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Evaluation of upper airways depth among patients with skeletal Class I and III

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Background: The aim of this study was to determine the value of upper and lower pharyngeal depth among patients with skeletal Class III malocclusion on lateral cephalograms, as well as to examine the relationship between SNA, SNB, and ANB angles, along with Wits appraisal and the cross-sectional value of upper airway space at the level of the soft palate and tongue base among patients with skeletal Class I and III.

Materials and methods: The material consisted of lateral cephalograms taken from 80 patients living in the Lubelskie voivodeship. The study group consisted of cephalograms of 50 patients with skeletal Class III malocclusion (17 male and 33 female), whereas the control group consisted of 30 roentgenograms of patients with Class I malocclusion with proper jaw to mandible relation (14 male and 16 female). The study and the control group shared no statistically significant differences considering basic sociographic data such as gender (chi = 1.267, p = 0.26) and age (U = 727.5, p = 0.82). The upper and lower pharyngeal depths were assessed with the use of McNamara's method. Spearman's rho test, Mann--Whitney's U test, and chi test were used for statistical analysis.

Results: Among both males and females the pharyngeal depths were greater considering patients with skeletal Class III in comparison to patients with Class I malocclusion (p < 0.001). Furthermore, it was determined that the lower as well as the upper pharyngeal width is statistically significantly dependent on ANB and SNB angles and Wits appraisal (p < 0.001).

Conclusions: Pharyngeal width at the level of the soft palate and tongue base depends on skeletal class, namely ANB angle and Wits appraisal; it increases with the increase of SNB angle (forward movement of the mandible). The SNA angle (position of the maxilla) does not influence the anterior-posterior nasopharyngeal dimension. (Folia Morphol 2013; 72; 2: 155–160)

Key words: upper airways diameter

INTRODUCTION

The study of the upper airway diameter has become a topic of interest for researchers ever since its connection with obstructive sleep apnoea (OSA) was discovered [9]. Breathing disorders during sleep have been connected with the narrowing of nasopharyngeal airways among patients with craniofacial structure disorders [14]. The measurements were based on lateral cephalograms.

Nowadays, researchers look towards ever more sophisticated diagnostic methods. For a more accurate visualisation of upper airways they use, for

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example, cone beam computed tomography [1, 10]. However, such kinds of research are expansive, relatively inaccessible, and expose patients to high doses of radiation. Therefore, for screening purposes, it is wiser to use lateral cephalograms, which are commonly used for orthodontic diagnostic. As well as price and availability, yet another advantage is the possibility of individual evaluation and measurement performance without the assistance of a specialist radiologist. Despite the 2-dimensional imaging, the measurements taken from such images proved to be highly reliable, and their accordance with the measurements made in 3D technique is as high as 92% [20].

It seems that specialists should act in a much earlier phase considering the contemporary state of knowledge. Having knowledge of the influence of the craniofacial structure on the upper airways cross-section, one can qualify patients for specific risk groups. It will give them a chance to take prophylactic action and will encourage them to monitor their health.

Simultaneously, it is important to constantly monitor and evaluate the influence the orthodontic treatment has on the cross-sectional value of upper airways. One needs to remember that properly matched treatment may secure a proper width of upper airways, whereas poor planning may constrict the airways.

The aim of this study was to determine the value of upper and lower pharyngeal depth among patients with skeletal Class III malocclusion on lateral cephalograms in comparison to patients with Class I malocclusion. Also examined were the relationship between SNA, SNB, and ANB angles, along with Wits appraisal and the cross-section value of upper airway space at the level of soft palate and tongue base.

MATERIALS AND METHODS

The material consisted of lateral cephalograms of 80 patients (50 patients comprised the study group, 30 comprised the control group) living in the Eastern Polish macroregion. The study group encompassed 50 cephalograms of patients with skeletal Class III malocclusion, of which 17 male patients constituted 34% and 33 female patients constituted 66%, all aged from 14 to 36 years (mean age 21.4). The control group consisted of 30 radiograms of patients with Class I malocclusion (proper jaw to mandible relation), in which 14 male patients constituted 46.7% and 16 female patients constituted 53.3%, all aged from 15 to 32 years (mean age 21.1). The study and the control group shared no statistically significant differences considering basic sociographic data such as gender (chi = 1.267, p = 0.26) and age (U = 727.5, p = 0.82).

Radiograms were taken with the lamp placed 1.52 m from the patient's face and the cassette, using a 70 kV voltage camera, and the exposure time was 0.65 s. The fibular surface was parallel to the roentgen film. The images were taken in the right-side natural position of the head. The patients were asked to swallow before the roentgen picture was taken. If the patient swallows during the picture taking, the shape of the palate resembles an inverted letter "V" and such images lose their diagnostic value [16, 18].

All radiograms were outlined by the same researcher using a 0.3 mm pencil on carbon paper. The measurements of the upper and lower pharynx depth were conducted using McNamara's method [16]. The upper anterior-posterior dimension determined the distance between the soft palate and the posterior pharyngeal wall. The section from the posterior nasal spine to the end of the soft palate was divided into 2 equal halves. Within the upper half the shortest distance from the palate's outline to the posterior wall of the upper airways was measured. The lower anterior-posterior pharyngeal depth was measured from the intersection of the mandibular and lingual outlines to the nearest point on the posterior pharyngeal wall. Additionally, the following points were outlined on the cephalograms: sella turcica (S), nasion (N), point A and point B; and the following angles were measured: SNA, SNB, and ANB along with Wits appraisal (Table 1, Fig. 1).

The obtained results were subjected to statistical analysis in order to determine the relation between the value of the upper and lower dimensions of the upper airways, and the location of the jaw and the mandible expressed in the SNA, SNB, and ANB angles and Wits appraisal. The influence of gender on the abovementioned results was also examined. The value of the analysed parameters was characterised by the mean, the median, the standard deviation, the

Table 1. Brittni Colleps. Interpretation of variables

Variable	Interpretation
Angular [degree]:	
SNA	Anteroposterior position of maxilla
SNB	Anteroposterior position of mandible
ANB	Anteroposterior maxilla/mandible discrepancy
Linear [mm]:	
Wits	Anteroposterior maxilla/mandible discrepancy

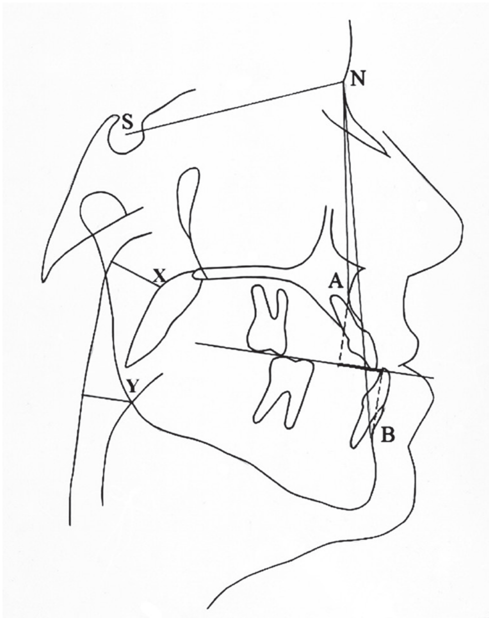

Figure 1. Cephalometric tracing with marked measurements; X — upper width of nasopharynx; Y — lower width of nasopharynx; S — sella turcica; N — nasion; A, B — point A and point B.

minimum, and the maximum. To examine the relation between the 2 measured parameters significance testing Spearman's rho test was applied, whereas Mann Whitney's U test was used for comparison of the results' distribution in the 2 independent groups, and chi test was applied to determine whether the 2 groups differed considering gender. A significance level $p < 0.05$ was adopted as showing statistically significant differences or relationships [21].

RESULTS

In the study group the mean depth value of the upper airways at the level of the palate was 14.7 mm (min. 8 mm, max. 29 mm). In women with skeletal Class III the mean value of this measurement was higher than in men (13.7 mm) at 15.2 mm. The mean measurement value at the level of the tongue base in the study group was 12.8 mm (min. 5 mm, max. 23 mm); 12.4 mm for women and 13 mm for men (Fig. 2A).

In the control group the average depth value of the upper airways for all patients examined within the group was 12.9 mm (min. 7 mm, max. 20 mm); the mean value of this measurement for women was 12.25 mm, whereas for men it was 11.6 mm. The mean lower pharyngeal depth in the control group was 9.8 mm for all examined patients (min. 4 mm, max. 18 mm); the average for women was 9.25 mm and for men it was 10.5 mm (Fig. 2B). The mean values, median, and standard deviations of upper and lower pharyngeal depth, as well as SNA, SNB, and ANB angles and Wits appraisal are presented in Table 2.

As a result of the analysis a statistically significant difference between the size of the upper ($U = 406.0$, $p = 0.0006$) pharyngeal depth between patients with skeletal Class III and I malocclusion was determined. A similar difference between the study and control group was observed in measurements at the level of the tongue base ($U = 427.0$, $p = 0.001$). The results of female patients with skeletal Class III and I showed a statistically significant difference considering the cross-section of the upper ($p = 0.001$) as well as the lower ($p = 0.002$) dimension of the upper airways. Such a relation was not observed in men ($p > 0.05$).

Both in women and in men the upper pharyngeal depths were larger among patients with skeletal Class III than among patients with Class I malocclusion ($p < 0.05$); among women it was larger than among

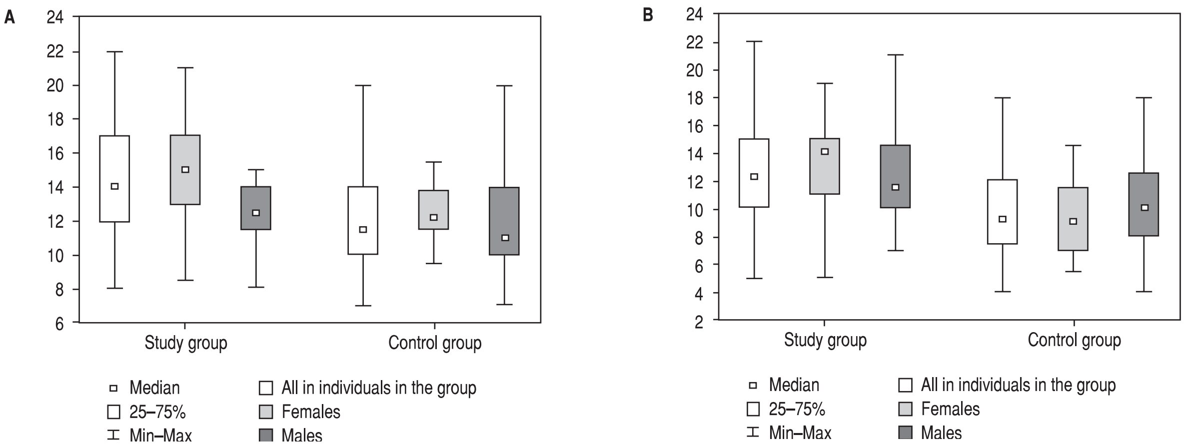

Figure 2. A. Upper pharyngeal median width in the study and control group; **B.** Lower pharyngeal median width in the study and control group.

Table 2. Mean, standard deviation, and statistical significance of upper and lower pharynx, SNA, SNB, ANB and Wits

	Group							
	Study			Control				
Variables	Mean	Median	SD	Mean	Median	SD	p	U
Airway [mm]:								
Upper pharynx	14.7	14.0	± 4.0	11.9	11.5	± 2.7	0.000**	406.0
Lower pharynx	12.8	12.25	± 4.1	9.8	9.25	± 3.0	0.001**	427.0
Angular [degree]:								
SNA	80.1	80.3	± 4.8	82.5	82.4	± 3.5	0.035*	538.0
SNB	83.6	83.65	± 4.7	80.5	80.45	± 3.9	0.01*	491.5
ANB	–3.5	–2.95	± 2.3	2.0	2.0	± 1.2	0.000**	0.0
Linear [mm]:								
Wits	–8.6	–8.6	± 3.9	–0.4	–0.2	± 1.5	0.000**	80.0

Variables that showed statistical significance were denoted: *$p < 0.05$; **$p < 0.01$.

men. The same results were observed in the case of the lower measurement of the width of the upper airways where its values were larger in the study group than in the control group ($p < 0.05$). The gender comparison of lower pharyngeal width showed larger values among male patients.

It was also observed that the lower pharyngeal depth significantly correlated with upper pharyngeal depth ($R = 0.36$, $p = 0.0009$), which means that with the increase of the upper dimension the lower pharyngeal dimension increased as well.

Furthermore, it was found that both the lower and the upper pharyngeal depths were significantly dependent on the ANB angle ($p < 0.001$). With the increase in ANB angle the anterior-posterior dimension of the upper airways decreased, and with the increase in negative values of ANB angle the depth of the nasopharynx increased. It was additionally stated that the cross-section of the upper airways is statistically significantly dependent on the Wits appraisal ($p < 0.001$). It showed a similar correlation as in the case of the ANB angle, namely, if the Wits appraisal increased, the nasopharynx depth decreased (Table 2).

It was also observed that the mandible position characterised by SNB angle correlated significantly with lower ($R = 0.34$, $p = 0,001$) and upper pharyngeal depths ($R = 0.28$; $p = 0.01$). If the SNB angle value increased, the lower and upper pharyngeal dimensions increased as well. The study showed no statistically significant relation between the pharynx depth at the level of the tongue base and soft palate and the SNA angle ($p > 0.1$) describing anterior-posterior mandible position (Table 2).

DISCUSSION

Recent years have brought new applications for standard orthodontic diagnostic examinations. Ever more often radiological examinations in orthodontics not only serve solely for the evaluation of a patient's occlusal disorders, but are also used to create soft tissue and skeletal characteristics of patients with, for instance, OSA [1, 8, 10, 11, 19]. Nowadays it seems advisable to make such characteristics for all orthodontic patients for OSA prevention. For that purpose it is necessary to thoroughly understand the influence that the position and movements of craniofacial bones have on the cross-sectional value of upper airways, which are essential in obstruction development.

The conducted study showed the influence of skeletal malocclusion on the cross-section of upper airways. Among patients with skeletal Class III the cross-section of the upper airways at the level of the palate and tongue base is larger than in patients with Class I; which means that with the increase of the ANB angle the size of the nasopharynx decreases. This is consistent with the results found in the quoted literature. A similar correlation was observed in the research of Iwasaki et al. [13] and Ceylan et al. [6]; however, it should be mentioned that their research referred to children. It ought to be noticed that the dimensions of the upper airways increase until the age of 13 years, and it can be stated that afterwards it does not change its final dimensions [12, 17, 22]. These results are also confirmed by the research on airways cross-sections among patients with OSA, who show a tendency towards Class II malocclusions and decreased dimensions of upper airways connected with it — Baik et al. [5] and Lowe et al. [15].

A different position on the subject is presented by Abu Allhaija et al. [2]. The results of their study showed no correlation between the size of ANB angle and the anterior-posterior dimensions of upper airways.

The data analysis of our own research determined the influence of maxilla and mandible positions on the cross-section dimension of upper airways. It was proven that mandible movement (SNB angle increase) results in a statistically significant increase of naso-pharynx depth. Such a relation was not detected in the case of the maxilla. This means that the changes of SNA angle do not influence the cross-section of airways. Such pieces of information are vital in the context of patients requiring surgical treatment of morphological disorders. While planning the treatment one needs to remember that the anterior-posterior maxilla movements do not influence the patency of upper airways. However, mandible movements may significantly change those dimensions, which should be taken into account in the case of mandible retraction. If initially the patient's nasopharyngeal depth is not large, double jaw surgery seems proper since the maxilla protraction will reduce the necessity of posterior mandible movement, which is unfavourable for the patient. Narrowing of the upper airways after mandible retraction surgery was determined by Archilleos et al. [3, 4]. In their research they analysed 31 cases of patients after osteotomy on both sides. Cephalograms taken before, during, and 3 years after the surgery were used to evaluate the procedure's influence on pharynx depth. The researchers observed a statistically significant decrease of this dimension among post-surgery patients. After 3 years there had been a slight improvement; however, the dimension remained statistically significantly smaller [3, 4]. Similar data was presented by Tselnik and Pogrel [23]. They examined 14 cases of patients after osteotomy on both sides. The dimensions were evaluated based on cephalograms taken 2 weeks before, 2 weeks after, and from 6 months to 2 years after the surgery. Although on the images 2 weeks after the surgery they noticed an increase of pharynx dimension, on average by 1.09 mm, the images from later periods showed an average decrease in cross-section of 4.77 mm [23]. Jaw surgery, encompassing protraction of the maxilla and retraction of the mandible, is beneficial for cross-sections of upper airways in patients. However, Chen et al. [7] comparing patients after both types of operation determined that there were no statistically significant differences in the naso-pharynx depth. These results were confirmed through long-term observation.

CONCLUSIONS

1. The width of the pharynx at the level of the soft palate and tongue base depends on skeletal class, i.e. the ANB angle and Wits appraisal, and it increases with the increase of forward movement of the mandible.
2. The anterior-posterior dimension of the naso-pharynx is not influenced by the position of the maxilla expressed in the SNA angle.
3. Both in the control and the study group the upper pharynx depth was larger among women than among men, whereas the lower pharynx depth was larger among men than among women.

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