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Research Paper

The Relationship between Obstructive Sleep Apnoea hypopnoea Syndrome and the Cranio-Cervical Morphology in Adults: *Angular Measurements*

Medical Science

KEYWORDS : Sleep Apnoea Cranio-cervical Lateral cephalometric

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ABSTRACT

Obstructive Sleep ApnoeaHypopnoea Syndrome (OSAHS) is a potentially life-threatening breathing disorder, caused by repeated upper airway occlusion during sleep. The gold standard for diagnosis is the polysomnography which is expensive.The development of alternative diagnostic methods would therefore appear to be a worthy goal, and indeed this subject has received a great deal of attention within the recent literature.

Aim: To determine if there are significant differences in cranio-cervical morphology between the OSAHS and the controls and to suggest possible skeletal morphology for the OSAHS patients.

Material and method : Sixty five lateral cephalometric radiographs of subjects (white Caucasian males aged between 35-65 years) who had been referred to Edinburgh Royal Infirmary Sleep Centre for polysomnographic testing were retrospectively selected at random between September to December 2002.

Results: Statistically significant correlations were found when measuring angular variables between the OSAHS subjects and the control group. Investigation of the angular relationship between the measurements and the OSAHS severity, revealed significant results of clinical interest.

Conclusion: subjects with OSAHS demonstrated significant alterations in cranio-cervical form that may reduce the upper airway dimensions and subsequently impair upper airway stability and function.

Introduction

Lateral cephalometric radiographs have been used by several investigators in an attempt to identify morphological parameters that might be characteristic of OSAHS.The cranial base may be short (Bacon et al., 1988) and the cranial base angle reduced (Jamieson et al., 1986). Battagel JM, (1996) reported that cranial base angle (Ba-S-N) was significantly smaller (3.7°) in OSAHS subjects and the length of the anterior cranial base reduced (2.4mm). This indicates a shortening of the antero-posterior dimension of the cranium and thus a more retruded face.Rivlin et al., (1984), reported decrease in mandibular body length. Battagel JM, (1996) found reduced mandibular body length (Go-Me) by 5.9mm in the OSAHS group (*P* = 0.002). Recording this distance in the horizontal plane, to take into account variations in mandibular plane inclination, the same differences were found. Gonion to menton was 6.6mm shorter and Gonion to point B was 5.6mm less in apnoeic individuals.Bimaxillaryretrusion (Lowe et al., 1986a; De Berry-Borowiecki et al., 1988) or retrognathia of the mandible alone have been reported (Jamieson et al., 1986; Tsuchiya et al., 1992). Battagel JM, (1996) found thatintermaxillary space length-the distance between the posterior pharyngeal wall and the lingual aspect of the lower incisor at the level of the occlusal planewas 5.7mm shorter in OSAHS subjects (*P*=0.001) and the intermaxillary space area was reduced, by 4.1cm^2, indicating a lack of vertical compensation for the diminished antero- posterior development.

A comprehensive cephalometric analysis of cervico-craniofacial skeletal morphology in 100 male patients with obstructive sleep apnoea (OSA) and 36 male controls was performed, with aberrations in the OSA group features are; shorter dimension of cranial base with slight counter-clockwise rotation and depression of clivus; shorter maxillary length with normal height; maxillo-mandibular retrognathia related to nasion perpendicular plane (N⊥FH) despite normal angles of prognathism; 47% of the OSA group had mandibular retrognathia; increased anterior lower facial height and mandibular plane angle; reduced size of bony pharynx; inferiorly positioned hyoid bone at C4–C6 level; deviated head posture with larger cranio-cervical angle, and came with the conclusion that cephalometric analysis is highly recommended in OSA patients as one of the most important tools in diagnosis and treatment planning (Tangugsorn et al., 1995).

The aim of this study is to determine if there are significant differences in cranio-cervical morphology between the OSAHS and the controls and to suggest possible skeletal morphology for the OSAHS patients.

Materials and Methods

All the lateral cephalograms were taken using a SiemansOrthophos CD at the Royal Infirmary of Edinburgh Radiography Department which has a cephalostat with intensifying screen and motorizes adjustable grid. The KVP (peak kilo-voltage) was adjusted to optimise the contrast of both hard and soft tissues. The distance from the focus to the median plane was (60 inches) and from the median plane to the film was (12 inches) (Proffit, 2000). The subject was standing upright with 'natural' head position that is the 'natural' posture of the head when standing with the visual axis being horizontal (Broca, 1862). Such a standardized position has been investigated by Solow and Tallgren (1971), who provided a detailed description of the method. Initially the subject assumes the "orthoposition" defined by Molhave (1958) as the 'intention' position from standing to walking. The median plane parallel to the film with the maximal intercuspation of the teeth and lips in light contact, and in natural head position (Moorees and Kean, 1958). A possible lateral head tilt or rotation was prevented by means of a cross-light beam projected onto the face and finally, the bilateral ear rods were gently inserted onto the external part of the auditory meatus to stabilize the head posture during exposure. All lateral cephalograms were taken before any medical or surgical intervention.

Radiographs were traced, oriented with the maxillary plane horizontal and skeletal points identified (Fig. 1). Definitions of the landmarks are given in the accompanying legend. Points were digitized twice (one week interval) in a predetermined sequence to a tolerance of 0.2 mm and the mean value taken.

The reference points and lines used in this research are given in Table (1 and 2). The definitions are taken from Solow, 1966; Solow and Greve, 1979; Lyberg et al., 1989. Some unfamiliar landmarks, planes and measurements which are not described in these papers are described and explained in details.

The material for this study comprised the anomaly group, control group, cephalogram, lateral cephalometric films, computer and software, x-ray viewer, and the accessories. The sample of the anomaly and the control were not restricted in any way by malocclusion but it was decided that due to the nature of the variables chosen, subjects would all be dentate. This was to maintain standard cephalometric tracing in all subjects.

All subjects were previously diagnosed with OSAHS by polysomnographic diagnostic sleep studies(Edinburgh Sleep Laboratory) before presenting to the orthodontic clinic.The group consisted of 65 white Caucasian male adults' and their age ranged between 35-65 years.Subjects had not undergone any surgery for the treatment of OSAHS.

The control subjects were asked if they had ever been known to snore. This was verified whenever possible by a sleeping partner. The group consisted of 30 white Caucationmale adults' between 20-35 years, matched for age and sex to the anomaly group;all subjects were in good medical health and did not suffer from any airway disease.

The lateral cephalogramic radiographs were taken using a SiemansOrthophos CD at the Royal Infirmary of Edinburgh Radiography Department which has a cephalostat with identifying screen and motorizes adjustable grid. The KVP (peak kilo voltage) was adjusted to optimize the contrast of both hard and soft tissues. The distance from the focus to the median plane was 60 inches, (152 cm) and the median plane to the film was 15 cm, (Proffit, 2000).

The lateral cephalometric films used in this study were Konica, 18 × 24 cm, Konica Europe GmbH, Friedrich-Bergius-Str., Gewerbgebiet, 85662Honenbrunn, Germany. The films were stored in a cool, dry place and adequately protected from x-rays, Gamma rays and others. The internal film package was retained for additional light protection.

Computer and software: Toshiba portable computer was used with Centrino™ mobile technology. Microsoft® windows® XP with Microsoft Office 2003 software.

Statistical software: SPSS for windows version 14.0 (Norusis MJ), [Prentice-Hall Inc., A Simon & Schuster Company, Upper Saddle Drive, New Jersey, USA].

Model: light box, from RMO® by Numonics Corporation, 101 Commerce Drive, Montgomeryville, Pa 18936, USA. Serial no: 047776, Voltage: 220 V , Hz: 50 – 60, Amperes: 1A.

Accessories: Tracing papers. Pencils (Staedtler, Noris 122, made in Germany), easy to sharpen with high break resistance.Eraser (Faber – Castell, made in Germany), 7092 vinyl eraser.Ruler (Crystal, India), 20cm - 8".Protractor 180° (Maped, China).60° set square (Maped, China).Pensilsharpner (Maped, China).Celluloid adhesive tape (Eagle® TY – 895).

Cephalometric Analysis: Radiographs were traced to allow identification of specific points and planes, which in turn allowed appropriate measurements to be made. Tracing was performed in a darkened room on a well-illuminated viewing screen / tracing box using good quality acetate tracing paper and a 4H pencil. Nine hard tissue points were identified (Table 1) which allowed the plotting of the 5 reference planes necessary for the measurements required, (Figure 1).

All measurements were adjusted for magnification factor, which could be measured directly from radiographs through the inclusion of a perpendicular ruler (Figure 1). This was found to be consistent at 10%.

Table 1.The Landmarks

Land-marks	***Description***
N	*Nasion: The most anterior point of the fronto-nasal suture.*
S	*Sella: The midpoint of the sellatursica.*
Or	*Orbitale: The deepest point on the infra-orbital margin.*
Po	*Porion: The uppermost, outermost point on the bony external auditory meatus*
ANS	*Anterior Nasal Spine: The tip of the anterior nasal spine.*
PNS	*Posterior Nasal Spine: The tip of the posterior nasal spine.*
cv2sp	*The most posterior-superior point on the corpus of the 2nd cervical vertebra.*
cv2ip	*The most inferior-posterior point on the corpus of the 2nd cervical vertebra.*
cv4ip	*The most inferior-posterior point on the corpus of the 4th cervical vertebra.*

Table 2. The Reference

Lines (Planes)	***Description***
NSL	NasionSella Line. The line through points N and S.
FH	Frankfurt Horizontal. The line through point Or and Po.
NL	Nasal Line (Maxillary Plane). The line connecting ANS with PNS.
CVT	Cerv Cervical Vertebra Tangent, which passes through cv2sp andcv4ip.
OPT	Odontoid Process Tangent, which passes through cv2sp and cv2ip.

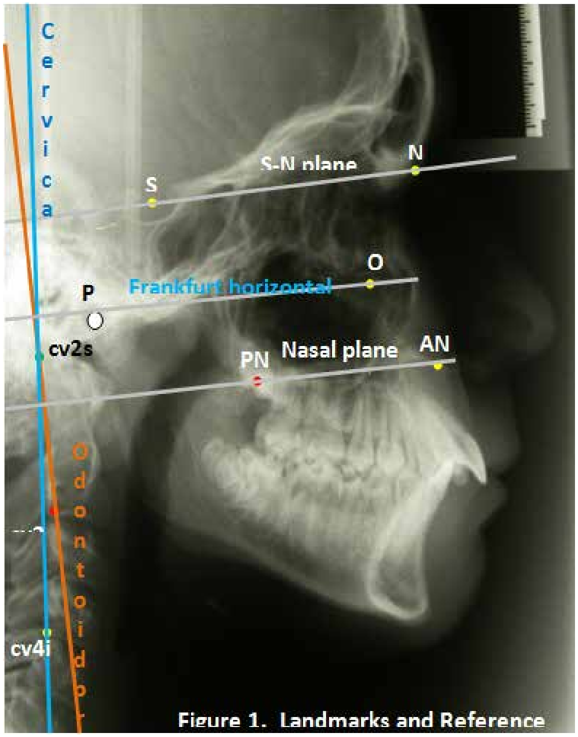


Figure 1. Landmarks and Reference

Table 3. The Angular Measurements

Angles	*Description*
NSL / OPT	The angle between the Nasion Sella line and the Odontoid process tangent.
FH / OPT	The angle between Frankfurt horizontal and the Odontoid process tangent.
NL / OPT	The angle between the Nasal line and the Odontoid process tangent.
OPT / CVT	The angle between the Odontoid process tangent and the Cervical Vertebra tangent.
NSL / CVT	The angle between the Sella-Nasion line and the Cervical Vertebra tangent.
FH / CVT	The angle between Frankfurt horizontal and the Cervical Vertebra tangent.
NL / CVT	The angle between the Nasal line and the Cervical Vertebra tangent.

Results

Sixty five patients and 30 healthy controls were selected for this study. The range age for the OSAHS group was 40-65 (median 47.5) years, 20-30 (median) space between 30 and (years.)

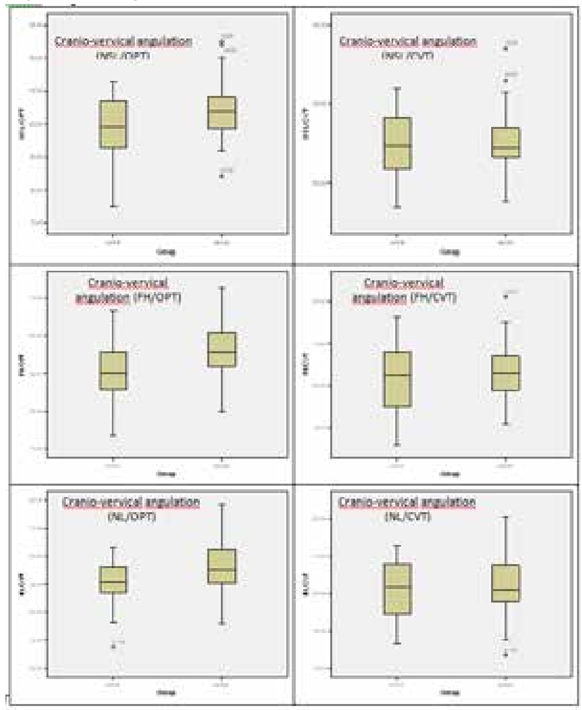
Cranio-cervical angulations

Descriptive data for the variables expressing the posture of the head and the cervical column for the OSAHS and the control are listed in Tables 4 and 5 and expressed in Figure 2.

The cranio-cervical angles were ***larger*** in the OSAHS group than that of the control and have shown significant correlation results with special high significances to NSL/OPT, FH/OPT andNL/OPT.

The independent- t- test have shown significant result in relation to the angles formed with the OPT than those with the CVT.

Figure 2. Angulations with OPT and CVT



Cervical curvature

The angle of the cervical curvature (OPT/CVT) of the OSAHS group has shown to be ***smaller*** than that of the control group, mean 6.46°, 10.60, SD 3.17498 and 4.41861 respectively, with a highly significant result *P=0.0001**** (Fig. 3, Tables 4 and 5).

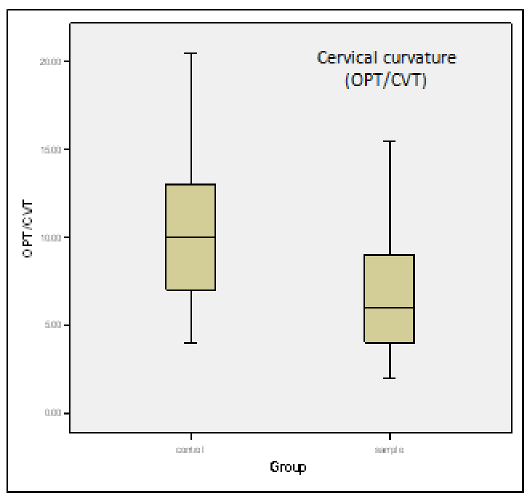


Figure 3. Cervical Curvature

Table 4. Comparison of Angular Measurements between OSAHS and the Controls

Group		Mean	Std. Deviation	N	*P* value
NSL/OPT	control	99.0667	8.70566	30	0.0103
	sample	103.8154	7.98953	65	
FH/OPT	control	91.2500	8.55182	30	0.0023
	sample	96.5385	7.17162	65	
NL/OPT	control	90.4667	7.86408	30	0.0028
	sample	95.8462	7.94951	65	
NSL/CVT	control	110.000	8.40874	30	0.8741
	sample	110.262	7.00060	65	
FH/CVT	control	102.183	8.29362	30	0.5295
	sample	103.138	6.09385	65	

NL/CVT	control sample	101.400 102.458	7.56626 7.04657	30 65	0.5081
OPT/CVT	control sample	10.6000 6.4615	4.41861 3.17498	30 65	0.0001

The angle formed with the OPT and cervical curvature angulations of the OSAHS group have expressed high significances when compared with the controls, where the angles formed with the CVT have shown no significances. This is show more forward downward facial tilt.

Table 5. ***Pearson Correlation Coefficient***

	NSL/OPT	FH/OPT	NL/OPT	NSL/CVT	FH/CVT	NL/CVT
FH/OPT	0.889**					
NL/OPT	0.901**	0.856**				
NSL/CVT	0.860**	0.704**	0.731**			
FH/CVT	0.757**	0.836**	0.699**	0.863**		
NL/CVT	0.754**	0.670**	0.843**	0.869**	0.811**	
OPT/CVT	-0.506**	-0.552**	-0.520**	-0.011	-0.040	-0.013

** P<0.001

The angles are highl correlated except of the angles formed with CVT and the cervical curvature angle.

Discussion

Cephalometric radiography has a long tradition as a diagnostic and follow-up technique in the study of cranio-cervico-facial morphology (Broadbent, 1931) and in the surgical management of cranio-facial deformities (Burstone et al., 1978). Availability of normative data and the possibility of superimposition of long-term serial records have given this method a unique position (Behrents 1985a and 1985b).Recently, several reports regarding the deviated cephalometric data of OSAHS patients have been published with some controversies (Maltais et al., 1991; Davies and Straddling, 1990). Consequently, a comprehensive study of the subject to solve some of these controversies is needed.

The characteristic appearance of the typical patient severely affected by obstructive sleep apnoea / hypopnoea syndrome led Osler (1901) to characterize this condition as 'Pickwickian' according to the novel by Charles Dickens (1836) in which such a condition was described. Subsequently the term 'Pickwick syndrome' has sometimes been used for OSAHS. Although no formal description of the head posture in this condition has been made, an extended head posture is generally recognized by clinicians as being a characteristic feature of the appearance of patients with obstructive sleep apnoea (Cote, 1988).

In the field of Orthodontics, the natural head posture is of interest from two aspects:Firstly, in the diagnostic assessment of facial aesthetics in orthodontic and orthognathic surgery treatment plan. Secondly, in the assessment of the role of head posture in postnatal facial morphogenesis.

In assessment of facial aesthetics, emphasis is laid on the posture of the head in relation to a gravity-determined true vertical.

Several cephalometric analyses have been developed for the purpose of performing such aesthetic assessments of the maxillary and mandibular protrusion in relation to a gravity-determined true vertical (Moorees et al., 1976; Cooke and Wei, 1988; Lundstrom and Lundstrom, 1989).It may be noted, however, that widely differing means of the cranio-cervical angulation have been reported by different authors. A survey by Solow and Tallegran (1971a) of means for NSL/VER in five different studies showed a range from 89.6º to 102.4º. This can be taken to indicate that the cranio-vertical angle is particularly very sensitive to differences in methodology for recording of head posture.

Assessment of facial protrusion in relation to a gravity-determined vertical thus would seem to require further standardization of the positioning procedures used in such studies.

The role of head posture in facial development has been demonstrated in a series of studies which provide for the existence of a sequence of events comprising: obstruction of the upper airways; increase in the cranio-cervical angulation; vertical direction of the facial development.

It is important to notice, however, that the posture involved in this sequence of events is the position of the head in relation to the cervical column. Changes in this angle are mediated by changes in the cranio-vertical and in the cervico-horizontal angles. An increase in cranio-cervical angulation thus can be mediated by an extension of the head in relation to the true vertical, by a forward inclination of the cervical column or by a combination of both.

An increase in the cranio-cervical angle can be triggered by various types of obstruction of the upper airway. One reason for this physiological mechanism could be that such a change in posture will increase the diameter of the airway and thus reduce the airway resistance. Another reason could be that, observed by Ricketts (1968), an increase in the cranio-cervical angle will lift the head away from the hyo-mandibular complex and thus, facilitate the transition from nasal breathing to mouth breathing which occurs in many subjects with a larger upper airway resistance caused by nasal or naso-pharyngeal obstruction.

Studies of head posture in subjects with adenoidal obstruction have demonstrated an average increase in cranio-cervical angulation of about 2° (Solow B and Greve E, 1979; Woodside D and Linder-Aronson S, 1979). This increase is mediated by an increase in the cranio-vertical relationship, whereas the average cervical inclination is not affected. After adenoidectomy this extended head posture in the obstructed children has shown to normalize. Thus, in individual children a reduction of the cranio-cervical angle of up to 9º has been found (Solow B and Greve E, 1979).

It has long been known that various kind of craniofacial anomalies are closely related to upper airway obstruction which may lead to the OSAHS condition. Craniosynostosis syndrome such as Crouzon or Apert (Schafer ME, 1982), Pierre Robin syndrome (Lapidot A and Ben-Hur N, 1975), and Treacher Collins syndrome (Johnston et al., 1981) were among these.

This present study provides further evidence for the suggestion that obstruction of the upper airway may trigger an increase in the cranio-cervical angulation. Six cranio-cervical angles were statistically different in the OSAHS group when compared to the control with special significance to the angles formed with the OPT. The large difference in cranio-cervical angulation was mediated by a forward inclination of the cervical column. A physiological requirement for a major increase in cranio-cervical angulation due to airway obstruction therefore can only be met by a forward inclination of the cervical column.

A similar mechanism, in head tilting mediates minor changes in head posture whereas larger changes are mediated by changes in cervical inclination, was observed in a study of how subjects produced the change in head posture from the self-balance position to the mirror position (Solow B and Tallegran A, 1971b).

The angle of the cervical curvature (OPT/CVT) has shown to be reduced in the OSAHS group (mean 7º, SD 3.05), when compared to the control (mean 10.9º, SD 4.91). This further shows forward positioning of the head. Solow et al. (1993) also found this angle to be lesser in the OSAHS group mean 4.5° and SD 2.91. Tangugsorn et al., (1995) got a different result, increased (OPT/CVT) angle in the OSAHS (100 patients, mean 3.55°, SD 2.96) than the control (36 patients, mean 1.08°, SD 2.96). Sakakibara et al., (1999) found (OPT/CVT) to be also reduced in the obese OSAHS group (mean 1.1°, SD 2.6), than the control (mean 1.5°, SD 3.1), and they have also found this angle to be more reduced in the non-obese OSAHS group (0.9°, SD 1.9).

Conclusion

These differences could be summarized as follows:-

Increased cranio-cervical angulations in general with marked increase in the angles formed with OPT, decreased cervical curvature (CVT/OPT), which shows further forward positioning of the head and counter clockwise rotation of the craniofacial complex.

The article recommends further studies in the use of lateral cephalometric radiograph analysis of the hard (cranio-cervico-facial morphology and hyoid bone position) and soft tissues (pharyngeal width, tongue and soft palate length) using different cephalometric analysis to further aid in the diagnosis and treatment of OSAHS.

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