Obstructive sleep apneas syndrome (OSAS) has been associated with a clinical reduction of the pharyngeal spaces. To define whether predisposing skeletal craniofacial conditions exist in OSAS patients, 32 OSAS adult patients were compared in a cephalometric investigation with a control sample of 40 adults with ideal dentofacial traits. A t-test assessed the statistical significance of the differences in the two groups; correlation matrix tabulation and discriminant function analysis helped in the identification of the influence of different variables in segregation of the two populations.

The following observations were made: There were no differences in maxillary or mandibular prognathism between the two groups. The sagittal dimension of the cranial base was significantly reduced in the OSAS sample, as was the bony pharyngeal opening and maxillary length. This posterior facial compression was associated with increased lower face height ($p < 0.01$ in all cases). There were significant correlations in both groups between cranial base length or angulation and pharyngeal opening ($p < 0.01$). Eighty percent of the population was correctly sorted out using the discriminant function analysis, with only eight controls and five OSAS patients misclassified. However, this analysis suggested that factors other than the cephalometric may be involved in OSAS.

KEY WORDS: obstructive sleep apneas syndrome, cephalometry, mandibular prognathism, cranial base.

The obstructive sleep apneas syndrome (OSAS) is characterized by the stopping of bucconasal airflow several hundred times during the night. This syndrome is rarely observed in young subjects, where it may exist without being detrimental. Crippling outbreaks usually appear in adults during their late forties and usually affect obese patients who are heavy snorers. The apneas involve an occlusion of the upper airway, which often lies at the level of the oropharynx but sometimes also at the nasopharynx or hypopharynx. Obstructive sleep apneas are accompanied by changes in sleeping habits, blood oxygenation, cardiovascular functions, and hemodynamics. Perturbations of cerebral and endocrine functions are observed.

The precise mechanism of upper airway occlusion is still under debate. Extensive reviews of OSAS have been published recently (Kuna and Remmers, 1985; Sullivan and Issa, 1985; Krieger, 1986). Schematically, occlusion results from an imbalance among those forces (static and dynamic) that tend to open the upper airway and those that tend to cause it to collapse. This imbalance is, to some degree, related to changes in breathing control, which normally start with sleep. Instability then appears in the breathing command, and a characteristic collapsibility of the upper airway manifests itself in these patients. The suggested reasons may be functional (muscular hypotony),
anatomic (shortening of some bones, soft tissue hyperplasia), or both. A reduction in pharyngeal spaces is a clinical observation commonly reported in OSAS patients. Nonetheless, it has not been tested whether pharyngeal reduction was due only to an increased soft tissue volume or whether the supporting skeletal structures could be a predisposing factor. In the present study, a cephalometric investigation is made of a group of OSAS patients and a control sample. Whether specific skeletal craniofacial variables exist in the disabled population and to what extent these variables may contribute to the discrimination of the two populations will be discussed in the statistical analysis.

**MATERIALS AND METHODS**

Two groups were compared:

The experimental group consisted of 32 adult males aged from 41 to 77 with a mean age of 55.2. OSAS was diagnosed following a polygraphic recording of sleep during the whole night. Only patients with more than 10 apneas per hour were considered, and at least 80% of the apneas had to be of the obstructive or mixed type. The mean index of apneas in the sample was 58.5 per hour of sleep.

The control group consisted of 41 young adult males whose growth was completed. They were between 20 and 30 years of age, with a mean age of 22.6. These subjects were selected among students at the dental school in Strasbourg. All showed a very good dentomaxillofacial equilibrium and were in possession of all their teeth besides the wisdom teeth. None of them had breathing problems or had ever undergone orthodontic therapy. All patients in both groups lived in the east of France and were Caucasian.

**Cephalometry**

The same apparatus (Siemens Nanodor 2) was used to carry out standardized cephalograms of the profiles. The distance from the focus to the median plane of the head was 150 cm, and the distance from the median plane of the head to the film was kept at 14 cm in all cases. No corrections were made for linear enlargement. The cephalograms were traced twice at an interval of several days. Only tracings free from discrepancies greater than 1 degree or 1 mm were kept for the study. The mean values were rounded off to half a degree or half a millimeter. To avoid imprecision, only medial structures easy to identify were selected as landmarks, excepting the Dc (Condyle) point. Definitions of the landmarks are given in Figure 1. Variables (V) are defined in Table 1.

The mean and standard deviation were estimated for each cephalometric variable in each group. Since the comparison tests of the means in the two groups were performed on many variables, standard Bonferroni probabilities were calculated. Because the Bonferroni procedure does not take into account the correlations between the variables, homogeneous clusters were formed according to the observed correlations. The Hotelling T² test was performed on each cluster of variables using the Bonferroni
corrections. Finally, a stepwise multivariate discriminant analysis provided a summary of the most important variables after eliminating redundancy and nonpertinent variables for the comparison of the two groups.

RESULTS

Differences in the Two Groups

Results are shown in Table 1. Differences between the two groups will be mentioned only if significant according to Bonferroni probabilities at the 0.05 level. The Hotelling T² test performed on clusters of homogeneous variables did not provide any additional information. The main observations follow.

Cranial Base

The measurement of SN (V1) corresponds to the sagittal dimension of the anterior cranial fossa, and the measurement BaN (V2) corresponds to the total length of the cranial base. The reduction in the OSAS group of these two variables was highly significant. The angle of the cranial base according to BaSN (V3) was comparable in the two groups.

Pharynx

The bony pharynx (distance BaPns:V4) was shortened to a great extent in the OSAS group.

Face

With reference to the cranial base, the anterior positions of the maxilla (angle SNA:V7) and the mandible (angle SNB:V8) were alike in the two populations. The length of the maxilla (distance PnsA V10) and the sagittal measurements of the median upper face (variables DcA and BaA:V12 and V11) were shortened in OSAS patients.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normals N = 41</th>
<th>OSAS N = 32</th>
<th>Bonferroni test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial Base</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V1 SN length of the anterior cranial base</td>
<td>76.3</td>
<td>71.9</td>
<td>*</td>
</tr>
<tr>
<td>V2 BaN overall length of the cranial base</td>
<td>113</td>
<td>108.7</td>
<td>*</td>
</tr>
<tr>
<td>V3 BaSN angulation of the cranial base</td>
<td>129.7</td>
<td>128.7</td>
<td>NS</td>
</tr>
<tr>
<td>Upper Pharynx</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V4 BaPns dimension of the bony pharynx</td>
<td>47.8</td>
<td>44.3</td>
<td>*</td>
</tr>
<tr>
<td>V5 BaH depth of the soft tissue in front of basion</td>
<td>20.7</td>
<td>19.8</td>
<td>NS</td>
</tr>
<tr>
<td>V6 HPns airway opening on BaPns line</td>
<td>27.1</td>
<td>24.4</td>
<td>NS</td>
</tr>
<tr>
<td>Face</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V7 SNA angle of maxillary prognathism</td>
<td>83.9</td>
<td>82.5</td>
<td>NS</td>
</tr>
<tr>
<td>V8 SNB angle of mandibular prognathism</td>
<td>81.3</td>
<td>80</td>
<td>NS</td>
</tr>
<tr>
<td>V9 ANB difference in prognathism</td>
<td>2.3</td>
<td>2.4</td>
<td>NS</td>
</tr>
<tr>
<td>V10 PnsA maxillary length</td>
<td>55.4</td>
<td>52.4</td>
<td>*</td>
</tr>
<tr>
<td>V11 BaA sagittal dimension of median upper face from Ba to A</td>
<td>103.3</td>
<td>96.9</td>
<td>5.3</td>
</tr>
<tr>
<td>V12 DcA sagittal dimension of median upper face from Dc to A</td>
<td>91.3</td>
<td>86.4</td>
<td>4.8</td>
</tr>
<tr>
<td>V13 DcGn overall length of the mandible</td>
<td>119.3</td>
<td>118.3</td>
<td>NS</td>
</tr>
<tr>
<td>Face Height</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V14 upper face height</td>
<td>57</td>
<td>57.4</td>
<td>2.3</td>
</tr>
<tr>
<td>V15 lower face height</td>
<td>71.3</td>
<td>77.2</td>
<td>6.1</td>
</tr>
</tbody>
</table>

*p < 0.01
† p < 0.001
NS = Not significant.
The length of the mandible was similar in the two groups according to DcGn (V13).

**Face Height**

The upper face height (V14) was unchanged in the two groups. The lower face height (V15) was considerably increased in OSAS patients.

**The Discriminant Analysis**

The three variables entered in the stepwise discriminant analysis were SN (V1), BaA (V11) and lower face height (V15) according to the usual $D^2$ Mahalanobis statistic.

The best discriminating formula is given by:

$$y = 9.10 + 0.48 \text{ SN} + 0.34 \text{ BaA} - 0.45 \text{ lower face height}$$

The jackknifed classification showed that 80% of the population was correctly classified. Only eight controls and five OSAS patients were misclassified.

**DISCUSSION**

**Validity of the Control Sample**

This study may be criticized because the two groups were not perfectly matched for weight and age. Weight may be considered of secondary importance, since the measurements selected concern mainly bony parts and not soft tissues. Furthermore, the changes taking place in the craniofacial skeleton with aging show few increases in skeletal dimensions and no reductions (Forsberg, 1979; Behrents, 1985). In our study, however, shorter dimensions were found in the older OSAS group, with the exception of lower face height. Accordingly, a younger control group was considered acceptable for our purposes.

**Differences Between the Two Groups**

In OSAS, the anteroposterior dimension of the cranial base was reduced, but maxillary prognathism remained constant in both groups. As a logical consequence, the lengths of the maxilla and of the bony pharynx were diminished. The same trends existed in both groups because significant linear correlations between the bony pharynx length (BaPns:V4) and the cranial base length (BaN:V2) were found in OSAS ($r = 0.66 p < 0.01$) as well as in controls ($r = 0.58$). The shorter the cranial base, the narrower the pharynx. Similarly, the angulation of the cranial base (variable BaSN:V3), although comparable in the two populations, correlated with the pharyngeal dimension in the two groups ($r = 0.54$ in OSAS; $r = 0.42$ in controls).

In reference to the cranial base, mandibular prognathism, like maxillary prognathism, was similar in the two samples. According to DcGn, however, mandibular dimension was not shortened in the OSAS sample. This observation reflects the important increase in vertical development of the lower face in OSAS, which is not taken into account in the evaluation of mandibular prognathism according to SNB. In OSAS patients the chin is situated lower in the face, thus increasing the DcGn measurement. In controls, the variable DcGn was not correlated with the inferior face height ($r = 0.24$); in OSAS patients, a significant correlation existed ($r = 0.46 p < 0.01$). The important increment of the lower face height in OSAS should probably be considered to be a specific compensatory phenomenon.

The discriminant analysis tested the influence of different variables on the segregation of the two populations. The strongest discriminating variables were, SN (V1), BaA (V11) and lower face height (V15). With the formula $0 = -9, 10 + 0.48 \text{ SN} + 0.34 \text{ BaA} - 0.45 \text{ lower face height}$, 80% of the whole population could be suitably regrouped. Only eight controls and five OSAS would be misclassified. This analysis points to the major influence of these variables in OSAS, but it also implies that further factors should sometimes be taken into consideration to explain the disease.

OSAS patients have often been described in association with pharyngeal obstruction factors such as micromandible, macroglossia, velar dysfunction, or soft tissue hyperplasia, but few cephalometric studies have been conducted on these patients. The first study (Riley et al, 1983), compared an OSAS group with a control group. All subjects were men between 18 and 65 (without further precision). The authors observed a mandibular deficiency for some of the OSAS patients. In the same work, upper and lower face height were recorded. Calculation of the means in the two groups showed that upper and lower face heights were smaller in controls, but it is not known whether growth was terminated in this group. Nonetheless, it is interesting to observe that calculations of the proportions of the face (ratio upper face:lower face) showed a tendency to an increased lower face height in OSAS.

Rivlin (1984), in another cephalometric report, used the occlusal plane as an anteroposterior line to project condyle, menton, and S point. This method allows an evaluation of the relative sagittal dimension of the mandible as it
projects on the reference line but does not indicate the measure of the real mandibular length. The author recorded a shortening of the mandible and a chin closer to point S. This observation should be interpreted with caution because it takes into account the sagittal projection of a few landmarks only and does not consider vertical components. Nevertheless, it is in agreement with our findings, as it may result from a shortening of the cranial base and a vertically oriented mandible.

A recent work using canonical correlation analysis on 25 OSAS patients (Lowe et al., 1986) reported a posteriorly positioned maxilla and mandible, with a steep mandibular plane, and an increased facial height, but with a more important increment in the lower face height. These observations showed further common trends with our study, i.e., facial compression and increased vertical development. But none of these studies analyzed cranial base components, which seem to be of primary importance in the organization of facial equilibrium. The conclusion of the present investigation into OSAS was a posterior facial compression with narrowing of the pharyngeal airway and vertical hyperdevelopment but also a shortening of the cranial base. This latter factor seemed to be of major influence in governing the others.

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References


