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**Temporomandibular disorders in Class II malocclusion patients after surgical mandibular advancement treatment as compared to non-treated patients**

Short running title: TMD after BSSO advancement

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## Abstract

**Background:** Severe malocclusions may cause functional and esthetic problems and symptoms of temporomandibular disorders (TMD). Studies have investigated association between malocclusions and TMDs and shown controversial findings.

**Objective:** Purpose of this investigation was to examine the prevalence of TMD sub-diagnoses, using Diagnostic Criteria for the TMD (DC/TMD), in patients with Class II malocclusion and retrognathic mandible who had undergone mandibular advancement surgery 4-8 years previously, and to compare their frequencies with non-treated patients with a similar preexisting condition.

**Methods:** Study cohort comprised 151 patients who had orthognathic treatment due to mandibular retrognathia in 2007–2011. 77 (51%) participated in the study (Group 1). Group 2 comprised 22 patients who were planned for orthognathic treatment but had not started their treatment. Patients filled in the Finnish version of the DC/TMD Symptom Questionnaire and were examined using to the DC/TMD Axis I. DC/TMD Symptom Questionnaire were inquired by phone from 24 of the 74 patients who did not participate in the study.

**Results:** Results showed that Group 2 had more myalgia (13% vs. 50%,  $p<0.001$ ) and arthralgia (18% vs. 65%,  $p<0.001$ ) sub-diagnoses than Group 1. A tendency was noted that Group 2 had more pain-related TMD symptoms than Group 1. No differences were found between Groups 1 and 3 in gender and age distribution or frequency TMD symptoms.

**Conclusion:** Prevalence of especially pain-related TMD diagnoses was higher in Group 2 compared to Group 1, thus indicating a possible beneficial effect of this treatment for TMD.

Keywords: Temporomandibular disorders; Surgery; Orthodontics; Surgery; DC/TMD

## 1 Introduction

Severe malocclusions can cause various problems, such as functional and esthetic problems and temporomandibular disorders (TMD). In a new paper the most prevalent self-reported TMD symptoms of prospective orthognathic-surgical patients were head and/or neck region pain and tiredness in the temporomandibular joint (TMJ) region, particularly in the morning.<sup>1</sup> Several studies have investigated the association between malocclusions and TMDs and have shown controversial findings. Untreated skeletal malocclusions, such as Class III, anterior open or deep bite, crossbite, large overjet and crowding of teeth have been reported to be related with TMD.<sup>2-7</sup> On the other hand, some studies have shown, when comparing a group of treated malocclusion patients to untreated controls, that the treated group had only fractionally lower prevalence of TMD.<sup>6,8</sup> It is also interesting that self-reported TMD symptoms and clinically defined severity of malocclusion do not necessarily match.<sup>1</sup> The etiology of TMD is multifactorial, including psychosocial factors, genetic factors, traumas, bruxism and occlusal factors.<sup>9</sup> McNamara et al. have suggested that the occlusal factors could increase the risk for TMD problems at 10-20 % level, but this does not follow a causation.<sup>10</sup>

Several studies have indicated a reduction of TMD after treatment of severe malocclusion with orthognathic surgery.<sup>4,5,11-13</sup> In some patients, however, TMD symptoms can worsen after surgery.<sup>14-17</sup> Studies have concluded that patients having orthognathic treatment to

treat severe malocclusion and who have TMD are more likely to have enhancement in signs and symptoms than a worsening of them.<sup>18-20</sup>

Surgical mandibular movement anteriorly using bilateral sagittal split osteotomy (BSSO) is a common orthognathic treatment with severe Class II patients with retrognathic mandible.<sup>21-24</sup> Pre- and postsurgical TMD status is one of the most important issues when deciding whether to start surgical-orthodontic treatment. A systematic review focusing on mandibular advancement surgery and TMD concluded that studies do not unambiguously confirm whether the treatment improves or worsens TMJ condition.<sup>25</sup> Kuhlefeldt et al. reported four out of 40 BSSO mandibular advancement patients to have more TMD signs and symptoms after treatment than before the treatment.<sup>26</sup> A new meta-analysis of the occurrence of TMD in retrognathic patients after BSSO showed statistically significant reduction.<sup>27</sup> Additional studies using valid criteria for TMD are needed to estimate the response of the BSSO on TMD in patients with severe malocclusion.<sup>28</sup>

The purpose of this study was to examine the prevalence of TMD sub-diagnoses, using Diagnostic Criteria for the TMD (DC/TMD) Axis I criteria, in patients with retrognathic mandible who had undergone mandibular advancement surgery 4-8 years ago, and to compare their frequencies with non-treated patients with a similar preexisting condition/diagnosis.

## **2 Material and methods**

The initial study cohort comprised 151 patients who had had orthognathic treatment at the Oral and Maxillofacial Unit of Tampere University Hospital, Tampere, Finland, in 2007–2011. All initial study cohort patients fulfilled the following criteria: mandibular retrognathia, Class II dental relationship with increased overjet, conventional orthognathic treatment including pre- and post-operative orthodontic phases (straight-wire orthodontic technique with Roth's bracket prescription) and mandibular advancement with BSSO and rigid fixation. Exclusion criteria were: TMJ arthritis, trauma history, cleft lip and palate or craniofacial anomalies, and patients whose orthodontic treatment was not performed at the hospital in question.

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Patients were evaluated jointly by the treating team (orthodontist and maxillofacial surgeon) around three months before the operation to ensure optimal post-operative occlusal stability. In patients with short anterior face height and deep bite, curve of Spee was not straightened pre-surgically, but the mandible was rotated clockwise with mandibular BSSO advancement to reduce overbite and increase face height. These patients had tooth contacts in the front and on the second molars and open bite in premolar and the first molar areas, which was closed with orthodontics post-surgically by extrusion of premolars and molars. A splint was used in all cases during the operation to obtain the planned occlusion. The splint was removed once osteosynthesis had been achieved, no maxillomandibular fixation was used. Orthodontics was made by four senior orthodontists and three senior surgeons performed the operations with or without a resident.

An invitation letter was sent to all 151 patients. Seventy-seven (Group 1, 51%) of them wanted to participate and signed an informed consent. The study took place an average six years (range 4–8 years) after the operation. The other half of the patients, who did not participate (n=74), had similar pre-existing medical condition and met the same inclusion criteria, but did not respond to the study invitation. Clinical examination of occlusion and TMD using the Finnish version of the DC/TMD<sup>29,30</sup> was made by one researcher (JP). The examiner was calibrated by examining 9 subjects against the reference standard of DC/TMD-FIN (KS) who had been educated in the protocol at the Malmo DC/TMD Training and Calibration Center. Diagnostic algorithms of the DC/TMD Axis I criteria were used to obtain the sub-diagnoses. Kappa values for each DC/TMD Axis I clinical sub-diagnosis, based on the examinations of the examiner and the reference standard are presented in Table 1. Kappa coefficients were based on the following: >0.75 indicating excellent reliability, 0.40-0.75 indicating fair good to good reliability and <0.40 indicating poor reliability.

A total of 77 patients (mean age 41 years, range 19–71 years, SD 12, 71% women) who had been treated with BSSO formed Group 1. The control group (Group 2) consisted of 22 (mean age 35 years, range 18-56 years, SD 13, 86% women) patients with Class II malocclusion who were planned for orthognathic treatment but had not yet started this treatment. All of them gave their informed consent to participate in the research. Clinical Axis I DC/TMD diagnoses were obtained for both groups based on DC/TMD Axis I clinical examination and the DC/TMD-FIN Symptom Questionnaire, according to the instructions of the international

DC/TMD protocol.<sup>29,30</sup> In addition, 24 patients (mean age 44 years, range 30-64 years, SD 10, 50% women) of the 74, who were invited but did not respond to the invitation letter, were reached and interviewed by phone using DC/TMD Axis I Symptom Questionnaire (Group 3). In the bias analysis, Groups 1 and 3 were compared regarding gender, age and TMD symptoms.

The number and percentage of each of the clinical Axis I diagnoses were presented separately for the two study groups (Group 1 and Group 2). Statistical comparisons of the proportions of the TMD symptoms and clinical sub-diagnoses between these groups were assessed using the Fisher exact test in IBM SPSS Statistics (version 23.0). P-values < 0.05 were considered as statistically significant. Fisher exact test was also used to evaluate the difference in TMD symptoms, based on DC/TMD Axis I Symptom Questionnaire, between Groups 1 and 3. T-test was used for comparing age distribution of group 1 to groups 2 and 3 separately. Ethical approval was obtained from the Ethics Review Committee of the Joint Municipal Authority of the Pirkanmaa Hospital District, Finland.

### 3 Results

The results showed that patients in Group 2 had more pain-related TMD symptoms than patients in Group 1, although the differences were not statistically significant (Table 2).

Patients in Group 2 showed significantly more pain-related TMD sub-diagnoses (except for myofascial pain with referral) and degenerative joint disease compared to Group 1 (Table 2).

There seemed to be mixed differences between groups with regard to different disc displacement variables. When disc displacement variables were combined, there were significantly more diagnoses in Group 1 (Table 3).

Compared to men, women had more TMD symptoms, i.e. pain ( $p=0.002$ ), headache ( $p<0.001$ ) and closed locking of the jaw ( $p=0.008$ ), when the groups were not separated.

Statistically significant differences were not found between Group 1 and Group 3 with regard to gender distribution, or presence of TMD symptoms. (Table 4). Age did not show statistically significant differences between Group 1 and 3 ( $p=0.280$ ).

#### 4 Discussion

According to this investigation it appears that patients who had undergone orthognathic surgery due to Class II malocclusion and retrognathic mandible had less TMD pain symptoms and pain-related TMD diagnoses as well as degenerative joint disease 4-8 years after surgery compared to untreated patients with similar malocclusion. Women had more TMD symptoms than men and the differences were statistically significant if the patient and control groups were not separated.

Difference in mean age (41 and 35 years in Groups 1 and 2, respectively) and gender distribution (71% women and 86% in Groups 1 and 2, respectively) between the groups may at least partly explain the higher frequency in TMD symptoms and sub-diagnoses in Group 2, which should be taken into account when interpreting the results. The average age of the Group 1 at the time of surgery (41 years) was higher than often reported for orthognathic surgical patients<sup>4,12</sup>

The pre-existing condition in all patients in this study was mandibular retrognathia with Class II dental relationship, which, based on several studies, may associate with TMD.<sup>2-7</sup> In the present study, 64% of the operated patients showed at least one DC-TMC Axis I sub-diagnosis, whereas the corresponding proportion was 82% in Group 2. Most patients had at least one TMD symptom in both groups (90% and 95% in Groups 1 and 2, respectively). In previous studies it has been noticed that orthognathic treatment has a positive influence on TMD, thus at least partly supporting the present study. The systematic review by Al Ryami et al. concluded that orthognathic surgery (Le Fort 1, mandibular advancement or setback) decreased the occurrence of TMD in those having TMD presurgically and TMJ clicking.<sup>31</sup> They also found that mouth opening and lateral movements returned to normal ranges at 2-year follow-up post-surgically. Positive results were found also by White and Dolwick when investigating 75 patients: 49% had presurgical TMD signs and symptoms, 89% had less TMD symptoms postsurgically. However, in 11% of the patients TMD had remained or worsened postsurgically.<sup>14</sup> Some studies have shown negative effects of orthognathic surgery on TMD. Wolford et al., based on 25 patients at two years follow-up, found that orthognathic surgery may increase postsurgical TMD if the patient had presurgical TMD.<sup>16</sup> Al Ryami et al. reported that 59% of mandibular retrognathia Class II patients had presurgery TMD and 72% after

surgery.<sup>31</sup> Similarly, a study by Athanasiou et al. found that the pooled estimate of TMD was 68% postsurgery in 43 patients with counterclockwise mandibular movement (n=26) or maxillary impaction (n=17) at the six-month follow-up.<sup>32</sup>

Previous studies of Finnish samples have examined the association between TMD and orthognathic surgery. Panula et al. found a decrease in TMD signs and symptoms from preoperative 73% to 60% at four years postsurgery. Interestingly, a remarkable decrease was found in the occurrence of headache from 63% to 25%.<sup>11</sup> Kellokoski and Pahkala found that TMD symptoms were significantly improved after BSSO (64 mandibular advancements and 18 mandibular setbacks), but symptoms were worse postsurgically in 12% of the patients.<sup>12</sup> In a recent study, four out of 40 BSSO mandibular advancement patients had more TMD signs and symptoms after treatment than before the treatment.<sup>26</sup> This finding led the authors to conclude that BSSO is not a predictable treatment for TMD.<sup>26</sup> In a Silvola et al. study, management of severe malocclusion seemed to reduce TMD.<sup>13</sup> Our study indicates that occurrence of TMD may be lower following BSSO, but the findings are not sufficient to recommend the use of orthognathic treatment to treat TMD in mandibular retrognathia.

The prevalence of TMD in the study participants was higher compared to the general population. The prevalence of TMD clinical findings in the Finnish adult population (age range 30-80 years) has been found to be 38% and the signs were more common in women.<sup>33,34</sup> In the Northern Finland Birth Cohort 1966 (NFBC) study, clinical DC/TMD Axis I diagnoses were examined using a modified protocol of the DC/TMD in 1,964 45-year-olds.<sup>35</sup> Our study showed higher prevalence in all sub-diagnoses in both groups compared to the NFBC study population, which showed a prevalence of less than 10% in all sub-diagnoses. The NFBC subjects also showed lower levels of pain-related TMD symptoms (18%)<sup>35</sup> compared to our study, where 57% of the controls (Group 2) and 50% of the treated patients (Group 1) had TMD-related pain.

Mavreas and Athanasiou suggested that a high postsurgical TMD prevalence of 68% could be due to condylar displacement (condyle was distracted caudally and anteriorly from the fossa) and new position of the muscles attached to the mandible in a study of 44 patients (10 maxillary, 24 mandible, 10 bimaxillary osteotomies) at six months follow-up.<sup>32</sup> In the



present study condyle shape and position or disc location were not evaluated radiologically, preventing proper assessment of this factor.

The strength and uniqueness of the present study was that the operated patients formed a homogenous group: all had retrognathic mandible, Class II malocclusion, were treated in a single hospital with same orthodontic-surgical principles. Furthermore, they were all studied 4-6 years postsurgically, when treatment affiliated factors (orthodontics, surgery, physiologic adaptation) can only indirectly be considered to relate to the findings.<sup>36</sup> It should be noted that the findings and interpretations cannot be generalized to cover all treated patients with this kind of malocclusion. Compared to previous corresponding studies, the present sample was relatively large (n=77).<sup>37-38</sup> The number of control patients was smaller, but all had the same diagnosis as operated patients and were just starting orthognathic-surgical treatment after the orthodontist`s and maxillofacial surgeon`s evaluation. Preoperative TMD status was inconsistently registered and could not be utilized in the present study.

We did not receive an answer from 74 patients to participate the study. Twenty-four non-respondents were, however, interviewed by phone and DC/TMD Axis 1 Symptom Questionnaire was received, the results of which showed no statistical difference compared to Group 1. Therefore, the studied patients (Group 1) can be considered well representing the whole initial sample.

Medial data of all eligible 151 patients was checked when the study was planned. The preoperative medical condition was similar between all 151 patients. 24 of 74 ( Group 3) was interwieved and DC/TMD Axis 1 symptom questionnaire was received, which showed no statistical difference to group 1.

Differing results concerning the effect of treatment of severe malocclusions on TMD can partly be explained due to variations in the assessment of TMD and heterogeneous samples. Several studies have highlighted the need for an international and valid protocol for TMD with standardized diagnostic criteria and classifications.<sup>1,27</sup> The DC-TMD Axis I protocol was introduced in 2014 for use in clinical and research settings.<sup>29</sup> Based on the recommendation of the DC/TMD protocol, the first author (JP) was calibrated and reliability tested against the reference standard of DC/TMD-FIN (KS), who was educated in the protocol at the Malmo

DC/TMD Training and Calibration Center. The high kappa values indicated excellent reliability (>0.75). Use of internationally validated evidence-based criteria in the TMD examination protocol allows future comparisons between studies to be more reliable.

## 5 Conclusions

In patients with mandibular retrognathia and Class II malocclusion, the prevalence of pain-related TMD diagnoses was found to be higher in non-treated patients compared to patients treated with BSSO. This indicates a possible beneficial effect of this treatment on pain-related TMD. Clinically, the study gives supporting results for justification of orthodontic-surgical treatment for TMD patients with mandibular retrognathia and Class II malocclusion, simultaneously taken into account other indications and contraindications. Findings based on a cross-sectional study, however, are not sufficient to recommend the use of orthognathic surgery to treat TMD in mandibular retrognathia patients.

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DC/TMD Axis I diagnoses	Kappa
Myalgia	1.000
Myofascial pain with referral	1.000
Arthralgia	1.000
TMD attributed headache	0.780
Degenerative joint disease	0.780
DD* with reduction	0.780
DD with reduction with intermittent jaw locking	1.000
DD without reduction	1.000

\*Disc displacement

Table 1. Kappa values for each DC/TMD Axis I clinical sub-diagnosis, based on the examinations of the examiner and the reference standard for 9 subjects. Kappa coefficients were based on the following: >0.75 indicating excellent reliability, 0.40-0.75 indicating fair to good reliability and <0.40 indicating poor reliability.

		Group 1		Group 2		p-value*
		n	%	n	%	
Pain (jaw, temple, ear)	Women	42	76.4	17	89.5	0.326
	Men	9	40.9	2	66.7	0.565
	All	51	66.2	19	86.4	0.109
Headache (temple)	Women	31	56.4	14	73.7	0.276
	Men	5	22.7	0	0.0	1
	All	36	46.8	14	63.6	0.227
Jaw joint noises	Women	28	50.9	9	47.4	1
	Men	8	36.4	0	0.0	0.527
	All	36	46.8	9	40.9	0.809
Closed locking of the jaw	Women	27	49.1	8	42.1	0.790
	Men	4	18.2	0	0.0	1
	All	31	40.3	8	36.4	0.809

\*Fisher exact test

Table 2. Number and percentages of pain, headache, jaw joint noises and closed locking of the jaw in Class II occlusion patients after surgical mandibular advancement treatment (Group 1) and non-treated controls (Group 2).



Diagnosis	Group 1 (n=77) n (%)	Group 2 (n=22) n (%)	p-value *
Myalgia	10 (13.0)	11 (50.0)	<0.001
Myofascial pain with referral	9 (11.7)	1 (4.5)	0.450
Arthralgia	14 (18.2)	14 (64.6)	<0.001
TMD attributed headache	12 (15.6)	11 (50.0)	0.003
Degenerative joint disease	21 (27.3)	12 (54.5)	0.022
DD** with reduction	36 (46.8)	5 (22.7)	0.052
DD without reduction, with limited mouth opening	0	2 (9.1)	0.048
DD dislocation without reduction, without limited mouth opening	13 (16.9)	0 (0)	0.066
DD dislocation without reduction and with limited mouth opening	0 (0)	0 (0)	-

\* Fisher exact test, \*\* Disc displacement

Table 3. Number and percentages (%) of sub-diagnoses of Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Axis I, in Class II occlusion patients after surgical mandibular advancement treatment (Group 1) and non-treated controls (Group 2).

	Group 1 (n=77)	Group 3 (n=24)	p-value *
	n (%)	n (%)	
<b>Gender (women)</b>	54 (70.1)	12 (50.0)	0.088
<b>Pain</b> - Ever felt pain in the jaw, temple, in the ear or in front of the ear on either side	50 (64.9)	11 (45.8)	0.102
<b>Pain in the last 30 days</b>			
-No pain	21 (42)	4 (36.4)	1.000
-Pain comes and goes	4 (49.0)	1 (40.0)	0.734
-Pain is always present	4 (8.2)	7 (11.1)	1.000
<b>Headache in the last 30 days</b>	36 (46.8)	7 (29.2)	0.159
<b>Jaw joint noises in the last 30 days</b>	36 (46.8)	8 (33.3)	0.346

**Table 4.** Symptoms of temporomandibular disorders (TMD), assessed using DC/TMD Axis I Symptom Questionnaire, in Class II occlusion patients after surgical mandibular advancement treatment (Group 1) and non-participants (Group 3).

\* Fisher exact test