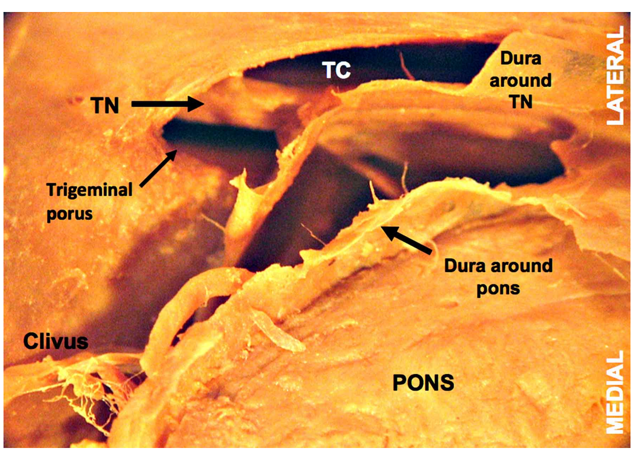

Fig. 1. Superio-lateral view of the pons and skull showing the trigeminal cave, trigeminal ganglion, trigeminal porus and the trigeminal nerve. TC= Trigeminal cave, TN= Trigeminal nerve.

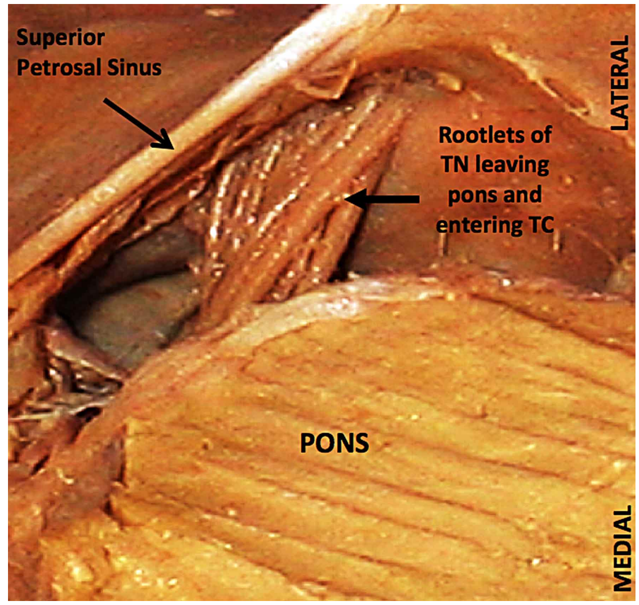

Fig. 2. Supero-lateral view of brainstem and skull showing the TN rootlets and the superior petrosal sinus. TC= Trigeminal cave.

Mean length (mm) of terminal branches from TG to point of exit within skull (Fig. 3): ophthalmic division: 28.0 (range: 19.7-36.6), maxillary division: 12.7 (range: 8.8-17.5) and mandibular division: 3.6 (range: 2.5-6.0).

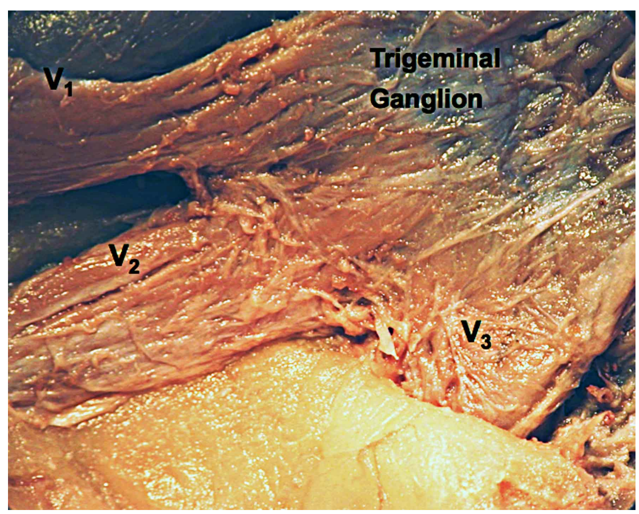

Fig. 3. Supero-lateral view of the skull showing the trigeminal ganglion and branches. V1= Ophthalmic division of TN, V2= Maxillary division of TN, V3= Mandibular division of TN.

DISCUSSION

An understanding of the anatomy of the TC and TG is clinically important in the evaluation of patients with symptoms referable to the TN and TG. Hovelaque in 1927 was the first to properly designate a dural and an arachnoidal component to the TC (Janjua *et al*., 2008), which was later clarified by Lockhart (1927) as a dural evagination of the posterior cranial fossa into the middle fossa. Chui *et al*., also defined the TC as an evagination of the dura of the posterior fossa under that of the middle fossa with a potential cleavage plane, which our study confirms. There has been a constant interest in the anatomy of the relations of the TG and the three divisions of the TN in order to improve the evaluation and management of the painful paroxysms of trigeminal neuralgia (Downs *et al*., 1996).

There is a considerable variation in the volume and shape of the trigeminal cistern, and the first radiological study of the trigeminal cistern was performed by Sicard in 1924 (Chui *et al*.). Putman & Hampton (1936) estimated the volume in TC to be approximately 1.5 ml, whereas Hakanson (1978) documented a mean volume of 0.6 ml (range: 0.2-1.4 ml) and Lunsford (1982) estimated a range between 0.15–0.5 ml. The mean volume of 0.14 ml (range 0.05–0.4) of the TC in our study differs considerably when compared to the reported volume in the literature reviewed (Table I). The management of trigeminal neuralgia includes the injection of glycerol into the TC, radiofrequency lesion and percutaneous balloon compression of the TG. Therefore, the anatomy and size of the TC determines the quantity of the injected glycerol and the degree of compression, if capacious, smaller balloons may fail to adequately compress the ganglion (Goerss *et al*., 2009). Furthermore, an appreciation of the volume of the TC may aid the success of the procedure.

Table I. Volume of the trigemical cave from the literature reviewed.

Author	Volume (ml)	Range (ml)
Putman & Hampton (1936)	1.5	-
Hakanson (1978)	0.6	0.2–1.4
Lunsford (1982)	-	0.15–0.5
Ajayi *et al*. (2013)	0.14	0.05–0.4

Frazier in 1901 carried out the first sensory root sectioning of the TN as an alternative to complete trigeminal ganglionectomy (Frazier & Whitehead, 1925). With the advent of radio-opaque medium and its subsequent application in determining the position of the TG in 1949 by Penman (1953), difficulty such as variability in the position of the sensory root were greatly overcome. Nevertheless, once the foramen ovale had been located during the procedure, it was important to determine the distance the needle shaft had to travel intracranially (Penman). In our study, we noted that the longest terminal branch of the TN is the ophthalmic division; whilst the mandibular nerve has the shortest exit distance (3.6 mm) (Table II). The average length of the ophthalmic division was recorded as 28.0 mm (range: 19.7–36.6 mm), which compared favorably to the 27.4 mm reported by Soeira *et al*. (1994) but differed to the 19.4 mm (range 16–24 mm) recorded by Janjua *et al*. (2008). The intracranial length of the maxillary division was measured by Soeira *et al*. as 12.5 mm and Janjua *et al*. (2008) recorded a mean length of 12.3 mm (range 8–19 mm). The mean length of the maxillary division in our study was measured as 12.7 mm (range : 8.8–17.5 mm), which falls within the range reported in earlier studies.

Tumors of the TC represent less than 0.5% of all histologically verified intracranial tumors (Chui *et al*.). In the surgical management of these tumors, there are three primary routes to access TC: anterolateral, lateral, and posterolateral. The choice of approach depends on the location, the type of pathology, anatomical relationships, familiarity and experience of the surgeon. In accessing the TC through the anterolateral and lateral approach, the foramen ovale with the mandibular division are the most important landmarks for identification of the TC (Arslan *et al*., 2012). The length of the mandibular division extends from the TG to the foramen ovale.

Henderson (1965) reported that the mandibular division of the TN had an exit range between 0-10 mm and Janjua *et al*. (2008), recorded a mean length of 7.4 mm (range 3–13 mm), which differs from the mean length of 3.6 mm (2.5–6 mm) in our study. However, Arslan *et al*.'s, finding was similar to ours, with the length of the mandibular division varying from 4.98 mm to 6.61 mm (mean value of 5.81 mm). Henderson, reported that the anterior edge of the TG was 3-4 mm anterior to the posterior lip of the foramen ovale in 8%, and was 3–4 mm posterior to the foramen ovale in 7% of specimens. Chui *et al*., in a computer tomographic study of the TC reported that the anterior limit of the TG was 0-4.5 mm behind the foramen ovale. In our study, we found that the TG was posterior to the posterior lip of the foramen ovale in all specimens which is similar to the finding of Arslan *et al*. The intracranial length of the mandibular division is also important during percutaneous rhizotomies and the correct placement of the needle into the TC (Janjua *et al*.). Therefore, in order to avoid the damage of the TG during these procedures, the variation in length of the mandibular division must be appreciated (Janjua *et al*.). Furthermore, during percutaneous fine needle aspiration biopsy or injection into the TG, the relationship of the foramen ovale to the TG must be considered (Arslan *et al*.).

The length and breadth of the TG measured in our study varied from 12.2–23.3 mm (mean 18.3 mm) and 4.6–9.3 mm (mean 7.9 mm), respectively (Table III). Our findings compare with ranges of 15–25 mm and 4–5 mm reported by Henderson but differed from 14.8–17.6 mm (mean 16.1 mm)

Table II. Length of the branches of the trigeminal nerve from the literature reviewed.

Author	Ophthalmic branch (mm)	Maxillary branch (mm)	Mandibular branch (mm)
Strobel (1980)*	15.2	-	6.6
Soeira *et al*. (1994)*	27.4	12.5	6.0
Janjua *et al*. (2008)	19.4 (16–24)	12.3 (8–19)	7.4 (3–13)
Ajayi *et al*. (2013)	28 (19.7–36.6)	12.7 (8.8–17.5)	3.6 (2.5–6.0)

*Cited by Janjua *et al*. (2008)

Table III. Length and breadth of the trigeminal ganglion from the literature reviewed.

Author	Length (mm)	Breadth (mm)
Henderson (1965)	15–25	4–5
Arslan *et al*. (2012)	16.1 (14.8–17.6)	3.78 (3.49–4.13)
Ajayi *et al*. (2013)	18.3 (12.3–23.3)	9.7 (4.6–9.3)

and 3.49–4.13 (mean 3.78 mm) recorded by Arslan *et al*., for the length and thickness of the TG, respectively. This difference in the dimensions of the TG in the different studies may be due to the variability in the sizes of the TG as stated by Chui *et al*. The dimension of the trigeminal porus connecting the TC to the posterior fossa was recorded as 7.9 mm (5.3–10.2 mm) and 4.1 mm (1.9–5.8 mm) for width and height, respectively. Our finding of 7.9 mm and 4.1 mm agrees with the values of 7.6 mm (range 6–8 mm) and 4.2 mm (range 3–5 mm) for the width and the height, respectively, reported by Sabanci *et al*. The trigeminal porous is a route for trigeminal tumors that extends between the posterior and the middle cranial fossae (Al-Mefty *et al*.).

Of particular clinical importance is the proposition by Kerr (1963) who suggested that contact between the ICA and the TG may be a cause of trigeminal neuralgia. He reported that the ophthalmic division of the TN is rarely affected, in 13% (4/30) of the specimens in our study, the ophthalmic division was recorded running immediately superior to the ICA. Therefore, in these patients the ophthalmic division of the TN is at risk of mechanical compression in the presence of ICA aneurysms.

In conclusion, an understanding of the precise formation of the TC, TG, TN and their relations is important in order to perform successful surgical procedures and localized neural block in the region of the TC.

AJAYI, N. O.; LAZARUS, L. & SATYAPAL, K. S. Cavo y ganglio trigeminal: Una revisión anatómica. ***Int. J. Morphol., 31(4)***:1444-1448, 2013.

RESUMEN: El cavo trigeminal (CT) de la duramadre es un conducto especial que se extiende desde la fosa craneal posterior a la parte posteromedial de la fosa craneal media en la base del cráneo. El CT contiene las raíces motoras y sensoriales del nervio trigémino (NT), ganglio trigeminal (GT), así como la cisterna trigeminal. Este estudio tuvo como objetivo examinar la anatomía del CT y GT y para determinar algunos parámetros del CT. El estudio se realizó en dos etapas: A) la disección anatómica de 30 cabezas seccionadas sagitalmente y B) la inyección para estimar volumen. Fueron encontrados tres capas distintas de duramadre asociadas al CT. El CT se relacionó con la arteria carótida interna, el seno cavernoso, el seno petroso superior, el vértice de la porción petrosa del hueso temporal y la dura endosteal de la fosa craneal media. El volumen medio del CT fue de 0,14 ml. La longitud media y la amplitud del GT fueron 18,3 mm y 7,9 mm, respectivamente. La media del ancho y alto del poro trigeminal fueron 7,9 mm y 4,1 mm, respectivamente; la longitud media de las ramas terminales del GT al salir del cráneo fue variable. El conocimiento preciso de la formación del CT, GT, NT y sus relaciones es necesario para realizar procedimientos quirúrgicos exitosos o el bloqueo nervioso localizado en la región del CT.

PALABRAS CLAVE: Cavo trigeminal; Ganglio trigémino; Nervio trigémino; Fosa craneal media.

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