Difference in morphology of the occipital condyles according to age using high resolution computer tomography

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Aims and objectives

Craniocervical instability is an uncommon condition [1] that involves a limitation in the range of motion of the occipitoatlantoaxial region. [2] It can be caused by congenital malformations, genetic disorders, tumors, postsurgical changes or trauma to the base of the skull. [1-5] Complications vary from paralysis, respiratory dysfunction to even life-threatening conditions. [1,4]

There has not been a consensus on the ideal treatment of craniocervical instability, however there are several alternatives. One option is the surgical fusion of the occipitoatlantal joint by mean of a posterior fixation using a "midline occipital keel plate" and fixing it to transpedicular screws in underlying vertebrae. However, this procedure is not feasible in patients with bone resection of the occipital bone, trauma or cases of suboccipital craniectomy. [4]

Another procedure in these situations is the "screw and rod" technique. [4] In this procedure, a pair of screws are inserted into each occipital condyle and then fixed to another pair of screws in underlying cervical vertebrae. This technique is complex and high risk due to the proximity of diverse anatomical structures of importance. [5] In pediatric patients it is particularly difficult to perform due to the size of the condyles, absence of complete ossification bodies, as well as the lack of adequate equipment in size and shape for this age group. [2] Due to this, a morphological study of the occipital condyles prior to the operation is important. [4-5]

Various morphometric studies of the occipital condyles have been made, finding significant population differences, therefore a preoperative imaging study is mandatory. [3] However there are few studies regarding pediatric population, one of them found a significant difference between different age groups within the pediatric population and confirmed the possibility of performing surgery in this population. [2]

The purpose of the study was to compare the morphology of the occipital condyles between age groups, estimate the growth pattern of the condyles and determine the feasibility of surgery in the pediatric population.
Methods and materials

This was an observational, cross-sectional, retrospective and descriptive study that included 175 HRCT studies obtained from the Radiology and Imaging Department database of the Hospital Universitario "Dr. José Eleuterio González". Patients with a history of fractures, tumors, surgical interventions of the skull base, as well as patients with cancer or other pathologies that could alter bone metabolism were excluded.

Data acquisition: All images were acquired using a 64-slice tomograph (General Electric CT99 Light Speed VCT) and Software 2978195VCT (GE Medical Systems, Milwaukee, WI) with a rotation of 0.4s helicoidal acquisition, a detector coverage of 20mm, Kv of 120mAs and 400; a slice thickness of 0.625mm, Pitch of 0.53:1mm/rot and FOV of 22 to 33cm. Afterwards, the data obtained was transferred and analyzed in an AW Volumen Share2 Workstation using multiplanar reformation (MPR) with maximum projection intensity and volume rendering. During measurements, a standardized window range of WW:4000 and WL:1000 was used in all specimens.

Data analysis: The images were independently evaluated by two experienced radiologists who form part of the Radiology and Imaging Department of the Hospital Universitario "Dr. José Eleuterio Gonzalez". These parameters were defined to measure the condyles: Length: the long axis from the anterior edge to the posterior edge of the condyle (Figure 1). Mean width: distance between medial and lateral border of the condyle at the midpoint of the length; proximal and distal width as points equidistant from the midpoint (Figure 2). Height: measured between the lower edge of the hypoglossal duct and the lower edge of the articular surface of the condyle in a sagittal plane (Figure 3). Condyle sagittal angle: measured between the long axis of the condyle and the sagittal midline (Figure 4). Intercondylar distance (anterior, mean and posterior): distance between the corresponding edges of the condyles (Figure 5). Intercondylar angle: formed between the anterior edge of both condyles and the midline (Figure 6).

Statistical analysis: The Kolmogorov-Smirnov test was used to evaluate data normality. Central tendency and dispersion data were obtained, expressed as mean and standard deviation for parametric data, and as median and interquartile range in non-parametric data. Comparisons between the different study groups were made using a two-tailed Student’s t-test and one-way ANOVA for parametric data, and Mann-Whitney U and the Kruskal-Wallis test for nonparametric data. A # 0.05 P value was considered statistically significant. SPSS version 20 (IBM, Armonk, NY) for Windows 7 was used for statistical analysis.
Fig. 1: Measurement of the length of the occipital condyle on the axial plane at the base of the OC. Purple dots indicates the anterior and posterior edge of the occipital condyle.

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Fig. 2: Measurement of the width occipital condyle (anterior, mean and posterior) on the axial plane at the base of the OC. Purple dots indicates the transversely widest points of the OC.

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**Fig. 3:** Measurement of the height of the occipital condyle on the sagittal plane. Purple dots indicates the measure between the lower edge of the hypoglossal duct and the lower edge of the articular surface

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Fig. 4: Condylar sagittal angle: measured between the long axis of the condyle and the sagittal midline.
Fig. 5: Intercondylar distance (anterior, mean and posterior): distance between the corresponding edges of the condyles.
Fig. 6: Intercondylar angle: formed between the anterior edge of both condyles and the midline

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Results

Analyzing the age groups among themselves, significant differences were found in all measures (Table 1) except the distal width (p=0.149) and the posterior intercondylar distance (p=0.067). The measures do not follow any growth pattern according to age.

When analyzing all the inter-gender groups we found significant differences between men and women in all measures (Table 2), except intercondylar angle (p=0.559), anterior intercondylar distance (p=0.398) and parasagittal angle (p=0.630). In most of the parameters, greater measures were found in the group of men than in women. When identifying each group, the differences between gender were mostly non-significant and variable between each parameter.

There were significant persistent differences in the height of the condyle when comparing it among all the age groups, the least measured being the one found in group 1. In this parameter, significant inter-gender differences were also found, the group of men it remains higher.
Table 1: Five age groups and the measures of the occipital condyles. Significant difference where found in all measures except for distal width (p=0.149) and posterior intercondylar distance (p=0.067).

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<table>
<thead>
<tr>
<th>Age group</th>
<th>Men</th>
<th>Women</th>
<th>P-value (intergender)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (5-9)</td>
<td>7.1 (6.6-7.575)</td>
<td>6.55 (6.3-7.1)</td>
<td>0.025</td>
</tr>
<tr>
<td>2 (10-19)</td>
<td>9.7 (8.65-10.65)</td>
<td>9.1 (8.3-9.65)</td>
<td>0.016</td>
</tr>
<tr>
<td>3 (19-34)</td>
<td>10.5 (9.8-10.9)</td>
<td>8.9 (8.4-9.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>4 (35-59)</td>
<td>9.8 (8.65-10.05)</td>
<td>9.2 (8.4-10.3)</td>
<td>0.049</td>
</tr>
<tr>
<td>5 (&gt;60)</td>
<td>9.8 (9-11.2)</td>
<td>9 (8.2-10.05)</td>
<td>0.003</td>
</tr>
<tr>
<td>P-value (intergender)</td>
<td>&lt;0.001 (ANOVA)</td>
<td>&lt;0.001 (ANOVA)</td>
<td></td>
</tr>
<tr>
<td>P-value (intergender total)</td>
<td>&lt;0.001 (T DE STUDENT)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Analyzing gender groups we found significant differences between men and women in all measures except intercondylar angle, anterior intercondylar distance and parasagittal angle. In most of the parameters, greater measures were found in the group of men than in women.

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Conclusion

The purpose of the study was to compare the morphology of the occipital condyles between age groups, estimate the growth pattern of the condyles and determine the feasibility of surgery in the pediatric population.

In conclusion, we found that there is a great variability in the size of the condyles, which confirms the need of a preoperative imaging study is necessary. Most of the women presented smaller measures compared to men which can determine the size of the screws to be used. Although we did not find a growth pattern proportional to age, we can note that the younger age group had the lowest measure of the height of the condyle (6.85mm), however, this may be enough to perform surgery with the frequently used screws (3.5mm diameter).
Personal information

R. Alvarez, MD.

Department of Radiology, Hospital Universitario "Dr. José E. González". Universidad Autónoma de Nuevo León.

Monterrey, Nuevo León, México.

e-mail: ricardo_611@hotmail.com
References


