Anatomy for Surgeons:
Volume 1

THE HEAD AND NECK

Third Edition

W. Henry Hollinshead, Ph.D.

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Preface

This third edition of Volume 1 of *Anatomy for Surgeons* attempts to present, as did the first and second editions, anatomic facts and concepts concerning the head and neck that are of particular interest to the surgeon. It is not intended to be a complete descriptive anatomy of these parts but is designed to serve both as a ready reference in which the surgeon can find descriptions of the basic anatomy and as a useful review of numerous, sometimes minute, anatomic details gathered from many sources. No attempt has been made to describe the indications for, or detailed technique of, specific operations, for these are matters that belong to surgery and not to anatomy. Particular care has been taken throughout this volume, however, to relate anatomic and physiologic details and concepts to underlying surgical procedures.

Most of the anatomy described in the second edition is still both valid and pertinent, for basic anatomy does not change. However, newer techniques, particularly the widespread use of the surgical microscope, have both enlarged our knowledge of anatomy and emphasized the practicality of such knowledge. Additions, improvements, and refinements in our understanding of anatomic details and in diagnostic and operative procedures on the head and neck have made revision of this book necessary. The basic descriptions have been carefully scrutinized. Some have been rearranged or partly rewritten in the interest of greater clarity and accuracy, and numerous minor revisions have been made to incorporate more recent findings and clinical applications.

Almost every chapter contains observations and interpretations that were not available at the time the second edition was written. To cite only a few, there are new studies of the accessory rootlets of the trigeminal nerve, relationships in the cavernous sinus, the course of the sympathetic fibers to the superior tarsal muscle, functions of the muscles of the tympanic cavity and of the muscles of mastication, relations of the nasal cartilages, effects of neurectomy on intractable parotitis, routes by which parasympathetic fibers reach the submandibular and sublingual glands, movements of the arytenoid cartilages, and the origin of the calcitonin-producing cells of the thyroid gland.

The Nomina Anatomica (NA), which was adopted in 1955, was used in the preceding edition of this book and is used here. Because many clinicians may be more familiar with the Basel Nomina Anatomica (BNA), however, I have also attempted to include the more commonly used BNA synonyms at least once if they differ appreciably from those of the NA.

I remain deeply indebted to those former colleagues at the Mayo Clinic who were so helpful in the two previous editions. They are listed in each of those editions, and I regret that I could not avail myself of their counsel in the current one.

I am also indebted to my publishers, Harper & Row.

W. Henry Hollinshead
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Contents

Chapter 1
THE CRANIUM

Scalp

The three layers[1] of the scalp (Fig. 1-1)—the skin, the subcutaneous tissue, and the aponeurotic layer (galea aponeurotica, epicranial aponeurosis) with its associated epicranial muscles—are intimately fused and move as a unit with the contraction of the muscles. The dense subcutaneous tissue of the scalp contains the larger blood vessels and nerves, and its strong retinacula not only unite the skin and the galea, but afford support to the blood vessels. These layers are separated from the external periosteum or pericranium by a loose fourth layer that allows easy movement of the scalp and also ready spread of fluid or infections beneath it. Because of the latter fact, the subaponeurotic layer is sometimes referred to as the danger space of the scalp; fluids contained therein find exit with difficulty, typically into the periorbital connective tissue. The periosteum is fairly tightly attached to the bone, especially at the sutures; it is through the loose subaponeurotic tissue that separation occurs most easily in tears or surgical reflections of the scalp.

NERVES AND VESSELS

The nerves and blood vessels of the scalp run up into it from below, the larger ones on the forehead and in the temporal and occipital regions; although the blood vessels anastomose so freely with each other that there is relatively little danger of reducing markedly the blood supply to an area of scalp unless a skin flap with an extremely narrow inferior pedicle is produced, the nerve supply must be taken into consideration when incisions for skin flaps are planned, or else an area of denervated or partially denervated scalp, with resulting numbness or paresthesia, will be produced.

Since the arteries of the scalp anastomose freely with each other and with those of the opposite side, they form a part of the potential collateral pathway available after ligation of the external or common carotid artery on one side. It is because of these abundant anastomoses, also, that wounds of the scalp involving the subcutaneous tissue typically show arterial bleeding from both cut surfaces. The profuseness of the bleeding is further contributed to by the fact that the blood vessels lie largely in the dense subcutaneous tissue, by which they are supported and to which they are attached, and tend therefore to be held open by this tissue when they are cut. The arteries of the scalp also send small twigs to the underlying bones of the skull.

The nerves to the scalp are branches of cranial and spinal nerves (Fig. 1-2), the spinal nerves being derived both from the cervical plexus and from the posterior primary rami of

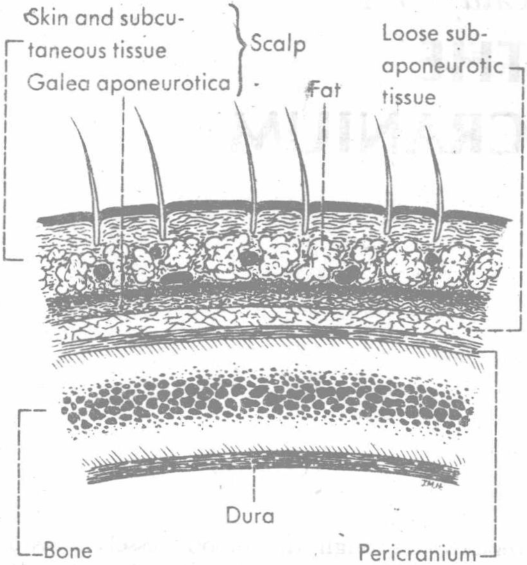
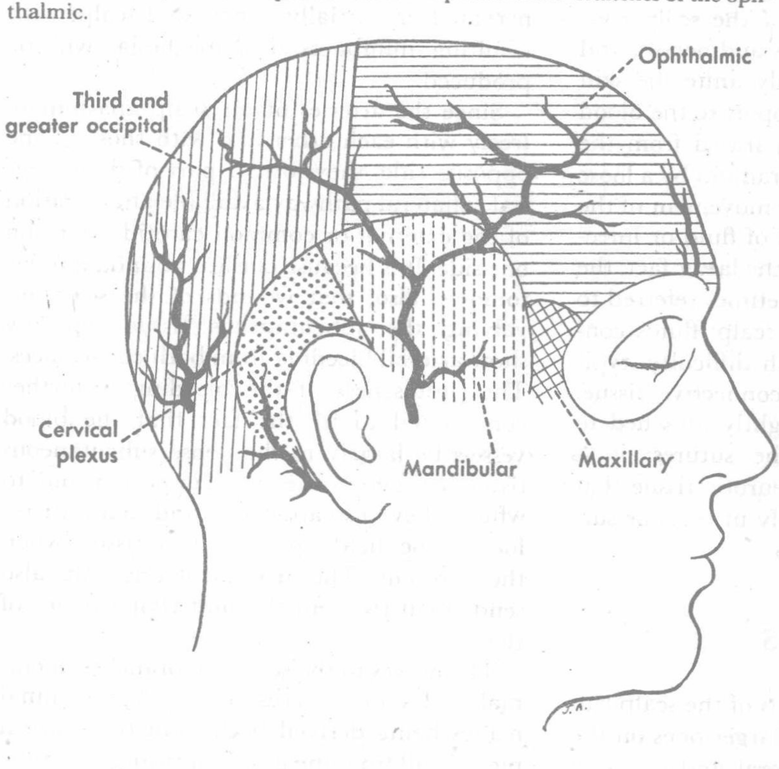


Fig. 1-1. The scalp.

the upper cervical nerves. Generally speaking, these nerves accompany the blood vessels of the scalp, which are derived largely from branches of the external carotid, but anteriorly are from the ophthalmic branch of the internal carotid.

Since the nerves of the scalp approach it from all directions and have, of course, a considerable overlap, it is usually impossible to produce adequate anesthesia of any large area of the scalp by a purely local injection; rather, the area in which anesthesia is desired must be ringed by a whole series of injections. Further, the nerves, like the vessels, run mainly in the subcutaneous tissue, and the solution must therefore be placed in this layer rather than in the subaponeurotic layer where it could spread much more easily but would be separated from the nerves by the tough galea aponeurotica.

Fig. 1-2. General areas of distribution of the main nerves to the scalp, and the positions of the principal arteries. The unlabeled arteries, from left to right, are the occipital, posterior auricular, and superficial temporal branches of the external carotid, and the supraorbital and supratrochlear branches of the ophthalmic.



Supraorbital Nerve and Artery

The supraorbital nerve (from the ophthalmic branch of the trigeminal) and the supraorbital artery (from the ophthalmic artery) emerge through the supraorbital notch or foramen to turn sharply around the upper margin of the orbit and be distributed to the scalp. At first they lie deep to the frontalis muscle but subsequently pierce this to run in the scalp's dense subcutaneous tissue. The small supraorbital artery forms anastomoses with the other vessels of the scalp, while the supraorbital nerve supplies a very large area on the scalp, extending backward over the vault of the skull to approximately the interauricular line or slightly beyond it. Medial to the supraorbital nerve and artery are the smaller supratrochlear nerve and the supratrochlear (frontal) artery, also branches of the ophthalmic nerve and artery; the nerve supplies a limited medial region of the forehead.

Because of the extensive distribution of the supraorbital nerve, frontal skin flaps or curved incisions over the front of the vault of the skull should be large to avoid an area of denervated tissue.

Auriculotemporal Nerve

Laterally, in front of the ear, the auriculotemporal nerve (a branch of the mandibular division of the fifth nerve) extends upward with the superficial temporal vessels to supply the chief portion of the temporal region of the side of the head as high as the superior temporal line on the skull—that is, especially over the area of the origin of the temporalis muscle. More anteriorly, supplying skin behind the orbital process of the zygomatic bone, but not extending so far upward, is the zygomaticotemporal branch of the maxillary division of the fifth cranial nerve. To avoid interference with this nerve supply and with the superficial temporal artery whose main branches, parietal and frontal, spread out in this same area, temporal skin flaps should be U- or horseshoe-shaped, with the base widely attached below.

Great Auricular Nerve

Although a small and probably variable area of skin behind the ear and over the mastoid process is innervated by the auricular branches of the seventh, ninth, and tenth cranial nerves (Chap. 3), the larger nerve distributed here, and extending upward to the scalp, is the great auricular from the cervical plexus (C2 and C3). The artery in this location is the posterior auricular branch of the external carotid, which roughly parallels the nerve. More posteriorly over the mastoid process is the mastoid branch of the occipital artery, which aids in supplying the scalp and also sends a branch into the bone to supply mastoid cells.

Occipital Nerves

Behind the area of distribution of the great auricular nerve is the *lesser occipital nerve*, also ascending from the cervical plexus (primarily second cervical). Small skin flaps over the mastoid region may be turned down by a U-shaped incision passing upward from the ear to the temporal line and then curving backward and downward along this line; larger reflections of scalp here will usually involve the distributions of the auriculotemporal or occipital nerves.

The *greater occipital nerve* is derived largely from the dorsal (posterior) primary branch of the second cervical nerve; it typically appears in the suboccipital region at about the lateral border of the trapezius muscle and becomes subcutaneous by piercing the fascia between the attachments of the trapezius and the sternocleidomastoid muscles to the skull; here it is joined by the occipital artery, and is distributed over the posterior part of the cranial vault to the vicinity of the interauricular line. Its area of distribution here overlaps that from the supraorbital branch of the ophthalmic, and laterally, at the level of the temporal line, overlaps the areas of distribution of the great auricular and lesser occipital nerves. Medial to the greater occipital nerve the *third occipital* (representing the dorsal ramus of C3) extends also upward to the scalp, but for a relatively short distance.

Straight midline incisions, and curved ones along the temporal lines, lie in general between nerves; incisions connecting the two necessarily denervate some scalp, but if the skin flap is turned downward with its base left attached in the occipital region its innervation can be preserved.

VEINS

The veins of the scalp parallel the arteries. They receive many of the emissary veins of the cranium, and through these communicate with the cranial venous sinuses. The usual *emissary veins* are the parietal that penetrate the parietal bones posterior to their midpoints a little on each side of the midline, connecting the occipital veins and the superior sagittal sinus; one or more mastoid veins that penetrate the posterior aspect of the base of each mastoid process and connect the sigmoid sinuses to the occipital or posterior auricular veins; and the condylar (condyloid) veins, not as constant, that traverse the condylar (condyoid) canals and connect the confluence of the sinuses to the suboccipital venous plexus. Occasionally there is an unpaired occipital emissary vein penetrating the external occipital protuberance and connecting the confluence of the sinuses to an occipital vein.

Arteriovenous malformations, more common in the head than elsewhere, occur more frequently in the scalp; they may be continuous through the skull with similar endocranial formations, or formed by dural arteries that penetrate the skull—in either case, of course, being supplied by the external carotid system.

LYMPHATIC VESSELS

The lymphatic vessels from the frontal region of the scalp drain downward and backward into the superficial parotid (preauricular) lymph nodes; those from the parietal and temporal regions pass downward both in front of and behind the ear to end in the superficial parotid, superficial cervical, and retroauricular (mastoid) nodes, or bypass these and end directly in upper nodes of the deep cervical group; those from the occipital region drain for the most part into both the occipital and upper deep cervical nodes, but one large vessel from this region is said to follow the posterior border of the sternocleidomastoid muscle to reach lower deep cervical nodes.

SENSITIVITY OF THE SCALP

Ray and Wolff, in their study of the pain-sensitive structures in the head, found that although the skin of the scalp is sensitive to all the usual forms of stimulation to which skin is elsewhere, the *galea aponeurotica* is sensitive only to pain; where the extracranial blood vessels are in close contact with the galea the pain sensitivity was found to be greater than at other points. Like the galea, the fascia over the temporal and occipital muscles, and these muscles themselves, were reported as sensitive only to pain, this pain being appreciated near the point of stimulus.

The *periosteum* on the outside of the skull varied in sensitivity, that over the vertex being entirely insensitive; there was a general increase in sensitivity just over the eyebrows, low in the temporal regions, and low in the occipital region—that is, in the areas in which the nerves were approaching the scalp. Even here, however, the periosteum apparently is not particularly sensitive, since stripping of periosteum around the base of the skull produced only moderate pain in the neighborhood of the point of stimulation.

The *arteries* of the scalp were all found to be sensitive to pain, while the veins were either less or not at all sensitive.

The *bony skull* itself, as also its veins, was found to be insensitive to all types of stimulation.

Calvaria

The bony vault of the cranium, the calvaria, consists, from before backward, of the unpaired frontal bone, the paired parietals, and the unpaired occipital bone (Fig. 1-3). Laterally, the greater wings of the sphenoid bone,

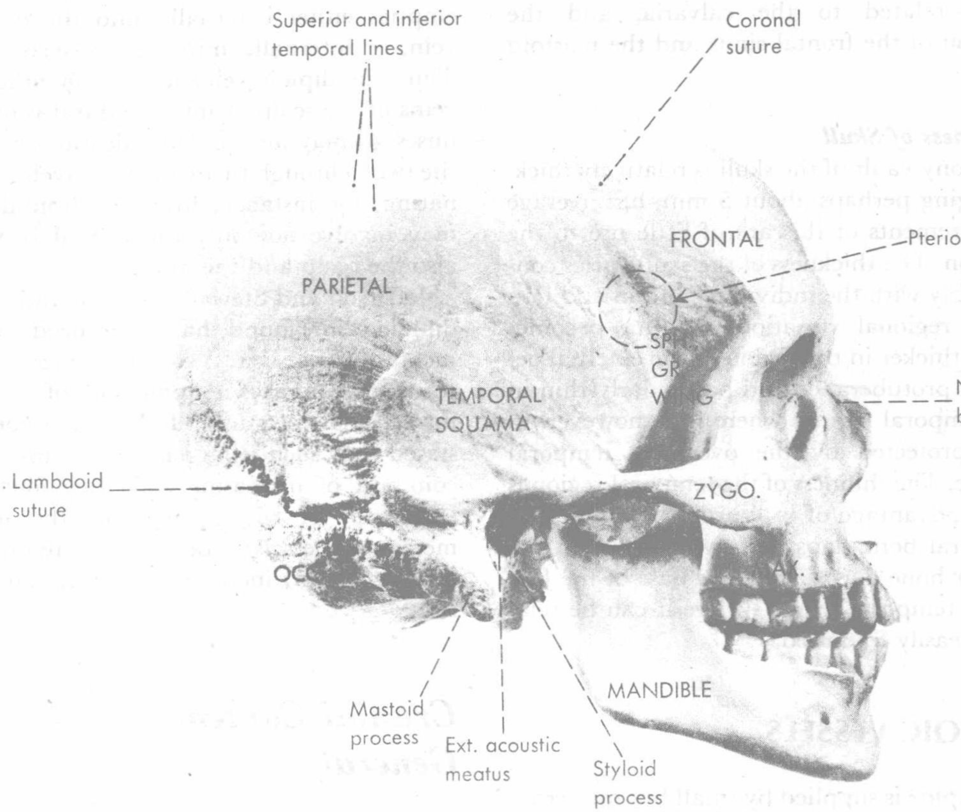


Fig. 1-3. Lateral view of the skull. *MAX., OCC., SPH. GR. WING,* and *ZYGO.* are the maxillary and occipital bones, the greater wing of the sphenoid, and the zygomatic bone.

and posterior to them the temporal bones, complete the sides of the brain case.

The calvaria is, of course, covered with periosteum on both its outer and inner surfaces; the inner periosteum is fused to the dura, forming its outer layer. The periosteum of the skull is, however, markedly deficient in osteogenic power in the adult, as compared with the periosteum of long bones; relatively little regeneration of the bones of the skull may be expected following a craniotomy unless the bone flap is replaced. Areas of bone removed and replaced in the temporal region usually heal better than bone elsewhere, presumably because of the greater blood supply furnished them by the deep temporal arteries.

The bones of the vault of the cranium show three distinct layers: hard external and internal laminae (outer and inner tables) and a cancellous middle layer or diploë. The inner table is distinctly thinner than the outer and may be fractured by blows that leave the outer table intact, thus rendering it more difficult to diagnose fractures of the skull.

Surgical approaches to the cerebral hemispheres, both diagnostic and operative, are usually made through the calvaria, as are also approaches to the other contents of the anterior and middle cranial fossae. A preliminary step is trephining the calvaria at a suitable and relatively safe spot; through the trephine opening a needle or other small instrument can be inserted or, if a larger opening is desired, several trephine openings can be made and connected by sawing through the intervening bone.

In planning trephine operations on the calvaria, factors to be considered are not only the relations of the calvaria to the various subdivisions of the cerebral hemispheres, but also the positions of the cranial venous sinuses—the superior sagittal and the transverse sinuses—related to the calvaria, and the position of the frontal sinus and the mastoid cells.

Thickness of Skull

The bony vault of the skull is relatively thick, averaging perhaps about 5 mm, but average measurements of this are of little use to the surgeon. The thickness of the skull varies considerably with the individual and in addition shows regional variations. It thus becomes much thicker in the region of the external occipital protuberance and particularly thin in the temporal region, where it is, however, in part protected by the overlying temporal muscle. The thinness of the temporal region is taken advantage of in "turning" frontal and temporal bone flaps, by sawing through the thicker bone and leaving the base of the flap in the temporal region, where it can be relatively easily fractured.

DIPLOIC VESSELS

The diploë is supplied by small but numerous diploic branches from arteries both on the external and internal surfaces of the skull—that is, from arteries of the scalp and from those of the dura mater. The diploic veins anastomose freely with each other, but usually form five chief veins on either side: the frontal, anterior temporal (typically two), posterior temporal, and occipital diploic veins.

The *frontal* diploic (Fig. 1-4*A*) veins communicate through the inner table with the superior sagittal sinus, but empty primarily downward into the supraorbital tributary to the ophthalmic vein, emerging from the skull through a small foramen located in the roof of the supraorbital notch. The two *anterior temporal* veins (Fig. 1-4*B*) usually pass downward in front of and behind the coronal suture, respectively, to communicate both with the veins of the temporal muscle and with the sphenoparietal sinus. The *posterior temporal* diploic vein, in the parietal bone, drains downward to the mastoid region where it perforates the inner lamina to join the transverse sinus. The *occipital* diploic vein (Fig. 1-4*C*) empties either externally into the occipital vein, or internally into the transverse sinus. Thus, the diploic veins may drain either into veins of the scalp or into the dural venous sinuses, or may form communications between the two. Through them an osteomyelitis originating, for instance, from the frontal sinus may involve not only the frontal bone but also the scalp and the dura.

Jefferson and Stewart, in their study of the diploic veins, found that generalized enlargement of these veins, as sometimes seen in roentgenograms, is no indication of increased intracranial pressure, and it is sometimes stated that such enlargement is a usual concomitant of increasing age; they found enlargement of the grooves for the middle meningeal vessels to be much more often associated with increased intracranial pressure.

Cranial Contents in General

Except for the relations to the cranial vault, the relationships of many of the components of the cranial contents—for instance, those of nerves and vessels to each other—can be more usefully discussed in connection with the individual cranial fossae. The following account is therefore a general one; more specific details will in many instances be found in connection with the descriptions of the cranial fossae.

DURA MATER

Where it is in contact with the bones of the skull the cranial dura mater, the general relations of which are shown in Figure 1-5, serves also as the internal periosteum of the skull. Its outer part is therefore continuous with the outer periosteum (pericranium) through the various foramina of the skull; the remainder is the equivalent of the spinal dura, with which it is continuous at the foramen magnum.

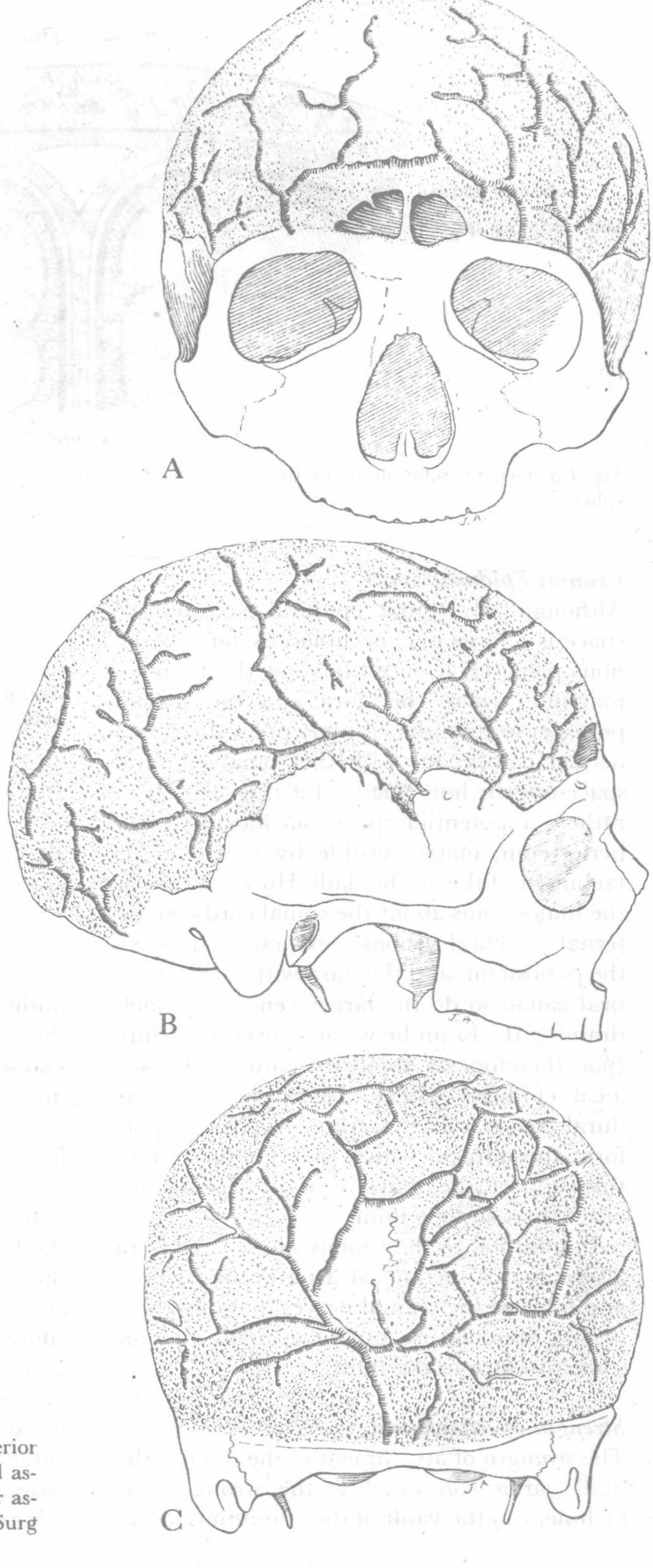


Fig. 1-4. *A.* The diploic veins from the anterior aspect. *B.* The diploic veins from the lateral aspect. *C.* The diploic veins from the posterior aspect. (After Jefferson G, Stewart D: Br J Surg 16:70, 1928)

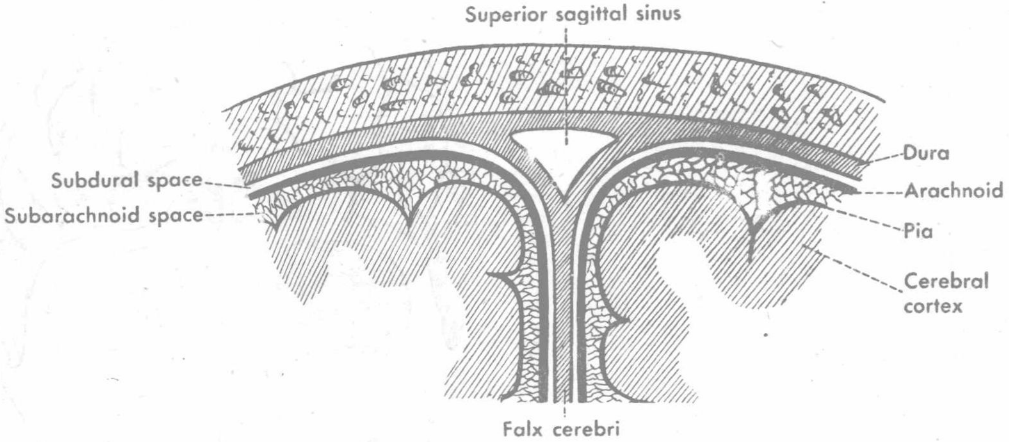


Fig. 1-5. General relation of the three meninges to each other and to the cerebral hemispheres.

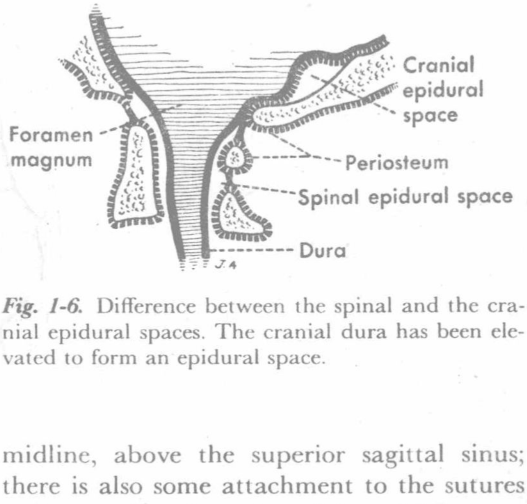


Fig. 1-6. Difference between the spinal and the cranial epidural spaces. The cranial dura has been elevated to form an epidural space.

Cranial Epidural Space

Although the spinal epidural (extradural) space is a large one, occupied by fat and venous plexuses, it ends above at the foramen magnum where the dura and the cranial periosteum fuse; the cranial epidural space is neither continuous with the spinal epidural space nor the homologue of it (Fig. 1-6). It is, rather, a potential space outside the inner periosteum, made possible by the loose attachment of this to the skull. However, just as the major veins about the spinal cord (the internal vertebral venous plexuses) lie between the periosteum and the dura within the vertebral canal, so do the larger venous channels draining the brain lie within the cranial dura (not, therefore, as about the cord, in the surgical epidural space). These channels, the dural venous sinuses, thus receive support form the dura in which they lie; because of this support, they have no walls of their own other than endothelium.

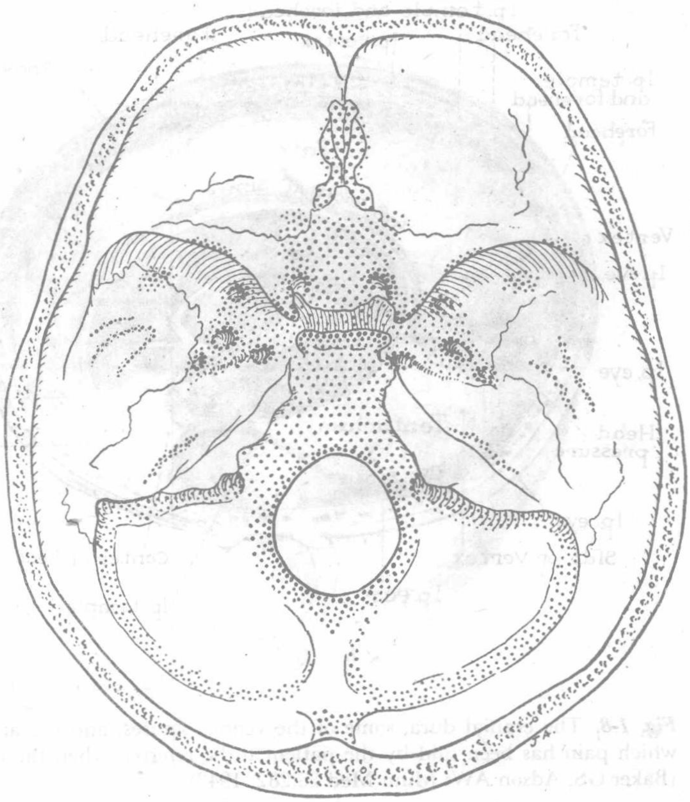
In addition to the venous sinuses, the dura also contains meningeal arteries and nerves, and some of the cranial nerves (notably those to the musculature of the eyeball) run for some distance in the dura.

Strength of Attachment

The strength of attachment of the dura to the skull varies considerably; the strongest attachment to the vault of the cranium is in the midline, above the superior sagittal sinus; there is also some attachment to the sutures and some along branches of the middle meningeal artery, but otherwise the attachment to the vault is weak, making removal of bone flaps relatively easy and allowing the development of massive epidural hemorrhages.

In contrast, the attachments of the dura into the base of the skull are relatively strong; in the anterior fossa the dura is attached especially strongly to the crista galli and the cribriform plate, and about the optic canal (Fig. 1-7). In the middle fossa the main attachments are about the edges of the numerous foramina through which nerves and vessels enter and leave this part of the cranium, especially the superior orbital fissure, the foramen rotundum, the foramen ovale, and

Fig. 1-7. Areas of stronger attachment of the dura to the base of the skull. (After Walker AE: Anat Rec 55:291, 1933)



the foramen lacerum. In the posterior cranial fossa the dura is attached especially to the basal portion of the sphenoid bone, to the margins of the foramen magnum and the jugular foramen, and to the internal acoustic meatus; it is less firmly attached about the venous sinuses.

Subdural Space

The dura's inner surface is lined by fibroblastic tissue (Leary and Edwards), and this layer therefore forms the outer lining of the subdural space. The subdural space is usually described as being a potential space only, but Penfield ('24), by freezing the heads of dogs, apparently demonstrated that there is in this space an appreciable amount of clear, yellow fluid that probably normally prevents intimate contact between the arachnoid and dura. Penfield and Norcross suggested that it is displacement of this fluid locally, thus allowing close contact between arachnoid and dura, that is responsible for posttraumatic headache. The origin of the subdural fluid is unknown.

DURAL SEPTA

In certain locations the dura, instead of remaining closely applied to the inner surface of the skull, projects inward to form septa that partially divide the cranial cavity. The largest and most important of these are the falx cerebri and the tentorium cerebelli (Figs. 1-8 and 1-9).

Falx Cerebri

The falx cerebri is a longitudinally directed septum, passing downward from the cranial vault in the midsagittal plane between the cerebral hemispheres; this large sickle-shaped fold is attached anteriorly to the crista galli and posteriorly blends with the upper surface of the tentorium cerebelli. Where it is continuous close to the midline with the dura of the vault of the skull, it helps to enclose the supe-

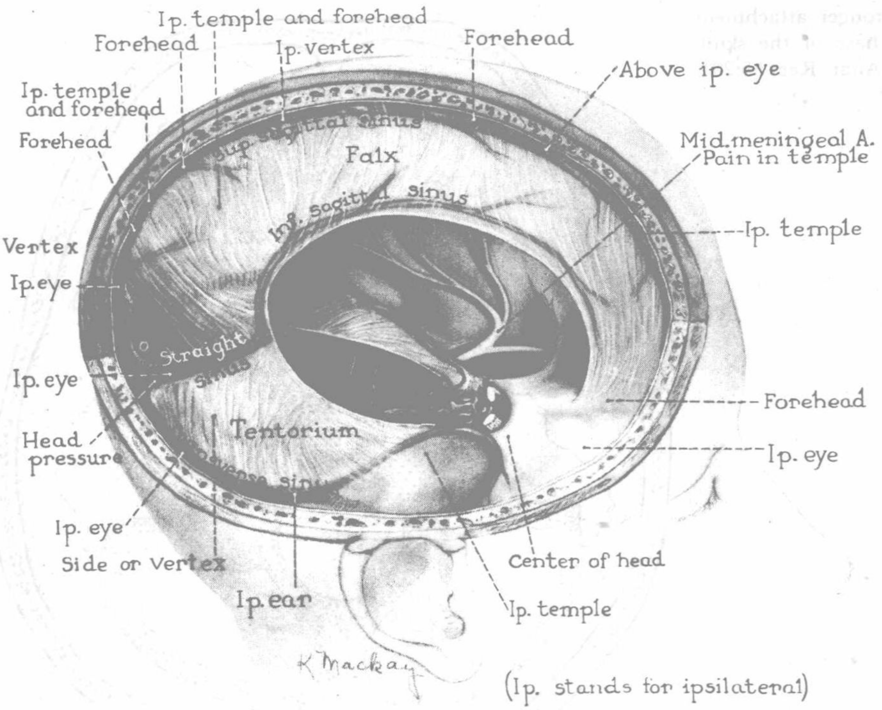


Fig. 1-8. The cranial dura, some of the venous sinuses, and the areas of the head to which pain has been said by the patient to be referred when the dura is stimulated. (Baker GS, Adson AW: Minn Med 26:282, 1943)

rior sagittal sinus; in its free margin, above the corpus callosum, it encloses the inferior sagittal sinus; finally, at its attachment to the tentorium cerebelli, it helps to form the walls of the straight sinus.

Tentorium Cerebelli

The tentorium cerebelli is placed approximately transversely, its center being, however, much higher than its sides (Fig. 1-9), so that it fits fairly snugly between the posterior portions of the two cerebral hemispheres and over the somewhat convex upper surface of the cerebellum. The line of attachment of the tentorium cerebelli to the skull extends backward from the posterior clinoid processes along the superior borders of the petrous portions of the two temporal bones ("petrous ridges") and backward and medially along the occipital bone at the grooves for the transverse sinuses; thus the tentorium largely separates the middle from the posterior cranial fossa. The superior petrosal and transverse sinuses, from before backward, lie at its line of attachment to the periosteal dura, and, as already mentioned, the straight sinus lies at the junction of its raised center and the falx cerebri; anteriorly, the tentorium cerebelli is entered, close to the posterior clinoid processes, by the trochlear nerves.

The anterior edge of the tentorium cerebelli presents a deep concavity, the tentorial notch (incisure) for accommodation of the brain stem as it passes into the posterior cranial fossa. Sunderland ('58) described variations in the anatomy at the tentorial notch and discussed injuries to the nerves, the cranial vessels, and the brain that may result from herniation through the notch as a result of increased supratentorial pressure.

In addition to the above-mentioned folds, there are others—the small falx cerebelli, the diaphragma sellae, and the arrangement of the dura about the trigeminal ganglion—