Does Orthognathic Surgery Cause or Cure Temporomandibular Disorders? A Systematic Review and Meta-Analysis

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Purpose: There is still controversy about whether orthognathic surgery negatively or positively affects temporomandibular disorders (TMDs). The purpose of this study was to determine whether orthognathic surgery has a beneficial or deleterious effect on pre-existing TMDs.

Materials and Methods: A systematic review and meta-analysis were conducted based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. We searched 3 major databases to locate all pertinent articles published from 1980 to March 2016. All subjects in the various studies were stratified a priori into 9 categories based on subdiagnoses of TMDs. The predictor variables were those patients with pre-existing TMDs who underwent orthognathic surgery in various subgroups. The outcome variables were maximal mouth opening and signs and symptoms of a TMD before and after orthognathic surgery based on the type of osteotomy. The meta-analysis was performed using Comprehensive Meta-Analysis software (Biostat, Englewood, NJ).

Results: A total of 5,029 patients enrolled in 29 studies were included in this meta-analysis. There was a significant reduction in TMDs in patients with a retrognathic mandible after bilateral sagittal split osteotomy (BSSO) (P = .014), but no significant difference after bimaxillary surgery (BSSO and Le Fort I osteotomy) (P = .336). There was a significant difference in patients with prognathism after isolated BSSO or intraoral vertical ramus osteotomy and after combined BSSO and Le Fort I osteotomy (P = .001), but no significant difference after BSSO (P = .424) or bimaxillary surgery (intraoral vertical ramus osteotomy and Le Fort I osteotomy) (P = .728).

Conclusions: Orthognathic surgery caused a decrease in TMD symptoms for many patients who had symptoms before surgery, but it created symptoms in a smaller group of patients who were asymptomatic before surgery. The presence of presurgical TMD symptoms or the type of jaw deformity did not identify which patients' TMDs would improve, remain the same, or worsen after surgery.

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Temporomandibular disorders (TMDs) is a collective term comprising a variety of clinical signs and symptoms confined to the temporomandibular joint (TMJ) and/or the related masticatory musculature. Symptoms of TMDs include facial pain, headache, earache, and joint pain, as well as signs such as limited jaw movement, jaw deviation on mouth opening, joint noise (clicking and popping), jaw locking, and dislocation. In addition, traumatic occlusion and wear of the dentition due to parafunctional habits (clenching and bruxism) are often present in patients with TMDs.[1,2]

The association between pre-existing TMDs in patients with dentofacial deformities and their treatment with orthognathic surgery has been a highly debated issue. There are studies supporting claims that orthognathic surgery has a beneficial effect on pre-existing TMDs[3-7] or at least does not aggravate the pre-existing condition,[8,9] and there are studies that claim that orthognathic surgery causes worsening of the pre-existing TMDs.[10-15] The specific aims of this study were to systematically analyze the existing literature to determine whether pre-existing TMDs in patients with retrognathism, prognathism, or various other dentofacial deformities would improve, worsen, or remain unchanged after orthognathic surgery.

Materials and Methods

The systematic review and meta-analysis adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for reporting systematic reviews.[16]

FOCUSED QUESTION

The clinical research question was "What is the effect of orthognathic surgery on pre-existing temporomandibular disorders?"

SEARCH STRATEGY

The search strategy located all pertinent articles published from 1980 to March 2016 and followed the PRISMA guidelines (http://www.prisma-statement.org). The electronic search and the PICOS strategy (population, intervention, comparisons, outcomes, and study design) are shown in Table 1.

SELECTION CRITERIA

Inclusion Criteria

The following inclusion criteria were adopted in accordance with the PICOS criteria[17]: The population (P) comprised patients with Class II and III skeletal and occlusal relationships or other dentofacial deformities indicated for orthognathic surgery. The intervention (I) was defined as orthognathic surgery such as bilateral sagittal split osteotomy (BSSO), intraoral vertical ramus osteotomy (IVRO), Le Fort I osteotomy, or combinations thereof. Comparisons (C) were not applicable. Outcomes (O) were defined as the risk ratios (RRs) between pre-existing preoperative and postoperative TMDs. The study design (S) was defined as clinical human studies, including randomized controlled trials, controlled clinical trials, retrospective studies, and case series with the aim of comparing pre-existing preoperative TMDs with postoperative TMDs after orthognathic surgery treatment.

Exclusion Criteria

The following exclusion criteria were applied: *1)* case reports, *2)* technical reports, *3)* animal or in vitro studies, *4)* review articles, and *5)* studies that did not report the data of interest (surgical and postsurgical changes) required for performing a meta-analysis.

DATA EXTRACTION

Data were extracted independently by 2 researchers (E.A.A.-M. and L.M.W.) using a previously prepared data extraction form. The following information was extracted from each study: authors, year of publication, study design, patients' age (average), male-female ratio, number of patients, dentofacial deformities, how outcomes were measured, follow-up period, and authors' conclusions.

QUALITY ASSESSMENT OF INCLUDED STUDIES

A methodologic quality rating was determined by combining the proposed criteria of the Meta-Analysis of Observational Studies in Epidemiology statement,[18] Strengthening the Reporting of Observational Studies in Epidemiology statement,[19] and PRISMA[17] to verify the strength of scientific evidence in clinical decision making. A study that had all the domains was classified as having a low risk of bias, whereas a study that did not have 1 of the domains was classified as having a moderate risk of bias. When 2 or more domains were missing, the study was considered to have a high risk of bias.

SUMMARY MEASURES

The predictor variables were those patients with Class II, Class III, and various other dentofacial deformities who underwent orthognathic surgery. The outcome variables were maximal mouth opening (MMO) and signs and symptoms of TMD in the presurgical and postsurgical phases according to the type of surgery.

META-ANALYSIS

The analysis was performed using subdiagnoses for the TMDs. The diagnoses were divided into 10 subgroups: arthralgia, disc displacement, joint clicking,

Table 1. PICOS CRITERIA AND SEARCH STRATEGY FOR SYSTEMATIC REVIEW

	Description
PICOS criteria	
Population	*1)* MeSH term: Class II skeletal malocclusion OR Class III skeletal malocclusion OR retrognathism OR prognathism OR apertognathia OR facial asymmetry OR open bite OR maxillary excess OR mandibular deficiency *2)* Text word: same
Intervention	*3)* MeSH term: orthognathic surgery OR bilateral sagittal split osteotomy OR BSSO OR intraoral vertical ramus osteotomy OR IVRO OR Le Fort I OR bimaxillary surgery OR setback OR advancement OR single jaw surgery OR double jaw surgery *4)* Text word: same
Comparisons	Not applicable
Outcomes	*5)* MeSH term: arthralgia OR disc displacement OR joint clicking OR myofascial pain OR deviation on mouth opening OR headache OR joint crepitation OR muscle tenderness OR TMJ pain OR signs OR symptoms OR TMD OR joint sound OR unreducible disc OR stomatognathic OR temporomandibular joint disorder OR temporomandibular joint disorder dysfunction *6)* Text word: same
Study design	*7)* MeSH term: randomized controlled trial OR RCT OR CCT OR controlled clinical trial OR retrospective study OR case series OR cohort study *8)* Text word: same
Search combination	1 AND 2 AND 3 AND 4 AND 5 AND 6 AND 7 AND 8
Language	English
Electronic database	PubMed, Embase, and Cochrane CENTRAL
Focused question	What is the effect of orthognathic surgery on pre-existing temporomandibular disorders?

Abbreviations: BSSO, bilateral sagittal split osteotomy; CCT, controlled clinical trial; CENTRAL, Central Register of Controlled Trials; IVRO, intraoral vertical ramus osteotomy; MeSH, Medical Subject Headings; RCT, randomized controlled trial; TMD, temporomandibular disorder; TMJ, temporomandibular joint.

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myofascial pain, deviation on mouth open, grinding, headache, joint crepitation, and muscle tenderness and TMJ pain on palpation.

The signs and symptoms of TMDs were pooled and reported as RRs with corresponding 95% confidence intervals (CIs). The weighted mean difference (WMD) was used to calculate MMO. Significant heterogeneity among the studies included in this analysis was formally assessed by the Cochran χ^2 test and the I^2 index, in which $P < .1$ by the χ^2 test and an I^2 value of less than 0.75 indicate a low degree of heterogeneity; a fixed-effects model was used. Otherwise, a random-effects model with 95% CIs was to be performed.[20] The significance level (null hypothesis) was rejected at the 5% level ($P < .05$). The meta-analysis was performed using Comprehensive Meta-Analysis software (Biostat, Englewood, NJ).[20]

Results

RESULTS OF LITERATURE SEARCH

Figure 1 shows the process of screening articles for inclusion in the meta-analysis. The search strategy yielded a total of 1,132 articles from all databases and 3 additional articles identified through a hand search. Of the 1,135 articles, 400 were duplicates and were removed and 450 were excluded after the titles and abstracts were read. The full-text articles of the remaining 285 studies were reviewed independently by 2 authors for eligibility; of these studies, 256 were excluded because they did not meet the inclusion criteria. Finally, a total of 29 studies met the inclusion criteria and were processed for critical review.[3,5-7,12,13,21-43]

DESCRIPTION OF INCLUDED STUDIES

A full description of the details of the included studies is presented in Table 2.

RISK OF BIAS WITHIN INCLUDED STUDIES

On the basis of the quality assessment tool used, 2 studies had a low risk of bias,[24,30] 25 studies had a moderate risk,[3,5-7,12,13,23,25-29,31-43] and 2 studies had a high risk[21,22] (Table 3).

RESULTS OF OUTCOME VARIABLES: TMDS

Preoperative Versus Postoperative TMDs in Retrognathic Patients

A total of 1,527 patients enrolled in 12 studies underwent a comparison of preoperative and postoperative TMDs after orthognathic

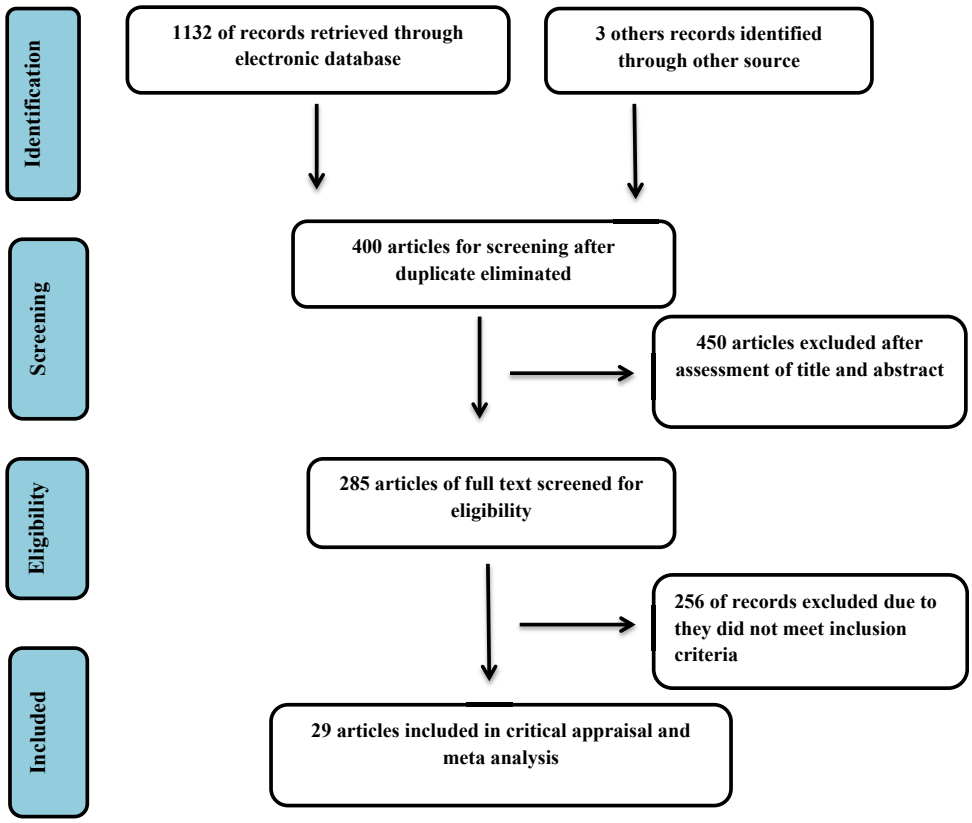

FIGURE 1. Screening process of studies based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.
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surgery.[3,5,6,13,24,26,27,30,33,34,38,41] The follow-up period varied from 6 months to 6.3 years.

Retrognathic patients who underwent BSSO. A total of 1,482 retrognathic patients enrolled in 10 studies underwent a BSSO to advance the mandible.[3,5,6,24,26,27,30,33,34,41] There was a significant reduction in TMDs after mandibular advancement. The RR was 0.592 (95% CI, 0.392 to 0.899; *P* = .014).

Retrognathic patients who underwent BSSO and Le Fort I osteotomy. There were 2 studies with 45 patients who underwent BSSO plus Le Fort I osteotomy.[13,38] There was no significant difference between pretreatment and post-treatment TMDs. The RR was 0.936 (95% CI 0.87 to 1.494; P = 783).

The overall cumulative analysis for the 12 studies showed that there was a significant reduction in TMDs after orthognathic surgery for retrognathic patients (RR, 0.724 (955 CI, 0.531 to 0.986); P =.04) [Mantel-Haenszel (MH) random-effects model]).[3,5,6,13,24,26,27,30,33,34,38,41] There was heterogeneity among studies, so the random-effects model was applied in all analyses (Fig 2).

Preoperative Versus Postoperative TMDs in Prognathic Patients

A total of 1,116 prognathic patients enrolled in 8 studies underwent a comparison of preoperative and postoperative TMDs after orthognathic surgery.[3,5,6,21,25,35,36,40] The follow-up period varied from 6 months to 6.3 years.

Prognathic patients who underwent BSSO. A total of 198 patients enrolled in 2 studies underwent BSSO to achieve setback of the mandible.[3,35] There was no significant difference between pretreatment and post-treatment TMDs. The RR was 0.465 (95% CI, 0.063 to 3.442; P = 0.452).

Prognathic patients who underwent isolated BSSO or IVRO. One study had 580 patients who underwent either BSSO or IVRO to achieve setback of the mandible.[6] There was a significant difference between pretreatment and post-treatment TMDs. The RR was 0.622 (95% CI, 0.516 to 0.750; *P* = .001).

Prognathic patients who underwent bimaxillary surgery: BSSO and Le Fort I osteotomy. Four studies involved 196 patients who underwent combined BSSO and Le Fort I osteotomy.[3,25,36,40] There was a significant difference between pretreatment and post-treatment TMDs. The RR was 0.550 (95% CI, 380 to 0.796; P = 0.002).

Prognathic patients who underwent bimaxillary surgery: IVRO and Le Fort I osteotomy. One study included 124 patients who underwent combined IVRO and Le Fort I osteotomy.[5] There was no significant difference between pretreatment and

Table 2. CHARACTERISTICS OF INCLUDED STUDIES

Authors, Year of Publication	Study Design	Patient Age (Average), yr	Male-Female Ratio	No. of Patients	Dentofacial Deformities	How Outcomes Were Measured	Follow-Up Period	Authors' Conclusions
Upton et al, 1984[21]	Retrospective study	Range, 15-39	70:32	102	Class III: 39 Class II: 46 Open bite: 14 Other: 3	Questionnaire	NM	Reduction in TMD
Karabouta and Martis, 1985[3]	Case series	NM	62:52	114	Class III: 54 Class II: 23 Open bite: 25 Other: 12	Clinical examination	6 mo	Reduction in TMD
Timmis et al, 1986[22]	Cohort, prospective	28.6 27.1	19:9	28	NM	Clinical examination	15.6 mo	Reduction in TMD
Magnusson et al, 1986[23]	Cohort, prospective	21	15:5	20	Class III: 11 Class II: 3 Other: 7	Questionnaire	2.5 yr	Reduction in TMD
Kerstens et al, 1989[6]		NM	NM	480	Class III: 142 Class II: 338	Questionnaire	3.6 yr	Reduction in TMD (Class II)
Rodrigues-Garcia et al, 1998[24]	Randomized, prospective	30.16	92:32	124	Class II	Clinical examination using dysfunction index and muscle index	2 yr	Reduction in TMD
Athanasiou and Melson, 1992[25]	Cohort, prospective	Range, 17-39	11:25	36	Class III: 36	Clinical examination using clinical dysfunction index of Helkimo	6 mo	No differences
Smith et al, 1992[26]	Prospective study	26.3	14:8	22	Class II	Clinical examination using clinical dysfunction index of Helkimo	6 mo	Clinical dysfunction remained unchanged
Athanasiou and Yucel-Eroğlu, 1994[27]	Cohort, prospective	Range, 17-39	NM	83	Class III: 43 Class II: 12 Open bite: 25 Other: 36	Clinical examination using clinical dysfunction index of Helkimo	6 mo	Reduction in maxillary and double-jaw surgery but increase in advancement surgery
De Clercq et al, 1995[7]	Retrospective study	19.81	149:89	238	NM	Questionnaire	2.5 yr	Improvement in TMJ function
Feinerman and Piecuch, 1995[28]	Retrospective study	NR: 30.4 RF: 365	24:42	42	66	Clinical examination	4 mo	Improved in RF, worsened in NF

Table 2. Cont'd

Authors, Year of Publication	Study Design	Patient Age (Average), yr	Male-Female Ratio	No. of Patients	Dentofacial Deformities	How Outcomes Were Measured	Follow-Up Period	Authors' Conclusions
Panula et al, 2000[29]	Case control, prospective	31.5	4:16	20	Class III: 9 Class II: 47 Class I: 6	Clinical examination, questionnaire	4 yr	Risk of new TMD is extremely low
Nemeth et al, 2000[30]	RCT	28.9	NRF: 47:17 RF: 48:15	127	NM	Questionnaire	2 yr	No difference for RF:WF
Westermark et al, 2001[5]	Cohort, retrospective	NM	985:558	1,516	Class III: 580 Class II: 526 Open bite: 396 Other: 170	Questionnaire	2 yr	Reduction in TMD
Aghabeigi et al, 2001[31]	Retrospective study	28.5	21:42	83	Anterior open bite	Clinical examination	1 yr	Not significant
Dervis and Tuncer, 2002[12]	Prospective	29.3	28:22	50	NM	Clinical examination, questionnaire	2 yr	Improved TMJ function
Wolford et al, 2003[13]	Retrospective study	24	2:23	25	NM	Clinical examination	2.2 yr	Worsening of TMD
Pahkala and Heino, 2004[32]	Cohort, prospective		49:23	72	Class III: 14 Class II: 46 Others: 11	Dysfunction index of Helkimo	2 yr	Reduction in TMD
Borstlap et al, 2004[33]	Cohort, prospective	25	196:53	222	Class II	Questionnaire	2 yr	Reduction in TMD
Kallela et al, 2005[34]	Retrospective study	29	29:11	42	NM	Anamnestic dysfunction index	2.2 yr	Reduction in TMD
Aoyama et al, 2005[35]	Cohort, prospective	24	21:16	37	Class III	Clinical examination	1 yr	Affected TMD, worse CL III with RF
Farella et al, 2007[36]	Cohort, prospective	22.9	NM	14	Class III	Clinical examination, anamnestic assessment	12 mo	Unchanged TMD
Dujoncquoy et al, 2010[37]	Retrospective study	31.21	22:35	57	NM	Questionnaire	2.5 yr	Reduction in TMD
Abrahamsson et al, 2013[38]	Prospective	NM	51:70	98	Class II: 27 Class III: 58	Clinical examination using RDC/TMD	3 yr	Positive outcome
Togashi et al, 2013[39]	Prospective	21	133:937		170		1 yr	Beneficial effect on TMJ signs and symptoms

Scolozzi et al, 2015[40]	Retrospective study	24.9	96:123	219	Class I: 4 Class II: 76 Class II: 88 Open bite: 42 Others: 13	Clinical examination using dysfunction index	1 yr	No improvement
Yoon et al, 2015[41]	Prospective study	24.4	18:36	54	Class III	Clinical examination, self-reported questionnaire	6 mo	Reduction in TMD
Kuhlefelt et al, 2016[42]	Prospective study	36.9	14:26	40	Class II	Clinical examination using dysfunction index	1 yr	Less predictable TMD
Sebastiani et al, 2016[43]	Cohort study	29	17:37	54	Class I: 4 Class II: 17 Class II: 33	Questionnaire, clinical examination	6 mo	Reduction in TMD

Abbreviations: CL, class; NM, not mentioned; NRF, non rigid fixation; RCT, randomized controlled trial; RDC/TMD, research diagnostic criteria for tempromandibular disorders; RF, rigid fixation; TMD, temporomandibular disorder; TMJ, temporomandibular joint; WF, wire fixation.

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post-treatment TMDs. The RR was 1.111 (95% CI, 0.614 to 2.010: P = .728).

The overall cumulative analysis for the 8 studies showed that there was a significant reduction in TMDs after orthognathic surgery in prognathic patients (RR, 0.633; 95% CI, 0.539 to 0.734; P = .001 [MH random-effects model]).[3,5,6,21,25,35,36,40] There was heterogeneity among studies, which is why a random-effects model was performed in all analyses (Fig 3).

Preoperative Versus Postoperative TMDs in Patients With Combinations of Different Dentofacial Deformities (Class I, Class II, Class III, Open Bite)

A total of 1,561 patients were enrolled in 13 studies that compared preoperative and postoperative TMDs in patients with different dentofacial deformities after orthognathic surgery.[6,7,12,22,23,28,29,31,32,36,37,39,42] The follow-up period varied from 6 months to 6.3 years.

Patients who underwent BSSO. A total of 166 patients enrolled in 3 studies underwent BSSO to achieve setback or advancement of the mandible.[22,28,32] There was a significant difference between pretreatment and post-treatment TMDs. The RR was 0.707 (95% CI, 0.516 to 0.996; P = .031).

Patients who underwent BSSO or IVRO. One study involved 566 patients who underwent BSSO or IVRO.[6] There was a significant difference between pretreatment and post-treatment TMDs. The RR was 0.803 (95% CI, 0.693 to 0.931; P = .004).

Patients who underwent bimaxillary surgery: BSSO and Le Fort I osteotomy. Seven studies involved 714 patients who underwent BSSO and Le Fort I osteotomy.[7,23,29,31,36,39,42] There was no significant difference between pretreatment and post-treatment TMDs. The RR was 0.845 (95% CI, 0.677 to 1.053; P = .133).

Patients who underwent bimaxillary surgery: BSSO or IVRO and Le Fort I osteotomy. Two studies involved 139 patients who underwent BSSO or IVRO and Le Fort I osteotomy.[12,37] There was a significant difference between pretreatment and post-treatment TMDs. The RR was 0.608 (95% CI, 0.485 to 0.762; P = .001).

The overall cumulative analysis for the 13 studies showed that there was a significant reduction in TMDs after orthognathic surgery for patients with a combination of dentofacial deformities (RR, 0.679; 95% CI, 0.679 to 0.819; P = .001 [MH random-effects model]).[6,7,12,13,22,23,28,31,32,36,37,39,42] There was heterogeneity among studies, which is why a random-effects model was applied in all analyses (Fig 4).

RESULTS OF OUTCOME VARIABLES: MMO

Seven studies (491 patients) compared MMO preoperatively and at the latest follow-up.[8,13,26-28,38,40]

Table 3. CRITICAL APPRAISAL OF INCLUDED STUDIES

Authors, Year of Publication	Random Selection in Population	Defined Inclusion and/or Exclusion Criteria	Loss of Follow-Up	Validated Measurement	Statistical Analysis	Estimated Potential Risk of Bias
Upton et al, 1984[21]	No	No	Yes	Yes	Yes	High
Karabouta and Martis, 1985[3]	No	Yes	Yes	Yes	Yes	Moderate
Timmis et al, 1986[22]	No	Yes	No	Yes	Yes	High
Magnusson et al, 1986[23]	No	Yes	Yes	Yes	Yes	Moderate
Kerstens et al, 1989[6]	No	Yes	Yes	Yes	Yes	Moderate
Rodrigues-Garcia et al, 1998[24]	Yes	Yes	Yes	Yes	Yes	Low
Athanasiou and Melson, 1992[25]	No	Yes	Yes	Yes	Yes	Moderate
Smith et al, 1992[26]	No	Yes	Yes	Yes	Yes	Moderate
Athanasiou and Yucel-Eroğlu, 1994[27]	No	Yes	Yes	Yes	Yes	Moderate
De Clercq et al, 1995[7]	No	Yes	Yes	Yes	Yes	Moderate
Feinerman and Piecuch, 1995[28]	No	Yes	Yes	Yes	Yes	Moderate
Panula et al, 2000[29]	No	Yes	Yes	Yes	Yes	Moderate
Nemeth et al, 2000[30]	Yes	Yes	Yes	Yes	Yes	Low
Westermark et al, 2001[5]	No	Yes	Yes	Yes	Yes	Moderate
Aghabeigi et al, 2001[31]	No	Yes	Yes	Yes	Yes	Moderate
Dervis and Tuncer, 2002[12]	No	Yes	Yes	Yes	Yes	Moderate
Wolford et al, 2003[13]	No	Yes	Yes	Yes	Yes	Moderate
Pahkala and Heino, 2004[32]	No	Yes	Yes	Yes	Yes	Moderate
Borstlap et al, 2004[33]	No	Yes	Yes	Yes	Yes	Moderate
Kallela et al, 2005[34]	No	Yes	Yes	Yes	Yes	Moderate
Aoyama et al, 2005[35]	No	Yes	Yes	Yes	Yes	Moderate
Farella et al, 2007[36]	No	Yes	Yes	Yes	Yes	Moderate
Dujoncquoy et al, 2010[37]	No	Yes	Yes	Yes	Yes	Moderate
Abrahamsson et al, 2013[38]	No	Yes	Yes	Yes	Yes	Moderate
Togashi et al, 2013[39]	No	Yes	Yes	Yes	Yes	Moderate
Scolozzi et al, 2015[40]	No	Yes	Yes	Yes	Yes	Moderate
Yoon et al, 2015[41]	No	Yes	Yes	Yes	Yes	Moderate
Kuhlefelt et al, 2016[42]	No	Yes	Yes	Yes	Yes	Moderate
Sebastiani et al, 2016[43]	No	Yes	Yes	Yes	Yes	Moderate

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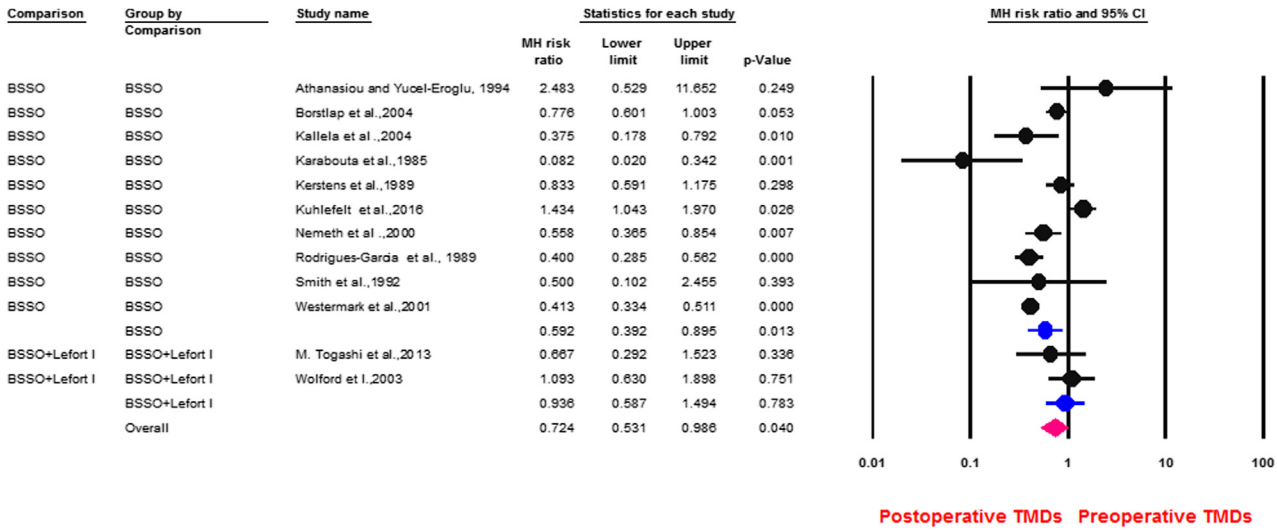

FIGURE 2. Preoperative versus postoperative temporomandibular disorders (TMDs) in retrognathic patients: risk ratios. BSSO, bilateral sagittal split osteotomy; CI, confidence interval; MH, Mantel-Haenszel.

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Subgroup analyses showed a significant difference. The WMDs for those patients with Class II, Class III, and various other dentofacial deformities were 5.7 mm (95% CI, 2.68 to 8.8 mm), 7.12 mm (95% CI, 4.31 to 9.92 mm), and 1.64 mm (95% CI, 0.294 to 2.681 mm), respectively. The overall cumulative analysis showed there was a significant increase in MMO after orthognathic surgery (WMD, 2.616; 96% CI, 1.69 to 3.45. $P = .001$) (Fig 5).

Discussion

The purpose of this study was to determine whether orthognathic surgery has a beneficial or deleterious effect on pre-existing TMDs. The relationships between TMDs and maxillomandibular deformities that require orthognathic surgery have been the object of many studies in the dental and/or medical literature. Clinicians have voiced 2 main philosophies: *1)* Correction of the deformity improves TMJ pathology,[3-7] and *2)* it is harmful to perform orthognathic surgery in a patient with pre-existing TMDs.[10-15]

The main findings of this study were as follows: *1)* There was a significant reduction in TMDs in patients with a retrognathic mandible after BSSO, but no significant difference after bimaxillary surgery. *2)* There was significant symptom reduction in patients with prognathism after isolated BSSO or IVRO or combined

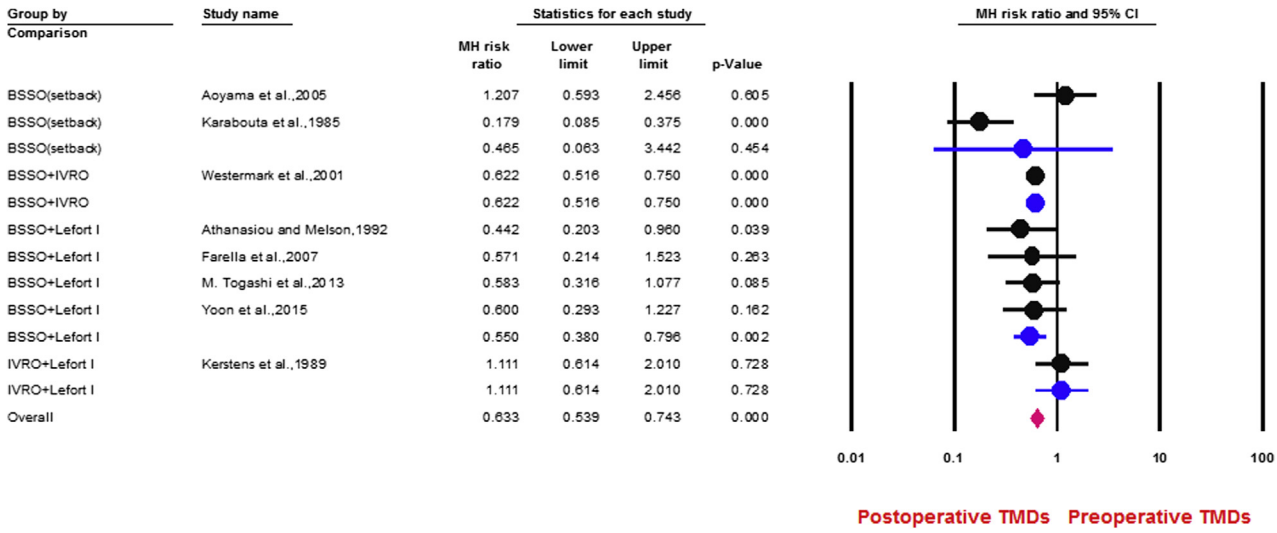

FIGURE 3. Preoperative versus postoperative temporomandibular disorders (TMDs) in prognathic patients: risk ratios. BSSO, bilateral sagittal split osteotomy; CI, confidence interval; IVRO, intraoral vertical ramus osteotomy; MH, Mantel-Haenszel.

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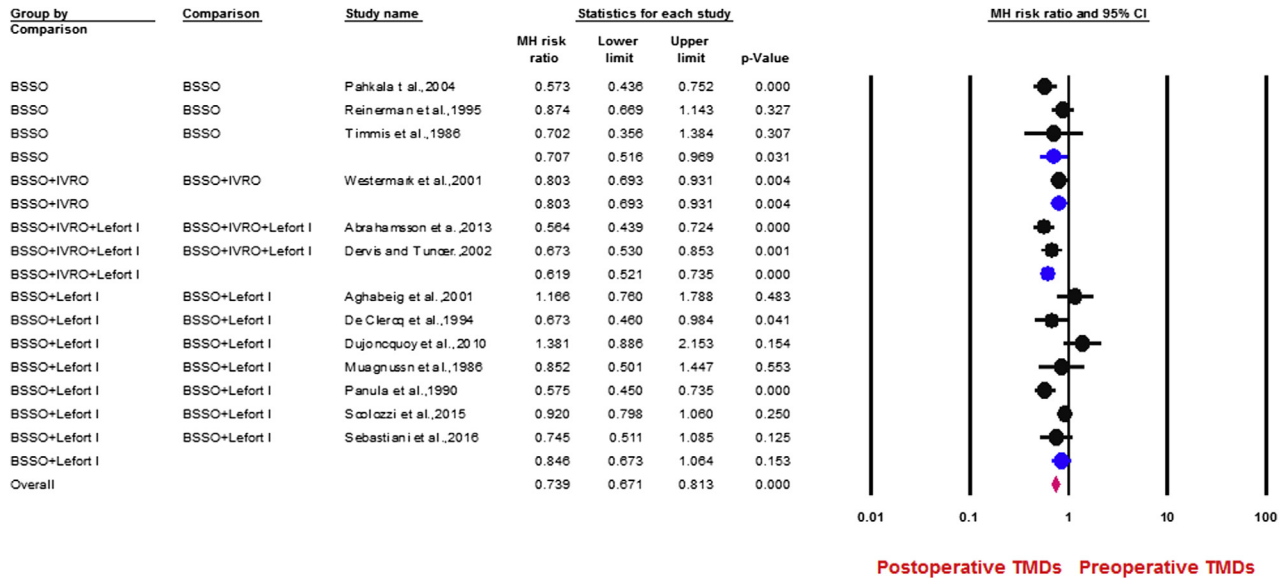

FIGURE 4. Preoperative versus postoperative temporomandibular disorders (TMDs) for patients with combination of different dentofacial deformities (Class I, Class II, Class III, and open bite): risk ratios. BSSO, bilateral sagittal split osteotomy; CI, confidence interval; IVRO, intraoral vertical ramus osteotomy; MH, Mantel-Haenszel.

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BSSO and Le Fort I osteotomy, but no significant difference after IVRO and Le Fort I osteotomy. *3)* There was a significant reduction in symptoms for patients with various other dentofacial deformities after mandibular advancement and setback treated with BSSO or IVRO or bimaxillary surgery using BSSO or IVRO with Le Fort I osteotomy. *4)* There was no significant difference in symptoms after bimaxillary surgery using BSSO and Le Fort I osteotomy in various other deformities. *5)* There was a significant increase in MMO after orthognathic surgery for all subgroups.

The results of this meta-analysis show that a preexisting TMD may improve with orthognathic correction in both Class II and III patients. It is important to note, however, that not all surgical procedures resulted in improvement in TMDs. For patients treated by mandibular advancement, an isolated BSSO resulted in significant improvement in TMDs, but the bimaxillary surgical procedure did not. Conversely, an isolated BSSO to achieve setback of the mandible resulted in no improvement in TMDs, but there was an improvement when it was combined with Le Fort I

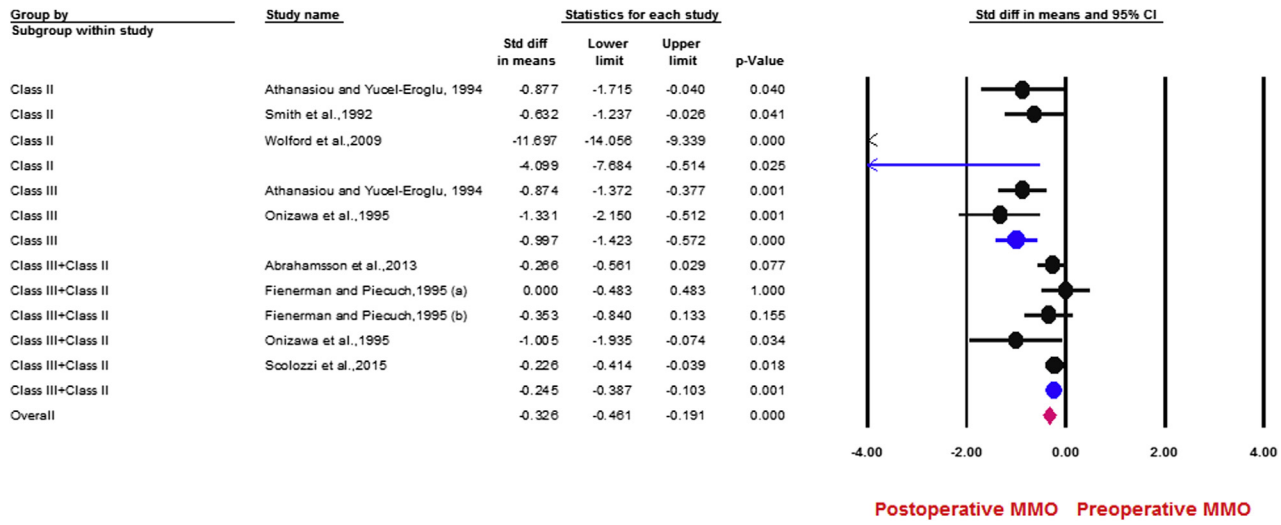

FIGURE 5. Preoperative versus postoperative maximal mouth opening (MMO) in subgroups (Class II, Class III, and various other dentofacial deformities): weighted mean differences. CI, confidence interval; Std diff, standardized difference.

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osteotomy. These different results may have much to do with sample sizes and many other individual variables such as the method of analysis, bias, presence and type of TMJ pathology, surgical technique, surgeon skill, postsurgical orthodontics and patient management, and adjunctive procedures. However, overall there was a reduction in TMD symptoms after orthognathic surgery.

The range of motion, specifically MMO, increased in all subgroups; however, this is not always a good measure of TMD improvement because mouth opening can change after vertical changes from orthognathic surgery (eg, open bite correction) and is not always linked to a less painful TMJ.[43,44]

POSSIBLE REASONS FOR SYMPTOM REDUCTION AFTER ORTHOGNATHIC SURGERY

Changes in Condyle-Disc Relationship

In patients with a pretreatment internal derangement, orthognathic surgery may result in a change in the condyle-disc relationship. Condyle-disc relationships and orthognathic surgery have been the subject of controversy and some research articles.[45,46] It is known that disc position can change after a mandibular osteotomy.[46] This change in position may explain why some of the pain in the TMJ decreases after corrective jaw surgery. Some authors, however, have suggested that a change in disc position is a potential source of increased symptoms.[13,47] Toll et al,[48] in 2010, using magnetic resonance imaging (MRI), found that patients with a Class II malocclusion have the highest incidence of disc displacement and this group may be most vulnerable after surgery, suggesting performing MRI as a part of the workup.

Disc displacement also has been confirmed in other studies. Fernández Sanromán et al,[49] in 1998, found 53.6% of patients diagnosed with a Class II dentofacial deformity had anteriorly displaced discs. The incidence of an internal derangement in the Class I and Class III groups was much lower (10%). Other authors have reported that disc position does not change after orthognathic surgery,[45] and its implications in resolving TMDs after orthognathic surgery are not clear.

Resolution of Muscle Disorders

A reduction in myofascial pain is another possible effect of orthognathic surgery. Ellis and colleagues[50,51] showed that, during the presurgical orthodontic phases, decreases occur in the range of motion and maximum voluntary bite force. There is no indication that these changes are the result of physiological alterations of the muscles of mastication, and they probably are a result of the pain and discomfort owing to the orthodontic appliances and induced malocclusion. This may explain why there is an improvement in TMDs of muscular origin after orthodontics and/or orthognathic surgery. The other possible mechanism is an improvement in masticatory ability and performance, as well as fewer occlusal interferences, which possibly helps reduce the patient's TMD symptoms.[52-55]

Decreased Bruxism and Clenching

Peripheral factors such as occlusal discrepancies and the anatomy of the bony structures of the orofacial region have been considered the primary causative factors for bruxism in the past, but we now know that they play only a small role, if any.[55-62] However, some studies have shown that occlusal interferences, especially nonworking interferences; centric relation - centric occlusion discrepancies; and molar asymmetry may worsen bruxism and have suggested that it would be useful to examine occlusal contacts in patients with bruxism to eliminate probable causative or contributing occlusal factors.[63,64] This supports the thesis that a malocclusion may worsen bruxism and increase some TMD symptoms in patients with dentofacial deformities. After the occlusion is corrected, elimination of occlusal interferences may decrease bruxism, allowing some muscular-related symptoms to improve.

PROBLEMS WITH STUDIES INCLUDED IN META-ANALYSIS

Some of the weaknesses of the studies used in this meta-analysis include that questionnaires rather than direct patient examination were used in some of the studies.[5-7,21,23,30,31,33,37,38] In addition, 6 reports had only 6 months of follow-up or less.[3,25,27,28,41,43] At 6 months, patients are still in the healing process and outcomes could differ at longer follow-up visits. Only 1 of the 29 studies evaluated skeletal stability[13] and only 1 study evaluated articular disc position using MRI,[13] indicating that the other 28 studies could only infer disc displacement when clicking was present. The elimination of clicking after surgery may be the result of the discs becoming non-reducing, particularly in mandibular advancement cases.

None of the studies described the postsurgical orthodontic mechanics used or identified the use of splints, physical therapy, medications, and so on in postsurgical patient management, as well as whether these modalities were still in use at the time of final evaluation. If any of these treatment modalities were used, the specific benefit of orthognathic surgery would be clouded, affecting the true treatment outcomes.

After orthognathic surgery to correct Class II, Class III, and open bite malocclusions, certain factors

associated with the etiology of TMDs tend to improve. There are fewer occlusal interferences, better masticatory efficiency and muscular-occlusal balance, and fewer centric relation - centric occlusion discrepancies. All of these factors, when corrected, help explain why there is an improvement in the overall symptoms of TMD. However, Class II patients with high occlusal plane angles and articular disc displacement may have a poorer outcome compared with those with normal- or low-angle mandibular retrognathism and prognathism. Although there is overall statistically significant TMD improvement in this study, the results do not indicate that orthognathic surgery will predictably improve a patient's TMD problem, and careful patient assessment needs to be conducted by the clinician before planning any surgical correction. Although many patients with TMD symptoms show improvement with orthognathic surgery, a significant percentage of patients do not show improvement, some patients' symptoms may become worse, and TMD develops after surgery in some asymptomatic patients. Because of this unpredictability, surgeons should inform patients that orthognathic surgery may or may not improve pre-existing TMJ and TMD signs and symptoms.

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