



# Microsurgical and illustrative anatomy of the cavernous sinus, middle fossa, and paraclival triangles: a straightforward, comprehensive review

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## Abstract

The middle fossa, cavernous sinus, and paraclival triangles consist of ten triangles. Their use in a surgical approach is vast; most are used as landmarks to access and identify other structures of surgical interest. Multiple labels, borders, and contents mentioned by different authors make understanding and reproduction challenging and confusing. This study aims to organize and clarify recent or most relevant publications and disclose our portrayal of the ten triangles using cadaveric dissection and simple and practical figures. Four middle fossa triangles, four cavernous sinus triangles, and two paraclival triangles were dissected and delineated in a cadaveric specimen. Drawings were simplified to eliminate confusion and evaluate the triangles effortlessly. Similarities and differences in triangle names, border limits, and contents are described in a precise form. The recognition of triangle landmarks allows for treating pathologies in a frequently distorted anatomy or challenging to access structure. That is why an accurate knowledge of the surgical anatomy should be mastered, and a safe approach should be accomplished.

**Keywords** Middle fossa · Cavernous sinus · Paraclival · Anatomy · Triangles · Review

## Abbreviations

CS	Cavernous sinus
GSPN	Greater superior petrosal nerve
ICA	Internal carotid artery
IAC	Internal auditory canal

## Introduction

For years, there has been confusion when determining the name and border descriptions of the cavernous sinus and middle fossa triangles. Various authors have mentioned multiple names, border defining limits, and contents that

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cause confusion and learning distrust. For this reason, we present a brief revision of history, triangle differences, and similarities described in different publications. Finally, we explain a knowledgeable description using our point of view concerning each triangle using cadaveric dissection and simple figures.

Multiple publications mention the practical use of the triangles. Escudeiro et al. describe the utilization of the Parkinson's triangle to access a cavernous sinus hemangioma [7]. Kusumi et al. used an extra-dural middle fossa approach to remove a schwannoma in the Glasscock triangle [21]. Ferrareze et al. performed an endoscopic endo-nasal approach through the oculomotor triangle to remove an extended pituitary tumor in the para-peduncular space [8]. Watanabe et al. access the anterior temporal fossa to the paranasal sinuses and nasal cavities through the anterolateral and anteromedial triangles in a microscopic and endoscopic approach [30]. For this reason, recognizing and comprehending the ten triangles' anatomy are critical to a safe and successful surgical approach.

## Materials and methods

We used a cadaveric specimen injected with red silicon for arteries and blue for veins. Specimen preserved in a 70% alcohol solution and refrigerated. A head holder was used to keep the head in the correct position. A Pico microscope (Zeiss) was used for intracranial visualization. Midas drill (Medtronic) was used to perform a crani-orbital approach. Microsurgical instruments, bipolar, and 11 scalpels were used. Dissection was documented step by step with a DCLR camera Sony A6300. Additional

◀ **Fig. 1** Anterolateral aspect of the middle cranial fossa depicting the triangles formed in this region. The roof and lateral aspect of the orbit have been drilled. The Sylvian fissure is shown splitted. The retractor is over the temporal lobe. From medial to lateral, the clinoidal triangle has been exposed after an anterior clinoidectomy has been done. It is between the optic and the oculomotor nerves and posteriorly bordered by the tentorial edge (Not shown). The oculomotor triangle (OM) is the site where the oculomotor nerve becomes extradural by entering the upper portion of the lateral wall of the cavernous sinus. Its margins are the anterior petroclinoid dural fold extending from the ACP to the petrous apex and the posterior petroclinoid dural folds extending from the posterior clinoid process to the petrous apex and medially by the interclinoid dural fold. The supratrochlear triangle (ST), the space between the oculomotor and the trochlear nerves, has a posterior border drawn by a line at the dural entry point of these two nerves. The infratrochlear triangle (IT/Parkinson's triangle) is lateral to the oculomotor and medial to the trochlear nerve. Its posterior border is the tentorial edge between these two nerves. The anteromedial triangle's (AM/Mullan's triangle) boundaries are the ophthalmic division of the trigeminal nerve medially and the maxillary division laterally. Its base is formed by a line connecting the superior orbital fissure to the foramen rotundum over the bony middle cranial fossa wall. The anterolateral triangle (AT) is formed medially by the maxillary division of the trigeminal nerve and laterally by the mandibular division (V3). The base is formed by a line connecting the foramen rotundum and the foramen ovale. Posteriorly over the middle cranial fossa, the Posteromedial and the posterolateral triangles can be found. The first of these two, the Posteromedial Middle Fossa Triangle (AKA Kawase's triangle), is bordered laterally by the medial margin of the greater superficial petrosal nerve (GSPN). The petrous ridge is found medially. Anteriorly its boundary is the mandibular division of the trigeminal and laterally by V3. Posteriorly, the limit is the arcuate eminence. The posterolateral middle fossa triangle (Glasscock) is located laterally to the line where the GSPN crosses under V3 and the foramen spinosum. Its lateral border is a line between the foramen spinosum and the geniculate ganglion. Its base is GSPN. The paraclival triangles are the Inferomedial and Inferolateral triangles (PCIM and PCIL). The inferomedial triangle contains the dura forming the posterior wall of the cavernous sinus. It is delimited medially by a line extending from the posterior clinoid process to the dural entry of the abducens nerve. Its lateral border is a line extending from the posterior clinoid process to the dural entry of the trochlear nerve. Its base is the line extending from the dural entry of the abducens nerve and the trochlear nerve. Over the posterior surface of the clivus and the temporal bone, we can find the Inferolateral triangle (PCIL). Its anterior border is a line extending from the dural entry of the abducens nerve and the trochlear nerve's dural entry. Its lateral border is a line extending from the entrance of the trochlear nerve and the petrosal vein. Its posterior border is a line extending from the dural entry of the abducens nerve to the petrosal vein

processing was done with Photoshop (Adobe) and Helicon Focus. Dissection was made at the laboratory of the Centre Hospitalier Universitaire Vaudois.

We searched PubMed (<http://www.ncbi.nlm.nih.gov/pubmed/>) for “cavernous sinus triangles,” “middle fossa triangles,” “paraclival triangles,” “oculomotor triangle,” “clinoidal triangle,” supratrochlear triangle,” “infratrochlear triangle,” “anteromedial triangle,” “anterolateral triangle,” “posteromedial triangle,” “posterolateral triangle,”

**Table 1** Triangle description by different authors

Name	Other names	Borders	Content
Oculomotor triangle Dolenc [5]	Hakuba's triangle Drazin et al. [6]	1. Anterior petroclinoid dural fold 2. Posterior petroclinoid dural fold 3. Interclinoid dural fold Drazin et al. [6]	Oculomotor Nerve ICA horizontal segment Drazin et al. [6]
Medial triangle Drazin et al. [6]		1. Medial border: A line between the anterior and posterior clinoid process 2. Lateral border: the fold of the dura between the anterior clinoid process and petrous apex 3. Base: the fold of the dura from the posterior clinoid process to the petrous apex Isolan et al. [14]	The site where the oculomotor nerve enters the roof of the cavernous sinus Distal intra-cavernous carotid artery
Clinoid triangle Isolan et al. [14]	Dolenc's triangle Fujimoto et al. [9]	1. Anterior petroclinoid fold: petrous apex to the anterior clinoid process 2. Posterior petroclinoid fold: petrous apex to the posterior clinoid process 3. Interclinoid fold: anterior and posterior clinoid process Gallardo et al. [10]	Isolan et al. [15] Cavernous sinus Gallardo et al. [10]
Anteromedial triangle Dolenc [5]		1. Optic nerve 2. Oculomotor nerve 3. Tentorial edge (a line between the dural entry point of the third cranial nerve and the optic nerve) Drazin et al. [6]	Clinoid internal carotid artery Anterior clinoid process Drazin et al. [6]
Anterior triangle Gallardo et al. [10]		1. Medial border: optic nerve 2. Lateral border: third cranial nerve from the entry point in the sinus roof to the point just before entering the superior orbital fissure 3. Base: the dura extending between the posterior limits of the medial and lateral border Isolan et al. [14]	Anteriorly: Optic strut Middle: Subclinoid segment of the ICA Posteriorly: the roof of cavernous sinus (after drilling de anterior clinoid process) Isolan et al. [14]
Supratrochlear triangle Isolan et al. [14]	Paramedian triangle Goel [11]	1. Medially: oculomotor nerve 2. Laterally: trochlear nerve 3. Inferiorly: tentorial edge (the dura extending between the dural entry points of the third and the fourth cranial nerves) Watanabe et al. [29]	Meningohypophyseal trunk, the inferolateral trunk and less commonly the medial loop of the ICA Drazin et al. [6]
Paramedian triangle Dolenc [5]		1. Oculomotor nerve 2. Trochlear nerve	

Table 1 (continued)

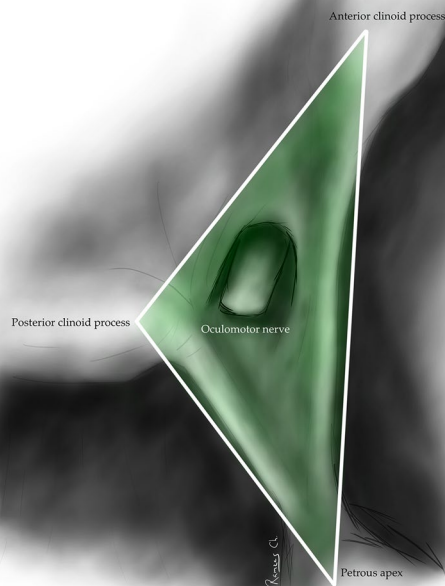
Name	Other names	Borders	Content
	Superior Fukushima Wanibuchi [28]	3. Tentorial edge Drazin et al. [6]	
Infratrochlear triangle Isolan et al. [14]	Parkinson's triangle Dolenc [5]	1. Medially: trochlear nerve 2. Laterally: ophthalmic division of the trigeminal nerve 3. Base: tentorial edge of these two nerves Watanabe et al. [29]	ICA (cavernous) and the abducens nerve Drazin et al. [6]
	Superolateral triangle Watanabe et al. [29]	1. Trochlear nerve 2. Ophthalmic division (V1) 3. Tentorial edge Drazin et al. [6]	Posterior–superior, anterior–inferior, and lateral venous spaces and lateral surface of the C5 and C6 Watanabe et al. [29]
		1. Superiorly: lower margin of the trochlear nerve 2. Inferiorly: upper rim of the ophthalmic nerve and of the trigeminal ganglion 3. Posterior: slope of the dorsum sellae and clivus Kayalioglu et al. [17]	Origin of the meningo-hypophyseal trunk Peltier et al. [24]
Anteromedial triangle Conti et al. [3]	Mullan's triangle Hakuba et al. [13]	1. Lower margin of ophthalmic nerve 2. Upper margin of maxillary nerve 3. Line connecting superior orbital fissure and foramen rotundum Granger et al. [12]	Sphenoid sinus Granger et al. [12]
	Anterolateral triangle Dolenc [5]	1. Upper margin of maxillary nerve 2. Line connecting the ophthalmic nerve at superior orbital fissure and the maxillary nerve at foramen rotundum Rhoton [26]	Superior orbital fissure artery Conti et al. [3]
Anterolateral triangle Kobayashi [19]	Lateral triangle Dolenc [5]	1. Lower Surface of maxillary nerve 2. Upper surface of the mandibular nerve 3. Line connecting the foramen ovale and rotundum Rhoton [26]	Pituitary gland Watanabe et al. [29]
	Far Lateral Day et al. [4]		Lateral wing of the sphenoid sinus Rhoton [26]
	Lateralmost Quinones-Hinojosa [25]	1. Medial border: Lower surface of the maxillary nerve, 2. Lateral border: upper surface of the mandibular nerve 3. Base: a line connecting the foramen ovale and rotundum Watanabe et al. [29]	Lateral wing of the sphenoid sinus Vidian nerve Pterygoid region Granger et al. [12]

Table 1 (continued)

Name	Other names	Borders	Content
Posterolateral Triangle	Glasscock	<ol style="list-style-type: none"> <li>1. Posterior border: maxillary division of the trigeminal nerve</li> <li>2. Anterior border: mandibular division of the trigeminal nerve</li> <li>3. Line connecting the foramen rotundum to the foramen ovale</li> </ol> Granger et al. [12]	Posterior and lateral loops of ICA
Dolenc [5]	Dolenc [5]	<ol style="list-style-type: none"> <li>1. Medial border: Line between where the GSPN crosses under V3 and the foramen spinosum</li> <li>2. Lateral border: Line between the foramen spinosum and geniculate ganglion</li> <li>3. Base: GSPN</li> </ol> Isolan et al. [14]	Greater and lesser petrosal nerves Tensor tympani muscle Eustachian tube Middle meningeal artery Infratemporal fossa
	Paullus Wanibuchi [28]	<ol style="list-style-type: none"> <li>1. Medial border: a line between the points on the lateral surface of the mandibular nerve where the greater petrosal nerve crosses to the foramen spinosum</li> <li>2. Lateral border: line between the foramen spinosum and the center of the geniculate ganglion</li> <li>3. Base: medial margin of the greater petrosal nerve</li> </ol> Watanabe et al. [29]	Isolan et al. [14]
Posteromedial Triangle	Kawase	<ol style="list-style-type: none"> <li>1. Medial border: GSPN</li> <li>2. Lateral border: Line between where the GSPN crosses under V3 and the petrous apex</li> <li>3. Base: Line between the crest of the petrous apex to the geniculate ganglion</li> </ol> Watanabe et al. [29]	Posterior cavernous sinus Entry point to the posterior fossa (anterior petrosectomy) Lateral apex: Cochlea, anterior wall of the IAC
Dolenc [5]	Dolenc [5]	<ol style="list-style-type: none"> <li>1. Anterior border: V3</li> <li>2. Posterior border: Arcuate Eminence</li> <li>3. Lateral border: GSPN</li> <li>4. Medial border: Petrous ridge</li> </ol> Isolan et al. [14]	Anterior margin: Petrous carotid Medial margin: Clivus and inferior petrosal sinus Isolan et al. [14]
	Kawase-Shiobara Kanzaki Wanibuchi [28]		

Table 1 (continued)

Name	Other names	Borders	Content
Paraclival Inferomedial Dolenc [5]	None	<ol style="list-style-type: none"> <li>1. Posterior clinoid process</li> <li>2. Dural entrance of the trochlear nerve</li> <li>3. Dural entrance of the abducens nerve</li> </ol> Isolan et al. [14]	Dorello's canal and Gruber's ligament Drazin et al. [6]  Dura forming the posterior wall of the cavernous sinus, the abducens nerve, the petrosphenoidal (Grüber's) ligament, The posterior genu of the internal carotid artery's intracavernous segment Dorsal meningeal artery Wysiadecki et al. [32]
Paraclival	None	<ol style="list-style-type: none"> <li>1. Medial: posterior clinoid process</li> <li>2. Supero-lateral: Dural entry of the Trochlear nerve</li> <li>3. Inferolateral: Dural entry of the abducens n</li> </ol> Dolenc [5]	The abducens nerve the posterior genu of the ICA the dorsal meningeal artery the basilar venous plexus the posterior petroclinoid fold Isolan et al. [14]
Inferolateral Dolenc [5]	None	<ol style="list-style-type: none"> <li>1. Medially: by a line between the dural entrance of the trochlear nerve into the tentorium cerebelli to the dural entry of the abducens nerve</li> <li>2. Laterally by a line between the dural entry point of the abducens nerve and the petrosal vein</li> <li>3. Petrous apex</li> </ol> Drazin et al. [6]	Porus trigemini (the Meckel's cave) Drazin et al. [6]
		<ol style="list-style-type: none"> <li>1. Line between the entry point of CN IV at the tentorium and CN VI at Dorello's canal</li> <li>2. Line between entry point of CN VI at Dorello's canal and the superior petrosal vein at the superior petrosal sinus</li> <li>3. Line between entry point of CN IV at the tentorium and the superior petrosal vein at the superior petrosal sinus</li> </ol> Isolan et al. [14]	Porus trigeminus The entrance of the sixth nerve in Dorello's canal The fourth cranial nerve entrance along the incisura into the lateral wall of the cavernous sinus Isolan et al. [14]
		<ol style="list-style-type: none"> <li>1. Anterior border: line connecting the dural entry point of the trochlear nerve to the dural entry point of the abducens nerve</li> <li>2. Posterior border: line connecting the dural entry point of the abducens nerve to the drainage site of the petrosal vein into the superior sagittal sinus</li> <li>3. Superior border: line connecting the dural entry point of the trochlear nerve to the petrosal vein</li> </ol> Kimball et al. [18]	



**Fig. 2** Oculomotor triangle: It is bordered anteriorly and posteriorly by the dural folds attached to the petrous apex and connected to the anterior clinoid process and posterior clinoid process (Anterior Petroclinoidal and Posterior petroclinoidal dural folds), respectively. Medially, its limit is the interclinoidal dural fold

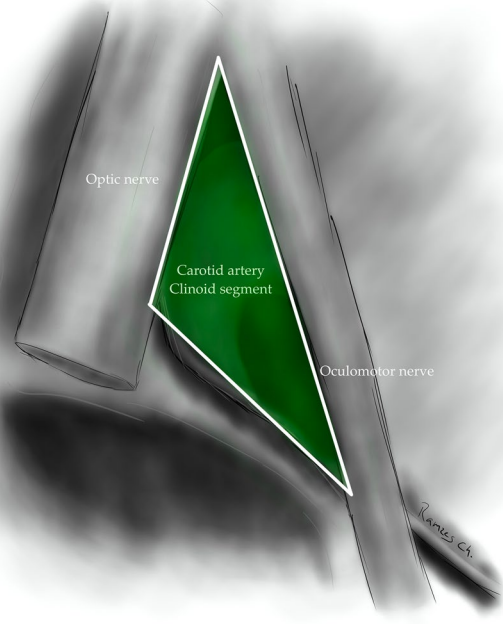
inferomedial triangle” and “inferolateral triangle.” The most relevant or recently published articles were used. Also, remarkable book literature was considered. The name, borders, and contents were analyzed (Table 1).

According to our cadaveric specimens, digital drawings of the ten triangles were optimized and simplified, eliminating distracting surroundings. The digital application platform “Procreate” was used in all drawings.

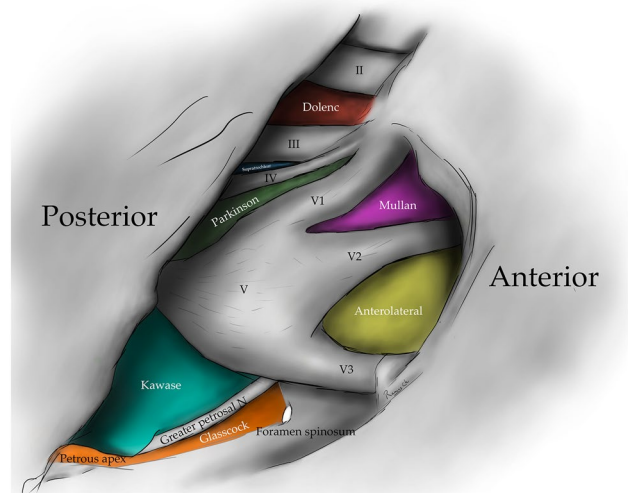
## Results

### Oculomotor triangle

The oculomotor triangle (Hakuba’s triangle and medial triangle) is delimited by three dural folds forming the medial or interclinoid border, lateral or anterior petroclinoid border, and posterior, base, or posterior petroclinoid border. In addition to surrounding the entry point of the third cranial nerve to the roof of the cavernous sinus, it contains the horizontal portion of the intra-cavernous segment of the internal carotid artery (ICA) [5, 6, 10, 14] (Figs. 1, 2, 4) (Table 1).



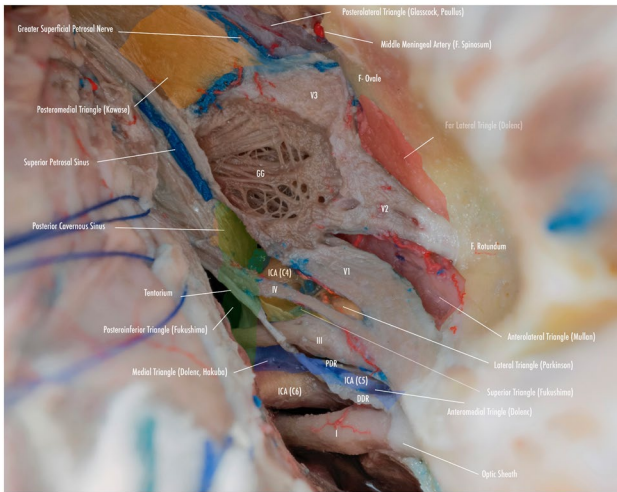
**Fig. 3** Clinoidal triangle (Dolenc’s, Anteromedial triangle); Bordered on its lateral side by the oculomotor nerve and limited medially by the optic nerve, posteriorly limited by the tentorial edge



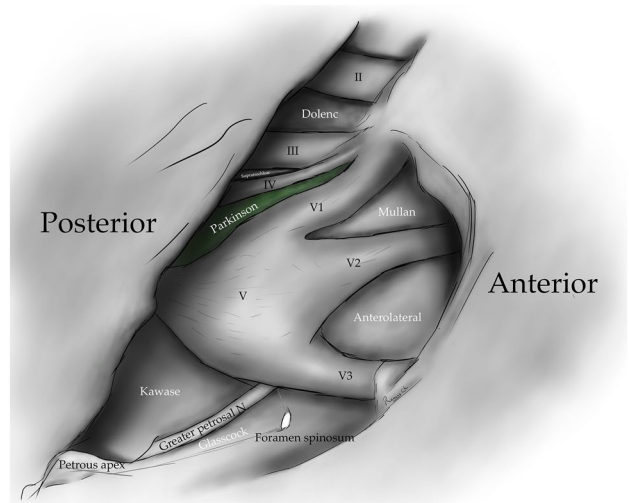
**Fig. 4** Drawing depicting the disposition of the triangles on the lateral wall of the cavernous sinus and middle cranial fossa

### Clinoid triangle

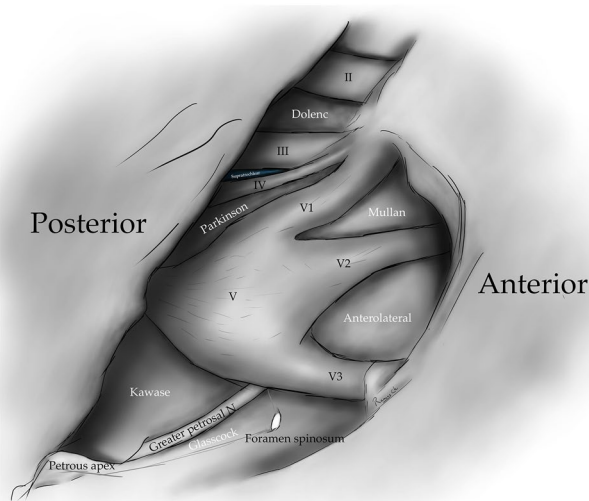
The clinoid triangle (Dolenc’s triangle, anteromedial triangle, and anterior triangle) is bounded on its medial border by the optic nerve, the lateral border by a line from the point of entry of the third cranial nerve in the roof of the cavernous sinus to its point of entry in the superior orbital fissure, and



**Fig. 5** Anatomical dissection depicting the disposition of the triangles on the lateral wall of the cavernous sinus and middle cranial fossa

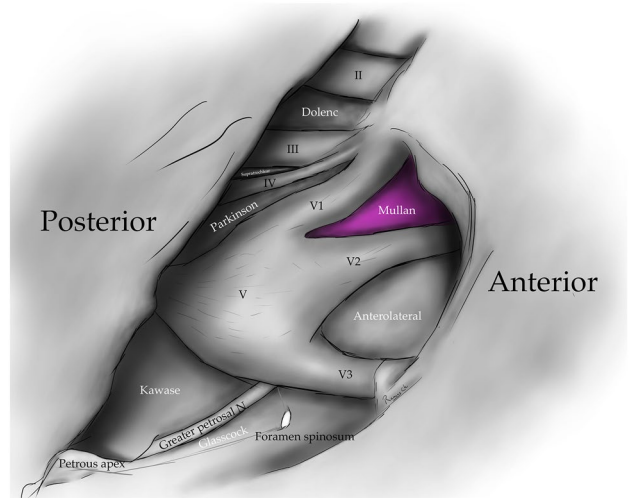


**Fig. 7** Infratrochlear triangle (Parkinson's triangle) Over the lateral wall of the cavernous sinus. This space is bordered medially by the trochlear nerve and laterally by the ophthalmic division of the trigeminal nerve. The base of this triangle is drawn by the tentorial between these two nerves



**Fig. 6** Supratrochlear triangle: Space bordered medially by the oculomotor nerve, laterally by the trochlear nerve. Its posterior border is the tentorial edge delimited by the dural entry point of these two nerves

the posterior border, corresponding to a line joining the posterior limits of the medial and lateral borders. To visualize this triangle fully, it is necessary to drill the anterior clinoid process. It contains in its anterior portion the optic strut, in its medial portion the clinoid segment of the ICA, and in its posterior segment the roof of the cavernous sinus. [5, 6, 9, 10, 15] (Figs. 1, 2, 3, 4, 5) (Table 1).

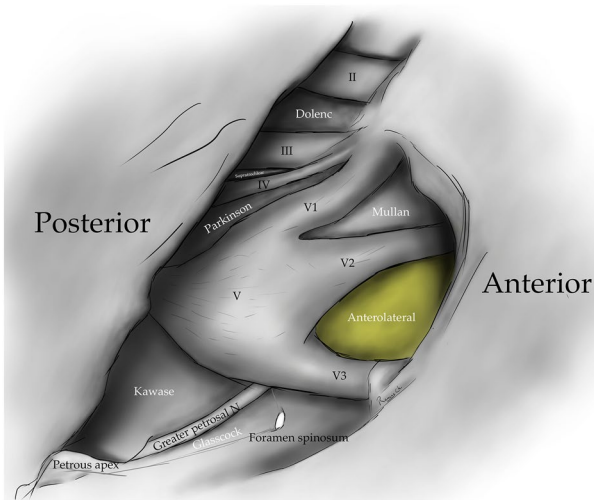


**Fig. 8** Anteromedial triangle (Mullan's triangle); Its boundaries are the ophthalmic division of the trigeminal nerve medially and the maxillary division of the trigeminal nerve laterally. This space's base is a line that connects the superior orbital fissure to the foramen rotundum over the bony middle cranial fossa

**Supratrochlear triangle**

The supratrochlear triangle (para-median triangle, paramedial triangle, superior triangle, and Fukushima's triangle) corresponds to the space between the oculomotor and trochlear nerves at their medial and lateral borders, respectively, forming the posterior border with a line at the dural entry point of these nerves. Through this triangle, we can find the



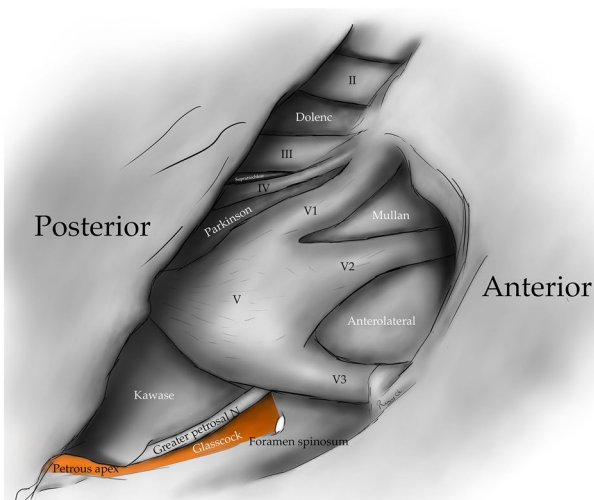


**Fig. 9** Anterolateral triangle; The lower margin of the maxillary nerve constitutes its medial border. The upper surface of the mandibular nerve is the lateral border. Anteriorly its base is a line between the foramen ovale and foramen rotundum

posterior curvature of the intra-cavernous segment of the ICA and, in some cases, the exit of the meningohypophyseal trunk, the inferolateral trunk, and, less frequently, the medial curve of the ICA. [5, 6, 11, 14, 28] (Figs. 4, 5, 6) (Table 1).

### Infratrochlear triangle

The infra-trochlear triangle (Parkinson's triangle, superolateral triangle) is bounded medially by the trochlear nerve,



**Fig. 10** Posterolateral triangle (Glasscock, Paullus); Bordered medially by a line drawn between the point where the greater superficial petrosal nerve (GSPN) crosses under the mandibular division of the trigeminal nerve (V3) and the foramen spinosum, laterally; by a line drawn between the foramen spinosum and the geniculate ganglion. Its base is the GSPN

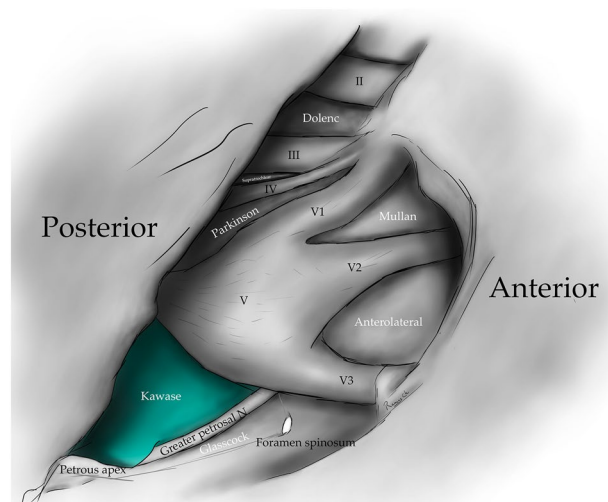
laterally by the ophthalmic division of the trigeminal nerve, and posteriorly by a line joining the posterior limit of the medial and lateral borders. It generally contains the origin of the meningohypophyseal trunk and the intra-cavernous portion of the sixth cranial nerve [4–6, 14, 17, 24, 29] (Figs. 1, 4, 5, 7) (Table 1).

### Anteromedial triangle

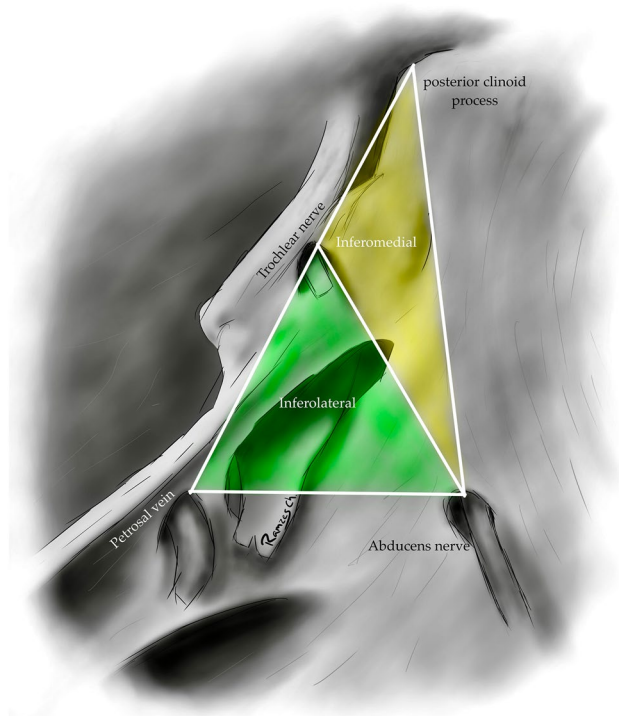
The anteromedial triangle's (Mullan's triangle and anterolateral) boundaries are formed by the ophthalmic division of the trigeminal nerve medially and the maxillary division of the trigeminal nerve laterally. The triangle base consists of the anterolateral wall of the bony middle cranial fossa formed by a line connecting the superior orbital fissure to the foramen rotundum. This corridor is well suited for exposing several important structures, including the superior orbital vein, sixth cranial nerve, sphenoid sinus, and ophthalmic vein. Further dissection within Mullan's space allows for access to carotid-cavernous fistulas [3, 5, 12, 13, 26, 29] (Figs. 1, 4, 5, 8) (Table 1).

### Anterolateral triangle

The anterolateral triangle (lateral triangle, far lateral triangle, lateral-most triangle) is formed medially by the maxillary division and laterally by the mandibular division of the trigeminal nerve. The base is identified via a line connecting the foramen rotundum and foramen ovale. The contents are the lateral wing of the sphenoid sinus, the Vidian nerve, and



**Fig. 11** Posteromedial triangle (Kawase, Kawase-Shiobara, Kanzaki); recent descriptions mentioned a quadrilateral. Its limits are; Laterally, the medial margin of the greater superficial petrosal nerve. Medially; the petrous ridge, anteriorly the mandibular (V3) division of the trigeminal nerve. Posteriorly, the arcuate eminence



**Fig. 12** Image depicting the paraclival triangles; Inferomedial and inferolateral. The inferomedial triangle is delimited by the posterior clinoid process, the trochlear nerve's dural entrance, and the abducens nerve's dural entrance. The inferolateral triangle is delimited anteriorly; by a line between the entry point of the trochlear nerve (CN IV) to the dural entry point of the abducens nerve (CN VI) at Dorello's canal. Posteriorly, it's bordered by a line between the dural entry point CN VI at Dorello's canal and the superior petrosal vein at the superior petrosal sinus. Its superior border is the line drawn between the entry point of CN IV at the tentorium and the superior petrosal vein at the superior petrosal sinus

the pterygoid region. Far antero-inferior, the maxillary sinus can be exposed, and posteriorly, the infratemporal Eustachian tube can be exposed under the lateral and medial pterygoid muscles. This space exposes the lateral sphenoid wing, sphenoidal emissary vein, and cavernous-pterygoid venous anastomosis [4, 5, 12, 19, 25, 26, 29] (Figs. 1, 4, 5, 9) (Table 1).

### Posterolateral triangle

The posterolateral triangle (Glasscock's triangle and Paullus's triangle) is formed by the anteromedial side of the lateral surface of the mandibular nerve distal to the point at which the greater superior petrosal nerve (GSPN) crosses below the lateral surface of the trigeminal nerve. The anterior margin of the GSPN forms the posterolateral side. It opens laterally to encompass the floor of the middle cranial fossa between these two structures [1]. It contains the posterior and lateral loops of the ICA in its

petrous segment, greater and lesser petrosal nerves, tensor tympani muscle, Eustachian tube, and middle meningeal artery that passes through the foramen spinosum. Opening the floor of this triangle exposes the infratemporal fossa [5, 14, 28, 29] (Figs. 1, 4, 5, 10) (Table 1).

### Posteromedial triangle

The posteromedial triangle (Kawase's triangle, Kawase-Shiobara's triangle, and Kanzaki's triangle) was first described by Kawase [15, 16]. This triangle consists of a line between the hiatus fallopii and the dural ostium of the Meckel's cave. Its posterior border is a line between the posterior border of the mandibular nerve and the center of the geniculate ganglion 15. Several structures surround it; at its lateral apex are the cochlea and anterior wall of the internal auditory canal (IAC), its anterior margin, the petrous carotid, and its medial margin, the clivus, and inferior petrosal sinus [16]. It contains the posterior cavernous sinus and the entry point to the posterior fossa exposed by performing an anterior petrosectomy. [5, 14, 28, 29] (Figs. 1, 4, 5, 11) (Table 1).

### Inferomedial paraclival triangle

The infero-medial triangle is one of two paraclival triangles of the skull base. It is delimited medially by a line from the posterior clinoid process to the dural entry of the abducens nerve, laterally by a line from the posterior clinoid process to the dural entry of the trochlear nerve, and a base by a line from the dural entry of the abducens nerve and the trochlear nerve. Its contents are the posterior genu of the internal carotid artery and the dorsal meningeal artery [5, 6, 14, 32] (Figs. 4, 12) (Table 1).

### Inferolateral paraclival triangle

The inferolateral triangle consists anteriorly of a line from the abducens nerve's dural entry and the trochlear nerve's dural entry, laterally with a line from the entrance of the trochlear nerve and the petrosal vein, posteriorly with a line from the dural entry of the abducens nerve to the petrosal vein. Its contents are the porus trigeminus [5, 6, 14, 18] (Figs. 4, 12) (Table 1).

## Discussion

Claudius Galen (119–199 a.d.), a confidant of royalty and physician to the gladiators, dissected animals and quietly transposed his findings to human anatomy. Those animals had parasellar carotid retia bathed in venous blood, which humans do not have. Winslow took it upon himself to name it "cavernous sinus" (CS), two sinus cavernosi, one on each

side, two orbitary sinuses, one on each side, and all these sinuses communicate with each other, and with the great lateral sinuses [23].

He thought that it would resemble the corpus cavernosum of the penis, which, in turn, he imagined to be a large, single, trabeculated venous cavern. His presumed concept of a single, large, trabeculated venous cavern persists today, becoming the most extended enduring myth in medical science [23].

Wepfer, in 1658, described the intra-cavernous internal carotid artery as passing through deep and conspicuous space [31].

Dorland, in 1985, found in a case of a long-standing arteriovenous fistula that the engorged and thickened “arterialized” veins were readily noted to be neither cavernous nor a dural sinus but a plexus of veins [23].

Schafer and Thane, in 1849; Anson, in 1953; Ferner, in 1963; Netter, in 1953, with beautiful drawings, they depict a plexus and call it CS, Anson in 1953 drew a single channel and called it a “plexus,” Spalteholtz, in 1938, drew a plexus with extension along the carotid canal on one page and a single large cavern on another page both labeled CS, Ferner, in 1963 drew a plexus with the actual extensions and labeled it CS [23].

Hamby, in 1966; Knosp et al., in 1987; Parkinson, in 1972; Taptas, in 1949, called the term CS inappropriate [23].

In 1965, Parkinson, the first deviser of the triangular space around CS, described the triangle between the trochlear and ophthalmic nerves to safely approach a lesion located at the internal carotid artery. Since Parkinson, several studies by clinical anatomists and neurosurgeons devised the triangular spaces around the CS. Since his pioneering studies, several critical triangular relationships formed by the convergence and divergence of cranial nerves have been described in the CS, in the middle cranial fossa, and in the paraclival region. Parkinson proposed the replacement of the “parasellar plexus of veins” in the “lateral sellar compartment” with the “parasellar plexus” because the plexus is present from early fetal life onward (Knosp et al., 1987; Solasol et al., 1966) extends about the sella in front of, behind, and beneath the pituitary beyond the lateral sellar compartments [22].

Browder and Parkinson performed the first cavernous sinus approaches to treat carotid-cavernous fistula. [2]

Parkinson, Dolenc, Taptas, and Umansky were pioneers in describing the surgical entry points into the sinus as triangular corridors. This geometric construct has been adopted as nomenclature for the region by most neurosurgeons [27].

Currently, cavernous sinus approaches are performed for basilar tip aneurysms, carotid-ophthalmic aneurysms, pituitary adenomas, some trigeminal neuromas, and other tumors in the region [20].

Although the anatomy of the cavernous sinus has been well described, the sinus remains a challenging and unfamiliar place for many neurosurgeons.

## Conclusion

Concise knowledge of the ten triangles is a strict requirement for any remarkable neurosurgeon. New surgical trans-triangle techniques or access pathways could be used to board different pathologies. We have left out measurements of each triangle to evade the premise of this simplified study. To thoroughly study each triangle profoundly, we advise you to investigate specific publications that only concentrate on each triangle or group of triangles.

**Authors' contributions** All authors reviewed the manuscript. VRC-H: wrote the main manuscript and prepared all the documents. AC: contributed to the main manuscript. DBH: Prepared Figs. 1 and 5 and contributed to the main manuscript. BAS-B: contributed to the main manuscript. PAG-Z: contributed to the main manuscript. CAP-C: contributed to the main manuscript. EJV-P: contributed to the main manuscript. DTS-R: contributed to the main manuscript. LAC-A: contributed to the main manuscript. JJR-H: contributed to the main manuscript.

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## Declarations

**Conflict of interest** All authors declare that they have no conflict of interest.

**Ethical approval and consent to participate** Ethical approval Anatomical study with cadaver heads and human subject approval was obtained from the Centre Hospitalier Universitaire Vaudois prior to the commencement of the study.

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