

Effect of bimaxillary orthognathic surgery on dysfunction of the temporomandibular joint: a retrospective study of 500 consecutive cases

W.B. Kretschmer^{a,*}, G. Baciut^b, M. Baciut^b, R. Sader^c

^a Department of Head-, Neck- and Facial Plastic Surgery, Medius Klinik Ostfildern-Ruit, Germany

^b Department of Cranio-Maxillofacial Surgery, University of Medicine and Pharmacy “Iuliu Hatieganu”, Cluj-Napoca, Romania

^c Department of Oral, Cranio-Maxillofacial and Facial Plastic Surgery, Medical Center of the Goethe University, Frankfurt, Germany

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Abstract

We investigated the effect of bimaxillary orthognathic surgery on symptoms in the temporomandibular joint (TMJ) and predictive factors for postoperative dysfunction. A total of 500 patients with different craniofacial deformities who were having bimaxillary orthognathic surgery were assessed for overjet, overbite, maximal mouth opening, maximal protrusion, maximal lateral movement to both sides, and symptoms of TMJ dysfunction (pain on palpation, clicking, or crepitus) before operation and one year postoperatively. The panoramic radiographs taken on the same dates were assessed for reduction in the height of the ramus. Other variables were age, sex, segmentation of the maxilla, and additional genioplasty. Changes in the symptoms of dysfunction were investigated with the McNemar test. Measurements of the maximum mandibular movements taken preoperatively and postoperatively were compared using the paired *t* test. Multivariate logistic regression was used to assess the influence of the variables on symptoms preoperatively and postoperatively. The effect of occlusal stability (overjet and overbite) on postoperative symptoms in the TMJ was investigated with the unpaired *t* test. Women and class II patients had significantly more pain on palpation preoperatively, and a significant reduction in pain on palpation and clicking after operation. Predictive factors were preoperative crepitus for postoperative pain, and preoperative clicking for postoperative clicking. Patients with and without symptoms showed no significant differences in overjet and overbite postoperatively. Condylar resorption was found in 29 patients (5.8 %), and only 14 of them had symptoms in the TMJ. In patients with no preoperative symptoms or radiological abnormalities of the condyle, condylar resorption was rare (0.8 %). Orthognathic surgery has a beneficial effect on dysfunction of the TMJ as it reduces pain and clicking considerably. Patients should be informed, however, that TMJ disorders could still develop even if they had no symptoms preoperatively.

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Introduction

Bimaxillary osteotomy is a routine procedure for the correction of craniofacial deformities, and the improvement of function is one of the main reasons for this kind of invasive treatment.¹ The role of temporomandibular disorders in orthognathic surgery is still controversial, however. Most authors have reported beneficial effects on the temporomandibular joint (TMJ),^{2–8} but several studies have shown no change or even the worsening of certain conditions.^{9–11} Post-

* Corresponding author at: Klinik für Kopf-, Hals- und Plastische Gesichtschirurgie, Medius Klinik Ostfildern-Ruit, Hedelfinger Str. 166, 73760 Ostfildern, Germany. Tel.: +49 711 4488 11980; fax: +49 711 4488 11989.

E-mail address: w.kretschmer@medius-kliniken.de (W.B. Kretschmer).

operative condylar resorption is considered to be a factor in the development of these disorders.⁶ In a recently published systematic review, Te Veldhuis et al stated that the number of subjects studied was low in almost all papers,¹² and that different surgical procedures (single and double jaw surgery as well as bilateral sagittal split osteotomy (BSSO) and vertical ramus osteotomy) were included in most studies.^{2,3,4,7,9} The aim of our retrospective study was to investigate the association between TMJ dysfunction and bimaxillary orthognathic surgery in a large and homogeneous sample.

Material and methods

We examined the data of 500 consecutive patients who had had bimaxillary orthognathic surgery with complete one-year follow-up. All had had orthodontic treatment with fixed appliances, and patients who had had previous joint or orthognathic surgery were excluded.

Two to three weeks before operation, cone-beam computed tomography (CT) was done with a wafer in centric occlusion. At the beginning of the operation, the position of the joint was controlled with the same type of splint. We used Onyx Ceph™ 2.7.15 software (Image Instruments GmbH) in the planning of treatment. Standardised Le Fort I and sagittal split osteotomies were done either by attending surgeons, or by residents with surgeons watching.^{13,14} Fixation of the maxilla was done with titanium 2.0 miniplates. In the mandible, we used two 2.0 miniplates on each side in class II cases, but we placed a bicortical screw and one 2.0 miniplate in class III procedures. We operated on either the maxilla or mandible first, according to the expected autorotation in the articulator during surgery on the model. No patient had intermaxillary fixation after operation.

We fixed the final interocclusal wafer to the maxilla for 2–4 weeks in patients who had one-piece-maxillary operations, and for 6 weeks in those with multi-piece maxillary operations.

On the day of discharge from hospital (4 or 5 days postoperatively) one elastic was inserted/side to guide occlusion until bony consolidation was reached (6 weeks postoperatively).

We examined patients several weeks before operation and one year after (mean (SD) 12.1 (3.2) months; range 9–46 months). The following variables were included in the study: age, sex, segmentation of the maxilla, additional genioplasty, overjet, overbite, maximal mouth opening, maximal protrusion, maximal lateral movement to both sides, pain on palpation, clicking, and crepitus.

For radiological examination of condylar changes, panoramic radiographs were taken before operation and after the hardware had been removed (at least 12 months after operation). The maximum length of the ramus was measured in parallel to its tangent (Fig. 1). According to Borstlap et al, a

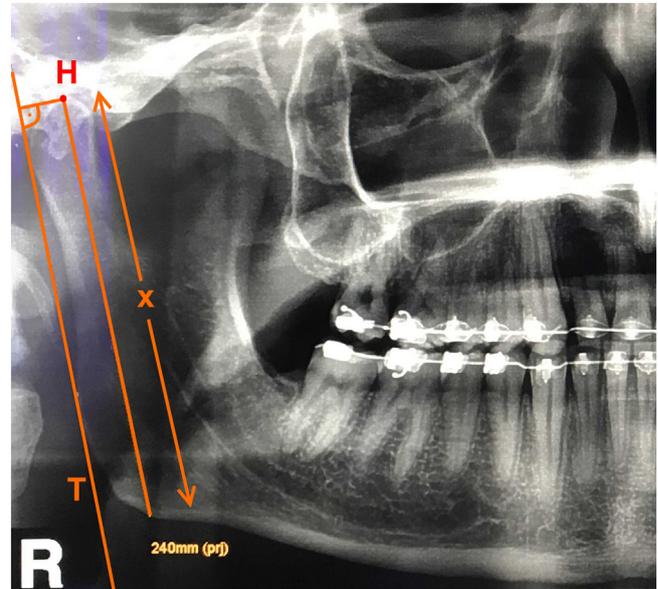


Fig. 1. Measurement of total height of the ramus on the panoramic radiograph. Total height (x) was measured in parallel to the tangent of the ramus (T) through the highest point of the condyle (H).

reduction of more than 6% of the total height of the ramus was considered to indicate condylar resorption.⁶

For statistical analysis we used PSPP 1.0.1 software (Free Software Foundation Inc). Changes in the variables (pain on palpation, clicking, crepitus) between T0 (before operation) and T1 (one year postoperatively) were investigated using the McNemar test. The differences between preoperative and postoperative measurements of the maximum mandibular movements (mouth opening, protrusion, right and left laterotrusion) were compared using the paired *t* test. We used multivariate logistic regression to assess the influence of sex, age, overjet, and overbite on preoperative TMJ symptoms, and the influence of sex, age, overjet, overbite, and preoperative symptoms on postoperative symptoms. To assess the effect of occlusal stability on postoperative symptoms, we used the unpaired *t* test to compare postoperative overjet and overbite in those with and without the respective symptoms. A probability of less than 0.05 was considered to be significant.

Results

A total of 500 patients who had had bimaxillary orthognathic procedures between August 2011 and March 2017 met the inclusion criteria. The study variables are given in Table 1.

A significant reduction in clicking, and pain on palpation, was found after operation, but no significant change was seen for crepitus (Table 2). In 90.9% of the cases TMJ pain improved after operation. On the other hand, 6.4% of the patients without complaints developed pain postoperatively. Clicking disappeared in 65.9% of the affected patients and, surprisingly, 19.1% of those who did not have it preoperatively had developed it by the last consultation. In contrast to

Table 1
Study variables. Data are number (%) unless otherwise stated.

Variable	No. (%)	Mean (SD)	Range
Sex:			
Male	173 (35)	–	–
Female	327 (65)	–	–
Age (years)	–	28 (10)	17 - 61
Overjet (mm)	–	2 (4)	–10 - 13
Overbite (mm)	–	1 (2)	–8 - 12
Genioplasty:			
Yes	77 (15)	–	–
No	423 (85)	–	–
Maxillary segmentation:			
One-piece	227 (45)	–	–
Two-piece	55 (11)	–	–
Three-piece	217 (43)	–	–

Table 2
TMJ symptoms and range of motion in 500 patients.

Variable	Preoperatively	One-year post-operatively	p value
Symptoms in the temporomandibular joint:			
Pain on palpation	44	33*	0.04
Clicking	138	116*	0.01
Crepitus	20	24	0.10
Mean (SD) maximum movements (mm):			
Mouth opening	49 (8)	48 (7)*	0.003
Protrusion	7 (3)	6 (3)*	0.000
Lateral right	8 (3)	8 (3)*	0.001
Lateral left	8 (4)	8 (5)	0.159

Symptoms in the temporomandibular joint = McNemar test.

Maximum movements = paired *t* test.

* Significant changes at $p < 0.05$.

Table 3
Correlation between preoperative and postoperative disorders of the temporomandibular joint.

Preoperatively	No.	One-year postoperatively	No. (%)
No pain	456	No pain	427/456 (94)
		Pain	29/456 (6)
Pain	44	No pain	40/44 (91)
		Pain	4/44 (9)
No clicking	362	No clicking	293/362 (81)
		Clicking	69/362 (19)
Clicking	138	No clicking	91/138 (66)
		Clicking	47/138 (34)
No crepitus	480	No crepitatus	457/480 (95)
		Crepitatus	23/480 (5)
Crepitus	20	No crepitatus	19/20 (95)
		Crepitatus	1/20 (5)

clicking, crepitus could be heard in only 4.8% of the patients who had had none preoperatively (Table 3). There was a minimal, but significant, reduction of maximum mouth opening, protrusion, and lateral movement to the right (Table 2).

Table 4a
Influence of study variables on the incidence of preoperative pain.

Variable	Beta coefficient	95% CI	p value
Sex	0.846	1.041 to 5.212	0.040*
Age	–0.019	0.946 to 1.016	0.285
Overjet	0.144	1.063 to 1.255	0.001*
Overbite	–0.053	0.826 to 1.088	0.448

Multivariate logistic regression; Nagelkerke R Square 0.084.

* Significant influence at $p < 0.05$.

Table 4b
Influence of study variables on the incidence of preoperative clicking.

Variable	Beta coefficient	95% CI	p value
Sex	0.006	0.660 to 1.531	0.979
Age	–0.001	0.978 to 1.021	0.919
Overjet	0.016	0.968 to 1.067	0.521
Overbite	–0.008	0.907 to 1.085	0.862

Multivariate logistic regression; Nagelkerke R Square 0.001.

Table 4c
Influence of study variables on the incidence of preoperative crepitation.

Variable	Beta coefficient	95% CI	p value
Sex	0.172	0.439 to 3.215	0.735
Age	0.004	0.956 to 1.054	0.884
Overjet	–0.046	0.856 to 1.066	0.415
Overbite	0.194	0.979 to 1.506	0.077

Multivariate logistic regression; Nagelkerke R Square 0.024.

Table 5a
Influence of study variables on the incidence of postoperative pain.

Variable	Beta coefficient	95 % CI	p value
Sex	0.787	0.852 to 5.666	0.103
Age	0.010	0.972 to 1.049	0.611
Maxillary segmentation	0.236	0.851 to 1.885	0.244
Genioplasty	–0.594	0.059 to 1.916	0.349
Overjet	0.026	0.935 to 1.126	0.585
Overbite	0.159	0.986 to 1.394	0.072
Preoperative pain	0.108	0.353 to 3.511	0.854
Preoperative clicking	0.514	0.781 to 3.575	0.185
Preoperative crepitus	1.850	2.148 to 18.844	0.001*

Multivariate logistic regression; Nagelkerke R Square 0.127.

* Significant influence at $p < 0.05$.

Preoperatively, a significantly higher rate of perceived pain was found in women and patients with major class II deformities (Tables 4a, 4b, and 4c).

Only few predictive variables for TMJ symptoms were identified. Preoperative clicking had a significant influence on postoperative clicking; preoperative crepitus was a highly significant factor for postoperative pain; and the influence of open bite deformities on postoperative clicking approached significance (Tables 5a, 5b, and 5c). A high occlusal stability without significant differences was seen in patients with and without TMJ symptoms (Table 6). In 29 patients (5.8%), condylar resorption could be found in at least one joint (27 female; 2 male), but only 14 patients in this group had postoperative symptoms. Severe preoperative deformities of at least one condyle were seen in 17 patients (59%). Only four

Table 5b
Influence of study variables on the incidence of postoperative clicking.

Variable	Beta coefficient	95 % CI	p value
Sex	0.143	0.724 to 1.841	0.547
Age	0.002	0.979 to 1.025	0.892
Maxillary segmentation	0.057	0.843 to 1.328	0.625
Genioplasty	0.033	0.574 to 1.861	0.912
Overjet	0.021	0.968 to 1.078	0.437
Overbite	0.101	1.000 to 1.225	0.051
Preoperative pain	0.212	0.606 to 2.525	0.560
Preoperative clicking	0.758	1.362 to 3.341	0.001*
Preoperative crepitus	0.133	0.419 to 3.117	0.795

Multivariate logistic regression; Nagelkerke R Square 0.059.

* Significant influence at $p < 0.05$.

Table 5c
Influence of study variables on the incidence of postoperative crepitation.

Variable	Beta coefficient	95 % CI	p value
Sex	0.768	0.775 to 5.991	0.141
Age	-0.008	0.948 to 1.039	0.746
Maxillary segmentation	0.307	0.866 to 2.134	0.182
Genioplasty	0.118	0.368 to 3.441	0.836
Overjet	-0.004	0.895 to 1.109	0.944
Overbite	0.027	0.846 to 1.248	0.783
Preoperative pain	-1.064	0.044 to 2.681	0.309
Preoperative clicking	0.669	0.836 to 4.556	0.122
Preoperative crepitus	-0.069	0.116 to 7.494	0.948

Multivariate logistic regression; Nagelkerke R Square 0.049.

Table 6
Influence of occlusal stability (overjet, overbite) on the incidence of postoperative symptoms in the temporomandibular joint.

Variable	Mean (SD)	p value
Postoperative overjet (mm):		
Pain	2.03 (1.10)	0.355
No pain	1.90 (0.76)	
Clicking	1.94 (0.90)	0.621
No clicking	1.90 (0.75)	
Crepitus	1.88 (0.80)	0.833
No crepitus	1.91 (0.79)	
Postoperative overbite (mm):		
Pain	2.05 (1.03)	0.140
No pain	1.82 (0.82)	
Clicking	1.97 (0.90)	0.062
No clicking	1.80 (0.81)	
Crepitus	2.13 (0.61)	0.084
No crepitus	1.82 (0.84)	

Unpaired *t* test.

Significant influence at $p < 0.05$.

patients without preoperative TMJ symptoms or radiological abnormalities of the condyles later developed condylar resorption (0.8%).

Discussion

The effect of orthognathic surgery on the TMJ is still controversial, although evidence-based benefits of the procedure are requested more and more by insurance companies and public

health systems. This is likely to be caused by the lack of studies with large and homogeneous samples. Earlier studies with large samples that show a reduction in TMJ disorders after operation were based only on questionnaires.^{6,8} Scolozzi et al presented one of the most extensive studies with meticulous clinical examination of 219 patients.⁹ They did not find a significant reduction in symptoms one year after operation, but the data included only 124 bimaxillary osteotomies. A significant reduction of TMJ symptoms was seen by Togashi et al.³ In their study, among a sample of 170 patients, only 112 had operations on the upper and lower jaw. Other studies involved patients with sagittal split and vertical ramus osteotomies or mandibular procedures with a different kind of fixation.^{2,4}

Recently, Ureturk and Apaydin showed in a 3-dimensional finite model that fixation with bicortical screws can lead to more stress on condyles than fixation with miniplates.¹⁵ This confirms the clinical findings of Yamashita et al in their long-term-study with a five-year follow up.¹⁶ A large number of variables may lead to researchers missing the significance of the results,¹⁷ and there have been studies with up to 27 different variables.⁹ Statistical analysis of an index that was composed of other different variables is mathematically questionable.¹⁷ Limited mouth opening is a fundamental factor in the Helkimo index and has been investigated in other studies,¹⁸ and sounds and pain in the TMJ are basic variables to be compared with other studies.^{2–11} Our work was therefore designed with a large homogeneous sample and limited variables. Because of the retrospective nature of the study and unclear anamnestic information from the patients, we did not include other non-specific symptoms of TMJ disorders (such as headache and tinnitus).

The high incidence of TMJ symptoms in patients with dentofacial malformations before treatment and the lack of a randomised control group with untreated major deformities are fundamental problems for any study. Abrahamsson et al included a control group with normal occlusion or minor malocclusion.⁴ Panula et al presented a non-randomised control group of only 20 patients with class II deformities who refused combined treatment.⁷ It is difficult therefore to prove that orthognathic surgery will prevent disorders in the TMJ.

The significant reduction of maximum mouth opening that we found corresponds to the results of most other studies.^{4,6,9} Extensive scars are a possible reason for this, but the clinical relevance of a mean reduction of 1.1 mm is questionable.

The significantly higher incidence of preoperative TMJ pain in women is supported by other studies.^{2,4} The same sex-specific risk can be found in the postoperative onset of condylar resorption, and our results comply with those of Borstlap et al.⁶ In a study on human cadavers, Kim et al showed that female condyles are more sensitive for TMJ loading as a result of differences in the subchondral bone.¹⁹ In contrast to Scolozzi et al, we did not find a significantly higher risk of postoperative TMJ disorders in women.⁹

The sex of the patient does not seem to have an effect on the outcome of the studies. The ratio of female:male patients was 57.9%:81.7% in the studies with beneficial effects of orthog-

nathic surgery, and 56.2%:81.7% in those with no effect or worsening of symptoms.^{2–11} We have identified significantly more pain in patients with major class II deformities, which agrees with previous published results.^{2,3,8} According to O’Ryan and Epker, this is caused by a different vector of compressive load in class II cases.²⁰ The significantly higher incidence of anterior disc displacement in class II patients found in the study of Jung et al might be another reason for the latter.²¹ Toll et al reported a rate of 93% of discs that were not correctly positioned in an MRI study on 58 candidates for orthognathic surgery, but he did not report postoperative results.²² MRI studies on the preoperative and postoperative positions of the disc have shown little effect from orthognathic surgery.^{23,24} Only a few surgeons have concluded that simultaneous surgical repositioning of the disc is necessary in cases with anterior disc replacement.²⁵ So far, there is no evidence that the latter procedure provides significantly better results than preorthodontic splints.

There are few studies that we know of on the predictive factors for postoperative disorders of the TMJ. Clicking has been reported to be a significant factor by Scolozzi et al and Antonarakis et al.^{9,26} We detected preoperative clicking and preoperative crepitus as significant factors for postoperative symptoms. Although the incidence of open bite deformities approached significance, our clinical experience underlines the importance of the latter for the risk of postoperative problems. The development of postoperative condylar resorption has no significant correlation with postoperative TMJ disorders as these were found in only 48% of the cases with radiologically-detected resorption of the condyle.

Despite the significant reduction of pain and clicking, the possible onset of disorders in patients without preoperative problems must not be neglected, and several studies have mentioned this specific risk.^{2,3,9,24,26} In our study, the percentage was low for pain (6.4%) and crepitus (4.8%), but relatively high for clicking (19.1%). Togashi et al reported TMJ disorders in 16.5% of patients with no symptoms preoperatively but did not differentiate them.³ The respective rates were lower (6.25%) in the study by Sebastiani et al and much higher (35% and almost 36%) in the studies by Scolozzi et al and Antonarakis et al.^{2,12,26} This topic has to be part of informed consent.

Conclusions

Orthognathic surgery has a beneficial effect on TMJ dysfunction as it significantly reduces pain and clicking. The development of condylar resorption in healthy joints is rare. Patients have to be informed, however, that disorders of the TMJ or condylar changes might develop in some cases where there were no symptoms preoperatively. Preoperative crepitus and preoperative clicking were predictive factors for postoperative disorders in the TMJ. Larger studies with both preoperative and postoperative MRI are indicated to investi-

gate the influence of disc position on postoperative disorders of the TMJ.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients’ permission

The study was approved by the IRB of the University of Cluj-Napoca (382/16.10.2018).

Each subject has given a written informed consent.

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