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Temporomandibular disorders and psychological status in adult patients with a deep bite

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SUMMARY Temporomandibular disorders (TMDs) and psychological status were examined in adult patients with a deep bite and compared with an adult age- and gender-matched control group with neutral occlusion. The deep bite group consisted of 20 females (mean age 30.3 years) and 10 males (mean age 33.1 years). The control group comprised 20 females (mean age 29.4 years) and 10 males (mean age 34.2 years). TMD examination, according to the Research Diagnostic Criteria for TMD (RDC/TMD), cephalometric lateral radiographs, registration of occlusion, and bite force were performed. To test the mean differences between craniofacial morphology, bite force, the occurrence of RDC/TMD diagnostic groups, and headache between the two groups, unpaired *t*-test, Fisher's exact test, Mann–Whitney *U* test, and multiple logistic regression analyses were performed.

Deep bite patients more frequently reported nocturnal and diurnal clenching ($P < 0.01$), an uncomfortable bite ($P < 0.001$), jaw stiffness ($P < 0.05$), and 'ringing' in the ears ($P < 0.001$) than the controls. Headache ($P < 0.001$), muscle disorders ($P < 0.001$), disc displacement ($P < 0.05$), and other joint disorders ($P < 0.05$) occurred significantly more often in the deep bite group compared with the controls. Somatization scores were significantly higher in the deep bite group compared with the controls ($P < 0.001$). Headache, muscle disorders, disc displacement, and other joint disorders were significantly associated with a number of craniofacial dimensions and psychological factors [R between 0.32 and 0.72; $P < 0.05$ and odds ratio (OR) from 0.45 to 7.46; $P < 0.05$]. These findings suggest that a deep bite, in particular with retroclined upper incisors, can represent a risk factor for TMD.

Introduction

The term temporomandibular disorder (TMD) refers to signs and symptoms associated with pain and functional and structural disturbances of the masticatory system, especially the temporomandibular joints (TMJs) and masticatory muscles. It is agreed that the most important signs and symptoms of TMD are headache, pain, and tenderness in the masticatory muscles and the TMJ, reduced or impaired mobility of the mandible, and TMJ sounds (Bush and Dolwick, 1995). The general opinion is that the aetiology of TMD is multifactorial, with structures, function, occlusion, craniofacial morphology, head posture, stress, psychological factors, trauma, and joint hypermobility as risk or contributing factors (Solberg *et al.*, 1972; Geissler, 1985; Ash, 1986; Bakke and Møller, 1992; Westling, 1992; Bakke, 1993; Olsson and Lindqvist, 1995; Sessle *et al.*, 1995; Okeson, 1996; Sonnesen *et al.*, 1998, 2001a,b; Henrikson, 1999; Egermark *et al.*, 2003; Liljeström *et al.*, 2005; Sonnesen and Bakke, 2005; Niemi *et al.*, 2006). Furthermore, neurobiological mechanisms such as peripheral and central sensitization, disturbances in the endogenous pain modulatory systems, and genetic factors have also been suggested to play important roles for the pathophysiology of painful TMDs (e.g. Svensson and Sessle, 2004; Diatchenko *et al.*, 2005, 2006).

From an orthodontic perspective, the question of whether or not the occurrence of malocclusion traits are related to signs and symptoms of TMD has attracted considerable interest (for surveys, see Reynders, 1990; Tallents *et al.*, 1991; Vanderas, 1993; Henrikson, 1999), and several studies have suggested that orthodontic treatment can neither cause nor prevent some types of TMD (Egermark *et al.*, 2003; Henrikson and Nilner, 2003; Koh and Robinson, 2003; Mohlin *et al.*, 2004). A few investigations have shown an association between TMD and deep bite (Lieberman *et al.*, 1985; Lous *et al.*, 1989; Kritsineli and Shim, 1992). In contrast, most studies have not found any associations between TMD and deep bite (de Boever and van den Berghe, 1987; Riolo *et al.*, 1987; Gunn *et al.*, 1988; Jämsä *et al.*, 1988; Keeling *et al.*, 1994; Sonnesen *et al.*, 1998; Thilander *et al.*, 2002; Vanderas and Papagiannoulis, 2002; Egermark *et al.*, 2003; Gesch *et al.*, 2004). Furthermore, a number of studies have examined whether particular characteristics of craniofacial morphology are present in subjects with symptoms and signs of TMD (Dibbets *et al.*, 1985; Stringert and Worms, 1986; Huggare and Raustia, 1992; Brand *et al.*, 1995; Dibbets and van der Weele, 1996; Nebbe *et al.*, 1997, 1999a,b; Muto *et al.*, 1998; Sonnesen *et al.*, 2001a). It has been found that skeletal vertical craniofacial dimensions are associated with the occurrence of signs and symptoms of TMD, e.g. muscle tenderness (Sonnesen *et al.*, 2001a).

No studies appear, however, to have been performed on adult pre-orthodontic patients with a deep bite, where the signs and symptoms of manifest TMD have been diagnosed according to the Research Diagnostic Criteria for TMD (RDC/TMD) and compared with an age- and gender-matched control group with neutral occlusion.

The aims of the present study were therefore (1) to compare TMD and psychological status in a group of adult patients with deep bite referred for orthodontic treatment with an age- and gender-matched control group with neutral occlusion and (2) to determine associations between TMD, psychological status, and craniofacial morphology in the total group (deep bite and control).

Subjects and methods

Subjects

The study was approved by the Ethical Committee for Aarhus County, Denmark (Ref. no. 2002 0040).

The sample comprised 60 adults, 30 patients with a deep bite (deep bite group), and 30 subjects with neutral occlusion (control group). None of the adults in either group had craniofacial anomalies or systemic muscle or joint disorders.

The deep bite group comprised 20 females, aged 22–42 years (mean 30.3 years), and 10 males, aged 23–43 years (mean 33.1 years), admitted for orthodontic treatment to the Department of Orthodontics, School of Dentistry, University of Aarhus, Denmark. All patients between 20 and 45 years of age with a deep bite and at least 24 permanent teeth present who applied for orthodontic treatment in the period from March 2002 to December 2003 were included in the study.

The control group consisted of 20 females, aged 23–40 years (mean 29.4 years), and 10 males, aged 25–44 years (mean 34.2 years), with neutral occlusion or minor malocclusions that did not require orthodontic treatment according to the Danish procedure for screening the population for malocclusions entailing health risks (Danish Ministry of Health, 1990; Solow, 1995). The control group was selected from either students or staff at the School of Dentistry, Aarhus University and were matched to the deep bite group with regard to age (±1 year) and gender.

Recordings

The study was based on four types of examinations: a TMD examination according to the RDC/TMD, cephalometric radiographs, registration of occlusion, and recording of the maximal unilateral bite force. One author (LS) performed all the recordings prior to orthodontic treatment of the deep bite group.

TMD examination

A questionnaire and a clinical examination were performed according to the RDC/TMD axis I and II (Dworkin and LeResche, 1992; software TMD Version 1.1, courtesy of Dr Yap, Singapore). Axis I diagnosis, groups I, II, and III, are as follows: myofacial pain, disc displacements, arthralgia, osteoarthritis, and osteoarthrosis.

The axis II profile expressed the psychological status of the patients. For the depression and the somatization scores, the checklist-90 revised (SCL-90) of the RDC/TMD was used (Dworkin and LeResche, 1992). Twenty of the questions were related to depression and 12 to somatization (Dworkin and LeResche, 1992).

Furthermore, tension-type headache was diagnosed according to the criteria of the International Headache Society (2004): frequent episodic tension-type headache (headache >1 day and <15 days/month), chronic tension-type headache (headache >15 days/month for >3 months), or no tension-type headache.

Cephalometric radiographs

The profile radiographs were taken with the teeth in occlusion and in a standardized head posture, the mirror position, as described by Siersbæk-Nielsen and Solow (1982). The radiographs were taken at the Department of Oral Radiology, School of Dentistry, Aarhus University, Denmark, in a Bucky Conds cephalometer (Petersen and Schmidt, Copenhagen, Denmark) with a film-to-focus distance of 180 cm and a film-to-median plane distance of 10 cm. No correction was made for the constant linear enlargement of 5.6 per cent. The digital radiographic system was a photostimulable phosphor plate, Digora (Soredex, Helsinki, Finland) placed in a traditional cassette without an intensifying screen. The reference points were marked and digitized in PorDios for Windows, version 6 (Institute for Orthodontic Computer Science, Middelfart, Denmark; Figure 1), and 16 variables representing the craniofacial morphology were calculated. A list of the variables is shown in Table 1.

Registration of occlusion and bite force

The occlusion was diagnosed according to Björk *et al.* (1964). A deep bite was recorded for the incisors. Patients with a deep bite of 5 mm or more were included in the study.

Occlusal support, in terms of number of teeth in contact in the intercuspal position (ICP) was assessed from the ability to hold a plastic strip, 0.05 mm thick and 6 mm wide (Hawe Transparent Strips No. 690, straight Kerr Hawe SA, Bioggio, Switzerland), between the teeth against a strong pull when the subject's teeth were firmly closed (Bakke *et al.*, 1990).

In order to assess the strength of the mandibular elevator muscles, the maximum unilateral bite force was measured.

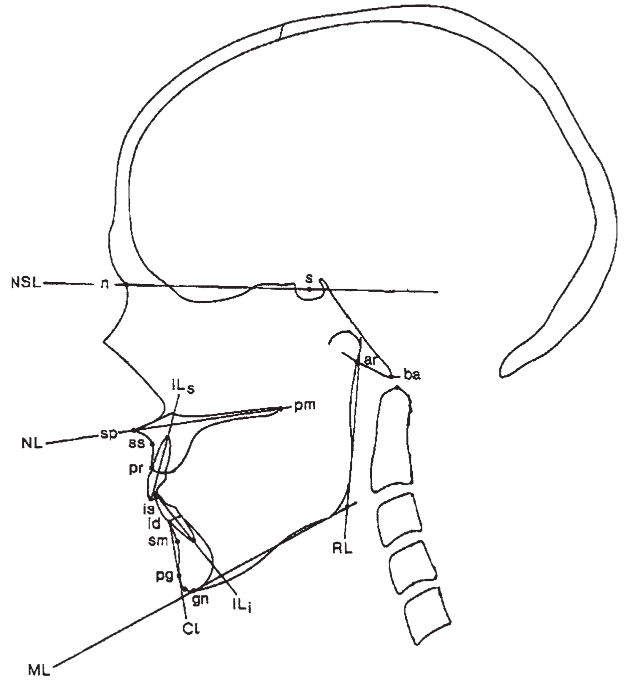

Figure 1 Reference points and lines according to Solow and Tallgren (1976).

The recordings were made at the first mandibular molars on each side by means of a pressure transducer (Aalborg University, Denmark; Svensson and Arendt-Nielsen, 1996) during 1–2 seconds of maximal clenching. The peak value was measured twice on each side, and the average used to determine the bite force.

Statistical

The normality of the distributions was assessed by the parameters of skewness and kurtosis and by Shapiro–Wilks *W*-test. Most of the variables representing craniofacial morphology and bite force were normally distributed, although a few variables showed moderate deviations from normal (overbite and overjet).

To test the mean differences between craniofacial morphology and bite force between the two groups and between genders, an unpaired *t*-test was used. To determine the difference in occurrence of RDC/TMD diagnostic groups and headache between the groups and between genders, Fisher's exact and Mann–Whitney *U*-tests were performed.

Associations between RDC/TMD diagnostic groups and craniofacial morphology and the possible effect of gender were tested by multiple logistic regression analyses. For logistic regression analysis, the significance of the results depends not only on the sample size but also on the prevalence of the dependent variable. Therefore, in each of the RDC/TMD diagnostic groups, the right and left mandibular joints and episodic and chronic tension-type headache were pooled. The multiple correlation coefficients (R^2) in the logistic regression analysis were calculated according to Nagelkerke (1991) and the odds ratio (OR) and 95 per cent confidence intervals. In all logistic regression models, the linearity of the effect was tested by Hosmer–Lemeshow goodness of fit. The results were considered to be significant at values below $P < 0.05$. The statistical analyses were performed using the Statistical Package for Social Sciences (version 13, SPSS Inc., Chicago, Illinois, USA).

Results

TMD examination

Significant differences in self-reported TMD-related symptoms were found between the groups (Table 2). Nocturnal and diurnal grinding was reported significantly more often in the deep bite group than in the control group ($P=0.003$ and $P=0.010$, respectively). Jaw ache or stiffness in the morning occurred significantly more often in the deep bite group compared with the control group ($P=0.050$) and a feeling of an uncomfortable bite or unusual bite occurred significantly more often in the deep bite group ($P < 0.001$). Furthermore, ringing in the ears occurred significantly more often in the deep bite group compared with the controls ($P < 0.001$). No significant gender-related differences were found for any of the self-reported symptoms.

According to the RDC/TMD axis I diagnosis (Table 3), myofacial pain occurred significantly more often in the deep bite group than in the controls ($P < 0.001$). In addition, disc displacement and arthralgia occurred significantly more often in the deep bite group ($P = 0.042$; $P = 0.011$) compared with the controls. No significant gender-related differences were found.

According to the RDC/TMD axis II profile (Table 4), somatization scores were significantly higher in the deep bite group than in the controls ($P < 0.001$). No significant gender-related differences were found.

Tension-type headache (Table 2) occurred significantly more often in the deep bite group than in the controls ($P < 0.001$). In females, 70 per cent had episodic tension-type headache and 5 per cent chronic tension-type headache. No chronic tension-type headache occurred in the males, and no significant gender-related differences were found.

Bite force and occlusal support

No significant differences in bite force or in the number of teeth in contact were found between the groups (Table 5), but bite force was significantly higher in males than in females ($P=0.001$, Table 5).

Craniofacial morphology

There were significant differences between the groups in sagittal craniofacial morphology, with a larger sagittal

Table 1 Craniofacial dimensions in the deep bite group and in the controls.

Variable (degrees)	Deep bite group (n = 30)		Controls (n = 30)		Differences (P values), unpaired t-test	
	Mean	SD	Mean	SD	Group	Gender
Sagittal dimensions						
ss–n–pg	0.97	3.5	1.11	3.0	NS	NS
ss–n–sm	3.3	2.5	1.98	2.3	0.036	NS
s–n–ss	82.0	3.6	82.2	3.3	NS	NS
s–n–pg	81.2	3.7	81.1	3.7	NS	0.026
pr–n–ss	2.2	1.3	3.3	1.2	0.003	NS
CL–ML	69.4	5.5	72.3	6.1	NS	NS
lls–nl	102.7	9.7	110.6	5.4	0.000	NS
lli–ml	96.1	7.9	102.1	8.2	0.005	NS
Overjet	5.5	1.9	2.9	0.6	0.000	NS
Vertical dimensions						
NL–ML	15.6	5.9	21.1	6.1	0.001	NS
NSL–NL	7.0	3.4	6.5	3.3	NS	0.037
NSL–ML	22.7	6.9	27.6	7.2	0.009	NS
Beta angle	25.1	2.9	22.9	3.2	0.010	0.024
Jaw angle	114.2	6.4	118.8	7.6	NS	0.014
Overbite	6.97	1.5	2.4	0.9	0.000	NS
Cranial base angle						
n–s–ba	130.8	3.9	131.2	4.9	NS	NS

Table 2 Self-reported temporomandibular-related symptoms in patients with a deep bite and in the controls.

Variables	Deep bite group (%) (n = 30)		Controls (%) (n = 30)		Differences (P), Fisher's exact test	
	Females	Males	Females	Males	Group	Gender
Tension headache	75	30	0	0	0.000	NS
Clicking	50	20	20	20	NS	NS
Grating	35	10	10	10	NS	NS
Nocturnal clenching	70	40	20	20	0.003	NS
Diurnal clenching	50	40	15	10	0.010	NS
Uncomfortable bite	60	30	5	0	0.000	NS
Jaw ache/stiffness	20	30	5	0	0.050	NS
Ringing in ears	65	60	0	0	0.000	NS

NS, not significant.

jaw relationship (ss–n–sm, $P = 0.036$) and horizontal overjet ($P < 0.001$) and a smaller maxillary dentoalveolar prognathia (pr–n–ss, P = 0.003) in the deep bite group compared with the control group (Table 1).

Significant differences between groups were also seen in the vertical craniofacial morphology as a larger beta angle ($P = 0.010$) and overbite ($P = 0.000$) and a smaller vertical jaw relationship (NL–ML, $P = 0.001$), inclination of the mandible (NSL–ML, $P = 0.009$), jaw angle ($P = 0.014$), and upper and lower incisor inclination (lls–nl, $P = 0.000$ and lli–ml, $P = 0.005$, respectively) in the deep bite group compared with the control group.

Few significant gender-related differences were found (Table 5). The maxillary inclination (NSL–NL, $P = 0.037$) was larger in females than in males, while mandibular prognathia (s–n–pg, $P = 0.026$) and beta angle ($P = 0.024$) were smaller in females than in males.

Associations

Associations between headaches (frequent episodic and chronic together), RDC/TMD diagnostic groups, and craniofacial morphology are shown in Tables 6 and 7. The numerical values of the significant multiple correlation coefficients ranged from 0.32 to 0.72 and OR from 0.45 to 7.46.

Headache was significantly and negatively associated with dentoalveolar prognathia in the upper jaw (pr–n–ss),

Table 3 Axis I diagnosis in patients with deep bite and in controls.

Diagnosis	Deep bite group (%) (n = 30)		Controls (%) (n = 30)		Differences (P), Fisher's exact test	
	Females	Males	Females	Males	Group	Gender
Muscle disorders (I)	50	20	0	0	0.000	NS
Disc displacement (II)	25	40	10	0	0.042	NS
Other joint disorders (III)	35	0	0	0	0.011	NS

Table 4 Axis II profile. Mean depression score and somatization in patients with deep bite and in controls.

Profile	Deep bite group (n = 30)		Controls (n = 30)		Differences (P), Mann–Whitney U-test	
	Females	Males	Females	Males	Group	Gender
Depression (SD)	1.5 (0.69)	1.7 (0.82)	1.5 (0.76)	1.0 (0.0)	NS	NS
Somatization (SD)	2.0 (0.79)	1.8 (0.79)	1.15 (0.37)	1.0 (0.0)	0.000	NS

Table 5 Bite force (kg), number of teeth present, and teeth in contact in the deep bite and in controls.

Variables	Deep bite group (n = 30)		Controls (n = 30)		Differences (P), unpaired t-test	
	Females	Males	Females	Males	Group	Gender
Bite force (SD)	56.2 (18.9)	65.1 (19.7)	54.8 (15.0)	69.9 (9.6)	NS	0.001
Teeth present (SD)	28.8 (1.6)	28.8 (1.7)	29.1 (1.7)	29.6 (1.5)	NS	NS
Teeth in contact (SD)	19.2 (5.2)	20.0 (4.4)	17.9 (2.9)	18.9 (3.1)	NS	NS

NS, not significant.

the inclination of the upper incisors (lli–NL), and vertical jaw relationship (NL–ML) and significantly and positively associated with sagittal jaw relationship (ss–n–sm), overjet and overbite, depression score, and somatization. Only the vertical jaw relationship and overbite were influenced by gender. According to OR (Table 7), the estimated highest risk factors were a deep bite (2.013), depression score (2.520), and somatization (7.468).

Specifically, in the RDC/TMD diagnostic group I, myofacial pain (Table 6) was significantly and positively associated with sagittal jaw relationship (ss–n–sm), overjet and overbite, and significantly and negatively associated with inclination of the upper incisors (lls–NL). None of the associations were due to gender. The highest estimated OR (Table 7) was the inclination of the upper incisors (lls–NL; OR = 1.105). No significant associations were found between myofacial pain and depression score and somatization (Tables 6 and 7).

For the RDC/TMD diagnostic group II, disc displacement (Table 6), there was a negative association with dentoalveolar prognathia in the upper jaw (pr–n–ss) and a positive association with overbite. None of the associations were due to gender. The highest estimated OR (Table 7) was a deep bite (1.347). No significant associations were found between disc displacement and depression score and somatization (Tables 6 and 7).

Finally, the RDC/TMD diagnostic group III, with other joint disorders (Table 6), demonstrated a significant and negative association with the inclination of the upper incisors (lls–NL) and a significant and positive association with somatization. None of the associations were due to

Table 6 Significant multiple regression coefficients (R) between headache and Research Diagnostic Criteria for temporomandibular disorder diagnostic groups (I, II, and III) and craniofacial morphology in the combined group of deep bite patients and controls (n=60).

Morphology and axis II profile	Headache	Group I	Group II	Group III
Sagittal dimensions				
ss–n–sm	0.32*	0.35*	NS	NS
pr–n–ss	−0.44**	NS	−0.43*	NS
lls–NL	−0.30*	−0.41*	NS	−0.43*
Overjet	0.56***	0.38**	NS	NS
Vertical dimensions				
NL–ML	−0.47*,[1]	NS	NS	NS
Overbite	0.72[1],***	0.43**	0.37*	NS
Axis II profile				
Depression	0.35*	NS	NS	NS
Somatization	0.51**	NS	NS	0.40**

NS, not significant, logistic regression analysis.
[1]Significant gender effect.
*P < 0.05; **P < 0.01; ***P < 0.001.

Table 7 Estimated odds ratios for significant correlations between headache and Research Diagnostic Criteria for temporomandibular disorder diagnostic groups (I, II, and III) and craniofacial morphology in the combined group of deep bite patients and controls (n=60).

Morphology and axis II profile	Headache	Group I	Group II	Group III
Sagittal dimensions				
ss–n–sm	1.3 (1.0–1.6)	0.7 (0.6–1.0)	NS	NS
pr–n–ss	0.5 (0.3–0.8)	NS	0.5 (0.2–0.9)	NS
lls–NL	0.9 (0.9–1.0)	1.1 (1.0–1.2)	NS	0.9 (0.8–1.0)
Overjet	1.9 (1.3–2.7)	0.6 (0.4–0.8)	NS	NS
Vertical dimensions				
NL–ML	0.9 (0.8–1.0)	NS	NS	NS
Overbite	2.0 (1.4–3.0)	0.6 (0.5–0.9)	1.3 (1.0–1.8)	NS
Axis II profile				
Depression	2.5 (1.1–5.5)	NS	NS	NS
Somatization	7.5 (2.6–20.9)	NS	NS	3.2 (1.2–9.0)

NS, not significant, logistic regression analysis.
95% confidence intervals given in parentheses.

gender. The estimated OR (Table 7) was 0.891 and 3.241 for the inclination of the upper incisors and the somatization, respectively.

Discussion

The present study investigated the occurrence of manifest TMD and psychological status according to the RDC/TMD in a deep bite group referred for orthodontic treatment, compared with controls, and examined associations between TMD, psychological status, and craniofacial morphology.

The differences between the two groups in craniofacial morphology were expected because of the selection criteria in the present study. No significant differences regarding bite force or occlusal support were, however, found between the two groups. This is surprising as correlations between masticatory muscle strength and craniofacial morphology are well documented in the literature (Møller, 1966; Ringqvist, 1973; Ingervall and Helkimo, 1978; Proffit *et al.*, 1983; Bakke and Michler, 1991; Raadsheer *et al.*, 1999; Sondang *et al.*, 2003; Sonnesen and Bakke, 2005). In those studies, a negative correlation was shown between bite force and vertical jaw relationship, mandibular inclination and form as well as a positive correlation between bite force and posterior face height, which are all components in subjects with rectangular craniofacial morphology and skeletal deep bite. In agreement with previous investigations on an adult population, bite force was significantly higher in males than in females (e.g. Bakke *et al.*, 1990; Cosme *et al.*, 2005; Sonnesen and Bakke, 2005).

TMD and psychological status

The findings from the present research show that manifest TMD occurred significantly more often in patients with a deep bite referred for orthodontic treatment. This is in agreement with some investigations (Lieberman *et al.*, 1985; Lous *et al.*, 1989; Kritsineli and Shim, 1992), but in contrast to the majority of studies in both child and adult populations (de Boever and van der Berghe, 1987; Riolo *et al.*, 1987; Gunn *et al.*, 1988; Jämsä *et al.*, 1988; Keeling *et al.*, 1994; Sonnesen *et al.*, 1998; Thilander *et al.*, 2002; Vanderas and Papagiannoulis, 2002; Egermark *et al.*, 2003; Gesch *et al.*, 2004). For example, an investigation of 3033 subjects showed that neither a deep bite nor an anterior open bite were significantly associated with any self-reported signs or symptoms of TMD, i.e. pain, limited opening capacity, and joint sounds/noises (John *et al.*, 2002). The discrepancy between the studies could in part be due to differences in the diagnostic systems used, objectively or subjectively registered signs and symptoms, sample size, or the selection criteria for the deep bite group and the controls in the present research. All the patients in this study were referred specifically for orthodontic treatment and may therefore represent a selected population of patients with deep bite.

There were no significant gender-related differences in the present study regarding manifest TMD, which is in contrast to previous investigations (for review, see Drangsholt and LeResche, 1999; Dao and LeResche, 2000; Sarlani and Greenspan, 2005), although the female to male ratio in the present deep bite group was 2:1, and 50 per cent of the females but only 20 per cent of the males had a RDC/TMD diagnosis of myofacial pain. However, the female to male ratio was 1:2, with only 25 per cent of the females and 40 per cent of the males having a RDC/TMD diagnosis of disc displacement (Table 3). The lack of significant gender differences in the clinical presentation of TMD seems to suggest that more risk factors than gender must be considered in the aetiology of TMD. For example, most clinicians dealing with TMD pain are aware of the psychological/psychosocial aspects, and there is good evidence that recognition of pain-related disability and psychosocial factors will play a role in the outcome of management and prognosis (Dworkin *et al.*, 2002a,b; Turner *et al.*, 2005). In accordance with these views, higher somatization scores according to SCL-90 were found in the deep bite group (Table 4), and there were positive associations with tension-type headache and other TMJ disorders (Table 6). However, no associations were found between somatization scores and myofacial pain and disc displacement (Tables 6 and 7). It has been suggested that it is important to tailor the treatment to each individual patient and not consider psychological interventions for TMD pain as a treatment of last resort, but rather to use it concurrently with biomedical/orthodontic treatment strategies. The present findings are in line with the hypothesis relating headache to other TMJ disorders.

In the present study, an increased sagittal jaw relationship and an increased horizontal maxillary overjet were associated with tension-type headache and myofacial pain (Tables 6 and 7). Patients with maxillary overjet have been shown to have changes in jaw-muscle function, e.g. chewing cycles are longer and associated with a longer duration of electromyographic (EMG) activity compared with control subjects (Ingervall and Egermark-Eriksson, 1979). Furthermore, resting posture, swallowing, and speech area have been shown to be located more anteriorly in patients with a maxillary overjet compared with control subjects, whereas the chewing area is connected to ICP (Michler *et al.*, 1987; Bakke and Møller, 1991). It has been speculated that such differences in jaw-muscle function could contribute to overloading of the muscles leading to symptoms such as headache and myofacial pain (Bakke and Møller, 1992).

Vertical overbite and retroclined upper incisors were also found to be associated with tension-type headache, myofacial pain, and disc displacement in the present study. The traditional view would be that the disc displacement was caused by a posterior forced bite due to the deep bite in combination with retroclined upper incisors. New technology such as computed tomography in two- and three-dimensional orthodontic imaging should make it possible to study the condyle position in symptomatic and asymptomatic patients with a deep bite (Okano *et al.*, 2002; Nakajima *et al.*, 2005) and thereby be able to image the position of the condyle in detail. Nevertheless, the present findings point towards associations, although relatively moderate, but significant, between tension-type headache and TMD and different characteristics of craniofacial morphology.

Conclusions

The present study showed that the occurrence of TMD and psychological status appeared to be significantly different in the deep bite group compared with the control group. Headache and muscle disorders, disc displacement, and other joint disorders diagnosed according to RDC/TMD occurred significantly more often in the deep bite group compared with the controls. Furthermore, somatization scores were higher in the deep bite group compared with the controls when using the SCL-90. Headache, muscle disorders, disc displacement, and other joint disorders were significantly associated with a number of craniofacial dimensions and psychological factors. These findings suggest that in patients with a deep bite referred for orthodontic treatment, and in particular in subjects with a deep bite with retroclined upper incisors, these malocclusions can represent a risk factor for TMD.

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