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# Variations of the Middle Meningeal Artery in the Middle Cranial Fossa

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LOYOLA UNIVERSITY SCHOOL OF MEDICINE

VARIATIONS OF THE MIDDLE MENINGEAL ARTERY  
IN THE MIDDLE CRANIAL FOSSA.

A THESIS  
SUBMITTED TO THE FACULTY  
of the  
GRADUATE SCHOOL  
of  
LOYOLA UNIVERSITY  
in  
CANDIDACY FOR THE  
DEGREE OF MASTER OF SCIENCE

by  
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## Introduction

Increased advances in the surgery of the head include operations upon the Gasserian ganglion and ligations of the middle meningeal artery when it has been subjected to trauma. Since this artery is intimately related to both operations, it follows that exact knowledge of its course and variations is necessary to the clinician for successful results. Kanavel and Davis ('22) have pointed out the close relations of this vessel to the semilunar ganglion; in connection with fractures of the temporal region of the skull, Rowan ('22) stressed the importance of the presence of a canal for the anterior branch of the artery. Bartlett ('02) emphasized the variability of the vessel encountered in surgery of the middle cranial fossa. Yatsuta ('95) discussed the surgical anatomy of the artery. These and all other authors who have studied the variations of the artery have done so with their own particular phase of the problem in mind. No one, however, has presented as full and complete a picture of the important variations as possible.

The purpose of this research is, therefore, to determine the course and variations of the middle meningeal artery as exactly as possible, and to interpret the results in the light of clinical and anatomical significance.

Grateful appreciation is due Dr. S. B. Chandler, Associate Professor of Anatomy at Loyola University Medical School, for suggesting the problem and for the helpful advice and criticism

rendered throughout the course of this research. Thanks are also due to Dr. O. F. Kampmeier of Illinois Medical School and Dr. B. J. Anson of Northwestern Medical, who have made their respective bone collections available for study. Had it not been for their cooperation, the number of skulls would have been too small to be conclusive.

#### Literature

The descriptions of the course of the middle menigeal artery as given in the standard text-books of anatomy are essentially the same. According to Cunningham's Anatomy ('31), "It is the largest branch of the internal maxillary artery. It passes through the foramen spinosum and enters the middle cranial fossa. In this fossa it passes forwards, for a short distance, in a groove on the great wing of the sphenoid, and divides into an anterior and posterior terminal branch. The artery lies in the outer layer of the dura mater. The anterior terminal branch passes upwards along the great wing of the sphenoid to the sphenoidal angle of the parietal bone, where it is sometimes enclosed in a bony canal. The posterior terminal branch passes backwards to the squamous part of the temporal bone, where it sends branches upwards to the vertex and backwards to the occiput. The smaller branches of the terminal arteries anastomose with each other and with those of the opposite side, and with the anterior and posterior meningeal arteries." The descriptions in Gray's Anatomy ('30),

Morris' Anatomy ('32), and Davis' Applied Anatomy ('26) are quite similar to that given in Cunningham's text-book. Morris' Anatomy adds that the canal for the anterior branch attains a size ranging from six to twelve millimeters, and Davis' text points out that this canal is located in the region of the pterion. These discussions give the impression that the course of the artery is essentially the same in all cases, and that no variations occur, with the possible exception of its relation to a canal.

Kanavel and Davis ('22), in an examination of one hundred skulls, found six distinct variations of the middle meningeal artery, all of which were confined to the posterior branch. They were as follows: (1) in 41 per cent. of the cases, the posterior branch was given off midway between the foramen spinosum and the region of the pterion; (2) in 36 per cent. of the instances, it was given off at a higher level, near the region of the pterion, and (3) in 8 per cent. of the cases, at a lower level, very soon after the artery emerged from the foramen spinosum; (4) two posterior branches arose at separate intervals in 8 per cent. and (5) simultaneously, in 5 per cent. of the cases; (6) no posterior branch was found in two instances.

Bartlett ('06) in his observations of one hundred half-skulls, found no instances of double branching of the posterior ramus. However, he described two other variations not here-to-

fore discussed: (1) in which the anterior branch was absent and (2) in which the main trunk, in addition to its anterior and posterior branches, gave off another ramus which coursed forwards and medially along the side of the sella turcica. He regards this additional branch as an anomalous condition. The frequency of occurrence of these variations was not mentioned.

Bartlett also discussed the variations in the relations of the foramen spinosum, by means of which the middle meningeal artery gains entrance into the middle cranial fossa. He found the foramen spinosum absent in one instance. In this case the artery entered the middle cranial cavity through the foramen ovale, accompanying the mandibular nerve. In all other cases the foramen spinosum was present. The distance between the foramen spinosum and the foramen ovale was less than one millimeter in four cases, from one to two millimeters in eleven cases, from two to three millimeters in thirty six cases, from three to five millimeters in thirty four cases, and from five to ten millimeters in twelve instances. In only one instance did the distance exceed ten millimeters. Whether these variations occurred unilaterally or bilaterally was not mentioned. Kanavel and Davis record the fact that the foramen spinosum was found to be continuous with the foramen ovale in four per cent. of their cases.

Yatsuta ('95), in the results obtained from an inspection of seventy five skulls, reported that the foramen spinosum was

present in every case. He noted that the posterior branch exhibited an inconstant course. It arose at a level varying from 1.5 cm. to 3.1 cm. superior to the foramen spinosum. He added that the anterior branch was contained in a bony canal in almost every case, and that the canal was situated posterior to the sphenoparietal sinus.

Rowan ('22), in a detailed account of the frequency of the presence of a canal for the anterior branch of the middle meningeal artery, noted that it was present in 110 of the 195 lateral halves of crania examined (56.4 per cent.). The canal occurred bilaterally in 31 per cent. of the crania, and was absent on both sides of the cranium in 25 per cent. of the cases. The bony canal was found on the right side only in 27.1 per cent of the instances, and on the left in 30 per cent. of the specimens.

The literature just cited shows that the standard textbooks of anatomy assume that no variations occur in the course of the middle, meningeal artery, with the possible exception of the presence of a canal. The clinical literature, on the other hand, describes eight different variations. All these variations were not described by the same author, and the number of crania examined was relatively small.

#### Methods and Materials

Observations have been carried out on 430 whole and 49 half crania obtained from the anatomical laboratories of

Loyola, Northwestern and Illinois Medical Schools. Of these, 324 whole and 39 half crania were bare of all soft tissues; as a result, the course of the middle meningeal artery was deduced from the presence of the groove which the vessel made upon the floor and sides of the cranium. The remaining 106 whole and 10 half crania were obtained directly from cadavers with the meninges still adherent to the bony parts. Here, the course of the artery could be directly traced as it traversed upwards, through the dura mater, toward the region of the calvarium. There were, in all, 907 lateral halves of crania examined. However, not every cranium, because of trauma or other circumstances which affected its physical condition, presented a complete picture of the course of the artery. For this reason, there is a difference in the number of crania examined for each type of variation.

The scope of this research embraces the variations of the middle meningeal artery found in the middle cranial fossa, commencing at the entrance of the vessel into the middle cranial cavity, and terminating when the artery crosses at the level of the lesser wing of the sphenoid. For this reason the variations of the middle meningeal artery have been classified according to its entrance into, its course within, and its exit from, the middle cranial fossa.

### Results

Entrance into the middle cranial fossa.



In the 758 lateral halves of crania examined, the middle meningeal artery was found to enter the middle cranial fossa by way of the foramen spinosum in all except seven instances. In the latter cases the vessel gained its entrance by coursing through the foramen ovale, in company with the mandibular trunk of the trigeminal nerve. Thus the foramen spinosum was present in 751 cases, or 99.1 per cent. of the instances. The foramen spinosum, when present, likewise presented some variations. It was situated postero-lateral to the foramen ovale in all but five cases. In two of these latter instances it was found directly medial to the foramen ovale, within two millimeters of it; in the remaining three cases it was closely related to the lateral aspect of the foramen ovale.

The distance between the foramen spinosum and the foramen ovale varied considerably. In eight cases (1 per cent.) the one communicated with the other. In twenty five instances (3.3 per cent.) the two foramina were separated by a thin spicule of bone less than one millimeter in thickness. A partition of bone that separated the foramina measured one to three millimeters in length in 326 cases (43.4 per cent.), from three to five millimeters in length in 334 instances (44.5 per cent.), and from five to ten millimeters in fifty three cases (7 per cent.). In one instance the interval measured seventeen millimeters.

### Course within the middle cranial fossa:

The variations of the middle meningeal artery as it courses through the middle cranial fossa are divided into those of its anterior and posterior branches.

#### a. Variations of the anterior branch.

This branch was present in all but five of the 903 lateral halves of crania examined. In nine cases (1 per cent.) the middle meningeal artery, immediately after its exit from the foramen spinosum, bifurcated into two anterior branches. The lateral branch coursed in the manner typical of the anterior ramus, while the medial ramus proceeded forwards along the side of the sella turcica, either to supply the meninges in that region or else to bend laterally to anastomose with branches from the anterior meningeal artery. The medial anterior branch was intimately related to the mandibular and maxillary nerves as it coursed along the lateral aspects of the foramen ovale and foramen rotundum. In 99 instances (10.9 per cent.) the anterior branch (or the main trunk, if the posterior branch arose at a high level) gave off a medial branch midway in its course. This ramus proceeded medially towards the lesser wing of the sphenoid bone. In a few instances it supplied the meninges in that region, and in all other cases it was seen to enter the orbital cavity either through the superior orbital fissure or by way of a separate foramen, to anastomose with the ophthalmic artery.

Two anterior branches were found to be bilaterally present in one cranium, and a medial terminal branch occurred on both sides in forty eight crania.

b. Variations of the posterior branch:

Eight distinct variations were noticed in the 894 lateral halves of crania observed. The posterior branch was absent in six cases (.6 per cent.). It was found as a single branch in 722 cases (80.7 per cent.), and when in this state it was given off at one of three levels: in the majority of the cases (295 instances, or 33 per cent.), it was situated midway between the foramen spinosum and the region of the pterion; less frequently (258 instances, or 28.8 per cent.), it arose very soon after the artery proper emerged from the foramen spinosum. In the remaining 169 instances (18.9 per cent.) it originated at a high level, at or near the region of the pterion.

Two posterior branches were given off simultaneously in thirteen cases (1.4 per cent.). Two posterior branches arose at separate intervals in forty eight cases (16.5 per cent.). These branches, like those of the single posterior ramus, were given off at various levels.

A bony canal containing the posterior branch of the middle meningeal artery was found in seven instances (.8 per cent.). In thirty two cases (4.5 per cent.) the posterior branch bifurcated very near its origin.

As to the bilateralism of these variations, fifty two of the 423 whole crania inspected exhibited a bilateral presence of the single posterior branch arising at a level midway between the foramen spinosum and the region of the pterion (12.3 per cent.). The same branch originated at a lower level, near the foramen spinosum, on both sides in a like number of specimens. In thirty three crania (7.8 per cent.) it was bilaterally situated high up near the region of the pterion. Two posterior branches arose at separated intervals on each side in forty eight whole specimens.

It is to be noted that two variations may be found on the same lateral half of a specimen, *i.e.*, a variation of the posterior branch occurring together.

#### Exit from the middle cranial fossa.

The posterior branch presented no significant variations for the reason that it usually breaks into a large network of smaller branches as it reaches the calvarium. The anterior branch, on the other hand, continued for a longer period of time before subdividing. Above the level of the lesser wing of the sphenoid bone, which bounds the upper limit of the middle cranial fossa, this branch coursed upward toward the region of the calvarium as a single artery in 842 out of the 870 cases examined (96.7 per cent.). In the remaining twenty eight cases (3.3 per cent. ), it divided into two ascending branches.

The single anterior ascending branch was enclosed in a bony canal in 502 instances (59.6 per cent.). In six instances the ascending branch emerged from one canal to enter another canal after a short interval during which it was superficial to the bony plate of the cranium. In the remaining 340 instances (40.4 per cent.) the ascending branch proceeded toward the calvarium in a groove on the side of the cranium. When the ascending branch was double, both of these anterior rami were in grooves in seven instances, and in eighteen other instances one branch was contained in a canal, and the other lay in a groove. In the remaining three instances both branches were found in canals.

The bony canal, when present, contained the sphenoparietal sinus in addition to the ascending branch in twenty cases (2.3 per cent.). In eleven cases the single ascending branch bifurcated within the canal, and in this manner formed a canal with a single entrance and a double exit.

The canal was absent on both sides of the same cranium in 96 out of the 408 specimens that were observed (23.5 per cent.). It occurred bilaterally in 170 instances (41.6 per cent.).

Of the 152 whole specimens possessing a canal on one side alone, sixty seven of these demonstrated a canal on the right side, and eighty five exhibited a canal on the left side, thus

showing that this bony tunnel tends to be present <sup>often</sup> more on the left side than the right side.

An inspection of 522 canals revealed considerable differences in their lengths, which varied from one to thirty five millimeters. The length of the canals, with their number of percentage and instances of occurrence, are as follows:

Length	No. of instances	Percentage
1 to 5 mm	123	23.5
5 to 10 mm	118	22.6
10 to 15 mm	131	25.1
15 to 20 mm	93	17.7
20 to 25 mm	32	6.1
25 to 30 mm	19	3.6
30 to 35 mm	5	.5

It should be noted that the length of the canal measures from one to fifteen millimeters in the greatest number of cases.

The relations of the entrance of the canal for the anterior branch of the middle meningeal artery were found to be at variance with those described by the standard text-books of anatomy. Cunningham's Anatomy ('31) and Davis Applied Anatomy ('26) state that this entrance of the canal lies in at the pterion. Of the 419 lateral halves of crania containing a canal only sixty of these canals demonstrated a definite relationship to the pterion, that is, they were topographically

situated within a five millimeter of it. The canal was related posterior to the pterion, in the region of the Sylvian point, in 165, or 39.3 per cent. of the remaining 359 cases. The distance between it and this landmark ranged from five to ten millimeters in ninety cases, from ten to fifteen millimeters in fifty six other instances and from fifteen to twenty millimeters in seventeen additional cases. The distance measured twenty four millimeters in two instances.

The entrance of the bony canal was situated inferior to the pterion in 132 casws (31.5 per cent). In seventy five of these cases it was located from five to ten millimeters inferior to the pterion, and in thirty eight other instances, from ten to fifteen millimeters inferior to it, while in the remaining seventeen cases it was from fifteen to twenty millimeters inferior to that landmark. In two instances the distance measured twenty three millimeters.

In two cases the canal was located superior to the pterion at a distance of thirteen millimeters, and was found to be anterior to it in two additional cases at a distance of twelve and fifteen millimeters respectively.

The canal was both posterior and superior to this topographical landmark within a fifteen millimeter radius in forty nine lateral halves of crania (11.7 per cent) anterior and inferior within a ten millimeter range in sixteen other cases (3.8 per cent.).

Obviously, the pterion is not a constant landmark for the location of the canal for the anterior branch of the middle meningeal artery. Inasmuch as the entrance of this canal is found to be posterior to it in more than one third of the cases, and inferior to it in almost as many instances, it would seem that there is no dependable landmark for the canal, the pterion least of all.

#### Summary and conclusions.

By way of summary, the observations made on 907 lateral halves of crania have brought out the following facts:

In 99.1 per cent of the cases the middle meningeal artery entered the middle cranial fossa by way of the foramen spinosum. When the foramen was absent, the artery gained entrance into the middle cranial cavity through the foramen ovale, accompanying the mandibular trunk, of the trigeminal nerve. When the foramen spinosum was present, it infrequently communicated with the foramen ovale, or was separated from it by a thin spicule of bone. In the greater number of instances it was situated posterolateral to the foramen ovale at a distance varying from one to seventeen millimeters. In the majority of the cases the distance measured one to five millimeters.

The anterior branch of the middle meningeal artery usually was found to be a single branch. In one per cent. of the cases it was given off either by the main trunk or the



anterior branch. This additional branch coursed forwards and medially, and in the majority of the cases it anastomosed with the ophthalmic artery within the orbital cavity.

The posterior branch was found to be single in 80.7 per cent. of the cases and arose most frequently midway between the foramen spinosum and the region of the pterion. Less frequently it arose low down, near the foramen spinosum, and least frequently its origin was situated at a high level, near the region of the pterion. Two posterior branches were found in 17.9 per cent. of the cases. In most instances they arose at separate intervals, and in relatively few cases originated simultaneously. Absence of the posterior branch existed in .6 per cent. of the cases.

In six cases a canal was found containing the posterior branch. In 28 instances the posterior branch bifurcated very soon after its origin.

The posterior branch presented no variations as it made its exit from the middle cranial fossa, because of the fact that it branched extensively early in its course. The anterior branch, however, continued for a considerable distance before subdividing. Usually it ascended as a single branch; in twenty eight cases it divided into two ascending rami. In its course it was contained in a bony canal in 59.6 per cent. of the cases. In all other instances it lay in a groove on the side of the cranium. In addition to the anterior branch, the canal

also contained the sphenoparietal sinus in 2.3 per cent. of the cases. The length of the canal varied from one to thirty five millimeters; in most of the cases observed it measured from five to fifteen millimeters in length. It was present more often on the left side than the right side. In many cases (41.5 per cent.) the canal was bilateral and in almost one half as many instances it was bilaterally absent.

The relations of the entrance of the bony canal were found to be quite variable. In only 14.3 per cent. of the cases was it related directly to the pterion. In the greatest number of cases (39.3 per cent.) it was situated posterior to it, at a distance varying from five to twenty millimeters. In those instances it was intimately related to the Sylvian point. Less frequently, yet in sufficiently large number (31.5 per cent.), it was located inferior to the pterion, also at a distance varying from five to twenty millimeters. In very few instances it was found either anterior or superior to that landmark. There is therefore no constant landmark for the entrance of the canal.

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\*The article was kindly translated from the Russian by Dr.J.M.Essenberg, Associate Professor of Anatomy at Loyola University Medical School.



Fig. 1. Middle meningeal artery entering the middle cranial fossa through the foramen ovale.

Fig. 2. Posterior branch of the middle meningeal artery arising midway between the foramen spinosum and the pterion.

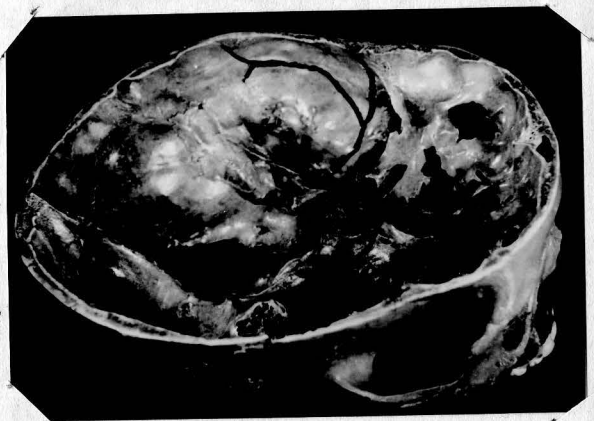


Fig. 3. Posterior branch arising at a low level, near the foramen spinosum.

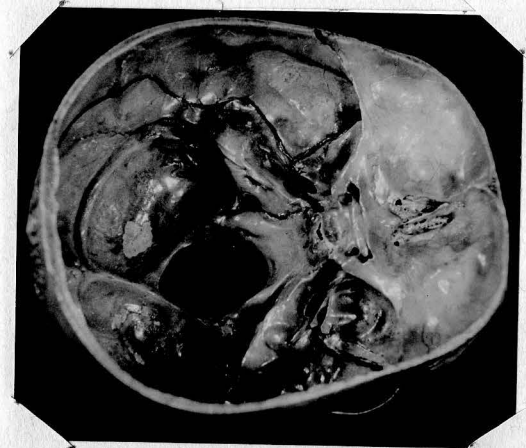




Fig. 4. Posterior branch arising at a higher level, near the region of the pterion.

Fig. 5. Two posterior branches, arising at separate intervals.

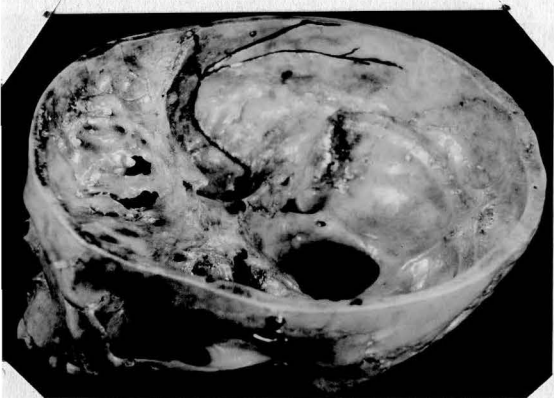


Fig. 6. Two posterior branches, arising simultaneously.



Fig. 7. No posterior  
branch.

Fig. 8. Posterior  
branch enclosed in a  
bony canal.

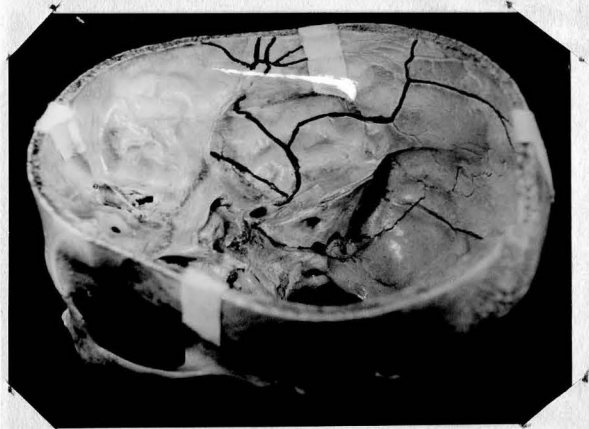
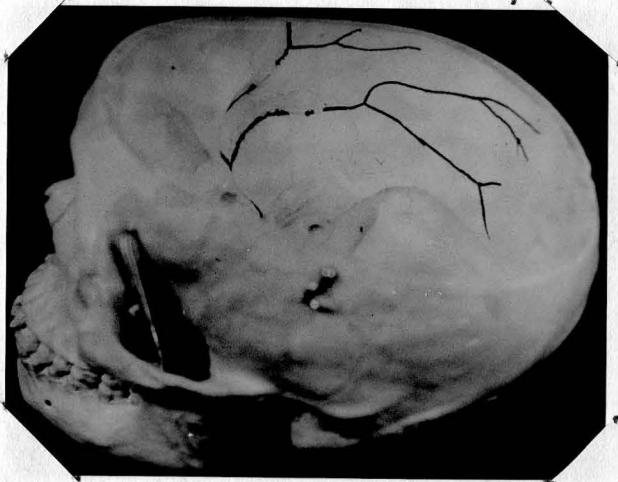


Fig. 9. Middle meningeal  
artery dividing into two  
main trunks.



Fig. 10. Anterior branch of the middle meningeal artery bifurcating into two ascending lateral branches.

Fig. 11. Anterior branch embedded in a groove throughout its course.

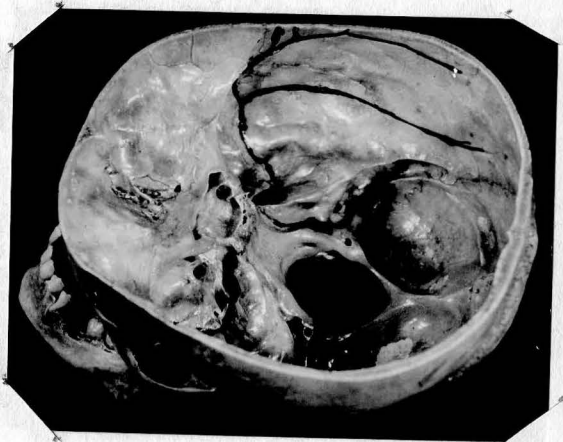


Fig. 12. Anterior branch contained in a bony canal 3 cm. in length.

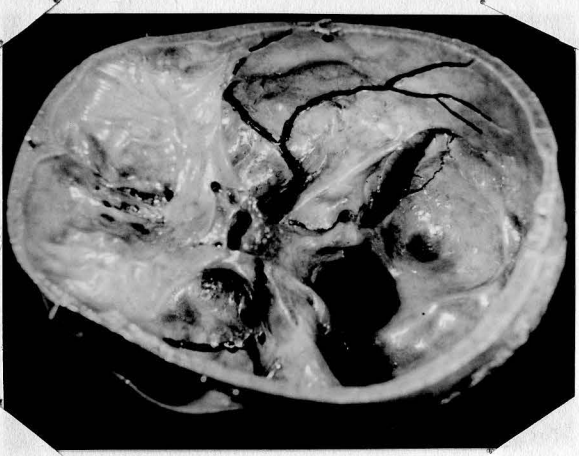


Fig. 13. Anterior branch contained in two bony canals at separate intervals.

Fig. 14. Anterior branch bifurcating within its canal, thus forming a canal with a single entrance and two exits.



Fig. 15. Sphenoparietal sinus contained in the canal together with the anterior branch.