Evaluation of the effects of Adenotonsillar Hypertrophy on the Craniofacial development by using CT scans

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Table of Contents

List of Figures

List of Tables

Abstract

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The aim of this study was to evaluate craniofacial proportions in children classified into adenoid and tonsillar hypertrophic patients, by using a systematic reproduceable method for the assessment, utilizing computerized tomography (CT) scans.

This retrospective study included a total of 63 subjects (age range, 3-7 years) who were distributed as the following: control group (C group) had 17 subjects (10 males and 7 females; mean age, 5.18 ± 1.51 years), adenoid hypertrophy group (A group) had 15 subjects (10 males and 5 females; mean age, 5.13 ± 1.41 years), tonsillar hypertrophy group (T group) had 15 subjects (9 males and 6 females; mean age, 5.27 ± 1.44 years), and adenotonsillar hypertrophy group (AT group) had 16 subjects (8 males and 8 females; mean age, 5.00 ± 1.41 years). The differences in the following measurements between the four groups were compared using one-way ANOVA test and post-hoc Scheffe test: inter-gonion width, inter-J width, nasal cavity width, maxillary inter-canine width, maxillary inter-molar width, palatal depth, maxillary arch length, and nasion-crest of the alveolar bone between the central incisors height (N-Cr).

The inter-Gonion width was smaller in T and AT groups compared to the C group ($p < 0.05$). The inter-J width was significantly smaller in AT group compared to T group ($p < 0.05$). The maxillary inter-molar width was significantly smaller in A and AT groups compared to T group ($p < 0.05$).

The results indicate that the tonsillar hypertrophy led to a reduction of the inter-gonion width in young children aged between 3 to 7 years old. The adenoid hypertrophy led to a reduction of the inter-J width and the maxillary inter-molar width in young children aged between 3 to 7 years old. Both the tonsillar and adenoid hypertrophy did not have any other significant effect within the scope of the current study.

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I. Introduction

Adenotonsillar hypertrophy is the most common etiologic factor of mouth breathing syndrome (Gislason, Benediktsdóttir 1995). The syndrome usually peaks in children aged between 3 to 7 years (Williams et al. 1991), and it leads to anterior or lower position of the tongue, lip incompetence, a lowered position of the mandible, and reduced orofacial muscle tone (Josell 1995, Linder-Aronson 1970). These changes often lead to a syndrome known as the long face syndrome (or adenoid face), manifested primarily by excessive lower vertical facial height that is usually correlated with clockwise rotation of the growing mandible (Harari et al. 2010). These individuals are also characterized by having a narrow nose, lip incompetency, and a retrognathic chin. Dentally these individuals usually have a Class II malocclusion, with or without open bite deformity. In addition, there is a deep palatal vault and a narrow or v-shaped maxillary dental arch (Schendel et al. 1976).

However, there has been a controversy regarding these findings as some previous studies have provided evidence that nasal obstruction is not associated as a major factor causing abnormal dentofacial and craniofacial development (Tourné 1991, Warren 1990). A study found that mouth breathing has no effect on maxillary size (Solow, Siersbaek-Nielsen, Greve 1984). Another study found no differences between the mouth breathing and nasal breathing groups in terms of palatal height and intermolar width (Vieira et al. 2012).

The reason for this diversity is probably that in those studies there was no systematic method for classification of the subjects. A study used rhinomanometric recordings to find the nasal respiratory resistance by measuring pressure and flow during normal inspiration and expiration through the nose(Solow, Siersbaek-Nielsen, Greve 1984). Another study used oroscopy, lateral nasopharyngeal x-ray and anterior rhinoscopy to grade palatine tonsils(Harari et al. 2010, Vieira et al. 2012). Also, these studies did not classify the subjects into two separate adenoid hypertrophic and tonsillar hypertrophic groups. Therefore, the purpose of this study is to evaluate craniofacial proportions in children classified into adenoid and tonsillar hypertrophic patients, by using a systematic reproduceable method for the assessment, utilizing computerized tomography (CT) scans.

II. Materials and methods

1. Materials

The sample of this retrospective study consisted of 63 subjects who had attended the department of Otorhinolaryngology in Severance Medical Center in South Korea, between the years 2009 and 2015 and were selected based on the following inclusion criteria: availability of pre-operative PNS CT, 3 to 7 years of age, and no history of adenoidectomy, tonsillectomy, and orthodontic treatment. Non contrast spiral CT scans (GE Healthcare, Chicago, IL, USA; 5 mm of slice thickness, 5 mm of slice interval, 120 kV, 240 mA) were taken to assess the adenoid and tonsil hypertrophy.

The adenoid hypertrophy and tonsil hypertrophy were assessed on both mid-sagittal and axial planes of PNS CT images, and the subjects were divided into four groups: control group (C group), adenoid hypertrophy group (A group), tonsillar hypertrophy group (T group), and adenotonsillar hypertrophy group (AT group).

For the assessment of adenoid hypertrophy the Cohen and Konak method (Wormald, Prescott 1992). The anterior curvature of the pharyngeal tonsil border was located and the distance between it and a point on the posterior border of the soft palate located 10 mm away from the posterior nasal spine (PNS), was measured, this distance resembled the air column (AC). The thickness of the soft palate was measured 10 mm away from PNS and was identified as SfP. The ratio of AC to SfP is calculated, and if it was smaller than 0.5 the patient was classified as an adenoid hypertrophic patient (Figure 1).

For the assessment of tonsillar hypertrophy, a transverse section was created, it included the slices ranging from the soft palate to the bottom of the epiglottic vallecula. Then an elliptical shape passing the boundary of airway was drawn and the airway width (AW) was measured as the smallest distance between the two tonsils and tonsillar width (TW) was identified as the distance between the points where extension of AW collides with the elliptical shape drawn. The ration of AW to TW was calculated and it if was smaller than 0.5 the patient was classified as a tonsillar hypertrophic patient (Figure 1).

For the patients who did not meet the criteria for both adenoid hypertrophic patient and tonsillar hypertrophic patient, they were classified as C group subjects. While if the patient met the criteria for both groups they were classified as AT group subjects.

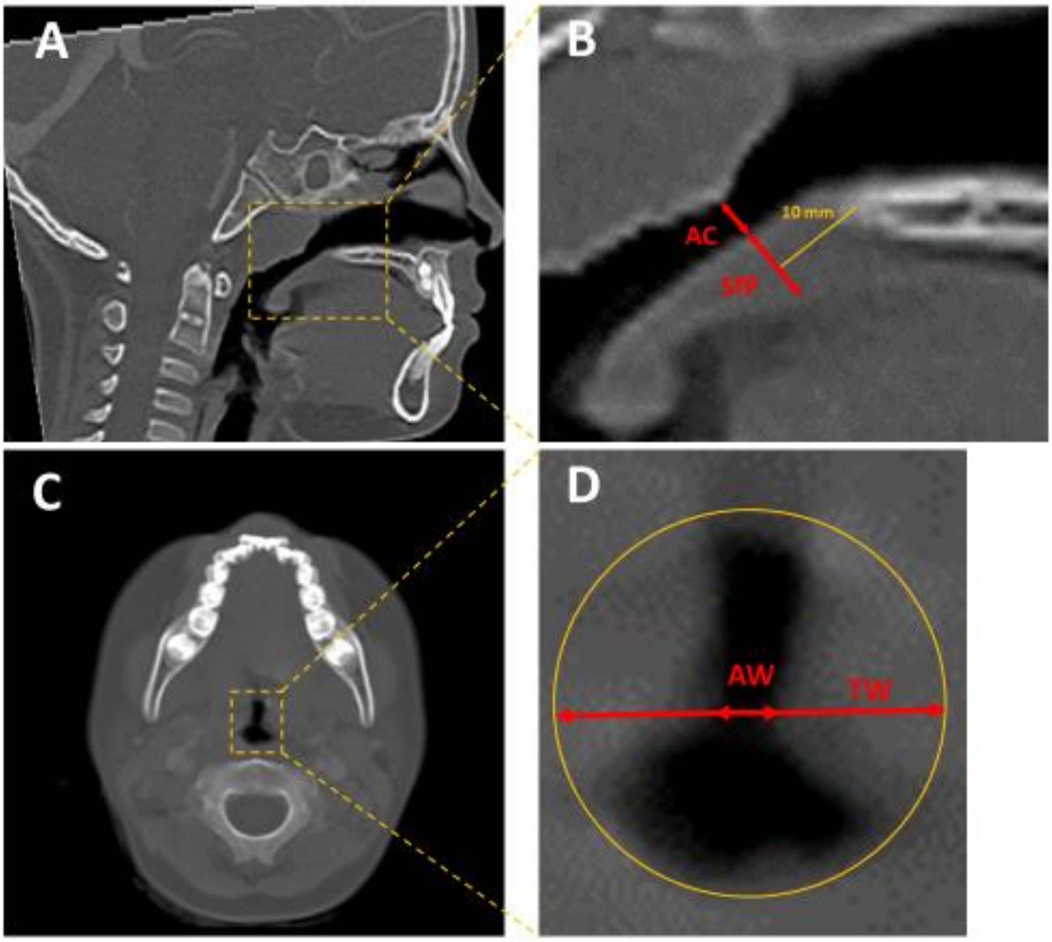

Figure 1. (A, B) Assessment of adenoid hypertrophy. (C, D) Assessment of tonsillar hypertrophy

AC, air column; SfP, thickness of soft palate; AW, airway width; TW, tonsillar width

2. Image Reorientation

Images were retrieved as digital imaging and communications in medicine (DICOM) files and were three dimensionally (3D) reconstructed and reoriented using InVivo5® software (Anatomage, San Jose, CA, USA). The reference planes are sagittal reference plane, which includes nasion, anterior nasal spine (ANS), and posterior nasal spine (PNS), horizontal reference plane, which is perpendicular to the sagittal plane that includes ANS-PNS line, and coronal reference plane, which is perpendicular to the horizontal and sagittal planes that includes nasion point.

3. Measurements

Using three dimensional (3D) reconstructed images that has been set to the same level of brightness and contrast across all subjects, the following measurements were calculated: The distance between the Nasion point and the point of the crest of the alveolar bone between the central incisors (N-Cr), inter-gonion width with gonion point located by intersecting the lines tangent to the posterior ramus and the inferior border of the mandible and finding the closest point on the mandible to the intersection, Inter-J width with J point identified as the junction between the maxillary tuberosity outline and the zygomatic process, Nasal cavity width measured as the distance between the two most lateral points on the lateral wall of the nasal cavity, maxillary Inter-canine width measured as the distance between the cusp tips of the right and left deciduous canines, and the maxillary inter-molar width measured as the distance between the mesiobuccal cusp tips of the right and left deciduous second molars (Figure 2).

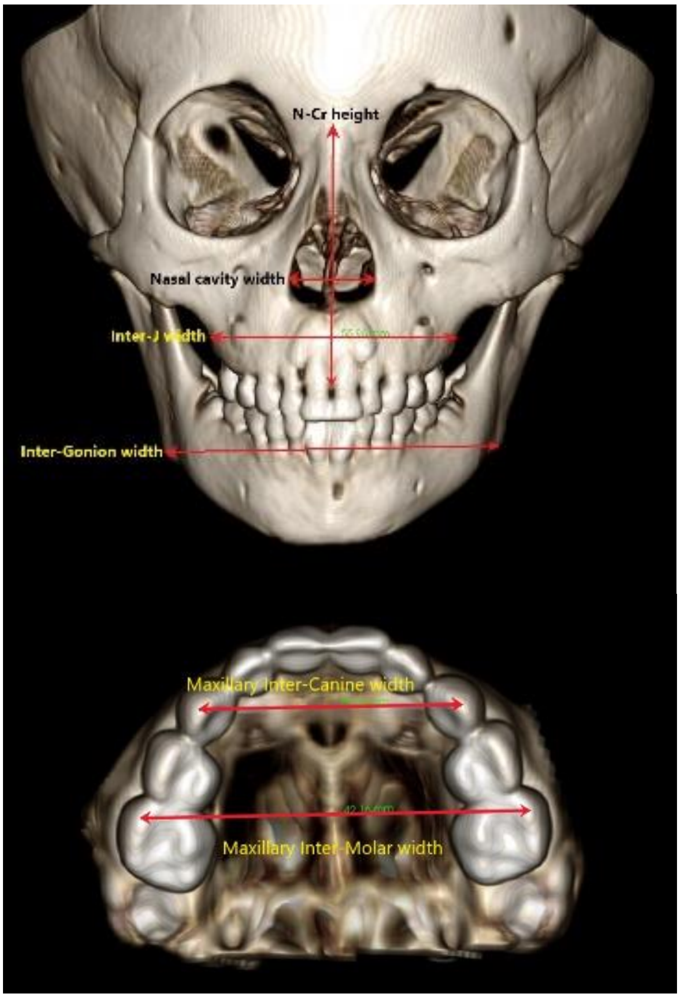

Figure 2. Measurements obtained from 3D reconstructed images

A coronal section passing through the most distal point of the right second deciduous molar was made; all the sections were perpendicular to the nasal floor, and the palatal depth was measured as the shortest distance between the most inferior point of the right second deciduous molar and a line extended from the nasal floor (Figure 3).

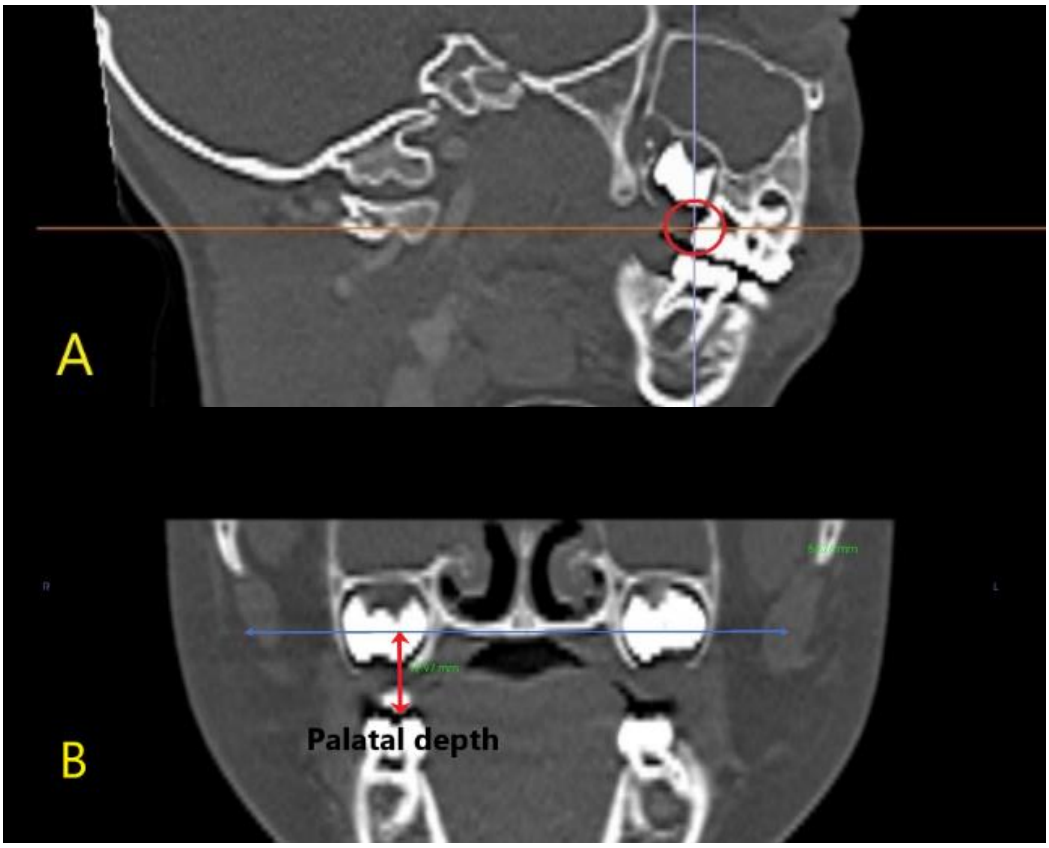

Figure 3. Measurement of the palatal depth. (A) locating the most distal point of the right second deciduous molar. (B) Coronal section in which the palatal depth was measured.

A sagittal section was made with a width of 15-25 mm. to include the right deciduous central incisor; or the right permanent central incisor, along with the right deciduous second molar, and the maxillary arch length was measured as the distance between the incisal tip of the right central incisor to the most distal point of the right deciduous second molar (Figure 4).

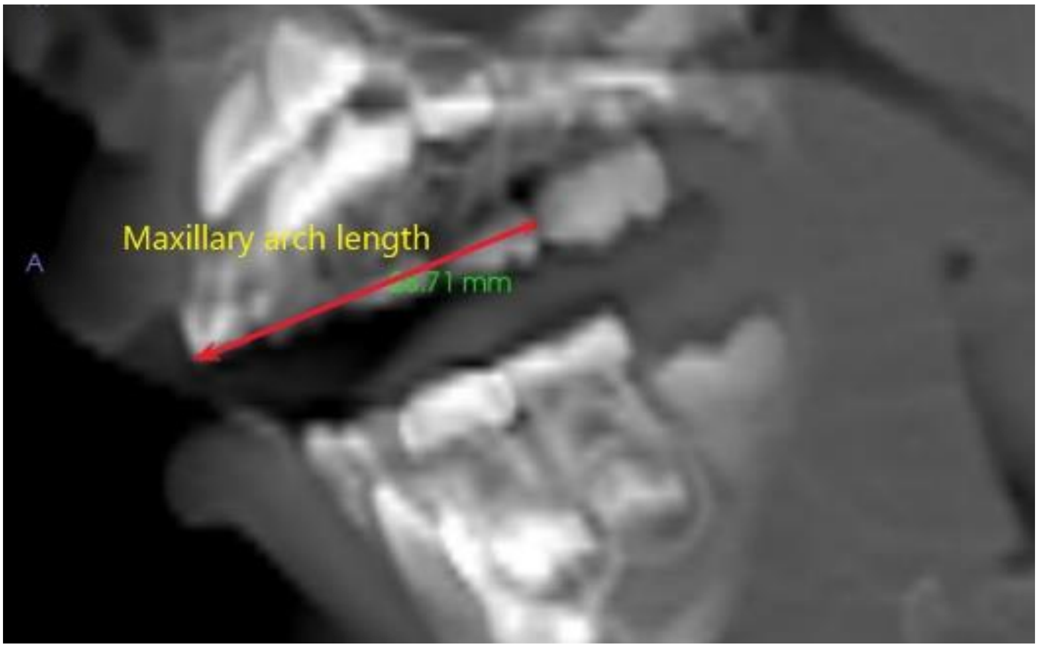

Figure 4. Measurement of the maxillary arch length

4. Statistical analysis

For the statistical analysis SPSS version 27 (SPSS Inc., Illinois, USA) was used. The measurements were tested to determine the distribution of the data using the Shapiro-Wilk test. P value below 0.05 was considered the level of statistical significance. Descriptive statistics were calculated for all measurements.

To determine the differences across all study groups for each measurement, one-way ANOVA test was used, followed by multiple comparison Scheffe test to find the specific differences between each group. For the non-homogenous measurements Brown-Forsythe test and independent samples Kruskal-Wallis test were used instead.

III. Results

This retrospective study included a total of 63 subjects who were distributed as the following: group C had 17 subjects (10 males and 7 females; mean age, 5.18 ± 1.51 years), group A had 15 subjects (10 males and 5 females; mean age, 5.13 ± 1.41 years), group T had 15 subjects (9 males and 6 females; mean age, 5.27 ± 1.44 years), and group AT had 16 subjects (8 males and 8 females; mean age, 5.00 ± 1.41 years). Statistical tests showed no difference for age and sex distribution (Table 1).

Table1. Demographic features of the study subjects

Variable		Group				P value
		C (n = 17)	A (n = 15)	T (n = 15)	AT (n = 16)	
Age (years)		5.18 ± 1.51	5.13 ± 1.41	5.27 ± 1.44	5.00 ± 1.41	0.964
Sex (n)	Male	10 (58.8%)	10 (66.6%)	9 (60%)	8 (50%)	0.835
	Female	7 (41.2%)	5 (33.3%)	6 (40%)	8 (50%)	

C, control group; A, adenoid hypertrophy group; T, tonsillar hypertrophy group; AT, adenotonsillar hypertrophy group.

Values are presented as mean ± standard deviation or number (percentage)

P value according to one-way ANOVA test

The inter-Gonion width was smaller in T and AT groups compared to the C group ($p < 0.05$). The inter-J width was significantly smaller in AT group compared to T group ($p < 0.05$). The maxillary inter-molar width was significantly smaller in A and AT groups compared to T group ($p < 0.05$). The rest of the measurements showed no statistical difference among the four groups ($p > 0.05$) (Table 2, Figure 5).

Table 2. Mean and standard deviation along with multiple comparison test results for all groups in this study.

Measurement (mm)	Group				P value
	C (n=17)	A (n=15)	T (n=15)	AT (n=16)	
Inter-Gonion width	83.3 ± 4.1^{B}	80.3 ± 4.1^{AB}	79.4 ± 2.2^{A}	79.1 ± 4.4^{A}	0.009*
Inter-J width**	56.2 ± 3.1^{AB}	55.0 ± 2.8^{AB}	56.6 ± 1.1^{B}	54.0 ± 2.2^{A}	0.022*
Nasal cavity width**	21.4 ± 1.7	21.3 ± 1.2	21.4 ± 0.9	20.9 ± 0.8	0.580
Maxillary Inter-Canine width	31.6 ± 2.4	30.0 ± 1.5	31.3 ± 1.9	30.0 ± 2.0	0.041*
Maxillary Inter-Molar width	45.5 ± 2.4^{AB}	44.1 ± 2.4^{A}	46.5 ± 1.2^{B}	44.2 ± 2.3^{A}	0.009*
Palatal depth	15.9 ± 1.7	15.4 ± 1.4	15.3 ± 2.1	14.9 ± 1.7	0.417
Maxillary arch length	28.8 ± 2.3	28.1 ± 1.5	28.8 ± 0.9	28.1 ± 1.4	0.420
N-Cr height	59.4 ± 3.3	58.3 ± 1.9	59.1 ± 2.7	57.5 ± 3.8	0.287

C, control group; A, adenoid hypertrophy group; T, tonsillar hypertrophy group; AT, adenotonsillar hypertrophy group; J, jugular process; N, nasion; Cr, crest of alveolar bone between the maxillary central incisors.

One-way ANOVA test and post-hoc Scheffe test were used.

*$p < 0.05$, different letters indicate that there are statistically significant differences.

** Brown-Forsythe test and independent samples Kruskal-Wallis test were used because of non-homogenous distribution.

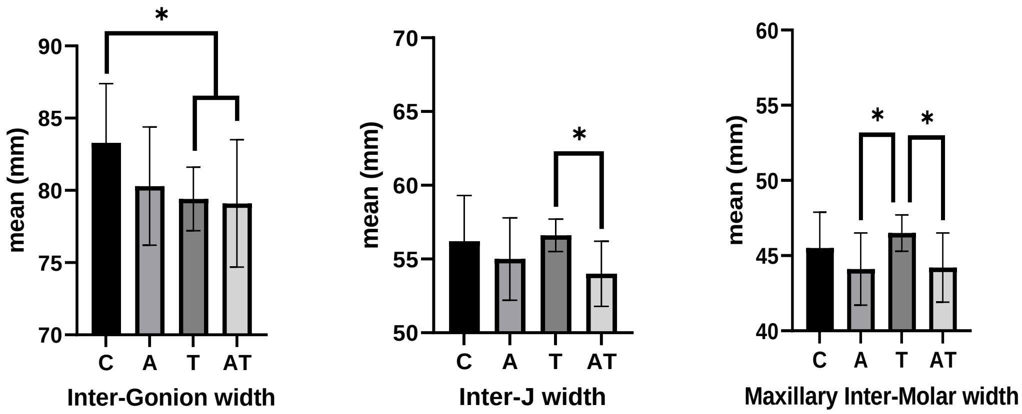

Figure 5. Graphs illustrating the statistical differences between the four groups obtained from the multiple comparison test.

C, control group; A, adenoid hypertrophy group; T, tonsillar hypertrophy group; AT, adenotonsillar hypertrophy group.

* indicates that there are statistically significant differences.

IV. Discussion

This study investigated skeletal and dental transverse changes along with length of the maxillary arch, and palatal vault depth in children with mean age of 5 years old, who were classified into control group, and adenoid, tonsillar and adenotonsillar hypertrophic groups using computed tomography scans. The skeletal transverse dimensions of the maxilla and the mandible and maxillary dental transverse dimension were affected, meanwhile the vertical and longitudal dimensions that were measured were not affected.

The results showed that there is a remarkable decrease in the inter-gonion width measurements for the T and AT groups when compared to the C group. This could be due to the position of the tonsils that is on the side of the back of the throat and when enlarged it affects the swallowing process (Holmlund et al. 2016), which could lead the child to adapt a habit of spitting instead of swallowing resulting in reduction in the swallowing force that could stimulate mandibular growth. Also, the enlarged tonsils can affect speech (Abdel-Aziz et al. 2019) that could also be a stimulus for mandibular growth. Meanwhile the adenoids when enlarged they mainly lead to obstruction of the nasopharynx and have no direct effects on swallowing or speech. These findings are similar to a previous study that used anthropometric and clinical data of sample of children with an age group similar to the age group of children in this study, it was found that children whose first mouth breathing disorder symptoms had occourd at young age had smaller inter-gonian measuments in relation to face width(Pawłowska-Seredyńska et al. 2020).

For the dental measurements, in this study the maxillary inter-molar width was smaller in A and AT groups when compared to T group. Meanwhile there was no difference in maxillary inter-canine width measurements between all groups. This could be due to that when the adenoids enlarge they obstruct the nasopharynx forcing the child to breathe through the mouth, the child then tends to lower the tongue and open the mouth by clockwise rotation of the mandible to allow more volume of air to be consumed (Josell 1995). Opening the mouth leads to an increase in the tensity of the buccinator muscles which results in a lingual pressure on the maxillary bicuspids and molars (Grippaudo et al. 2016), leading to a smaller maxillary inter-molar width. However, probably because the children in this study are extremely young, the inter-canine width was not affected. Harari, D. et al, found in their study that, nasal obstruction with mouth breathing in critical growth period of children with mean age of 12 years old, that the inter-molar and inter-canine widths were significantely smaller when compared to control group of children with no symptoms of mouth breathing disorder (Harari et al. 2010). The tonsils however when enlarged they block the oropharynx and have no effect on the nasopharynx meaning that the child will keep trying to breathe from the nose, or rather would breathe harder from the nose along with the mouth, this mixed mouth and nose breathing could have opposite effects to the adenoid hypertrophy effects, as in this study the mean of inter-molar width was in fact larger that the C group.

The inter-J width was significantely smaller in AT group compared to T group, it was also smaller for the A group, however it did not result in statistical significance. This gives a suggestion that the adenoid hypertrophy that leads to mouth breathing can; to a certain degree, restrict the transverse growth of the maxilla, probably for a similar reason as mentioned above in the dental measurements. The adapted lower position of the tongue results In a lack of thrust of tongue on the palate and on the upper jaw that will lead to a transverse maxillary skeletal deficit (Grippaudo et al. 2016)

The only sagittal plane measurement in this study; the maxillary arch length, resulted in no difference between all groups. This gives a suggestion that the mechanism of breathing and adenotonsillar hypertrophy might not have an effect on sagittal growth of the maxilla, or based on previous findings by (Langford et al. 2003), the length of maxillary arch increase, occurs mostly during and after permanent dentition eruption, and since all children in this study were in deciduous or early permanent dentition, even if the maxillary arch length was affected it was not to a noticeable amount. These results are also similar to those obtained by previous studies that used dental study casts of mouth breathing children with the same age group as the children in this study.(Löfstrand-Tideström et al. 1999, Osiatuma et al. 2017)

There was also no difference in palatal depth across all groups suggesting that in young children prior to growth spurt, adenotonsillar hypertrophy has no significant impact on the palatal depth. When comparing these results with previous studies, children with mouth breathing pattern have been characterized as having a high palatal vault(McNamara 1981). However Primozic. Et al. (Primožič et al. 2013), did not find differences in palatal surface area and volume between mouth and nose breathers. Vieira et al.(Vieira et al. 2012), in their study of mouth breathing children pre and post adenotonsillectomy, the age group of the children was similar to the age group of the children in this study. They concluded that breathing pattern has little or no influence on palatal depth.

In this study the distance between nasion point and crest of alveolar bone between the maxillary central incisors was measured instead of anterior facial height (N-Me) because the CT scans were taken with each child had their mouth open to a different degree making it impossible to obtain accurate anterior facial height measurements. There was no difference in the results indicating that maxillary vertical dimension is not affected by the breathing pattern in this age group of children. Another study found that the tongue is positioned abnormally downward due to mouth breathing when compared to healthy children who breathe from their noses. This abnormality leads to a disturbance in the balance between tongue and mandible resulting in lower positioning of the mandible and postural extension of the head, these characteristics will make the anterior facial height look abnormally longer with increased mandibular plane angle (Peltomäki 2007). Based on these findings the results of the current study can be justified.

Also in this study the nasal cavity width had no difference. This could mean that even though the hypertrophied adenoids restriced the air passage in the correspoding area of the adenoids, the anteior portion of the nasal cavity where the measurement was done, did grow normally and was not affected by the hypertrophied adenoids. Another study that dealt with soft tissue by Koca et al. (Koca, Erdem, Bayındır 2016) found that there is no difference in ala-ala distance between adenoid hypertrophic and normal children in their photographic analysis.

This study has advantages over other studies in that the patients were classified specifically into adenoid, tonsillar and adenotosillar hypertrophic children using three dimensional computed tomography scans and all the measurements for each subject were done using the same CT scans. However the relatively small number of subjects and the lack of data about the onset and duration of the disease, lack of long-term follow up data including data about growth effects after adenoidectomy or tonsillectomy can be considered the weak points of this study.

V. Conclusions

The tonsillar hypertrophy significantely restricted the inter-gonion width in young children aged between 3 to 7 years old.

The adenoid hypertrophy significantely restricted the maxillary width and the maxillary inter-molar width in young children aged between 3 to 7 years old.

Both the tonsillar and adenoid hypertrophy did not have any other significant effect within the scope of the current study.

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국문 요약

이 연구의 목적은 computerized tomography (CT)를 이용하여 adenoid hypertrophy patients and tonsillar hypertrophic patients 으로 분류되어 있는 어린이들의 두개안면의 비율을 평가하는 것이다.

이 후향연구의 총 63 명 환자는 대상으로 다음과 같은 그룹으로 나누어져 있다: control group (C group)에 17 명 (10 명 남성과 7 명 여성; 평균 나이, 5.18 ± 1.51 세), adenoid hypertrophy group (A group)에 15 명 (10 명 남성과 5 명 여성; 평균 나이, 5.13 ± 1.41 세), tonsillar hypertrophy group (T group)에 15 명 (9 명 남성과 6 명 여성; 평균 나이, 5.27 ± 1.44 세) 그리고 adenotonsillar hypertrophy group (AT group)에 16 명 (8 명 남성과 8 명 여성; 평균 나이, 5.00 ± 1.41 세). 4 그룹의 사이의 다음 측정치의 차이를 one-way ANOVA 와 post-hoc Scheffe test 으로 통하여 비교하였다: inter-gonion width, inter-J width, nasal cavity width, maxillary inter-canine width, maxillary inter-molar width, palatal depth, maxillary

arch length, and nasion-crest of the alveolar bone between the central incisors (N-Cr).

Inter-Gonion width 가 T 와 AT group 에서 C group 보다 통계적으로 유의성이 있는 차이로 작았다 ($p < 0.05$). Inter-J width 가 AT group 에서 T group 보다 통계적으로 유의성이 있는 차이로 작았다 ($p < 0.05$). Maxillary inter-molar width 가 A 와 AT group 에서 T group 보다 통계적으로 유의성이 있는 차이로 작았다 ($p < 0.05$).

결과를 통하여 tonsillar hypertrophy 가 3-7 세 나이의 어린이들의 inter-gonion width 를 유의성이 있게 제한할 수 있음을 확인할 수 있었다. adenoid hypertrophy 가 3-7 세 나이의 어린이들의 maxillary width 와 maxillary inter-molar width 를 유의성이 있게 제한할 수 있음을 확인할 수 있었다.