Original Research

Craniofacial Changes after Combined Atlas-Orthogonal and Biomimetic Oral Appliance Therapy

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Abstract

Objective: There are several chiropractic techniques available to improve head and neck alignment but none use a combined approached in conjunction with an oral appliance. A previous study demonstrated synergistic effects of biomimetic oral appliance therapy (BOAT) and transdermal atlas positioning procedures (TAPP) on leg length discrepancies in adults. Therefore, this current study investigates changes in head and neck alignment using Cartesian analysis, to test the hypothesis that combined TAPP and BOAT improves craniofacial alignment in adults.

Subjects and Methods: A consecutive series of 11 adults (mean age 39.5yrs; 4 female, 7 male) were included in this study. Each subject was evaluated for the presence of malocclusion by a dentist, and also for the presence of an atlas subluxation by an atlas-orthogonal (AO) chiropractor. Pre-management cranio-cervical relationships were evaluated from frontal, horizontal and axial radiography, using strict positioning and analysis protocols. Following pre-management assessment, each subject was treated for atlas subluxation by an AO chiropractor, and the radiographic procedure was repeated. Next, the subject inserted the oral appliance (a DNA appliance®) and the radiographic procedure was repeated. For radiographic assessment, craniofacial parameters were calculated: pre-care (T0); after AO adjustment (T1), and finally after oral appliance insertion (T2).

Results: Of the following individual parameters: Atlas cephalic displacement; Un-leveling/atlas frontal plane line; Cephalic tilt; Cervical spine-atlas angle; Cervical spine angular rotation; Axis (C2) rotation, and Atlas-foramen magnum angular rotation, showed improvements at both T1 and T2. The initial, total Z- and Y-axis discrepancy for the sample had a mean value of $22.7^0 \pm 7.4$. After AO adjustment (T1), the mean change in craniofacial alignment improved to $9.7^0 \pm 6.3$ ($p < 0.001$) but combining AO adjustment with the oral appliance (T2), the mean change in craniofacial alignment improved further to $6.0^0 \pm 4.1$ ($p < 0.001$). The total, mean decompensation was found to be 68.2%.

Conclusions: When a biomimetic oral appliance is used in combination with AO adjustment, there appears to be a synergistic effect that significantly improves craniofacial alignment in adults. However, further studies are required to corroborate these preliminary findings.

Keywords: *Atlas orthogonal, chiropractic adjustment, oral appliance therapy, biomimetic*

Introduction

In a systematic review, Moon and Lee[1] determined that dental occlusion/temporo-mandibular joint (TMJ) status exert an influence on head, jaw and other muscles for proper body posture, as well as body equilibrium (balance), center of gravity fluctuation, and horizontal gaze stability. In contrast, Marini et al.[2] suggest that occlusal interference does not influence body posture. Earlier, Manfredini et al.[3] proposed that the reason why posturographic techniques and devices have not found firm associations between body posture and dental occlusion is due to compensation mechanisms occurring within the neuromuscular system regulating body balance. However, it has been suggested that disorders of the masticatory system, such as malocclusions, can influence body posture, and some studies show associations between occlusal factors and postural alterations, but there is not enough scientific evidence to support a causal relationship[4].

Tingey et al.[5] undertook measurements of mandibular rest position in males with Class I occlusion/skeletal patterns, and normal TMJ function. Jaw movements were tracked using an optoelectric computer system, and their results showed that the pattern of jaw movement is influenced by head support and body postures. Thus, a tentative relationship appears to exist between jaw position and body posture, and in to order to synchronize these two components, cranio-cervical relationships need to be evaluated objectively.

Similarly, Kibana et al.[6] examined the relationship between occlusal support and head posture, using an electromagnetic tracking instrument with 6-degrees-of-freedom. They reported that with lateral imbalance of occlusal support, EMG activity of the jaw closing muscles and sternocleidomastoid (SCM) muscle on the occlusal support side was greater than those on the non-occlusal support side, and the neck was bent in the direction of the occlusal support side. Thus, lateral imbalance of the occlusal support may promote imbalance in SCM activity, causing lateral bending and contralateral rotation of the neck from the ipsilateral, hypertonic SCM.

This postural compensational effect was also observed by Maeda et al.[7] along the postural (spinal and pelvic) kinetic chain, as observers experimentally-induced postural and occlusal changes using 1mm increment heel lifts. Based on their findings, it was concluded that leg length discrepancy affected pelvic tilt, body posture and occlusion in a predictable, ipsilateral fashion with a discrepancy as little as 4mm. From these studies, it is suggested that there is a close relationship between occlusal support, head posture and body posture.

In this present study, we define compensation as deviation or displacement from the ideal physiological rest points, which can be measured in degrees. Thus, craniofacial discrepancies/deviations from normal axes during resting posture are likely representative of craniofacial postural compensation. Therefore, the aim of this study is to investigate changes in head and neck alignment, to test the hypothesis that combined atlas-orthogonal and BOAT improves head and neck alignment in adults.

Methods and Sample

For this study, we recruited 14 consecutive subjects that reported to a multi-disciplinary clinic for chiropractic consultation. The rights of the subjects were protected by following the Declaration of Helsinki.

In addition, the following inclusion criteria were applied: adults >21yrs diagnosed with atlas subluxation (following clinical examination by a chiropractor); no history of hospitalization for craniofacial trauma or craniofacial surgery; no congenital craniofacial anomalies, and fully-dentate upper and lower arches. The exclusion criteria included: age <21yrs; positive history of cervical surgery; and drug therapy for vestibular dysfunction, balance and equilibrium. After obtaining informed consent, a clinical history was taken, as well as a chiropractic examination and a craniofacial examination for each subject. In addition, pre-treatment craniocervical relationships were assessed using standard, frontal, horizontal and axial radiography, using strict, upper cervical chiropractic positioning protocols.

Each subject was assessed for the presence of a Type 1 atlas subluxation (atlanto-axial rotation ≤ 3mm), and a transdermal atlas positioning procedure (TAPP), which reduces the atlas cephalic displacement (ACD) and atlas-axis distortion (AXSP) around Cartesian axes, was performed by an atlas orthogonist following a positive diagnosis. The atlas subluxation assessment consisted of 4 definitive examinations: 1) bilateral scanning palpation of the posterior sub-occipital regions in the area superficial to the C1 nerve root, the vertebral arteries and the dorsal root ganglion of C2; 2) George's vertebro-basilar insufficiency test; 3) supine leg length assessment against a fixed grid with photographic record; and 4) radiographic and/or cone-beam computerized axial tomographic scan (CBCT) assessment. Following pre-treatment assessment, each subject was treated for atlas subluxation by a chiropractor and the radiographic procedure was repeated.

Each subject was evaluated also for the presence of malocclusion by a dentist, and a DNA appliance® was prescribed following a positive diagnosis. The DNA appliance (Fig. 1) putatively differs from traditional dental appliances[8] as it has a biomimetic approach that has been successfully deployed in children[10] and adults[11-16] in an attempt to mimic or harness developmental mechanisms.

The DNA appliance is preferentially worn for approx. 12-16hrs during the afternoon, evening and at nighttime, but not during the day and not while eating, partly in line with the circadian rhythm of tooth eruption[17]. Thus, following chiropractic and craniofacial examination, a DNA appliance was custom-fabricated and delivered by a dentist. Therefore, the subject inserted the oral appliance and the radiographic procedure was repeated after occlusal equilibration of the appliance by a dentist.

For radiographic assessment, the following parameters were calculated pre-treatment (T0); after chiropractic adjustment (but prior to oral appliance insertion; T1), and finally after oral appliance insertion (T2):

- Z-axis: Atlas cephalic displacement (ACD)
- Z -axis: Un-leveling/atlas frontal plane line (APL)
- Z-axis: Cephalic tilt
- Z-axis: Cervical spine-atlas angle
- Z-axis: Cervical spine angular rotation
- Y-axis: Axis (C2) rotation
- Y-axis: Atlas-foramen magnum angular rotation

These parameters are illustrated in Figure 1 and Figure 2. From these measurements the following additional parameters were calculated:

- Total craniocervical discrepancy: Pre-treatment (T0)
- Change in discrepancy: Post-adjustment/pre-appliance (T1)
- Change in discrepancy: Post-adjustment/post-appliance (T2)

All findings were subjected to statistical analysis using paired t-tests.

Figure 1. Craniocervical relationships were evaluated objectively from frontal, horizontal and axial radiography. Components are thought to be in a decompensated state when adjacent structures such as the spinal segments and the cranial base are perpendicular and without angular rotation.

Results

From the consecutive series of 14 patients, three were excluded from the study as two did not meet the age criteria, and one had a history of craniofacial trauma. The mean age of the study sample was found to be 39.5yrs, comprising 4 females and 7 males.

Table 1 shows that all craniofacial parameters assessed improved significantly after both AO adjustment (T1) and oral appliance therapy (T2) individually. For example, the atlas cephalic displacement (ACD) improved from $2.5^{0} \pm 1.9$ to $1.1^{0} \pm 1.1$ ($p < 0.01$) at T1 and to $0.5^{0} \pm 0.7$ ($p < 0.001$) at T2.

Similarly, un-leveling/atlas frontal plane line (APL) improved from $3.2^{0} \pm 2.3$ to $1.8^{0} \pm 1.7$ ($p < 0.05$) at T1 and to $0.9^{0} \pm 1.6$ ($p < 0.001$) at T2. The Cephalic tilt improved from $1.5^{0} \pm 1.3$ to 0.9 ± 1.1 ($p < 0.01$) at T1 and to 0.7 ± 1.0 ($p < 0.05$) at T2.

In addition, Cervical spine-atlas rotation improved from $3.1^{0} \pm 2.6$ to 1.6 ± 1.7 ($p < 0.05$) at T1 and to 0.6 ± 0.6 ($p < 0.01$) at T2.

Similarly, the Cervical spine angle improved from $3.6^{0} \pm 2.8$ to 2.1 ± 1.5 ($p < 0.01$) at T1 and to 0.8 ± 0.9 ($p < 0.001$) at T2. As well, Axis (C2) rotation improved from $6.6^{0} \pm 4.9$ to 2.8 ± 4.9 ($p < 0.01$) at T1 and to 1.5 ± 2.5 ($p < 0.001$) at T2. Finally, the Atlas-foramen magnum rotation improved from $2.3^{0} \pm 1.9$ to 1.8 ± 1.7 ($p < 0.05$) at T1 and to 1.0 ± 1.3 ($p < 0.001$) at T2. These parameters are illustrated in Figure 1 and Figure 2.

Table 2 shows the initial, total Z- and Y-axis discrepancy for the sample had a mean value of $22.7^{0} \pm 7.4$. After AO adjustment (T1), the mean change in craniofacial alignment improved to $9.7^{0} \pm 6.3$ ($p < 0.001$) but combining AO adjustment with the oral appliance (T2), the mean change in craniofacial alignment improved further to $6.0^{0} \pm 4.1$ ($p < 0.001$). The total, mean decompensation was found to be 68.2% ± 18.2. Therefore, as expected the total, mean, craniofacial alignment improved after atlas-orthogonal adjustment and oral appliance insertion, indicating an enhancement of craniofacial alignment after combined atlas-orthogonal and BOAT in adults. The results are summarized in Tables 1 and 2, and in Figure 3.

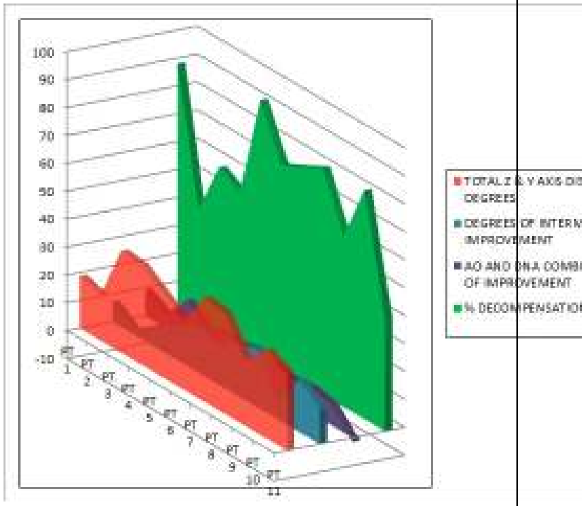

Figure 3.

Discussion

The structural elements of the body are thought to be in a maximally efficient and decompensated state when adjacent structures, such as the spinal segments and cranial base, are perpendicular and without angular rotation. While Amat[18] explored relationships between occlusion and scoliosis, we define ideal bipedal posture using decompensation criteria. Maximum resting postural efficiency occurs when the anatomical mid-sagittal points of the axial skeleton are aligned with the vertical axis and along the midsagittal plane; the axial skeleton is symmetrically distributed outward from the aligned axial skeleton, and the cranium, spine and pelvis are maximally efficient in the sagittal plane through optimization of the primary and secondary spinal curvatures (Fig. 4).

In this study, we define compensation as deviation or displacement from the ideal physiological planes, and these deviations from orthogonality can be measured in degrees and millimeters. Thus, discrepancies and resting posture deviations from normal axes are likely representative of descending craniofacial developmental compensation or ascending postural compensation[19]. But, the roles of components that determine head posture remain controversial. Since our previous study demonstrated synergistic effects of BOAT and TAPP on leg length discrepancies in adults[19], this present study tested the notion that head and neck alignment can also be improved in adults using the same procedure.

For example, Bergamini et al.[20] assessed resting activity of the SCMs, erector spinae and soleus muscles in adults with malocclusions. Their findings confirmed a beneficial effect of occlusal equilibration (with an acrylic wafer) on the postural muscles investigated. Therefore, occlusal and postural factors can affect head alignment, and the findings of our present study (Tables 1 and 2) show that the effect is enhanced when the two modalities are used in conjunction.

In terms of functional impact, Muto et al.[21] investigated the relationship between cranio-cervical inclination and upper airway space. They concluded that an increase of 10^0 in cranio-cervical angulation (or 10mm in C3-Me length) increased the pharyngeal airway space by approx. 4mm in the sagittal plane.

Later, Svanholt et al.[22] analyzed craniofacial profiles and head posture in patients with obstructive sleep apnea (OSA). Patients with fusion of cervical vertebrae (C2 and C3) showed differences in jaw relationship from patients with no fusions, even though both groups exhibited OSA. That study suggests that in patients diagnosed with OSA, jaw position may be used to ameliorate the effects of upper airway obstruction when changes in cervical posture are limited.

But, when Inoko and Morita[23] assessed changes in the cervical spine associated with the use of mandibular advancement devices (MADs) in patients with OSA, cephalometric analysis showed that the craniocervical angles with MADs were larger than those without MADs. It appeared that MADs caused significant flexion of the cranium on the upper cervical spine with a concomitant increase in the craniocervical angle. Their study implies that changes in the craniocervical relationship should be evaluated periodically after a MAD has been inserted, and reflects the protocol adopted in this present study, following our previous findings[10, 12].

Indeed, earlier McGuinness and McDonald[24] studied the effects of rapid maxillary expansion (RME) on natural head position. No significant changes were observed after expansion but one year post-expansion, however, they found a mild change in head posture, possibly due to a change in the mode of breathing from oral to nasal as a result of RME. Thus, a combined TAPP and BOAT may provide a potentially-useful method of capturing an improved upper airway position in adults, and might provide a starting point for managing patients diagnosed with OSA. Further studies will be directed towards identifying this type of clinical protocol.

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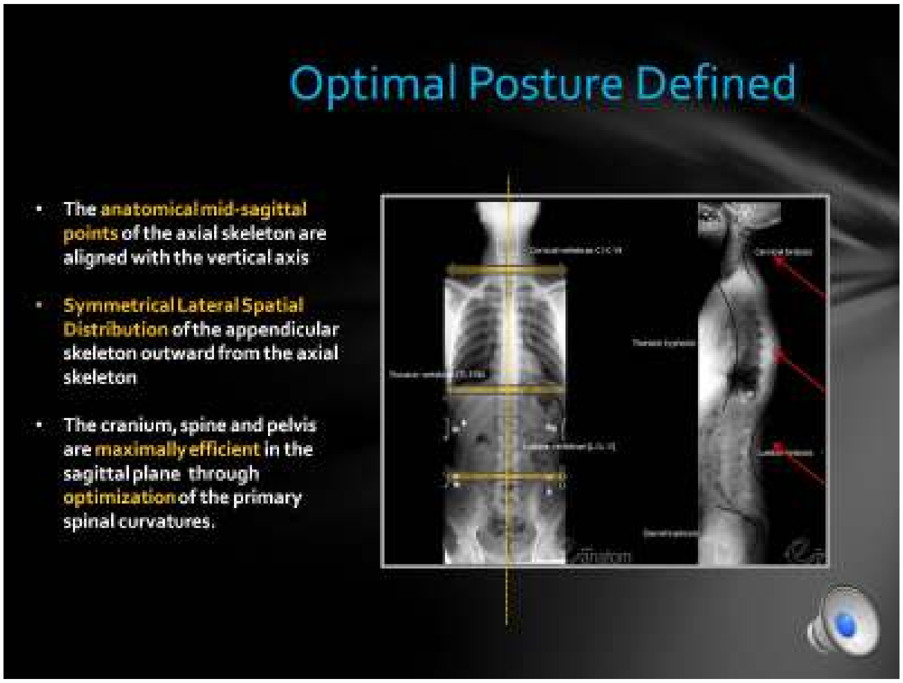
Tables and Figures

Figure 2. The following parameters were measured from the radiographs
Z-AXIS: ACD (ATLAS CEPHALIC DISPLACEMENT)
Z -AXIS: APL (ATLAS FRONTAL PLANE LINE) UNLEVELING
Z-AXIS:CEPHALIC TILT
Y-AXIS AXIS ROTATION
Z-AXIS: CERVICAL SPINE-ATLAS ANGLE
Z-AXIS: CERVICAL SPINE ANGULAR ROTATION
Y-AXIS: ATLAS-FOREMAN MAGNUM ANGULAR ROTATION



Optimal Posture Defined

- The anatomical mid-sagittal points of the axial skeleton are aligned with the vertical axis
- Symmetrical Lateral Spatial Distribution of the appendicular skeleton outward from the axial skeleton
- The cranium, spine and pelvis are maximally efficient in the sagittal plane through optimization of the primary spinal curvatures.

Figure 4. Optimal Posture Defined

Table 1.

C2 ROTATION T0	C2 ROTATION T1	C2 ROTATION T2	ATLAS-FM ROTATION T0	ATLAS-FM ROTATION T1	ATLAS-FM ROTATION T2
2.00	0.75	0.00	4.00	2.50	1.50
2.00	0.75	1.00	2.25	2.25	1.50
15.00	14.00	7.00	4.00	2.50	2.00
11.00	12.00	6.00	4.25	3.00	2.25
13.00	0.00	0.00	3.00	2.75	0.50
9.00	3.00	1.00	2.00	0.75	0.25
14.00	5.00	3.00	6.50	6.50	4.50
10.00	1.00	3.00	0.50	1.00	0.75
8.00	1.00	0.00	0.75	1.50	0.25
7.00	2.00	0.00	0.75	0.00	0.25
1.00	0.00	0.00	4.75	1.75	0.25
6.57	2.82	1.50	2.34	1.75	1.00
4.95	4.89	2.55	1.92	1.69	1.31
	0.0025	0.0001		0.0228	0.0007

Table 2.

TOTAL DISCREPANCY (^{0})		T0	T1	T2	% DECOMPENSATION
SUBJECT					
P 1		18.75	7.25	9.25	88
P2		16.25	1.75	4.75	40
P3		36.50	7.50	14.25	60
P4		35.50	11.75	7.75	55
P5		30.00	16.75	11.00	93
P6		24.50	14.00	4.00	73
P7		37.25	18.75	10.00	77
P8		36.00	21.00	8.25	81
P9		23.75	5.25	9.25	61
P10		31.75	18.75	7.25	82
P11		27.25	12.50	-1.50	40
MEAN		**22.68**	**9.66**	**6.02**	**68.20**
STD		7.4	6.3	4.1	18.2