Acta Odontologica Scandinavica. 2016; 74: 44–50

informa
healthcare

ORIGINAL ARTICLE

Do changes in oral health-related quality-of-life, facial pain and temporomandibular disorders correlate after treatment of severe malocclusion?

ANNA-SOFIA SILVOLA[1], MIMMI TOLVANEN[2], JAANA RUSANEN[1], KIRSI SIPILÄ[3,4], SATU LAHTI[2] & PERTTI PIRTTINIEMI[1]

[1]*Department of Orthodontics, Oral Health Sciences, Faculty of Medicine, University of Oulu, MRC, Oulu University Hospital, Oulu, Finland,* [2]*Department of Community Dentistry, Institute of Dentistry, University of Turku, Turku, Finland,* [3]*Institute of Dentistry, University of Eastern Finland, Kuopio, Finland, and* [4]*Kuopio University Hospital, Kuopio, Finland*

Abstract

Introduction. The aim was to evaluate the relationships of changes in facial pain, temporomandibular disorders (TMDs) and oral health-related quality-of-life (OHRQoL) in adults who underwent orthodontic or orthodontic/surgical treatment. ***Methods.*** Sixty-four patients (46 women, 18 men, range 18–64 years) with severe malocclusion and functional problems were treated in Oulu University Hospital. Of these, 44 underwent orthodontic-surgical and 20 orthodontic treatment. Data were collected with questionnaires and clinical stomatognathic examinations before and on average 3 years after treatment. The OHRQoL was measured with OHIP-14 (The Oral Health Impact Profile), the intensity of facial pain with the Visual Analogue Scale (VAS) and the severity of TMD with the Helkimo's anamnestic (Ai) and clinical (Di) dysfunction indices. ***Results.*** A significant improvement was found in facial pain, signs and symptoms of TMD and OHRQoL after the treatment ($p < 0.05$). The decrease in VAS was associated with improvement in OHIP-14 severity ($r = 0.296$, $p = 0.019$). The correlations between changes in OHIP-14 severity and Ai and Di were not statistically significant. ***Conclusion.*** Treatment of severe malocclusion seemed to improve OHRQoL via decreased facial pain. Decreased facial pain was associated especially with improved OHRQoL dimensions of physical pain, physical disability and social disability.

Key Words: *Temporomandibular disorders, orofacial pain, quality-of-life, orthodontic treatment, orthognathic surgery*

Introduction

Severe malocclusions can be associated not only with esthetic impairment, but also with multiple functional problems such as temporomandibular disorders (TMD) and facial pain. The self-perceived impacts of malocclusion can vary between individuals and are associated with impaired oral health-related quality-of-life (OHRQoL) [1,2]. Even though treatment planning and outcome measures are mainly based on clinical assessment by professionals, the improvement of patient's OHRQoL is regarded as one outcome measure of orthodontic treatment [3]. Orthodontic and orthodontic-surgical treatments are expensive, long-lasting and cause pain and discomfort for a patient. To improve the quality and effectiveness of orthodontic care, it is essential to understand how signs and symptoms of TMD and facial pain are associated with OHRQoL during treatment of malocclusion, and which kind of patients benefit most from the treatment.

TMDs are characterized as a heterogeneous set of clinical problems involving the masticatory muscles and/or temporomandibular joints (TMJs) [4]. Facial pain that originates from the musculoskeletal structures of the masticatory system is included to be one symptom of TMD [5]. TMD has a multifactorial background, with structures, occlusion, craniofacial morphology, function, trauma, stress and psychological factors as possible risk or contributing factors, the importance of occlusion in TMD etiology being still under debate [6–11].

Correspondence: Anna-Sofia Silvola, Department of Orthodontics, Oral Health Sciences, Faculty of Medicine, University of Oulu, PO Box 5281, FI-90400 Oulu, Finland. Tel: +358405634864. E-mail: anna-sofia.silvola@oulu.fi

(Received 15 August 2014; accepted 4 April 2015)

ISSN 0001-6357 print/ISSN 1502-3850 online © 2015 Informa Healthcare
DOI: 10.3109/00016357.2015.1040063

Pullinger and Seligman [12] have found that occlusal characteristics are co-factors for only a small portion of TMD patients. However, studies have found that subjects with malocclusion and dentofacial deformities have higher prevalence of facial pain and TMD than subjects with normal occlusion [13,14]. The malocclusion types which have been shown to associate to some degree with TMDs include unilateral crossbite, anterior open bite and extreme maxillary overjet [12,15–17]. Also, other occlusal factors like deep bite and Angle Class II/III occlusion have been suggested to be risk factors for TMD [16,18–20], but these associations are being questioned in other studies [13,21,22]. Because pain and TMD-related reasons are common motivation factors for seeking orthodontic/orthodontic-surgical treatment, the prevalence of TMD has been high in previous studies concerning adults with severe malocclusion [23–25]. A systematic review suggested that orthodontic-surgical treatment is more likely to improve than worsen the signs and symptoms of TMD [26]. Associations between TMD, facial pain and OHRQoL have been mostly studied in TMD patients who have not sought orthodontic treatment. A decreased OHRQoL in TMD patients has been described in systematic reviews [27,28]. The intensity of pain has also been found to be associated with poorer OHRQoL in adults with orofacial pain [29].

In our earlier study we found that, among patients with severe malocclusion, TMD and OHRQoL were directly and indirectly (via facial pain) associated before treatment [30]. The strongest association was seen between facial pain and OHRQoL in both genders. Orthodontic and orthognathic treatment has been shown to be associated with improved OHRQoL [31–33]. However, there are no studies concerning the associations of the changes between TMD, pain and OHRQoL during treatment of malocclusion. The aim of this longitudinal study was to evaluate the relationships of the changes in facial pain, TMDs and OHRQoL in adults who underwent orthodontic or orthodontic/surgical treatment. The hypotheses were that signs and symptoms of TMD and facial pain decrease after treatment and the changes are correlated with changes in OHRQoL. Accordingly, the hypothesis was that females have more TMD signs and symptoms and more facial pain compared to males.

Materials and methods

A total of 169 adult patients who were referred for orthodontic treatment to the Oral and Maxillofacial Department at Oulu University Hospital, Finland, were screened for the investigation during the years 2001–2004. Both an orthodontist and a maxillofacial surgeon screened all the patients. Of these, 99 met the inclusion criteria, which was severe malocclusion with considerable functional problems such as pain, traumatic occlusion or chewing problems. These malocclusion types were severe mandibular retrognathia/maxillary prognathia, anterior crossbite, severe open bite, traumatic deep bite, severe lateral crossbite or asymmetry or oligodontia. Exclusion criterion was neuropathic pain. Only patients with adequate pre- and post-treatment data (questionnaires and clinical examinations) were included in the analysis. Five patients had an incomplete pre-treatment questionnaire; nine patients were not reached after follow-up and a post-treatment questionnaire was given or sent to 85 patients, 21 of whom did not respond to the questionnaire. The subjects in the final study consisted of 64 patients (46 women, 18 men, mean age = 37.5 years, range = 18–64 years), 44 of whom underwent combined orthodontic-surgical treatment involving either a sagittal ramus osteotomy and/or Le Fort I osteotomy, while 20 patients underwent conventional orthodontic treatment. Distributions of patients according to malocclusion types are described in Table I. Occlusal characteristics of the study group have been described earlier in more detail [34].

Data on OHRQoL, facial pain and severity of TMD symptoms were collected with self-completed questionnaires before (T1) and an average of 3 years after treatment (T2). OHRQoL was measured with a Finnish translation of the 14-item Oral Health Impact Profile (OHIP-14) using a 1-month recall interval. OHIP-14 is a valid and reliable instrument, which is based on Locker's [35] conceptual model of oral health. It has been used in representative surveys to get population estimates for prevalence, extent and severity, also in Finland [36–38]. OHIP-14 includes seven dimensions: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap. Responses were coded as follows: 0 = 'never', 1 = 'hardly ever', 2 = 'occasionally', 3 = 'fairly often' and 4 = 'very often'. The OHIP-14 severity score (potential range = 0–56) was calculated by summing the response codes for 14 items. Item-specific responses were categorized by using two cut-off points: FoVo (fairly often, very often) and OFoVo (occasionally,

Table I. Main diagnoses of the patients describing the occlusal characteristics of the study group before treatment (T1).

Main diagnosis	*n*	%
Extreme overjet (8 mm or more)/Retrognathic mandible	12	18.8
Anterior open bite (6 teeth or more)	12	18.8
Traumatic deep bite	16	25.0
Anterior crossbite	10	15.6
Unilater crossbite/Severe asymmetry	12	18.8
Oligodontia	2	3.0

fairly often, very often). The extent and prevalence scores were calculated using both cut-off points. The extent score is the number of items reported (potential range = 0–14). The prevalence is the percentage of people reporting one or more items. Higher OHIP-14 scores indicate worse and lower scores indicate better OHRQoL. For cases with one or two missing OHIP-14 items, values were imputed using the item's sample mean. Additionally, dimension scores for seven dimensions were calculated by summing two response codes of each dimension.

Prevalence of facial pain was asked in the pre-treatment questionnaire with the following question: 'Have you had pain in the face during the last 12 months? no/yes (now and then/fairly often/often or continuously)'. If the patient reported facial pain, the patient was asked to assess the intensity of facial pain with a visual analog scale (VAS) with the following instruction: 'Mark the intensity of facial pain at the moment on the pain line. If you do not have pain at the moment, think about the pain during the last 12 months'. The VAS had anchor points at the left- (no pain) and right-hand (worst pain imaginable) ends of a 100-mm horizontal line. If the patient reported having no facial pain, the VAS value was coded as 0. The same questions with 1-week reference period were asked in the post-treatment questionnaires.

The severity of TMD symptoms was measured with Helkimo's [39] anamnestic dysfunction index (Ai) and classified according to anamnestic dysfunction index as 0 (no symptoms), I (mild symptoms) and II (severe symptoms).

Clinical examinations were performed before and on average 3 years after treatment. The degree of TMD was assessed with the total score of Helkimo's [39] clinical dysfunction index (Di). The clinical dysfunction index is based on the evaluation of five clinical signs: impaired range of movement, impaired function of the temporomandibular joint (TMJ), muscle pain, TMJ pain and pain on movement of the mandible. The signs of TMD were classified with standardized classification of Helkimo: Di 0 (0 points, no signs and symptoms), Di I (1–4 points, mild TMD), Di II (5–9 points, moderate TMD) and Di III (10–25 points, severe TMD). The clinical examinations were performed by three dentists trained by one dentist specialized in stomatognathic physiology.

Statistical analysis

Changes in OHIP-14, facial pain (VAS) scores and Helkimo's Di were found to be asymmetrically distributed and, therefore, non-parametric methods were used in the analysis. Statistical significances of differences in OHIP-14 severity and extent scores and VAS scores between male and female and orthognathic and orthodontic patients at different time points were evaluated using Mann-Whitney U-test. Statistical significances of differences in OHIP-14 prevalence measures, Helkimo's Ai and Di indices between male and female and orthognathic and orthodontic patients at different time points were evaluated using χ^2-test. Statistical significance of the changes occurring during the study was evaluated using Wilcoxon signed-rank test for OHIP-14 severity and extent, VAS, Di and Ai and McNemar's test for OHIP-14 prevalence scores. Associations between changes in OHIP-14 severity, VAS, Di and Ai scores were evaluated using Spearman correlation coefficients. In addition, associations between changes in OHIP dimensions and VAS were tested with Spearman correlation coefficients. The statistical analyses were performed using IBM SPSS Statistics 20.

The study was approved by the Ethics Committee of the Northern Ostrobothnia Hospital District, Finland.

Results

The patients showed significant improvement in VAS regarding the intensity of facial pain and in OHIP-14 values during follow-up ($p < 0.05$, Wilcoxon test and McNemar test). Sixty-two per cent of the patients reported facial pain before treatment and 20% after follow-up. Mean values for OHIP-14 variables are shown in Table II. Statistically significant improvements in VAS and OHIP-14 and all OHIP-14 dimensions were seen among both treatment groups and among both genders ($p < 0.05$). There were no statistically significant differences between genders or between treatment groups in OHIP scores or VAS.

Ninety per cent of patients were classified as Ai I or Ai II of Helkimo's anamnestic index before treatment, compared to 60% after treatment (Table III). Before treatment, 84% of the patients were classified as having moderate or severe TMD (Di II, Di III), the corresponding proportion after treatment being 29% (Table III). The positive changes in Ai and Di occurring between the time points were statistically significant ($p < 0.05$, Wilcoxon test) among all patients and among all sub-groups, except that among men the improvement in Ai was not statistically significant. No statistically significant difference (χ^2-test) was found at T1 or T2 between genders or between treatment groups.

The changes in OHIP-14 severity scores and VAS were significantly associated ($r = 0.296$, $p = 0.019$) (Table IV), the decrease in facial pain associating particularly with improvement in the OHIP dimensions physical pain, physical disability and social disability ($r = 0.253$, $r = 0.263$, $r = 0.281$, respectively, $p < 0.05$) (Table V). A statistically significant positive correlation was found between changes in Ai and Di ($r = 0.387$, $p = 0.005$). The changes in Ai or Di were not associated with OHIP-14 severity or VAS (Table IV).

Table II. Mean values of the Oral Health Impact Profile (OHIP-14) and facial pain intensity (VAS) before treatment (T1) and at follow-up (T2).

	Time	All (n = 64)	Gender		Treatment	
			Male (n = 18)	Female (n = 46)	Orthognathic (n = 44)	Orthodontic (n = 20)
Severity mean	T1	18.1*	16.2*	18.8*	18.3*	17.6*
	T2	4.5	4.2	4.6	4.2	5.3
Extent mean, FOVO cut-off	T1	2.8*	2.2*	3.0*	2.8*	2.6*
	T2	0.2	0.1	0.2	0.2	0.3
Extent mean, OFOVO cut-off	T1	5.9*	5.2*	6.2*	6.0*	5.8*
	T2	1.3	1.0	1.3	1.2	1.5
Prevalence (%) FOVO cut-off	T1	71*	65*	73*	74*	63*
	T2	11	11	11	9	15
Prevalence (%) OFOVO cut-off	T1	94*	88*	96*	93*	95*
	T2	52	50	52	50	55
Facial pain mean (VAS)	T1	3.1*	2.2*	3.5*	3.2*	2.9*
	T2	0.9	0.4	1.1	0.6	1.5

Severity, sum of OHIP impacts (potential range = 0–56); extent, number of items reported 'fairly often' or 'very often' (FoVo) or 'occasionally', 'fairly often' or 'very often' (OFoVo) (potential range = 0–14); prevalence, the percentage of subjects reporting at least one OHIP impact; facial pain, VAS (potential range = 0–10).
* statistically significant change ($p < 0.05$, Wilcoxon test) between T1 and T2.

Table III. The Helkimo clinical dysfunction index (Di) and anamnestic dysfunction index (Ai) scores before (T1) and after (T2) treatment.

		Dysfunction index				Anamnestic index		
		Di 0	Di I	Di II	Di III	Ai 0	Ai I	Ai II
All	T1	2*	14*	32*	52*	10*	21*	69*
	T2	7	64	20	9	40	28	32
Male	T1	0*	28*	17*	55*	19	31	50
	T2	6	76	18	0	40	33	27
Female	T1	2*	9*	39*	50*	7*	17*	76*
	T2	7	59	22	12	40	27	33
Orthognathic	T1	2*	11*	32*	55*	12*	17*	71*
	T2	5	64	23	8	42	26	32
Orthodontic	T1	0*	22*	33*	45*	6*	29*	65*
	T2	11	63	15	11	35	35	30

* Statistically significant change ($p < 0.05$, Wilcoxon test) between T1 and T2.

The hypotheses were partly rejected. Although the intensity of facial pain and signs and symptoms of TMD decreased during the follow-up, only the decrease of facial pain intensity correlated positively with the decrease of OHIP impacts. Opposite to the hypothesis, the gender differences were not found in facial pain intensity, Ai or Di.

Discussion

The decrease in the intensity of facial pain was associated with improved OHRQoL during the follow-up, but the changes in signs and symptoms of TMD were not.

The strengths of the present study were the long follow-up and the valid and reliable instruments used to measure OHRQoL and signs and symptoms of TMD. In a current study, the Helkimo index was chosen to measure the signs and symptoms of TMD. Currently, the most often used indices are the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) or the recently published Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) [40], but these indices were not translated and validated in Finnish when the study was initiated. However, an advantage of the Helkimo index is that it allows numerical scoring, in contrast to RDC/TMD and DC/TMD. As this was secondary

Table IV. Correlations between changes in Oral Health Impact Profile (OHIP-14) severity score, intensity of facial pain (VAS), the Helkimo clinical dysfunction index (Di) and anamnestic dysfunction index (Ai) during follow-up (T1–T2).

	OHIP-14 severity	Facial pain (VAS)	Di
Facial pain (VAS)	0.296 (p = 0.019)	1	
Di	0.165 (p = 0.228)	0.009 (p = 0.948)	1
Ai	0.196 (p = 0.144)	0.189 (p = 0.156)	0.387 (p = 0.005)

analysis of data collected for a longitudinal study, no power analysis was performed particularly for this part. For ethical reasons it was not possible to have an untreated control group with the same level of malocclusion and oral impacts, but the prevalence of facial pain and OHRQoL can be compared to the national epidemiologic samples instead [38,41]. Since the present study was part of a larger longitudinal study, including several time points, the shorter reference period in the post-treatment questionnaire concerning facial pain intensity was chosen to exclude pain due to treatment. However, based on previous results, the duration of the reference period (1 month vs 12 months) does not seem to have a statistically nor clinically significant effect on reported oral impacts [42]. A re-analysis of the same data on four single-item questions was conducted, showing the agreement to be substantial for three items: facial pain, jaw pain and OHIP-14 pain item [43]. The re-analysis showed moderate agreement for the fourth item, dental pain, which is commonly acute compared to facial pain, which is more often chronic. Although the facial pain questions in the present study concerned primarily the pain at that moment, it is possible that the shorter periods have under-estimated the prevalence and intensity of facial pain. For that reason, the amount of the improvement should be interpreted with caution.

The prevalence of reported facial pain at baseline was manifold compared to Finnish young adults (62% vs 12.2% among men and 17.9% women) [41]. The decrease in reported facial pain confirms the earlier findings of several studies after orthognathic treatment [14,44–46]. In this study, women reported facial pain more often at baseline than men. It has generally been shown that the prevalence of facial pain and TMDs is higher among women [47]. The gender differences in experienced pain have been explained by biological, hormonal, psychosocial and social factors, among others [47,48]. There was no difference in the intensity of facial pain between genders after treatment, showing that treatment outcome was not dependent on gender.

The majority of the patients had moderate or severe TMD at baseline. The results are in line with previous studies reporting that patients seeking orthognathic surgery treatment have more symptoms and signs of TMD compared to matched controls [14,49,50]. In the present study, the percentages of severe signs and symptoms of TMD before treatment were higher than the corresponding levels reported in previous studies among orthognathic patients [46,49]. The high prevalence of TMD in the present study can be explained by the inclusion criterion of considerable functional problems. The inclusion criterion were the same as in publicly funded orthodontic care for adults in Finland. The marked improvements in the dysfunction indices confirm the results of other longitudinal studies that have used the Helkimo index at pre- and post-surgery [45,46,49,51]. In a systematic review, Al-Riyami et al. [26] concluded that orthognathic surgery decreased both self-reported pain symptoms and clinically diagnosed pain on palpation tenderness measured with the Helkimo indices.

Pain has multidimensional influences on physical functioning. Therefore, it seems logical that change in facial pain was associated with changes in the OHRQoL dimensions of physical pain and physical disability. Interestingly, change in pain was also associated with change in the social disability dimension (irritability and difficulty in doing usual jobs). These findings are in accordance with the empirically derived model of oral health presented by Nuttall et al. [52]. In this empirically-derived model, pain is linked with disability (physical, psychological and social) and handicap, whereas functional limitation is not, as was suggested in the original model of

Table V. Mean scores for Oral Health Impact Profile (OHIP-14) dimensions before treatment (T1) and after follow-up (T2) and changes during follow-up (T1–T2) and correlations between changes in dimensions and change in facial pain intensity (VAS).

	Functional limitation	Physical pain	Psychological discomfort	Physical disability	Psychological disability	Social disability	Handicap
Mean T1	1.8	4.3	3.9	1.6	2.8	1.9	1.8
Mean T2	0.7	1.8	0.9	0.2	0.4	0.2	0.3
Change	–1.1	–2.5	–3.0	–1.4	–2.4	–1.7	–1.5
Facial pain (VAS) r^*	0.165	$0.253^{\dagger}$	0.239	$0.263^{\dagger}$	0.210	$0.281^{\dagger}$	0.185
p	0.207	0.044	0.059	0.037	0.102	0.027	0.147

r^*, Spearman correlation coefficient for association between changes in OHIP dimensions and facial pain (VAS), $^{\dagger}p < 0.05$.

Locker [35]. A similar hierarchy was also found in the path model at baseline of this study, where stronger association was observed between facial pain and OHRQoL than between TMD or occlusal characteristics and OHRQoL [30]. The results of the present study support both the empirically derived model and the path models, emphasizing the direct association of pain with OHRQoL.

Changes in OHRQoL were not conveyed via clinically assessed TMD signs or TMD symptoms. This finding can be due to the fact that, besides pain-related TMD signs, the Helkimo indices include also TMJ joint sounds, which reportedly do not improve after treatment and do not necessarily affect the patient's quality-of-life [26]. To our knowledge, this is the first long-term study investigating associations between OHRQoL, pain and TMD during orthodontic/orthodontic-surgical treatment; therefore, comparative data is missing.

The results showed a remarkable change in OHRQoL from low level to normal population level. It can be suggested that OHRQoL improves via decreased facial pain, rather than improved signs and symptoms of TMD. Although the results showed an association between facial pain and OHRQoL after orthodontic or orthodontic-surgical treatment, more longitudinal studies are needed to study causality between these factors.

In conclusion, orthodontic and orthodontic-surgical treatment of severe malocclusion seems to improve OHRQoL via decreased facial pain in adults with pre-existing functional problems.

Acknowledgment

This work was supported by the Planmeca group and the Finnish Doctoral Program in Oral Sciences (FINDOS).

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

[1] Hassan AH, Amin H. Association of orthodontic treatment needs and oral health-related quality of life in young adults. Am J Orthod Dentofacial Orthop 2010;137:42–7.
[2] Frejman MW, Vargas IA, Rosing CK, Closs LQ. Dentofacial deformities are associated with lower degrees of self-esteem and higher impact on oral health-related quality of life: Results from an observational study involving adults. J Oral Maxillofac Surg 2013;71:763–7.
[3] Cunningham SJ, Hunt NP. Quality of life and its importance in orthodontics. J Orthod 2001;28:152–8.
[4] Okeson JP. Management of temporomandibular disorders and occlusion. 7th ed. St. Louis: Mosby; 2013.
[5] Sipilä K. Temporomandibular disorders (TMD) and widespread pain. In Pederson JA, editor. New research on fibromyalgia. New York: Nova Science Publishers, Inc; 2006. pp 111–27.
[6] Pullinger AG, Seligman DA, Gornbein JA. A multiple logistic regression analysis of the risk and relative odds of temporomandibular disorders as a function of common occlusal features. J Dent Res 1993;72:968–79.
[7] Huang GJ, LeResche L, Critchlow CW, Martin MD, Drangsholt MT. Risk factors for diagnostic subgroups of painful temporomandibular disorders (TMD). J Dent Res 2002;81:284–8.
[8] Michelotti A, Farella M, Gallo LM, Veltri A, Palla S, Martina R. Effect of occlusal interference on habitual activity of human masseter. J Dent Res 2005;84:644–8.
[9] Mohlin B, Axelsson S, Paulin G, Pietilä T, Bondemark L, Brattstrom V, et al. TMD in relation to malocclusion and orthodontic treatment. Angle Orthod 2007;77:542–8.
[10] Slade GD, Diatchenko L, Bhalang K, Sigurdsson A, Fillingim RB, Belfer I, et al. Influence of psychological factors on risk of temporomandibular disorders. J Dent Res 2007;86: 1120–5.
[11] Mladenovic I, Jovic N, Cutovic T, Mladenovic G, Kozomara R. Temporomandibular disorders after orthognathic surgery in patients with mandibular prognathism with depression as a risk factor. Acta Odontol Scand 2013; 71:57–64.
[12] Pullinger AG, Seligman DA. Quantification and validation of predictive values of occlusal variables in temporomandibular disorders using a multifactorial analysis. J Prosthet Dent 2000; 83:66–75.
[13] Egermark I, Magnusson T, Carlsson GE. A 20-year follow-up of signs and symptoms of temporomandibular disorders and malocclusions in subjects with and without orthodontic treatment in childhood. Angle Orthod 2003;73:109–15.
[14] Abrahamsson C, Henrikson T, Nilner M, Sunzel B, Bondemark L, Ekberg EC. TMD before and after correction of dentofacial deformities by orthodontic and orthognathic treatment. Int J Oral Maxillofac Surg 2013;42:752–8.
[15] McNamara JA, Seligman DA, Okeson JP. Occlusion, Orthodontic treatment, and temporomandibular disorders: A review. J Orofac Pain 1995;9:73–90.
[16] Thilander B, Rubio G, Pena L, de Mayorga C. Prevalence of temporomandibular dysfunction and its association with malocclusion in children and adolescents: An epidemiologic study related to specified stages of dental development. Angle Orthod 2002;72:146–54.
[17] Alamoudi N. The correlation between occlusal characteristics and temporomandibular dysfunction in Saudi Arabian children. J Clin Pediatr Dent 2000;24:229–36.
[18] Celic R, Jerolimov V, Panduric J. A study of the influence of occlusal factors and parafunctional habits on the prevalence of signs and symptoms of TMD. Int J Prosthodont 2002;15:43–8.
[19] Selaimen CM, Jeronymo JC, Brilhante DP, Lima EM, Grossi PK, Grossi ML. Occlusal risk factors for temporomandibular disorders. Angle Orthod 2007;77:471–7.
[20] Sonnesen L, Svensson P. Temporomandibular disorders and psychological status in adult patients with a deep bite. Eur J Orthod 2008;30:621–9.
[21] Gesch D, Bernhardt O, Kocher T, John U, Hensel E, Alte D. Association of malocclusion and functional occlusion with signs of temporomandibular disorders in adults: Results of the population-based study of health in Pomerania. Angle Orthod 2004;74:512–20.
[22] Sousa ST, Mello VV, Magalhães BG, Morais MP, Vasconcelos MM, Junior AD, et al. The role of occlusal factors on the occurrence of temporomandibular disorders. Cranio 2014. [Epub ahead of print].

[23] Espeland L, Høgevold HE, Stenvik A. A 3-year patient-centred follow-up of 516 consecutively treated orthognathic surgery patients. Eur J Orthod 2008;30:24–30.
[24] Pabari S, Moles DR, Cunningham SJ. Assessment of motivation and psychological characteristics of adult orthodontic patients. Am J Orthod Dentofacial Orthop 2011;140: e263–72.
[25] Trovik TA, Wisth PJ, Tornes K, Bøe OE, Moen K. Patients' perceptions of improvements after bilateral sagittal split osteotomy advancement surgery: 10 to 14 years of follow-up. Am J Orthod Dentofacial Orthop 2012;141:204–12.
[26] Al-Riyami S, Cunningham SJ, Moles DR. Orthognathic treatment and temporomandibular disorders: A systematic review. Part 2. Signs and symptoms and meta-analyses. Am J Orthod Dentofacial Orthop 2009;136:626.e1–16.
[27] Naito M, Yuasa H, Nomura Y, Nakayama T, Hamajima N, Hanada N. Oral health status and health-related quality of life: A systematic review. J Oral Sci 2006;48:1–7.
[28] Dahlström L, Carlsson GE. Temporomandibular disorders and oral health-related quality of life. A systematic review. Acta Odontol Scand 2010;68:80–5.
[29] Zheng J, Wong MC, Lam CL. Key factors associated with oral health-related quality of life (OHRQOL) in Hong Kong Chinese adults with orofacial pain. J Dent 2011;39:564–71.
[30] Rusanen J, Silvola AS, Tolvanen M, Pirttiniemi P, Lahti S, Sipilä K. Pathways between temporomandibular disorders, occlusal characteristics, facial pain, and oral health-related quality of life among patients with severe malocclusion. Eur J Orthod 2012;34:512–17.
[31] Lee S, McGrath C, Samman N. Impact of Orthognathic Surgery on Quality of Life. J Oral Maxillofac Surg 2008;66: 1194–9.
[32] Nicodemo D, Pereira MD, Ferreira LM. Effect of orthognathic surgery for class III correction on quality of life as measured by SF-36. Int J Oral Maxillofac Surg 2008;37: 131–4.
[33] Gazit-Rappaport T, Haisraeli-Shalish M, Gazit E. Psychosocial reward of orthodontic treatment in adult patients. Eur J Orthod 2010;32:441–6.
[34] Silvola AS, Rusanen J, Tolvanen M, Pirttiniemi P, Lahti S. Occlusal characteristics and quality of life before and after treatment of severe malocclusion. Eur J Orthod 2012;34: 7049.
[35] Locker D. Measuring oral health: a conceptual framework. Community Dent Health 1988;5:3–18.
[36] Slade GD. Derivation and validation of a short-form oral health impact profile. Community Dent Oral Epidemiol 1997;25:284–90.
[37] Allen PF, McMillan AS, Walshaw D, Locker D. A comparison of the validity of generic- and disease-specific measures in the assessment of oral health-related quality of life. Community Dent Oral Epidemiol 1999;27:344–52.
[38] Lahti S, Suominen-Taipale L, Hausen H. Oral health impacts among adults in Finland: competing effects of age, number of teeth, and removable dentures. Eur J Oral Sci 2008;116: 260–6.
[39] Helkimo M. Studies on function and dysfunction of the masticatory system. II. Index for anamnestic and clinical dysfunction and occlusal state. Svensk Tandlakaretidskrift 1974;67:101–21.
[40] Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, et al. International RDC/TMD Consortium Network, International association for Dental Research; Orofacial Pain Special Interest Group, International Association for the Study of Pain. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for Clinical and Research Applications: Recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. J Oral Facial Pain Headache 2014;28:6–27.
[41] Rauhala K, Oikarinen KS, Järvelin MR, Raustia AM. Facial pain and temporomandibular disorders: an epidemiological study of the Northern Finland 1966 Birth Cohort. Cranio 2000;18:40–6.
[42] Sutinen S, Lahti S, Nuttall NM, Sanders AE, Steele JG, Allen PF, et al. Effect of a 1-month vs. a 12-month reference period on responses to the 14-item Oral Health Impact Profile. Eur J Oral Sci 2007;115:246–9.
[43] Sipilä K, Tolvanen M, Mitrirattanakul S, Sitthisomwong P, Järvelin MR, Taanila A, et al. Orofacial pain and symptoms of temporomandibular disorders in Finnish and Thai populations. Acta Odontol Scand 2015;1–6; Epub ahead of print.
[44] Egermark I, Blomqvist JE, Cromvik U, Isaksson S. Temporomandibular dysfunction in patients treated with orthodontics in combination with orthognathic surgery. Eur J Orthod 2000;22:537–44.
[45] Dervis E, Tuncer E. Long-term evaluations of temporomandibular disorders in patients undergoing orthognathic surgery compared with a control group. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002;94:554–60.
[46] Pahkala R, Heino J. Effects of sagittal split ramus osteotomy on temporomandibular disorders in seventy-two patients. Acta Odontol Scand 2004;62:238–44.
[47] Sanders AE, Slade GD. Gender modifies effect of perceived stress on orofacial pain symptoms: National Survey of Adult Oral Health. J Orofac Pain 2011;25:317–26.
[48] Dao TT, LeResche L. Gender differences in pain. J Orofac Pain 2000;14:169–84.
[49] Panula K, Somppi M, Finne K, Oikarinen K. Effects of orthognathic surgery on temporomandibular joint dysfunction. A controlled prospective 4-year follow-up study. Int J Oral Maxillofac Surg 2000;29:183–7.
[50] Abrahamsson C, Ekberg E, Henrikson T, Nilner M, Sunzel B, Bondemark L. TMD in consecutive patients referred for orthognathic surgery. Angle Orthod 2009;79: 621–7.
[51] Pahkala R, Qvarnstrom M. Can temporomandibular dysfunction signs be predicted by early morphological or functional variables? Eur J Orthod 2004;26:367–73.
[52] Nuttall NM, Slade GD, Sanders AE, Steele JG, Allen PF, Lahti S. An empirically derived population-response model of the short form of the Oral Health Impact Profile. Community Dent Oral Epidemiol 2006;34:18–24.