Clinical predictive factors for temporomandibular disorders following combined orthodontic and orthognathic surgical treatment in patients with Class III malocclusion

ANTONARAKIS, Gregory, et al.

Abstract
The aim of this study was to identify clinical factors predisposing to the development or worsening of temporomandibular disorders (TMDs) following orthodontic surgical treatment for Class III malocclusion.


DOI : 10.1080/08869634.2017.1283764
PMID : 28129722

Available at:
http://archive-ouverte.unige.ch/unige:93732

Disclaimer: layout of this document may differ from the published version.
Clinical predictive factors for temporomandibular disorders following combined orthodontic and orthognathic surgical treatment in patients with Class III malocclusion

Gregory S. Antonarakis, Nicole Kalberer, Delphine S. Courvoisier & Paolo Scolozzi

To cite this article: Gregory S. Antonarakis, Nicole Kalberer, Delphine S. Courvoisier & Paolo Scolozzi (2017): Clinical predictive factors for temporomandibular disorders following combined orthodontic and orthognathic surgical treatment in patients with Class III malocclusion, CRANIO®, DOI: 10.1080/08869634.2017.1283764

To link to this article: http://dx.doi.org/10.1080/08869634.2017.1283764

Published online: 27 Jan 2017.

Article views: 48
MAXILLOFACIAL SURGERY

Clinical predictive factors for temporomandibular disorders following combined orthodontic and orthognathic surgical treatment in patients with Class III malocclusion

Gregory S. Antonarakis DDS, MSc, PhD, Nicole Kalberer DMD, Delphine S. Courvoisier PhD and Paolo Scolozzi MD, DMD

aDivision of Orthodontics, University of Geneva, Geneva, Switzerland; bDivision of Fixed and Removable Prosthodontics, University of Geneva, Geneva, Switzerland; cDivision of Oral and Maxillofacial Surgery, University Hospitals of Geneva, Geneva, Switzerland

ABSTRACT

Objective: The aim of this study was to identify clinical factors predisposing to the development or worsening of temporomandibular disorders (TMDs) following orthodontic surgical treatment for Class III malocclusion.

Methods: A retrospective cohort study was performed on 88 patients with Class III malocclusion having undergone a combined orthodontic and orthognathic surgical treatment. Temporomandibular joint and masticatory muscle examinations were available prior to treatment and one year post-operatively. Multivariate logistic regression was used to predict the development of post-operative TMDs, and linear regression was used to predict the worsening of TMDs using Helkimo indices.

Results: Patients with Class III malocclusion presenting with pre-treatment anamnestic TMJ clicking (OR = 5.8; \(p = 0.03\)) and undergoing bimaxillary osteotomy procedures (OR = 18.6; \(p = 0.04\)) were more at risk for the development of TMDs.

Discussion: TMDs must be evaluated, monitored, and managed with caution in patients with Class III malocclusion presenting with pre-treatment joint clicking and who are planned for bimaxillary osteotomies.

Introduction

Temporomandibular disorders (TMDs) are believed to be multifactorial in etiology [1]. Associations between different occlusal factors or specific types of malocclusion have been put forward as one of the factors involved in this etiology [2–4]. Although not the sole malocclusion to be associated with TMDs, Class III malocclusion, or mandibular prognathism, has been shown to be a risk factor. Prevalence rates of individuals with Class III malocclusion being diagnosed with TMDs vary, with reports ranging from 24 to 88% [5–10]. Populations investigated, however, also vary, with some studies investigating individuals with untreated mandibular prognathism without asymmetry, and others investigating individuals with Class III malocclusion referred for orthognathic surgical treatment.

Strong correlations between Class III malocclusion and the presence, as well as the severity, of symptoms of mandibular dysfunction have been reported in children, adolescents and adults [3,11,12]. Moreover, asymmetrical Class III malocclusion patients seem to have higher rates of internal derangement or disc displacement [5–7].

TMDs may represent a factor motivating patients to seek orthodontic surgical treatment [6,13]. Some authors, however, have suggested that orthognathic surgical procedures may lead to the development of signs and symptoms of TMDs in asymptomatic patients or worsening in signs and symptoms in those with pre-existing TMDs, by its effects on the joint itself, the masticatory musculature, and the surrounding soft tissues [14–18]. At the same time, however, TMDs in symptomatic patients can also improve following orthognathic surgery [6,15,17–21].

TMDs following orthognathic surgery are a reality for some patients initially presenting with a Class III malocclusion, some pre-existing, while others develop post-treatment. The occurrence of signs and symptoms of TMDs have been found to fluctuate with an unpredictable
pattern after orthognathic surgery for Class III malocclusions [8]. Therefore, identifying which patients will present with TMDs post-operatively, based on pre-operative diagnosis, will improve patient education and the process of informed consent, as well as their overall management. It can be hypothesized that certain symptoms or clinical signs may be able to predict, at least in part, the development or worsening of TMDs. The aim of the present study, therefore, was to try to identify predictive factors predisposing to the development or worsening of TMDs following combined orthodontic and orthognathic surgical treatment in patients with Class III malocclusion.

Materials and methods

The present retrospective cohort study was approved by the local research ethics committee. The study sample consisted of 88 patients (39 male; 49 female), aged 24.5 ± 9.6 years. The inclusion criteria were as follows: patients presenting with a symmetric Class III malocclusion (with mixed etiology, including maxillary hypoplasia and/or mandibular prognathism) treated at the authors’ institution using a combined orthodontic and orthognathic surgical approach, with Le Fort I osteotomy and/or bilateral sagittal split ramus osteotomy (BSSO), performed by one experienced maxillofacial surgeon. Exclusion criteria were: syndromic patients, previous history of maxillofacial trauma or maxillofacial surgery, patients with evident temporomandibular joint deformity, previous orthodontic treatment, patients with multiple missing teeth, previous history of treatment for TMDs, those undergoing Le Fort II or Le Fort III osteotomies, those undergoing genioplasty alone, and those having had maxillomandibular fixation post-operatively. All patients underwent preliminary orthodontic treatment to prepare for orthognathic surgery.

The medical records of each patient were consulted and data extracted with regard to age, sex, surgical procedure, temporomandibular joint (TMJ), and masticatory muscle examinations. The TMJ and masticatory muscle examinations, consisting of an anamnestic questionnaire and clinical examination, were carried out prior to treatment and one year post-operatively, following the end of active treatment. The anamnestic questionnaire included questions on parafunctional habits (such as nail or pen biting), jaw function, and the subjective presence of pain or TMJ sounds. Clinical examination included TMJ palpation determining the presence of pain at rest and mouth opening; masticatory muscle palpation determining the presence of pain; maximal mouth opening; deviation at mouth opening; maximal mandibular protrusion and laterotrusion; and the presence of articular sounds on palpation (joint clicking or crepitus). All measurements were recorded in millimeters using a millimeter ruler. No magnetic resonance imaging (MRI) was performed.

Based on the objective assessment, TMDs were classified according to recommended Diagnostic Criteria for TMDs (DC/TMD) [22]. The anamnestic and clinical data from the examination were also used to calculate the Helkimo indices, namely the anamnestic dysfunction index (Ai) and the clinical dysfunction index (Di) to score TMD severity [23].

One examiner carried out all of the clinical examinations and all of the orthognathic surgical procedures. This provided for standardization with regard to examination and surgical procedure. No formal blinding was carried out, due to the retrospective nature of the current study. The examiner however, when performing the one year post-operative clinical examination, deliberately did not consult the patient records so that the results of the pre-treatment clinical examination as well as the type of surgery performed was unknown to the examiner at the time of clinical examination.

The following statistical analyses were carried out:

- For all variables, pre-treatment and one year post-operative scores or numbers were compared using paired t-tests for continuous variables (Helkimo indices and range of motion millimeter measurements); or
- McNemar tests for bivariate variables (McNemar exact tests were used for variables where fewer than five patients were positive).

To assess for predictive factors, patients with the development of TMDs (where no signs of symptoms of TMDs were present prior to treatment) or worsening of TMDs (based on the Helkimo score) were both evaluated. Multivariate logistic regression was used to predict post-operative TMDs according to age, sex, specific surgical procedure, and pre-treatment TMDs. Possible associations were assessed by measuring odds ratios (OR). Linear regression was used to predict post-operative Helkimo scores, again according to age, sex, specific surgical procedure, and pre-treatment Helkimo scores. All statistical tests were performed using R 3.1.1 software (R Development Core Team, Vienna, Austria). Significance was set at the p < 0.05 level.

Results

In the present study population of patients with Class III malocclusion referred for a combined orthodontic and orthognathic surgical treatment, the surgical procedures used were conventional Le Fort I osteotomy (one-, two-, or three-piece) for 29 patients (33%), BSSO for 4 patients (4.5%), and combined Le Fort I osteotomy and BSSO for 55 patients (62.5%).
Fixation was performed, in the case of a Le Fort I osteotomy, with two 5-hole, 1.5-mm titanium L-plates at the zygomatic buttress and two 5-hole, 1.5-mm straight titanium plates at the piriform rim. For BSSO procedures, fixation was performed with the placement of two bicortical positioning screws. The orthognathic surgery was followed by a phase of post-surgical orthodontic treatment and finishing.

TMDs were diagnosed pre-treatment in 49 out of the 88 patients (55.7%). Determined by clinical examination only, disc displacement was identified in 38 patients (43.2%), while myofascial pain was present in 21 patients (23.9%), and no other DC/TMD diagnoses were observed. As can be discerned from these numbers, 10 (11.4%) patients had both disc displacement and myofascial pain. The mean Helkimo indices were 0.53 (±0.76) for Ai and 0.99 (±0.65) for Di. This data is presented in Table 1.

Comparison of pre-treatment to one-year post-operative findings revealed that the number of patients with TMDs did not change significantly (Table 1). There was, however, a trend towards a decrease. The Helkimo scores also showed no significant changes from pre-treatment to one year post-operatively, but a trend towards a decrease in the Ai was observed (Table 1). The agreement analysis between pre-treatment and one year post-operative TMDs showed that the percentage of patients with TMDs before treatment who improved following treatment (37%) was similar to the percentage of patients not presenting any TMD before treatment and who developed TMDs following treatment (36%) (Table 2). The majority of patients (64%), however, did not change TMD status.

Looking at the subjective signs and symptoms of TMDs, the objective signs and symptoms, and the range of motion measurements, the only variables showing significant changes from pre-treatment to one year post-operatively were the maximum protrusive and lateral mandibular movements (Table 1). Protrusive movements decreased by 0.8 mm (p = 0.02) and lateral movements increased by 1.1 mm (p < 0.001).

When performing multivariate analysis to predict the development of TMDs, anamnestic TMJ clicking was found to be the only significant pre-treatment predictor of post-operative TMDs (OR = 5.8; p = 0.03) (Table 3). Objective TMJ clicking diagnosed upon clinical examination may also be considered to be a predictor of post-operative TMDs, although statistical significance at the p < 0.05 level was not reached (OR = 7.6; p = 0.06) (Table 3). Finally, simultaneous Le Fort I and BSSO procedures were found to be predictors of the development of TMDs (OR = 18.6; p = 0.04) (Table 3).

When performing multivariate analysis to predict the post-operative worsening of the Helkimo scores, anamnestic TMJ clicking was found to be the only significant predictor of post-operative worsening of the Helkimo Di (mean difference = 0.35; p = 0.01) (Table 4). Pre-treatment objective TMJ clicking may also be a predictor of post-operative worsening of Helkimo Ai, although this did not reach statistical significance (mean difference = 0.26; p = 0.08) (Table 4). Considering surgical procedure, simultaneous Le Fort I and BSSO may be a predictor of the worsening of the Helkimo Ai, although statistical significance was not reached (p = 0.08) (Table 4).

**Discussion**

The results of the present study illustrate that individuals with Class III malocclusion referred for a combined orthodontic and orthognathic surgical treatment presented...
TMDs in roughly 56% of cases, with disc displacement being more common than myofascial pain determined by clinical examination only. The majority of patients did not change TMD status following treatment, although some showed a change towards improvement, while some showed deterioration. The only objective variable showing significant post-operative change was mandibular range of motion, with a decline in protrusive movements but an improvement in lateral movements, although these differences may be too small to be clinically significant. Concerning predictive factors, pre-treatment TMJ clicking and bimaxillary osteotomy procedures may predispose to the development of TMDs. These factors may also predispose to a worsening of the Helkimo anamnestic and clinical dysfunction scores.

The prevalence of TMDs following orthognathic surgical treatment in patients with Class III malocclusion has been found to be similar in frequency to untreated individuals with Class III malocclusion [11]. However, whether the severity of TMDs in those with pre-existing TMDs changes post-treatment is a debated question, as is whether those with no pre-existing TMDs can develop TMDs following orthognathic surgery. Much research has been carried out in this respect looking into a mixed orthognathic surgery population with various types of dentofacial deformities pooled together. The few studies that look specifically at patients with Class III malocclusion report the following: Athanasiou and Melsen [19] found that orthognathic surgery might alleviate signs and symptoms of TMDs in patients with Class III malocclusion. Likewise, White and Dolwick [24] found a decrease in TMDs after orthognathic surgery in patients with Class III malocclusion. Ueki et al. [25] also reported symptomatic relief in a large number of patients having undergone mandibular setback, with or without Le Fort I osteotomy advancement for a Class III malocclusion. Abrahamsson et al. [26] found that those with a Class III malocclusion and normal vertical jaw relationships having myofascial pain or arthralgia saw a significant alleviation of TMD pain after orthognathic surgery. The frequency of disc displacement, however, did not change.

Fang et al. [27] suggested that combined orthodontic and orthognathic surgical treatment can be used safely to correct skeletal class III malocclusion without causing additional TMJ symptoms. Moreover, patients with Class III malocclusion treated with a combined orthodontic and orthognathic surgical approach do not show any differences in post-operative TMDs when compared to those treated with orthodontics alone [28]. Wolford et al. [29] suggested that in Class III malocclusion patients with mandibular condylar hyperplasia, orthognathic surgery combined with high condylectomies and articular disc repositioning, provides stable and predictable outcomes without compromising jaw function. Several reasons have been suggested to explain the reduction in TMDs following orthognathic surgery, such as a post-operative reduction of mandibular mobility or altered activity of the masticatory muscles [30]. Yoon et al. [31] added to these explanations and proposed that the improvement in TMJ symptoms is not solely due to post-operative reduction of muscular function or jaw mobility but also to the improvement in occlusal, skeletal and neuromuscular balance following treatment.

Some authors suggest that fewer patients with Class III malocclusion show improvement after orthognathic surgery than patients with other dentofacial deformities [24,32]. These findings, however, are contradicted by other authors who report greater improvement in TMD symptoms in patients with Class III malocclusion than Class II malocclusion following orthognathic surgery [6,33]. Dujoncuqoy et al. [15], on the other hand, found no difference in post-operative TMDs in Class III vs. Class II patients.

In the present study, the recommended evidence-based DC/TMD was used [22]. This tool has the advantage of
providing very specific diagnostic criteria for the TMD sub-groups. Only a few other studies, however, have applied the original research diagnostic criteria, the predecessor of the DC/TMD, as a diagnostic tool for assessing TMDs in patients treated by a combination of orthognathic surgery and orthodontic treatment [8,9,26]. This would be beneficial, especially in order to make results comparable, and to aid in providing homogeneity for any future meta-analysis to be performed.

Neither have the Helkimo indices been used extensively when assessing the severity of TMDs in patients having undergone orthodontic and orthognathic surgical treatment. Pahkala and Heino [20] found that the severity of clinical dysfunction greatly reduced following orthognathic surgery. Panula et al. [34] also showed significant improvement in both anamnestic and clinical dysfunction following orthognathic surgery. Similar findings with respect to the anamnestic and clinical dysfunction indices have also been reported by Dervis and Tuncer [33] and Kallela et al. [35]. A decrease in anamnestic dysfunction, but no change in clinical dysfunction was reported by Smith et al. [36] However, none of these studies have specifically investigated patients with Class III malocclusion. Among the few studies reporting on patients with Class III malocclusion, Athanasiou and Melsen [19] found no change in the clinical dysfunction index following orthognathic surgery, whereas Landes [37] found a reduction in dysfunction.

Mandibular range of motion seemed to be affected by orthognathic surgery in the present sample, with a reduction in protrusive movements and an increase in lateral movements. Why this apparent paradox in the observed changes in joint motility occurred is not known. Previous studies have shown that maximum interincisal opening and maximal mandibular protrusion were significantly decreased after orthognathic surgery [38], although some data suggest that any deterioration after orthognathic surgery can fully recover within six months, reaching mandibular motion seen in normal subjects [39].

Factors predicting the development or worsening of TMDs following orthodontic and orthognathic surgical treatment in patients with Class III malocclusion are largely unknown. Type of surgery may be a predictive factor, with the present study finding that bimaxillary surgery (simultaneous Le Fort I and BSSO osteotomies) may predispose to the development or worsening of TMDs. Yoon et al. [31] however, studying patients with Class III malocclusion, stated that favorable changes of TMJ symptoms were observed after bimaxillary orthognathic surgery, with a stable post-operative position of the condyle during follow-up. Dervis and Tuncer [33] found that in patients with Class III malocclusion, vertical ramus osteotomy (VRO) decreases TMDs, whereas BSSO increases TMDs. These results also agree with findings of Westernmark et al. [6]. Results from Ueki et al. [7] suggest that both BSSO and VRO can improve TMJ symptoms, but only VRO improves anterior disc displacement in the initial post-surgical period. Aoyama et al. [40] found that a large bilateral mandibular setback predisposed to TMDs. The finding that bimaxillary surgery predisposed to the development of TMD in this study, with an approximate 18-fold increased risk, may be explained by the fact that in these patients, the condyle undergoes two repositioning procedures: one due to the rotation of the maxillomandibular complex following the Le Fort I osteotomy, and the second during the BSSO procedure.

Pre-treatment TMJ clicking may be another predictive factor predisposing to the development or worsening of TMDs following orthognathic surgery in patients with Class III malocclusion. Anamnestic TMJ clicking increased the risk of developing TMDs almost sixfold. The rationale for this may simply be that patients with pre-treatment TMJ clicking already present with symptoms indicative of an anterior luxation of the disc. This has not been investigated in other studies. In the search for other predictive factors, in a mixed group of patients undergoing BSSO, results from Aoyama et al. [40] point to age as a positive predictive factor for TMDs. Another study examining a mixed group of patients having undergone orthognathic surgery found that patients with anamnestic TMJ clicking, TMJ pain on palpation, and pain on masticatory muscle palpation were more prone to the development of TMDs or worsening of TMD severity [41].

Inconsistencies in studies with regard to dentofacial deformities, surgical approach and technique, and ways

---

**Table 4. Influence of clinical variables on the severity of TMDs (Helkimo indices) one year post-surgery.**

<table>
<thead>
<tr>
<th></th>
<th>Helkimo (Ai)</th>
<th>Helkimo (Di)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean difference</td>
<td>p</td>
</tr>
</tbody>
</table>

**Subjective symptoms and signs**
- TMJ clicking: 0.26 0.09 0.35 0.01
- Parafunctional habits: 0.08 0.56 0.00 0.99

**Objective symptoms and signs**
- Pain to masticatory muscles palpation: –0.01 0.95 0.12 0.44
- TMJ clicking: 0.07 0.64 –0.10 0.47

**Surgical procedure**
- Le Fort I (reference: BSSO): 0.25 0.44 –0.24 0.42
- Bimaxillary (reference: BSSO): 0.55 0.08 –0.11 0.70

**Age**
- Mean: 0.00 0.73 –0.01 0.28

**Sex (reference: female)**
- Mean: –0.03 0.85 0.02 0.85

Notes: Ai = anamnestic dysfunction index; Di = clinical dysfunction index; BSSO = bilateral sagittal split ramus osteotomy.
of recording and measuring TMDs make direct comparisons between studies challenging. Sample size is also a factor that can appear to be lacking in numerous studies. Additionally, in a review by Al-Riyami et al. [38], the authors suggested that the incorporation of various dentofacial deformities in a study complicates comparison of the results of different studies. In the present study, a homogeneous patient sample with regard to dentofacial deformity was desired, including only patients with symmetric Class III malocclusion. Furthermore, the authors decided to use specific criteria to assess the presence and severity of TMDs (namely the DC/TMD as well as the Helkimo anamnestic and clinical dysfunction indices). The current sample size of 88 patients seems reasonable, especially when compared with many other similar studies, which include a smaller number of patients. Although, with a larger sample size, it might have been possible to disclose more significant predictive factors associated with TMD development or worsening in patients with Class III malocclusion following orthodontic and orthognathic surgical treatment. Moreover, another limitation to the present study concerns the post-operative assessment, in that this could have potentially been influenced by the fact that the surgeon may have recalled the pre-treatment results and the surgical procedure performed for any particular patient, despite the large interval from the pre-treatment to the one year post-operative examination. Finally, no MRI assessment was performed on the patients included in the study, and thus displaced discs with silent joints could not be diagnosed.

Conclusions

A group of patients with Class III malocclusion having undergone a combined orthodontic and orthognathic surgical treatment was investigated, trying to identify clinical predictive factors predisposing to the development or worsening of TMDs, post-treatment. Results demonstrate that in this population, TMDs are present pre-treatment in more than half of patients, with disc displacement being more common than myofascial pain. The majority of patients do not change TMD status following treatment, and the average Helkimo score does not undergo significant change, although on average, protrusive mandibular movements decrease, while lateral movements increase. Concerning clinical predictive factors, pre-treatment anamnestic TMJ clicking and bimaxillary osteotomy procedures may predispose to the development or worsening of clinical dysfunction in TMDs. As a consequence, TMDs must be evaluated and managed with caution, treated if necessary, and carefully monitored in patients with Class III malocclusion presenting with pre-treatment TMJ clicking who are being treated with bimaxillary osteotomies.

Acknowledgments

The authors would like to thank PA Wandeler for his valuable help in the collection of patient records for the present study.

Contributors

GA participated in the writing of the manuscript, data interpretation, and helped in the coordination of the study. NK participated in data collection and the writing of the manuscript. DC participated in the design of the study and performed the data analysis. PS conceived and coordinated the study, and participated in its design and the acquisition of the data. All authors read, critically revised, and approved the final manuscript.

Funding

No funding was obtained for the present research.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethical approval

All procedures performed were in accordance with the ethical standards of the institutional and national research committee and with the Helsinki Declaration and its later amendments or comparable ethical standards. The present study was approved by the cantonal commission on research ethics (No 14-156). Prior written informed consent was obtained from all individual participants included in the study.

References


