Effects of sagittal split ramus osteotomy on temporomandibular disorders in seventy-two patients

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Preoperative and postoperative temporomandibular disorders (TMDs) were observed in 72 patients before surgical-orthodontic treatment and about 2 years after bilateral sagittal split osteotomy. Prevalence and degree of TMD were assessed using the modified clinical dysfunction index of Helkimo. A total of 49 women and 23 men (mean age 32 years) were included in the study. To find out which patients benefit most from the treatment, the sample was classified into subgroups—myogenous, arthrogenous, or both components of TMD. The prevalence of clicking and headache decreased significantly with the treatment, while the incidence of crepitation increased. In general, severity of the dysfunction was greatly reduced. Furthermore, multiple regression analysis showed that patients with excessive overjet and previous occlusal splint therapy benefit most from orthognathic treatment. In addition, patients with signs of mainly myogenous origin got more relief from their dysfunction than patients with mainly arthrogenous components of TMD. The results suggest that in patients with severe maxillomandibular discrepancy surgical-orthodontic therapy is a good choice of treatment for reducing myogenous TMD pain and discomfort. □ *Sagittal split osteotomy; surgical orthodontic treatment; temporomandibular disorders*

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McNeill (1) has defined temporomandibular disorders (TMDs) as a collective term embracing a number of clinical problems that involve the temporomandibular joint (TMJ) and/or the masticatory musculature. It predisposes a patient to headache and facial pain (2, 3). Between 5% and 35% of adults are reported to have subjective symptoms of TMD, while clinical signs are estimated to be twice as common as symptoms. Although most of the signs and symptoms are mild, it has been estimated that about 10% of the population seek care for severe signs and symptoms of TMD (4, 5). On the whole, the etiology of TMD is known to be multifactorial, including both central and local factors. One of those factors is malocclusion, since dysfunction of the masticatory system has been reported to be more frequent in subjects with dentofacial anomalies than in those without (6, 7). However, in most studies the etiological role of the malocclusion on TMD has proved to be minor (8–11). If, however, malocclusion is of etiological importance, it is reasonable to assume that surgical-orthodontic correction of malocclusion has a favorable effect on TMD.

Orthognathic surgery is widely used to correct severe congenital and acquired dentofacial discrepancies. Apart from improvement in appearance, one important goal of orthognathic treatment is to improve masticatory function and reduce TMD. Most studies report that surgical correction of dentofacial anomalies has a beneficial effect on certain signs and symptoms of TMD (12–14), and that the relief or impairment of clinical signs in individual patients cannot be predicted preoperatively (15). Since surgical-orthodontic treatment is a long-lasting and costly process, it is important to investigate its effectiveness on TMD in order to be able to estimate the significance of occlusion on harmonious masticatory function, and to direct the treatment towards the major cause of the problem.

Besides structural abnormalities of TMJ (e.g. internal derangement of the temporomandibular joint or degenerative disease), muscular hyperfunction is considered to play an important part in the pathogenesis of TMD (16, 17). Recently, distinctions have been made between subgroups of TMD patients according to the primary diagnostic categories; temporomandibular joint articular disorders and masticatory muscle disorders (1).

The aim of this study was to test the following hypotheses: 1) surgical-orthodontic treatment usually relieves the signs of TMD, and 2) the benefit of orthognathic treatment is better in patients with mainly myogenic components of TMD than in subjects with mainly arthralgic components of dysfunction.

Subjects and methods

There were 49 women and 23 men with maxillomandibular discrepancies referred for consultation and treatment to the Department of Oral and Maxillofacial Diseases, Kuopio University Hospital. Their mean age was 32 years (standard deviation (s) 11.1, range 16–53 years) and they underwent surgical-orthodontic treatment between 1998 and 2004. All were operated on with bilateral sagittal split osteotomy (BSSO); 56 had advancements and 16 setbacks

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Table 1. Distribution of the subjects ($n = 72$) according to the primary clinical diagnosis

Diagnosis	*n*	%
Mandibular hypoplasia/retrognathia	46	64
Mandibular hyperplasia/prognathia	14	19
Mandibular asymmetry	1	1
Anterior open bite	4	6
Dentoalveolar malposition	7	10

of the mandible. Internal rigid fixation with the screws was used for the osteosynthesis, and all the patients had preoperative and postoperative orthodontics. The distribution of preoperative primary diagnoses is given in Table 1. Patients who had BSSO because of obstructive sleep apnea syndrome (4 subjects) and those who moved away during the orthognathic treatment (9 subjects) were excluded from the study. Six of the patients had polyarthritides, 1 had operated cleft palate, 4 had cardiovascular disease, and 9 had allergies or asthma. Preoperatively, 72% of the patients named TMD as the main reason for requesting orthognathic treatment, and 28% had previously had stabilization occlusal splint therapy because of TMD.

Before preoperative orthodontic treatment, the patients were asked to give their subjective symptoms of TMD, including the frequency of headache. The clinical examinations were performed by two senior orthodontists and two dentists specializing in orthodontics. Occlusion was registered in the intercuspal position in accordance with the criteria of Björk et al. (18), but with slight modifications (19). The underlying skeletal deformity for the diagnoses was assessed on lateral cephalograms.

With the patient in a supine position, clinical signs of TMD (jaw deviation on maximal opening, palpatory tenderness of the masticatory muscles and that of the TMJ, and TMJ sounds such as clicking and crepitation), mandibular mobility (maximal opening, maximal laterotrusion to the right and left and maximal protrusion), and slide between the retruded contact position (RCP) and intercuspal position (ICP) were registered. Degree of TMD was assessed using the modified clinical dysfunction index of Helkimo (20), where category E, 'Pain on movement of the mandible', was substituted by frequency of headache (never/rarely = 0, 2–3 times a week = 1 point, almost daily = 5 points). Hardly any patient had pain on movement of the mandible, and so this sign was not systematically recorded in the study.

Before the start of the treatment, one of the specialist dentists inspected the morphology of each condyle visually on panoramic radiographs. The smoothness of cortical outline of the condyle was classified as follows (the prevalences of the findings in parentheses): bilaterally normal (28%), subcortical sclerosis (38%), irregular/coarse outline (19%), osteophyte (12%), marginal erosion (3%), and microcyst (0%) at least on one side (21). The articular space and temporal parts of the TMJ were not analysed. Furthermore, the severity of the change in condylar morphology was classified according to the modified method of Rohlin & Petersson (22): no change, slight, moderate, and severe abnormality. With the present method, intra-examiner reproducibility for the radiological registrations was good; the kappa values ranged from 0.83 to 1.00. The values were satisfactory only in the case of sklerosis, varying from 0.23 (left condyle) to 0.61 (right condyle). Therefore, for the statistical analyses we considered sklerosis as a variation of normality/mild condylar change with no sign of pathology. The kappa value for the change in condylar shape (0 = no change/ mild change, 1 = moderate/severe change) was 0.69.

After the postoperative orthodontic treatment and retention period (mean 1.9 years (*s* 0.5) after BSSO), the subjects were clinically re-examined and asked in the questionnaire about the influence of the treatment on their masticatory function and symptoms of TMD. The study was approved by the Ethics Committee of the Kuopio University Hospital in 2004.

Statistical methods

Chi-square statistics and the Fisher exact test were used to analyse the differences in prevalence of TMD signs between genders. The differences in dysfunction index (Di0-DiIII) between preoperative and postoperative examinations were tested with the Wilcoxon signed-ranks test. The McNemar test was used to assess the significance of changes in TMD signs before and after surgery.

For the statistical analysis, the subjects were classified into three subgroups depending on type of disorder based on the modified criteria described by the American Academy of Orofacial Pain (AAOP) (23). Initially, 17 subjects had no clinical or radiologic signs of TMD. The *TMD myo group* comprised 22 patients with pain on palpation of at least one masticatory muscle and no TMJ tenderness or no radiographic evidence of organic changes in the TMJs. The *TMD arthro group* was composed of 22 subjects with no palpatory tenderness of the muscles, but pain on palpation of TMJs and/or radiographic evidence of organic changes in the TMJs and/or clicking. Eleven patients with signs both in muscles and TMJs were classified in the *TMD combi group*.

Multiple regression analyses were used to estimate the associations between reduction of the dysfunction index (pretreatment index score minus post-treatment index score) and the following dichotomized (0 = no, 1 = yes) variables: myo group, arthro group, combi group, previous occlusal splint therapy, direction of the BSSO (1 = mandibular advancement, 2 = mandibular setback), radiological evidence of organic condylar changes (0 = no/ mild changes, 1 = moderate/severe changes), and an asymmetrical ($\geq$3 mm difference between the right and left sides) movement of the mandible during surgery. Pretreatment overjet (mm) and overbite (mm), and the amount of mandibular movement during surgery (mm), were included in the models as continuous independent

Table 2. Prevalence of preoperative and postoperative TMD signs in 72 orthognathic patients according to gender

Sign	Female (*n* = 49) Preop. %	Female (*n* = 49) Postop. %	Male (*n* = 23) Preop. %	Male (*n* = 23) Postop. %	Total (*n* = 72) Preop. %	Total (*n* = 72) Postop. %
TMJ pain	25	12	13	4	21	10
Clicking	35	12	35	13	35	13
Crepitation	12	18	0	0	8	12
Locking of the TMJ	4	2	9	0	6	1
Muscle pain	39	31	17	4	32	22*
Deviation on opening	35	27	13	26	28	26
Headache	49	14	39	9	46	13

* Significant difference between gender by the Fisher exact test.

variables. The effects of age (in years) and gender (0 = female, 1 = male) were also considered. For all comparisons, P values ≤ 0.05 were considered statistically significant.

Results

Although females tended to have numerically more signs of TMD and headache than males, both preoperatively and postoperatively, the difference between genders was statistically significant only in postoperative muscle pain (Table 2). The most consistent sign seemed to be crepitation, since there was only one patient whose sign disappeared between the examinations, while four new cases with crepitation appeared (Table 3). The improvement was most remarkable in clicking and in headache.

Table 4 gives the severity of the modified clinical dysfunction index before and after surgical-orthodontic treatment. After treatment, severity of the dysfunction was significantly reduced. In 37 patients the signs disappeared or became milder with the treatment, while in 10 subjects new signs appeared or previous signs became worse. Preoperatively, 8 patients (11%) had had severe signs of dysfunction, but about 2 years postoperatively nobody suffered from severe dysfunction (DiIII), and 9 out of 10 patients were either free of TMD or had only mild signs.

Figures 1–3 show the scatterplots of preoperative and postoperative dysfunction indexes in the arthro-, myo-, and combi groups. The effect of the surgical-orthodontic treatment on TMD was significantly beneficial in the myo- and combi groups (P values <0.001 for the changes in both groups). In the arthro group the change was not statistically significant. The mean score of the dysfunction index in the myo group was 6.9 preoperatively and 1.9 postoperatively. In the arthro group the scores were 3.2 and 1.0, and in the combi group 10.2 and 3.4, respectively.

Multiple regression analysis (Table 5) showed that pretreatment overjet and occlusal splint therapy were

Table 3. Changes in TMD signs between preoperative and postoperative examinations in 72 patients who underwent bilateral sagittal split osteotomy (BSSO)

TMD sign	*n*	*P**
TMJ pain		0.057
Disappeared	11	
No change	4	
Appeared	3	
Clicking		0.002
Disappeared	20	
No change	5	
Appeared	4	
Crepitation		0.375
Disappeared	1	
No change	5	
Appeared	4	
Locking of the TMJ		0.375
Disappeared	4	
No change	0	
Appeared	1	
Muscle pain		0.167
Disappeared	13	
No change	10	
Appeared	6	
Deviation on opening		<0.001
Disappeared	15	
No change	5	
Appeared	14	
Headache		<0.001
Disappeared	27	
No change	6	
Appeared	3	

* McNemar test.

Table 4. Changes in clinical dysfunction index (Di0-DiIII) between preoperative and postoperative examinations in 72 patients who underwent bilateral sagittal split osteotomy (BSSO)

Preoperative examination (*n*)	Postoperative examination Di0 (*n*)	DiI (*n*)	DiII (*n*)	DiIII (*n*)	*P**
Di0 (16)	7	9	0	0	
DiI (26)	9	16	1	0	
DiII (22)	6	14	2	0	
DiIII (8)	2	3	3	0	
Total (72)	24	42	6	0	
					<0.001

* Wilcoxon signed-ranks test.

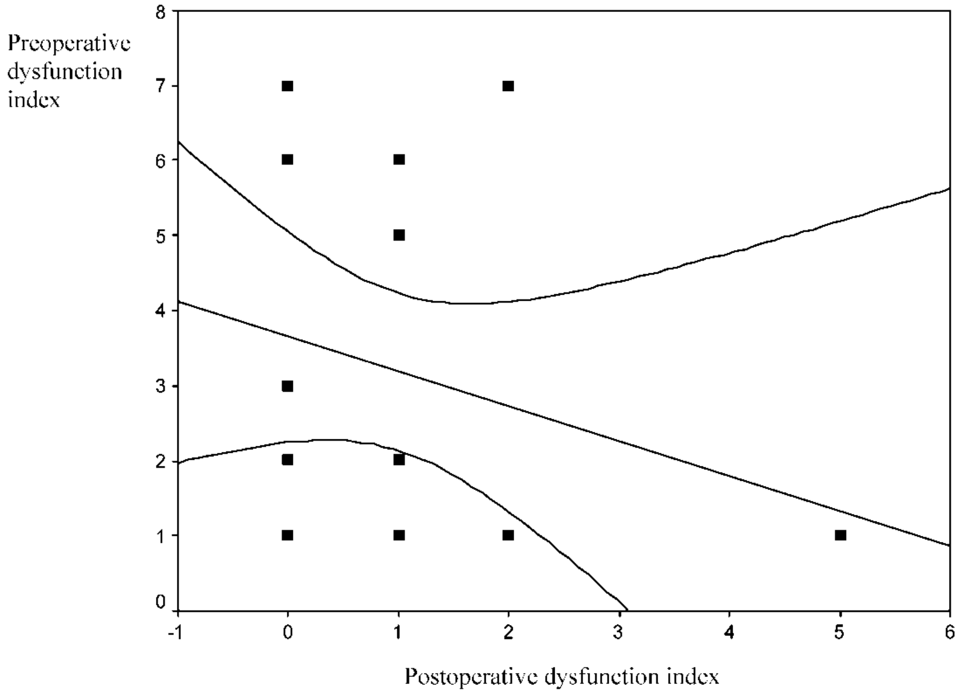

Fig. 1. Scatterplot of preoperative and postoperative dysfunction index and mean regression prediction line with 95% confidence intervals in the arthro group ($n = 22$).

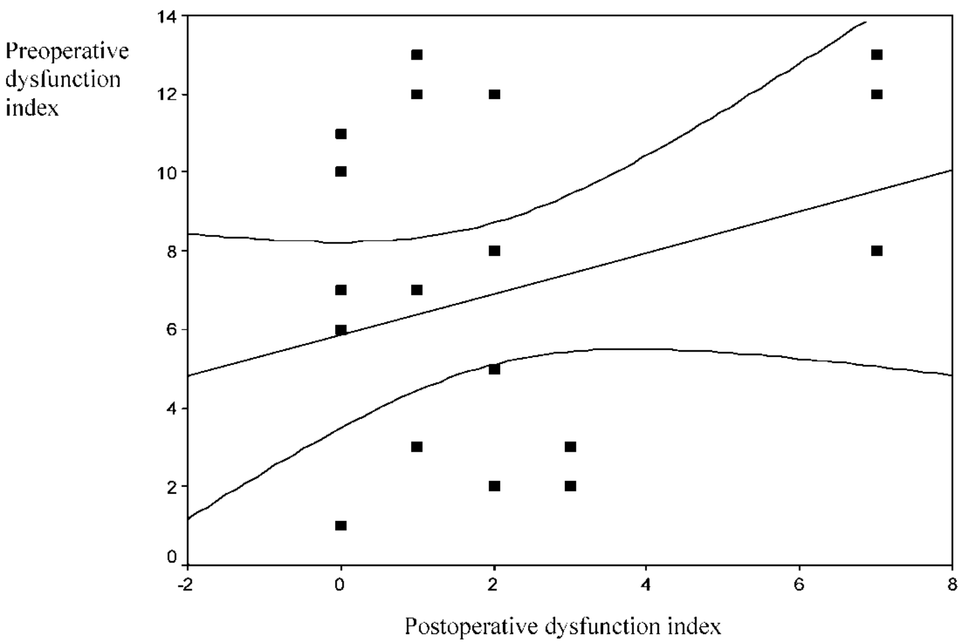

Fig. 2. Scatterplot of preoperative and postoperative dysfunction index and mean regression prediction line with 95% confidence intervals in the myo group ($n = 22$).

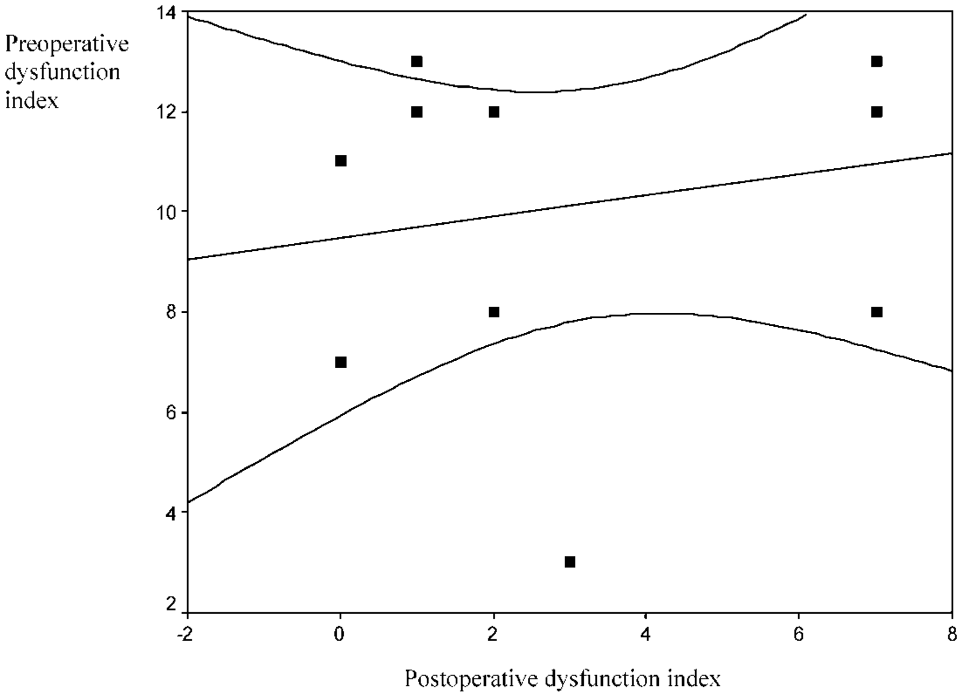

Fig. 3. Scatterplot of preoperative and postoperative dysfunction index and mean regression prediction line with 95% confidence intervals in the combi group ($n = 11$).

significantly related to decrease in dysfunction index. Furthermore, in the myo- and combi groups in particular, the effect of the surgical-orthodontic treatment on TMD was good, while no significant association was found between the reduction of the index and the arthro group.

Discussion

One senior orthodontist started some of the treatments at the beginning of 1998, but another senior orthodontist has continued in his position since autumn 1998. The latter orthodontist (RP) also supervised the treatments performed by the specialist dentists. The recording methods of the juniors had thus been calibrated. The radiological registrations of the condyles were done by one specialist dentist (JH), calibrated by one senior radiologist. Panoramic radiography is a routine method in general practice screening TMJ areas in orthodontic/orthognathic patients, although it is known that even slight variations in head posture during X-ray can produce distortions simulating condylar flattening, ostophytes, decrease of the articular space and asymmetry (24). Intraobserver reliability in condylar panoramic diagnosis has proved fairly good (25), but the sensitivity of the method is low (26). For more accurate diagnosis of TMJ abnormalities, more sophisticated methods, such as MRI and CT, are therefore needed.

There has been criticism of Helkimo's index in that it does not distinguish between joint and muscle dysfunction (27) and for producing false-positive results (28). Despite these problems, however, we used it as the basis of the present index in order to determine the effectiveness of the orthognathic treatment on TMD. In the original Helkimo's index there are basically two categories for TMJ dysfunction (impaired TMJ function and TMJ pain), one category for muscular dysfunction (muscle pain), and two categories which may relate to the masticatory muscles as well as to the TM joints (impaired range of movement and pain on movement of the mandible). Since pain on movement of the mandible was not recorded in this study (this is a rare sign among our orthognathic patients) it was substituted by headache in order to balance the muscular and arthralgic components of the index. Although the etiology of headache is known to be heterogeneous, in the present sample we considered this symptom as represen-

Table 5. Relationship between the change in preoperative and postoperative dysfunction index and independent variables by multiple regression analysis

Independent variable	Regression coefficient	*P*
Pretreatment overjet (mm)	0.15	0.011
Myo group (0,1)	3.13	<0.001
Arthro group (0,1)	1.34	0.078
Combi group (0,1)	2.60	0.025
Previous occlusal splint therapy (0,1)	2.03	0.010

$R^2 = 0.508$.

tative of mainly tension-type headache, since patients with migraine were already diagnosed and medicated.

It has been widely reported in the literature that TMDs are more common in females than in males. The pattern of TMD signs is also suggested to be more consistent in women than in men (29). Regarding preoperative and postoperative signs of TMD in orthognathic patients, Smith et al. (30) found an increase especially in clicking in some of the females but not in males. In agreement with the study of Westermark et al. (31), no significant difference between genders was found in improvement of TMD in the present report. In the multiple regression analyses, neither gender nor age of the patients was related to the improvement of the index.

The prevalence of crepitation increased, but clicking decreased after treatment; these findings parallel those of Feinerman and Piecuch (32), but contrast with those of Panula et al. (15). In addition to being an indicator of degenerative changes in the TMJ (33, 34), crepitation is presumed to be present in TMJs with altered disk position (34). Although condyles have been found to displace only minimally with surgery (30), an alteration in disk-condyle integrity cannot usually be avoided in surgical procedures. Furthermore, Harper and co-workers (35) have shown in their EMG investigations that surgical advancement of the mandible in Class II cases normalizes the preoperative hyperactivity of the lateral pterygoid muscle; this may partly explain the decrease in postoperative joint sounds, e.g. clicking (30).

In the present report, degree of overjet was significantly related to decreased dysfunction index, indicating that patients with an excessive overjet clearly benefit from the surgical-orthodontic treatment. In our previous longitudinal studies on children and adolescents, excessive overjet has been found to increase the risk of TMD signs systematically, mainly muscular tenderness (36). This kind of malocclusion also predisposes to large mandibular movements (37), most likely for functional (articulation of speech and bite) and esthetic (habitual protrusion to compensate mandibular hypoplasia) reasons, and is thus likely to cause muscular hyperactivity. In their arthrographic study on orthognathic patients, Dahlberg et al. (38) found that disk displacement is frequent in patients with dentofacial anomalies. To conclude, these findings underline the importance of harmonious occlusion on physiological fine oral motor activities.

In order to find out what patients might benefit most from the orthognathic treatment, we classified the sample into subgroups according to type of TMD. Previously, Rauhala et al. (39) used this method based on the criteria of AAOP. In order to get enough patients in the arthro group, we modified the criteria to include clicking as one indicator of an arthralgic component of TMD, although current opinion is that TM joint sounds as a sign of TMD can be questioned. This new classification made comparisons between the groups possible.

The finding that improvement of dysfunction was most marked in orthognathic patients with mainly muscular origin of TMD is in agreement with the studies of Kerstens et al. (40) and Panula et al. (15). However, it has to be taken into account that preoperatively the dysfunction scores in the present study were higher in the myo- and combi groups than in the arthro group. Considering the organic changes in the condyles, and specific structural abnormalities of the TMJs (e.g. internal derangement and degenerative diseases), it is usually unrealistic to expect normalization in condylar form and disk-condyle integrity after orthognathic treatment. As Solberg and co-workers (41) have found, there are likely to be extensive TMJ changes with a long exposure of severe malocclusion. This raises the question whether severe malocclusions should be treated early, either orthodontically or with surgical-orthodontic treatment, as soon as the growth has ceased, if irreversible organic TMJ changes are to be avoided.

Furthermore, multiple regression analyses have shown that subjects with previous occlusal splint therapy benefit from the surgical-orthodontic treatment. Although the effectiveness of previous (in some cases even several years before the surgical-orthodontic treatment) occlusal splint therapy was not recorded in this study, most of the patients claimed that the splint had relieved their signs and symptoms of TMD. It seems that balancing severe malocclusion with surgical-orthodontic treatment is effective in decreasing especially myogenous signs of TMD. Further research will give information on the effectiveness of orthognathic treatment on subjective symptoms of TMD, changes in mandibular movement capacity, and improvement of occlusion by the treatment.

In conclusion, the present results show that in cases with severe maxillomandibular discrepancy, orthognathic therapy is a good choice of treatment for reducing orofacial pain and discomfort, especially in patients with myogenous components of TMD. In addition, the importance of harmonious occlusion in producing a physiological masticatory muscle pattern cannot be underestimated.

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