Surgical Anatomy of the Temporal Bone and Measurements of the Skull Base for Transpetrosal Approaches

By

Mustafa BOZBUĞA¹, Adnan ÖZTÜRK², Zafer ARI², Kayihan ŞAHİNOĞLU², Bülent BAYRAKTAR², Gürsel POLAT³ and İsk GÜREL¹

¹Neurosurgical Clinic of Kartal Research and Teaching Hospital, Istanbul, Turkey
²Department of Anatomy, Istanbul Medical Faculty, Istanbul University, Istanbul, Turkey

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Summary: Transtemporal approaches exposing the petroclival region require extensive drilling of the petrous bone. This is only possible with an understanding of the three dimensional anatomy of the temporal bone and the cranial base. The purpose of this study is to review the topographic anatomy of the petrous bone and peripetrous region, with emphasis on the relationships critical to the lateral approaches for posterior and lateral skull base. To understand the surgical anatomy and the cranial base approaches to this area, 8 cadaveric heads and 76 dry skulls were studied. Cadaveric dissections were performed, and morphometric data from measurements of the relationships of the surface landmarks in the petroclival region were provided. The results and the observations could be useful to understand the anatomy better, and to estimate the degree and direction of a safe bony removal for the most radical transpetrosal surgery.

The temporal bone is a critical component of the basicranium, being surrounded by the posterior and middle cranial fossae superiorly, and the infratemporal fossa and the upper cervical region inferiorly. The clival area lies medial to the temporal bone. Being the seat of the auditory apparatus, it also transmits or borders important neurovascular structures which include the internal carotid artery (ICA), the sigmoid sinus and the jugular bulb, the superior and inferior petrosal sinuses, and the cranial nerves V through XI [2, 3, 16].

The temporal bone is divided into tympanic, squamous, mastoid, and petrous parts. While the removal of the squamous part of the temporal bone (temporal craniotomy) has long been used to gain access to the middle cranial cavity, surgical approaches through the mastoid, petrous and tympanic parts of the temporal bone have enjoyed increasing popularity in the last two decades [1, 6, 7, 11, 12, 14, 15, 19-23]. Key to understanding these transtemporal approaches and to the innovation of any new approaches is an understanding of the anatomy of the temporal bone (Fig. 1). For transtemporal surgery, an overall orientation and identification of the strategic points in the middle and posterior fossae is most useful for guidance during surgery. Transtemporal approaches can enable the exposure of neoplastic, vascular, and traumatic lesions of the cranial base widely and without much brain retraction.

The purpose of this study is to review the topographic anatomy of the petrous bone and peripetrous region, with emphasis on the relationships critical to the lateral approaches for posterior and lateral skull base. Identifying easily recognizable bony landmarks, on the skull base with strategic locations, necessary measurements could be done to be of help during the transtemporal surgery to the petroclival region.

Materials and Methods

Eight fixed cadaveric heads (constituting 16 specimens) were dissected, the cranial base approaches including transtemporal ones were carried...
out on them, bony and the other landmarks were identified, and all observations and measurements were recorded in a specially designed software. Seventy six adult human dry skulls (constituting 152 specimens) were studied; the landmarks were identified, and the measurements were taken of the various relationships, and these data were also recorded in detail. All measurements were taken using standard calipers in millimeters. This morphometric analysis included the following measurements:

1) the shortest distance from the foramen ovale to the foramen spinosum on the temporal fossa;
2) the shortest distance from the foramen spinosum to the greater superficial petrosal nerve (GSPN) on the anterior surface of the petrous bone;
3) length of the petrous ridge (from the most discernible point on the ridge to the superior most point on the suture line between the petrous apex and the clivus);
4) the shortest distance from the petrous ridge to the superior margin of the internal auditory meatus (IAM);
5) inferolateral lip of the internal auditory meatus (ILIAM) to the sigmoid sulcus;
6) from the posterior end of the petrous ridge to the ILIAM;
7) midpoint of the anterior margin of the sigmoid sulcus to the external aperture of the vestibular aqueduct in the foveate impression;
8) ILIAM to the external aperture of the vestibular aqueduct in the foveate impression;
9) ILIAM to the jugular bulb;
10) from the ILIAM to the subarcuate fossa;
11) ILIAM to the arcuata eminence;
12) the shortest distance from the arcuata eminence to the lateral margin of the trigeminal impression;
13) length of the sulcus of the inferior petrosal sinus;
14) vertical length of the upper clivus, the midclivus, and the lower clivus.

These external landmarks and the distances are illustrated in Fig. 2 (a,b,c).

Results

Morphometric data are presented in Table 1. Interestingly a wide spectrum of variations were observed in the specimens. In cadaveric dissections after the skin incision and soft tissue dissection, the step of craniotomy-osteotomy-bone drilling was performed; then the temporal fossa exploration was started extradurally from a lateral to medial, and from posterior to an anterior direction. The middle meningeal artery was identified, and followed to the foramen spinosum; next the (GSPN) and the lesser superficial petrosal nerve (LSPN) were seen. The GSPN could be distinguished from the LSPN by the fact that the LSPN joins the middle meningeal artery at the foramen spinosum. Keeping on the dissection the other neurovascular structures and bony landmarks, arcuate eminence, the branches of the trigeminal nerve, the horizontal segment of the petrous internal carotid artery were identified. In the next step, the posterior surface of the petrous bone was exposed. Medially the clivus was dissected and measured.

<table>
<thead>
<tr>
<th>Distance</th>
<th>Right side</th>
<th>Left side</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5–6.5 (3.6)</td>
<td>1.0–10.0 (3.6)</td>
</tr>
<tr>
<td>2</td>
<td>4.6–9.1 (6.4)</td>
<td>4.7–8.9 (6.5)</td>
</tr>
<tr>
<td>3</td>
<td>53.0–71.0 (60.4)</td>
<td>48.5–72.0 (59.2)</td>
</tr>
<tr>
<td>4</td>
<td>1.5–5.7 (4.2)</td>
<td>2.4–7.4 (4.8)</td>
</tr>
<tr>
<td>5</td>
<td>20.2–42.0 (31.8)</td>
<td>17.9–47.0 (31.3)</td>
</tr>
<tr>
<td>6</td>
<td>34.2–46.0 (39.9)</td>
<td>33.6–45.0 (39.5)</td>
</tr>
<tr>
<td>7</td>
<td>4.4–21.5 (11.6)</td>
<td>4.2–21.5 (13.2)</td>
</tr>
<tr>
<td>8</td>
<td>8.0–22.0 (13.8)</td>
<td>4.0–19.9 (14.1)</td>
</tr>
<tr>
<td>9</td>
<td>7.8–13.6 (11.1)</td>
<td>7.6–13.4 (11.0)</td>
</tr>
<tr>
<td>10</td>
<td>3.8–23.0 (12.8)</td>
<td>3.1–24.0 (13.9)</td>
</tr>
<tr>
<td>11</td>
<td>13.2–21.6 (16.7)</td>
<td>14.2–22.3 (15.9)</td>
</tr>
<tr>
<td>12</td>
<td>15.5–24.9 (18.6)</td>
<td>13.6–25.1 (17.8)</td>
</tr>
<tr>
<td>13</td>
<td>14.1–30.0 (19.9)</td>
<td>13.0–26.0 (18.8)</td>
</tr>
<tr>
<td>14 upper clivus</td>
<td>5.0–10.5 (7.5)</td>
<td></td>
</tr>
<tr>
<td>midclivus</td>
<td>10.5–25.0 (15.9)</td>
<td></td>
</tr>
<tr>
<td>lower clivus</td>
<td>6.0–18.0 (11.4)</td>
<td></td>
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</table>

Discussion

Pathologic processes arising at the petroclival region present challenging surgical problems since their intimate relationship to the brain stem, cranial nerves and major vessels. The clinical presentation, as well as the selection of the best surgical approach, depends on the location, extension, size, and nature of the pathology. A variety of skull base approaches to the petroclival region have been described in the past 15 to 20 years. These approaches require extensive extradural and/or intradural drilling of the posterior aspect of the petrous pyramid, and petrous apex. The anatomy of the petrous bone is very complicated due to the intricate and variable relationships of the inner-ear
structures among themselves and with their bone coverings, and other neurovascular structures. An overall understanding of the surgical anatomy of this critical area and a detailed knowledge of the intrinsic anatomy of the petrous bone become essential for transtemporal approaches to the petroclival region.

Some relatively constant bony landmarks can be chosen, the anatomical relationships among these structures can be studied, and the results can be used in the major skull base operations to the petroclival region. During the preauricular subtemporal/infratemporal approach foramen spinosum is an important landmark, and just medially to the foramen spinosum the GSPN is identified. The average distance between these two structure was 6.4 mm on right, and 6.5 mm on left in our series. In the morphometric study of Khosla et al., this distance was found to be 5.14–5.63 averagely. GSPN, which serves as a landmark/, leads the surgeon in a posterolateral direction to the geniculate ganglion. The geniculate ganglion can be used as a guide for orientation since posteromedial to the geniculate ganglion lies the semicircular canal (SSC), and the facial nerve can be easily identified from this point proximally and distally/. One can expose the clival structures through a subtemporal transtemporal approach or a subtemporal and preauricular infratemporal fossa approach. The petrous apex resection creates a large window towards the prepetontine space which not only allows clipping of aneurysms but allows to remove the tumors involving the petroclival and clival area as far as to the internal auditory canal. The limitation of bone resection at the petrous apex is given by the trigeminal nerve medially, by the ICA inferiorly and by the internal auditory canal laterally. On the basis of our studies, this transtemporal approach provides good exposure of the middle and lower clival structures not only extradurally but also intradurally. The distance between the petrous ridge and the superior margin of the IAM (distance 4 in the present series), and also the distance between the arcuate eminence and the lateral margin of the trigeminal impression (distance 12 in the present series) are critical for this approach. In this area care must be taken because the GSPN and the geniculate ganglion may be dehiscent and lack the protective bony covering in about 15% of the temporal bones, rendering them prone to injury during the perigeniculate dissection. Also the facial nerve, the basal turn of the cochlea, and the ampullated posterior of the SSC all lie within 4 mm of each other, requiring the utmost surgical skill in order to prevent injury to these critical structures. The area between the ampullated end of the SSC and the cochlea is very narrow. Kartush et al. have reported on the relationship between the arcuate eminence and the SSC.

Along the posterior surface of the petrous bone, the anterior margin of the sigmoid sulcus is easily exposed. The identification of the external aperture of the vestibular aqueduct is important, and this aperture is about 10–12 mm medial to the sigmoid sulcus. This distance was quite variable in our series (see, the results 7). The external aperture of the vestibular aqueduct is an important landmark; it lies midway between the IAM and the anterior margin of the sigmoid sulcus and dissecting along this structure the posterior semicircular canal is encountered, anteromedially lying about 4.3 mm from the posterior surface of the temporal bone and 7.9 mm from the petrous ridge at or slightly below the aperture.

Although relatively constant relationships exist between the certain landmarks, a wide spectrum of variations are possible, too. The results in this series have demonstrated these probable variations. Each patient is thus better evaluated if the bony radiology of the petrous can be studied preoperatively and correlated with available anatomic data. This practice will increase the success of the maximal removal of the bone, and the morbidity secondary to violation of the bony labyrinth and the neurovascular structures will be minimized. The bony landmarks studied in this series were found to be constant and easily identifiable. Therefore, these bony landmarks are very useful especially if attention is directed to the three dimensional anatomy of the region. The distances between the landmarks also provide to guide the direction and degree of bone removal for a safe and radical surgery.

References

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Explanation of Figures

Plate I

Fig. 1. Anatomy of the temporal bone.
Plate II

Fig. 2 (a, b, c). The external landmarks and distances are illustrated in this figure.