SIGNIFICANCE OF VARIATIONS OF THE SKULL IN BLOCKING THE MAXILLIARY NERVE—AN ANATOMICAL AND RADIOLOGICAL STUDY

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The deep location of the maxillary nerve makes its anesthetization by regional block difficult and complicated. To have satisfactory results it is necessary to know the structures of the infratemporal and pterygopalatine fossae and orbit and their relationships. In addition one must consider the variations in and relations of the bony structures of these regions.

Many techniques have been devised to provide a safer and easier approach to the maxillary nerve and its branches, but in a number of cases the results are unsatisfactory even in the hands of experienced anesthesiologists. This study considers variations of the skull which may account for difficulties in regional block anesthesia of the maxillary nerve.

The material, used in this study, consisted of 250 dried skulls, mostly aged persons, including 125 whole skulls, 66 right halves, and 59 left halves.

Anatomical Relationships of Maxillary Nerve

The maxillary nerve after it leaves the foramen rotundum is located deep in the pterygopalatine fossa which it shares with the sphenopalatine ganglion, the terminal part of the internal maxillary artery (located below the maxillary nerve), and a part of the pterygoid venous plexus. This fossa opens laterally via the pterygomaxillary fissure into the infratemporal fossa. Anteriorly and upward it communicates with the orbit by the inferior orbital or sphenomaxillary fissure and downwards it is continuous with the pterygopalatine canal which ends at the major palatine foramen. These openings are traversed in order to reach the maxillary nerve in the pterygopalatine fossa.

Accepted for publication September 14, 1960.
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Technique of Maxillary Nerve Block

Several extraoral and intraoral approaches to the maxillary nerve have been described.[1-12] The nerve may be blocked in the pterygopalatine fossa or at the foramen rotundum.

Extraorally two routes are in use: the lateral and anterior. In the lateral approach the most commonly used point of entrance of the needle is the lower border of the zygomatic arch just anterior to the coronoid process of the mandible. From there the needle is directed upward, medially and somewhat posteriorly until it contacts the tuberosity of the maxilla. Then without changing direction, the needle is inserted along the maxilla passing through the pterygomaxillary fissure to the point where it contacts the great wing of the sphenoid bone near or within the pterygopalatine fossa. The necessary depth is about 5.5 cm. Less commonly the needle is inserted below the zygomatic arch posteriorly to the coronoid process through the notch of the mandible and perpendicular to the median sagittal plane. When the lateral pterygoid plate of the sphenoid bone is contacted then the needle is directed medially, forward and upward into pterygopalatine fossa a total depth of about 5.5 cm.

In the *anterior* or *orbital* route the needle is passed over the inferolateral corner of the orbit a little below the lateral canthus of the eye along the orbital wall about 1.5–2 cm. backward and somewhat medially and downward until it traverses the inferior orbital fissure. The needle is then directed through the inferior orbital fissure posteriorly, medially and slightly upward to the pterygopalatine fossa close to the foramen rotundum. The depth of insertion of the needle is about 5 cm.

Two intraoral approaches are also used. *One* is to insert the needle through the oral mucosa opposite the roots of the third upper molar. The needle is directed toward the maxillary tuberosity and then along it medially,

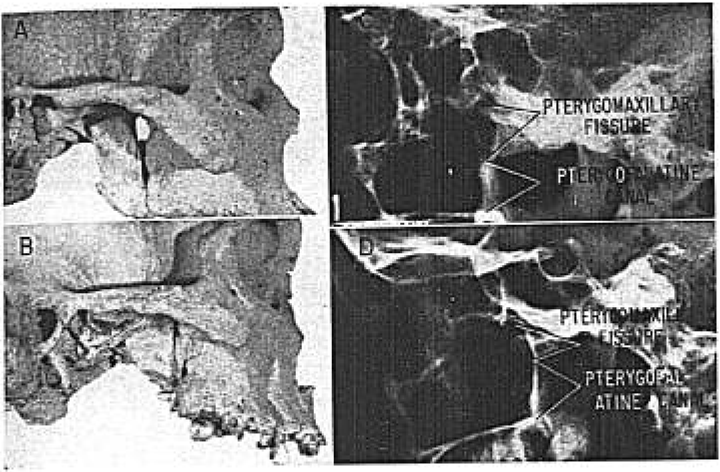

FIG. 1. Photographs of two skulls. One (*A*) with a long and wide pterygomaxillary fissure and the other (*B*) with a narrow and short pterygomaxillary fissure. The skulls are tilted to show the whole length of the fissure. Radiograph (*C*) of skull showing long and wide pterygomaxillary fissure and radiogrpah (*D*) of skull showing a narrow and short pterygomaxillary fissure.

posteriorly and upward until it passes through the pterygomaxillary fissure into the pterygopalatine fossa. The required depth is approximately 3.5 cm. The second intraoral route is through the greater palantine foramen and pterygopalatine canal. Via this approach the maxillary nerve is contacted near the foramen rotundum if the needle is directed from the greater palatine foramen upward and slightly backward to a depth of approximately 3.5–4.0 cm.

It may be difficult to enter the pterygopalatine fossa by any of these routes due to the many variations common to the bones forming the infratemporal and pterygopalatine fossae, the pterygomaxillary and inferior orbital fissures and the position of the zygomatic arch.

To achieve successful lateral access to the maxillary nerve one must consider the size of the pterygomaxillary fissure and the position of the zygomatic arch.

The Pterygomaxillary Fissure. Because the pterygoid process of the sphenoid bone joins the maxilla by extending downward and somewhat forward the largest part of the pterygomaxillary fissure is directed upward. The width and the length of this fissure varies in different individuals. In our material the length of the pterygomaxillary fissure (measured from its lower end up to the inferior orbital fissure) varied from 1.0 to 2.9 cm. (mean 1.8 cm.). The width of this fissure, taken at its widest part, averaged 5.0 mm. (extremes 0.2 to 1.0 cm.). In cases where the width of the fissure is of average or larger dimensions it is not difficult to pass a needle into the pterygopalatine fossa. This was the case in 82 per cent of the skulls in our material. It is more difficult to reach the pterygopalatine fossa when the pterygomaxillary fissure is narrow, this is especially so if it is narrow and short. Our skull sample included 18 per cent with narrow fissures, and of these 8 per cent also were short. In one case this fissure was very narrow and very short (see fig. 1*B*) so that it would have been almost impossible to place the needle in the pterygopalatine fossa via this route. The width of the pterygomaxillary fissure is mainly influenced by the height and shape of the sphenomaxillary crest (crista sphenomaxillaris of the pterygoid process (forming the posterior boundary of the fissure) and by the convexity of the infratemporal surface of the maxilla (forming the anterior boundary). The sphenomaxillary crest, in most cases, extends from the anterior end of the infratemporal crest downward and medially over the pterygoid process. If it is high and sharp then it is closer to the maxilla and more or less obstructs the pterygomaxillary fissure. This crest may sometimes have one or more small spines. A low and obtuse crest together with a flattened infratemporal surface of the maxilla leads to a wider fissure. The size and shape of the sphenomaxillary crest and flattening of the infratemporal part of the maxilla are possibly influenced by the development and function of the lateral pterygoid muscle.

A short pterygomaxillary fissure is always accompanied by long pterygopalatine canal; the reverse is also true. Therefore it is more advantageous to block the maxillary nerve through the pterygopalatine canal when the pterygopalatine fissure is long and the canal short. The length of the pterygopalatine canal, in our material varied from 1.3 cm. to 2.7 cm. The size of the canal was highly variable but in shape was chiefly laterally compressed, like the greater palatine foramen. The canal was always directed upward from the palate with more or less inclination backward (fig. 1*A*). The radiographic features of the pterygomaxillary fissure and the pterygopalatine canal are illustrated in figure 1, *C-D*.

The Zygomatic Arch. As previously stated the lateral approach to the maxillary nerve is *below* the zygomatic arch.

The position of the zygomatic arch varies greatly in relation to the pterygomaxillary fissure. It can be seen easily, when viewing the lateral aspect of the skull, held horizontally in vertical position at eye level, that the upper part of the pterygomaxillary fissure often lies above the zygomatic arch (fig. 2*A*). Among the 182 skulls available for this study 67 (37 per cent) had the zygomatic arch low in position, and very low in 22 (12 per cent)

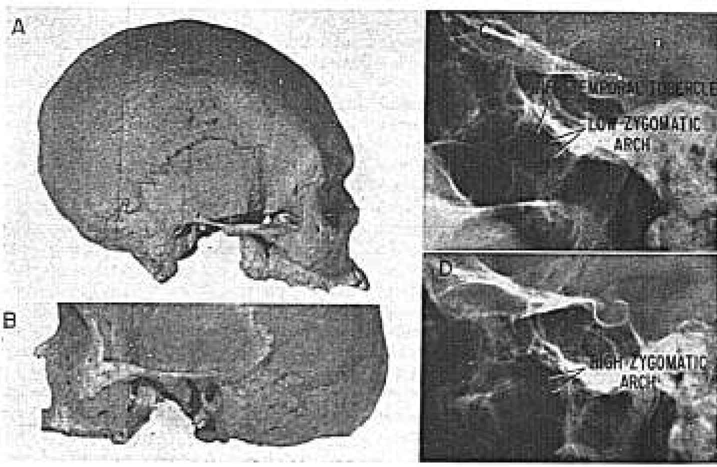

Fig. 2. Photograph of two skulls. One (*A*) with a low and second (*B*) with a high zygomatic arch. In the first the pterygomaxillary fissure extends considerably above the arch. The skulls are in sagittal and horizontal position. Radiograph (*C*) showing low zygomatic arch and (*D*) showing a high zygomatic arch.

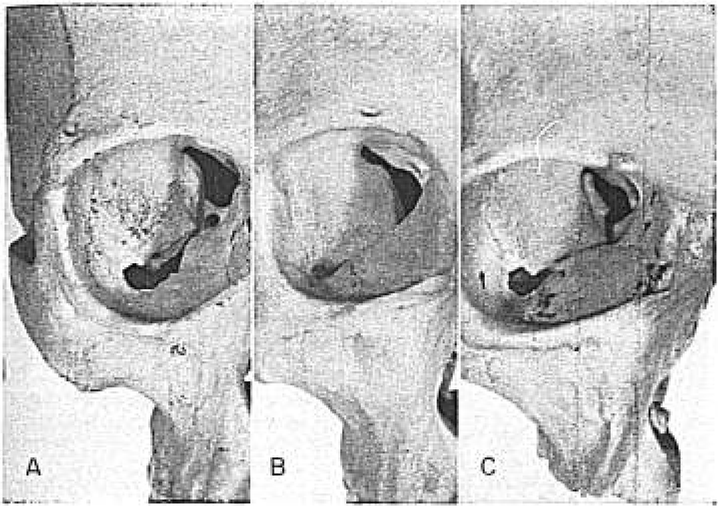

FIG. 3. Photographs showing a wide (*A*), narrow (*B*) and tortuous (*C*) inferior orbital fissure. Note that the anterior part of the fissure is longer and wider. In skull (*A*) the fissure is straight and the foramen rotundum is seen. The skulls are in frontal position with slight tilt anteriorly downward to show better the inferior wall of the orbit.

skulls. We considered the zygomatic arch to be low if approximately the upper third of the pterygomaxillary fissure was visible above the upper margin of the arch and very low if half or the greater part of the fissure ascended above the arch.

The remaining 115 skulls (63 per cent) had medium or high zygomatic arches. Of these, there were 49 specimens (27 per cent) in which the pterygomaxillary fissure did not extend above the arch at all (fig. 2*B*). A lateral radiograph of a skull with a low zygomatic arch is shown in figure 2*C*, one with a high one is illustrated in figure 2*D*.

The reason for the development of the different position of the zygomatic arch is not known. Neither the width nor the direction of the arch contribute much to its relative level.

Our observations indicate that by the lateral extraoral approach to the maxillary nerve in skulls with a *low* zygomatic arch the needle may be passed *above* the zygomatic arch. This is especially important in those cases in which the pterygomaxillary fissure is short or short and narrow. Our material shows that this approach to the maxillary nerve may be used often. The jugal point (*i.e.*, the right angle between the upper margin of the zygomatic arch at the posterior border of the orbit) can be used as a landmark for the primary point of insertion of the needle. The inserted needle should be directed horizontally and perpendicularly to the median sagittal plane with a slight forward angulation. After the infratemporal surface of the maxilla is contacted the needle should be advanced along the bone inward, backward and somewhat upward into the upper part of the pterygopalatine fossa. The depth necessary is approximately 5.0–5.5 cm.

To our knowledge, only Waldeyer[10] mentions the route above the zygomatic arch in blocking the mandibular nerve at the foramen ovale. He remarks that the passage of the needle below the arch has to be considered the safest one due to the anatomical relations.

In approaching the pterygopalatine fossa from above the zygomatic arch the presence of the "infratemporal tubercle" must be considered (fig. 2C). This tubercle, a bony process at the anterior extremity of the infratemporal crest, serves as an additional attachment for the lateral pterygoid muscle. Some anatomists have named this tubercle differently ("tuberculum spinosum," "triangular process," and "tubercle sphenoidal" and "infratemporal spine"). Other anatomists fail to mention it. We prefer to call it "infratemporal tubercle" since it is related to the infratemporal crest and often is not spine-like. The size and shape of this tubercle varies greatly. Apparently its size has no close relationship to the development of the infratemporal crest because often skulls with a well developed infratemporal crest may have a small or absent tubercle. In our material it was strongly developed in 28 per cent (in 10 cases very strongly) and weak or absent in 72 per cent (absent in 30 skulls). The largest tubercle was 13 mm. in length and 15 mm. in diameter at the base. Most often the tubercle is a triangular pyramid or flattened and hook-like and is nearly always directed downward and backward in line with the direction of the fibers of the lateral pterygoid muscle. If it is triangular, the temporal, infratemporal and sphenomaxillary surfaces of the sphenoid bone are continuous with the tubercle thus forming its three surfaces. The sphenomaxillary surface varies most and is often reduced to a narrow strip or absent, if the tubercle is markedly flattened and close to the inferior orbital fissure. In anesthetization of the maxillary nerve via the lateral route above the zygomatic arch, a large infratemporal tubercle may cause technical difficulty because it may overhang the upper end of the pterygomaxillary fissure laterally. If such is the case the passage of the needle into the pterygopalatine fossa may be prevented. Twenty per cent of the specimens we examined had the tubercle laterally overhanging the pterygomaxillary fissure. In most cases it overhung the infratemporal surface of the maxilla and rarely the laterial pterygoid plate.

The Inferior Orbital Fissure. The size and shape of the inferior orbital fissure are important in the orbital approach to the maxillary nerve at the foramen rotundum within the pterygopalatine fossa (fig. 3). The long axis of the fissure lies on a level with the jugal point or upper border of the zygomatic arch and is directed backward and inward parallel to the lateral wall of the orbit. The length of the fissure is about 2.5 cm. Anteriorly the fissure ends approximately 1.5 cm. from the inferior orbital margin. Posteriorly the fissure reaches the apex of the orbit somewhat above and medial to the foramen rotundum but below and lateral to the optic foramen. Normally the fissure is narrowest in the middle, approximately 1.5 cm. backward from the anterior extremity (fig. 3B). The median constriction is the result of a tongue-like recess of the maxillary sinus or due to a posterior ethmoid cell, or because of thickening of the maxilla immediately posterior to the infraorbital sulcus of the orbit. The longest and widest part of the fissure lies anterior to the constriction (fig. 3A). This part of the fissure in the elderly individual is abnormally enlarged due to the reabsorption of its margin. According to Wolff [11] the inferior orbital fissure is relatively wide in the fetus and infant depending on the degree of development of the maxillary sinus. In our specimens the infraorbital fissure was wide in 36 per cent, (very wide in 5 per cent), of medium width in 42 per cent and narrow in 22 per cent (very narrow in 5.6 per cent) (fig. 3). It is apparent that in approximately one-fifth of our skulls the inferior orbital fissure is not a suitable route for blocking the maxillary nerve at the foramen rotundum via the orbit. In addition, the curved shape of the fissure or the inclination of its posterior end markedly medialward in relation to the foramen rotundum, may render it difficult to insert the needle into the sphenopalatine fossa. In some cases the fissure had a zigzag course due to the well developed tongue-like process of the maxilla and the infraorbital crest (inferior border of the orbital surface of the sphenoid bone) which projected posteriorly markedly medially. Such tortuous fissures would render this route of injection virtually impossible (fig. 3C). Our data disagrees with that of Smith [8]

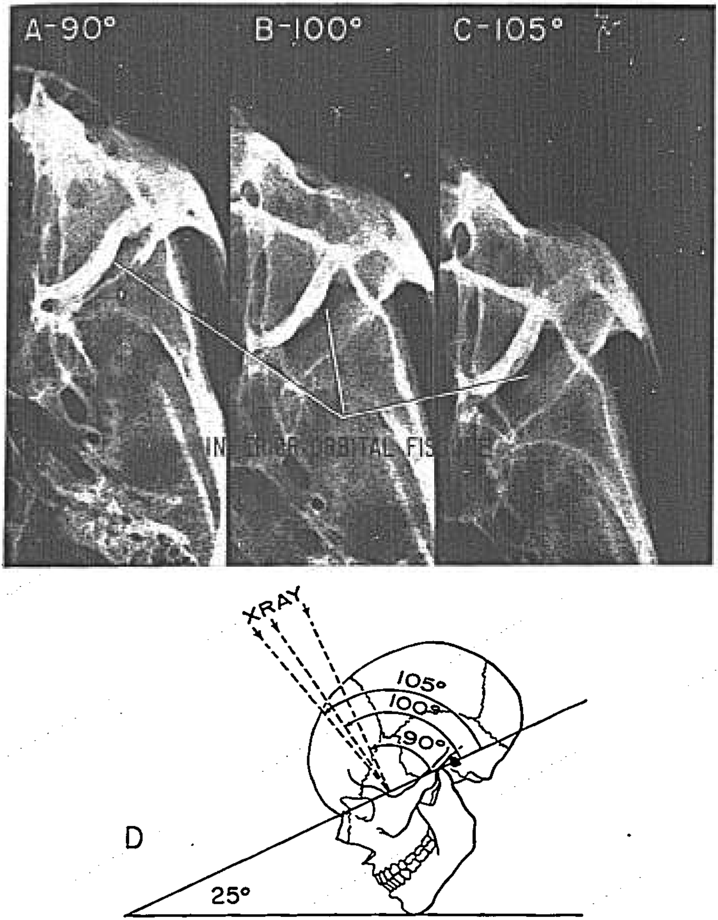

FIG. 4. Radiographs *A*, *B*, *C* and diagram *D* showing optimal angle of 105 degrees of the central X-ray to the cantho-meatal line in the vertico-submental (basal) projection of the skull. This projection delineates clearly the size, shape and direction of the inferior orbital fissure.

who has observed narrow or tortuous inferior orbital fissures in only 10 per cent of the skulls examined. In one skull among our material the inferior orbital fissure was bridged by a narrow osseous bar at the site of its constriction. See also figure 4 for radiographic considerations.

Discussion

The variations of the bones of the skull, as described, clearly show that before attempting to block the maxillary nerve it would be of great value to have information concerning the size and shape of the pterygopalatine and inferior orbital fissures and the position of the zygomatic arch. With such data it will be easier to select the best route of approach to the maxillary nerve and thus achieve a high degree of accuracy. Such necessary morphological landmarks can be provided only by the radiologists. Sweet[9] first indicated the value of radiographic control in blocking the mandibular and maxillary nerves. Using this method his results were better. Sweet has described the technique of how best to ascertain the position of the foramen rotundum in a radiograph and how to direct the needle to block the maxillary nerve by using the lateral extraoral route via the mandibular notch.

Summary

The variations of the size and shape of the pterygomaxillary and inferior orbital fissures, useful for directing the route of the needle in blocking the maxillary nerve have been studied in 250 skulls and are described. The variable position of the zygomatic arch in 182 skulls in relation to the pterygomaxillary fissure has been given. The suggestion is made that the maxillary nerve can also be blocked by going *above* the zygomatic arch if it is *low* in position. The proposition is made that before blocking the maxillary nerve the bony variations related to this procedure should be checked by roentgenograms to select the best route of approach.

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