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The effects of two methods of Class III malocclusion treatment on temporomandibular disorders

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SUMMARY The aim of this research was to evaluate, within a controlled clinical study, the effects of a Delaire-type facemask or a modified Jasper Jumper (JJ) used in the treatment of children with Class III malocclusions due to maxillary retrognathia on temporomandibular disorders (TMDs).

Forty-six patients with Class III malocclusions referred for orthodontic treatment were divided into two groups, a test and a control. The test group comprised 33 randomly chosen patients (15 females, 18 males) aged 8–11 years. The control group included 13 patients (eight females, five males) with similar features. TMD assessment was performed before and after treatment using a two-axis questionnaire, the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMDs). Qualitative data were evaluated using chi-square and McNemar tests.

No statistically significant differences related to the presence of TMD were observed pre- or post-treatment ($P > 0.05$). The most commonly encountered diagnosis was arthralgia in the JJ group both before and after treatment. Evaluation of joint and muscle regions showed decreased symptoms, apart from the diagnosed discomforts, in the JJ group ($P < 0.05$). Reduced symptoms were observed in the Delaire group; however, this reduction was not statistically significant. An increase, not considered to be statistically significant, was observed in the control group. The Delaire-type facemask and modified JJ used in the early phase of Class III malocclusion treatment did not result in TMD.

Introduction

Temporomandibular disorders (TMDs) are a common condition that involves problems related to the temporomandibular joint (TMJ), masticatory muscles, and associated structures. Epidemiologic research has shown that TMD occurs in children as well as in adults, and several studies have investigated the prevalence of TMD in children. TMD in various populations has been reported to be between 17 and 90 per cent (Egermark-Eriksson *et al.*, 1981, 1983; Nilner and Lassing, 1981; Lieberman *et al.*, 1985; Kirveskari *et al.*, 1992; Kritsinelli and Shin, 1992; Keeling *et al.*, 1994; Deng *et al.*, 1995; Sönmez *et al.*, 2001; Thilander *et al.*, 2002). TMD prevalence varies according to age, number, diagnostic method, and diagnostic criteria of the investigated individuals (Deng *et al.*, 1995; Thilander *et al.*, 2002).

It is difficult to isolate a single factor or to evaluate individual factors in the aetiology of TMD. Accordingly, TMD is considered to be a disorder with a multifactorial and complex aetiology (Greene, 2006; Okeson, 2008).

A diagnosis of TMD can be established via clinical examination and imaging. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD; Dworkin and LeResche, 1992) is an index frequently used in epidemiologic studies (Haiter-Neto *et al.*, 2002; Lindroth *et al.*, 2002; Yap *et al.*, 2002, 2003, 2004; Pergamalian *et al.*, 2003; Ferrando *et al.*, 2004; Schmitter *et al.*, 2005) and clinical (Emshoff and Bertram, 1998; Pettengill *et al.*, 1998; Carlson *et al.*, 2001; Dworkin *et al.*, 2002a,b; Ekberg *et al.*, 2003; Wig *et al.*, 2004) and is accepted as a reliable diagnostic criterion for the most frequently seen types of TMD. In addition to its use in adults, it has also been utilized in the evaluation of adolescents (Wahlund *et al.*, 1998).

Although the factors that constitute TMD aetiology in children are classified by age, malocclusions, parafunctional movements, traumatic injuries, and orthodontic treatment, psychological factors are also thought to play a role (Hirata *et al.*, 1992; Luther, 2007; Mohlin *et al.*, 2007). Among these contributing factors, morphological and functional occlusions have been discussed, and their influence on natural muscle function is accepted.

Class III malocclusions are less frequently seen compared with other malocclusions, with a frequency of 1–14 per cent. Class III malocclusions comprise various skeletal and dental components, such as an insufficient (retrusive) maxilla or excessive (protrusive) mandible (Campbell, 1983; Guyer *et al.*, 1986). Several treatment options for Class III malocclusions with a skeletal component are

classified as orthodontic treatment [facemask, modified Jasper Jumper (JJ), chin cap, etc.] when performed during the growth and developmental period and as orthodontic treatment together with surgery when performed post-adolescence.

Treatment aims to orthopaedically correct the disharmony between the jaws in skeletal Class III malocclusions. In this way, the protrusive effects of the forces are directed to the mandible via bones. The presence of a Class III malocclusion has been emphasized as an aetiologic factor in TMD (Mohlin, 1983; Heikinheimo *et al.*, 1989; Egermark-Eriksson *et al.*, 1990); while other authors have not supported this point of view (Pilley *et al.*, 1992). A further controversial issue with respect to Class III malocclusions is whether TMD begins due to the forces that occur in the joint area as a result of treatment (Ricketts, 1966; Riolo *et al.*, 1987; Wyatt, 1987; Tanne *et al.*, 1996; Deguchi *et al.*, 1998) or not (Jansen and Bluher, 1965; Dibbets and van der Weele, 1991; Gavakos and Witt, 1991; Baik, 1995; Deguchi *et al.*, 1998; Gökalp *et al.*, 2000; Arat *et al.*, 2003; Gökalp and Kurt, 2005).

The aim of this preliminary investigation was to evaluate the effect of a Delaire-type facemask or a modified JJ in children with a Class III malocclusion related to maxillary retrognathia on TMD in a controlled clinical study.

Subjects and methods

The protocol of this project (number: 2007/2936) was reviewed by the Ethics Committee of Istanbul University. Each subject's parent or guardian signed an informed consent form prior to treatment.

Forty-six patients with functional Class III malocclusions referred to the Department of Orthodontics, Istanbul University, were included in the study. The treatment group comprised 33 (15 females, 18 males) patients aged 8–11 years and the control group 13 patients (eight females, five males) with the same features and in the same age range. All patients were chosen via single randomization and distributed to a treatment groups in accordance with their order of arrival at the clinic. The treatment group was further divided into two groups: a modified JJ appliance was used in one group (16 patients) and a Delaire-type facemask in the second group (17 patients). Selection was made on the basis of the following criteria:

1. Skeletal relationship: skeletal Class III with maxillary retrognathism (SNA ≤ 79 degrees), ANB angle less than −1 degree, and a horizontal growth pattern (S–N/Go–Me: 30–32 degrees).
2. Dental relationship: Angle Class III with an anterior crossbite. The patients could achieve an edge-to-edge incisor position.

No subjects had a history of any other craniofacial anomalies and none had undergone prior orthodontic treatment.

The gender distributions and chronological and skeletal mean ages at the beginning of treatment are shown in Table 1. Hand–wrist radiographs taken for determining growth potential and bone age before treatment were evaluated according to Greulich and Pyle (1959).

TMD was evaluated with the RDC/TMD in the study group prior to appliance placement and removal. This evaluation was also performed in the control group before and after 6 months. In the two-axis questionnaire used for examination and diagnosis, some elements, such as evaluation of depression and somatization, occupation, marital status, monthly income, and educational status, were excluded to create an easier protocol through elimination of demographic information and data not related to TMD diagnosis. A prosthodontist (HK) trained in RDC/TMD examined the patients without the appliance *in situ*, with no knowledge to which of the groups the patients were assigned. Diagnoses were performed in accordance with the proposed criteria of RDC/TMD. Ten right and 10 left intra–extraoral muscles

Table 1 Age, gender and investigation period of the study population.

		Jasper Jumper (n = 16)	Delaire facemask (n = 17)	Control (n = 13)	P
		Mean ± SD			
†Chronological age (years)		9.67 ± 0.95	9.55 ± 0.97	9.14 ± 0.40	0.209
†Skeletal age (years)		9.63 ± 1.09	9.88 ± 1.04	9.36 ± 0.88	0.332
†Investigation period (months)		4.90 ± 0.37	6.41 ± 0.50	6.00 ± 0.00	**
‡Gender	Female	8	7	8	0.543
	Male	8	10	5	

†Kruskal–Wallis test. ‡Chi-square test.
**$P < 0.01$.

and the lateral and posterior poles of the TMJ were palpated in both treatment groups for evaluation of changes in symptoms. The means of these values were obtained and the number of joints and muscles with pain was determined.

Treatment protocols and periodic follow-ups were performed by the same orthodontist (CA) for each subject. The patients were instructed to wear the facemask for 14 hours per day. The amount of force selected was 400 g on each side. In the modified JJ group, the amount of force was 200 g on each side. All treatment was discontinued once the Class III molar relationship and the anterior crossbites were satisfactorily corrected. As the patients were in the mixed dentition period, other treatment mechanics were not utilized. The patients were recommended to use a sleeping chin cap for 8 hours and monthly controls were conducted during the retention period. Clinical investigations were performed 1 day after appliance removal.

The NCSS (Number Cruncher Statistical System) 2007 and PASS 2008 Statistical Software packages (NCSS, Kaysville, Utah, USA) were used for analyses. For evaluation of the study data, along with descriptive statistical methods, parameters that were not normally distributed were evaluated using Kruskal–Wallis, Mann–Whitney *U*, and Wilcoxon signed rank tests. Qualitative data were evaluated using chi-square and McNemar tests. The results are given at the 95 per cent confidence interval and significance was accepted at the $P < 0.05$ level.

Results

TMD was observed in four subjects in the modified JJ group both before and after treatment. In the Delaire-type facemask group, TMD was observed in two subjects before treatment, but in three patients (including the two subjects before treatment) after treatment ($P > 0.05$). In the control group, the same two patients had TMD ($P > 0.05$; Table 2).

The distribution of the TMD types and the appliances provided before and after treatment are shown in Table 3.

Table 2 Evaluation of the presence of temporomandibular disorders (TMDs).

		Jasper Jumper	Delaire facemask	Control	*P*
		n (%)			
TMDs	†Pre-treatment	4 (25.0)	2 (11.8)	2 (15.4)	0.590
	†Post-treatment	4 (25.0)	3 (17.6)	2 (15.4)	0.785
	‡PreT–PostT. *P*	1.000	1.000	1.000	

†Chi-square test. ‡McNemar test.

The most widely diagnosed disorder was arthralgia. The predicted occurrence of disc displacements due to applied forces was seen in only one patient. Evaluation of TMD symptoms revealed a statistically significant decrease in the mean number of painful muscles after treatment in the modified JJ group ($P < 0.05$).

Statistically significant differences were found between the two groups with respect to the number of painful TMJs before treatment ($P < 0.05$). The mean in the modified JJ group before treatment was found to be higher than in the control group ($P < 0.05$). A statistically significant reduction was observed in the number of painful TMJs post-treatment compared with pre-treatment ($P < 0.001$; Table 4).

Discussion

In order to evaluate the effects of forces on the TMJ, the effect of chin cap application has been assessed (Deguchi *et al.*, 1998; Gökalp *et al.*, 2000; Gökalp and Kurt, 2005). However, there are only a limited number of studies that have investigated the effect of a facemask on the TMJ, even though it has an effect similar to that of the chin cap. It is known that a facemask that applies force to the maxilla obtains its support from the tip of the chin. Approximately 75 per cent of this force is transmitted to the TMJ region (Deguchi *et al.*, 1998). In some studies, it was found that the forces did not result in inflammation in the bilaminar zone located in the posterior of the disc and condyle (Greene, 1982, 1988). However, in other research, it was reported that these reactive forces destroyed the relationship between the structural elements that make up the TMJ region. It was demonstrated that the pressure of the mandibular condyle on the nerve and vessel mesh in the bilaminar zone could cause clinical signs of TMD (Wyatt 1987; Drace and Enzmann, 1990).

It is therefore important that clinicians understand the effect of orthopaedic facemask application in Class III malocclusion subjects related to maxillary retrognathia. JJ appliances used in a modified manner are regarded as an alternative to extraoral appliances in order to eliminate problems of cooperation in the early period of treatment of Class III malocclusions with maxillary retrognathia. In this study, no effect on TMD was found for either appliance.

In the present study, the RDC/TMD was utilized in the diagnosis of TMD (Dworkin and LeResche, 1992). It has been reported that RDC/TMD can be used in multicentre research, is appropriate in multicultural comparisons, and is extremely reliable in children and adolescents (Wahlund *et al.*, 1998). The present study used only RDC/TMD, rather than magnetic resonance imaging (MRI) or the Helkimo Index, as previously reported research focused on the effect of the appliances chosen for Class III malocclusion treatment (Gökalp *et al.*, 2000; Arat *et al.*, 2003; Gökalp and Kurt, 2005). The factors underlying this decision were the cost, the likelihood that children would not be

Table 3 Distribution of temporomandibular dysfunction types before and after treatment.

	Diagnosis	Jasper Jumper	Delaire facemask	Control	*P*
		n (%)			
Myofacial pain	†Pre-treatment	1 (6.3)	0 (0.0)	1 (7.7)	0.532
	†Post-treatment	0 (0.0)	1 (5.9)	1 (7.7)	0.566
	‡PreT–PostT. *P*	1.000	1.000	1.000	
Disc displacement	†Pre-treatment	0 (0.0)	0 (0.0)	0 (0.0)	—
	†Post-treatment	1 (6.3)	0 (0.0)	0 (0.0)	0.384
	‡PreT–PostT. *P*	1.000	—	—	
Arthralgia	†Pre-treatment	3 (18.8)	2 (11.8)	1 (7.7)	0.666
	†Post-treatment	3 (18.8)	3 (17.6)	1 (7.7)	0.669
	‡PreT–PostT. *P*	1.000	1.000	1.000	

†Chi-square test. ‡McNemar test.

Table 4 Evaluation of painful muscles and temporomandibular joints (TMJs) before and after treatment.

		Jasper Jumper	Delaire facemask	Control	*P*
		Mean ± SD			
Number of painful muscles	†Pre-treatment (median)	5.69 ± 5.29 (5.5)	3.35 ± 5.28 (0)	3.23 ± 4.85 (0)	0.121
	†Post-treatment (median)	2.13 ± 3.42 (1.5)	2.06 ± 3.94 (0)	4.23 ± 4.04 (3)	0.050
	‡PreT-PostT. *P*	0.041*	0.463	0.149	
Number of painful TMJs	†Pre-treatment (median)	1.75 ± 1.61 (1.5)	1.12 ± 1.57 (0)	0.38 ± 1.12 (0)	*
	†Post-treatment (median)	0.50 ± 1.15 (0)	1.06 ± 1.60 (0)	0.46 ± 1.13 (0)	0.460
	‡PreT-PostT. *P*	**	0.951	0.317	

†Kruskal–Wallis test. ‡Wilcoxon signed rank test.
*$P < 0.05$ **$P < 0.01$.

cooperative during MRI, the fact that the Helkimo Index has only superficial relevance for TMD, and the characteristic of the RDC/TMD as a diagnostic method that includes standardized criteria that provides separate diagnoses of a patient with multiple TMDs, and that can diagnose subgroups. These factors are important in the evaluation of disc displacement resulting from Class III malocclusions. Additionally, the reliability and validity of RDC/TMD have been tested and can be safely used in children.

No correlation between orthodontic treatment and TMDs has been shown in several epidemiologic and long-term studies. However, the effects from occlusal discrepancies and orthodontic treatment have been shown to affect TMD development (Egermark *et al.*, 2003).

The current research showed no significant differences before or after treatment with respect to the presence of TMD. Between-group values also demonstrated no significant differences among the Delaire-type facemask, the modified JJ, and the control groups.

No similar studies using RDC/TMD were found in the literature. However, the finding, that treatment in Class III malocclusion subjects had no effect on TMD, supports previous results (Gavakos and Witt, 1991; Deguchi *et al.*, 1998; Gökalp *et al.*, 2000; Henrikson and Nilner, 2000; Arat *et al.*, 2003; Valle-Corotti *et al.*, 2007; Rey *et al.*, 2008).

The appliances used in the treatment of Class III malocclusions exert posterior forces on the mandible and the condyle, and these are associated with TMD. Depending on the protraction of the facemask, some of the force is transmitted to the TMJ through the mandible. It is thought that chin cap application, which applies a force via the mandibular condyle, could cause TMJ internal derangement. The research consensus on this subject is that the reactive forces due to chin cap treatment cause no TMJ derangement (Gökalp *et al.*, 2000; Arat *et al.*, 2003; Gökalp and Kurt, 2005). However, there is contradictory research (Deguchi *et al.*, 1998).

The number of painful muscles and joints was found to be lower in the treated groups and significantly higher in the untreated control group. From these results, it can be speculated that treatment has a positive effect on the musculature system. In parallel with these results, there is research demonstrating a reduction in TMD symptoms after orthodontic treatment (Egermark and Thilander, 1992;

Kremanak *et al.*, 1992; Egermark and Rönnerman, 1995; Henrikson *et al.*, 1997, 1999; Henrikson and Nilner, 2000).

Conclusions

Within the limitations of this study, it can be concluded that the Delaire-type facemask and the modified JJ, used early in the treatment of Class III malocclusions, have no effect on the occurrence of TMD. Due to the reduced observed in the study group and the increase found in the control group, it can be accepted that these two treatments have a positive effect on patient quality of life.

References

Arat Z M, Akcam M O, Gökalp H 2003 Long-term effects of chin-cap therapy on the temporomandibular joints. European Journal of Orthodontics 25: 471–475

Baik H S 1995 Clinical results of maxillary protraction in Korean children. American Journal of Orthodontics and Dentofacial Orthopedics 108: 583–592

Campbell P M 1983 The dilemma of Class III treatment. Angle Orthodontist 53: 175–191

Carlson C R, Bertrand P M, Ehrlich A D, Maxwell A W, Burton R G 2001 Physical self-regulation training for the management of temporomandibular disorders. Journal of Orofacial Pain 15: 47–55

Deguchi T, Uematsu S, Kawahara Y, Mimura H 1998 Clinical evaluation of TMJ in patients treated with chin-cup. Angle Orthodontist 68: 91–94

Deng Y, Fu M, Hägg U 1995 Prevelance of temporomandibular joint dysfunction (TMJD) in Chinese children and adolescents. A cross-sectional epidemiological study. European Journal of Orthodontics 17: 305–309

Dibbets J M, van der Weele L T 1991 Extraction, orthodontic treatment, and craniomandibular dysfunction. American Journal of Orthodontics and Dentofacial Orthopedics 99: 210–219

Drace J E, Enzmann D R 1990 Defining the normal TMJ: closed, partially open, and open mouth MRI of asymtomatic subjects. Radiology 177: 73–76

Dworkin S F, LeResche L 1992 Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. Journal of Craniomandibular Disorders 6: 301–355

Dworkin S F *et al.* 2002a A randomized clinical trial using research diagnostic criteria for temporomandibular disorders-Axis II to target clinical cases for a tailored self-care TMD treatment program. Journal of Orofacial Pain 16: 48–63

Dworkin S F *et al.* 2002b A randomized clinical trial of tailored comprehensive care treatment program for temporomandibular disorders. Journal of Orofacial Pain 16: 259–276

Egermark I, Rönnerman A 1995 Temporomandibular disorders in the active phase of orthodontic treatment. Journal of Oral Rehabilitation 22: 613–618

Egermark I, Thilander B 1992 Craniomandibular disorders with special reference to orthodontic treatment: an evaluation from childhood to adulthood. American Journal of Orthodontics and Dentofacial Orthopedics 101: 28–34

Egermark I, Magnusson T, Carlsson G E 2003 A 20-year follow-up of signs and symptoms of temporomandibular disorders and malocclusions in subjects with and without orthodontic treatment in childhood. Angle Orthodontist 73: 109–115

Egermark-Eriksson I, Carlsson G, Ingervall B 1981 Prevalance of mandibular dysfunction and orofacial parafunction in 7-, 11-, and 15-year-old Swedish children. European Journal of Orthodontics 3: 163–172

Egermark-Eriksson I, Ingervall B, Carlsson G 1983 The dependence of mandibular dysfunction in children on functional and morphological malocclusion. American Journal of Orthodontics 83: 187–194

Egermark-Eriksson I, Carlsson G E, Magnusson T, Thilander B 1990 A longitudinal study on malocclusion in relation to signs and symptoms of cranio-mandibular disorders in children and adolescents. European Journal of Orthodontics 12: 399–407

Ekberg E, Vallon D, Nilner M 2003 The efficacy of appliance therapy in patients with temporomandibular disorders of mainly myogenous origin. A randomized, controlled, short-term trial. Journal of Orofacial Pain 17: 133–139

Emshoff R, Bertram S 1998 The short-term effect of stabilization-type splints on local cross-sectional dimensions of muscles of the head and neck. Journal of Prosthetic Dentistry 80: 457–461

Ferrando M, Andreu Y, Galdón J M, Dura E, Poveda R, Bagan J V 2004 Psychological variables and temporomandibular disorders: distress, coping, and personality. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics 98: 153–160

Gavakos K, Witt E 1991 The functional status of orthodontically treated prognathic patients. European Journal of Orthodontics 13: 124–128

Gökalp H, Kurt G 2005 Imaging of the condylar growth pattern and disc position after chin cup therapy: a preliminary study. Angle Orthodontist 75: 494–501

Gökalp H, Arat M, Erden I 2000 The changes in temporomandibular joint disc position and configuration in early orthognathic treatment: a magnetic resonance imaging evaluation. European Journal of Orthodontics 22: 217–224

Greene C S 1982 Orthodontics and the temporomandibular joint. Angle Orthodontist 52: 166–182

Greene C S 1988 Orthodontics and tempormandibular disorders. Dental Clinics of North America 32: 522–538

Greene C S 2006 Concepts of TMD etiology: effects on diagnosis and treatment. In: Laskin D M, Greene C S, Hylander W L (eds). TMDs: an evidence-based approach to diagnosis and treatment Quintessence Publishing Co. Inc., Chicago, pp. 219–228

Greulich W W, Pyle S I 1959 Radiographic atlas of skeletal development of the hand and wrist. Oxford University Press, Oxford

Guyer E C, Ellis E, McNamara J A, Behrents R G 1986 Components of Class III malocclusion in juveniles and adolescents. Angle Orthodontist 56: 7–30

Haiter-Neto F, Hollender L, Barclay P, Maravilla K R 2002 Disk position and the bilaminar zone of the temporomandibular joint in asymptomatic young individuals by magnetic resonance imaging. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics 94: 372–378

Heikinheimo K, Salmi K, Myllarniemi S, Kirveskari P 1989 Symptoms of craniomandibular disorder in a sample of Finnish adolescents at the ages of 12 and 15 years. European Journal of Orthodontics 11: 325–331

Henrikson T, Nilner M 2000 Temporomandibular disorders and the need for stomaognathic treatment in orthodontically treated and untreated girls. European Journal of Orthodontics 22: 283–292

Henrikson T, Ekberg E C, Nilner M 1997 Symptoms and signs of temporomandibular disorders in girls with normal occlusion and Class II malocclusions. Acta Odontologica Scandinavica 55: 229–235

Henrikson T, Nilner M, Kurol J 1999 Symptoms and signs temporomandibular disorders before, during and after orthodontic treatment. Swedish Dental Journal 23: 193–207

Hirata R H, Heft M W, Hernandez B, King G J 1992 Longitudinal study of signs of temporomandibular disorders (TMD) in orthodontically treated and nontreated groups. American Journal of Orthodontics and Dentofacial Orthopedics 101: 35–40

Jansen E K, Bluher J 1965 The cephalometric, anatomic, and histologic changes in *macaca mulatta* after application of a continuous-acting retraction force on the mandible. American Journal of Orthodontics 51: 823–855

Keeling S D, McGorray S, Wheeler T T, King G J 1994 Risk factors associated with temporomandibular joint sounds in children 6 to 12 years of age. American Journal of Orthodontics and Dentofacial Orthopedics 105: 279–287

Kirveskari P, Alanen P, Jämsä T 1992 Association between craniomandibular disorders and occlusion ınterferences in children. Journal of Prosthetic Dentistry 67: 692–696

Kremanak C R *et al.* 1992 Orthodontics as a risk factor for temporomandibular disorders II. American Journal of Orthodontics and Dentofacial Orthopedics 101: 21–27

Kritsinelli M, Shin Y S 1992 Malocclusion body posture and temporomandibular disorder in children with primary and mixed dentitions. Journal of Clinical Pediatric Dentistry 16: 86–93

Lieberman M A, Gazit E, Fuchs C, Lilos P 1985 Mandibular dysfunction in 10-18-year-old school children as related to morphological malocclusion. Journal of Oral Rehabilitation 12: 215–228

Lindroth J E, Schmidt J E, Carlson C R 2002 A comparison between masticatory muscle pain patients and intracapsular pain patients on behavioral and psychosocial domains. Journal of Orofacial Pain 16: 277–283

Luther F 2007 TMD and occlusion part I. Damned if we do? Occlusion: the interface of dentistry and orthodontics. British Dental Journal 202: 38–39

Mohlin B 1983 Prevalence of mandibular dysfunction and relation between malocclusion and mandibular dysfunction in a group of women in Sweden. European Journal of Orthodontics 4: 115–123

Mohlin B *et al.* 2007 TMD in relation to malocclusion and orthodontic treatment. Angle Orthodontist 77: 542–548

Nilner M, Lassing S A 1981 Prevalance of functional disturbances and disease of the stomatognathic system in 7-14-year-olds. Swedish Dental Journal 5: 173–187

Okeson J P 2008 Management of temporomandibular disorders and occlusion. Mosby Inc., St. Louis

Pergamalian A, Rudy T E, Zaki H S, Greco C M 2003 The association between wear facets, bruxism, and severity of facial pain in patients with temporomandibular disorders. Journal of Prosthetic Dentistry 90: 194–200

Pettengill C A, Growney M R, Schoff R, Kenworthy C R 1998 A pilot study comparing the efficacy of hard and soft stabilizing appliances in treating patients with temporomandibular disorders. Journal of Prosthetic Dentistry 79: 165–168

Pilley J R, Mohlin B, Shaw W C, Kingdon A 1992 A survey of craniomandibular disorders in 800 15-year-olds: a follow-up study of children with malocclusion. European Journal of Orthodontics 14: 152–161

Rey D, Oberti G, Baccetti T 2008 Evaluation of temporomandibular disorders in Class III patients treated with mandibular cervical headgear and fixed appliances. American Journal of Orthodontics and Dentofacial Orthopedics 133: 379–381

Ricketts R M 1966 Clinical implications of the TMJ. American Journal of Orthodontics 52: 416–439

Riolo M L, Brandt D, Ten Have T R 1987 Associations between occlusal characteristics and signs and symptoms of TMJ dysfunction in children and young adults. American Journal of Orthodontics and Dentofacial Orthopedics 92: 467–477

Schmitter M, Kress B, Ohlmann B, Henningsen P, Rammelsberg P 2005 Psychosocial behaviour and health care utilization in patients suffering from temporomandibular disorders diagnosed on the basis of clinical findings and MRI examination. European Journal of Pain 9: 243–250

Sönmez H, Sarı S, Oksak Oray G, Camdeviren H 2001 Prevalance of TMD in Turkish children with mixed and permanent dentition. Journal of Oral Rehabilitation 28: 280–285

Tanne K, Tanaka E, Sakuda M 1996 Stress distribution in the temporomandibular joint produced by orthopedic chin cup forces applied in varying directions: a three-dimensional analytic approach with the finite element method. American Journal of Orthodontics Dentofacial Orthopedics 110: 502–507

Thilander B, Rubio G, Pena L, Mayorga C 2002 Prevalence of temporomandibular dysfunction and its association with malocclusion in children and adolescent: an epidemiologic study related to specified stages of dental development. Angle Orthodontist 72: 146–154

Valle-Corotti K, Pinzan A, DoValle C V M, Nahas A C R, Corotti M V 2007 Assessment of temporomandibular disorder and occlusion in treated Class III malocclusion patients. Journal of Applied Oral Science 15: 110–114

Wahlund K, List T, Dworkin S F 1998 Temporomandibular disorders in children and adolescents: reliability questionnaire, clinical examination, and diagnosis. Journal of Orofacial Pain 12: 42–51

Wig A D, Aaron L A, Turner J A, Huggins K H, Truelove E 2004 Short-term clinical outcomes and patient compliance with temporomandibular disorder treatment. Journal of Orofacial Pain 18: 203–213

Wyatt W E 1987 Preventing adverse effects on the temporomandibular joint through orthodontic treatment. American Journal of Orthodontics and Dentofacial Orthopedics 91: 76–82

Yap A U, Tan K B, Chua E K, Tan H H 2002 Depression and somatization in patients with temporomandibular disorders. Journal of Prosthetic Dentistry 88: 479–484

Yap A U, Dworkin S F, Chua E K, List T, Tan K B, Tan H H 2003 Prevalance of temporomandibular disorder subtypes, psychologic distress, and psychosocial dysfunction in Asian patients. Journal of Orofacial Pain 17: 21–28

Yap A U, Chua E K, Tan K B, Chan Y H 2004 Relationships between depression/somatization and self-reports of pain and disability. Journal of Orofacial Pain 18: 220–225