A Morphometric study of the jugular foramen in human adult skulls of south India.
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Abstract:
It is well known that the jugular foramina are essential for venous drainage of the brain. The size of the foramen is related to the size of the sigmoid sinus and the presence or absence of prominent jugular bulb. An anatomical study was undertaken in order to investigate the size of jugular foramen in human adult skulls. A total of 125 human skulls were examined to determine the diameter, area and side predominance of the foramen. In 64.8% of cases the right foramina were larger than the left, in 24.8% of cases the left foramina were larger than the right and in 10.4% cases they were equal in size on both sides. The mean length of the foramen on the right and left were 23.62mm and 22.86mm; the width measured 7.83mm and 6.83mm on the right and left respectively; the mean area on the right was 584.36cmm and on the left 493.30cmm.

Key words: Skull, Jugular foramen, Anatomy

Introduction
The jugular foramen is difficult to understand and to access surgically; it is difficult to conceptualize because it varies in size and shape in different crania, from side to side in the same cranium, from its intracranial to extracranial end in the same foramen, because of its complex irregular shape, its curved course, its formation by two bones, and the numerous nerves and venous channels that pass through it.
It is generally said that although the jugular foramen is larger on the right side compared to the left, its size as well as its height and volume vary in different racial groups and sexes [1]. The jugular foramen is the main route of venous outflow from the skull and is characterised by laterality based on the predominance of one of the sides [2]. Ligation of the internal jugular vein is sometimes performed during radical neck dissection with the risk of venous infarction, which some adduce to be due to ligation of the dominant internal jugular vein.
The jugular foramen located at the posterior end of the petro-occipital suture is formed by the petrous temporal bone anterolaterally and the occipital bone posteromedially[3]. It courses anteriorly then laterally and finally inferiorly through the skull base. Anteriorly it is separated from the inferior carotid opening by a bony ridge, the carotico jugular spine. The jugular foramen is lateral to the hypoglossal canal and the two are separated by an osseous bar[4].
foramen including its dimensions, and to
discover the degree of predominance, if
any, of this opening in human adult skulls
of south India.

Material and methods
A total of 250 jugular foramina were
examined from 125 adult dry skulls. The
skulls were obtained from the Department
of Anatomy, JMJ Medical College,
Davangere, India. The length, width and
area of the jugular foramina were
determined. Metric measurements were
taken using Vernier calipers.
The mean standard deviation and range of
each dimension and derived index were
computed. Right and left side differences
were analysed. A comparison was made by
means of the dimensions using the
Student's t-test. The association between
continuous variables was investigated by
means of Pearson's correlation coefficient.

Results
The mean length of jugular foramen on the
right and left were 23.62mm and
22.86mm, while their widths measured
7.83mm and 6.83mm respectively(Table -
1). The mean area on the right was
584.36mm and on the left was 493.30mm.
Predominance of one of the two foramina
appeared in 89.6% of cases. Predominance
on the right was 64.8% and 24.8% on the
left. 10.4% cases were equal on both sides.
There was statistical significance between
the two sides in the length and area but
there was no significant difference
between the two sides in the width. There
was a positive correlation between length
and width on each side (Table -2, 3).
Statistical analysis did show significant
positive correlation between the width and
length of the skull and the length of the
jugular foramen on both sides.

Discussion
The size and shape of the jugular foramen
is obviously related to the size of the
internal jugular vein and the presence or
absence of a prominent superior bulb. The
right foramen is usually larger than the
left. There is a very wide variation in the
anatomy of the intra cranial venous sinuses
which accounts for variation in size and
shape of jugular foramen.
The difference in size of the two internal
jugular veins is already visible in the
human embryo at the 23mm stage and
probably results from differences in the
pattern of development of the right and left
brachiocephalic veins.
Hovelacque[8] was the first to propose the
subdivision of jugular foramen. The
foramen is divided by a fibrous or bony
septum that joins the jugular pine of the
petrous bone to the jugular process of the
occipital bone in to an anteromedial
compartment and a posterolateral
compartment. The pars nervosa receives
the 9th cranial nerve, inferior petrosal
sinus and the meningeal branch of the
ascending pharyngeal artery, while the
remaining structures pass via the pars
vascularis.
Tekdemir et al[7] observed no partition in
their studies while Ekinci et al.[9] found
bony bridges in 20% and tripartite jugular
foramen in 0.7%. Rhoton and Buza [10]
noted 26% bony bridges; this was
bilaterally represented in 8%. A bony
bridge in 3 (7.5%) of the jugular foramen
with 1 skull bilaterally was found in this
series. Rhoton et al and DiChiro et al[5]
observed a separate bony canal anterior to
the pars nervosa in 6% of skulls, while
Patridge[14] noted a frequency of 25%.
This bony canal was for the exit of the IX
cranial nerve. The present study did not
notified a separate bony canal anterior to
the pars nervosa. The smaller pars nervosa
is relatively consistent in size compared
with the larger and more variable pars
vascularis.
Navsa and Kramer[1] noted a significantly
larger exocranial area on the right in
blacks but one of normal size in whites in
South Africa. Predominance of jugular
foramen appeared in 83% of cases in
Wysocki’s series and the predominance of
the left and the right side were equally
possible [2]. In 61.4% of cases the right
jugular foramen was larger in Ekinci’s
series, while Rhoton et al noted that 68%
Table 1: Dimensions of the jugular foramen

<table>
<thead>
<tr>
<th></th>
<th>Rt L</th>
<th>Lt L</th>
<th>Rt W</th>
<th>Lt W</th>
<th>Rt A</th>
<th>Lt A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>23.62</td>
<td>22.86</td>
<td>7.83</td>
<td>6.83</td>
<td>584.36</td>
<td>493.30</td>
</tr>
<tr>
<td>SD</td>
<td>2.29</td>
<td>3.13</td>
<td>1.36</td>
<td>1.63</td>
<td>131.28</td>
<td>145.51</td>
</tr>
<tr>
<td>Minimum</td>
<td>19.4</td>
<td>12.0</td>
<td>3.0</td>
<td>4.0</td>
<td>209.31</td>
<td>199.89</td>
</tr>
<tr>
<td>Maximum</td>
<td>29.3</td>
<td>27.4</td>
<td>11.4</td>
<td>11.0</td>
<td>913.63</td>
<td>825.53</td>
</tr>
</tbody>
</table>

Rt L – right length, Lt L- left length, Rt W – right width, Lt W – left width, Rt A- right area, Lt A – left area,
SD- standard deviation. All measurements in mm

Table 2: Student`s t-test and Pearson correlation of the continuous variables

<table>
<thead>
<tr>
<th></th>
<th>t-test</th>
<th>p-value</th>
<th>r-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rt L – Lt L</td>
<td>2.1692</td>
<td>0.0310</td>
<td>0.340</td>
<td>0.0001</td>
</tr>
<tr>
<td>Rt W – Lt W</td>
<td>5.2684</td>
<td>0.0001</td>
<td>0.039</td>
<td>0.5394</td>
</tr>
<tr>
<td>Rt A – Lt A</td>
<td>5.1942</td>
<td>0.0001</td>
<td>0.074</td>
<td>0.2437</td>
</tr>
<tr>
<td>Rt L – Rt W</td>
<td>66.121</td>
<td>0.0001</td>
<td>0.296</td>
<td>0.0001</td>
</tr>
<tr>
<td>Lt L – Lt W</td>
<td>50.726</td>
<td>0.0001</td>
<td>0.156</td>
<td>0.0135</td>
</tr>
</tbody>
</table>

Rt L – right length, Lt L- left length, Rt W – right width, Lt W – left width, Rt A- right area, Lt A – left area, r – Pearson correlation coefficient, p<0.05

Table 3: The Pearson correlation coefficient and p-value of the continuous variables

<table>
<thead>
<tr>
<th></th>
<th>Rt L</th>
<th>Lt L</th>
<th>Rt W</th>
<th>Lt W</th>
<th>Rt A</th>
<th>Lt A</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>------</td>
<td>0.340</td>
<td>0.296</td>
<td>-0.005</td>
<td>0.670</td>
<td>0.131</td>
</tr>
<tr>
<td>p</td>
<td>------</td>
<td>0.0001</td>
<td>0.0001</td>
<td>0.9373</td>
<td>0.0001</td>
<td>0.0385</td>
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<tr>
<td>Lt L r</td>
<td>0.340</td>
<td>------</td>
<td>-0.036</td>
<td>0.156</td>
<td>0.123</td>
<td>0.603</td>
</tr>
<tr>
<td>p</td>
<td>0.0001</td>
<td>------</td>
<td>0.5710</td>
<td>0.0135</td>
<td>0.0521</td>
<td>0.0001</td>
</tr>
<tr>
<td>Rt W r</td>
<td>0.296</td>
<td>-0.036</td>
<td>------</td>
<td>0.039</td>
<td>0.904</td>
<td>0.029</td>
</tr>
<tr>
<td>p</td>
<td>0.0001</td>
<td>0.5710</td>
<td>------</td>
<td>0.5394</td>
<td>0.0001</td>
<td>0.6482</td>
</tr>
<tr>
<td>Lt W r</td>
<td>-0.005</td>
<td>0.156</td>
<td>0.039</td>
<td>------</td>
<td>-0.003</td>
<td>0.877</td>
</tr>
<tr>
<td>p</td>
<td>0.9373</td>
<td>0.0135</td>
<td>0.5394</td>
<td>------</td>
<td>0.9624</td>
<td>0.0001</td>
</tr>
<tr>
<td>Rt A r</td>
<td>0.670</td>
<td>0.123</td>
<td>0.904</td>
<td>-0.003</td>
<td>------</td>
<td>0.074</td>
</tr>
<tr>
<td>p</td>
<td>0.0001</td>
<td>0.0521</td>
<td>0.0001</td>
<td>0.9624</td>
<td>------</td>
<td>0.2437</td>
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<tr>
<td>Lt A r</td>
<td>0.131</td>
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<td>------</td>
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<tr>
<td>p</td>
<td>0.0385</td>
<td>0.0001</td>
<td>0.6482</td>
<td>0.0001</td>
<td>0.2437</td>
<td>------</td>
</tr>
</tbody>
</table>

Rt L – right length, Lt L- left length, Rt W – right width, Lt W – left width, Rt A- right area, Lt A – left area, r – Pearson correlation coefficient, p<0.05.
of jugular foramen were larger on the right, 12% equal and 20% smaller. None of these studies tested for any significant statistical difference. In the present study the right jugular foramen was larger in 55% of cases, while in 25% of cases it was larger on the left; this, however, was not statistically significant.

In Sturrock’s investigation of 156, skulls the right foramen was larger in 68.6%, the left larger in 23.1% and equal on both sides in 8.3%. He observed complete separation on the right side in 3.2%, on the left side in 3.2% and partial separation on the right side in 1.3% and on the left side in 10.9%.

Hatiboglu and Anil[12] studied 300 Anatolian skulls from the 17th and 18th centuries and observed that in 61.6% the foramen was larger on the right side and in 26% it was larger on the left side and in the reminder of equal size. they observed complete separation on the right side in 5.6%, on the left side in 4.3% and partial separation on the right side in 2.6%, on the left side in 19.6%.

Patel and Singel[13] studied 91 Indian skulls(Saurashtra region) and observed in 60.4% cases larger right foramen, in 15.4% larger left foramen and in 24.2% equal on both sides. They observed complete separation on the right side in 23.1%, on the left side in 17.6% and partial separation on the right side in 49.5%, on the left side in 59.3%.

**Conclusion**
The present study observed variation in the size of jugular foramen sizes. The foramen are larger on the right than the left in Indian population.

**References:**