ISSN: 1812–1217

The Relation Between Cervical Vertebral Body Morphology and Craniofacial Parameters in Normal and Deep Bite Patients

Khawla M.Awni
BDS, MSc. (Asst. Prof.)
Pedod, Orthod and Preve Dentistry Department
College of Dentistry, University of Mosul

Hind T. Jarjees
BDS, MSc. (Asst. Prof.)
Pedod, Orthod and Preve Dentistry Department
College of Dentistry, University of Mosul

Enas T. Muhseen
BDS, MSc (Lect.)
Pedod, Orthod and Preve Dentistry Department
College of Dentistry, University of Mosul

الخلاصة

الاهداف: تهدف الدراسة الى وصف شكل العمود الفقري العنقي في المرضى البالغين ذوي الاطباق العميق والاطباق الطبيعي, معدل انتشار هذه الاشكال بينهم ولتحليل العلاقات بين شكل الفقرات العنقية والقياسات الوجهية القحفية. **المواد وطرائق العمل**: تكونت عينة هذه الدراسة من مجموعتين,مجموعة الاطباق الطبيعي التي تكونت من (٥٠) بالغا (٢٥ ذكرا و٢٥ انثى) تراوحت اعمارهم بين (١٨- ٢٥) سنة ومجموعة الاطباق العميق التي تكونت من (٥٩) بالغا (٢٠ ذكرا و٣٩ انثى) تراوحت اعمارهم بين(١٨- ٢٥) سنة. أخذت صور شعاعية جانبية للرأس لكلا المجموعتين. استخدمنا (١٢) متغيرا, (١١) زاوية وقياس خطي واحد. قيم شكل العمود الفقري العنقي بالفحص العيني للفقرات العنقية الخمسة الاولى والتي من الممكن رؤيتها في الصورة الشعاعية الجانبية للرأس. **النتائج**: كان لاصحاب الاطباق العميق (٤و٥٣) ٪ تلاحم بين الفقرات الثانية والثالثة مقارنة بـ (٩و١٢) ٪ لاصحاب الاطباق العميق, و(٢و٢٣) ٪ نقص في القوس الخلفي للفقرة الاولى مقارنة بـ(٣٥و٥) ٪ لاصحاب الاطباق العميق. وجدت علاقات نسبية بين تلاحم الفقرات والزاوية المحصورة بين المستوى الحنكي ومستوى الفك السفلي, الزاوية بين الطول القطري للقاطع العلوي الاول والمستوى الحنكي والمسافة بين الحافة القاطعة للقاطع العلوي والسفلي. كذلك كانت هناك علاقة نسبية بين النقص الخلفي للفقرة الاولى والزاوية المحصورة بين المستوى الحنكي ومستوى الفك السفلي , الزاوية بين مستوى الفك السفلي والخط الذقني ,زاوية الفك السفلي والزاوية بين الطول القطري للقاطع العلوي الاول والمستوى الحنكي. **الاستنتاجات**: الانحرافات الشكلية للعمود الفقري العنقي حدثت كثيرا في الاطباق العميق مقارنة بالاطباق الطبيعي. اشارت النتائج الى ان الانحرافات الشكلية للعمود الفقري العنقي (الالتحام ونقص في القوس الخلفي للفقرة الاولى) له علاقة ليس فقط بأنحرافات الفكين ولكن ايضا بالشكل الوجهي الدماغي والاطباق.

ABSTRACT

Aims: The aims of the present study were to describe the morphology of the cervical column in adult patients with a skeletal deep and normal bite occlusion, the prevalence of these morphology within them and to analyse the associations between the morphology of the cervical column and craniofacial parameters. **Materials and Methods:** The sample of this study composed of two groups, deep bite and normal over bite. The normal or control group composed of 50 adult subjects (25 males and 25 females) aged 18-25 years. The deep bite group composed of 59 adult subjects (20 males and 39 females) aged 18-25 years. Lateral cephalometric radiograph were taken for both normal and deep bite groups. We used 12 variables 11 angular and 1 linear measurements. The morphology of the cervical column was evaluated by visual inspection of the first five cervical vertebrae as they are normally seen in on a standardized lateral cephalometric radiograph. **Results:** In the skeletal deep bite group, 53.4 per cent had fusion of the cervical column and 23.2 per cent posterior arch deficiency (partial cleft). The fusion always occurred between C2 and C3. In the normal over bite group, 12.9 per cent fusion of the cervical column and 5.35 per cent of posterior arch deficiency, the fusion always occurred between C2 and C3. The significant correlations were seen between fusion and the angle between palatal plane and mandibular plane, the angle formed between the long axis of upper central incisor and palatal plane and the distance between the incisal edges of upper and lower central incisors, also the significant correlation between posterior arch deficiency and the angle between palatal plane and mandibular plane, the angle between the mandibular plane and chin line, gonial angle and the angle formed between the long axis of upper central incisor and palatal plane. **Conclusions:** The deep bite group had more deviations of the cervical column than the normal group. Our results showed that the craniofacial parameters, occlusion and malformations of the jaws were affected by morphological deviations of the upper cervical vertebrae including fusion and posterior arch deficiency.

Key words: Cervical vertebrae, Normal bite, Deep bite

Awni KM, Jarjees HT, Muhseen ET, The Relation Between Cervical Vertebral Body Morphology and Craniofacial Parameters in Normal and Deep Bite Patients. *Al-Rafidain Dent J.* 2013; 14(3): 448-455.
Received: 30/5/2013 ***Sent to Referees:*** 6/6/2013 ***Accepted for Publication:*** 8/10/2013

INTRODUCTION

Cephalometric radiographs, a key element of orthodontic diagnosis, contain useful information related to the cervical spine often neglected by orthodontists and medical specialists.[1] The radiographic appearance of congenital anomalies of the cervical vertebrae on lateral planar radiographs has been described in detail, for example, anomalies of the vertebral bodies due to defects in fusion or normal segmentation, occipitalization of the atlas, basilar impression, odontoid malformations, atlas malformations, spina bifida, and abnormal ossifications[2,3]. Recently, there has been increased interest in the study of anomalies of the cervical vertebrae in the orthodontic literature, probably stemming from the demonstrated association between such anomalies and craniofacial syndromes, non-syndromic congenital anomalies, such as clefts, and also conventional orthodontic malocclusions[4,5,6,7]. Interstudy differences in the prevalence of these anomalies are large and difficult to explain; they could be attributed to true population differences or to methodological errors, arising from the choice of plain visual assessment as the method of evaluation.[8] Deviations of the cervical column morphology occur in healthy subjects with neutral occlusion and normal craniofacial morphology as well as patients with craniofacial syndromes, deviating craniofacial morphology, and severe malocclusion traits. Recent study found that fusions between the upper cervical vertebrae (C2 and C3) occurred in 14 % of healthy subjects. Fusions of the upper cervical column within that range are thus considered normal. [9] Morphologic deviations of the upper cervical vertebrae are not only associated with malformation of the jaws but also with craniofacial morphology and occlusion.[10]

The aims of the present study were to describe the morphology of the cervical column in adult patients with a skeletal deep and normal bite occlusion, the prevalence of these morphology within them and to analyse the associations between the morphology of the cervical column and craniofacial parameters.

MATERIALS AND METHODS

The sample of this study composed of two groups, deep bite and normal over bite. The normal or control group composed of 50 adult subjects (25 males and 25 females) aged 18-25 years, the selection criteria were the followings:

1. Class I molar and skeletal relationship (ANB=0^o-4^o).
2. Normal occlusion or minor malocclusion not requiring orthodontic treatment (over jet 1-4mm,over bite 1-3mm,crowding/ spacing less than 3mm).
3. No previous history of orthodontic treatment.
4. No obvious craniofacial anomalies.
5. Accessibility of a lateral cephalometric radiograph with the five first cervical vertebrae units visible.
6. Iraqi adults lived in the Mosul City.

The deep bite group composed of 59 adult subjects (20 males and 39 females) aged 18-25 years. The selection criteria were the followings:

1. No previous history of orthodontic treatment.
2. Deep bite was measured by taking the linear measurement from the incisal edge of the lower central incisor to the occlusal plane (5mm or more)[11,12].
3. At least 24 permanent teeth present (excluding second and third molars).[13]
4. No obvious craniofacial anomalies.
5. Accessibility of a lateral cephalometric radiograph with the five first cervical vertebral units visible.[13]
6. Iraqi adults lived in the Mosul City.

Lateral cephalometric radiographs were taken for both normal and deep bite groups (the cephalometric machine was STRATO X:Model 2000-Italy). Twelve variables, 11 angular and 1 linear measurements were used:

Angular cephalometric measurements:

1. SNA:Anteroposterior position of the maxilla in relation to anterior cranial base[14].
2. SNB: Anteroposterior position of the mandible in relation to anterior cranial base.[14]
3. ANB: The differences between SNA and SNB angles.[14]
4. SN-Pog:It determines the basal position of the mandible to the anterior cranial base.[14]
5. SN-MP: Mandibular plane angle.[14]
6. SN-PP: Palatal plane angle.[15]
7. PP-MP: The angle between palatal plane and mandibular plane.[15]
8. NSBa: The anteroinferior angle, is formed by the intersection of SN and SBa lines.it indicates the configuration of the cranial base.[16]
9. MP-Cl: The angle between the mandibular plane and chin line (the tangent to the chin through id).[17]

10. Ar-Go-Me: Gonial angle.[15]
11. U1PP: The angle formed between the long axis of upper central incisor and palatal plane.[15]

linear cephalometric measurements:

OB: The distance between the incisal edges of upper and lower central incisors, measured in millimeters.[18]

The morphology of the cervical column was evaluated by visual inspection of the first five cervical vertebrae as they are normally seen in on a standardized lateral cephalometric radiograph. Characteristics of the cervical column were classified according to the method of Sandham,[19] and divided into two categories:

1.*Posterior arch deficiency*, defined as partial cleft and dehiscence.[19] Partial cleft is defined as failure to fuse of the posterior part of the neural arch Figure (1,3), and dehiscence is defined as failure to develop of a part of a vertebral unit.

2.*Fusion anomalies*, defined as fusion, block fusion, and occipitalization.[19] Fusion is defined as fusion of one unit with a another at the vertebral bodies, articulation facets, neural arch, or transverse processes Figure (2,4).

Figure (1):A profile radiograph illustrating a partial cleft of the posterior part of the neural arch of the atlas (p).[10]

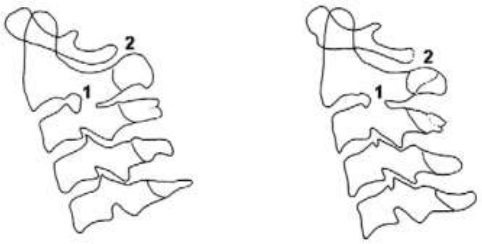

Figure (3): 1.Fusion of C2 and C3. 2.Partial cleft of C1.[29]

Figure (2): A profile radiograph llustrating fusion of the C2 and C3 vertebrae (F).[10]

Figure (4): Fusion of C2 and C3.[8]

Atypical vertebra is composed of a body, a short cylinder anteriorly, and the vertebral arch that is attached to each side of the body posteriorly.The space enclosed by the body and the arch is the vertebral foramen. The atlas or C1 lacks a body and a spinous process and consists basically of an anterior and a posterior arch.The axis or C2 is a typical with a distinguishing feature, the dens or odontoid process, that fits in the place of the absent body of the atlas.[1]

Tracing technique is taken for drawing the cervical spine in a lateral cephalometric radiograph.[1] Fusions between the cervical

vertebrae were identified cephalometrically as osseous continuities, without complete separation at the intervertebral disk or at the articular surfaces,while Posterior arch deficiency is defined as failure to fuse of the posterior part of the neural arch.[2,3]

The reliability of the measurements was assessed by remeasuring 25 lateral cephalometric radiographs after 15 days which were selected from the previously measured radiographs (the selection was randomly), t-test at $p<0.01$ and $p<0.05$ level of significant was used. No significant differences were found between the two measurements.

Analysis of data by using SPSS software was done including descriptive statistics (means and standard deviations) of all measurements for males, females and total group. Comparison between normal and deep bite group were done using independent samples t-test at $p> 0.01$ and $p>0.05$ level of significant .Fishers exact test was used for cervical anomalies. Spearman correlations were examined for inter relationships between morphology of the cervical column and craniofacial measurements, correlation is significant at $p> 0.01$ and $p>0.05$ level of significance.

RESULTS

Table (1) and (2) describe descriptive statistics (means and standard deviation) and t-test between normal and deep bite groups for both sexes and total sample. Significant differences were seen for SN-MP, PP-MP, GO and OB between normal and deep bite groups. Table (3) showes the prevalence of morphological characteristics of cervical column in patients with skeletal deep bite and subjects with normal over bite. 53.4 % of the skeletal deep bite group had fusion of the cervical column and 23.2 % posterior arch deficiency.No statistical gender differences were found between the two groups. 12.9 % fusion of the cervical column and 5.35 % of posterior arch deficiency were found in the normal over bite group. No statistical gender differences were found between the two groups. The morphological deviations of the cervical column occurred significantly more often in deep bite group. Table (4) described the correlations between morphology of the cervical column and craniofacial morphology. Significant correlations were seen between fusion and PP-MP, U1PP and OB, also the significant correlation between posterior arch deficiency and PP-MP, MP-CL, GO and U1PP were noticed.

Table (1): Descriptive statistics (means and standard deviations) and p-value in normal and deep bite groups for total sample.

Variables	Deep biteMean	SD	Normal bite Mean	SD	t-value	p- value
SNA	82.58	4.47	81.37	3.53	1.86	0.16
SNB	80.18	4.19	79.08	3.66	3.05	0.43
ANB	2.39	1.38	2.29	0.60	-1.44	0.17
SN-Pog	78.94	4.17	79.52	2.52	3.20	0.77
SN-MP	30.17	5.17	35.24	6.07	4.2	0.03*
SN-PP	9.71	3.76	8.55	3.35	-1.13	0.86
PP-MP	15.84	5.53	23.40	4.79	2.44	0.001*
NSBa	129.71	5.64	129.91	5.64	3.14	0.90
MP-CL	70.16	4.75	71.3	5.1	3.03	0.45
GO	111.58	6.65	123.72	5.30	2.40	0.002*
U1PP	110.73	9.72	112.07	6.04	5.01	0.32
OB	6.13	1.42	3.10	0.75	-1.01	0.02*

*Sig. at P> 0.01 and 0.05 level.

Table (2): Comparison between deep bite and normal bite groups for males and females.

Variables	Sex	Deep biteMean	SD	Normal bite Mean	SD	t-value	p-value
SNA	**Male**	80.71	4.08	80.90	3.73	1.36	0.32
	Female	83.25	4.47	81.86	3.27	1.12	0.40
SNB	**Male**	79.42	3.69	78.48	3.88	1.02	0.22
	Female	80.46	4.37	79.72	3.33	1.21	0.31
ANB	**Male**	1.28	1.05	2.42	1.77	0.12	0.41
	Female	2.79	1.39	2.14	1.56	0.19	0.38
SN-Pog	**Male**	78.07	3.38	79.34	2.55	1.33	0.11
	Female	79.25	4.42	79.67	2.49	1.25	0.17
SN-MP	**Male**	30.63	5.61	35.64	5.00	2.17	0.001*
	Female	29.69	4.66	35.10	6.47	2.01	0.002*
SN-PP	**Male**	9.85	2.37	8.88	3.15	0.66	0.13
	Female	8.48	4.16	7.76	3.40	0.45	0.20
PP-MP	**Male**	16.64	5.90	24.62	4.38	2.17	0.02*
	Female	15.56	5.45	22.18	4.22	1.99	0.01*
NSBa	**Male**	129.50	5.43	130.11	6.45	0.06	0.15
	Female	129.79	5.78	129.69	4.69	0.30	0.11
MP-CL	**Male**	69.07	4.66	70.32	4.30	1.09	0.24
	Female	70.92	5.97	71.62	5.12	1.21	0.30
GO	**Male**	112.85	6.16	124.96	5.67	1.90	0.002*
	Female	111.48	6.89	122.41	4.58	1.80	0.001*
U1PP	**Male**	112.57	7.68	113.20	4.81	1.20	0.12
	Female	108.71	10.25	110.95	7.02	1.49	0.19
OB	**Male**	6.42	1.28	3.35	0.72	2.11	0.002*
	Female	5.88	1.41	2.90	0.75	1.89	0.003*

*Sig. at P ≤ 0.01 and 0.05 level.

Table (3): Comparison of morphological characteristics of cervical column in patients with skeletal deep bite and subjects with normal over bite (Fishers exact test).

Variables	Sex	Deep bite group	p-value	Normal bite group	p-value	Deep bite group Total	Normal bite group Total	p-value
Normal	**Male**	44.7%	0.33	85.4%	0.66	46.6%	87.1%	0.002*
	Female	49.2%		88.8%				
Fusion anom-alies	**Male**	55.3%	0.16	14.6%	0.17	53.4%	12.90%	0.001*
	Female	50.8%		11.2%				
Posterior arch deficiency	**Male**	24.4%	0.50	7.12%	0.19	23.2%	5.35%	0.003*
	Female	21.2%		4.9%				

* P < 0.05

Table (4): The correlations between morphology of the cervical column and craniofacial measurements.

Variables	Fusion	Posterior arch deficiency
SNA	-0.12	-0.11
SNB	+0.19	+0.20
ANB	+0.20	+0.18
SN-Pog	+0.14	+0.19
SN-MP	-0.15	-0.18
SN-PP	-0.13	-0.20
PP-MP	-0.35**	-0.27*
NSBa	-0.14	-0.20
MP-CL	-0.16	-0.31*
GO	-0.16	-0.30*
U1PP	-0.39**	-0.35**
OB	+0.47**	-0.13

* $P \leq 0.05$ ** $P \leq 0.01$

DISCUSSION

1.Craniofacial dimensions:

No Statistical gender differences between cephalometric measurements within the group were found. This result was contrary to previous studies.(11,20) SN-MP, PP-MP and GO angles in this research was higher in normal bite group than in deep bite group which comes in agreement with Loufty (1973)[21] for SN-MP and disagreement with Beane etal., (2003)[22] for PP-MP and Bishara (2001) [23] for GO angle who showed no significant differences between the two groups. Forward or horizontal and upward mandibular growth rotation leads to decrease of these angles in deep bite groups.[15,24]

2.Morphology of the cervical column:

The fusion of the cervical column occurred always between C2 and C3 for both deep and normal bite groups. On some instances, fusion occurred not only between C2 and C3 but also between C3 and C4 in 9 %, in addition to occipitalization. The cause for these different patterns of morphological deviations of the cervical column is unknown. [9] Sonnesen and Kjaer said that the cervical column morphology differs phenotypically in the different types of skeletal malocclusion.[7] The cause of these malformations that occured in the cervical column with different frequencies is unknown. The vertebral bodies were formed around the notochord, and thus the notochord might be responsible for their location and morphology in the prenatal period.[25] Previous studies found that different genes act in different regions, which might be the focus of future studies on the pathogenesis.[26]

Significant differences in the sagittal jaw relationship were seen when two vertebrae are fused.[27] Klimo et al.,(28) considering that most fusions at the C2 and C3 level remain asymptomatic and do not require any intervention.

3.Correlations between morphology of the cervical column and craniofacial measure -ments.

Some studies showed that there were an association between malformations of the upper cervical vertebrae and malformation of the maxilla, due to the developmental fault of the mesenchyme,[19] because the areas dependent on the same paraxial mesoderm. [25] In the present study there were an association between morphological deviations of the upper cervical vertebrae, craniofacial morphology and deep bite, Which means that the morphological deviations of the upper cervical vertebrae are associated with malformation of the jaws , craniofacial morphology and occlusion.Our results were closer to the results showed by Sonnesen and Kjaer, in which 41.5% had fusion of the cervical vertebrae and 9.8% had posterior arch deficiency. [13] Recently, an association has been shown between malformation of the upper cervical vertebrae and condyle, as the cranial base angle was significantly positively correlated

with fusion of the cervical column,[9] also the mandibular retrognathia, cranial base angle, and over jet were correlated with fusion of the cervical column,[29] maxillary retrognathia and increased maxillary inclination also correlated with cervical column morphology,[7] and also fusion between C2 and C3 was associated with a large sagittal jaw relationship, and occipitalization was associated with retrognathia of the jaws and a large inclination of the jaws.[10]A significant correlation exists between cervical vertebrae anomalies and skeletal malocclusions. Therefore, genetic studies relevant to the formation and development of the head and neck during embryonic and fetal periods may help to better understand this correlation.[30]

The relation found in the present study between the cervical column, deep bite, and vertical craniofacial morphology may be due to the signalling from the notochord to the neural crest cells for the craniofacial dimensions before the notochord is surrounded by bone tissue and disappears.(25,31) The cause of these migration of the neural crest cells is still unknown.(10)

CONCLUSIONS

The percentage of the fusion of the cervical column that occurred between C2 and C3 in the deep bite group was 53.4 % and 23.2 % of posterior arch deficiency. Deviations of the cervical column occurred significantly in the deep bite group compared with the normal group. PP-MP, MP-CL, GO, U1PP and OB were significantly correlated with fusion of the cervical column. The results showed that deviations of the cervical column , fusion of C2 and C3 and posterior arch deficiency are associated with craniofacial dimensions,occlusion and deviations of the jaws.

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