Effects of Major Class II Occlusal Corrections on Temporomandibular Signs and Symptoms

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This study explored the relationship between malocclusion and signs and symptoms of temporomandibular disorders (TMD) in 124 patients with severe Class II malocclusion, before and 2 years after bilateral sagittal split osteotomy (BSSO). Patients were evaluated with the Craniomandibular Index (CMI), the Peer Assessment Rating Index (PAR Index, to assess gross changes in the occlusion), and symptom questionnaires. The results showed a significant improvement in occlusion; PAR Index scores dropped from a mean of 18.1 before surgery to a mean of 6.1 at 2 years postsurgery ($P < 0.001$). The CMI and masticatory index (MI) for muscle pain indicated clinically small but statistically significant improvement ($P = 0.0001$) from before surgery (mean CMI = 0.14, mean MI = 0.15) to after surgery (mean CMI = 0.10, mean MI = 0.08). The number of patients with clicking upon opening decreased significantly from 33 (26.6%) to 13 (10.5%) ($P = 0.001$). However, the number of patients with fine crepitus increased from 5 (4.0%) before surgery to 16 (12.9%) at 2 years postsurgery ($P = 0.005$). Significant reductions in subjective pain and discomfort were also found 2 years after surgery. The magnitude of change in muscular pain was not related to the severity of the pretreatment malocclusion, a finding that suggests that factors other than malocclusion may be responsible for the change in TMD.

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A relationship between certain broadly defined occlusal factors and the signs and symptoms of temporomandibular disorders (TMD) has been considered by many authors.[1–7] Although strong positive correlations have not been found for most occlusal variables, there may be specific types of malocclusion that are associated with the occurrence of TMD. These malocclusion types include Angle Class II and III, anterior open-bite, posterior cross-bite, and deep bite.[1,5,6,8,9] Most available evidence comes from correlational designs, which do not provide strong evidence of causation. A stronger test of the role of occlusion in TMD would be to experimentally manipulate occlusal conditions and observe the effect on signs and symptoms over time. This strategy was employed in several studies with mostly negative results.[10–13] Study design weaknesses that possibly contributed to these negative results include the minimal occlusal alterations performed and the relatively brief periods of follow-up time allowed.

Combined orthodontic and surgical procedures are used to correct serious dentofacial malrelationships such as Angle Class II or III malocclusion, and they have a dramatic effect on the occlusion.[14,15] Some investigators have reported improvement in TMD symptoms following these major orthodontic and surgical corrections.[16–23] Magnusson et al[20] noted that temporomandibular joint (TMJ) pain-dysfunction is a common reason for treatment requests. In the present sample, 28% of patients reported TMD as a reason for seeking surgery and 17.5% reported that treatment of current TMD was a reason given by their referring orthodontist. Magnusson et al[20] reported that surgical correction of dentofacial anomalies benefits both signs and symptoms of TMJ pain-dysfunction 1 to 2.5 years after surgery. Some authors have attempted to explain these results by occlusal parafunctions and occlusal interferences. It is uncertain how orthognathic surgery affects small occlusal interferences. However, the impact of orthognathic surgery on the gross occlusion can be dramatic. A risk of creating TMJ symptoms or internal derangements also exists with orthognathic surgery.[19,23–26] Kerstens et al[21] showed a higher incidence of TMJ symptoms after surgical correction of high angle, absolute mandibular retrognathism by bimaxillary surgery. Another recent study by Onizawa et al[27] showed that TMJ symptoms did not always improve and sometimes worsened after surgical correction of Class II or Class III malocclusion.

It is clear that orthognathic surgery can dramatically improve severe dental malocclusion.[20,22] If TMD is related to this type of malocclusion, one would expect to find significant improvement or deterioration in TMD symptoms in patients whose occlusion has been surgically and orthodontically corrected. Also, one would expect to see the most improvement in the patients who had the most extreme malocclusions before treatment. This study tests these hypotheses by the assessment of the long-term signs and symptoms of TMD after mandibular advancement with bilateral sagittal split osteotomy (BSSO). It was not possible to include a nontreatment randomized control group in this study; however, the data were collected in the context of a multicenter clinical trial that employed a prospective design, calibrated examiners, a large sample size, and a 2-year follow-up period. These factors overcome some of the limitations of previous studies.

Materials and Methods

A total of 215 eligible patients were identified at the three sites (San Antonio, Texas; Atlanta, Georgia; and Gainesville, Florida). Of the eligible patients, 140 agreed to participate; 70 patients were randomly selected to receive rigid fixation, and 70 patients received wire fixation. Thirteen patients (7 wire and 6 rigid) withdrew from the study before surgery or elected not to have the surgery. The remaining 127 patients (63 wire and 64 rigid) constituted the sample of this study. During the course of the study three patients were lost to follow-up. The results reported here are based on the remaining 124 patients. Patients were eligible to participate if they were at least 14 years of age with horizontal mandibular deficiency that required mandibular advancement via BSSO. Patients who had not had previous TMJ arthrotomies, who had not had maxillary surgery in the prior 6 months, and who had a stable residence were included in the study. Patients who had undergone TMJ arthroscopies and/or arthrocentesis were also eligible for the study. Patients who suffered from any serious medical, physical, or mental condition were excluded, as were patients who had fewer than 20 teeth total or 10 teeth in either arch, or had severe periodontal disease. Detailed inclusion and exclusion criteria were described by de Boever et al.[28]

Between October 1990 and September 1994, all patients (32 males and 92 females, mean age 30.16 years, range 14.7 to 57.3 years), underwent orthodontic treatment and a BSSO procedure to advance the mandible. The patients received either nonrigid internal fixation or rigid internal fixation. Analysis indicated that TMD signs and symptoms were similar before and after the treatment in the rigid and nonrigid fixation groups.[29] These two groups were therefore combined for this analysis.

The rigid fixation group received three 2-mm bicortical position screws[30] without maxillomandibular fixation. Soft tissue dissection for the sagittal split was performed as described by Bell et al.[31] To check the mandibular rotation and occlusion upon completion of the rigid internal fixation procedures, the condyles were seated both vertically and distally and rotated through opening and closing movements. The nonrigid fixation group had the proximal and distal bone segments secured with inferior border wires according to techniques described by Booth[32] and by Singer and Bays.[33]

Maxillomandibular fixation was maintained in these patients for 6 weeks. Postoperative physiotherapy was similar for patients treated with rigid fixation and with wire fixation. At 3 weeks an exercise protocol was prescribed for the rigid fixation group. The nonrigid fixation group had an exercise protocol initiated at the release of fixation.

The subjects were assessed for TMD signs and symptoms before orthodontic appliances were applied (T1), 2 weeks before surgery (T2), and at intervals of 1 week (T3), 6 weeks (T4), 6 months (T5), 1 year (T6), and 2 years (T7) after surgery. In this study, only the data collected immediately presurgery (T2) and at 2 years postsurgery (T7) are reported. A previous analysis of this patient group showed no significant change in TMD symptoms from T1 to T2;[28] the T2 assessment was therefore chosen as the appropriate baseline. The surgery and assessments were performed at the University of Texas Health Science Center at San Antonio (n = 76); at Emory University, Atlanta, Georgia (n = 26); and at the University of Florida, Gainesville (n = 22).

Patients were evaluated using the Craniomandibular Index (CMI). The CMI includes two subindices: a dysfunction index (DI) and a muscle index (MI). The CMI is the average of the DI and MI. All three scales range between 0 and 1. The DI quantifies the degree of joint dysfunction and MI quantifies the number of muscle sites that are tender to palpation.[34] The CMI also allows separate assessment and comparative scoring for: *(1)* jaw movement and range of motion, *(2)* TMJ noise such as clicking and crepitus, *(3)* tenderness of specific groups of muscles, and *(4)* TMJ tenderness. It also provides an overall index of dysfunction and provides comparative norms.

All of the clinical procedures for this examination were performed as described by Fricton and Schiffman,[35] and the examiners were recalibrated each year by Fricton. Data collected during these calibration sessions were used to estimate interrater reliability. The intraclass correlations for a single fixed-effect rater taken over all calibration sessions were 0.75 for the CMI, 0.74 for the MI, and 0.63 for the DI. All study procedures were approved by the appropriate Human Subjects Review Committee at the participating site, and all subjects gave written informed consent for their participation.

The surgeons and patients were not blinded. The intervention assignment was concealed from the clinical examiners; however, it was not possible to assure blinded ratings because wire fixation patients were still in maxillomandibular fixation in the first steps of evaluation, and this was apparent to clinical raters. Data analysis was postponed until all patients had been randomized so that surgeons and clinical examiners would remain unaware of any trends in the data that might affect treatment and/or assessment decisions.

The Peer Assessment Rating Index (PAR Index) was used to assess the gross occlusion before and after surgery in a subset of 56 subjects. The PAR Index is a measure of the severity of dental malocclusion and does not address relatively small interferences such as balancing contacts. The PAR Index was applied in this study to pretreatment (T2) and posttreatment (T7) dental casts as a measure of the relatively gross effects of treatment on dental occlusion and alignment.[36,37] The PAR Index was completed by an independent examiner who was not otherwise associated with the study. Millimeters of horizontal overlap were also measured; this measurement was used as the primary index of malocclusion.

The subjective symptoms of TMD were measured before and after surgical correction by means of a self-report questionnaire. A standard drawing of the head was shaded by patients to indicate areas of pain or discomfort. Patients then rated the shaded pain areas on a scale that ranged from 1 (very mild) to 7 (very extreme). Patients who reported no pain were assigned a score of 0. In addition, patients completed an Oral Health Status Questionnaire.[38] One item on this questionnaire allowed patients to subjectively rate the difficulty of mouth opening as a result of pain on the intensity scale that is described above.

Statistical Methods

Wilcoxon's signed rank test was used to compare the CMI, the DI, and the MI scores at T2 and T7. McNemar's test was used to analyze individual MI items (coded 0 or 1) and to identify which muscles or groups of muscles contributed to the improvement in the MI index from T2 to T7. Evaluation of the PAR Index before and after BSSO was done by means of Wilcoxon's signed rank test. The association between the change in the MI score between T2 and T7 and the overlap measured on entry into the study was evaluated using Spearman's rank correlation coefficient. Spearman's rank correlation coefficient was also used to correlate the unweighted total PAR Index score that was measured at T2 and the change in the MI scores from T2 to T7. A value of $P < 0.05$ (two-tailed) was considered statistically significant for all tests.

Table 1 CMI, DI, MI, and PAR Index Scores* Before and After BSSO

Variable	T2 Mean (SD)	T7 Mean (SD)	P†	n
CMI	0.14 (0.11)	0.10 (0.10)	0.0001	124
DI	0.13 (0.10)	0.12 (0.11)	0.1293	124
MI	0.15 (0.16)	0.08 (0.12)	0.0001	124
PAR	18.09 (7.43)	6.07 (5.94)	0.0000	56

*CMI, DI, and MI scores had a possible range of 0 to 1.0. No maximal cut-off level was established for the PAR Index; however, a score of 0 indicates good alignment, while higher scores suggest greater irregularity.
†Wilcoxon's signed rank test.

Table 2 Percent of Patients with Joint Sounds Before (T2) and 2 Years After (T7) BSSO

Sound	T2	T7	P*
Reciprocal click	19.4	10.5	0.063
Popping	13.7	8.1	0.162
Opening click	26.6	10.5	0.001*
Closing click	3.2	3.2	1.000
Fine crepitus	4.0	12.9	0.005*
Coarse crepitus	0.8	1.6	0.564

*Significant change as determined by McNemar's test.

Results

The presurgery CMI scores of these severe Class II patients were similar to normative scores reported for a nonclinical population.[34] Presurgery and postsurgery CMI, MI, and DI scores are provided in Table 1. Although the absolute change values for CMI and MI were relatively small—0.04 and 0.07, respectively—both scores showed statistically significant decreases ($P = 0.0001$). The severity of malocclusion was examined in a subset of 56 patients before and after orthognathic surgery by the PAR Index. The mean unweighted PAR scores dropped from 18.1 at T2 to 6.1 at T7 ($P < 0.0000$), which demonstrates improvement in occlusion. Means and standard deviations for the PAR Index are listed in Table 1. The subset of 56 patients did not differ significantly from the remaining patients in terms of age, overlap, fixation type, or gender. There was a significantly greater representation of non-Hispanic Caucasian subjects in the PAR Index group compared to the total study population.

Joint sounds were evaluated before and after surgery and analyzed by McNemar's test. The number of patients with clicking upon opening decreased from 33 (26.6%) at T2 to 13 (10.5%) at T7 ($P = 0.001$). The number of patients with fine crepitus, however, increased from 5 (4.0%) at T2 to 16 (12.9%) at T7 ($P = 0.005$). Other types of joint sounds did not show significant changes. Percentages and P values are presented in Table 2.

Head and neck muscles were palpated before surgery (T2) and after surgery (T7) as part of the CMI exam, and these results were evaluated by means of McNemar's test. Muscles that exhibited a significant drop in the frequency of palpation pain from T2 to T7 were: anterior temporalis, deep masseter, anterior masseter, posterior digastric, medial (intraoral and extraoral) pterygoid, temporalis insertion, lateral pterygoid, and middle sternocleidomastoid. All muscle sites on both sides showed a numerically lower frequency of palpation pain 2 years after surgery. These results demonstrated that reduction in muscle pain was anatomically widespread. Although pain also decreased after BSSO in the middle and posterior temporalis, inferior masseter, trapezius insertion, and upper trapezius muscles, the changes were not statistically significant.

The relationship between the change in MI scores from T2 to T7 and overlap was analyzed by Spearman's rank correlation coefficient and the results are shown in Fig 1. The data indicated that there was no statistically significant correlation between overlap and MI scores ($r = -0.03$, $P > 0.05$). The Spearman's rank correlation between the unweighted PAR Index before surgery and the MI change scores from T2 to T7 ($r_s = 0.01$, $P > 0.05$) was also not statistically significant (data not shown).

Subjective pain was evaluated for each patient before surgery (T2) and after surgery (T7) on a standard self-report pain questionnaire. Of 57 patients who reported any facial pain at T2, 23 continued to report pain at T7 and 34 no longer reported pain at T7. Of the 66 patients who did not report facial pain at T2, 50 continued to be pain-free, but 16 reported some pain by T7. Differences in these values were significant ($P < 0.05$) according to McNemar's test. Discomfort upon opening of the jaw was measured at T2 and T7 by the Oral Health Status Questionnaire and examined by means of Wilcoxon's signed rank test. The means and standard deviations at T2 and T7 were 2.06 (1.60) and 1.61 (1.21), respectively, which reflects a significant reduction in reported discomfort on opening after surgery ($P = 0.01$).

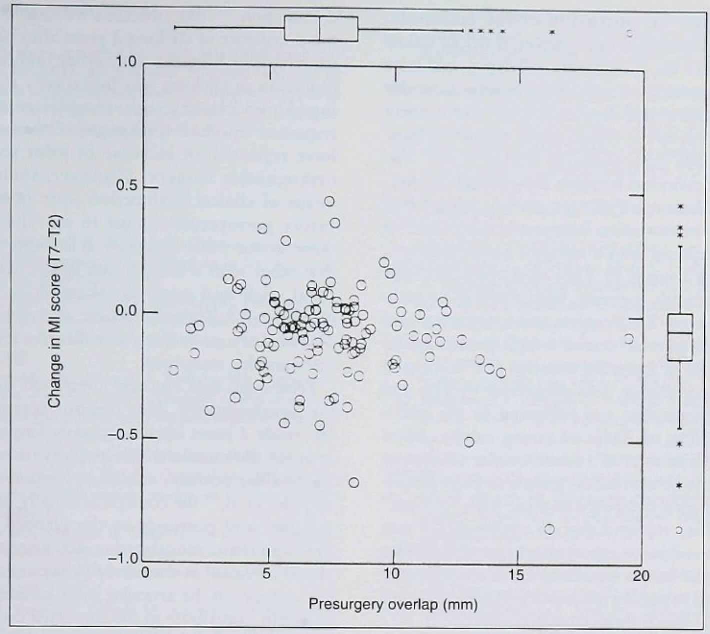

Fig 1 Relationship between presurgery overlap (malocclusion) and change in MI score ($r = -0.03$, $n = 124$, $P > 0.05$).

Discussion

Based on the assumption that there is a relationship between gross malocclusion and TMD, this study tested the hypothesis that signs and symptoms of TMD would significantly change following the correction of severe Class II malocclusion. It was also hypothesized that the amount of change in signs and symptoms would be related to the severity of the presurgery malocclusion.

Improvement in the occlusion was documented 2 years after surgery. The mean PAR Index scores in Table 1 indicate a dramatic improvement in the severity of overlap and tooth alignment. This dramatic improvement in malocclusion is consistent with other findings,[20,22,39,40] and it validates the success of surgical and orthodontic treatment. Accompanying this change, we found a small but statistically significant improvement in MI scores, but no change in DI scores. The second hypothesis that the amount of change in CMI scores would be related to the severity of malocclusion was not confirmed. Patients with more severe malocclusion (PAR Index scores) did not show the greatest change in CMI scores. Perhaps the most important outcome is that, with the possible exception of fine crepitus, we found no evidence that orthognathic surgery increases the risk of TMD.

The improvement in CMI scores 2 years after surgery was mainly a result of the change in the muscular tenderness (MI scores) rather than in the joint assessments (DI scores). Although these results were obtained from a sample that was not being treated specifically for TMD, they are in general agreement with results of Smith et al,[41] who found improvement in clinical TMD because of decreased muscular pain in the temporalis and masseter muscles. The results are also in agreement with Harper et al,[42] who verified that after mandibular advancement surgery the lateral pterygoid and temporalis muscles decrease their activity patterns.

One interpretation of these results is that Class II malocclusion patients may posture the jaw forward for functional and/or esthetic reasons, and that this posturing may result in minor muscular symptoms. Correction of the malocclusion would reduce the need for forward posturing of the mandible. However, if this theory were correct, it would follow that those with the most severe overlap would have the most posturing and the most severe muscular symptoms, and would show the most improvement after correction of the discrepancy. Neither of these hypotheses was supported. De Boever et al[28] also found no relationship between the amount of overlap and CMI scores. Pullinger et al[3] reported that there was no association between vertical overlap that was combined with a minimal horizontal overlap and joint sounds or TMJ tenderness. At least three other studies, however, have reported an association between TMD signs and symptoms and overlap. Motegi et al[9] found a high percentage of TMD in cases of excessive overlap, and Solberg et al[2] found a correlation between greater overlap and disc displacement that was evidenced by the extensive remodeling of TMJs of young adults. Most recently, Henrikson et al[43] found muscle tenderness to palpation to be statistically greater in Class II malocclusion subjects compared to those with "normal" occlusion. They reported that an overjet of ≤ 6 mm increased the odds for reported pain on mandibular movement. In future research, electromyography could be used to resolve questions related to forward posturing in Class II malocclusion patients.

Other studies have reported improvement in signs and symptoms of TMD after orthognathic surgery.[20,21] However, these studies did not test the assumption that the degree of improvement should be related to the degree of the original malocclusion. We found no relationship in the present study. This finding suggests that other factors such as passage of time, natural variation, parafunction, presurgery anxiety, and/or regression to the mean may be responsible for the reduction in muscular signs and symptoms 2 years after surgery. It would be necessary to run a no-treatment control or a sham orthognathic treatment to control for these factors. A simple biomechanical model of malocclusion and TMD is not supported.

It is important to note that the subjects of this study were not seeking care for TMD. As a group, they had relatively minor muscle and joint tenderness levels. The average CMI, MI, and DI scores were comparable to normative scores found in a nonpatient population. However, 11 patients had CMI scores greater than 0.30. The CMI scores ranged from 0 to 0.7. The 11 patients with CMI scores greater than 0.30 did not have greater malocclusion than patients in the other group. This does not support a malocclusion/TMD therapy.

Joint sounds and/or TMJ pain are the symptoms that most frequently occur in "orthognathic TMJ dysfunction."[19] We observed a reduction (16%) in the prevalence of clicking 2 years after orthognathic surgery, which agrees with other findings.[19,20] The reduction in clicking was found only during opening. Upon closing, the occurrence of clicking remained low and unchanged. Other authors[21,22] have reported an increase in joint sounds after orthognathic surgery. However, their measurements of clinical dysfunction were obtained at an earlier postoperative stage (6 months) than were those in our study (2 years). It is important to note that other joint sounds in our study, such as reciprocal click and popping, showed no significant change at T7. Thus, we believe that the changes we observed are most likely not directly related to the orthognathic treatment.

Feinerman and Piecuch[23] reported higher crepitus postoperatively. Fine crepitus was increased in our study 2 years after treatment. The possible reasons for the increased fine crepitus include changes in condylar position caused by surgery. According to Alder et al,[44] the condyle is usually located more superior and posterior in the glenoid fossa after orthognathic mandibular advancement. This altered position of the condyle may cause degenerative changes in the articular joint surfaces, and consequently contribute to the increased crepitus found after BSSO. It is also possible that the increased crepitus is a result of the aging of the subjects. Without a control group, we cannot tell. We will complete a 5-year postoperative examination of our patient population to further assess the issues of increased crepitus.

The results of the subjective pain questionnaire revealed an overall decrease from T2 to T7 in the number of patients who had muscle/TMJ pain. There is about a 50% chance that patients with one or more symptoms before surgery will report no symptoms 2 years after surgery. Patients who do not report symptoms before surgery have about a 25% chance of reporting symptoms 2 years after surgery. These changes cannot be attributed to the orthognathic surgery without the completion of a carefully controlled study. It has been shown that signs and symptoms of TMD fluctuate dramatically over time with or without treatment.[45] Our results suggest that the correction of Class II malocclusion does not cause a clinically significant increase or decrease in TMD signs or symptoms. Patients with more extreme malocclusion, which was measured by horizontal overlap, did not respond differently than those with a lesser degree of overlap. The results do not provide support for the theory that TMD is related to Class II malocclusion.

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Resumen

Los Efectos de las Principales Correcciones Oclusales Clase II Sobre los Signos y Síntomas Temporomandibulares

Este estudio examinó la relación entre la maloclusión y los signos y síntomas de los desórdenes temporomandibulares (DTM) en 124 pacientes con maloclusiones severas Clase II, antes y después de 2 años luego de realizar osteotomías fragmentadas sagitales bilaterales (OFSB). Los pacientes fueron evaluados por medio del Indice Craneomandibular (ICM), el cual incluye un índice de disfunción de la articulación temporomandibular (ID) y un índice masticatorio (IM) para el dolor muscular. Se utilizó el índice de Clasificación y Evaluación Comparable (Indice CEC) para evaluar los cambios notorios en la oclusión de un pequeño grupo de personas. Los síntomas subjectivos de los DTM fueron medidos por medio de dos cuestionarios diferentes. Los resultados demonstraron una mejoría significativa en la oclusión; las puntuaciones del Indice de CEC disminuyeron, originalmente la media del índice fue de 18,1 antes de la cirugía, y 2 años después de la cirugía fue de 6,1 ($P < 0{,}001$). El ICM y el IM indicaron que existía una mejoría estadísticamente significativa ($P = 0{,}0001$) comparando los valores antes de la cirugía (media ICM = 0,14, media IM = 0,15), a después de la cirugía (media ICM = 0,10, media IM = 0,08). El ID mostró una ligera mejoría que no fue significativa estadísticamente ($P = 0{,}13$). El número de pacientes con sonidos de clic al abrir la boca, disminuyó significativamente de 33 (26,6%) a 13 (10,5%) ($P = 0{,}001$). Sin embargo, el número de pacientes con crepitación aumentó de 5 (4,0%) antes de la cirugía, a 16 (12,9%) 2 años después de la cirugía ($P = 0{,}005$). También se observaron reducciones significativas en cuanto al dolor subjetivo y a las molestias, 2 años después de la cirugía. La magnitud del cambio en el dolor muscular no fue relacionada a la severidad de la maloclusión antes del tratamiento, un hallazgo que indica que otros factores y no la maloclusión, pueden ser responsables por el cambio. Como grupo, los pacientes de este estudio con maloclusión Clase II, no tenían DTM clínicamente significativos, antes o depués de la corrección de la maloclusión. Es importante mencionar que en promedio y con la excepción de la crepitación, no se encontró ninguna evidencia que indique que la cirugía ortognática que envuelve las OFSB aumenta el riesgo de los DTM.

Zusammenfassung

Auswirkungen von Grossen Klasse II-Okklusionskorrekturen auf Temporomandibuläre Zeichen und Symptome

Diese Srudie untersuchte die Beziehung zwischen Malokklusion und Zeichen und Symptomen von temporomandibulären Erkrankungen (TMD) bei 124 Patienten mit starker Klasse II-Malokklusion, vor und 2 Jahre nach beidseitiger sagittaler Spaltung (BSSO). Die Patienten wurden mit dem kraniomandibulären Index (CMI) ausgewertet, welcher einen Kiefergelenk-Dysfunktions Index (DI) und einen mastikatorischen Index (MI) für Muskelschmerz beinhaltet. Der Peer Assessment Rating Index (PAR Index) wurde verwendet, um grobe Abweichungen in der Okklusion einer Untergruppe der Personen auszuwerten. Subjektive TMD-Symptome wurden mit Hilfe zweier verschiedener Fragebögen ermittelt. Die Resultate zeigten eine signifikante Verbesserung der Okklusion; die Werte des PAR Index fielen von einem Mittelwert von 18.1 vor der Operation auf einen Mittelwert von 6.1 zwei Jahre postoperativ ($P < 0.001$). Der CMI und der MI deuten auf eine statistisch signifikante Verbesserung ($P = 0.0001$) zwischen den Werten vor Chirurgie (durchschnittlicher CMI = 0.14, durchschnittlicher MI = 0.15) und den postoperativen Werten (durchschnittlicher CMI = 0.10, durchschnittlicher MI = 0.08) hin. Der DI zeigte eine leichte Verbesserung, die nicht statistisch signifikant war ($P = 0.13$). Die Anzahl der Patienten mit einem Oeffnungsknacken sank signifikant von 33 (26.6%) auf 13 (10.5%) ($P = 0.001$). Dagegen stieg die Anzahl der Patienten mit einem feinen Krepitus von 5 (4.0%) zum Zeitpunkt vor der Operation auf I6 (12.9%) zwei Jahre postoperativ ($P = 0.005$). Signifikante Abnahmen beim subjektiven Schmerz und Diskomfort wurden ebenfalls zwei Jahre nach der Operation gefunden. Das Ausmass der Veränderung im muskulären Schmerz stand nicht in Beziehung zur Stärke der Malokklusion vor Behandlung, ein Befund, der vermuten lässt, dass andere Faktoren als die Malokklusion für die Veränderung verantwortlich sind. Als Gruppe betrachtet, weisen die Personen dieser Studie mit einer Klasse II-Malokklusion keine klinisch signifikante TMD vor als auch nach Korrektur der Malokklusion auf. Es ist wichtig zu bemerken, dass im Durchschnitt und rnit Ausnahme des Krepitus kein Beweis gefunden wurde, welcher nahelegt, dass orthognathe Chirurgie, die BSSO beinhaltet, das Risiko einer TMD erhöht.