Oral and Maxillofacial Surgery and Chronic Painful Temporomandibular Disorders—A Systematic Review

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Purpose: To provide a systematic review of the best available research literature investigating the relation of oral and maxillofacial surgical procedures to the onset or relief of chronic painful temporomandibular disorder (TMD).

Materials and Methods: A comprehensive review of the databases CINAHL, Cochrane Library, Embase, Medline, NHS Evidence—Oral Health, PsycINFO, Web of Knowledge, and MetaLib was undertaken by 2 authors (P.S., M.H.) up to June 2009 using search terms appropriate to establishing a relation between orofacial surgical procedures and TMD. The search was restricted to English-language publications.

Results: Of the 1,777 titles reviewed, 35 articles were critically appraised but only 32 articles were considered eligible. These were observational studies that fell into 2 groups; 9 were seeking to establish a surgical cause for TMD. Of these, only 2 of a series of 3 claimed that there was a significant link, but this claim was based on weak data (health insurance records) and was abandoned in a subsequent report. Twenty-three studies were seeking to achieve relief by orthognathic surgical intervention. These were also negative overall, with 7 articles showing varying degrees of mostly nonsignificant improvement, whereas 16 showed no change or a worse outcome. No published report on the putative effect of implant insertion was found.

Conclusion: These apparently contradictory approaches underline a belief that oral surgical trauma or gross malocclusion has a causative role in the onset of TMD. However, there was no overall evidence of a surgical causal etiology or orthognathic therapeutic value. This review emphasizes that it is in the patients' best interest to carry out prospective appropriately controlled randomized trials to clarify the situation.
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Temporomandibular disorders (TMDs) include a well-recognized chronic syndrome consisting of mandibular dysfunction associated with joint and/or masticatory muscle pain. The pain tends to be intermittent but may persist for substantial periods and is exacerbated by jaw movement with the clinical features of reducible internal derangement (clicking and sticking) and limitation of opening.[1] When persistent, the painful condition appears to be determined by the release of nociceptive inflammatory agents that include substance P, leukotriene B_4 and prostaglandin E_2, serotonin, and bradykinin into the joint capsule and the synovial fluid.[2-4] Unfortunately, the failure of nonsteroidal anti-inflammatory analgesics to inhibit neuropeptides and leukotrienes may explain the persistent nature of the problem and the search for alternative analgesic therapies.

The intracapsular neuropeptide inflammation also induces the release of fibrillar collagen adhesions from the fibrocartilage meniscus, which can be seen

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with arthroscopy and are responsible for the internal derangement of the meniscus and limited jaw opening.

The disputed primary causes of this dysfunctional arthromyalgia are traumatic or occlusal disturbances of the condyle-meniscus-glenoid fossa relation or a biopsychosocially provoked peripheral release of inflammatory neuropeptides associated with dysregulation of central pain processing.[5] Although the etiology has been described as multifactorial because of the wide range of identified precipitating factors, like many common pains that are readily recognized and treated, the underlying mechanism is idiopathic.

TMD appears to be part of a whole-body pain vulnerability for which there may be a common neurotransmitter and psychological basis. Patients are found to suffer significantly from atypical (idiopathic) nonjoint, nonmuscular facial pain, atypical odontalgia, oral dysesthesia, headaches, throat, neck and back pain,[6] irritable bowel, pelvic pain, pruritus, and fibromyalgia,[7] to varying degrees at some time or other. This tendency often remains undetected in the dental history as does the relation of the pain with psychosocial stress factors and somatization.[8] A somatoform disorder is essentially a disturbance in bodily sensation or function, manifesting a psychological disturbance and is characteristically associated with prominent patient concern. Because serotonin appears to play a central role in pain perception and inhibition, the recently observed association of serotonin gene polymorphism with TMD and similar functional somatic disorders could well prove to be a unifying genetic defect.[9,10]

This systematic review was undertaken to establish if a causal relation exists between any oral and maxillofacial surgical procedures and the onset or relief of TMD.

Materials and Methods

SEARCH STRATEGY

A comprehensive search used electronic bibliographic databases with subject headings and keywords and hand searches of journals where electronic studies were not available. The period examined was from 1980 when records began until June 2009 according to the general principles in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[11] The following databases were explored by 2 authors (P.S. and M.H.): CINAHL, Cochrane Library, Embase, Medline, NHS Evidence—Oral Health, PsycINFO, Web of Knowledge, Google Scholar, and MetaLib (Appendix 1). The search was restricted to English-language publications.

DATA COLLECTION AND ANALYSIS

Three reviewers (P.S., A.L., and M.H.) performed a systematic screening of identified evidence to determine eligibility, apply quality criteria, and extract data from included studies. At the title and abstract sifts, a random selection of 20% of articles were screened by 2 reviewers (M.H. and P.S.) to assure consistency and to discuss any disagreements. The remaining 80% of articles were then split equally and screened by the same authors (P.S. and M.H.). All studies included at abstract level were then read and screened for inclusion by 2 reviewers (M.H. and A.L.), jointly discussed, summarized, and data were extracted and appraised. In view of the clinical and medicolegal implications, pain and dental forensic specialists Mehri Eghtessad, Roger Goulden, and Bernard Speculand reviewed the data and final draft.

QUALITY ASSESSMENT AND EVIDENCE SYNTHESIS

The characteristics and outcomes of the included studies are summarized in tabular form (Tables 1 and 2).[12-44] The quality of the articles was judged using the appraisal tool for case-control studies provided by the Centre for Appraisal Skills in Practice at the Public Health Resource Unit, York, UK (http://www.phru.nhs.uk/pages/PHD/CASP.htm) because it was appropriate for most of the studies analyzed and adaptable to larger cohorts (Appendix 2). From these appraisals, 3 overall quality ratings were developed:

1. prospective controlled case or cohort studies
2. retrospective well-controlled case or cohort studies
3. uncontrolled retrospective studies

SELECTION CRITERIA

As stated, only cohort and case-control observational studies were available for review. There were no randomized controlled trials.

INCLUSION CRITERIA

Studies with the primary aim to investigate the relation between TMD and oral surgery procedures, especially the removal of impacted third molars, orthognathic surgery, or implant insertion were included.

EXCLUSION CRITERIA

Studies on patients with diagnosable degenerative joint pathology such as osteoarthritis, rheumatoid arthritis, and post-traumatic condylar derangement were excluded. Studies dealing with orthodontic therapy or orthodontic surgery to relieve crowding were also excluded.

Table 1. SURGERY AS A POSSIBLE CAUSE OF TMD

Study Number	Lead Author	Year	Journal Issue	Surgery as Possible Cause of TMD	Trial Design and Patient Numbers	TMD Definition	Outcome	Quality	Strengths	Weaknesses
1	Raustia[12]	1991	Cranio 9(4):356	Causative effect of third molar removal	Prospective cohort study (n = 22)	Helkimo index[13]	Increased incidence of TMD after third molar removal	C	Prospective design	Small/equal numbers of men and women indicate bias, no controls
2	Berge[14]	2002	Acta Odontol Scand 60(2): 108	Causative effects of third molar removal and atypical odontalgia	Retrospective case study (n = 1,035)	Not prime focus of study	No difference from general population	C	Sound for prevalence of idiopathic dental pain	Retrospective, uncontrolled study of third molar removal
3	Huang[15]	2002	J Dent Res 81(4):284	Causative effect of risk factors; bruxism gender somatization, third molar removal and trauma on TMD	Retrospective case-control study (n = 397/195)	Research diagnostic criteria RDC/TMD[1]	Odds ratios: female, 4.2; bruxism, 4.8; somatization, 3.7; third molar, 3.2; trauma, 2.0	B	Well-designed controls and statistical analysis	Based on retrospective records of unseen patients
4	Israel[16]	2003	J Oral Maxillofac Surg 61(6): 662	Causative effects of endodontics; extractions; apicectomy; TMJ surgery; neurolysis; orthognathic surgery; bone debridement	Retrospective case study (n = 38/120)	History and examination only	Chronic orofacial pain is common; surgery can exacerbate and perpetuate pain	B	Compassionate study of chronic idiopathic facial pain	Relation of chronic facial pain with a list of interventions, retrospective with unclear data
5	Threlfall[17]	2005	Br J Oral Maxillofac Surg 43(1):13	Causative effect of third molar removal on disc derangement	Retrospective matched case-control study (n = 220/220)	Questionnaire	No significant disc displacement or reduction	B	Adequate group size; controls	Subjective qualitative retrospective data
6	Huang[18]	2006	J Am Dent Assoc 137:1547	Causative effect of third removal on TMD in 15- to 20-yr-olds	Retrospective cohort study of postextraction TMD versus no postextraction TMD (n = 34,481)	Insurance claim forms; 17,245 (50%) had third molar extractions at <20 yr and 391 had claims indicating TMD	Third molar extraction risk factor for TMD; risk ratio, 1.6; 95% CI, 1.3–2.0; 23% appeared to have postoperative risk of TMD	B	Large numbers, robust statistics	Diagnosis based on patient insurance records >5 yr after extraction
7	Huang[19]	2008	J Dent Res 87(3):283	Causative effect of third molar removal on TMD	Retrospective case-control study with matched controls (n = 2,217/2,217)	Diagnosis from medical records ICD-9 for diagnosis	TMD risk after third molar removal not significantly increased; overall risk ratio, 1.4; 95% CI, 0.8–3.1	B	Well-designed, large numbers, matched controls	Retrospective, diagnosis from records of unseen patients
8	Akhter[20]	2008	J Orofac Pain 22(1):50	Causative effect of *1)* jaw injury, *2)* third molar removal, *3)* orthodontic treatment	Cross-sectional study of medical students (n = 2,374)	Self-assessed questionnaire with observer supervision and insurance classification, life events checklist; no clinical examination	Trauma to jaw and third molar extraction may be cumulative and precipitate TMD	C	Comparing stress as a major factor in TMD with trauma/surgery	Overconcern with clicking/sticking, not pain; retrospective, uncontrolled
9	Juhl[21]	2009	J Oral Rehabil 36:199	Effect of third molar removal on TMD	Prospective cohort study (n = 72 cases and 25 healthy age- and gender-matched controls, no third molar controls)	Research diagnostic criteria RDC/TMD[1]	Slight increased incidence of varied TMD clinical features up to 6 mo but not significantly greater than nonoperated controls	A	Well-designed and statistically robust; relevant discussion of central pain mechanisms	Would have been optimized by randomized controls with unoperated impacted third molars

Abbreviations: CI, confidence interval; ICD-9, *International Classification of Diseases, Ninth Revision*; RDC, research diagnostic criteria; TMD, temporomandibular disorder.

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Table 2. ORTHOGNATHIC SURGERY AS A POSSIBLE CURE OF TMD

Study Number	Lead Author	Year	Journal Issue	Surgery as Possible Cure of TMD	Trial Design and Patient Numbers	TMD Definition/Diagnosis	Outcome	Quality	Strengths	Weaknesses
1	Upton[22]	1984	J Prosthet Dent 51(5):686	Effect of major jaw mal relation (orthognathic surgery) correction on TMD	Retrospective questionnaire cohort study (n = 102)	Based purely on recalled symptomology	*1)* maxillary/mandibular disharmony is an important etiologic factor in TMD, *2)* surgical correction improves symptoms, BUT *3)* some develop TMD postoperatively	C	Adequate group size	Retrospective questionnaire; uncontrolled without statistical analysis
2	Magnusson[23]	1986	Int J Oral Maxillofac Surg 15(6):707	Effect of orthognathic surgery on TMD	Prospective cohort study (n = 20)	Helkimo index	Decreased signs and symptoms of TMD; Helkimo index significantly decreased	B	Prospective design	Small numbers, underpowered, uncontrolled
3	White[24]	1992	Int J Adult Orthodon Orthognath Surg 7(1):7	Effect of orthognathic surgery on TMD surgical patients	Retrospective cohort study, from records (n = 75) uncontrolled	Standardized 7-criteria TMD questionnaire	Prevalence in patients almost 50%, significantly better after surgery	C	Adequate group size	No reference confirming standardized questionnaire; no statistics
4	Feinerman[25]	1995	Int J Oral Maxillofac Surg 24(4):268	Effect of bilateral sagittal split osteotomy for mandibular advancement on TMD	Retrospective case-control study (n = 141)	Nonvalidated examination	No change	B	Adequate group size	Retrospective, nonrandomized comparators
5	De Clercq[26]	1995	J Craniomaxillofac Surg 23(3):195	Effect of bilateral sagittal split osteotomy for mandibular advancement on TMD	Retrospective case series (n = 196)	Clinical examination, questionnaire, insurance classification	Fewer TMD symptoms after surgery for normal/low-angle cases, not high-angle cases	C	Adequate group size and stratification	Retrospective, uncontrolled
6	Onizawa[27]	1995	J Oral Maxillofac Surg 53(2):117	Effect of combined bilateral sagittal split osteotomy and Le Fort I procedure for TMD	Prospective cohort study with healthy controls (n = 30/30)	Questionnaire and clinical examination	No significant difference in TMD sounds, deviation, or tenderness	A	Prospective controlled	Small numbers but probably satisfactory power; not randomized
7	Moenning[28]	1997	Int J Adult Orthodon Orthognath Surg 12(2):153	Effect of orthognathic surgery on TMD	Retrospective cohort study (n = 150)	Questionnaire and VAS	Significant decrease in all TMJ symptoms except facial pain	C	Adequate group size	Self-reported retrospective questionnaire
8	Scott[29]	1997	J Am Dent Assoc 128(7):999	Retrospective comparison of case notes using a precise index	Case-control study (n = 58)	Helkimo index	Patient notes were retrospectively reviewed and worse than structured format	B	Illustrates weaknesses of retrospective studies	Lack of statistical support
9	De Clercq[30]	1998	J Craniomaxillofac Surg 26(1):29	Effect of orthognathic surgery on TMD	Retrospective cohort study (n = 238)	VAS pain; TMJ questionnaire; TMJ function; masticatory efficiency but no clinical examination	Chewing was only significant improvement	B	Substantial group size; detailed outcome measurements	Retrospective, uncontrolled; limited statistical analysis
10	Egermark[31]	2000	Eur J Orthod 22(5): 537	Effect of combined bilateral sagittal split osteotomy and Le Fort I procedure with orthodontics on TMD	Retrospective cohort study by questionnaire (n = 53)	Helkimo index	Improved signs and symptoms including headaches	B	Used recognized diagnostic index	Retrospective cohort from notes and questionnaire; evidence of bias?
11	Panula[32]	2000	Int J Oral Maxillofac Surg 29(3):183	Effect of orthognathic surgery on TMD	Prospective cohort study of consecutive patients (n = 60) with comparators	Helkimo index	Clicking/crepitus no change but improved pain/tenderness	A	Prospective study with comparators	Controls are nonrandomized self-selected, ie, declined surgery
12	Agabeighi[33]	2001	Int J Adult Orthodon Orthognath Surg 16(2):153	Anterior open bite corrected by orthognathic surgery to improve TMD	Retrospective cohort study (37 responded to questionnaire; 13 examined)	*1)* TMJ scale, *2)* SCL-90 (psychological symptoms), *3)* Spielberger (anxiety), VAS satisfaction	Female subjects and higher SCL-90 scores relate to higher risk of persistent TMD pain	B	Appropriate design and measurements	Retrospective, but low response rate (37/83)

Table 2. ORTHOGNATHIC SURGERY AS A POSSIBLE CURE OF TMD (Cont'd)

Study Number	Lead Author	Year	Journal Issue	Surgery as Possible Cure of TMD	Trial Design and Patient Numbers	TMD Definition/Diagnosis	Outcome	Quality	Strengths	Weaknesses
13	Yamada[34]	2001	Oral Surg Oral Med Oral Pathol Oral Radiol Endod 91(5):603	Effect of orthognathic surgery on TMD patients	Cross-sectional study of pretreatment tomographs (n = 129)	CT scan, clinical examination, questionnaire; stethoscope auscultation of joint	*1)* unchanging pain and trismus, *2)* association between joint deformity and disc displacement, *3)* joint sounds improved	B	Baseline well established, adequate group size	Hard to interpret data
14	Westermark[35]	2001	Int J Adult Orthodon Orthognath Surg 16(2):145	Effect of bilateral sagittal split compared with intraoral vertical osteotomy	Retrospective cohort study from records (n = 1,516)	Self-evaluated questionnaire of TMD symptoms 2 yr postoperatively	Intraoral vertical osteotomy more effective than sagittal split; significant decrease of symptoms from 43% to 28%	B	Large patient sample	Retrospective, subjective data; no examination
15	Ueki[36]	2002	J Oral Maxillofac Surg 27(5):501	Effect of mandibular osteotomy for prognathism on TMD (BSSO compared with IVRO)	Comparison of 20 intraoral vertical subsigmoid osteotomies and 23 bilateral sagittal split osteotomies	Examination by surgeon, no diagnostic index	Improvements reported by patients but no significant difference	C		Small group; historical controls
16	Dervis[37]	2002	Oral Surg Oral Med Oral Pathol Oral Radiol Endod 94(5):554	Orthognathic surgery and TMD	Prospective controlled cohort study (n = 50/50)	Helkimo index	No significant difference before and after operation; significant improvement after 2 yr	A	Control group; well-designed trial with useful outcome	Late improvement, probably natural history of condition and placebo effects
17	Pruitt[38]	2002	J Oral Maxillofac Surg 60(9):996	Effect of bilateral sagittal split osteotomy with Le Fort I on TMD	Retrospective cohort (n = 16)	Unvalidated classification	Nonsignificant decrease in pain/ symptoms	C		Unjustified exclusions of patients, small numbers, unvalidated diagnosis
18	Wolford[39]	2003	Jf Oral Maxillofac Surg 61(6):655	Effect of orthognathic surgery on TMD in pts with MRI defined internal derangement	Retrospective cohort study from treatment records and MRI scans (n = 25)	MRI and clinical examination	Patients with TMD have significant worsening symptoms after orthognathic surgery	C		
19	Pahkala[40]	2004	Acta Odont Scand 62(4):238	Effect of bilateral sagittal split osteotomy on TMD	Prospective cohort study (n = 72)	Helkimo index	TMD cases with severe jaw deformity showed significant benefit	B	Prospective study	Uncontrolled for no treatment or confounding factors
20	Aoyama[41]	2005	J Med Dent Sci 52(2):109	Effect of bilateral sagittal split osteotomy on TMD	Prospective cohort study (n = 37)	*1)* diagnostic questionnaire, *2)* insurance record, *3)* clinical examination; ≥1 of sounds, pain, pain on chewing, trismus	No significant difference between pre- and postoperative symptoms	B	Prospective study	Overdiagnosis of TMD, small numbers, uncontrolled
21	Farella[42]	2007	Int J Oral Maxillofac Surg 36(7):583	Effect of combined bilateral sagittal split osteotomy and Le Fort I procedure on TMD	Prospective cohort study (n = 14)	Axis I RDC/TMD; pressure algometer	No significant improvement	C	Impressive statistics for very small group	Small numbers, no justified use of algometer
22	Pahkala[43]	2007	Am J Orthod Dentofac Orthop 132(2):158	Effect of bilateral sagittal split osteotomy on TMD	Prospective cohort study (n = 82)	Helkimo index	Orthognathic surgery significantly decreased prevalence of TMD	B	Prospective study	No nonintervention control for natural remission
23	Ueki[44]	2007	Int J Oral Maxillofac Surg 36(3):207	Effect of Le Fort I and IVRO on changes in TMJ	Retrospective cohort (n = 50)	MRI morphology for position of disc	90% improvement with Le Fort I and 90.5% with IVRO	C		No controls, unreliable way to assess TMD, improbable improvements

Abbreviations: BSSO, bilateral sagittal split osteotomy; CT, computed tomographic; IVRO, intraoral vertical ramus osteotomy; MRI, magnetic resonance imaging; RDC, research diagnostic criteria; TMD, temporomandibular disorder; TMJ, temporomandibular joint; VAS, visual analog scale.

Results

DATABASE SEARCH RESULTS

The search yielded 153 articles from CINAHL, 19 from the Cochrane Library, 609 from Embase, 1,118 from Medline, 5 from PsycINFO, 358 from Web of Knowledge, and 1 from NHS Evidence–Oral Health; these were confirmed by MetaLib and Google Scholar. A total of 2,262 references were found; 1,776 remained after removal of duplicates.

Of these 1,776 articles, 35 full studies were included in the review for analysis but 3 proved to be inappropriate; see the PRISMA algorithm (Fig 1). The eligible 32 articles were observational studies that fell into 2 groups:

1. 9 seeking to establish the possibility of a surgical cause for TMD
2. 23 seeking to achieve relief by orthognathic surgical intervention

This apparent paradoxical finding underlines the strongly held belief that trauma to the mandible and malocclusion are the principal causes of a chronic dysfunctional arthromyalgia.

Discussion

META-ANALYSIS

It was not possible to conduct a meta-analysis or pool the results of the appraised literature because the studies were too heterogeneous. The 9 studies examining surgical causes of TMD are split between 6 considering third molar extraction and 3 looking at a variety of additional risk factors (Table 1). The retrospective nature and sources of patient data (medical records, insurance records) also make them an unreliable source for meta-analysis.

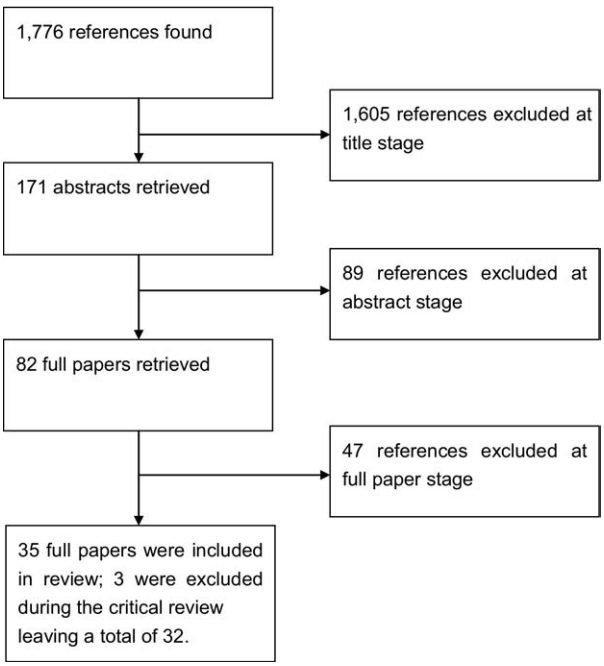

FIGURE 1. PRISMA chart.

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Studies looking at orthognathic surgery as a cure for TMD (Table 2) were equally heterogeneous in *1*) their definition of TMD and the tools to diagnose it; *2*) the different types of surgery (eg, the change from mandibular intraoral vertical ramus osteotomy to bilateral sagittal split osteotomy (BSSO) and then to bimaxillary procedures); and *3*) differing types and severity of malocclusion. The results are therefore summarized in Tables 1 and 2; the main points are summarized below.

SURGERY AS A POSSIBLE CAUSE OF TMD

Trial Design

Six of the 9 studies investigated the removal of third molars (Table 1; studies 1,[12] 2,[14] 5,[17] 6,[18] 8,[20] and 9[21]). Three studies (3,[15] 4,[16] and 7[19]) also examined other risk factors such as bruxism, jaw trauma, other dentoalveolar procedures, and orthognathic surgery.

The sources of the data were also heterogeneous. Huang et al appeared to focus on third molar extraction as a risk factor for TMD based on a cohort of patients referred for facial pain (study 3[15]), insurance claim forms (study 6[18]), and diagnoses of TMD in medical records (study 7[19]). Berge and Berge (study 2[14]) carried out a telephone survey of patients who had undergone third molar extraction and invited those with symptoms of TMD to attend for examination. Threlfall et al (study 5[17]) conducted a retrospective questionnaire study with patients identified from clinical records as having TMD symptoms. Akhter et al (study 8[20]) conducted a cross-sectional questionnaire study with a cohort of medical students, and Raustia et al (study 1[12]) followed a small cohort of 22 students who had undergone third molar extraction. Although identifying patients from clinical and insurance records led to impressively large cohorts, the retrospective records of unseen patients can produce only imprecise results, as shown by Scott et al (Table 2, study 8[29]).

TMD Diagnosis

Only studies 1,[12] 3,[15] and 9[21] of the 9 used a validated TMD diagnostic index (such as the Research Diagnostic Criteria/Temporomandibular Disorders [RDC/TMD][1]and the Helkimo index[13]). The patient questionnaires of Threlfall et al (study 5[17]) and Akhter et al (study 8[20]) would be subject to recall bias.[45] The study by Israel et al (study 4[16]) was a retrospective and uncontrolled investigation illustrating the surgical upregulation of idiopathic facial pain. How-

ever, their compassionate examination of postoperative patients of a pain clinic population who may have undergone multiple interventions could not be considered reliable data.

Outcome

Summarizing the outcomes of those investigating third molar extraction, Raustia et al (study 1[12]) found that third molar extraction increased TMD; Huang et al (studies 2[15] and 6[18]) also claimed that the risk of TMD was increased, whereas their final study (study 7[19]) found the risk was not significantly elevated. Berge and Berge (study 2[14]) and Threlfall et al (study 5[17]) found no increased incidence of TMD. Juhl et al (study 9[21]), using the highest quality protocol, did not find any significant difference from age- and gender-matched untreated controls at 6 months postoperatively. This was the only study to consider the role of centrally acting pain processing in TMD.

In summary, the combination of heterogeneous weak patient data from retrospective clinical records or questionnaires, imprecise TMD criteria, small or uncontrolled studies, and the lack of any statistically significant causal relation represents a rejection of the surgically removed third molar etiology of chronic painful TMD.

ORTHOGNATHIC SURGERY AS A POSSIBLE CURE FOR TMD

Surgical Procedures

Some groups investigating the potential of orthognathic surgery to improve TMD focused on specific operations such as sagittal split osteotomy (Table 2; studies 4,[25] 19,[40] 20,[41] and 22[43]) or the intraoral vertical ramus osteotomy with a Le Fort I osteotomy (study 23[44]). Westermark et al (study 14[35]) compared the BSSO against intraoral vertical ramus osteotomy. Studies 6,[27] 10,[31] 17,[38] and 21[42] included patients undergoing a combination of BSSO and Le Fort I procedures. Aghabeigi et al (study 12[33]) focused on surgery for anterior open-bite associated TMD and Ueki et al (study 15[36]) on TMD and prognathism. Studies 1,[22] 2,[23] 7,[28] 9,[30] 10,[32] 13,[34] 3,[24] 16,[37] and 18[39] were nonspecific in their choice of procedures.

Rationale

The 3 different rationales for the orthognathic surgical treatment of TMD were condylar-disc derangement (studies 4,[25] 7,[28] 13,[34] 15,[36] 17,[38] and 23[44]), whereas studies 1,[22] 2,[23] 6,[27] 14,[35] 19,[40] 20,[41] and 22[43] proposed occlusal instability as a contributing factor. Studies 5,[26] 9,[30] 10,[31] 11,[32] 12,[33] 3,[24] 16,[37] and 21[42] argued that there was insufficient evidence from previous research, which therefore necessitated further investigation.

Diagnosis

As with the third molar studies, there were discrepancies in the definition and diagnosis of TMD and the study methods involved. Most investigators studied patients' retrospective data after undergoing orthognathic surgery for malocclusion.

Studies 4,[25] 5,[26] 12,[33] 13,[34] and 23[44] extracted signs and symptoms of TMD from existing records of presurgical clinical examinations and compared these with a postsurgical examination; White and Dolwick (study 3[24]) used a standard pre- and post-treatment TMD questionnaire routinely completed by all patients. Egermark et al (study 10[31]) and Aghabeigi et al (study 12[33]) used patient notes and a questionnaire sent to patients; the latter also applied scales to detect psychological symptoms (SCL90/Spielberger Anxiety Inventory). Several investigators conducted an entirely retrospective questionnaire study where patients were asked to recall and describe their symptoms before and after the operation (studies 1,[22] 7,[28] 9,[30] 14,[35] and 17[38]). Data collected by this method are weak because open to recall bias. Ueki et al (study 15[36]) compared results from pre- and postoperative magnetic resonance imaging scans, which alone are also unreliable to assess TMD.

Prospective studies were able to diagnose baseline TMD more reliably as data collection procedures were focused on the condition. The Helkimo index[13] was used by studies 2,[23] 8,[29] 10,[32] 16,[37] 19,[40] and 22.[43] Farella et al (study 21[42]) only used the RDC Axis I for clinical evaluation and TMD classification but omitted the psychosocial Axis II. Aoyama et al (study 20[41]) and Onizawa et al (study 6[27]) diagnosed TMD by clinical examination by a specialist.

Outcomes

Reported outcomes were also inconsistent. No article considered quality of life as a measurement of outcome especially in relation to chronic pain. Of the 7 prospective studies, 2 groups (studies 2[23] and 22[43]) found TMD symptoms improved significantly; 2 studies reported improvement for cases with severe jaw deformity (study 19[40]) or only in the area of pain and tenderness (study 11[32]). Four studies (6,[27] 13,[34] 16,[37] and 21[42]) did not discern any improvement.

Of the 14 retrospective studies, 6 studies (7,[28] 10,[31] 14,[35] 3,[24] 18,[39] and 23[44]) claimed a significant improvement. In 5 studies (1,[22] 9,[30] 3,[24] 15,[36] and 17[38]), TMD symptoms improved partly or nonsignificantly. No improvement was found by studies 4,[25] 12,[33] and 13.[34] Scott et al (study 8[29]) was primarily concerned with the accuracy of reporting outcome processes. Their retrospective study data from clinical notes were more positive than the prospective questionnaire results of the same cohort. This revealed that retrospective studies based on clinical records are

imprecise in establishing a diagnosis and tend to overestimate treatment benefits.

Cost-Effectiveness

Moenning et al (study 7[28]) argued that surgery for the relief of severe TMD fulfills the criteria of "medical necessity" needed for reimbursement by US health insurers, but did not justify this in any robust clinical investigation or by an economic analysis. None of the 32 articles discussed results from a health economic evaluation.

Many of these problems have been corroborated by a recent systematic review[46] on the clinical features of TMD before and after orthognathic surgery. Unfortunately, the study appeared to anticipate relief, but despite this bias found that no conclusions could be drawn because of methodologic deficits in the reviewed studies.

In summary, all 9 studies investigating a surgical causality for TMD were observational and did not establish any statistically significant, prospective controlled evidence of a relation between the removal of impacted third molars, trauma, and other dentoalveolar procedures and the onset or worsening of painful TMD. There was no published study on the putative effect of implant insertion on TMD, and no studies showing that the removal of impacted third molars relieved TMD.

Twenty-three appraised studies set out to establish a therapeutic role for orthognathic surgery for TMD and were negative in their overall outcome. Seven articles showed varying degrees of improvement based on weak data, whereas 16 showed little or no change. One study[39] concluded that this failure of orthognathic outcome indicated the need for simultaneous joint surgery to achieve a cure.

In conclusion, despite a substantial selection of studies for critical appraisal, the absence of a consistent pattern raises grave concern as to the validity of the underlying concepts for which these trials were carried out. Furthermore, the absence of randomized controls from the same study population was an obvious omission.

Many of these studies, if read or cited independently, could encourage unnecessary surgery that often upregulates TMD to intractable pain and occasional litigation. These studies compare badly with other surgical specialities where blinded randomized controlled trials are now held to be essential to validate surgical procedures and eliminate common confounding factors such as natural remission and the placebo effect.[47]

Such trials would also offer the opportunity to explore outcome in relation to markers of TMD vulnerability such as serotonin genetic polymorphism.[9,10]

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Appendix 1. SEARCHING PROCEDURE (MEDLINE STRATEGY)

1	exp Tooth Extraction/
2	exp Molar/
3	exp Tooth, Impacted/
4	exodontia.mp.
5	("tooth extract$" or "teeth extract$" or "dental extract$" or "surgical extraction$" or "surgical exodontia$").mp. [mp=title, original title, abstract, name of substance word, subject heading word]
6	("wisdom tooth" or "wisdom teeth" or "third molar$").mp. [mp=title, original title, abstract, name of substance word, subject heading word]
7	"impacted tooth".mp. [mp=title, original title, abstract, name of substance word, subject heading word]
8	"impacted teeth".mp.
9	"oral surg$".mp.
10	(dento-alveolar or dentoalveolar or dento alveolar).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
11	Dental Implants/
12	Dental Implantation/ or dental implantation.mp. [mp=title, original title, abstract, name of substance word, subject heading word]
13	((osseointegrated adj implant$) and (dental or oral)).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
14	(implant$ adj5 dent$).mp. [mp=title, original title, abstract, name of substance word, subject heading word]

Appendix 1. SEARCHING PROCEDURE (MEDLINE STRATEGY) (Cont'd)

15	orthognathic surgery.mp. or Oral Surgical Procedures/
16	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
17	Temporomandibular.mp. or exp Temporomandibular Joint Disk/ or exp Temporomandibular Joint Dysfunction Syndrome/ or exp Temporomandibular Joint/ or exp Temporomandibular Joint disorders/
18	exp Myofascial Pain Syndromes/
19	exp Craniomandibular Disorders/
20	temporomandibular $.mp.
21	craniomandibular $.mp.
22	tmj$.mp.
23	cmd$.mp.
24	tmd$.mp.
25	mps$.mp.
26	"temporo mandibular".mp.
27	temporo-mandibular$.mp.
28	("cranio mandibular" or cranio-mandibular).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
29	Facial Pain/ or Facial arthromyalgia.mp.
30	17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29
31	16 and 30

Appendix 2. QUALITY APPRAISAL TOOL ADAPTED FOR TEMPOROMANDIBULAR DISORDER

1		Did the study address a clearly focused issue?
2		Did the study use an appropriate method?
	a	Method used?
	b	Quality of design?
3		Were the cases recruited in an acceptable way?
	a	Defined precisely?
	b	Representative of population?
	c	System for selecting the cases reported?
	d	Anything special about the cases?
	e	Is the time frame relevant to the problem?
	f	Sufficient number of cases?
	g	Power calculation?
4		Were the controls/comparators selected in an acceptable way?
5		Was the prevalence of temporomandibular disorder accurately measured?
	a	Was the prevalence clearly defined?
	b	Subjective or objective measurements?
	c	Validated measure?
6		Reported confounding factors?
7		Describe Results
8		How precise are the results?
9		Are the results believable?
10		Are they applicable locally?
11		Do they fit with available evidence?
12		Overall quality?