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Relationship of TMJ osteoarthritis/osteoarthrosis to head posture and dentofacial morphology

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Structured Abstract

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Objective – The purpose of this study was to test the hypothesis that there is a relationship between the temporomandibular joint (TMJ) osteoarthritis/osteoarthrosis (OA), head posture and dentofacial morphology.

Design – Case–control study.

Subjects and Methods – The subjects consisted of 34 Japanese females with TMJ OA (aged 24.7 ± 6.1 years) and a control group of 25 healthy Japanese females (aged 23.6 ± 1.3 years). Six cranio-cervical angular measurements were constructed for head posture analysis. Nine angular and three linear measurements were constructed for the skeletal hard tissue analysis. Five angular and one linear measurements were constructed for the dental hard tissue analysis. Unpaired *t*-tests were used to compare the mean differences of head posture measurements and dentofacial cephalometric measurements between the TMJ OA and the control group.

Results – The TMJ OA group had significantly larger cranio-cervical angles ($p < 0.05$) and had more posteriorly rotated mandibles ($p < 0.0001$) than those in the control group. They also had a significantly shorter posterior facial height ($p < 0.0001$). The TMJ OA group had more retroclined lower incisors ($p < 0.05$).

Conclusion – These results suggest that an association may exist between TMJ OA, head posture and dentofacial morphology.

Key words: dentofacial morphology; head posture; osteoarthritis; osteoarthrosis; temporomandibular joint

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Introduction

Arthritis refers to inflammation of the articular surfaces of a joint. Osteoarthritis is one of the most common arthritis forms, affecting the temporomandibular joint (TMJ), and has been referred to as a degenerative joint disease (1). Although the precise causes of osteoarthritis are unknown, its most common aetiologic factor is generally thought to be overloading of the articular structures of the joint (2–4). When bony changes are active, the condition is often painful and referred to as osteoarthritis. On the other hand, as remodelling occurs, the clinical symptoms can decrease, although the bony changes still remain. This condition is referred to as osteoarthrosis. Radiographic changes are commonly detected in osteoarthritis/osteoarthrosis (OA). Females are more likely to be affected with OA than males (5–8).

The relationship between head posture and temporomandibular disorders (TMD) has been studied in the literature (9–14). Several authors reported the close association between a forward head posture and TMD. Because of this assumption, some clinicians (15, 16) have suggested that correction of the forward head posture was indicated for the reduction of TMD symptoms. On the contrary, Darlow et al. (9) and Hackney et al. (11) stated no significant relationship between head posture and TMD. As there has been lack of the scientific studies to investigate the relationship between head posture and TMD, it appears that the association between them has not yet been clearly established. Armijo-Olivo et al. (17) who conducted a systematic review concerning the association between head and cervical posture to TMD, emphasized that better controlled studies with comprehensive TMD diagnosis, greater sample size, adequate power and objective posture evaluation were necessary. The relationship between deformed condyles and dentofacial morphology has been studied (18–23). This study is the first to investigate the association between TMJ OA which is clearly diagnosed by a radiographic examination and head posture. The purpose of this study was to test the hypothesis that there is a relationship between TMJ OA, head posture and dentofacial morphology by means of a sex- and age-matched case–control study design.

Materials and methods

This study was a retrospective analysis of existing radiographs, and was performed in accordance with the guidelines of the Helsinki Declaration (1996).

Sample size

A sample size calculation was undertaken using nQuery Advisor (Version 6.01; Statistical Solutions, Cork, Ireland). According to our pilot study, the difference in means of cranio-cervical angle was estimated at 7.2° (±7.0). On the basis of significance level of α 0.05 (two-sided) and a β of 0.1, the sample size for each group was calculated to achieve 90% power to detect the standardized effect size of 1.029 (7.2 / 7.0°). The sample size calculation showed that 21 subjects for each group were necessary.

Sample selection

The female sample was selected from the case files of the Department of Orthodontics, Faculty of Dentistry, Kyushu University, Fukuoka, Japan. Their records contained a pre-treatment questionnaire, medical history, pre-treatment facial photographs, cephalograms, dental photographs, panoramic radiographs, transcranial projection radiographs, dental casts, diagnosis and treatment plan. The questionnaire included documentation regarding TMJ pain, TMJ sound and restriction of mouth opening.

Determination of TMJ OA status of each patient was established when bilateral condylar bony changes (flattening, osteophyte and erosion) were evident on the dental panoramic or the transcranial projection radiographs. The radiographs were interpreted by an experienced radiologist who implemented the TMJ OA definitions and scoring system published by Muir and Goss (24). We determined scores of 'one' and 'two' corresponding to 'mild bony change' and 'gross bony change' as constituting TMJ OA (Fig. 1). Some TMJ OA cases, in which radiographic interpretation was ambiguous, were excluded from this study. In this sample, 34 females (aged 24.7 ± 6.1 years) were determined, by our criteria, to have developed bilateral TMJ OA and were assigned to the TMJ OA group. The patients with rheumatoid arthritis, condylar hyperplasia and congenital craniofacial syndrome were excluded from this study. The patients who had undergone a previous orthodontic treatment were also excluded from this study. The prevalence of the subjective signs and symptoms of TMJ dysfunction in the patients with TMJ OA are shown in Table 1.

A control group was selected from dental students and staff members at Kyushu University. Twenty-five healthy Japanese females (aged 23.6 ± 1.3 years) who did not display bilateral radiographic evidence of TMJ OA were included. We defined a normal TMJ by the absence of a

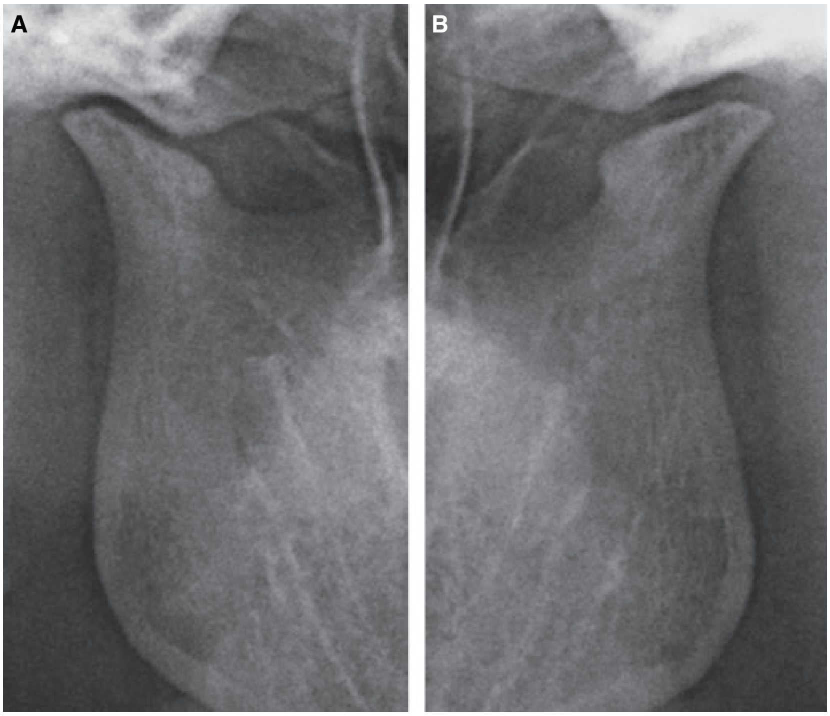

Fig. 1. Examples of TMJ OA: (A) right side of TMJ and (B) left side of TMJ.

Table 1. **Prevalence of subjective signs and symptoms of TMJ dysfunction in patients with TMJ OA**

TMJ OA group (n = 34), %	
TMJ pain	52.9
TMJ sounds	67.7
Restriction of mouth opening	26.5

TMJ OA group, bilateral temporomandibular joint osteoarthritis/osteoarthrosis.

history and symptoms of TMJ dysfunction. These subjects have also never been treated for facial trauma, facial pain, or any other TMJ disorder. Further inclusion criteria were Class I occlusion with minor or no crowding, all teeth present except third molars and no previous orthodontic treatment. The Welch's *t*-test was used to compare the mean difference in age between the TMJ OA and the control group. No significant difference in the mean age was found between the two groups.

Cephalometric analysis

All lateral cephalometric radiographs were taken with the teeth in maximal intercuspation, in a cephalostat with the Frankfort horizontal plane parallel to the floor. The radiographs were taken with a DR-155-23HC (SSR-2B) (Hitachi Medical Co., Tokyo, Japan), and exposed at 100 kV, 10 mA. All radiographs were traced by hand on matte acetate sheets and digitized on a personal computer by one orthodontist, to eliminate inter-examiner variability. Cephalometric analyses were performed with the aid of a cephalometric software program (WINCEPH 5.5) (Rise, Sendai, Japan), on a personal computer. Six cranio-cervical angular measurements were constructed for head posture analysis according to Solow and Tallgren (25) (Fig. 2). Nine angular and three linear measurements were constructed for the skeletal hard tissue analysis (Fig. 3). Five angular and one linear measurements were constructed for the dental hard tissue analysis (Fig. 4). The mean and standard deviations for the cranio-cervical angles and dentofacial cephalometric measurements were determined for each group.

- NSL/OPT, angle between nasion-sella line and odontoid line (line through cv2tg and cv2ip).
- NSL/CVT, angle between nasion-sella line and upper part of cervical spine (line through cv2tg and cv4ip).
- FH/OPT, angle between Frankfort horizontal line and odontoid line.
- FH/CVT, angle between Frankfort horizontal line and upper part of cervical spine.
- NL / OPT, angle between nasal line (line through ANS and PNS) and odontoid line.
- NL/CVT, angle between nasal line and upper part of cervical spine.

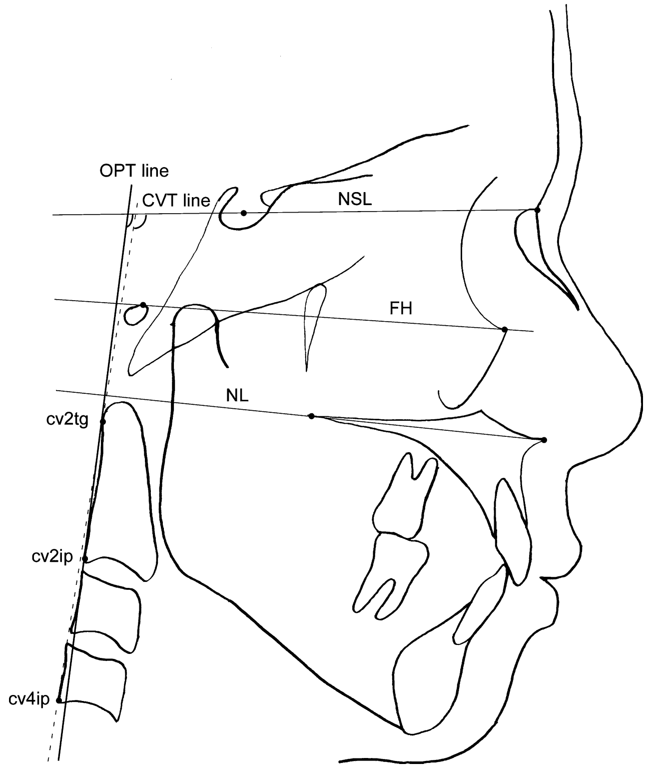

Fig. 2. Head posture measurements: NSL ⁄ OPT, NSL ⁄ CVT, FH ⁄ OPT, FH ⁄ CVT, NL ⁄ OPT and NL ⁄ CVT.

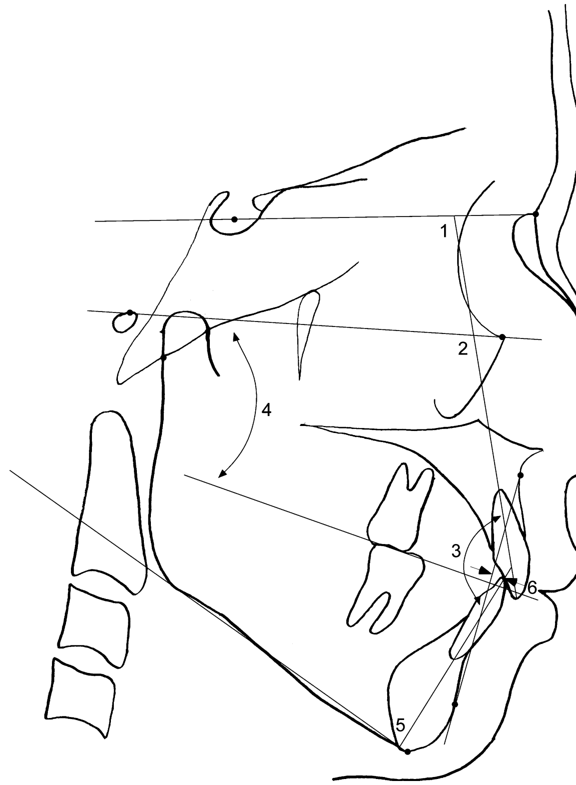

Fig. 4. Dental hard tissue cephalometric measurements: (1) upper incisor to SN, (2) upper incisor to FH, (3) interincisal angle, (4) occlusal plane angle, (5) lower incisor to mandibular plane and (6) lower incisor to A-Pog line.

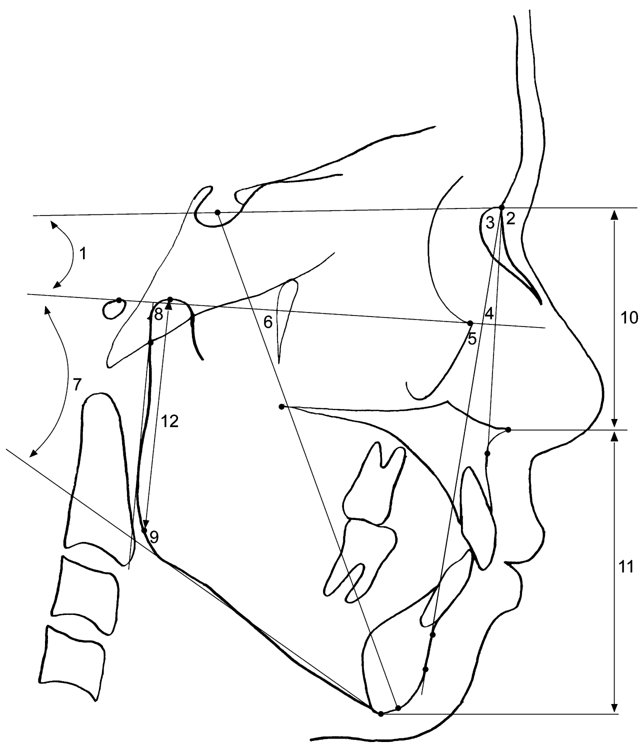

Fig. 3. Skeletal hard tissue cephalometric measurements: (1) FH–SN, (2) SNA, (3) SNB, (4) ANB, (5) facial angle, (6) *Y*-axis, (7) FH to mandibular plane, (8) FH to ramus plane, (9) gonial angle, (10) upper facial height (N–ANS), (11) lower facial height (ANS–Me) and (12) posterior facial height (Co-Go).

Reliability

To calculate the error of the method, 10 randomly selected cephalometric radiographs were traced and digitized twice within a 2-week period by the same investigator. Measurement error was calculated according to Dahlberg's formula ($S^2 = \sum D^2/2N$), where D is the difference between duplicated measurements, and N is the number of duplicated measurements (26). The measurement errors (S) in landmark identification for the linear and angular measurements were within 0.58 mm and 0.61° respectively. The method error can thus be considered negligible.

Statistical analysis

Unpaired *t*-tests were used to compare the mean differences of each head posture measurement as well as dentofacial cephalometric measurement between the TMJ OA and the control group after *F*-tests for equal and unequal variances utilizing the Stat View 5.0

program (SAS Institute Inc., Cary, NC, USA). The minimum level of statistical significance was set at $p < 0.05$.

Results

Table 2 represents the mean and standard deviations of head posture measurements for the TMJ OA and the control group. The TMJ OA group had significantly larger NSL / OPT ($p = 0.0084$), NSL / CVT ($p = 0.0006$), FH / OPT ($p = 0.0191$), FH / CVT ($p = 0.0016$), NL / OPT ($p = 0.0079$) and NL / CVT ($p = 0.0021$) than those in the control group.

Table 3 represents the mean and standard deviations of the dentofacial cephalometric measurements for the TMJ OA and the control group. For the skeletal angular measurements, the subjects with TMJ OA had significantly smaller SNB ($p < 0.0001$) and facial angle ($p < 0.0001$) than those in the control group. The subjects with TMJ OA also had significantly larger ANB ($p < 0.0001$), *Y*-axis ($p < 0.0001$), FH to mandibular plane ($p < 0.0001$), FH to ramus plane ($p < 0.0001$) and gonial angle ($p = 0.0014$). For the skeletal linear measurements, the subjects with TMJ OA had significantly shorter posterior facial height than the control group ($p < 0.0001$). For the dental measurements, the subjects with TMJ OA had significantly smaller lower incisor to mandibular plane angle ($p = 0.0441$). They also had significantly larger occlusal plane angle ($p = 0.0078$) than the control group.

Table 2. **The mean and standard deviations of head posture measurements for the TMJ OA and the control group**

	TMJ OA group (n = 34)		Control group (n = 25)		
Variables (°)	Mean	SD	Mean	SD	*p*-value
NSL / OPT	107.4	4.7	102.9	7.1	0.0084
NSL / CVT	110.3	4.6	105.4	5.7	0.0006
FH / OPT	99.9	5.2	96.0	7.3	0.0191
FH / CVT	102.8	5.0	98.3	5.4	0.0016
NL / OPT	98.1	5.2	93.9	6.5	0.0079
NL / CVT	100.9	5.0	96.4	5.8	0.0021

TMJ OA group, bilateral temporomandibular joint osteoarthritis/osteoarthrosis; control group, normal bilateral temporomandibular joints; NSL/OPT, angle between nasion-sella line and odontoid line (line through cv2tg and cv2ip); NSL/CVT, angle between nasion-sella line and upper part of cervical spine (line through cv2tg and cv4ip); FH/OPT, angle between Frankfort horizontal line and odontoid line; FH/CVT, Frankfort horizontal line and upper part of cervical spine; NL/OPT, nasal line (line through ANS and PNS) and odontoid line; NL/CVT, nasal line and upper part of cervical spine.

Table 3. **The mean and standard deviations of the cephalometric measurements for the TMJ OA and the control group**

	TMJ OA group (n = 34)		Control group (n = 25)		
Variables	Mean	SD	Mean	SD	*p*-value
Skeletal relationship					
FH–SN (°)	7.5	2.3	7.1	2.0	0.5179
SNA (°)	82.6	2.3	83.6	3.1	0.1362
SNB (°)	73.9	3.2	79.0	3.2	<0.0001
ANB (°)	8.6	2.6	4.6	2.0	<0.0001
Facial angle (°)	81.0	3.8	86.3	2.9	<0.0001
Y-axis (°)	68.5	4.1	63.8	3.1	<0.0001
FH to mandibular plane (°)	38.4	6.9	26.3	6.1	<0.0001
FH to ramus plane (°)	92.2	4.9	86.2	5.4	<0.0001
Gonial angle (°)	126.2	6.6	120.1	7.5	0.0014
Upper facial height (N–ANS) (mm)	56.6	3.7	57.2	3.2	0.5224
Lower facial height (ANS–Me) (mm)	71.3	5.8	70.8	4.6	0.7630
Posterior facial height (Co-Go) (mm)	51.5	5.8	62.3	4.6	<0.0001
Dental relationship					
Upper incisor to SN (°)	105.4	10.8	106.0	5.7	0.7737
Upper incisor to FH (°)	112.9	10.6	113.1	5.4	0.9056
Interincisal angle (°)	114.3	14.2	120.6	9.9	0.0657
Occlusal plane angle (°)	15.3	5.3	11.8	4.2	0.0078
Lower incisor to mandibular plane (°)	94.4	8.7	98.6	6.2	0.0441
Lower incisor to A-Pog line (mm)	5.9	3.0	4.8	2.6	0.1448

TMJ OA group, bilateral temporomandibular joint osteoarthritis/osteoarthrosis; control group, normal bilateral temporomandibular joints.

Discussion

It has been suggested that bony tissues are best imaged with computed tomography (CT) (27). The greatest advantage of the CT scan is that it images both hard and soft tissues (28). However, the disadvantages of the CT scans are that they are time consuming, expensive and are a high radiation exposure procedure. Although there is a controversy regarding the utility of panoramic radiographic imaging in both general practice and when evaluating the TMJ (29), panoramic and transcranial radiographs have been widely used in dental offices and provide diagnostic images for screening purposes (30). The accuracy of determining bony changes using the panoramic radiographs was reported to be from 71% to 84% (31, 32). In this study, the subjects were grouped into the TMJ OA group when the bilateral bony changes (flattening, osteophyte and erosion) were obvious using the panoramic and transcranial radiographs according to the definitions and scoring system published by Muir and Goss (24).

Two procedures have been conducted to measure head posture in the cephalometric analysis. One is the Frankfort method and another is the self-balanced position or the natural head posture method. However, there is no agreement about a standardized method of positioning the head and neck for taking the radiographs in order to accurately evaluate the head position (33–42). Armijo-Olivo et al. (43) who recently evaluated the two methods stated that cranio-cervical variables and cervical lordosis were not significantly different between the Frankfort method and the self-balanced position. Therefore in this study, we utilized the Frankfort method to evaluate the relationship between TMJ OA, head posture and dentofacial morphology, because this method has been popular in clinical practice and makes the patient's head position reproducible over time, avoiding the overlapping of the images (38). However, more studies are needed to determine the variation between different procedures and to define a good procedure for evaluating head posture (43).

Sample size and sample selection

In the scientific study, it is important that the power is enough high. The sample size calculation revealed that a sample of 21 subjects was sufficient. As 34 subjects for the TMJ OA group and 25 subjects for the control group were analysed in this study, it can be stressed that the power was sufficiently high to reveal reliable results. Cervical spine inclination has been linked to gender, that is men usually exhibit a straightened curve and women usually exhibit a partly reversed curvature (44–50). Therefore, we selected all female subjects for both the TMJ OA and the control subjects. Hellsing et al. (48) found that craniofacial inclination to the cervical column measured as the angle NSL / OPT and NSL / CVT increased with increasing age. They also found that cervical lordosis (CVT / EVT) decreased with increasing age (47). All these indications suggest that it is prudent to conduct the study in a sex- and age-matched case–control design.

Relationship between TMJ OA, head posture and dentofacial morphology

Most studies that investigated the association between head posture and TMD included mixed TMD diagnoses, i.e. patients with a combination of signs and symptoms that sometimes lacked clear and defined criteria for TMD classification. As Armijo-Olivo et al. (17) stressed to arrive at clear conclusions regarding TMD and head and cervical posture, more accurate diagnoses and definition of terms were needed. On that premise, we defined the TMJ OA subjects from a radiographic examination by an experienced radiologist.

We found significant differences for head posture measurements between the TMJ OA and the control group. The TMJ OA patients had significantly larger cranio-cervical angles, meaning that they had a tendency to have more extended head positions than the control subjects. Sonnesen et al. (13) reported that TMD was seen in connection with a marked forward inclination of the upper cervical spine and an increased cranio-cervical angulation. Huggare and Raustia (10) also showed the tendency of the extended head posture for the craniomandibular disorders group. D' Attilio et al. (51) reported that the cervical lordosis angle was significantly lower in the TMD group with disc displacement. On the other hand, Hackney et al. (11) and Visscher et al. (14) stated that there were no differences in head posture between patients with internal derangement and articular disorders and a control group. This lack of consistency may be due to different techniques and different sometimes unspecified patient groups. The findings in the present study using the well-defined classification of our participants suggest that there may be an association between TMJ OA and head posture.

The subjects with TMJ OA had significantly smaller SNB. They also had significantly larger ANB, FH to mandibular plane and FH to ramus plane compared with the subjects in the control group. For the linear measurements, they had significantly shorter posterior facial height. These characteristics are in agreement with our pilot study (52) and might lead to Class II skeletal relationships with posteriorly rotated mandibles. A large gonial angle may also be associated with a skeletal open bite tendency. Arnett et al. (53) suggested that patients with condylar resorption might exhibit decreased ramus height, progressive mandibular retrusion (adult) or decreased growth rate (juvenile). Byun et al. (54) also reported that patients with TMJ internal derangement demonstrated a more posteriorly rotated ramus, a steeper mandibular plane, a smaller mandible and a tendency toward skeletal Class II pattern, compared with those having normal disc positions. A cause-and-effect relationship between TMJ OA and head posture and dentofacial morphology is unclear. One of the factors that can induce an extended head posture is obstruction of the nasopharyngeal airways. This association has been confirmed by several reports (55, 56). It might be feasible to speculate that extended head position produces a tendency for the mandible to rotate posteriorly due to the passive tension of the suprahyoid muscles (57). Posterior rotation of the mandible may contribute to dislocation of the articular disc as the mandibular condyle migrates posterior to the disc. The anterior disc displacements to the condyles might lead to the TMJ OA when overloading of the articular structures of the joint was sustained. Dysfunctional remodelling due to the excessive and sustained physical stress to the articular structures might also lead to a backward mandibular rotation. On the contrary, the extension of head posture might be due to the compensated functional response to maintain breathing for the TMJ OA patients with a posteriorly rotated mandible. A cause-and-effect relationship should be carefully interpreted.

The subjects with TMJ OA had a significantly larger occlusal plane angle and smaller lower incisor to mandibular plane angle. There was no significant difference in the upper incisors to SN or FH plane, interincisal angle and lower incisor to A-Pog line between the two groups. Yamada et al. (58) and Gidarakou et al. (59) reported a more retroclined lower incisor for the patients with degenerative joint disease. However, a more retroclined lower incisor may not be equal to a retrusive tendency of the lower incisor. Because we found a relatively protrusive tendency of the lower incisor (lower incisor to A-Pog line) in the TMJ OA group compared with the control group. The retroclined tendency of the lower incisor to mandibular plane angle might be attributed to a steeper mandibular plane in the TMJ OA group. Additional research, on the issue of the relationship of head posture and the cephalometric variables between the TMJ OA and a class II group, appears to be warranted.

Conclusion

In this study, the relationships between TMJ OA, head posture and dentofacial morphology were investigated. The TMJ OA patients had significantly larger craniocervical angles, meaning that they had a tendency to have more extended head positions than the control subjects. The TMJ OA patients had a more posteriorly rotated mandible and also had more retroclined lower incisors compared with the control group. They also had significantly shorter posterior facial height ($p < 0.0001$). These results suggest that an association might exist between TMJ OA, head posture and dentofacial morphology.

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