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Proposed Classification of Segments of the Internal Carotid Artery: Anatomical Study With Angiographical Interpretation

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Abstract

The nomenclature and borders of the segments of the internal carotid artery (ICA) remain confusing. A classification of segments of the ICA is proposed based on constant anatomical structures, such as the carotid foramen and canal, the petrous bone, the petrolingual ligament (PLL), and the proximal and distal dural rings. The bilateral ICAs were dissected in 15 cadaveric head specimens using different neurosurgical approaches. The bilateral lacerum foramina were studied in five dry skulls. The bilateral segments of the ICA were also examined on carotid angiograms of 10 normal patients and another with the ophthalmic artery originating from the intracavernous portion of the ICA. The present classification divides the ICA into five segments in the direction of the blood flow. The cervical segment is extradural and extracranial, the petrous segment is extradural and intraosseous, the cavernous segment is interdural and intracavernous, the clinoidal segment is interdural and paracavernous, and the cisternal segment is intradural and intracisternal. The ICA did not pass through the lacerum foramen in any specimen. In all specimens, 1/8 to 5/8 of the lacerum foramen was under the deep dural layer of the cavernous sinus. The term 'lacerum segment' as used previously and called the 'trigeminal segment' by us cannot be justified. The PLL is the posterolateral border of the cavernous sinus and the lacerum and trigeminal segments should be included in the cavernous and petrous segments. The ophthalmic artery may originate from the clinoidal ICA, from the cavernous ICA, or from the middle meningeal artery. Instead of using the term 'ophthalmic segment,' the term 'cisternal segment' should be used for the anatomically distinct ICA in the subarachnoid space. This classification should be minimally affected by anatomical variations.

Key words: classification, internal carotid artery, segment

Introduction

Classification of the segments of the cerebral arteries are usually based on the relationship with anatomical structures for maximum clinical usefulness. The two main arteries in the skull, the internal carotid artery (ICA) and the vertebral artery, have close relationships with the bone and dural/ligamentous structures. Bone, dura, and dural/periosteal folds are constant anatomical structures which can be used to accurately describe the course of an artery, a vein, or a nerve. The classical segmental classification of the vertebral artery into four segments is a good example.[22] On the other hand, classification of the segments of a main artery based on its branches without taking possible anatomical variations into consideration may be confusing. As an example, the ophthalmic artery originates from the clinoidal segment in 6% of cases, from the cavernous segment of the ICA in 3%, and rarely from the middle meningeal artery to a total of 10% of cases.[6,12,14,15] Therefore, the term 'ophthalmic segment' could be misleading.

The first classification of the segments of the ICA by Fischer in 1938[4] was based on angiography. All other classification systems have numbered the segments of the ICA in the direction of the blood flow.[1,2,6,7,9,13] The most recent classification by Bouthillier et al.[1] divided the ICA into seven seg-

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ments, and was a modification of Fisher classification. This classification described a new segment, the lacerum segment, which ended at the superior margin of the petrolingual ligament (PLL).[1] However, the term lacerum segment is unclear because the artery never passes through the lacerum foramen (LF), although part of the LF may lie under the deep dural layer of the cavernous sinus (CS), and consequently under the cavernous segment of the ICA. We preferred to name this part of ICA as the 'trigeminal segment' in our recent studies,[23–25] because this segment is covered by the trigeminal ganglion and root. However, whether a new segment between the petrous and the cavernous segments of the ICA is necessary remains open to discussion. We believe that the classification of the segments of the ICA should be easy to use, minimally affected by anatomical variations, and suitable for clinical application.

Here we propose a classification of segments of the ICA based on constant anatomical structures closely related to the ICA.

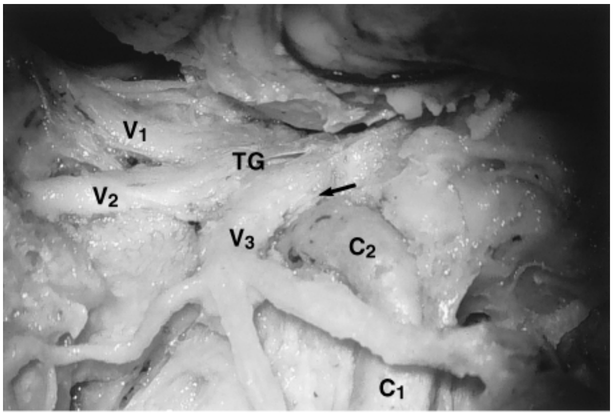

Fig. 1 Photograph showing the cervical segment (C_1) enters the skull via the carotid foramen. The petrous segment (C_2) was exposed via the left transfacial approach. The petrolingual ligament under the trigeminal nerve is shown (*arrow*). V_1: ophthalmic nerve, V_2: maxillary nerve, V_3: mandibular nerve, TG: trigeminal ganglion.

Materials and Methods

The ICA was dissected from 15 cadaveric heads treated with microfil using the pterional, orbitozygomatic, subtemporal, subtemporal-infratemporal, petrosal, transsphenoidal, transbasal, and transfacial approaches. The cranial base, especially the LF, and the sphenoid, petrous, and occipital bones, was studied bilaterally in five dry skulls. The course of the ICA was studied on the bilateral carotid angiograms of 10 normal patients and another with the ophthalmic artery originating from the cavernous segment of the ICA.

Results

The main anatomical landmarks used to define the course and the segments of the ICA were the carotid foramen (CF) and canal (CC), the petrous bone, the PLL, and the proximal and distal dural rings. The ICA was divided into five segments.

Cervical segment (C_1): The C_1 is both extradural and extracranial. The C_1 extends from the common carotid bifurcation to the CF where the ICA enters the skull and passes through the CC. The carotid artery branched from the common carotid artery at the C-4 level in 26 (14 left, 12 right) specimens and at the C-3 level in four (3 left, 1 right) specimens. The C_1 enters the CC anterior to the jugular foramen, and was exposed via the subtemporal-infratemporal approach with blunt dissection (Fig. 1).

Petrous segment (C_2): The C_2 is extradural and intraosseous. The C_2 extends from the CF to the superior margin of the PLL. The inner layer of the carotid sheath continues as the periosteum of the CC. After entering the skull, the ICA initially courses horizontally in the CC, then bends under the greater superficial petrosal nerve (GSPN) and reaches vertically to the CS. The GSPN crosses laterally and anteriorly to the PLL and the ICA, and exits the skull through the anterior part of the LF. In all specimens, the ICA passed above the LF during the vertical course, but never through the foramen.

The LF is bounded posteriorly by the petrous apex, anteriorly by the body and posterior border of the greater sphenoid wing, and posteromedially by the basioccipital bone (Fig. 2A). The CC opens to the posterolateral part of the LF turning anteromedially to reach the posterior wall of the LF. The inferior portion of the foramen is filled by fibrocartilage and only the meningeal branches of the ascending pharyngeal artery and small veins pass through the foramen. In all specimens, 1/8 to 5/8 of the LF was under the deep dural layer of the CS (Fig. 2B). Part of the cavernous ICA courses tangential to the LF (Fig. 1). Just posterior to this point, the artery is covered by the PLL and by the trigeminal ganglion and root.[23–25] We named this part of the artery the 'trigeminal segment,'[23,24] otherwise called the lacerum segment, although the artery does not pass through the LF.[1]

The terminal point of the C_2 is the PLL. The PLL is the posteromedial border of the CS, and attaches

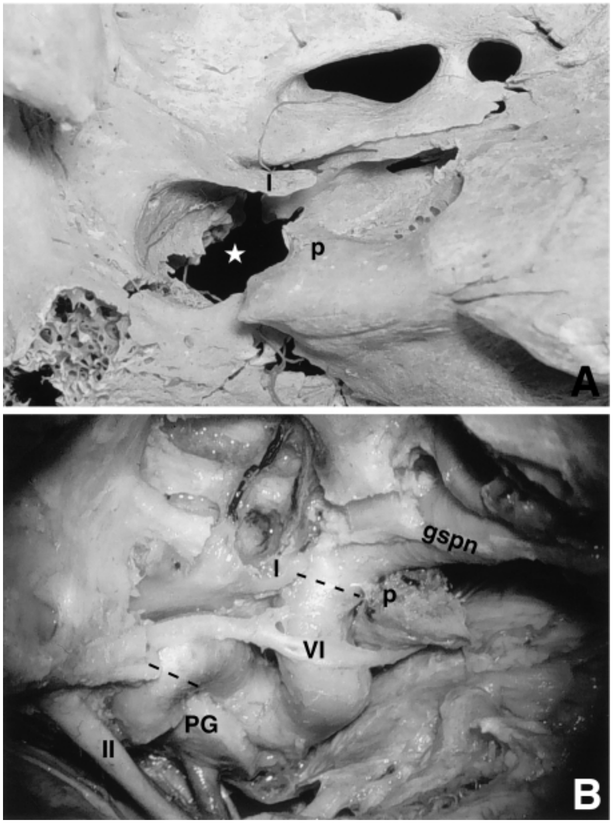

Fig. 2 A: Photograph showing the lacerum foramen (*star*) is bounded posteriorly by the petrous apex (p), anteriorly by the body and posterior border of the greater sphenoid wing, and posteromedially by the basioccipital bone. In all specimens, 1/8 to 5/8 of the lacerum foramen was under the deep dural layer of the cavernous sinus. l: lingula of sphenoid bone. B: The oculomotor, trochlear, and trigeminal nerves were removed. The part of the internal carotid artery between two *dotted lines* is intracavernous. II: optic nerve, VI: abducens nerve, gspn: greater superficial petrosal nerve, PG: pituitary gland.

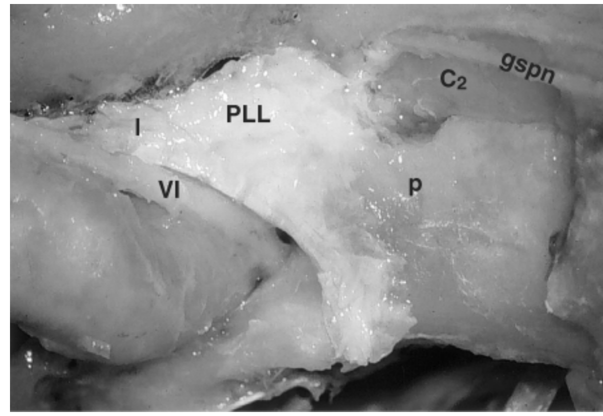

Fig. 3 Photograph showing that the petrous internal carotid artery (C_2) is covered by the petrolingual ligament (PLL) before entering the cavernous sinus. The trigeminal ganglion and roots were removed during the right subtemporal approach. VI: abducens nerve, gspn: greater superficial petrosal nerve, l: lingula of sphenoid bone, p: petrous apex.

medially to the lingula of the sphenoid bone and laterally to the petrous apex (Fig. 3). The medial part of the bone where the ICA courses from the CC to the PLL is the petrous bone. The PLL is the landmark for identification of the ICA where it enters the CS. This bow-shaped ligament has been divided into horizontal and vertical parts.[10] Our previous study divided the PLL into the anterior tail, body, and posterior tail, depending on the relationship with the CS, the cranial nerves, and the ICA.[24] The anterior tail is parallel to the cranial nerve VI. The body which is the center of the ligament is the superior projection of the body and is under the junction of the second and the third divisions of the trigeminal nerve. The lateral tip of the body is a very important landmark to determine the direction of the C_2 before entering the CS. The lateral tip is the termination of the CC and indicates its width.[24] This triangle, described first by us, is formed laterally by the PLL, medially by the ICA, and posteriorly by the petrous apex, the dorsum sellae, and the petrosphenoid ligament. This area is where the cranial nerve VI leaves Dorello's canal and enters the CS.[24] The transition between the C_2 and the C_1 of the ICA is under the PLL. The lateral part of the PLL which extends along the bone and runs over the ICA has also been called the 'lateral ring.'[3] The C_2 was exposed using the petrosal, subtemporal, and transfacial approaches with drilling of the petrous bone (Figs. 1 and 3).

Cavernous segment (C_3): The C_3 is interdural and intracavernous. The C_3 extends from the superior margin of the PLL to the proximal dural ring. In all specimens, 1/8 to 5/8 of the LF was below the C_3 and distal to the PLL. The C_3 and the PLL were exposed via the subtemporal extradural approach (Fig. 4). The C_3 was also exposed using the transsphenoidal and transbasal approaches (Fig. 5). The ophthalmic artery originated from the C_3 (Fig. 6).

Clinoidal segment (C_4): The C_4 is interdural and paracavernous. The C_4 is wedge-shaped and extends between the distal and the proximal dural rings. Here, the artery is surrounded by the carotid collar.

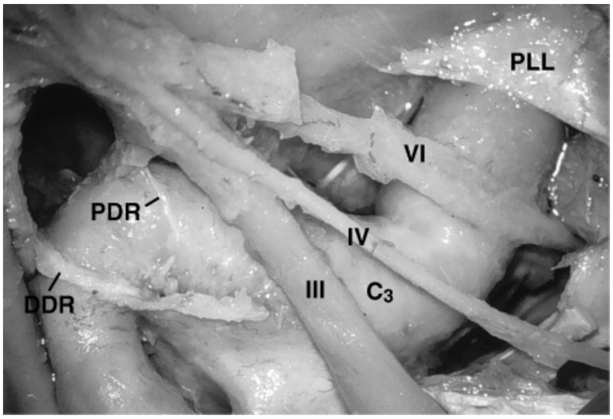

Fig. 4 Photograph showing the cavernous segment of the internal carotid artery (C_3) extends between the superior margin of the petrolingual ligament (PLL) and the proximal dural ring (PDR). The trigeminal nerve and the anterior clinoid process were removed. III: oculomotor nerve, IV: trochlear nerve, VI: abducens nerve, DDR: distal dural ring.

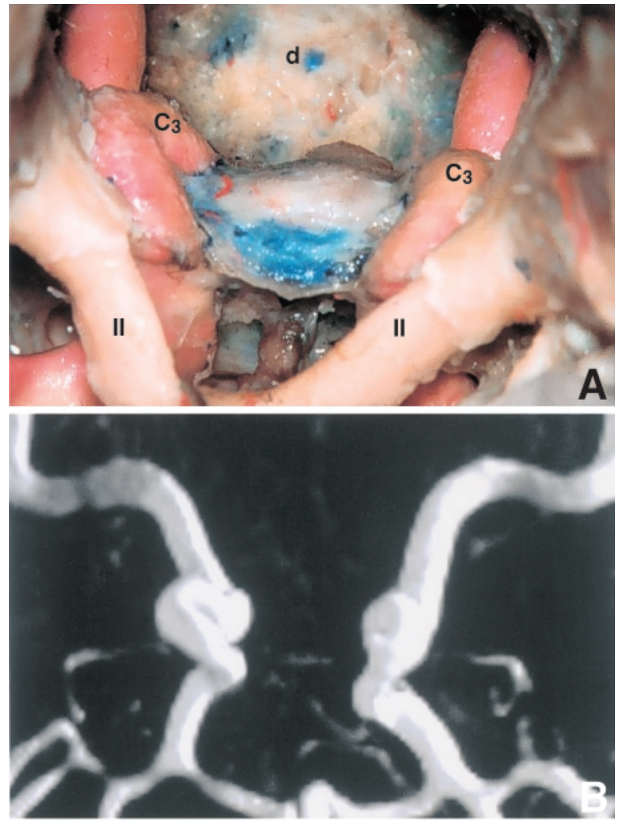

Fig. 5 A: Photograph showing the bilateral cavernous segments of the internal carotid arteries (C_3) were exposed via the transbasal approach. After drilling the clivus, the dura (d) was exposed. II: optic nerve. B: Three-dimensional carotid angiogram demonstrating the bilateral C_3.

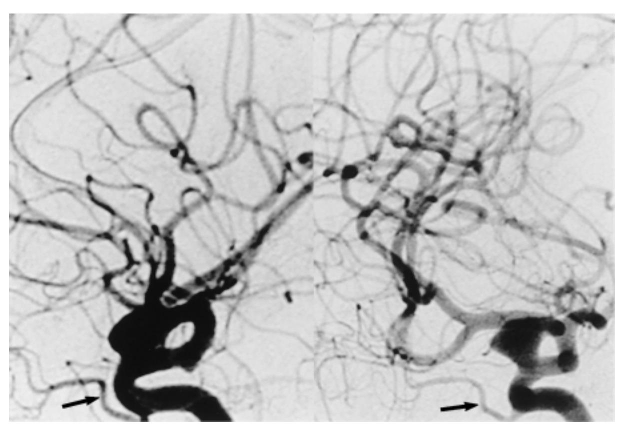

Fig. 6 Carotid angiograms showing that the ophthalmic artery originated from the cavernous segment of the internal carotid artery (*arrow*).

The upper dural ring (distal dural ring) is the extension of the dura arising from the upper surface of the anterior clinoid process (ACP). The lower dural ring (proximal dural ring, Perneczky's ring) is the extension of the dura arising from the lower surface of the ACP. The lower dural ring is separated from the ICA with a space laterally which extends along the lateral aspect of the C_4, reaching the distal dural ring. This space is called the clinoidal venous space, contains the clinoidal venous plexus, and is an extension of the CS. Here, the location of the ICA is paracavernous. Medially, there is no such space between the dural rings. On the other hand, the distal dural ring is incomplete at the medial and posterior parts of the C_4. This small part of the artery is intradural, and the dural evagination mesial to the distal dural ring is known as the 'carotid cave.'[11] The C_4 was exposed via the pterional and orbitozygomatic approaches after removing the ACP (Fig. 7).

Cisternal segment (C_5): The C_5 is intradural and intracisternal. The C_5 extends between the distal dural ring and the carotid bifurcation where the artery divides into anterior and middle cerebral arteries. The main branches of the C_5 are the superior hypophyseal, ophthalmic, posterior communicating, and anterior choroidal arteries. The pterional approach was used to expose the C_5 (Fig. 8).

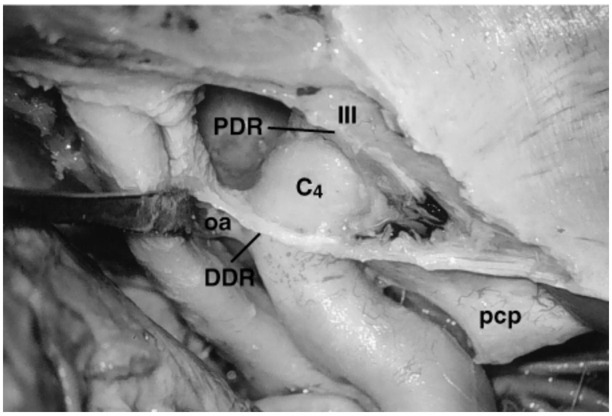

Fig. 7 **Photograph showing the clinoidal segment of the internal carotid artery (C_4) extends between the proximal dural ring (PDR) and the distal dural ring (DDR). The C_4 was exposed via the right pterional approach after removing the anterior clinoid process. III: oculomotor nerve, oa: ophthalmic artery, pcp: posterior clinoid process.**

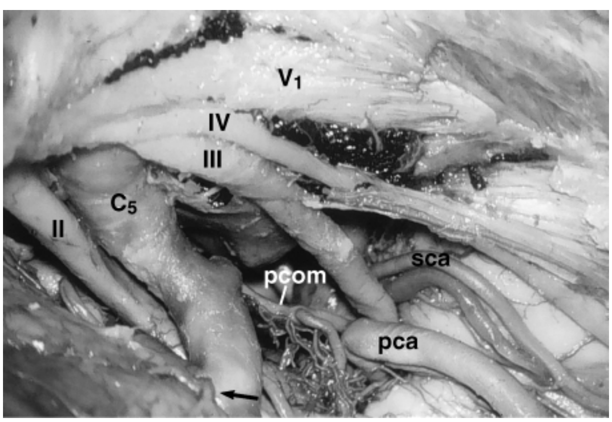

Fig. 8 **Photograph showing the cisternal segment of the internal carotid artery (C_5) extends between the distal dural ring and the carotid bifurcation (*arrow*). The C_5 was exposed via the right pterional approach. The superficial layer of the cavernous sinus dura was removed. II: optic nerve, III: oculomotor nerve, IV: trochlear nerve, V_1: ophthalmic nerve, pca: posterior cerebral artery, pcom: posterior communicating artery, sca: superior cerebellar artery.**

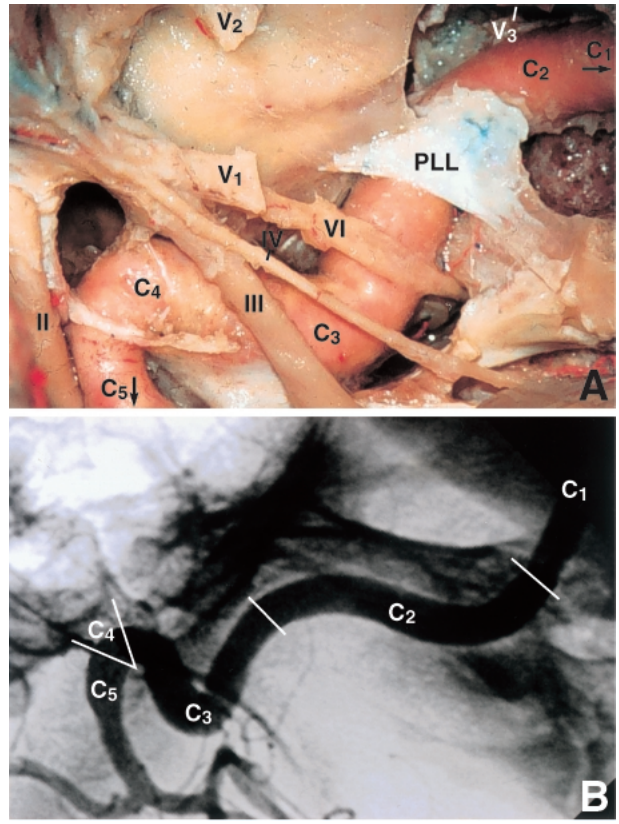

Fig. 9 **Proposed classification dividing the internal carotid artery into five segments as shown by anatomical (A) and angiographical (B) illustrations: C_1, cervical; C_2, petrous; C_3, cavernous; C_4, clinoidal; C_5, cisternal. II: optic nerve, III: oculomotor nerve, IV: trochlear nerve, V_1: ophthalmic nerve, V_2: maxillary nerve, V_3: mandibular nerve, VI: abducens nerve, PLL: petrolingual ligament.**

Discussion

The present study proposes to divide the ICA into five segments which are more suitable for clinical practice: C_1, cervical; C_2, petrous; C_3, cavernous; C_4, clinoidal; and C_5, cisternal (Fig. 9).

The cervical segment of the ICA, the part of the artery between the common carotid bifurcation and the base of the skull, is universally accepted in all proposed classification systems.[1,2,4,6,13] After entering the skull through the CF, the artery passes through the CC which is part of the petrous bone. Previously, the part of the ICA to the point where it enters the CS has been called as the 'petrous segment.'[6] Bouthillier et al.[1] described the lacerum segment as part of the petrous or the cavernous segments. They suggested that this part of the ICA was neither petrous nor cavernous, and the original proximal border of the cavernous ICA was the medial loop of the ICA which was extended to the PLL.[1] Our study of the anatomy of the PLL showed that the PLL is the posteromedial border of the CS.[24] The ICA enters the CS after passing under the PLL and above the LF. The ICA never passes through the LF. Recently, we called this part of the ICA the 'trigeminal segment' because the ICA passes under the trigeminal nerve.[23,24] However, we do not think that it is either necessary or clinically useful to add a short segment between the petrous and cavernous segments of the ICA. Bouthillier et al.[1] claimed that the lacerum segment was incorporated in the C_5 segment of the original Fischer system. We do not agree, because Fischer marked neither the PLL nor the lacerum foramen on the angiograms.

The anterior, medial, and posterior walls of the vertical canalicular portion of the LF consist of basisphenoid bone.[1,22] Bouthillier et al.[1] suggested that the vertical portion of the ICA before entering the CS is surrounded only by the sphenoid bone, which is not true. The PLL is the continuation of the periosteum of the CC which is part of the petrous bone.[24] Bouthillier et al.[1] considered the petrous segment to end along a vertical line at the posterior lip of the exocranial LF. This transition occurred inferomedial to the edge of the gasserian ganglion within the Meckel's cave.[1] However, the transition between the petrous and cavernous segments of the ICA is located under the PLL, and the medial part of the bone where the ICA courses after the CC towards the PLL is the petrous bone. Bouthillier et al.[1] pointed out that the lacerum segment begins where the CC ends and ends at the superior margin of the PLL. We do not agree because the PLL is not the landmark for the position, width, and extension of the LF. We observed that 1/8 to 5/8 of the LF was under the deep dural layer of the CS. Here, the initial part of the cavernous ICA is coursing tangential to the LF. That means that the LF is not completely distal to most distal fibers of the PLL. Therefore, to show the lacerum segment as a pure extracavernous segment of the ICA is not correct. In other words, the PLL is a continuation of the fibrous covering of Meckel's cave and separates Meckel's cave from the CS. The ICA before entering the CS is extradural, but becomes interdural in the CS.

After entering the CS under the PLL, the ICA forms posterior and anterior bends.[9,16] The cavernous segment ends at the proximal dural ring where the interdural-paracavernous clinoidal segment begins. The distal dural ring is the termination of the clinoidal segment.[9] Formerly, the clinoidal carotid artery was suggested to be extracavernous. The clinoidal venous plexus is lateral to the clinoidal ICA and so this segment should be intracavernous.[17] However, the clinoidal venous space covers only the lateral part of the clinoidal segment. During surgical removal of the ACP, venous bleeding is frequently observed coming from this space.[3] The artery is not completely surrounded with CS blood between the two dural rings. Therefore, we suggest that the clinoidal ICA is 'paracavernous.' Only the small part of the clinoidal ICA facing the carotid cave is intradural.

The ICA leaves the distal dural ring intradurally-intracisternally. Recently the cisternal segment has been divided into ophthalmic and communicating segments.[1,5,19] The ophthalmic segment extends between the distal dural ring and just proximal to the origin of the posterior communicating artery. However, the ophthalmic artery does not always originate from the supraclinoid portion of the ICA within the subarachnoid space, but may originate from the clinoidal segment or as a branch of the inferolateral trunk of the cavernous segment.[16,21] If the ophthalmic artery arises extradurally from the clinoidal or the cavernous segments of the ICA, it passes through the superior orbital fissure instead of the optic foramen. The ophthalmic artery may originate outside the so-called ophthalmic segment in up to 10% of cases.[8,14,16,18,20,21] In two of 170 specimens, the ophthalmic artery arose completely from the middle meningeal artery without an orbital contribution from the ICA.[8] The ophthalmic artery arose from the middle meningeal artery in three cases.[18] Bouthillier et al.[1] suggest that the communicating segment begins just proximal to the origin of the posterior communicating artery and ends at the ICA bifurcation. Two major arteries, the posterior communicating and the anterior choroidal arteries, arise from their C_7 segment. We prefer to call the entire subarachnoidal (cisternal) part of the ICA the 'cisternal segment.' The branches of the artery in the subarachnoid space may have variations. We suggest that the part of the ICA between the distal dural ring and the bifurcation should be accepted anatomically as a unique segment.

References

1) Bouthillier A, Loveren HR, Keller JT: Segments of the internal carotid artery. *Neurosurgery* 38: 425–433, 1996
2) Debrun G, Lacour P, Vinuela F, Fox A, Drake CG, Caron JP: Treatment of 54 traumatic carotid-cavernous fistulas. *J Neurosurg* 55: 678–692, 1981
3) Dolenc VV: A combined epi- and subdural direct approach to carotid-ophthalmic artery aneurysm. *J Neurosurg* 62: 667–672, 1985
4) Fischer E: Die Lageabweichungen de vorderen hirnarterie im gefaessbild. *Zentralbl Neurochir* 3: 300–313, 1938 (Ger)
5) Fox JL: Microsurgical treatment of ventral (paraclinoid) internal carotid artery aneurysms. *Neurosurgery* 22: 32–39, 1988

6) Gibo H, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. *J Neurosurg* 55: 560–574, 1981
7) Harris PS, Rhoton AL Jr: Anatomy of the cavernous sinus. A microsurgical study. *J Neurosurg* 45: 169–180, 1976
8) Hayreh SS, Dass R: The ophthalmic artery. *Br J Ophthalmol* 46: 65–98, 1962
9) Inoue T, Rhoton AL Jr, Theele D, Barry ME: Surgical approaches to the cavernous sinus: A microsurgical study. *Neurosurgery* 26: 903–932, 1990
10) Knosp E, Müller G, Perneczky A: The paraclinoid carotid artery. Anatomical aspects of a microneurosurgical approach. *Neurosurgery* 22: 896–901, 1989
11) Kobayashi S, Kyoshima K, Gibo H, Hegde SA, Takemae T, Sugita K: Carotid cave aneurysms of the internal carotid artery. *J Neurosurg* 70: 216–221, 1989
12) Kyoshima K, Oikawa S, Kobayashi S: Interdural origin of the ophthalmic artery at the dural ring of the internal carotid artery. Report of two cases. *J Neurosurg* 92: 488–489, 2000
13) Lasjaunias P, Berenstein A: Arterial anatomy: Introduction, *in*: *Surgical Neuroangiography. Functional Anatomy of Craniofacial Arteries, vol 2*. Berlin, Springer Verlag, 1987, pp 1–32
14) Liu Q, Rhoton AL Jr: Middle meningeal origin of the ophthalmic artery. *Neurosurgery* 49: 401–407, 2001
15) Renn WH, Rhoton AL Jr: Microsurgical anatomy of the sellar region. *J Neurosurg* 43: 288–298, 1975
16) Rhoton AL Jr, Natori Y: *The Orbit and Sellar Region: Microsurgical Anatomy and Operative Approaches*. New York, Thieme Medical, 1996, pp 11, 92–93
17) Seoane E, Rhoton AL Jr, de Oliveira E: Microsurgical anatomy of the dural collar (carotid collar) and rings around the clinoid segment of the internal carotid artery. *Neurosurgery* 42: 869–886, 1998
18) Shima K, Kawasaki T, Shimizu A, Takiguchi H, Chigasaki H: [An ophthalmic artery occlusion after a craniotomy using the pterional approach: A report of three cases, one resulting in blindness]. *No Shinkei Geka Journal* 4: 163–169, 1995 (Jpn, with Eng abstract)
19) Spetzler RF, Fukushima T, Martin N, Zabramski JM: Petrous carotid-to-intradural carotid saphenous vein graft for intracavernous giant aneurysms, tumor, and occlusive cerebrovascular disease. *J Neurosurg* 73: 496–501, 1990
20) Watanabe A, Hirano K, Ishii R: Dural caroticocavernous fistula with both ophthalmic arteries arising from middle meningeal arteries. *Neuroradiology* 38: 806–808, 1996
21) Weinberg PE, Patronas NJ, Kim KS, Melen O: Anomalous origin of the ophthalmic artery in a patient with amaurosis fugax. *Arch Neurol* 38: 315–317, 1981
22) Williams PL, Warwick R, Dyson M, Bannister LH: *Gray's Anatomy*. Edinburgh, London, Melbourne, New York, Churchill Livingstone, 1989, pp 353–752
23) Ziyal IM, Özgen T: Endoscopic endonasal cavernous sinus surgery: An anatomic study. *Neurosurgery* 49: 1271–1272, 2001
24) Ziyal IM, Salas E, Wright DC, Sekhar LN: The petrolingual ligament: The anatomy and surgical exposure of the posterolateral landmark of the cavernous sinus. *Acta Neurochir (Wien)* 140: 201–205, 1998
25) Ziyal IM, Sekhar LN, Özgen T, Söylemezoğlu F, Alper M, Beşer M: The trigeminal nerve and ganglion. An anatomical, histological and radiological study addressing the transtrigeminal approach. *Surg Neurol* 61: 564–574, 2004

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Commentary

To be useful for and adapted by clinicians, a classification system must be easy to use, improve communication among physicians, and have clinical relevance. Furthermore, anatomical classifications should be minimally affected by normal variations in anatomical structures being classified. The authors have proposed a classification for the extracranial and intracranial internal carotid artery that is similar in most respects to previous classification systems. The significant difference is reclassification of the subarachnoid portion of the internal carotid artery, which the current authors term the "cisternal" segment. Prior classification systems divided this segment of the aneurysm on the basis of its usual branching arteries. Additionally, the authors clarify a minor controversy over whether there is a segment of carotid between the petrous and cavernous segments. I agree with the authors that a segment inserted between these two is not justified by anatomical or clinical criteria.

The authors have provided elegant dissections to illustrate the various segments of the internal carotid artery included in their classification scheme. One of the detractors of all classification systems of the internal carotid artery is the inability to routinely identify the petrolingual ligament and dural rings on routine imaging studies, making precise determination of each of the proposed segments difficult on current imaging studies.

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Ziyal et al. present a new classification of the segments of the ICA, based on dissection of 15 cadaveric heads specimen, the study of five dry skulls, and the examination of the carotid angiograms in 10 normal patients and another with the ophthalmic artery originating from the intracavernous portion of the ICA. The authors proposed to divide the ICA into five segments: 1) the cervical segment, from the common carotid bifurcation to the carotid foramen; 2) the petrous segment, from the carotid foramen to the superior margin of the petrolingual ligament; 3) the cavernous segment, from the superior margin of the petrolingual ligament to the proximal dural ring; 4) the clinoidal segment, from the proximal dural ring to the distal dural ring; and 5) the cisternal segment, from the distal dural ring to the carotid bifurcation. With respect to the clinoidal segment of the ICA, we believe that it is part of the cavernous segment of the ICA, so that portion should be included in the cavernous segment. The authors also stressed that the ophthalmic artery may originate outside the so-called ophthalmic segment in up to 10% of cases, and the branches in the subarachnoid space may have variations, suggesting that the cisternal portion of the ICA should not be divided in segments. It is our opinion that the division of the cisternal segment of the ICA in three portions (ophthalmic, communicating and choroidal segments) is easy to use and suitable for clinical application. In the case of an extradural origin of the ophthalmic artery, the ophthalmic segment of the cisternal ICA extends from the anterior part of the roof of the cavernous sinus (distal dural ring) to the origin of the PComA.

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The authors are wise to revisit nomenclature of the ICA segmentation with an anatomical perspective, better based than the classical one on the (constant) bony and dural/periosteal structures. As actually mentioned but not finally retained by the authors, we find it important from a surgical stand-point to individualize the carotid segment comprised between the intrapetrous and the intracavernous portions of ICA; we think it should be named paratrigeminal as a matter of fact this segment lies underneath the Meckel's cave, between exit of the carotid from the horizontal portion of the petrous canal and entry into the true vascular compartment of the parasellar lodge, that is the cavernous sinus itself. Individualizing this segment is the more important as it can be exposed through an endocranial extradural approach, just posterior to the posterior edge of the dural sheath of V3 medially to penetration in foramen ovale. Carotid can be reached there through foramen lacerum without (in about one-third of cases) or with (in about the two other thirds) ronging and/or drilling the roof of the petrous canal. Access to this segment may be useful when dealing with intra-cavernous tumors, not only to identify ICA but also to assure its proximal control in the eventually of so-called of hemorrhagic difficulties (for temporary clamping).

So, our preferred classification from a surgical point of view would be the following: 1) cervical, 2) intrapetrous, 3) (extradural, through foramen lacerum) paratrigeminal, 4) (inter-periosteo-dural) intracavernous, 5) (extradural-interdural) paraclinoid, 6) (intradural) cisternal.

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