Obstructive site localization in patients with Obstructive Sleep Apnea Syndrome: a comparison between otolaryngologic data and cephalometric values

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SUMMARY

Purpose. Obstructive Sleep Apnea Syndrome (OSAS) is a respiratory disorder characterized by repeated obstructive episodes affecting upper airways.

This study aims at examining the anatomical craniofacial and pharyngeal characteristics of the patient as to identify the obstructive site which triggers the pathologic process.

Correlations between otolaryngologic data observed in the patient and the cephalometric ones for the identification of the obstructive site were also highlighted.

Materials and methods. We worked on a sample of 16 patients, 12 males and 4 females, attended to at the Otolaryngology Operative Unit of Bari University Hospital.

The patients underwent an otolaryngologic (ORL) diagnostic procedure which provided for ApneaGraph (AG) recording, and a dental diagnostic procedure with cephalometric assessment.

Results.The statistical analysis highlighted a strict correlation between the otolaryngologic value of AHI and the cephalometric values of the ANB angle, with the distance between the hyoid bone and the mandibular plane and with the distance between the hyoid bone and the plane passing between C3 and Me.

Conclusions. We observed a concurrence between the ORL diagnosis of the obstruction level assessed with AG and the cephalometric values regarding respiratory tracts (IPAS and SAS). More precisely, we observed the correlation between the otolaryngologic value of AHI with cephalometric values of the ANB angle, with the distance between hyoid bone and mandibular plan, and with the distance between the hyoid bone and the plane passing between C3 and Me. Furthermore, the identification of the caudal position of the hyoid bone can be considered an alarm bell in the diagnosis of severe OSAS.

Key words: sleep apnea, cephalometric evaluation, apneagraph, upper airways obstruction.

Introduction

OSAS is a respiratory disorder characterized by repeated episodes of apnea and/or hypopnea, occurring during sleep, caused by the obstruction of upper airways (mainly upper airways-VAS), but it is also characterized by diurnal symptoms (sleepiness, fatigue). Obstructions are normally associated with phasic falls of oxygen saturation of blood (1, 2).

Nowadays, most epidemiologic studies define

OSAS on the basis of the number of obstructive sleep apnea/hypopnea episodes per hour (AHI) setting a severity cutpoint at a value of 5.15 and 30 sleep episodes per hour to indicate mild, moderate and severe OSAS. The definition of 'OSA Syndrome' means a clinical entity characterized by high AHI>30/sleep hour, associated with excessive diurnal sleepiness, arterial hypertension, cardiovascular diseases, stroke, increased frequency of car and work accidents, impaired cognitive abilities with consequent impaired quality of life (3-6).

The prevalence of the syndrome in adult population fluctuates between 2 and 10% showing an increase with age and a male preponderance.

If initially the syndrome was exclusively relevant for neurology because of the relation with sleep phases and the presence of diurnal sleepiness, it has then involved cardiologists, pneumologists, otorhinolaryngologists, maxillofacial surgeons and odontologists, becoming a multidisciplinarily relevant pathology (7-27).

Since, in most cases, OSAS reveals itself to be a pathology deriving from the obstruction of the airways at the level of the pharynx, our first aim was to study the anatomical craniofacial and pharyngeal characteristics of the patient as to identify the assumed obstructive site triggering the pathologic process.

In addition, our second aim was to assess the existence of a correlation between the values obtained by the otorhinolaryngologist with ApneaGraph (AG) and those obtained by the odontologist through the cephalometric studio of the latero-lateral X-rays in the search for the obstructive site.

The gold standard investigation for the diagnosis of OSAS is polysomnography (PSG) (28) even though the cardio-respiratory monitoring (AG) is usually sufficient for the diagnosis of OSAS (over 90% of the cases). In dubious cases PSG is opportune (diagnosis of neurologic disorders). As compared to traditional PSG, AG does not provide for the application of thorax and abdominal sensors and it could potentially be done at home with considerable economic saving and a higher compliance for patients. AG is a screening procedure which is well tolerated, safe and with low morbidity, reproducible, sufficiently reliable and, once the initial purchase cost is offset, cheaply and easily manageable (29, 30).

This study is characterized by the assessment of the alterations which can be observed in patients with OSAS associated with high BMI, that is in overweight and obese patients. This is due to the fact that alterations in soft tissues are susceptible to body weight alteration creating anatomical alterations which can affect the obstructive site or sites.

We investigated the identification of new relationships between cephalometric measurements and otolaryngologic values aiming at simplifying diagnostic procedures, making them faster, less expensive and harmful for the patient (think of radiations taken, for instance, with a volumetric tomography) as to identify, as quickly as possible, the obstructive site in order to set a suitable treatment plan.

Materials and methods

The study refers to observations performed on a sample of 20 patients attended to at Otolaryngology Operative Unit of Bari University Hospital. The work covered a time period of about 20 months, from September 2012 to the end of April 2014.

The *inclusion criteria* were adult (or coinciding with the end of growth) age of the patient, acceptance diagnosis of roncopathy or suspect OSAS, consent to hospitalization, for one night, with ApneaGraph nasogastric tube (cooperation of the patient was necessary), consent to high-resolution radiographic exam and tolerability of the nasogastric tube as to allow the carrying out of the normal physiologic sleep processes.

The *exclusion criteria*, instead were: non-cooperative patient or in developmental age, refuse to hospitalization, missing tolerability of nasogastric tube with missing capability to fall asleep or reduction of minimum sleep hours to obtain a reliable exam, displacement of the nasogastric

tube due to brisk movements, low radiographic quality.
On the basis the aforementioned criteria, 4 patients were excluded, the final sample therefore resulting in a group of 16 patients, 12 males and 4 females of age ranging from 17 and 74 (average 41.5 +/-16.31) (Table 1).
Patients were informed about all the procedures and signed the consent form provided.
During hospitalization, all the patients underwent otolaryngologic diagnostic procedures including ApneaGraph recording.
Patients were then addressed to the Dentistry Operative Unit in order to carry out a radiographic exam and finally, to the Orthodontics clinic for cephalometric assessment.
The otolaryngologic exam consisted in carrying out anamnesis, objective examination, rhinomanometry, acoustic rhynometry, fibroendoscopy and, finally, ApneaGraph (AG 200 – MRA, Medical Ltd.) with the execution of Muller manoeuvre and the overall exam of the obstructive site of the patient, with following assessment and recording of the saturation, cardiac activity and monitoring of the number of apneas and hypopneas (Table 2).
AG enabled us to observe obstructive sites, by means of a catheter with temperature and pressure sensors:

- pressure transducer for upper airways placed under the soft palate;
- sensor for temperature/air flux for upper airways placed in the nasal cavity;
- pressure transducer for lower airways placed in the esophageal cavity;
- sensor for temperature/air flux for lower airways placed on the base of the tongue.

For the exam of the cephalometric values, a trace on the radiographic picture was drawn by a sole operator.
For what concerns the craniofacial skeletal assessment, we used the parameters as provided by Giannì technique (intermaxillary angle, SNA, SNB, ANB, craniomandibular angle, PC-Go-Gn, S-N-Pog, Ba-S-SNP, SNP-A, SN, Go-Me, Sor-SNA, SNA-Me, Ba-Snp); for the assessment of

Table 1 - Anthropometric values and patients' acceptance diagnosis.

Patient	Age	Sex	BMI	Diagnosis of acceptance
1	39	M	21,1	Roncopathy
2	44	M	20,9	Roncopathy and hypertrophy ugula
3	37	F	22,43	OSAS
4	53	M	26,9	Nocturnal snoring and nasal septum deviation
5	20	F	38	OSAS and recurrent tonsillitis
6	31	M	28	OSAS
7	38	M	27,5	Severe OSAS
8	74	M	28	Roncopathy
9	27	M	28,7	OSAS
10	26	M	26	Roncopathy and sleep apnea
11	40	M	41,2	OSAS
12	60	M	31,6	OSAS
13	41	M	34,7	OSAS
14	43	F	44,9	OSAS
15	17	M	39,3	Post-operative monitoring in patient operated adenotonsillectomy for OSA
16	74	F	40	Roncopathy and OSAS

Table 2 - Main values recorded by AG for each patient.

Patient	Total AHI	Upper Mixed	Upper Obstr	Upper Obstr Hypo	Lower Mixed	Lower Obstr	Lower Obstr Hypo	Lowest Sao2 (%)
1	7,71	0	0	13	1	5	24	94
2	10,29	0	0	17	0	3	36	90
3	3,27	0	0	7	0	0	5	92
4	10.00	0	0	12	0	0	31	91
5	7,71	2	3	18	2	2	14	92
6	17,71	0	10	99	0	0	4	88
7	39	65	80	72	0	1	1	72
8	24.43	0	2	11	0	30	67	85
9	22.14	0	0	15	0	16	64	86
10	3,86	0	1	22	0	0	0	92
11	52,28	4	59	21	0	10	18	56
12	30,57	42	70	25	0	16	30	80
13	24,71	0	8	14	2	47	30	79
14	16,14	0	4	9	0	17	55	87
15	37,29	0	37	174	0	0	0	73
16	18,43	0	3	30	4	6	45	88

the space of the upper airways, and in particular, of the lower pharyngeal region, of the dimension of the soft palate and of the position of the hyoid bone in relation to the mandibular plane, we mainly relied on the parameters as provided by Riley (31), Bibby (32) and Baik (33) (Me-C3, H-C3, H-MP, H-C3Me, H-Me, pm-P, pm-UPW, pm-P-NL, P-SNP e PAS, IPAS, SAS, MAS).
From a statistical point of view, the first approach was to elaborate the anthropometric data obtained through the calculation of the mean and the standard deviation for each single value.
Then, for each selected patient a data collection file was filled in (Tables 3-5).
The files were entered in a data base created with File Maker Pro and then processed with Stata MP11 software.
In order to assess the correlation between total AHI per hour and the other measured parameters, the Pearson (ρ) coefficient was calculated performing the hypothesis test with significativity set at $p < 0,05$.
For indicators resulting to be correlated in a statistically significant way, we drew the correlation line with 95% confidence intervals we will analyze later.
The Pearson correlation coefficient was used to identify the correlation variable with total AHI, whereas multivariable regression analyses were created to define the contribution of anthropometric and cephalometric variables in the identification of the pharyngeal obstructive site.

Results

After completing the overall otolaryngologic diagnostic framing, patients were divided in two groups: Simple Snoring Group (SSG) and OSAS Group (OSASG). Simple Snoring Group consisted in 5 patients, 3 males and 2 females whose age ranged between 20 and 53 (average age 38.6+/- 10.81). At AG these patients recorded a AHI value which was not congruous with OSAS diagnosis. OSAS Group (OSASG): 11 patients,

Table 3 - Linear and angular values concerning the craniofacial skeletal structures.

Patient	Intermaxillary ang	SNA	SNB	ANB	Cranioman-dibular ang	Snp-a	SN	Go-Me	SOR-SNA	SNA-Me	PcGoGn
1	14	83	81	2	24	51	71	68,5	65	66	118
2	26	77	78	-1	33	46	68,5	75	62	70,5	121
3	28	75	76	-1	36	50,5	75	70	61	77	128
4	10,5	81	78	3	17,5	53	75,5	85	69	63	111
5	24	85	81	4	33	49	71	76	62,5	67,5	125
6	26	83	79	4	32	53,5	75	74	68	73	123
7	14	77	72	5	25	46	73	65	67	61	115
8	22	83	78	5	33	55,5	74	62	74	71	127
9	22	84	80	4	31	57	80	91	68	76	122
10	28	80	76	4	32,5	48	67	66,5	62	77	123
11	12,5	85	79	6	23	58	70	71	64	69	118
12	20	77	77	0	30	56,5	80	70	70	69	133
13	18	77	74	3	38	53	78,5	66	76	68,5	133
14	31	80	77	3	42	52	72	70	70	79	131
15	24	89	81	8	31	54	70	74	57,5	68	121
16	7	83	84	-1	17	46	69	68,5	68	52	119

9 males and 2 females whose age ranged between 17 and 74 (average age 45.8 +/- 17.75), who displayed definitive diagnosis of OSAS. In this group we also distinguished patients according to BMI, observing the absence of normal weight patients, and the presence of 5 overweight patients (average BMI= 27.8 +/- 0.97) and 6 obese patients (average BMI = 38.6 +/- 4.18).

For each group, we calculated the mean and standard deviation of data concerning the obstructive site that we obtained from the analysis with AG (Table 6).

From the analysis of the obtained data we can observe that the apneas and hypopneas values, both upper and lower, are higher in OSAS patients, whereas the oxygen saturation in this group is considerably reduced.

From the comparison of the patients classified according to BMI, it emerges that in obese individuals the clinic frame is worse due to more frequent apneas and hypopneas, both upper and lower, with impaired oxygen saturation (Table 7).

From a strictly dentistry point of view, we calculated the mean and standard deviations of the aforementioned cephalometric values (Table 8).

We also calculated mean and standard deviation of cephalometric values of hard tissues and soft tissues in the two subgroups of OSASG, overweight patients and obese patients (Table 9).

The statistical analysis highlighted cephalometric variables strictly associated to total AHI value per hour.

From the same statistical analysis, we can observe a strict correlation between the otolaryngologic value of AHI with cephalometric values of ANB angle, with the distance between hyoid bone and mandibular plane and with the distance between hyoid bone and plane passing through C3 and Me (Table 10).

For these indicators, correlated in a more statistically relevant way, we outlined graphs (Figures 1-5).

Any correlation was observed between AHI and other cephalometric values.

Table 4 - Data about the position of the hyoid bone and soft palate.

Patient	Iode including bone	C3-ME	HC3	H-MP	H-C3Me	H-Me	pm-P	pm-UPW	pm-P-NL	SNPog	P-Snp	Ba-Snp	BaSSnp
1	1	68	30	19	-3	38	41	21	123	80	42,5	44	52
2	0	77	31	33	13	52	41	18	120	80	39	42	52
3	1	74	32	10	-4	41	43	23	120	77	41,5	40	59
4	0	97	51	18	11	48	44	24	122	85	42	51,5	62
5	1	89	40	19	-1	41	37	11	124	83	31	45	56
6	0	89	49	25	9	44	37	21	128	79	32	44,5	50,5
7	0	82	47	36	24	36	46	11	125	75	38	45	59
8	0	68	34	21	10	37	48	23	110	77	41,5	47	57
9	0	84	45	27	11	43	48	24	115	81	44	49	60
10	0	74	39	17	3	36	40	7	89	76	35	45	58
11	0	99	48	26	22	60	42	16	130	81	38,5	46	64
12	0	106	50	20	15	61	58	26	127	77	56	54	52
13	0	86	38	26	8	49	53	19	118	65	50	47,5	59
14	1	83	38	23	3	46	45	22	115	78	40	37	47
15	0	92	42	28	12	54	41	6	145	82	39	47,5	66
16	0	68	41	22	14	34	43	25	107	87	37	43	50

Table 5 - Data about airways.

Patient	PAS	IPAS	SAS	MAS
1	6	5,5	8	5
2	11	11	10	9
3	8	6	17	8
4	19	18	15	16
5	17	13	14	10
6	14	14	10	13
7	5	4	6	5
8	12	10	9	15
9	15	15	9	9
10	14	12	9	9
11	18	17	11	7
12	16	14	13	8
13	13	6	8	8
14	15	8	8	13
15	20	19	8	5
16	5	6	11	5

The second aim was to highlight the existence of a concordance between ORL diagnosis of the obstruction level detected with AG and the cephalometric values concerning airways (IPAS and SAS) (Table 11).

Of the 6 patients showing higher percentage of upper apneas and hypopneas, 5 also displayed a reduction of SAS (Table 12).
Of the 5 patients displaying, instead, a higher percentage of lower apneas and hypopneas, 4 also displayed a reduction of IPAS (underlined in Table 13).

Discussion

Latero-lateral teleradiography was used in this study, as referred in literature, as an indispensable method to assess craniofacial anatomical characteristics of soft tissues and upper airways of patients with OSAS.
Despite this, significant variations may occur in cephalometric values of craniofacial and airway characteristics of patients with obstructive apneas associated with both the nature of the exam and the selection of the sample.
The limiting techniques of teleradiography are based on the phase of the respiratory act in which the X-rays is done and on the position of the patient, standing and not supine, not comparable with the position of the head during night recording as it happens for polysomnography and for AG.

Table 6 - Mean and standard deviation of the number of apneas and hypopneas distinguished in upper and lower in the two patient groups.

	Simple Snoring		OSAS	
	AVERAGE	D.S.	AVERAGE	D.S.
UPPER-MIXED	**0,4**	0,8	**10,09**	21,07
UPPER-OBSTR	**0,6**	1,2	**24,9**	29,41
UPPER-OBSTR-HYPO	**13,4**	3,92	**44,72**	48,92
LOWER-MIXED	0,6	0,8	0,54	1,23
LOWER-OBSTR	**2**	1,89	**13**	14,1
LOWER-OBSTR-HYPO	**22**	11,26	**28,4**	26,09
LOWEST-SASO2	**91,8**	1,32	**80,54**	9,85

Table 7 - Mean and standard deviation of the number of apneas and hypopneas distinguished in upper and lower, in patients with OSAS, distinguished by BMI.

	OSAS with BMI < 30		OSAS with BMI > 30	
	AVERAGE	D.S.	AVERAGE	D.S.
UPPER-MIXED	13	26	7,6	15,42
UPPER-OBSTR	**18,6**	30,9	**30,16**	27,01
UPPER-OBSTR-HYPO	**43,8**	35,27	**45,5**	57,87
LOWER-MIXED	0	0	1	1,52
LOWER-OBSTR	**9,4**	11,95	**16**	15,02
LOWER-OBSTR-HYPO	**27,2**	31,3	**29,66**	17,76
LOWEST-SASO2	**84,6**	6,74	**77,16**	10,73

As a result, the position of the soft tissues and the parameters calculated on them are not always 100% concordant because the soft tissues alter their position according to the position taken and the action of gravity.
A further limitation of cephalometry is the bidimensional – not tridimensional - vision of the anatomical structures to study.
In the present study, some parameters which are relevant in literature were for us statistically non-significant. Among these parameters we can enlist, for instance, hyperdivergence, mandibular and maxillary retrognathia and increased thickness of soft palate which, in the present study, were not highlighted as being significant parameters. It cannot always be seen a strict concordance between the single study and what is reported in literature (34, 35).
The cephalometric variables which showed a significant correlation with skeletal and soft tissue alterations in patients with OSAS were: reduced linear value Go-Me indicating hypomandibulism, development of a skeletal open bite highlighted by the alteration of the standard proportion between SNA-Me and SOR-Me (SOR-Me = SNA-Me + 5.6mm in females, SOR-Me = SNA-Me + 11,2 mm in males) in favor of SOR-Me segment, increased PcGpGn angle, increased length of soft palate (Snp-P > 37 mm) and dorsocaudal position of the hyoid bone.
Among the alterations characterizing patients with OSAS, it is important to underline the position of the hyoid bone. This bone, as seen before, has a vital role in the keeping of respiratory space. A correct position of the hyoid bone would enable geniohyoid muscles, genioglossus muscle and extrinsic tongue muscles to carry out a suitable function in keeping first airways accessible and in protruding the tongue in inspiratory acts.
A low and retruded position of the hyoid muscle, instead, could determine a posterior lingual posture engendering a mechanical disadvantage for the activation of the suprahyoid and genioglossus muscles. Such low position of the hyoid bone could also affect the onset of sleep apneas favoring a open-mouth posture and consequent back sliding of mandible and tongue during sleep due to the stretching of mandibular muscles.
The values which indicate the altered position of the hyoid muscle in patients with OSAS are multifarious (for instance the hyoid triangle of Bibby); in the present study we propose what we believe to be easiest to use (also for non-specialists): the analogue of hyoid bone-mandibular plane distance. This is the visual detection of the position, upper or lower, of the hyoid bone in re-

Table 8 - Mean and standard deviation of the cephalometric values of hard and soft tissues distinguished by the two study groups. The most relevant values in the comparison of the two groups are in bold.

	Simple Snoring		OSAS	
	AVERAGE	**D.S.**	**AVERAGE**	**D.S.**
INTERMAXILLARY ANG	20,4	7,08	20,36	6,85
SNA	80,2	3,7	81,63	3,64
SNB	78,8	1,93	77,9	3,14
ANB	1,4	2,05	3,72	2,41
CRANIOMANDIBULAR ANG	28,6	7,05	30,36	6,52
SNP-A	49,8	2,31	52,54	4
SN	72,4	2,65	73,54	4,33
Go-Me	**74,8**	5,91	**70,63**	7,35
SOR-SNA	**63,8**	2,92	**67,63**	5,05
SNA-Me	**68,6**	4,75	**69,36**	7,3
PC-Go-Gn	**120,66**	5,88	**124,09**	5,85
PAS	12,2	5,03	13,36	4,47
IPAS	10,6	4,75	11,36	4,69
SAS	12,8	3,31	9,27	1,81
MAS	9,6	3,61	8,81	3,32
C3-Me	81	10,52	84,63	11,33
H-C3	**36,8**	7,93	**42,81**	5,05
H-MP	**19,8**	7,41	**24,63**	4,79
H-C3-Me	**3,2**	7,27	**11,09**	6,38
H-Me	44	5,17	45,45	9,18
MP-P	**41,2**	2,4	**45,54**	5,77
MP-UPW	19,4	4,67	18,18	6,85
MP-P-NL	**121,8**	1,6	**119**	13,93
S-N-POG	81	2,75	78	5,22
P-SNP	39,3	3,85	40,09	6,54
BA-SNP	44,4	3,72	45,81	3,95
BA-S-SNP	56,2	3,91	56,54	5,78

lation to the between Menton/Me and third vertebra (C3) line (35).
To confirm the data from literature, the 90.9% of our patients with OSAS showed a position of the hyoid bone which was lower than the straight line between Me and C3 (Figures 6, 7), whereas in non-OSAS patients this is strictly related to the straight line (Figure 8).

Since the characteristics of the craniofacial variables of the soft tissues can differ in patients with and without obesity (18), we also described the morpho-functional alterations which characterize overweight patients with OSAS, always assessing the mean and standard deviations of the values.
The main fluctuations were: distance between

Table 9 - Mean and standard deviation of the cephalometric values of hard and soft tissues distinguished by the two subgroups of OSASG, overweight patients and obese patients.

	OSAS with BMI < 30		OSAS with BMI > 30	
	AVERAGE	**D.S.**	**AVERAGE**	**D.S.**
INTERMAXILLARY ANG	22,4	4,8	18,6	7,78
SNA	81,4	2,57	81,8	4,33
SNB	77	2,82	78,66	3,19
ANB	4,4	0,48	3,1	3,13
CRANIOMANDIBULAR ANG	30,6	2,87	30,16	8,43
SNP-A	51,8	4,16	53,16	3,76
SN	73,8	4,16	73,33	4,45
Go-Me	71,6	10,4	69,83	2,47
SOR-SNA	67,8	3,81	67,5	5,88
SNA-Me	71,6	5,71	67,5	7,93
PC-Go-Gn	122	3,89	125,83	6,59
PAS	12	3,63	14,5	4,78
IPAS	11	3,89	11,6	5,24
SAS	8,6	1,35	9,83	1,95
MAS	10,2	3,48	7,66	2,68
C3-Me	**79,4**	7,47	**89**	12,13
H-C3	42,8	5,52	42,81	5,05
H-MP	25,2	6,4	24,16	2,73
H-C3-Me	11,4	6,88	12,33	5,9
H-Me	**39,2**	3,54	**50,66**	9,19
MP-P	**43,8**	4,48	**47**	6,29
MP-UPW	17,2	6,88	19	6,73
MP-P-NL	**113,4**	13,83	**123,6**	12,18
S-N-POG	77,6	2,15	78,33	6,77
P-SNP	38	4,24	43,33	7,11
BA-SNP	46	1,78	45,66	5,08
BA-S-SNP	56,8	3,54	56,5	7,04

Menton and third cervical vertebra (overweight OSAS: 79.4 +/- 7.47; obese OSAS: 89+/-12.13), distance between Menton and hyoid bone (overweight OSAS: 39.2+/- 3.54; obese OSAS: 50.66+/- 9.19) and the vertical position of soft palate which can be highlighted by the exam of the angle between the nasal line (NL o spinal plane) and the straight line given by the intersection between pm and P: (overweight OSAS: 113.4+/- 13.83; obese OSAS: 123.6+/-12.18).

We could also highlight that in obese OSAS patients there is a significant decrease of O2 saturation and about a doubling of the number of apneas recognized as low.

Table 10 - Pearson correlation coefficient of the relationship between AHI and cephalometric and otolaryngologic values.

	Coefficient of correlation (Rho)	p
Intermaxillary ang	-0,4431	0,0856
Sna	0,2154	0,423
Snb	-0,0312	0,9088
→ Anb	0,5232	0,0376
Craniomandibular ang	-0,2895	0,2768
Snp_a	0,486	0,0563
Sn	0,1756	0,5153
Go_me	-0,1752	0,5164
Sor_sna	0,3045	0,2515
Sna_me	-0,2756	0,3015
Pcgogn	-0,0996	0,7135
Pas	0,1844	0,4943
Ipas	0,2024	0,4523
Sas	-0,3656	0,1637
Mas	-0,3605	0,1702
→ Including bone iode	-0,5954	0,015
C3_me	0,425	0,1008
Hc3	0,4683	0,0673
→ H_mp	0,7178	0,0017
→ H_c3me	0,7856	0,0003
H_me	0,381	0,1454
Pm_p	0,4741	0,0635
Pm_upw	-0,0649	0,8111
Pm_p_nl	0,4171	0,108
Snpog	-0,0909	0,7377
P_snp	0,1444	0,5936
Ba_snp	0,4889	0,0546
Bassnp	0,3198	0,2273
Total_ahi	0,4785	0,0608
Upper_mixed	0,7617	0,0006
Upper_obstr	0,4709	0,0656
Upper_obstr_hypo	-0,1539	0,5693
Lower_mixed	0,4081	0,1166
Lower_obstr	0,0486	0,858
Lower_obstr_hypo	-0,9705	0,000
Lowest_sao2	-0,4431	0,0856

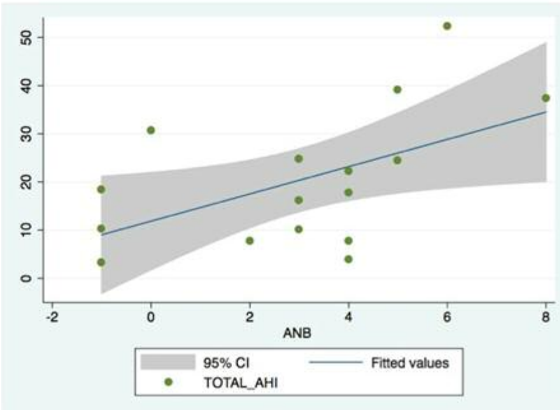

Figure 1
Graph about the correlation between AHI and ANB angle. Each patient is represented by a dot.

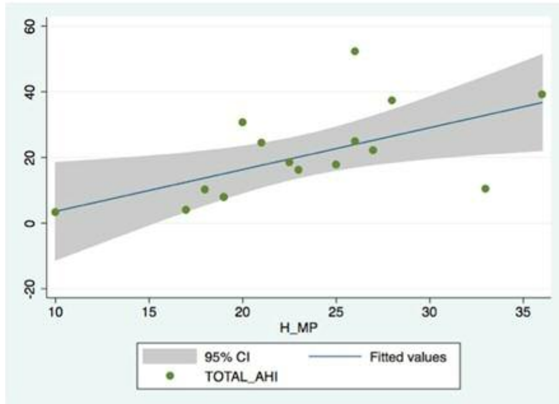

Figure 3
Graph about the correlation between AHI and the distance between the hyoid bone and the mandibular plane. Positively correlates variables.

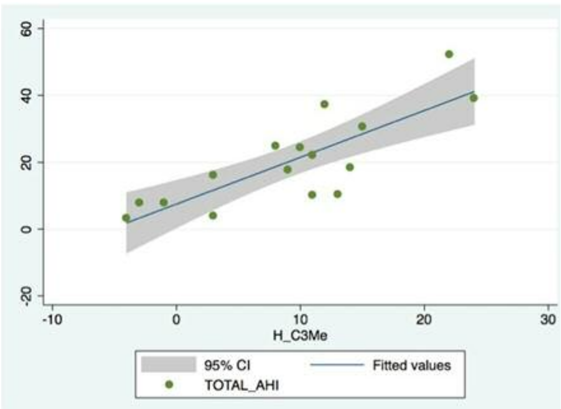

Figure 2
Graph about the correlation between AHI and the distance between the hyoid bone and the C3Me line. Directly correlated variables.

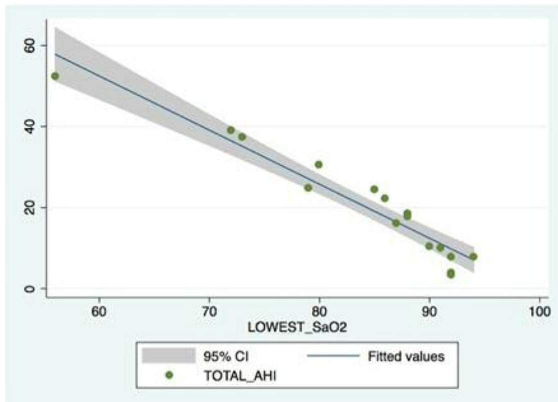

Figure 4
Graph about the correlation between AHI and the lowest O2 saturation observed. The two values are inversely correlated with the worsening of the pathology: as AHI increases, O2 saturation decreases.

Conclusions

The identification of the caudal position of the hyoid bone in relation to the straight line can be considered an alarm bell in the diagnosis of severe OSAS, when immediately highlighted. It is also true that so far it has not been possible to understand if this position of the hyoid bone is the cause or the consequence of OSAS yet.

When MP-H is > 20, and so the hyoid bone is below the C34Me line and when we have IPAS < 11 mm and SAS < 13 mm, the chance or the risk for OSAS dramatically increases (35).
For what concerns the second aim of the study, to highlight the existence of a concordance between ORL diagnosis of the level of obstruction observed with ApneaGraph and the cephalometric values about airways (IPAS and SAS), our results, even though statistically non-relevant, de-

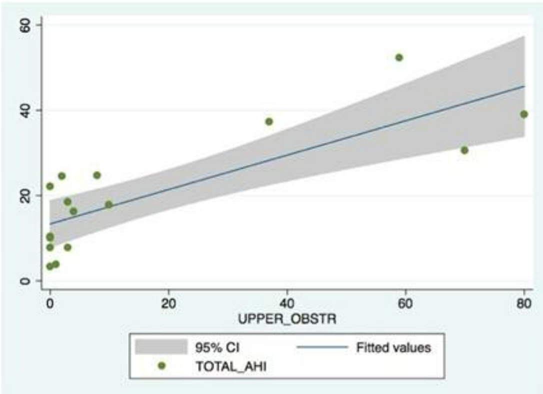

Figure 5
Graph about the correlation between AHI and upper apneas. Positively correlated variables.

Table 12 - Concordance between number of apneas/hypopneas observed with AG and SAS measurements.

PATIENT	SAS	UPPER	% UPPER
6	10	109	87,9
7	6	217	79,4
10	9	23	85
13	8	22	45,6
15	8	211	80
12	13	137	64

serve further study. In fact, of the 6 patients displaying higher percentage of upper apneas and hypopneas, 5 of them also showed a reduction in SAS; of the 5 patients with a higher percentage of lower apneas and hypopneas, 4 of them also showed reduced IPAS.
These values are in line with literature which demonstrates the relevance of the obtained data (36).

Table 11 - Correlations in patients with OSAS between obstructive site and percentage of apneas/hypopneas recorded with ApneaGraph.

PATIENT	TOTAL AHI OF 7h	IPAS	SAS	LOWER	UPPER	% LOWER	% UPPER
6	124	14	10	4	109	3,2	87,9
7	273	4	6	2	217	0,73	79,4
8	171	10	9	97	13	56,7	7,6
9	155	15	9	80	15	51,61	9,67
10	27	12	9	0	23	/	85
11	366	17	11	28	84	7,65	22,9
12	214	14	13	46	137	21,49	64
13	173	6	8	79	22	45,66	45,6
14	113	8	8	72	13	63,71	11,5
15	261	19	8	0	211	/	80
16	129	6	11	55	33	42,63	25,5

(grey)	Patients in whom there is no correlation
(yellow)	Patients in which there is a relationship between the high percentage of apneas and hypopneas high with a reduction of the value of the SAS
(green)	Patients in which there is a relationship between high percentage of apneas and hypopneas low with a reduction of the value of IPAS

Table 13 - Concordance between number of apneas/hypopneas observed with AG and IPAS measurements.

PATIENT	IPAS	LOWER	% LOWER
8	10	97	56,7
13	6	79	45,66
14	8	72	63,71
16	6	55	42,63
9	15	80	51,61

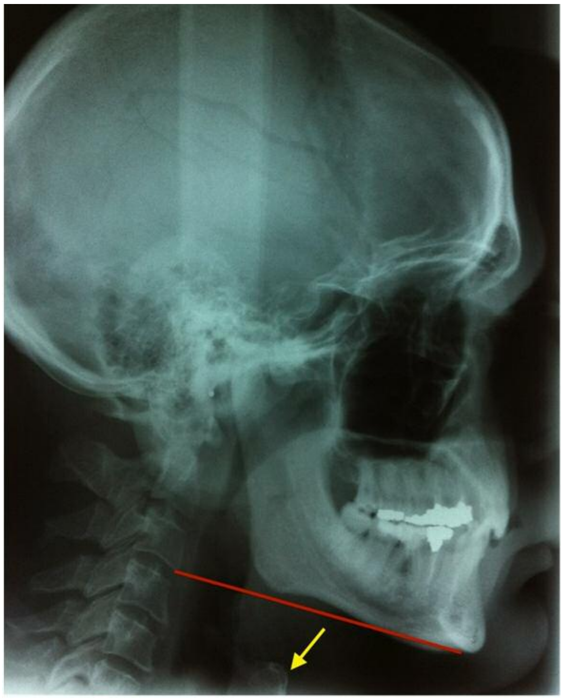

Figure 6
OSAS patient (indicated in our study by the number 11) where we observe that the hyoid bone, indicated by the yellow harrow, is located lower than the C3e line, highlighted in red.

Figure 7
OSAS patient (indicated in our study by the number 9) where we observe that the hyoid bone, indicated by the yellow harrow, is located lower than the C3e line, highlighted in red.

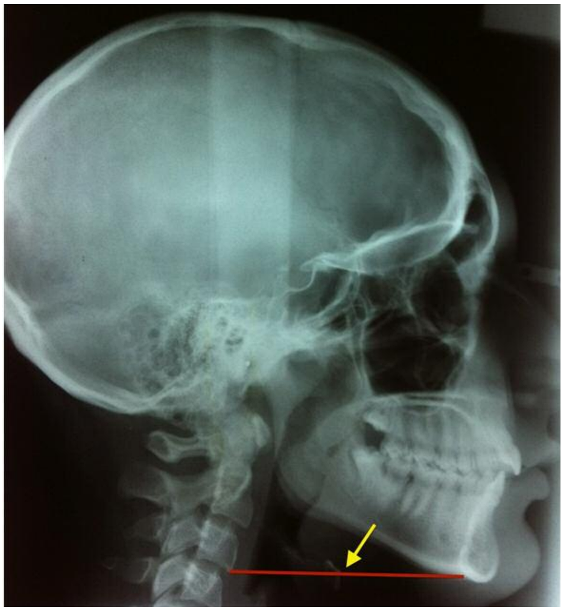

Figure 8
Simple Snoring patient (indicated in our study by the number 5) where we observe that the hyoid bone, indicated by the yellow arrow, is included in the C3Me line highlighted in red.

Our future aim will be to increase the number of patients in both groups as to confirm these preliminary data and follow our patients after the execution of the treatment plan, both surgical and medical, after the multidisciplinary identification of the obstruction site.

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