Presence and types of anterior clinoid process pneumatization, evaluated by Multidetector Computerized Tomography

Abstract

Purpose: The types and ratio of anterior clinoid process (ACP) pneumatization in paranasal sinus Multidetector Computerized Tomography (MDCT) were investigated the importance of ACP in neurosurgical approaches discussed.

Methods: Paranasal MDCT images of 499 subjects (259 male, 240 female), between 17 and 65 years of age, were included in the study. Presence and types of pneumatization of the ACP and pneumatization types (I, II or III) were evaluated.

Results: ACP pneumatization was detected in 37.5% of the males and 33.3% of the females. Right, left and bilateral ACP pneumatizations were detected in 12.7%, 9.3% and 15.4% of males and 9.2%, 8.3% and 15.8% of the females, respectively. The most commonly detected types of pneumatization were Type I (49.1%) for right pneumatizations and Type II pneumatization for left (40.9%) and bilateral (37.2%) pneumatizations. In males, Type I (37.1%) and in females, Type II (40.0%) pneumatizations were detected more frequently. Type III pneumatization was detected in 29.9% of the males and 22.5% of the females. ACP pneumatization ratios were higher in younger subjects and lower in older subjects.

Conclusion: Sclerosis process related to aging may be responsible for the lower pneumatization ratios in older subjects. When Type III ACP pneumatization is present, clinoidectomy should not be performed: in this type of ACP pneumatization, cerebrospinal fluid fistula develops in all cases.
Certain parts of the sphenoid bone are connected by ligaments, including the pterygospinous (between the spine and the upper part of the lateral pterygoid plate), the interclinoïd (joining the anterior and posterior clinoid process) and the caroticoclinoid (connecting the anterior and middle clinoid process), and these ligaments occasionally ossify [1].

The anterior clinoid process (ACP) is a posterior and medial continuation of the lesser sphenoid wing [2-5] and is connected to the body of the sphenoid bone (basisphenoid bone) by superior and inferior roots [4,5]. The superior root is flat, forms the roof of the optic canal, and continues as the planum sphenoidale. The inferior root (optic strut) forms the lateral and ventral walls of the optic canal and connects the lesser sphenoid wing with the basisphenoid bone [1].

Pneumatization of the ACP involves extending a paranasal sinus, such as the sphenoid or ethmoid sinus, into the ACP through the optic strut (OS) or anterior root (AR). Tearing these paranasal sinuses can cause pneumocephalus or liquorrhea [6-10]. In this study, we investigated the types and ratio of ACP pneumatization and discussed the importance of it to neurosurgical approaches.

Materials and Methods

This retrospective study was conducted in December 2015 in Kirikkale University Faculty of Medicine according to the principles of the Declaration of Helsinki. Computerized Tomography (CT) images were obtained from the archives of Kirikkale University Faculty of Medicine Radiodiagnostic Department. The study was sanctioned by the local Ethics Committee of Kirikkale University Faculty of Medicine (17 November 2015, No: 2015-25-03).

Subjects

Paranasal CT images of 499 subjects (259 male, 240 female), between 17 and 65 years of age, selected from a digital radiology database of all cranial CT in Kirikkale University Faculty of Medicine Radiodiagnostic Department, were included in this study. An effort was made to balance the numbers of male and female subjects and to balance the age profiles of the male and female groups. Age of the males was 35.3 (mean) ± 13.34 years (ranged from 18.0 to 65.0 years) and age of the females was 34.5 (mean) ± 12.9 years (ranged from 17.0 to 65.0 years).

Inclusion criteria were as follows: subjects ≥17 years old and with no chronic diseases. Exclusion criteria were as follows: subjects with cranio-facial fractures; endocrinological problems; ossceous pathologies; previous trauma or surgery history; cranial tumor; pituitary tumor; sinonasal tumor; sinonasal polyposis; CSF leak; or marked facial deformity.

Clinical indications for the CT examinations were headache, sinusitis (except the CTs showing complete obstruction of at least one of the paranasal sinuses) and nasal congestion. This clinical information was present in the original referrals. The subjects were included in the study according to this information. None of the CT examinations was excluded from the study after the study started.

Statistical Analyses

SPSS for Windows 16.0 (SPSS, INC, an IBM Company, Chicago, Illinois) was used for statistical analyses. Chi-square test and Spearman’s correlation Rho efficient test were used. ACP pneumatization (absent and present; right, left, bilateral); and, type of ACP pneumatization, Type I, Type II or Type III [11]. The definitions of ACP pneumatizations were as follows: Type I, in which less than 50% of the ACP was pneumatized; Type II, in which more than 50% but less than 100% of the ACP was pneumatized; and, Type III, in which the ACP was totally pneumatized [11].
correlation Rho efficient test and p value < 0.05 was considered as statistically significant.

**Results**

Both coronal and axial paranasal sinus CT slides were evaluated (Figure 3A-B). ACP in males and females are presented in Table 1. In males, ACP pneumatization was detected in 37.5% of the subjects and in females it was detected in 33.3% of the subjects. Right, left and bilateral ACP pneumatization were detected in 12.7%, 9.3% and 15.4% of males and 9.2%, 8.3% and 15.8% of the females, respectively (p= 0.592 X2= 1.907) (Table 1).

Types of ACP pneumatization, according to the sides, are shown in Table 2. The most commonly detected types of pneumatization were Type I (49.1%) for right pneumatizations and Type II pneumatization for left (40.9%) and bilateral (37.2%) pneumatizations (p=0.278 X2=5.096) (Table 2).

### TABLE 1. Anterior clinoid process pneumatization in males and females

<table>
<thead>
<tr>
<th>Anterior clinoid process pneumatization</th>
<th>Males (n=259)</th>
<th>Females (n=240)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Present</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>33</td>
<td>12.7</td>
<td>22</td>
</tr>
<tr>
<td>Left</td>
<td>24</td>
<td>9.3</td>
<td>20</td>
</tr>
<tr>
<td>Bilateral</td>
<td>40</td>
<td>15.4</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>259</td>
<td>100.0</td>
<td>240</td>
</tr>
</tbody>
</table>

*p value shows the results of Chi-square test

### TABLE 2. Types of the anterior clinoid process pneumatization according to the sides

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
<th>Total</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Right (n=55)</td>
<td>27</td>
<td>49.1</td>
<td>17</td>
<td>30.9</td>
<td>11</td>
</tr>
<tr>
<td>Left (n=44)</td>
<td>13</td>
<td>29.5</td>
<td>18</td>
<td>40.9</td>
<td>13</td>
</tr>
<tr>
<td>Bilateral (n=78)</td>
<td>26</td>
<td>33.3</td>
<td>29</td>
<td>37.2</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>37.3</td>
<td>64</td>
<td>36.2</td>
<td>47</td>
</tr>
</tbody>
</table>

*p value shows the results of Chi-square test

### TABLE 3. Types of the anterior clinoid process pneumatization in males and females

<table>
<thead>
<tr>
<th>Anterior clinoid process pneumatization</th>
<th>Males (n=97)</th>
<th>Females (n=80)</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Type I</td>
<td>36</td>
<td>37.1</td>
<td>30</td>
</tr>
<tr>
<td>Type II</td>
<td>32</td>
<td>33.0</td>
<td>32</td>
</tr>
<tr>
<td>Type III</td>
<td>29</td>
<td>29.9</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>97</td>
<td>100.0</td>
<td>80</td>
</tr>
</tbody>
</table>

*p value shows the results of Chi-square test
Types of ACP pneumatization in both males and females are shown on Table 3. In males, Type I (37.1%) and in females, Type II (40.0%) pneumatizations were most commonly detected. Type III pneumatization was detected in 29.9% of the males and 22.5% of the females ($P=0.472 \ \chi^2=1.501$) (Table 3).

Spearman correlation Rho efficient test results showed that in younger subjects, pneumatization of ACP was higher than older subjects ($p=0.000, r=-0.225$). There was no significant correlation between gender and presence of ACP pneumatization ($p=0.338, r=-0.043$).

**Discussion**

In the present study, ACP pneumatization was detected in 37.5% of the males and 33.3% of the females. Right, left and bilateral ACP pneumatizations were detected in 12.7%, 9.3% and 15.4% of males; and 9.2%, 8.3% and 15.8% of the females, respectively. The most commonly detected types of pneumatization were Type I (49.1%) for right pneumatizations and Type II for left (40.9%) and bilateral (37.2%) pneumatizations. In males, Type I (37.1%) and in females, Type II (40.0%) pneumatizations were most commonly detected.

In the paper by Mikami et al., pneumatization of the ACP was found in 55 sides (9.2%) of 600 sides in 300 consecutive patients [9]. Pneumatized patterns were divided into three groups according to the route: pneumatization occurred via the optic strut (OS) in 41 sides (74.5%), via the AR in eight sides (14.8%) and via OS and AR in six sides (10.9%). In our study, ACP pneumatization ratios were higher than Mikami’s study. We evaluated both coronal and axial paranasal sinus CT slides: ACP pneumatization can more easily be detected in coronal CT sections in comparison with axial sections. The difference in ACP rates between Mikami’s study and our study may be related to the genetic differences in subject populations or to environmental exposures to different agents; however, these issues should be investigated in further studies.

In the study by Sirikci et al., pneumatization of the ACP was encountered in 27 (29.3%) patients [12]: on the right side in six (6.5%), on the left in eight (8.7%) and bilateral in 13 (14.1%). Aerated ACP was reported in 6-24% of cases in several imaging studies, occurring bilaterally in over 50% of these cases [9,11,13-15]. In our study, the bilateral ACP pneumatization ratio was found to be lower.

In the present study, pneumatization of ACP was higher in younger subjects and lower in older subjects. Sclerosis
A process related to the aging may be responsible for the lower pneumatization ratios in older subjects. In future studies, the possible effect of chronic mucosal inflammation and age-related sclerotic changes should be investigated.

Complete or partial removal of the ACP is an important step in the superior approach to the cavernous sinus, management of carotid-ophthalmic, giant internal carotid artery and paraclinoid aneurysms [16-22]. In middle cranial fossa surgery, ACP was drilled and, therefore, better exposure was obtained in the surgical area, especially in suprachindoid and paraclinoid segment aneurysms. Complications of anterior clinoidectomy include opening of paranasal sinuses and the risk of resultant rhinorrhea, impaired vision, oculomotor nerve palsy, damage to optic nerve and/or the internal carotid artery, ophthalmic artery injury, aneurysm rupture and pneumocephalus [11,16,23-26]. Complications following removal of pneumatized ACP include opening of the paranasal sinuses, the concomitant risk of rhinorrhea, and the consequent high risk of sepsis [27]. Performing anterior clinoidectomy causes potential complications owing to its deep location between the ICA and CN II and III. Injuries to CN II and III can be caused by unexpected motion of the drill or by heat caused by insufficient irrigation [28].

In the present study, Type III pneumatization was detected in 29.9% of the males and 22.5% of the females. When ACP is pneumatized, there is relationship between ACP and sphenoid sinus. In this condition, fistula of the cerebrospinal fluid (CSF) may develop when clinoidectomy was performed. Type III ACP pneumatization is more dangerous in terms of fistula risk. When Type III ACP pneumatization is present, clinoidectomy should not be performed because, in this type of ACP pneumatization, CSF fistula developed in all cases. In these cases, high pterional approach should be used to operate the supraclinoid and paraclinoid aneurysms.

We recommend that paranasal CT slides be evaluated in detail during the preoperative period to detect any ACP pneumatization. Neurosurgeons should avoid performing anterior clinoidectomies in patients with Type III ACP pneumatization, to prevent CSF fistulas.
References