Morphometry of Glasscock’s Triangle Pertinent to the Exposure of Horizontal Intrapetrosal Segment of the Internal Carotid Artery

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Abstract

Background and Aim The specific anatomical triangles around the cavernous sinus are frequently explored areas in neurosurgeries and thus require a methodical approach keeping in mind the possibility of variational anatomy and morphometric differences. One of the most inconsistent triangles is the Glasscock’s (posterolateral) triangle (GT) in the middle cranial fossa.

Materials and Methods The present study was undertaken on 26 skull bases of the middle cranial fossa from cadavers and 42 dry adult skulls from the departmental collection to analyze parameters of the GT pertinent to the horizontal intrapetrosal segment of the internal carotid artery. The measurements of all sides of the GT were done and the mean surface area was calculated using Heron’s formula. The findings of the study were compared with earlier works where other methods of investigation were employed, such as, dry bones/computed tomography scans, cadaveric studies.

Observations The GT in the present study had a mean surface area of 43 mm². The study presented with variable morphological and morphometric data as compared with earlier studies. The scientific attribute to the differences in parameters is presumably relevant to the racial differences as well as the pathophysiological condition of the subject.

Conclusions Surgical interventions to the base of the skull have evolved enormously over the years. Earlier studies have described the triangle on cadaveric specimen. We have attempted to revisit the area in cadaveric as well as dry skull base. Flawless information of the area under surgery augments safer procedures and reduction in the damage to brain tissue as well as the cranial nerves. The putative clinical implications of the present study are useful in helping in high precision surgeries and enhanced patient care. The highly variable GT needs to be understood properly for a desired culmination in ICA exposure in the intrapetrosal segment.

Keywords
► skull base  
► Glasscock’s triangle  
► posterolateral triangle  
► intrapetrosal  
► internal carotid artery

Introduction

The skull base, due to its complex anatomy, has always intrigued the neurosurgeons, interventionists, and academicians. A methodical and analytic knowledge of the area has great repercussions in approaching the intricately located neurovascular characters in a coherent manner. Surgical approaches to the base of the skull has evolved enormously over the years. Better equipment and scanning modalities have reduced the chances of damage to cranial nerves,
arteries, veins, and the parenchyma of the brain. Approach to these deep-seated areas require a perfect knowhow of the various anatomical characters and more so the landmarks of the area concerned. Flawless knowledge of the area under surgery augments safe surgeries and reduction in the trauma to the brain.

One of the most complex areas at the skull base is the region around the cavernous sinus (CS). Various authors have described different landmarks and triangles in relation to this area.1-4 Parkinson in 1965, Dolenc in 1985, Glasscock in 1979, and Kawase in 1985 have described different anatomical triangles.5-8 Apart from these named triangles there are various other clinically relevant triangles present around the CS. It has been quoted that there are around 10 different triangles around the CS.1-4 Watanabe classified the triangles in three subregions—the parasellar group (anteromedial, paramedial, oculomotor, and superolateral), the middle cranial fossa group (anterolateral, posterolateral, and posterosmedial), and the paracical group (inferomedial and inferolateral).4

Out of the plethora of specific anatomical triangles (regions) around the CS, one of them is posterolateral triangle—the Glasscock’s triangle (GT). This triangle is a commonly explored area for exposing the horizontal intrapetrosal segment of the internal carotid artery (ICA), for providing proximal control that is used for a bypass graft and/or anastomosis. This approach also permits surgical access to the deep-seated CS for resection of tumors. Whenever interpositional vascular bypass is planned for the ICA, the GT and the petrous part of ICA presents a useful site for anastomosis. However, performing this procedure is demanding and poses a lot of challenge to the surgeon because of the restricted area of approach.

The GT is relatively inconsistent in size and Glasscock was the earliest to describe it. It is bounded laterally by a line from the foramen spinosum (FS) to the arcuate eminence (AE) of the petrous bone, medially by a line between where the greater petrosal nerve (GPN) crosses under the mandibular division of the trigeminal nerve (V1). The GT was planned by slowly stripping of the dura and thus, roots along with dura were left intact. The approach to the GT was planned by slowly stripping of the dura and thus, providing exposure to the target characters. Special precautions were undertaken to preserve the trigeminal nerve (TN) and its divisions (especially the mandibular nerve—V1), the GPN, and the middle meningeal artery (MMA) emerging from the FS. The anatomical landmarks pertinent to the GT and the contents of the same were defined, recorded, and photographed. Distances among the foramina/landmarks were measured with digital Vernier calipers. For measuring the distance between two foramina, the shortest span between the openings were recorded. The parameters were compared with studies of earlier authors and tabulated in Table 1. All the readings were taken by three authors independently and validated as the final measurements after taking mean and standard deviation.

The measurements of the sides of the GT were defined as per the details below

Medial border (Side a) = mandibular division of the trigeminal nerve (V1)

Lateral border (Side b) = the GPN

Base (Side c) = between FS to AE

As regards the calculation of the area of the GT, we measured all the three sides, namely a, b, and c. The exact area was calculated according Heron’s formula,18 which calculates the area of the triangle as follows.

\[ \text{Area} = \sqrt{s (s - a) (s - b) (s - c)} \]

where \( s \) (semiperimeter) = \( \frac{a + b + c}{2} \)

### Materials and Methods

The present study was undertaken on 26 skull bases of the middle cranial fossa from cadavers and 42 dry adult skulls from the departmental collection. The brains were dissected out from all the cadaveric specimen and the cranial nerve roots along with dura were left intact. The approach to the GT was planned by slowly stripping of the dura and thus, providing exposure to the target characters. Special precautions were undertaken to preserve the trigeminal nerve (TN) and its divisions (especially the mandibular nerve—V1), the GPN, and the middle meningeal artery (MMA) emerging from the FS. The anatomical landmarks pertinent to the GT and the contents of the same were defined, recorded, and photographed. Distances among the foramina/landmarks were measured with digital Vernier calipers. For measuring the distance between two foramina, the shortest span between the openings were recorded. The parameters were compared with studies of earlier authors and tabulated in Table 1. All the readings were taken by three authors independently and validated as the final measurements after taking mean and standard deviation.

### Table 1 Analysis of the parameters of the GT in various studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Mode of study</th>
<th>Medial border mean ± standard deviation (mm)</th>
<th>Lateral border mean ± standard deviation (mm)</th>
<th>Base mean ± standard deviation (mm)</th>
<th>Area of Glasscock’s triangle (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolan et al2 2007 (United States)</td>
<td>18 cadaveric</td>
<td>14.71 ± 1.16</td>
<td>7.04 ± 0.47</td>
<td>15.33 ± 0.82</td>
<td>49.25 ± 5.23</td>
</tr>
<tr>
<td>Watanabe et al4 2003 (Japan)</td>
<td>24 cadaveric</td>
<td>12.2 ± 3</td>
<td>8.5 ± 3.6</td>
<td>8.7 ± 1.7</td>
<td>34 ± 14.2</td>
</tr>
<tr>
<td>Present study 2019 (Central India)</td>
<td>26 (cadaveric) 42 (dry skulls)</td>
<td>13.5 ± 4.2</td>
<td>9.3 ± 0.54</td>
<td>9.8 ± 2.8</td>
<td>43 ± 12</td>
</tr>
</tbody>
</table>
Observations

Table 1 gives the analysis of the parameters of the GT in various studies. The triangle varied in dimensions and the surface area. The area of the GT in our study had a mean of $43 \text{ mm}^2$. The smallest area recorded was $29 \text{ mm}^2$. Watanabe described the smallest area of the triangle as $26 \text{ mm}^2$ in his study.

Discussion

The GT is an important paraclival corridor and is a commonly utilized anatomical area for exposing the horizontal intrapetrous part of the ICA. This exposure is of profound use in the surgical management of the CS aneurysm, CS tumor, and stenosis of the cavernous part of the ICA. Apart from the exposure of the ICA, the triangle is of great use in exposing the greater and lesser petrosal nerves, the tensor tympani muscle, the Eustachian tube, and the MMA. Moreover, the drilling of this triangle provides a working window to the infratemporal fossa.

The emergence of endovascular surgery and radiosurgery are well documented for enhanced safety levels and reduced recovery time for the patients. However, many conditions such as tumors are still approached in an invasive manner by the neurosurgeons. Conventional surgeries still demand a high level of precision as far as the anatomical landmarks are concerned. In this era of fast-evolving techniques and equipment being utilized for approaches to the middle cranial fossa and skull base, it would be relevant to say that access to these hidden areas is a daunting task for the interventionists. Before finalizing the surgery, it is also admissible that an enhanced assessment of blood supply patterns should be investigated with the aid of venograms and angiograms. The utility of the parameters undertaken in our study is of profound use in the drilling of the horizontal segment of petrous bone, where the rate of morbidity is very high.

Studies on the different triangles have been undertaken by various authors and all have enforced upon the accurate localization of the landmarks for an ideal surgical plan. It would be worthwhile to mention that computed tomography (CT)/magnetic resonance imaging (MRI) scans along with the possibility of bone remodeling should also be taken into consideration. In conclusion to the present findings, certain parameters that would be helpful in making anterior petrosectomy safer have been described. Surgeries of the skull base demand for high-end precision and proficiency and, thus, our findings provide enhanced alertness for a better and safe procedure. A methodical approach to the area with the background knowledge of these parameters shall culminate in desired neurosurgical outcomes.

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It becomes very obvious that exact localization and genuine identification of the various anatomical structures plays a crucial role in improving surgical outcomes. The present study contributes to general education in neuroanatomy, neurosurgical training, and a methodical approach to the middle cranial fossa in particular. A scientific combination of the data presented along with further exploration of the area via radiological means shall be helpful as a harbinger for further safe surgeries and patient benefit.

Fig. 1 Depiction of the Glasscock’s triangle (GT) as the triangular area enclosed between the following sides: medial border (a) represented by mandibular division of trigeminal nerve (V1), base (b) represented by the greater petrosal nerve and lateral border (c) by a line joining foramen spinosum to the arcuate eminence. (A) is from dry specimen, (B) is from cadaveric specimen.
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Conflict of Interests
None.

References

2. Isolan GR, Krayenbühl N, de Oliveira E, Al-Mefty O. Microsurgical anatomy of the cavernous sinus: measurements of the triangles in and around it. Skull Base 2007;17(6):357–367

Fig. 2 (A) The Glasscock’s triangle (GT) is the blue-colored area described as per the boundaries in Fig 1. The dotted red line shows the course of horizontal intrapetrosal segment of the internal carotid artery (ICA). (B) Photograph depicting the exposed ICA after drilling the GT (V1 = mandibular nerve).