Cephalometric traits in children and adolescents with and without atypical swallowing: A retrospective study

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Abstract

Aim It has been suggested that atypical swallowing (AS) may negatively influence the skeletal and alveolar development, but its specific effects are still unclear. The aim of this work is to compare the cephalometric characteristics of children and adolescents with and without AS.

Materials and methods Study design: Case-control retrospective cross-sectional study**.** One hundred patients with (AS group) and 100 patients without AS (control group, C) were retrospectively selected. Their cephalometric data before orthodontic treatment were compared using a 3-way ANOVA variance test to detect any differences between groups considering: the type of swallowing (AS vs C); whether or not the second dentition was completed (SDC vs SDNC); and the gender (males-M and females-F). In addition, a Student-t test for unpaired data was carried out to detect differences between M and F within the AS and C groups.

Results When compared to the controls, AS patients showed a significantly decreased SNB angle ($p<.01$), increased ANB and SN^Go. Me angles ($p<.0001$), increased overjet and lower facial height ($p<.01$), decreased overbite ($p<.0001$), and increased proclination of the upper incisors. AS-SDC patients also showed significantly increased alveolar length. Within the AS and C groups, skeletal and alveolar measurements were larger in males, with higher significance in the C group, suggesting a different trend of growth in AS patients.

Conclusion AS seems to affect the skeletal growth causing mandibular clockwise rotation, skeletal Class II, open bite and incisor proclination. To compensate for these effects, an increase in alveolar growth together with molar eruption seems to be induced.

KEYWORDS Atypical swallowing, Cephalometric traits, Skeletal growth.

Introduction

The development of the orofacial complex is provided by a close relationship between form and function of the stomatognathic system that starts in the first week of gestation and increases significantly during the foetal period [Begnoni et al., 2018]. Most of the interest shown in the literature about this relationship concerns the effects of the tongue on the oral environment [Proffit et al., 2008]. It has been hypothesized that alterations in size [Liu et al., 2008; Lowe et al., 1985; Vig and Cohen, 1975], function [Fuhrmann and Diedrich, 1994; Lowe, 1980] and posture [Karacay et al., 2006] of the tongue could affect not only the position of the teeth [Jalaly et al., 2009], but also the oral development [Begnoni et al., 2018], involving speech problems and the appearance of malocclusion [Proffit et al., 2008].

In the early childhood, swallowing provides a major activity of the tongue, that is positioned between the lips, permitting the suction effect and the deglutition. In this period, authors speak about visceral swallowing, also known as "infantile swallowing" or "tongue thrust". This type of deglutition is characterised by a forward movement of the tongue tip and pressure against the lingual surfaces of the anterior teeth. Normally, this swallowing pattern changes gradually into a mature or somatic swallowing after dental eruption. If this does not happen after the fourth year of life, infantile swallowing persists as atypical swallowing (AS) and is then considered a dysfunction that can potentially affect the growth of the stomatognathic system resulting in malocclusion [Peng et al., 2003; Machado and Crespo, 2012].

Some authors have stated that 50% of 5-year-old patients present AS, while this percentage decreases to 38% during the early mixed dentition and drops to 25-30% once the second dentition is completed, persisting in adults in about 15% of subjects [Proffit et al., 2008; Ovsenik et al., 2007; Melsen et al., 1979]. Therefore, not all patients with atypical swallowing profit from occlusal development, and some of them maintain the dysfunction even after completion of the permanent dentition.

So far, the morphological traits of patients with AS have been associated to open bite [Lowe and Johnston, 1979], long face, open growth pattern, proclination of upper teeth [Brauer and Holt, 1965], high or narrow maxillary arch [Cayley et al., 2000] and Class II division 1 malocclusion [Subtelny, 1965]. However, the few studies that have tried to demonstrate the cephalometric characterisation of the skeletal and alveolar changes that occur in patients with tongue thrust present limitations. They compared skeletal changes of children with and without open bite without specifically relating it with tongue thrusting [Tsang et al., 1997, Barber and Bonus, 1975], included very small samples [Dixit and Shetty, 2013] or focused only on specific characteristics such as the incisor relationship [Jalaly et al., 2009] or the facial plane [Machado and Crespo, 2010] without extending their work to skeletal and tissue landmarks.

The aim of this retrospective study is therefore to analyse and compare cephalometric differences in dental, skeletal and soft tissue characteristics of children and adolescents with and without AS to detect any significant changes in their craniofacial characteristics due to their particular type of swallowing, after the onset of permanent dentition.

Materials and methods

This retrospective study was registered and approved by the Medical Ethics Committee of the University of Leuven (Belgium), with the registration number B322201316750.

Patient Selection

Patients with (AS group) and without (control group, C) atypical swallowing were retrospectively selected from the patient archive of the Department of Orthodontics, University Leuven.

Exclusion criteria were: previous orthodontic or orthognatic treatment, premature loss of primary teeth, trauma in the dentofacial region, presence of any other oral habits like finger or lip sucking and systemic diseases or craniofacial syndromes.

For the AS group, the inclusion criterion was atypical swallowing. This information was retrospectively obtained from the report of the first clinical examination. During this examination, the diagnosis of AS was performed clinically by a specialist orthodontist by asking the patients to swallow their saliva. Hyper activation of lips or of orbicularis muscles, facial muscle tension or abnormal movement of the head and mandible inclined the operator towards the diagnosis of atypical swallowing. If the presence of tongue thrust was observed without any doubts and was then associated with any of the myofunctional alterations already listed, the diagnosis of AS was considered definitive. Tongue thrust was defined as protrusion of the tongue between upper and lower incisors or cuspids during swallowing.

For the control group, patients with normal occlusion were selected. Specific inclusion criteria were: absence of skeletal discrepancies either on the sagittal (0<ANB<4) or the vertical (30<SN/MP<34) dimension with overjet (OJ) and overbite (OB) values set between 0 and 4 mm.

"Second dentition completed" (SDC) was defined as the absence of deciduous teeth, confirmed by the intraoral pictures and cephalograms present in the patients' files. The presence of one or more deciduous teeth or the absence of one or more permanent teeth classified the patient in the group "Second dentition not completed" (SDNC).

We retrospectively selected patients complying with our selection criteria for both the AS and C groups by analysing the medical files of treated patients until we gather a sample big enough to obtain representative cephalometric results, following the indications of previous studies [Machado and Crespo, 2010; Marquezin et al., 2014].

Cephalometric analysis

For this retrospective study, the digital lateral radiographs available in the patients' files were used. Only head films adjusted for magnification were chosen. The conventional cephalometric radiographs were taken with a Siemens Orthophos C (Sirona Dental, Bensheim, Germany) or a Cranex Tome (Soredex, Tuusala, Finland). An Epson Expression 1680 Pro flatbed scanner (Seiko Epson Corp., Nagano, Japan) was used for scanning the films, and digitising was performed with Epson Twain scanning software (Seiko Epson Corp., Nagano, Japan). A Veraviewepocs 2D (J. Morita Co., Kyoto, Japan) was employed for making the direct-digital cephalometric radiographs. These lateral head films were traced, and landmarks were located using the Vistadent AT 3.1 software (GAC International, Bohemia, New York, USA).

A total of 29 cephalometric measurements (14 skeletal, 10 dental, 4 alveolar and 1 concerning the soft tissue profile) were performed on all radiographs. The cephalometric analysis used for this study was a combination of the Steiner analysis, the method of Kinzinger et al. and De Almeida et al. as in our previous work [Zelderloo et al., 2017]. The comparisons between groups and subgroups can be seen in Figure 1.

The cephalometric analysis was performed by different operators at the Department of Orthodontics. All cephalometric analyses were checked by the same operator, specialist in Orthodontics and PhD fellow (GB), who individually assessed that the landmarks of each tracing had been correctly located. As cephalometry is a validated method used for decades in orthodontics the error of the method was not calculated for this specific study. Also, as digital cephalometry has repeatedly been proved to be reliable

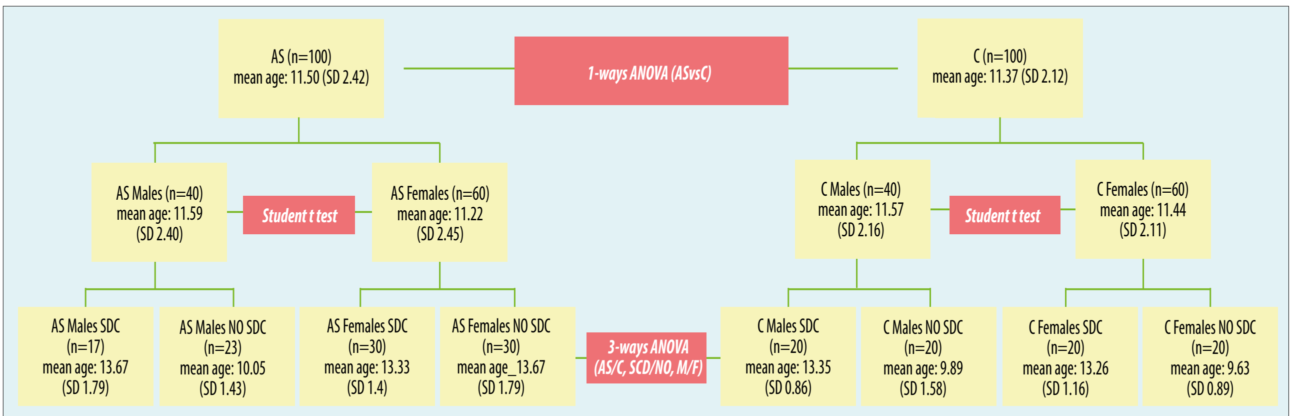

FIG. 1 Summary of the 8 subgroups analyzed and descriptive statistics of the sample.

	Mean Values in different subgroups									
Variable	AS	C	AS-SDC-M (n 17)	AS-SDNC-M (n 23)	AS-SDC-F (n 30)	AS-SDC-F (n 30)	C-SDC-M (n 20)	C-SDNC-M (n 20)	C-SDC-F (n 30)	C-SDNC-F (n 30)
Age	11.50 ± 2.12	11.37 ± 2.42	13.67 ± 1.79	10.05 ± 1.43	13.33 ± 1.54	9.12 ± 0.77	13.35 ± 0.86	9.89 ± 1.58	13.26 ± 1.16	9.63 ± 0.8
SNA (°)	80.75 ± 4.32	80,76 ± 3,53	81.18 ± 3.52	80.87 ± 4.27	81.63 ± 4.78	79.53 ± 4.20	80.35 ± 3.93	80.1 ± 3.98	80.6 ± 3.23	81.63 ± 3.20
SNB (°)	76.07 ± 4.22	77,82 ± 3,27	77.41 ± 3.52	75.65 ± 3.7	77.03 ± 4.78	74.66 ± 4.04	77.4 ± 3.97	77.15 ± 3.66	78.1 ± 3.08	78.26 ± 2.66
ANB (°)	4.7 ± 2.32	2,82 ± 1,69	3.65 ± 2.06	5.26 ± 2.33	4.63 ± 2.28	4.93 ± 2.40	2.55 ± 1.53	2.85 ± 1.59	2.47 ± 1.75	3.33 ± 1.72
Wits (mm)	0.82 ± 2.90	-1,31 ± 2,35	-0.41 ± 2.55	2.26 ± 2.71	0.16 ± 2.91	1.06 ± 2.83	-1.95 ± 2.43	-0.75 ± 1.94	-1.43 ± 2.41	-1.13 ± 2.47
SN^AnsPns (°)	7.52 ± 3.88	7,2 ± 3,29	6.33 ± 3.84	6.65 ± 3.94	7.73 ± 4.18	8.53 ± 3.40	7.6 ± 3.13	6.5 ± 4.28	7.43 ± 3.26	7.17 ± 2.7
SN^OP (°)	19.31 ± 4.62	18,47 ± 3,58	18.35 ± 4.42	18.15 ± 3.98	19.31 ± 5.07	20.75 ± 4.53	19.25 ± 3.79	17.67 ± 3.55	18.38 ± 3.44	18.59 ± 3.65
SN^GoMe (°)	36.40 ± 6.43	32,71 ± 4,83	35.43 ± 4.70	34.1 ± 4.88	37.28 ± 7.45	37.84 ± 6.91	32.46 ± 5.25	33.81 ± 3.95	32.23 ± 4.77	32.63 ± 5.24
GoMe^OP (°)	17.21 ± 4.22	14,17 ± 3,54	17.59 ± 4.12	16.04 ± 3.33	18.06 ± 5.04	17.03 ± 3.95	13.5 ± 4.24	15.95 ± 2.45	14.13 ± 3.25	13.47 ± 3.65
OJ (mm)	4.96 ± 2.35	3,64 ± 1,23	4.57 ± 2	5.71 ± 2.54	4.7 ± 2.36	4.87 ± 2.34	3.88 ± 1.35	4.08 ± 1.33	3.65 ± 0.70	3.17 ± 1.36
OB (mm)	0.29 ± 2.30	2,36 ± 1,34	0.78 ± 2.53	0.99 ± 2.03	0 ± 2.4	-0.23 ± 2.16	2.31 ± 1.63	2.62 ± 1.32	2.74 ± 0.85	1.84 ± 1.42
U1^NA (°)	24.59 ± 7.43	22,38 ± 5,98	27.48 ± 8.54	25.24 ± 8.14	24.41 ± 5.36	22.65 ± 7.75	22.48 ± 5.39	23.36 ± 4.67	22.34 ± 6.10	21.7 ± 7.07
L1^NB (°)	27.98 ± 7.35	24,67 ± 5,59	28.51 ± 7.44	27.65 ± 6.19	29.37 ± 8.38	26.55 ± 7.08	23.80 ± 5.81	23.74 ± 4.73	24.30 ± 4.90	26.29 ± 6.48
U1-NA (mm)	5.03 ± 2.28	4,71 ± 1,71	6.59 ± 2.96	4.48 ± 2.27	5.46 ± 1.96	4.13 ± 1.54	5.05 ± 1.50	4.95 ± 1.76	5 ± 1.61	4.03 ± 1.79
L1-NB (mm)	5.49 ± 2.24	4,36 ± 1,67	6.59 ± 2.29	4.91 ± 1.7	6.2 ± 2.63	4.6 ± 1.67	4.45 ± 1.82	4.15 ± 1.49	4.43 ± 1.43	4.37 ± 1.93
U1^SN (°)	106.46 ± 12.17	103,41 ± 6,27	108.75 ± 8.52	106.56 ± 7.94	106.1 ± 6.65	105.46 ± 19.21	103.25 ± 6.46	103.45 ± 4.71	103.63 ± 6.23	103.27 ± 7.30
L1^Go.Me	95.45 ± 7.82	94,09 ± 6,30	95.18 ± 6.45	97.82 ± 6.8	95.06 ± 8.63	94.17 ± 8.36	93.35 ± 6.63	92.75 ± 5.82	94 ± 5.90	95.57 ± 6.75
U1^AnsPns	113.02 ± 7.56	110,51 ± 5,86	115.19 ± 7.64	113.23 ± 8.12	113.57 ± 6.11	111.08 ± 8.28	110.72 ± 5.30	110.12 ± 3.89	110.67 ± 5.75	110.49 ± 7.52
U1-AnsPns (mm)	25.58 ± 3.38	25,53 ± 2,60	28.71 ± 3.46	24.73 ± 3.09	26.5 ± 2.47	23.53 ± 2.75	26.95 ± 2.43	26 ± 2.57	25.97 ± 2.38	23.83 ± 2.11
U6-AnsPns (mm)	19.82 ± 3.20	19,17 ± 2,54	23.18 ± 3.71	18.78 ± 2.41	21.23 ± 1.99	17.3 ± 1.68	20.6 ± 2.50	18.8 ± 2.23	20 ± 2.13	17.63 ± 2.34
L1-GoMe (mm)	36.91 ± 4.52	36,15 ± 2,97	41.29 ± 4.70	35.78 ± 4.57	38 ± 3.78	34.2 ± 2.48	38.1 ± 3.43	37 ± 2.69	36.23 ± 2.12	34.2 ± 2.46
L6-GoMe (mm)	27.93 ± 3.51	27,41 ± 2,86	30.50 ± 3.41	26.87 ± 3.27	29.2 ± 3.5	25.97 ± 2.10	29.2 ± 3.27	27.35 ± 2.43	27.6 ± 3.04	26.07 ± 1.89
U1^L1 (°)	121.99 ± 11.70	129,98 ± 8,68	120.15 ± 13.63	121.45 ± 9.74	123.53 ± 13.73	125.16 ± 11.73	131.13 ± 10.09	130.04 ± 5.54	130.47 ± 7.23	128.70 ± 10.71
Ans-Me (mm)	61.87 ± 6.95	59,34 ± 4,91	68.35 ± 6.93	59.6 ± 6.2	63.69 ± 5.9	58.13 ± 5.25	62.39 ± 5.39	60.81 ± 4.39	59.68 ± 4.11	56.02 ± 3.7
N-Me (mm)	106.45 ± 10.10	104,77 ± 7,65	116.24 ± 8.84	102.91 ± 10.81	109.5 ± 7.3	100.57 ± 7.16	111 ± 8.13	105.75 ± 6.81	105.9 ± 5.12	98.83 ± 5.87
Co-A (mm)	78.64 ± 6.24	78,42 ± 5,74	83 ± 5.47	78.04 ± 7.99	79.8 ± 4.77	75.47 ± 4.67	82.05 ± 6.75	79.1 ± 5.38	78.43 ± 4.09	75.53 ± 5.54
Go-Me (mm)	64.05 ± 7.62	65,39 ± 5,78	69.82 ± 7.12	63.74 ± 9.34	65.43 ± 6.68	59.63 ± 4.18	70.2 ± 6.84	65.8 ± 6.09	65.37 ± 4.07	61.93 ± 3.75
Co-Gn (mm)	100.84 ± 9.31	101,94 ± 7,85	109.82 ± 9.17	97.82 ± 9.63	103.83 ± 6.81	95.07 ± 5.87	107.9 ± 8.93	103.2 ± 7.07	103.03 ± 5.18	96.03 ± 5.93
ArGo^GoMe (°)	130.54 ± 5.81	128,21 ± 5,45	129.36 ± 6.47	129.34 ± 4.56	130.92 ± 6.14	131.74 ± 5.90	126.96 ± 5.81	128.62 ± 5.57	127.92 ± 5.45	129.07 ± 5.21
N'Sn'^Sn'Pog' (°)	158.19 ± 5.78	160,97 ± 4,70	159.47 ± 7.02	157.21 ± 6.11	158.83 ± 4.85	157.57 ± 5.69	161.05 ± 5.67	160.55 ± 3.17	161.63 ± 4.83	160.53 ± 4.86

TABLE 1 Mean values and standard deviation of cephalometric measurements in all the subgroups analyzed.

FIG. 2 Intraoral and extraoral images of a male patient with atypical swallowing and second dentition not completed.

and repeatable when involving different observers, no inter- or intra-observer measurements were analysed [Chen et al., 2004; Yu S-H et al., 2008].

Statistical analysis

A 3-way analysis of variance (ANOVA test) was performed to detect any cephalometric differences between groups considering the kind of swallowing (AS vs C), whether or not the second dentition was completed (SDC vs SDNC), and the genders (males and females). Intragroup differences (within the AS and C groups) between the cephalometric characteristics of males and females were detected with an independent sample Student t test. Significance level was set at $p < 0.05$. All analyses were performed using SAS software, version 9.2 of the SAS System for Windows.

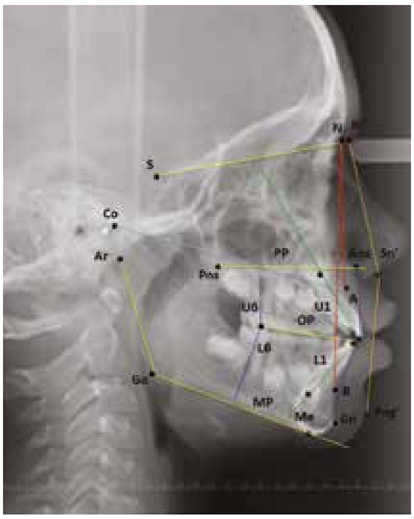

FIG 3 Cephalogram of the male patient with atypical swallowing and second dentition not completed.

Results

Two hundred patients were included in the present study, 100 in the AS group and 100 controls. Each group was composed of 40 males and 60 females. In the AS group we identified 47 patients with SDC (17 males and 30 females) and 53 patients with SDNC (23 males and 30 females). In the C group there were 50 patients with SDC (20 males and 30 females) and 50 patients with SDNC (20 males and 30 females). The descriptive statistics are reported in Figure 1. The mean values obtained from the cephalometric measurements are reported in Table 1.

Intraoral and extraoral images and cephalogram of an example case of a male patient with atypical swallowing and second dentition not completed are shown in Figures 2 and 3.

Intraoral and extraoral images and cephalogram of an example case of a female patient without atypical swallowing and second dentition completed are shown in Figures 4 and 5.

No significant differences with age were recorded between the AS and C groups or between the gender groups. Only significant differences in age were found between patients with and without second dentition complete (p<.0001) which is obvious because tooth eruption is directly linked with age. The results of the

FIG. 4 Intraoral and extraoral images of a female patient without atypical swallowing and second dentition completed.

statistical analysis between groups considering all possible variables (swallowing, dentition and gender) are shown in Table 2.

Regarding the skeletal characteristics, AS patients showed greater values for ANB (P<.0001), SN^Go.Me (P<.0001) and lower facial height (LFH, P<.01) suggesting a posterior position of the mandible linked to clockwise rotation and a consequent increase of the lower facial height.

Regarding the dental characteristics, AS patients showed an increased overjet (P<.0001), decreased overbite (P<.0001), increased inclination of the upper incisors (U1) towards NA (P<.05), SN (P<.05) and the palatal plane (PP) lines (P<.05), as well as increased inclination of the lower incisors (L1) with respect to the NB line (P<.001) and a higher interincisal angle (P<.0001).

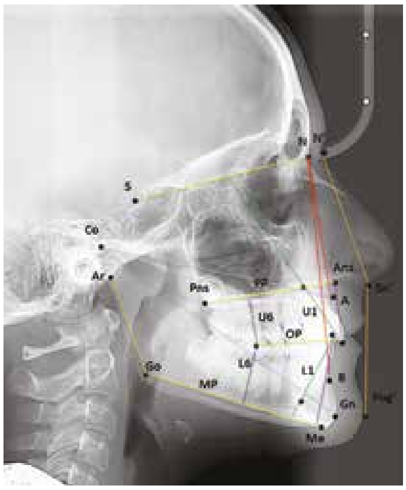

FIG. 5 Cephalogram of the female patient without atypical swallowing and second dentition completed.

Discussion

This retrospective study has been conducted with the aim to identify cephalometric characteristics that could better explain how atypical swallowing can influence the development of the oral environment after the onset of permanent dentition.

The significant intra-group differences among M and F within the AS and C groups for all linear distances in skeletal and alveolar dimensions could be linked to the different growth potential related to genders. Nevertheless, even if the growth potential between genders is different, the dentoalveolar compensation taking place in individuals with AS seems to even these differences. This is supported by the fact that differences between genders were much larger in the control group.

In the comparison between AS and C, AS patients show a more retruded mandible with clockwise rotation and a consequent increase in the gonial angle and the LFH and a decrease in profile convexity. These results are significant because they contradict the ones obtained by Dixit and Shetty [2013] and Machado and Crespo [2010], according to whom tongue thrust would not cause any skeletal changes when compared to controls, except for the increase in cranio-mandibular angle. The reason of this difference could depend on their smaller sample sizes. In the AS group, the OJ was significantly increased, confirming the results obtained

	Student t-Test p-value		ANOVA p-value		
Variable	AS-M vs AS-F	CM vs CF	AS vs C	AS-SDC vs AS-SDNC vs C-SDC vs C-SDNC	AS-SDC-M vs AS-SDNC-M vs AS-SDC-F vs AS-SDNC-F vs C-SDC-M vs C-SDNC-M vs C-SDC-F vs C-SDNC-F
Age	N.S.	N.S.	N.S.	N.S.	N.S.
SNA (°)	N.S.	N.S.	N.S.	N.S.	N.S.
SNB (°)	N.S.	N.S.	<.01	N.S.	N.S.
ANB (°)	N.S.	N.S.	<.0001	N.S.	N.S.
Wits (mm)	N.S.	N.S.	<.0001	N.S.	N.S.
SN^AnsPns (°)	N.S.	N.S.	N.S.	N.S.	N.S.
SN^OP (°)	N.S.	N.S.	N.S.	N.S.	N.S.
SN^GoMe (°)	<.05	N.S.	<.0001	N.S.	N.S.
GoMe^OP (°)	N.S.	N.S.	<.0001	N.S.	N.S.
OJ (mm)	N.S.	<.01	<.0001	N.S.	N.S.
OB (mm)	N.S.	N.S.	<.0001	N.S.	N.S.
U1^NA (°)	N.S.	N.S.	<.05	N.S.	N.S.
L1^NB (°)	N.S.	N.S.	<.01	N.S.	N.S.
U1-NA (mm)	N.S.	N.S.	N.S.	N.S.	N.S.
L1-NB (mm)	N.S.	N.S.	<.0001	<.01	N.S.
U1^SN (°)	N.S.	N.S.	<.05	N.S.	N.S.
L1^Go.Me	N.S.	N.S.	N.S.	N.S.	N.S.
U1^AnsPns	N.S.	N.S.	<.05	N.S.	N.S.
U1-AnsPns (mm)	<.05	<.01	N.S.	<.05	<.05
U6-AnsPns (mm)	<.05	<.05	<.05	<.01	<.05
L1-GoMe (mm)	N.S.	<.01	N.S.	<.01	<.05
L6-GoMe (mm)	N.S.	<.01	N.S.	<.05	N.S.
U1^L1 (°)	N.S.	N.S.	<.0001	N.S.	N.S.
Ans-Me (mm)	0.05	<.0001	<.01	<.05	<.05
N-Me (mm)	<.05	<.0001	N.S.	N.S.	<.05
Co-A (mm)	<.05	<.01	N.S.	N.S.	N.S.
Go-Me (mm)	<.01	<.0001	N.S.	N.S.	N.S.
Co-Gn (mm)	<.05	<.0001	N.S.	N.S.	N.S.
ArGo^GoMe (°)	N.S.	N.S.	<.01	N.S.	N.S.
N'Sn'^Sn'Pog' (°)	N.S.	N.S.	<.01	N.S.	N.S.

TABLE 2 Statistical analysis of the measurements analysed in all subgroups.

from Jalaly et al. [2009], whereas the OB was significantly decreased, contrarily to the data gathered by these same authors, that did not show any significant difference.

When it comes to incisor proclination, U1 was significantly proclined towards the NA, SN and PP lines in AS patients, whereas L1 was significantly proclined only with respect to the NB line. The fact that AS has a stronger effect on U1 than on L1 is confirmed by Dixit and Shetty [2013] and Alexander and Sudha [1997]. In opposition, Barber and Bonus [1975], Cayley et al. [2000] and Jalaly et al. [2009] found no significant differences in the inclination of U1 to SN and NA in children with or without tongue thrust, which might also be explained by the smaller sample sizes recruited.

Many authors have suggested that there is a strong association between tongue thrust and the transversal constriction of the maxilla [Fuhrmann and Diedrich, 1994; Brauer and Holt, 1965; Harvold, 1968] which has been attributed to an abnormally low position of the tongue at rest. Taking this in consideration, it is plausible that the proclination of upper incisors and the consequent increase in OJ may be due to palatal contraction rather than to the forces exerted by the tongue thrust.

If the upper incisor proclination was purely a consequence of the tongue thrust, L1 proclination should also be expected towards Go-Me, which can be considered as a more reliable skeletal measurement than NB, because it contains the B point that can also be altered by incisor position. However, in our study, the L1 inclination towards Go-Me does not show an increased value in the AS group when compared to controls. This corroborates the idea of Proffit that the resting position of the tongue contributes more than its position during swallowing in determining the dental arch form [Proffit et al., 2008]. In fact, according to Caylay et al. [2000], children who swallow incorrectly very rarely touch the anterior part of the palate with the tip of the tongue. They perform predominantly horizontal tongue movements and place the tongue between their anterior teeth while speaking and swallowing.

Therefore, proclination of L1 to the N-B line could probably be linked to the clockwise rotation of the mandible, that creates a higher divergence from the cranial base. Therefore, also the N-B line gets longer and moves downwards and backwards. In addition, the distance from the labial surface of the crown of L1 to the NB line, which is significantly increased in AS-SDC patients, could be considered as a consequence of the clockwise rotation of the mandible. Then, the extrusion of L1 in AS-SDC patients over time to compensate the increased craniomandibular angle could also be affected by the tongue position at rest that forces L1 to extrude in a forward position as it usually happens in AS patients [Proffit et al., 2008].

Regarding the linear measurements of alveolar and skeletal distances, no significant differences were noticed between AS and C groups. This may suggest that the persistence of the atypical swallowing can alter the position of the skeletal structures but not the skeletal lengths (maxillary, mandibular ramus, mandibular base, mandibular bone) that are also genetically predetermined.

On the other hand, all alveolar distances recorded significant differences between groups, with the highest values found in AS-SDC patients. This could suggest that in AS patients there is an adaptive dentoalveolar growth to compensate for the clockwise rotation of the mandible. This is even more relevant if we consider that the upper and lower incisors are proclined, thus not aggravating the already significant perpendicular distance from the tips of the crown with PP and MP, respectively.

Regarding the difference between patients with mixed dentition and SDC, there are still no differences between groups regarding the alveolar bone growth during mixed dentition, but then, if the patients are not treated, the compensatory growth of the alveolar processes increases until a significantly higher growth and extrusion is achieved once the second dentition is completed. This confirms the conclusions of Hanson and Andrianopoulos [1982] and Harvold [1968], according to whom deleterious forces of the tongue and the prolonged low tongue position during the growth period in AS children result in excessive eruption of posterior teeth, clockwise rotation of the mandible, increase in LFH, OJ and open bite.

Although the clinical implications of this study are limited because of its cross-sectional, retrospective nature, our results suggest that in patients where AS persists until the onset of permanent dentition, alveolar and skeletal traits tend to deviate from the normal values. In this perspective, early interceptive treatment of atypical deglutition seems to be a valid alternative to prevent the worsening of this dysfunction over time. To this respect, myofunctional therapy or crib therapy have been demonstrated to be successful in correcting tongue thrust in order to establish a new neuromuscular pattern, correcting the abnormal function and resting posture of the tongue [Cayley et al., 2000; Alexander and Sudha, 1997; Van Dyck et al., 2016; Huang et al., 1990].

A greater awareness of the possible consequences of atypical swallowing should be shared by all general dentists to intercept these patients and treat them at the right time and with the appropriate modality to restore a correct growth trend.

Conclusion

Patients with AS show a clockwise rotation of the mandible with increased OJ and decreased OB when compared to controls, which seems to be compensated by a vertical growth of the alveolar processes and molar extrusion. The proclination of the upper incisors could be both a consequence of the altered lingual posture at rest and to the tongue thrust exerted during swallowing. After the onset of permanent dentition, dentoalveolar and skeletal traits of AS patients deviate from the norm. To this respect, early interceptive treatment could be beneficial in patients with atypical swallowing in order to prevent the compensatory effects related to the maintenance of this swallowing dysfunction over time.

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