ORIGINAL ARTICLE

CORRELATION BETWEEN SADDLE ANGLE AND MINIMAL CROSS SECTION AREA OF THE UPPER AIRWAY

Zahra Khalid, Usman Ahmed*, Ayesha Anwar

Armed Forces Institute of Dentistry, *Margalla Institute of Health Sciences, Rawalpindi, Pakistan

Background: The relationship between airway and facial morphology is one of the components of facial skeleton that has extensively been debated in the literature. Studying this relationship to find conclusive results has clinical importance. Hence, the current study was carried out with the objective to determine association between saddle angle and the cross-section area of upper airway as assessed on Cone beam Computed Tomography. **Methods:** It was a descriptive cross sectional study in which sixty patients (38 males, 22 females) who met the inclusion criteria were included through non-probability purposive sampling. Cephalometric landmarks (Nasion, Sella and Basion) were identified on the sagittal view of Cone beam Computed Tomography software to calculate the cranial base angle. The Minimal Cross-section Area of the upper airway was calculated at the level where the soft palate drops down posteriorly. Pearson correlation coefficient was applied to see the correlation between saddle angle and minimal cross section area of the upper airway, and $p \leq 0.05$ was considered significant. **Results:** There were 38 (63.3%) males and 22 (36.6%) females with a mean age of 30.5±14.9 years. The mean values of saddle angle and minimal cross-section area were 129.7° and 207.9 mm^2 respectively. The mean value of saddle angle recorded in the females and males was 131.5°±5.9 and 128.9°±5.8 respectively and the median values were 131.6° and 129.1° respectively. There was positive and significant correlation between saddle angle and the cross-section area of upper airway ($r=0.34$, $p=0.007$). **Conclusions:** The cranial base angle is positively correlated with airway cross section. Saddle angle on a lateral cephalogram can give an indication of an upper airway patency problem without having need to expose the patient to an excessive radiation dosage as of a Cone Beam Computed Tomography.

Keywords: Saddle angle, Upper airway, Airway cross section area, Cone Beam Computed Tomography

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INTRODUCTION

Upper airway obstruction is associated with many dental and skeletal malocclusions. The malocclusions caused by upper airway obstruction can be addressed and corrected at different stages of dentitions using various types of appliances and orthodontic techniques and it is recommended to recognise and remove the problems related to upper airway at an early age.[1] The relationship between airway and facial morphology is one of the components of facial skeleton that has extensively been debated in the literature.[2] It has been documented that cranial base flexure angle is associated with the sagittal relationships of maxilla and mandible.[3] This indicates that a relationship might also exist between the cranial base angle and upper airway morphology.

The routine lateral cephalometric radiograph is used for calculating saddle angle but research has proven that this may be an unreliable diagnostic tool for estimating upper airway patency as it does not take into account the mediolateral dimension of the upper airway.[4] Cone Beam Computed Tomography (CBCT) on the other hand provides a cross-sectional image of upper airway in axial plane which provides a better understanding of its shape and structure.[5]

If an association between cranial base morphology and upper airway can be established, then it may highlight the patients having upper airway problems. This would be helpful for orthodontists to diagnose airway problems on a lateral cephalogram which exposes the patient to a radiation dosage of only 3 microsieverts[6] as opposed to a CBCT which exposes to a radiation dosage of 84 microsieverts (small field of view) to 212 microsieverts (large field of view).[7]

The objective of this study was to determine a relationship between saddle angle and the cross-section area of upper airway as assessed on CBCT.

MATERIAL AND METHODS

It was a descriptive cross-sectional study conducted from Mar to May 2016 after getting approval from Ethical Review Committee of Armed Forces Institute of Dentistry, Rawalpindi. Written informed consent was obtained from all participants. Sixty patients were included in the study by checking record of CBCT through non-probability purposive sampling. Patients who had any sort of breathing difficulty, upper airway obstruction, craniofacial syndromes or trauma of head and neck were excluded. CBCT scans were obtained in a standing position for all patients. Newtom software was used to study the CBCT images, and cephalometric landmarks were identified.[8]

The cranial base angle was measured on the sagittal section. The landmarks of Nasion, Sella and

Basion were marked and the angle was measured automatically by the software. Minimal cross-sectional area (MCA) was calculated at the end-curvature point (ECP) of the soft palate where the soft palate drops inferiorly.[9] (Figure 1). Gridlines were superimposed on the cross-section which was automatically calibrated by the software. (Figure-2)

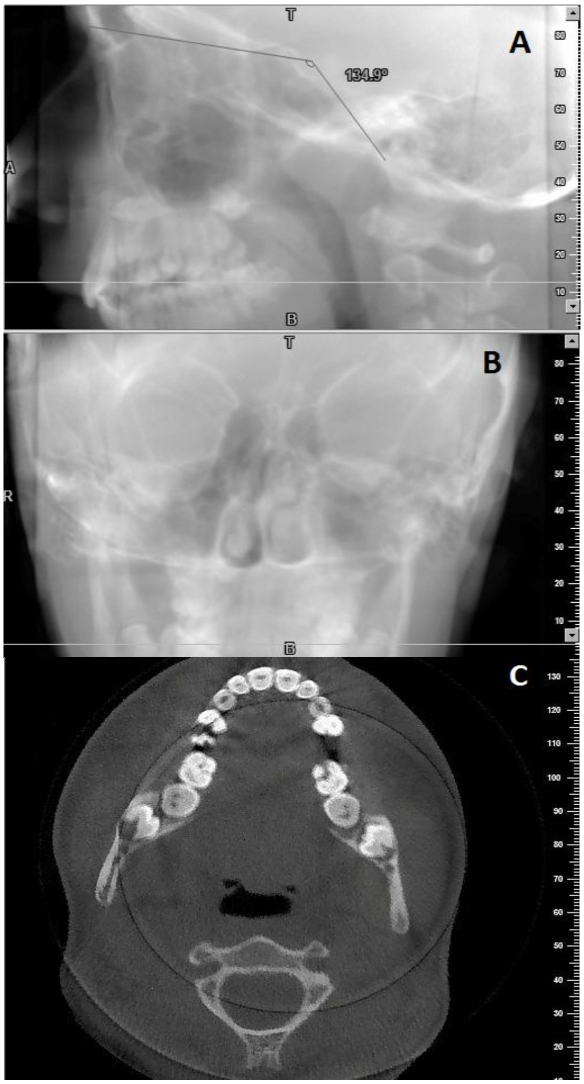

Figure-1: Sagittal view on a CBCT (A) showing saddle angle (Na-S-Ba), with a horizontal line at end curvature point of soft palate (A, B) where MCA is measured (C)

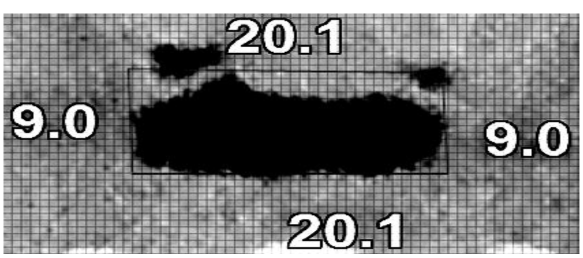

Figure-2: Calculation of minimal cross-section area of the upper airway using the CBCT software

Area was calculated by simple mathematical formula: C + (0.5) P, where 'C' is the number of squares completely covered and P is the number of squares at the boundary.

All statistical analyses were performed using SPSS-21. Means and standard deviation were calculated for all the numerical variables. The frequency and the percentage distribution of the MCA and saddle angle were calculated separately for both male and female patients. Pearson correlation coefficient was estimated to determine the correlation between saddle angle and MCA. The statistical significance of the correlation was tested by keeping $p \leq 0.05$ as statistically significant.

RESULTS

There were 38 (63.3%) males and 22 (36.6%) females with a mean age of 30.5±14.9 years. The mean values of saddle angle and minimal cross-sectional area were 129.7° and 207.9 mm^2 respectively. The mean value of saddle angle recorded in the females and males was 131.5°±5.9 and 128.9°±5.8 respectively and the median values were 131.6° and 129.1° respectively (Table 1).

There was positive and significant correlation between saddle angle and the cross-section area of upper airway (r=0.34, p=0.007).

Table-1: Saddle angle and MCA in subjects

Parameters	Females			Males		
	Mean	SD	Median	Mean	SD	Median
Saddle angle	131.52	5.95	131.6	128.69	5.85	129.1
MCA	188.07	99.08	176.8	219.38	176.51	179.7

DISCUSSION

The cranial base angle or the saddle angle is measured radiographically between the points Nasion, Sella and Basion. The value of this angle at birth is approximately 142° but reduces to 130° at around 5 years of age.[10] It remains stable from 5 to 15 years of age.[11] The cranial base angle has been shown to influence the craniofacial morphology, the type of malocclusion and thus transitively the airway.[12] Thus, a relationship between saddle angle and airway cross-section area could be speculated.

Our results showed the saddle angle positively correlated with minimal cross-section area at the level of soft palate. This could be because as the point Basion is moved posteriorly, it positions the attached soft tissue posteriorly, thus increasing the saddle angle, the area between the distal most aspect of soft palate and posterior pharyngeal wall increases. This is in contradiction with some other studies who showed that minimal cross-section area was negatively associated with sagittal jaw relationship, that is patients with class III skeletal pattern, with smaller saddle angle, have a greater airway volume[13] and more flat shaped airway, whereas Class I patients have a more square shaped airway.[14]

Previous work has shown that patients with obstructive sleep apnoea have a smaller saddle angle and are characterised by upper airway stenosis.[15] Thus, patients with a significantly smaller saddle angle can be speculated to develop or have some airway patency issues. Banabilh *et al*[16] showed that functional airway impairments are predominantly associated with the morphology of the posterior regions of the airway, whereas some studies[8] have highlighted no relationship between the skeletal pattern and airway.

Lateral cephalogram has been a prosaic diagnostic tool for airway evaluation in orthodontics. There is a tendency to believe that the two-dimensional nature of this diagnostic modality does not give a true representation of the complexity of the airway. The use of CBCT has been in vogue for quite some time now and it is shown to give a new insight into the landmarks not visible on conventional two dimensional lateral cephalograms.[17] Our results suggest that saddle angle on a lateral cephalogram can be a harbinger of some airway inadequacy which can be further investigated if required on a CBCT thus exposing only a few patients to additional radiation dose.

We calculated the cross-section area of the airway at the end-curvature point. This is in consonance with Banabilh *et al*[16] who showed that the maximum decrease in airway occurs in the nasopharyngeal area at the level of soft palate. The area at this level decreases by 58% as opposed to oropharyngeal area at the level of base of tongue and hypopharyngeal area at the level of hyoid bone where the area decreases by 32% and 23% respectively.[16] There is a positive correlation between saddle angle and cross-section area of the airway albeit it is prone to landmark identification errors especially of the point Basion and errors related to a crude method of cross-section area calculation. Thus, this needs to be investigated further overcoming these limitations.

Because pharyngeal airway is not regularly three dimensionally assessed in orthodontic clinics, the results of this study can help identifying the right patients who need to be subjected to more comprehensive three dimensional investigations for detailed analysis of the airway.

CONCLUSION

Saddle angle has a positive correlation with minimal cross-section area of the upper airway. Saddle angle on a lateral cephalogram gives an indication of an upper airway patency problem reducing the need to expose the patient to additional radiation dose of a CBCT.

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Address for Correspondence:

Dr Zahra Khalid, Resident, Department of Orthodontics Armed Forces Institute of Dentistry, Rawalpindi, Pakistan.
Tel: +92-321-2997621
Email: zahrakhalid26@gmail.com

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