FOCUS ARTICLE

Application of Principles of Evidence-Based Medicine to Occlusal Treatment for Temporomandibular Disorders: Are There Lessons to Be Learned?

Heli Forssell, DDS, PhD
Senior Lecturer
Department of Oral Diseases/Pain Clinic
Turku University Central Hospital
Turku, Finland

Eija Kalso, MD, PhD
Associate Professor
Pain Clinic
Department of Anesthesia and Intensive Care Medicine
Helsinki University Central Hospital
Helsinki, Finland

Correspondence to:
Dr Heli Forssell
Department of Oral Diseases/Pain Clinic
Lemminkäisenkatu 2
Fin-20520 Turku
Finland
Fax: +358-2-3338248
E-mail: heli.forssell@tyks.fi

Critical evaluation of treatment methods has become an important part of health care and will certainly have a major influence on decisions about acceptable treatment methods in the future. Evidence-based medicine (EBM) means the systematic, explicit, and judicious implementation of the best evidence in patient care. The most reliable sources of evidence are high-quality systematic reviews and randomized controlled trials (RCTs). A systematic EBM approach could be particularly useful in the treatment of temporomandibular disorders (TMD), where controversial and conflicting ideas about management are common. In this field, concerns about the lack of evidence are often expressed. This article aims to elucidate and discuss the application of EBM to the treatment of TMD, using the most controversial treatments (ie, occlusal treatments) as an example. By applying the principles of EBM to TMD treatments, we wish to highlight some of the important issues that form the basis for high-quality care in this field. A systematic review of occlusal treatments (occlusal splints and occlusal adjustment) updated to January 2003 revealed 16 RCTs of occlusal splints and 4 of occlusal adjustment. The overall quality of the trials was fairly low. Recently, however, some high-quality RCTs of occlusal splints have been published. The most obvious methodologic shortcomings in published trials included problems in defining the patient population, inadequacies in performing randomization and blinding, problems in defining the therapies or appropriate control treatments, short follow-ups, and problems in monitoring patient compliance. Occlusal splint studies yielded equivocal results. Even in the most studied area, stabilization splints for myofascial face pain, the results do not justify definite conclusions about the efficacy of splint therapy. Their clinical effectiveness to relieve pain also seems modest when compared with pain treatment methods in general. None of the occlusal adjustment studies provided evidence supporting the use of this treatment method. The clinical implications of the findings and future perspectives are discussed. J OROFAC PAIN 2004;18:9–22.

Key words: dentistry, evidence-based medicine, occlusal adjustment, occlusal splints, randomized controlled trials, temporomandibular disorders

The term *evidence-based medicine* (EBM) refers to the systematic, explicit, and judicious use of best evidence in patient care. In practice, EBM means the integration of individual clinical expertise with the best available evidence, moderated by patient circumstances and preferences.[1,2] The goal is obvious: EBM aims to improve patient care. The efficacy and cost-effectiveness of health services are also in the best interest of patients, as well as insurance companies, governments, and others controlling payment plans.[3]

I. Strong evidence from at least 1 systematic review of multiple well-designed RCTs
II. Strong evidence from at least 1 properly designed RCT of appropriate size
III. Evidence from well-designed trials without randomization, single group pre-post headwork, cohort, time series, or matched case-control studies
IV. Evidence from well-designed nonexperimental studies from more than 1 center or research group
V. Opinions of respected authorities, based on clinical evidence, descriptive studies, or reports of expert committees

Fig 1 Type and strength of efficacy evidence (McQuay and Moore[4]).

Critical evaluation of treatment methods has become an important part of health care and will certainly have a major influence on decisions about acceptable treatment methods in the future. The positive effects of the practice of EBM can already be seen in many areas, such as pain treatment in general.[4] We believe that a systematic implementation of EBM could be particularly useful in the field of temporomandibular disorders (TMD), where a wide range of controversial and conflicting ideas concerning management exists and where concerns about lack of evidence are frequently expressed.[5–7]

The present article aims to elucidate and discuss the application of EBM in the most controversial treatment methods of TMD: occlusal treatments. By doing so, we hope to highlight some of the important issues bearing on improvements in the scientific standards of the treatment of TMD.

About EBM

The importance of developing an evidence-based approach to clinical care and treatment is emphasized frequently.[8,9] Traditionally, treatment plans in clinical practice have been based on a mixture of knowledge gained through training, practice traditions, and subjective perception of clinical experiences. This can result in highly varying treatments for the same condition, as well as ineffective, expensive, and sometimes even harmful interventions.[3,10] EBM aims to move beyond anecdotal clinical experience by bridging the gap between research and the practice of medicine and dentistry. The aim is to use an intervention that is as accurate, safe, and effective as possible.[11] The most reliable sources of evidence are high-quality systematic reviews and large randomized controlled trials (RCTs)[4] (Fig 1).

Why RCTs?

Uncontrolled clinical studies and case series can give preliminary evidence of the benefit of a treatment. However, the extent to which patient outcomes reflect nonspecific effects, the natural history of a disease, regression to the mean, or specific effects of treatment is unclear in the absence of RCTs.[12–14] Nonspecific or placebo effects, such as physician attention and patient expectations, influence patients to report improvement. Many pain conditions can have a favorable natural history, and they may resolve on their own irrespective of treatment. Patients with pain problems often have fluctuating symptoms, and they seek treatment when symptoms are at their worst. The tendency of extreme symptoms to return toward the individual's more typical state is known as *regression to the mean.*[12] All these effects can be substantial and explain many of the benefits attributed to treatment.

The RCT has become the gold standard for the assessment of treatment efficacy because of its potential ability to control bias.[15] Bias can be minimized by randomization, blinding, description of dropouts, and the use of appropriate control groups. Random allocation of treatments is of crucial importance. If trials are not randomized, estimates of treatment effect may be exaggerated by up to 40%.[16]

In practice, the quality and validity of published RCTs can show considerable variation.[17] Different types of quality and validity scales can be used to assess these.[18–21] Rigorous studies should be given more weight, whereas flawed RCTs do not necessarily offer advantages over nonrandomized or cohort studies. Recently, consolidated standards for reporting trials have been published to improve the quality of reporting of RCTs.[22]

Why Systematic Reviews?

Research evidence can be reviewed by either informal or systematic approaches. The informal approach is used by traditional narrative reviews. In these, the reviewers do not follow formal strategies to identify, extract, and summarize the research evidence.[19] They can easily be biased and present a "personal estimate" of the evidence by the reviewer.[17] Systematic reviews try to overcome the limitations of narrative reviews and be as objective and transparent as possible.[19] For a systematic review to be scientifically sound, reviewers must clearly describe the research question, the criteria for inclusion or exclusion of the primary studies, the techniques to assess the methodologic quality of

the studies included, and the methods used to extract and synthesize the results of the primary trials on which the conclusions are based.[23] It is often not possible or sensible to combine (pool) data; this results in a qualitative rather than a quantitative systematic review (meta-analysis).[17] Systematic reviews offer obvious advantages over traditional reviews for the synthesis of the available evidence.[19] However, one of the greatest benefits of systematic reviews is the lessons they teach about trial methodology. They provide a means for quality control over clinical trials and help clinicians to develop and apply better research methodology and to produce more reliable evidence.[17]

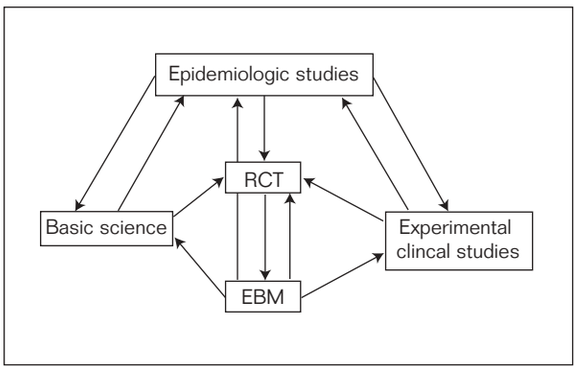

Fig 2 Algorithm showing how different methods of research complement each other.

EBM: One Part of Scientific Work

EBM should be seen as one part of scientific work. Its foundation is in the knowledge achieved through epidemiologic studies and through basic science and experimental studies. This knowledge is used to guide the questions asked in clinical patient care and tested in RCTs. The information obtained through EBM can, on the other hand, feed basic science, experimental, and epidemiologic studies (Fig 2).

EBM and Pain Treatment

Because of the subjective character of pain and the significant placebo effect of pain treatments, the need to pay attention to trial design was emphasized much earlier in pain research than in other areas of medicine. Up to 1994 there were more than 14,000 published RCTs of pain relief.[4] Most of these RCTs examined the pharmacotherapy of acute and chronic pain, where rigorous trial methodology is easiest to follow. Many other pain treatment methods have been tested in RCTs. In many cases, appropriate controls and problems with blinding may make these trials more challenging to perform.

Many statistical methods, such as odds ratios and relative risk, have been used to report treatment effects. The most "user-friendly" is the number needed to treat (NNT). It tells how many patients need to be treated with a particular treatment for 1 patient to achieve at least a 50% reduction in pain beyond what would have been achieved with a placebo. The following formula is used to calculate the NNT:

$$NNT = 1/(A_{improved}/A_{total}) - (C_{improved}/C_{total})$$

where A stands for active treatment and C for control treatment (placebo). NNT can be used to compare the relative effectiveness of different treatments across different studies, given that the treatment effect has been measured with the same outcome measures against the same comparator.[24]

Several meta-analyses have used this criterion for a range of treatments in pain. According to these, the best NNTs for at least 50% pain relief for analgesics in postoperative pain are about 2. NNTs for antidepressants in the treatment of neuropathic pain vary from 2.3 to 3.4. In general, NNTs of 2 to 4 indicate that a treatment is effective.[24]

TMD: Musculoskeletal Pain Conditions

The term *temporomandibular disorders* refers to a subclassification of musculoskeletal disorders affecting the masticatory muscles and/or the temporomandibular joint (TMJ). The most common presenting symptom is pain, which is usually aggravated by chewing or other jaw functions.[6] A separation of masticatory muscle pain disorders from TMJ disorders is currently advocated. The most frequently used classification subdivides TMD into muscle (myofascial) pain, internal derangements of the joint, and degenerative joint diseases.[25] Although the myalgia subtype is the most prevalent form, it is very usual for TMD patients to receive a combined diagnosis, with both muscle and joint problems. Masticatory muscle pain seems to partly overlap with other pain conditions, such as tension-type headache, neck pain, and fibromyalgia.[26]

The etiology and the pathophysiologic mechanisms of TMD, like those of other musculoskeletal pain problems, are so far poorly understood.[7,27,28] Earlier etiologic concepts based on a single factor, eg, prematurities in the occlusion, have lost scientific and clinical credibility.[27] According to the prevailing multifactorial etiologic concept, many initiating, predisposing, and perpetuating biomechanical, neuro-

muscular, and psychosocial factors are involved.[27] Intensive research on the pathophysiology underlying joint and muscle pain has characterized the last decade of the TMD field. Understanding of the mechanisms has increased, along with advances in the understanding of pain mechanisms in general.[29–31] Today, new treatment strategies are expected to arise from basic research rather than from clarification of etiologic concepts.[28,30,32]

TMD are considered the most common cause of nondental pain in the orofacial region. These conditions affect about 10% of women and 6% of men in any given year, giving a rough estimate of 450 million adults afflicted worldwide.[26] Annually, 1% to 3% of people seek professional help for the symptoms, thus making TMD a significant health care problem.

Although they are prevalent disorders, TMD seem to have a favorable course.[6,33–35] Longitudinal epidemiologic findings indicate substantial fluctuation of symptoms and signs. Progression to severe pain and dysfunction is very rare.[36] A minority, usually fewer than 20%, have either continued or increased pain.

Chronic TMD pain is similar to many other common pain problems, such as low back pain and headache, in terms of levels of pain intensity and interference and psychologic and psychosocial profiles.[37,38] Psychologic factors are also seen as the most important risk factors for chronicity.[26,39] Along with this, comprehensive diagnostic systems incorporating psychosocial, behavioral, and physical components of the TMD problem have become widely accepted.[40,41]

TMD Controversies

Treatment goals for patients with TMD include pain alleviation, decreased loading of the masticatory system, and restored function.[33] The methods used to achieve these goals can be highly variable, such as patient education and self-care, exercises, physical therapy, relaxation, biofeedback, cognitive-behavioral interventions, occlusal splints, occlusal adjustment, occlusal rehabilitation, orthodontics, pharmacotherapy including intra-articular injections, and TMJ surgery. All treatment approaches claim success, and the majority of patients are reported to improve.[33,34] It is well recognized, however, that we lack prospective studies that use appropriate outcome measures and controls to validate the results.[6,7,42]

Different treatments and the rationales behind them constitute one of the most controversial areas in the field of TMD. Perhaps the most conflicting of these is the role of occlusal factors.[6,43–47]

The interest in occlusal and other structural factors was started by Costen's hypothesis about the importance of these as etiologic factors in TMD.[48] Although the original hypothesis was later refuted, the occlusal-structural model of TMD causation has been extremely popular among dentists for decades. Along with the belief that unfavorable occlusal contacts can lead to neuromuscular disturbances and pain and dysfunction, occlusal treatments such as occlusal adjustment of the natural dentition or occlusal splints were recommended and widely used.[44] However, there is no universal agreement about which type of occlusal interferences are considered detrimental to function or about the best way to perform occlusal adjustment.[43,47] No consensus has been reached about the design and occlusal scheme of the splints or about whether the mechanism of action is related to occlusal or other factors.[34,49,50]

In recent years, the etiologic significance of occlusal factors has been increasingly questioned. Based on epidemiologic data and systematic studies, the relationship between these and TMD is considered weak or nonexistent.[33,34,42,47,51,52] In line with this, the strategy of occlusal treatments has been increasingly criticized.[34,45,53–55] In particular, the use of irreversible forms of occlusal treatments (such as occlusal adjustment) has been discouraged in recent guidelines and textbooks on TMD.[6,33,34,56]

However, all in the field do not agree.[43,46,57,58] According to the most frequently presented argument, the current empirical evidence is not sound enough to justify the rejection of the hypothesis about the etiologic importance of occlusal factors because of methodologic problems in the studies.[43,58] Furthermore, Kirveskari et al[59] showed in an RCT, in which young subjects underwent occlusal adjustment or mock adjustment over a period of 4 years, that the elimination of the presumed structural risk by real adjustment significantly decreased the incidence of TMD. With these results, they suggested that the discussion about occlusal factors and TMD should continue.

Despite the uncertainties in the field of TMD, some general guidelines are offered for management today. It is argued that TMD as a variant of musculoskeletal disorders should be considered as disorders that can be managed rather than cured.[7,34,56,60] Practice guidelines recommend reversible treatments, which should be tailored to individual symptoms and patient characteristics.[6,7,33,39,41] A unifying consensus seems to prevail as regards 1 important point in TMD therapy. Expert panels, new textbooks, and new curricula for TMD education all

emphasize that the treatments used should be evidence-based.[3,6,11,33,53,61] To avoid pure lip service here, the next logical question is: What is evidence-based treatment of TMD?

TMD and EBM

The actual starting point for discussion about TMD and evidence-based treatment was the report describing the epidemiology of research for TMD by Antczak-Bouckoms.[5] It was compiled to evaluate in broad terms the strength of evidence regarding TMD therapy. In this systematic search of literature published between 1980 and 1992, more than 4,000 references to TMD were found. Of these, about 1,200 examined therapy. Forty-one percent of the 1,200 references were classified as reviews, and only about 15% were clinical studies. Less than 5% (n = 51) were RCTs. The findings indicated that virtually all the evidence regarding therapy for TMD was likely to be subject to considerable bias. Concerns about the state of science in the field were expressed, and the importance of basing patient care decisions on evidence was emphasized. Later, the same concerns were expressed by many experts in the field.[14,28,44,53,62–64]

Despite the great interest in EBM and its possibilities to improve the treatment of TMD problems, systematic searches for evidence have been rare. Only a few systematic reviews of TMD treatments have been published.[65–70] In addition, in a recent systematic review of pharmacotherapy of facial pain, studies concerning drugs used to treat TMD pain were also analyzed.[71] The scarcity of systematic reviews at this point is somewhat surprising, given the important role they are thought to have in trying to create a comprehensive and unbiased picture about a particular clinical area.[19]

Systematic Review of RCTs of Occlusal Treatments

In the field of TMD, the question about evidence is especially intriguing when considering controversial, albeit widely used, methods such as occlusal treatments. To find out whether studies are in agreement with current clinical practices, we decided to conduct a systematic review of all relevant RCTs of occlusal treatments for TMD symptoms.[67] The review gave a qualitative overview of the evidence on these treatment methods. A quantitative review (ie, systematic pooling of results) was not possible because of the heterogeneity of the data. The research question, the search strategy to locate the studies, the criteria for inclusion and exclusion of primary studies, the techniques used to assess the methodologic quality of the studies included, and the methods used to extract and synthesize the results of the primary studies were carefully described to allow critical appraisal.

The objective of our systematic review was to evaluate the effectiveness of occlusal treatments (ie, occlusal splints and occlusal adjustment) for the symptoms of TMD. A study was included in the review if it was a randomized comparison of occlusal splint therapy or occlusal adjustment with placebo, no treatment, or some other intervention used to treat TMD symptoms in patients who sought treatment for these symptoms.

The search strategy for identification of studies included different database searches (MEDLINE, EMBASE, Cochrane, DARE) of literature published between 1966 and March 1999. This was complemented by extensive hand searching.

Each trial was read independently by the authors and scored with the use of the quality scale presented by Antczak et al,[18] with minor modifications. The scale evaluates both the quality of the study protocol and the presentation and analysis of the data. The scale assigns an arbitrarily defined set of weights to a list of items, the presence and correctness of which are assumed to reflect the quality of the research. If a study fulfills all the requirements, a score of 1.00 is given. The specific items and weight given to each of them are presented in Table 1.

In the review, a positive result was defined as a statistically significant difference, as reported by the authors, between occlusal splint therapy/occlusal adjustment and a control, in pain intensity, overall success rating, or any other outcome measure used in the studies. Finally, we reached consensus about the overall outcome of each trial and put emphasis on the results of the latest follow-up.

Twenty-eight RCTs of occlusal treatments were found. Eighteen studies met the inclusion criteria[72–91] (Table 2). Fourteen of the RCTs examined splint therapy and 4 examined occlusal adjustment. One study compared occlusal splint therapy to several types of control treatments.[73]

Based on simple vote counting, we summarized that splint therapy was found to be superior to 3 control treatments and comparable to 12 control treatments. Furthermore, splints were superior to a passive control in 4 studies and comparable to it in another 4 (Table 2). Occlusal adjustment was found to be equivalent to control treatment in 2

Table 1 Quality of Study Protocol, Data Analysis, and Presentation According to the Quality Scale of Antczak et al[18]

Items evaluated	Potential score
Selection description*	3
No. of patients seen and reasons for rejections	3
Definition of therapeutic regimen*	3
Follow-up schedule*	3
Test of adherence to treatment*	3
Blinding randomization*	10
Patient blind to treatment*	8
Observer blind to treatment*	8
Observer blind to results*	4
Testing randomization*	3
Testing blinding*	3
Stopping rules	3
Prior estimate of sample size*	3
Error measurements	3
Dates of the study	2
Results of randomization*	2
Major endpoints	4
Post beta estimate†	3
Confidence limits	3
Repeat measures	2
Timing of events	4
Regression/correlation analysis	2
Statistical analysis	4
Withdrawals*	4
Handling withdrawals	4
Side effects discussion	3

*Discussed further in text.
†An estimate of the probability of Type II error.

studies and inferior to control treatment in 1 study. It was equivalent to a passive control in 1 study (Table 2).

On the basis of our analysis, we concluded that RCTs seem to suggest that the use of occlusal splints may be of some benefit in the treatment of TMD, but the evidence is scarce. On the other hand, the few available studies do not provide evidence for the use of occlusal adjustment.

To update the information of the review, a literature search using the same search strategy as that in the published review was undertaken to cover the time interval from March 1999 to January 2003. The search provided 5 new RCTs of occlusal treatments for TMD.[92–96] Kuttila et al[94] studied the efficacy of an occlusal splint in a nonpatient population with secondary otalgia and TMD, and therefore the study did not meet our inclusion criteria. The trial by Minakuchi et al[92] was excluded from further analysis because patients were treated with other forms of therapy in addition to splint therapy, which precluded the assessment of the effects of occlusal splint therapy. The studies by Raphael and Marbach[93] and Ekberg et al[96] met our inclusion criteria and are included in the following evaluation (Table 2). The study by Raphael at al[95] was excluded, because it reported results of a group of patients that was part of the material presented in their earlier study.[93]

In the RCT by Raphael and Marbach,[93] 63 women meeting criteria for the myofascial subtype of TMD[25] were assigned to use either a flat-plane, hard acrylic splint or a palatal splint at night for 6 weeks. At the end of the study period, the groups were compared for pain, number of painful muscles, functional complaints, and psychologic measures (mood and depression). The treatment groups differed significantly after 6 weeks on only 1 of the 3 self-reported pain severity measures. The authors concluded that active splints were of modest value for patients with myofascial pain, but according to our estimate about the overall outcome of the result of the trial, there were no significant differences between the groups. Post hoc comparisons of study subjects with local versus widespread pain[93] indicated that patients with local pain who received the active splint experienced more improvement than the other patient groups.

In the study by Ekberg et al,[96] 60 patients suffering from myofascial pain were randomized to a stabilization splint or a palatal splint. The study design was similar to an earlier trial by the same authors.[86] After 10 weeks of treatment, there were significant differences between the groups in favor of the use of stabilization splints for the improvement of overall subjective symptoms, the prevalence of daily or constant pain, and the number of painful muscles. The overall result of the study was considered positive.

Occlusal Treatment Studies and EBM Rules: What Makes a Good RCT?

As discussed earlier, the methodologic quality of the trial dictates the credibility of the results. In the following, some of the most important methodologic aspects concerning the study protocol of a good RCT will be discussed. We assessed these under the headings of the quality scoring system by Antczak et al[18] (items marked with an asterisk in Table 1). The evaluation is based on the RCTs analyzed in our review, and it complements the remarks in the discussion section of our systematic review.[67] We focused particularly on the lessons that could be learned for future studies in this field.

Table 2 Details of RCTs on Use of Occlusal Splints and Occlusal Adjustment for Treatment of TMD

Study	Treatments	Outcome measures	Score	Overall efficacy*
Occlusal splints				
Dahlström et al[72]	Stabilization splint; biofeedback	Subjective rating of symptoms; Helkimo Clinical Index	0.32	> BL = Control treatment
Brooke and Stenn[73]	Stabilization splint; ultrasound; relaxation training + biofeedback; relaxation training	Successful outcome = symptom-free or only minor/a few symptoms	0.22	> 1 control treatment = 2 control treatments
Lundh et al[74]	Stabilization splint; anterior repositioning splint; control group	Reciprocal clicking; tenderness to muscle palpation	0.39	= Control treatment = Passive control
Rubinoff et al[75]	Stabilization splint; palatal splint	Pain diary; success rating; joint sounds; palpation score	0.60	> BL = Control treatment (placebo?)
Lundh et al[76]	Stabilization splint; occlusal onlays; control group	Pain VAS; clicking; tenderness to palpation	0.44	= Control treatment (< Control treatment regarding clinical signs) = Passive control
Monteiro and Clark[77]	Stabilization splint; movement feedback	TMD questionnaire	0.12	= Control treatment
Johansson et al[78]	Stabilization splint; acupuncture; control group	Pain VAS; improvement of subjective symptoms; Helkimo Clinical Index	0.44	> BL = Control treatment > Passive control
List et al[79] (List and Helkimo[80])	Stabilization splint; acupuncture; waiting list control	Pain VAS; subjective improvement; Helkimo Anamnestic Index; Helkimo Clinical Index; activity of daily living	0.47	> BL = Control treatment > Passive control
Lundh et al[81]	Stabilization splint; control group	Overall treatment results; 79 clinical variables	0.24	= Passive control
Turk et al[82]	Stabilization splint; biofeedback/ stress management; waiting list control	Pain severity scale; Muscle Pain Palpation Index; depression scales	0.42	> BL = Control treatment > Passive control
Dao et al[83]	Stabilization splint; stabilization splint (4 × 30 min = passive control); palatal splint	Pain VAS; pain unpleasantness VAS; quality of life	0.78	> BL = Control treatment (placebo?) = Passive control
Linde et al[84]	Stabilization splint; TENS	Positive responders; frequency of complaints; severity of complaints; symptom questionnaire; pain registration	0.44	= Control treatment
Wright et al[85]	Soft splint; palliative treatment (= self care); control group	Symptom Severity Index; pressure algometer score; maximum pain-free opening	0.62	> BL > Control treatment > Passive control
Ekberg et al[86]	Stabilization splint; palatal splint	Pain VAS; verbal pain rating; frequency of pain; overall change in subjective symptoms; tenderness to palpation of TMJ; Helkimo Clinical Index	0.71	> BL > Control treatment
Raphael and Marbach[93]	Stabilization splint; palatal splint	Pain VAS; no. of painful muscles; functional complaints; average mood scale; SCL-90 depression scale	0.62	> BL = Control treatment (placebo?)
Ekberg et al[96]	Stabilization splint; palatal splint	Pain VAS; verbal pain rating; frequency of pain; improvement of overall subjective symptoms; no. of painful muscles; Helkimo Clinical Index	0.71	> BL > Control treatment (placebo?)
Occlusal adjustment				
Werndahl et al[87]	Occlusal adjusment; muscle exercise	Subjective improvement	0.24	= Control treatment
Wenneberg et al[88]	Occlusal adjustment; different stomatognathic treatment methods	Subjective dysfunction score Clinical dysfunction score	0.40	> BL < Control treatment
Vallon et al[89] (Vallon et al[90])	Occlusal adjustment; control group	Pain VAS; overall changes in severity; clinical signs	0.57	> BL = Passive control
Tsolka et al[91]	Occlusal adjustment; mock occlusal adjustment	Prevalence of symptoms; Helkimo Anamnestic Index; Helkimo Clinical Index	0.36	= Control treatment (placebo)

*Reviewers' overall conclusion of efficacy when emphasis was put on results at the longest follow-up of each study. > results significantly better than; = results comparable to; < results significantly worse than.
Control treatment = any active control treatment; passive control = control group without any treatment or waiting list control, or stabilization splint used only 4 × 30 minutes (Dao et al[83]). BL = baseline; TENS = transcutaneous electrical nerve stimulation; pain VAS = pain visual analog scale; SCL-90 = symptom checklist 1990.

Selection Description

A detailed description of criteria for inclusion and exclusion is a minimum requirement for an RCT.[15] Except for a few studies,[77,81,91] most RCTs provided this information. The actual definitions of the patient samples varied, however. In 7 studies (including all studies of occlusal adjustment), the study population was described to consist of TMD (or alike) patients, and patients with muscle pain and different types of joint problems were placed into a single group. However, the distinct clinical entities that constitute TMD are likely to exhibit differences in treatment responses. Trials using more detailed case definitions would probably be more sensitive and give more clinically useful information. The Research Diagnostic Criteria for TMD (RDC/TMD) provide a systematic method of classifying the major subtypes of TMD along a physical disease axis (Axis I) through a standardized clinical examination.[25] In addition, the RDC/TMD allow classification of the subject's psychosocial status (Axis II) based on standardized psychometric instruments and include self-reports of pain intensity and pain-related disability. So far, this instrument has been used in only 1 RCT of occlusal treatments.[93] Its use in future trials would offer several advantages, including a common set of methods and terms and increased sensitivity to complex cases.[7]

TMD patients can also differ in terms of chronicity of their TMD pain, psychologic characteristics, and the presence or absence of widespread pain or concomitant bruxism. Possible differences in treatment responses based on these distinctions have so far not been tested in RCTs on occlusal treatments, except for spread of pain and severity of bruxism in the most recent trial.[93,95] Given the differing pathophysiologic mechanisms of acute and chronic pain, pain duration should receive more attention in future trials.

Definition of Therapeutic Regimen

The description of therapeutic procedures must be sufficiently detailed to allow comparison with other studies. This was usually accomplished in the RCTs of occlusal splints. In most studies, a flat-plane, hard acrylic splint adjusted to even out occlusal contacts and provide canine guidance was used. The issue seems to be much more complicated for occlusal adjustment procedures. The procedures performed varied from elimination of gross interferences to meticulous occlusal equilibration procedures consisting of four 60-minute treatment sessions.[87,88] Experts should agree about the way to perform the procedure so that credible RCTs on the subject may be instituted.[43,55]

Selection of the control treatment or condition is a complicated matter,[62,97] and ideal ways to handle this, especially in splint studies, have perhaps not yet been established.[62] Waiting list controls are used in some studies, but they do not rule out the placebo effect and can in fact include negative effects while reducing the expectation-fulfillment contamination.[62,97,98] The use of a placebo control group can balance the nonspecific effects in the treatment group and allow for independent assessment of the real treatment effect. The use of the palatal (nonoccluding) splint as a placebo condition in splint studies[99] can, however, result in unintended active treatment components, eg, by increasing cognitive awareness of oral habits[49,50] or changing muscle function.[100] They can thus overcontrol for the active ingredient of stabilization splint therapy.[14,62,63]

An obvious problem with the use of active control treatments in RCTs of occlusal treatments is that the efficacy of most of them is not known. While many RCTs indicated that occlusal splints were as effective as the control treatment, it remains unclear whether treatments were indistinguishable from each other because they were equally effective or because they were equally ineffective. For the time being, only placebo controls or inactive (waiting list) controls are justified.

Follow-up Schedule

Trials should be sensitive to the long-term outcomes. This was demonstrated clearly in our systematic review, where studies with longer follow-ups generally did not show favorable treatment results, despite good short-term results in some of them.[82,89,90]

Test of Adherence to Treatment

Future splint studies should pay attention to monitoring patient compliance with given instructions about splint use. In the published studies, this was assessed only seldom.[82,83,93] The same applies to the use of concomitant treatments. Only 3 RCTs clearly stated that no other pain treatments were allowed or performed during the trials,[83,84,86] or that the study groups did not differ on the use of cointerventions.[93] Two RCTs did not report on dropouts or loss to follow-up.[73,77] The number of dropouts in the RCTs was usually fewer than 10%, which is considered acceptable.[18] Systematic

reporting of protocol violations in RCTs allows more precise estimates of bias and of the generalizability of the findings.[101]

Randomization

Detailed instructions about acceptable ways to perform randomization are provided in several textbooks.[8,15] Randomization should be concealed so that it eliminates any influence of the investigators on the allocation of the interventions. Properly performed randomization is considered crucially important in trial design.[102] Trials that use inadequate or unclear allocation concealment tend to overestimate the effect of treatment and can yield up to 40% larger estimates of effect in comparison to studies that use adequate allocation concealment.[16] Surprisingly, the procedure of randomization was described in only 2 studies.[86,96]

Although randomization eliminates systematic bias, it does not necessarily produce perfectly balanced study groups with respect to prognostic factors. This was the case in 3 studies, where random assignment had failed to equate the study groups with respect to pretreatment symptoms.[75,79,91] The unbalanced randomization was not taken into consideration in 2 of them during the analysis of data.[75,91] Furthermore, 3 studies did not report the results of randomization.[73,77,81]

Blinding

Nine RCTs used blinding (single- or double-blind procedures), and the rest were open studies. Unfortunately, the fulfillment of the blinding procedures was not mentioned in any of the studies. Open trials always involve a risk of bias. This is a concern, especially in studies that use subjective measurements, such as pain scores, as outcome measures.[4,103] Double-blinding may not always be possible, but there should never be objections to blinding the investigator who assesses the treatment results.[15,103] However, the importance of blinding as a source of bias is considered somewhat less important than that of adequate allocation concealment. The lack of double blinding is reported to overestimate treatment effects by roughly 17%.[16]

Prior Estimate of Sample Size

The number of patients per study group was less than 15 in 7 of the RCTs. Reliable findings are considered unlikely in trials with inadequate group sizes.[104] Group sizes that are large enough to produce statistical significance should be chosen through power calculations. For pain studies, the usual size is 30 to 40 patients for a 30% difference between active treatment and placebo to become apparent.[4] Power and sample size calculations for clinical trials of myofascial pain of the jaw muscles are described by Dao et al.[105]

While the size of the sample population depends in part on the outcome measures of the study,[60] the primary outcome measure should be chosen at the outset of the study. Furthermore, the determination of the primary outcome measure beforehand is in general considered an important part of good trial methodology.[22] So far the methods to measure treatment success have varied, and for many outcomes used, there is no evidence about their reliability and validity.[60,106] The use of standardized outcome measures and reporting of data would enable pooling and comparison of different studies.

Most of the RCTs published after 1990 used visual analog scales (VAS) to measure pain. VAS are in general widely used in all types of pain studies[4] and have been shown to be a valid tool.[107] As a general rule, it is required that treatments improve outcomes that are important to patients.[108] The use of pain relief as the primary outcome measure in trials on TMD treatment makes sense, since pain is the cardinal symptom of TMD and the main reason to seek treatment.[105,109] Secondary outcomes should also take into account the multidimensional nature of TMD as a pain problem, and cost-effectiveness of the methods should be evaluated. Possible adverse effects connected with occlusal treatments have so far received very little attention.[76,84,85,88] All these outcomes are essential for clinicians and patients to make informed treatment decisions where the probability of benefit is weighed against the costs and possible adverse effects.

Is There Evidence of Efficacy for Occlusal Treatments?

The process of drawing conclusions about the efficacy of a particular treatment on the basis of the results of a qualitative systematic review is not easy. As described earlier, simple vote counting of the results of the RCTs of occlusal splints that were included in our systematic review yielded equivocal findings, and we were not able to draw firm conclusions. On the basis of our analysis, however, we did suggest that the use of occlusal splints might be beneficial. Unfortunately, the results of the 2 newest studies could not give the final answer on the efficacy of splint therapy. In the following, the process of analyzing the results

that led us to these conclusions is described in more detail.

A simple vote-counting procedure, in which the number of negative studies versus the number of positive studies is counted, ignores the possibility that this estimate may be invalid, eg, qualitatively weak studies may be given the same weight as high-quality studies. Previous studies have indicated that trials with lower quality may be more likely to report positive results.[17] Thus, the quality scores can be of assistance when drawing conclusions. No such trend, however, was found concerning studies included in our systematic review.

Obviously, studies with adequate/good quality should be given more weight.[17] If an arbitrary cut-off point of 0.50 for the quality score[18] is used, we are left with 5 stabilization splint studies[75,83,86,93,96] and 1 soft splint study.[85] The outcomes of the stabilization splint studies indicated that stabilization splint therapy is either statistically superior to palatal splint therapy[86,96] or that it is equivalent to palatal splint therapy.[75,83,93] The methodologically strongest studies came to different conclusions.[83,86,96] These studies differed from each other in the use of outcome measures and the analysis of the results. Dao et al[83] presented continuous data on pain intensity and unpleasantness and quality of life. The overall pattern of group differences was analyzed from baseline through the 8 weeks of follow-up to assess the effects of the treatment over time. This type of measurement best reflects the true changes in symptoms. Ekberg et al[86,96] used a different set of outcomes, and in statistical testing, time-by-time comparisons of dichotomous variables at baseline and end of the study were made. Some of the comparisons yielded statistically significant differences between the study groups.

In 4 of these RCTs the patients suffered mainly from a myofascial type of TMD pain,[75,83,93,96] and in 1 study the patients suffered mainly joint pain.[86] Thus we conclude that even in the most studied area—stabilization splint therapy for myofascial face pain—the results do not justify definitive conclusions about the efficacy of this therapy.

So far, we have discussed the statistical efficacy of splint therapy. What could be the clinical importance of the results presented? We can try to estimate this in several ways. First, a closer look at the changes in pain intensity over time in the studies by Dao et al[83] and Raphael and Marbach[93] indicates that the actual differences in VAS pain intensities between stabilization splints and palatal splints were marginal—about 1 or less on a 10-unit scale. In pain treatment studies, the NNT value is often used to give an impression about the clinical efficacy of the treatment methods, as described earlier. Unfortunately, most of the RCTs on occlusal splints did not provide data that made the calculation of these values possible. To give an example of the use of NNT in TMD splint studies, the NNT for 50% reduction of worst pain with stabilization splint versus palatal splint was calculated for the studies by Ekberg et al,[86,96] who reported the most positive outcomes among the high-quality studies. The calculated NNT values were 6 for TMD patients suffering from joint pain[86] and 4.3 for patients with TMD of mainly myogenous origin.[96] Thus, about 4 to 6 patients are needed for 1 more patient to receive a 50% reduction in worst pain with a stabilization splint compared to a palatal splint. Thus, compared with pain treatment methods in general, the therapeutic value of splints seems only modest, and the differences between stabilization splints and palatal splints seem to be clinically unimportant. The possibility that palatal splints pose active treatment ingredients, as discussed earlier, needs to be taken into account here. It might be interesting to note that the best NNT values for more than 50% pain relief in TMD for drugs versus placebo were calculated to be 2.7 and 3.5.[71]

None of the 4 RCTs of occlusal adjustment provided evidence for the use of this treatment method. The performed RCTs were mainly of low quality, and only the study by Vallon et al[89,90] had a quality score over 0.50. In that study, occlusal adjustment was compared to passive control (counseling only). Despite some short-term benefits, occlusal adjustment had little or no effect in the long-term perspective.

Clinical Implications and Future Perspectives

Does the widespread use of oral splints need to be re-evaluated because of the lack of clear evidence of their efficacy? The same question has been presented in other critical reviews about splint therapy, but the answers have varied. Marbach and Raphael[63] suggested that appliances should not be recommended for musculoskeletal facial pain because of a lack of evidence of their long-term efficacy. Dao and Lavigne[50] and Feine et al[60] had another view. Their arguments were based on a further analysis of the results of the RCT by Dao et al,[83] where additional data of perceived pain relief were added to compare these to true pain relief (efficacy).[60] Patients who had worn either the

stabilization splint or palatal splint reported significantly more pain relief than those in the passive control group. Because of the data to support the effectiveness, though not the efficacy, of oral splints they recommended that splints can be used as an adjunct to pain management. Although final answers to the question about the efficacy of splint therapy cannot be given at the moment, the latest studies have provided some further support for their use. The recommendation may still remain valid until the question is solved through new high-quality RCTs, or until evidence for other more effective and less costly therapies has appeared, as also suggested by Raphael et al.[95]

Since there is no evidence for the efficacy of occlusal adjustment in TMD, its use cannot be recommended. This conclusion is in line with that made in the recent reviews by Koh and Robinson[70] and Tsukiyama et al[55] and follows the recommendations made by several experts in the field.[6,33,34,56] The small number and the poor quality of most of the published RCTs do not, however, allow definite conclusions, because lack of evidence cannot be interpreted as evidence of lack of effect. If the principles of EBM are to be followed, good-quality RCTs are necessary to provide the answers and to solve the discrepancy in opinions.

We have focused here on the occlusal methods among the many treatments for TMD. On the whole, compared to the impression gained through uncontrolled studies that reported high success rates, the role of occlusal treatments as a treatment of choice for TMD problems changes radically when it is evaluated critically with the rules of EBM. It is clear that more research is needed before their final role in the treatment of TMD can be understood.

The principles of evidence and the rules about how to perform a good RCT are the same for all methods of treatment of TMD, and obviously all of them should be assessed with the same rigor as occlusal treatments. All relevant treatment methods should be assessed and tested, including all those that are widely used today. Effort should also be focused on pharmacotherapy, which is an underinvestigated area within the TMD field.

We firmly believe that acceptance of criteria for evidence-based clinical practices and a strong emphasis on performance of RCTs with good trial methodology would help to clarify many uncertainties and controversial issues in the TMD field, as has been done in many other areas of medicine. It would be exciting to consider the consequences of reversing the ratio between published review articles and original RCTs on the treatment of TMD during the next decade.[5] One can only speculate what difference it would make in our understanding about the high-quality care of TMD patients. However, EBM alone will not change the world. Innovative basic science, experimental clinical studies, and epidemiologic studies form the basis for the practice of EBM. The high standard of science in many areas of TMD studies should encourage all those who are working in the field to use the potential of EBM to move TMD treatment to a new level of scientific rigor.

References

1. Li Wan Po A. Dictionary of Evidence-Based Medicine. Oxon, United Kingdom: Radcliffe Medical Press, 1998.
2. Kalso E. Five easy pieces on evidence-based medicine (1). Eur J Pain 2000;4:217–219.
3. Feine JS. Evidence-based pain management. In: Lund JP, Lavigne GJ, Dubner R, Sessle BJ (eds). Orofacial Pain: From Basic Science to Clinical Management. Chicago: Quintessence, 2001:183–191.
4. McQuay HJ, Moore RA. An Evidence-Based Resource for Pain Relief. Oxford: Oxford University Press, 1998.
5. Antczak-Bouckoms AA. Epidemiology of research for temporomandibular disorders. J Orofac Pain 1995;9: 226–234.
6. Management of temporomandibular disorders. National Institutes of Health Technology Assessment Conference Statement. J Am Dent Assoc 1996;127(11):1595–1606.
7. Stohler CS, Zarb GA. On the management of temporomandibular disorders: A plea for a low-tech, high-prudence therapeutic approach. J Orofac Pain 1999;13: 255–261.
8. Sackett DL, Straus SE, Richardson WS, Rosenberg W, Haynes RB. Evidence-Based Medicine: How to Practise and Teach EBM, ed 2. Edinburgh: Churchill Livingstone, 2000.
9. Muir Grey JA. Evidence-Based Healthcare, ed 2. Edinburgh: Churchill Livingstone, 2001.
10. Niederman R, Badovinac R. Tradition-based dental care and evidence-based dental care. J Dent Res 1999; 78:1288–1291.
11. Zakrzewska JM, Harrison SD (eds). Pain Research and Clinical Management. Vol 14: Assessment and management of orofacial pain. Amsterdam: Elsevier, 2002.
12. Whitney CW, Von Korff M. Regression to the mean in treated versus untreated chronic pain. Pain 1992;50: 281–285.
13. Turner JA, Deyo RA, Loeser JD, Von Korff M, Fordyce WE. The importance of placebo effects in pain treatment and research. JAMA 1994;271:1609–1614.
14. Schiffman EL. The role of the randomized clinical trial in evaluating management strategies for temporomandibular disorders. In: Fricton JR, Dubner RB (eds). Orofacial Pain and Temporomandibular Disorders. New York: Raven Press, 1995: 415–463.
15. Wulff HR, Gotzsche PC. The randomized clinical trial. In: Wulff HR, Gotzsche PC (eds). Rational Diagnosis and Treatment. Evidence-Based Clinical Decision-Making, ed 3. Oxford: Blackwell Science, 2000:117–146.

16. Schulz KF, Chalmers I, Hayes RJ, Altman DG. Empirical evidence of bias: Dimensions of methodological quality associated with estimates of treatment effects in controlled trials. JAMA 1995;273:408–412.
17. Kalso E, Edwards J, McQuay HJ, Moore RA. Five easy pieces on evidence based medicine (4). Eur J Pain 2002; 6:89–93.
18. Antczak AA, Tang J, Chalmers TC. Quality assessment of randomized control trials in dental research. I. Methods. J Periodontal Res 1986;21:305–314.
19. Jadad AR. Systematic reviews and meta-analyses in pain relief research: What can (and cannot) they do for us? In: Campbell JN (ed). Pain 1996: An Updated Review. Seattle: IASP Press, 1996:445–452.
20. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: Is blinding necessary? Control Clin Trials 1996;17:1–12.
21. Smith LA, Oldman AD, McQuay HJ, Moore RA. Teasing apart quality and validity in systematic reviews: An example from acupuncture trials in chronic neck and back pain. Pain 2000;86:119–132.
22. Moher D, Schulz KF, Altman DG, Lepage L. The CONSORT statement: Revised recommendations for improving the quality of reports of parallel-group randomized trials. Lancet 2001;357:1191–1194.
23. Oxman AD, Guyatt GH. Guidelines for reading literature reviews. Can Med Assoc J 1988;138:697–703.
24. Kalso E, Edwards J, McQuay HJ, Moore RA. Five easy pieces on evidence-based medicine (3). Eur J Pain 2001; 5:227–230.
25. Dworkin SF, LeResche L. Research Diagnostic Criteria for Temporomandibular Disorders: Review, Criteria, Examinations and Specifications, Critique. J Craniomandib Disord Facial Oral Pain 1992;6:301–355.
26. Drangsholt M, LeResche L. Temporomandibular disorder pain. In: Crombie IK (ed). Epidemiology of Pain. Seattle: IASP Press, 1999:203–233.
27. DeBoever JA, Carlsson GE. Etiology and differential diagnosis. In: Zarb GA, Carlsson GE, Sessle BJ, Mohl ND (eds). Temporomandibular Joint and Masticatory Muscle Disorders. Copenhagen: Munksgaard, 1994:171–187.
28. Greene CS. The etiology of temporomandibular disorders: Implications for treatment. J Orofac Pain 2001;15: 93–105.
29. Ren K, Dubner R. Central nervous system plasticity and persistent pain. J Orofac Pain 1999;13:155–163.
30. Sessle BJ. The neural basis of temporomandibular joint and masticatory muscle pain. J Orofac Pain 1999;13: 238–245.
31. Stohler CS. Muscle-related temporomandibular disorders. J Orofac Pain 1999;13:273–284.
32. Stohler CS. Craniofacial pain and motor function: Pathogenesis, clinical correlates, and implications. Crit Rev Oral Biol Med 1999;10:504–518.
33. American Academy of Orofacial Pain. Okeson JP (ed). Orofacial Pain. Guidelines for Assessment, Diagnosis, and Management. Chicago: Quintessence, 1997.
34. Zarb GA, Carlsson GE, Rugh JD. Clinical management. In: Zarb GA, Carlsson GE, Sessle BJ, Mohl ND (eds). Temporomandibular Joint and Masticatory Muscle Disorders. Copenhagen: Munkgaard, 1994:529–548.
35. Stegenga B. Osteoarthritis of the temporomandibular joint organ and its relationship to disc displacement. J Orofac Pain 2001;15:193–205.
36. Magnusson T, Egermark I, Carlsson GE. A longitudinal epidemiologic study of signs and symptoms of temporomandibular disorders from 15 to 35 years of age. J Orofac Pain 2000;14:310–319.
37. Rudy TE, Turk DC, Zaki HS, Curtin HD. An empirical taxometric alternative to traditional classification of temporomandibular disorders. Pain 1989;36:311–320.
38. Von Korff MR, Ormel J, Keefe FJ, Dworkin SF. Grading severity of chronic pain. Pain 1992;50:133–149.
39. Dworkin SF. Behavioral and educational modalities. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83: 123–133.
40. Dworkin SF, Sherman J, Manc L, Ohrbach R, LeResche L, Truelove E. Reliablity, validity and clinical utility of RDC/TMD Axis II scales: Depression, non-specific physical symptoms and graded chronic pain. J Orofac Pain 2002;16:207–220.
41. Turk DC. Psychosocial and behavioral assessment of patients with temporomandibular disorders: Diagnostic and treatment implications. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83:65–71.
42. Mohl ND, Ohrbach R. The dilemma of scientific knowledge versus clinical management of temporomandibular disorders. J Prosthet Dent 1992;67:113–120.
43. Kirveskari P. The role of occlusal adjustment in the management of temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83:87–90.
44. McNeill C. History and evolution of TMD concepts. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83: 51–60.
45. Stohler CS. Phenomenology, epidemiology, and natural progression of the muscular temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997:83:77–81.
46. Dawson PE. Position paper regarding diagnosis, management, and treatment of temporomandibular disorders. J Prosthet Dent 1999;81:174–178.
47. De Boever JA, Carlsson GE, Klineberg IJ. Need for occlusal therapy and prosthodontic treatment in the management of temporomandibular disorders. Part I. Occlusal interferences and occlusal adjustment. J Oral Rehabil 2000;27:367–379.
48. Costen JB. A syndrome of ear and sinus symptoms dependent upon disturbed function of the temporomandibular joint. Ann Otol Rhinol Laryngol 1934;43:1–15.
49. Clark GT. Interocclusal appliance therapy. In: Mohl ND, Zarb GA, Carlsson GE, Rugh JD (eds). A Textbook of Occlusion. Chicago: Quintessence, 1988:271–284.
50. Dao TTT, Lavigne GJ. Oral splints: The crutches for temporomandibular disorders and bruxism? Crit Rev Oral Biol Med 1998;9:345–361.
51. Seligman DA, Pullinger AG. Association of occlusal variables among refined TM patient diagnostic groups. J Craniomandib Disord Facial Oral Pain 1989;3:227–236.
52. Clark GT, Tsukiyama Y, Baba K, Watanabe T. Sixty-eight years of experimental occlusal interference studies: What have we learned? J Prosthet Dent 1999;82:704–713.
53. Mohl ND. The anecdotal tradition and the need for evidence-based care for temporomandibular disorders. J Orofac Pain 1999;13:227–231.
54. Greene CS, Laskin DM.Temporomandibular disorders: Moving from a dentally based to a medically based model. J Dent Res 2000;79:1736–1739.

55. Tsukiyama Y, Kazuyoshi B, Clark GT. An evidence-based assessment of occlusal adjustment as a treatment for temporomandibular disorders. J Prosthet Dent 2001;86: 57–66.
56. Carlsson GE, Magnusson T. Management of Temporomandibular Disorders in the General Dental Practice. Chicago: Quintessence, 1999.
57. Ash MM. Paradigmatic shifts in occlusion and temporomandibular disorders. J Oral Rehabil 2001;28:1–13.
58. Alanen P. Occlusion and temporomandibular disorders (TMD): Still unsolved question? J Dent Res 2002;81: 518–519.
59. Kirveskari P, Jämsä T, Alanen P. Occlusal adjustment and the incidence of demand for temporomandibular disorder treatment. J Prosthet Dent 1998;79:433–438.
60. Feine JS, Lavigne GJ, Lund JP. Assessment of treatment efficacy for chronic orofacial pain. In: Morimoto T, Masuya T, Takada K (eds). Brain and Oral Functions. Amsterdam: Elsevier, 1995:257–262.
61. Mohl ND, Attanasio R. The Third Educational Conference to Develop the Curriculum in Temporomandibular Disorders and Orofacial Pain: Introduction. J Orofac Pain 2002;16:173–175.
62. Marbach JJ, Raphael KG. Treatment of orofacial pain using evidence-based medicine: The case for intraoral appliances. In: Campbell JN (ed). Pain 1996: An Updated Review. Seattle: IASP Press, 1996:413–422.
63. Marbach JJ, Raphael KG. Future directions in the treatment of chronic musculoskeletal facial pain: The role of evidence-based care. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;83:170–176.
64. Carlsson GE. Epidemiology and treatment need for temporomandibular disorders. J Orofac Pain 1999;13: 232–237.
65. Crider AB, Glaros AG. A meta-analysis of EMG biofeedback treatment of temporomandibular disorders. J Orofac Pain 1999;13:29–37.
66. Ernst E, White AR. Acupuncture as a treatment for temporomandibular joint dysfunction: A systematic review of randomised trials. Arch Otolaryngol Head Neck Surg 1997;125:269–272.
67. Forssell H, Kalso E, Koskela P, Vehmanen R, Puukka P, Alanen P. Occlusal treatments in temporomandibular disorders: A qualitative systematic review of randomized controlled trials. Pain 1999;83:549–560.
68. Kropmans TJ, Dijkstra PU, Stegenga B, De Bont LG. Therapeutic outcome assessment in permanent temporomandibular joint disc displacement. J Oral Rehabil 1999; 26:357–363.
69. Rosted P. Practical recommendations for the use of acupuncture in the treatment of temporomandibular disorders based on the outcome of published controlled studies. Oral Dis 2001;7:109–115.
70. Koh H, Robinson PG. Occlusal adjustment for treating and preventing temporomandibular joint disorders (Cochrane review). In: The Cochrane Library 2003 Issue 1. Oxford: Update Software.
71. Sommer C. Pharmakologische Behandlung orofazialer Schmerzen. Schmerz 2002;16:381–388.
72. Dahlström L, Carlsson GE, Carlsson SG. Comparison of effects of electromyographic biofeedback and occlusal splint therapy on mandibular dysfunction. Scand J Dent Res 1982;90:151–156.
73. Brooke RI, Stenn PG. Myofascial pain dysfunction syndrome: How effective is biofeedback-assisted relaxation training? In: Bonica JJ, Iggo A, Lindblom U, et al (eds). Advances in Pain Research and Therapy. Vol 5: Proceedings of the Third World Congress on Pain. New York: Raven Press, 1983:809–812.
74. Lundh H, Westesson P-L, Kopp S, Tillström B. Anterior repositioning splint in the treatment of temporomandibular joints with reciprocal clicking: Comparison with a flat occlusal splint and untreated control group. Oral Surg Oral Med Oral Pathol 1985;60:131–136.
75. Rubinoff MS, Gross A, McCall WD. Conventional and nonoccluding splint therapy compared for patients with myofascial pain dysfunction syndrome. Gen Dent 1987; 35:502–506.
76. Lundh H, Westesson P-L, Jisander S, Eriksson L. Disk-repositioning onlays in the treatment of temporomandibular joint disk displacement: Comparison with a flat occlusal splint and with no treatment. Oral Surg Oral Med Oral Pathol 1988;66:155–162.
77. Monteiro AA, Clark GT. Mandibular movement feedback vs occlusal appliances in the treatment of masticatory muscle dysfunction. J Craniomandib Disord Facial Oral Pain 1988;2:41–47.
78. Johansson A, Wenneberg B, Wagersten C, Haraldson T. Acupuncture in the treatment of facial muscular pain. Acta Odontol Scand 1991;49:153–158.
79. List T, Helkimo M, Andersson S, Carlsson GE. Acupuncture and occlusal splint therapy in the treatment of craniomandibular disorders. Part I. A comparative study. Swed Dent J 1992;16:125–141.
80. List T, Helkimo M. Acupuncture and occlusal splint therapy in the treatment of craniomandibular disorders. II. A 1-year follow-up study. Acta Odontol Scand 1992;50: 375–385.
81. Lundh H, Westesson P-L, Eriksson L, Brooks SL. Temporomandibular joint disk displacement without reduction. Treatment with flat occlusal splint versus no treatment. Oral Surg Oral Med Oral Pathol 1992;73:655–658.
82. Turk DC, Zaki HS, Rudy TE. Effects of intraoral appliance and biofeedback/stress management alone and in combination in treating pain and depression in patients with temporomandibular disorders. J Prosthet Dent 1993;70:158–164.
83. Dao TTT, Lavigne GJ, Charbonneau A, Feine JS, Lund JP. The efficacy of oral splints in the treatment of myofascial pain of the jaw muscles: A controlled clinical trial. Pain 1994;56:85–94.
84. Linde C, Isacsson G, Jonsson BG. Outcome of 6-week treatment with transcutaneous electric nerve stimulation compared with splint on symptomatic temporomandibular joint disk displacement without reduction. Acta Odontol Scand 1995;53:92–98.
85. Wright E, Anderson G, Schulte J. A randomized clinical trial of intraoral soft splint and palliative treatment for masticatory muscle pain. J Orofac Pain 1995;9:192–199.
86. Ekberg EC, Vallon D, Nilner M. Occlusal appliance therapy in patients with temporomandibular disorders. A double-blind controlled study in a short-term perspective. Acta Odontol Scand 1998;56:122–128.
87. Werndahl L, Seeman L, Carlsson GE. Bettslipning - rörelsebehandling. En jämförande studie av två behandlingsmetoder för patienter med käkledsbesvär. Tandläkartidningen 1971;3:560–565.

88. Wenneberg B, Nystrom T, Carlsson, GE. Occlusal equilibration and other stomatognathic treatment in patients with mandibular dysfunction and headache. J Prosthet Dent 1988;59:478–483.
89. Vallon D, Ekberg EC, Nilner M, Kopp S. Short-term effect of occlusal adjustment on craniomandibular disorders including headaches. Acta Odontol Scand 1991;49:89–96.
90. Vallon D, Ekberg EC, Nilner M, Kopp S. Occlusal adjustment in patients with craniomandibular disorders including headaches. A 3- and 6-month follow-up. Acta Odontol Scand 1995;53:55–59.
91. Tsolka P, Morris RW, Preiskel HW. Occlusal adjustment therapy for craniomandibular disorders: A clinical assessment by a double-blind method. J Prosthet Dent 1992;68: 957–964.
92. Minakuchi H, Kuboki T, Matsuka Y, Maekawa K, Yatani H, Yamashita A. Randomized controlled evaluation of non-surgical treatments for temporomandibular joint anterior disk displacement without reduction. J Dent Res 2001;80:924–928.
93. Raphael KG, Marbach JJ. Widespread pain and the effectiveness of oral splints in myofascial face pain. J Am Dent Assoc 2001;132:305–316.
94. Kuttila M, Le Bell Y, Savolainen-Niemi E, Kuttila S, Alanen P. Efficacy of occlusal appliance therapy in secondary otalgia and temporomandibular disorders. Acta Odontol Scand 2002;60:248–254.
95. Raphael KG, Marbach JJ, Klausner JJ, Teaford MF, Fischoff DK. Is bruxism severity a predictor of oral splint efficacy in patients with myofascial pain? J Oral Rehabil 2003;30:17–29.
96. Ekberg EC, Vallon D, Nilner M. The efficacy of appliance therapy in patients with temporomandibular disorders of mainly myogenous origin. A randomized, controlled, short-term trial. J Orofac Pain 2003;17:133–139.
97. Kreiner M, Betancor E, Clark GT. Occlusal stabilization appliances. Evidence of their efficacy. J Am Dent Assoc 2001;132:770–777.
98. Kalso E, Moore RA. Five easy pieces on evidence-based medicine (2). Eur J Pain 2000;4:321–324.
99. Greene CS, Laskin DM. Splint therapy for the myofascial pain-dysfunction (MPD) syndrome. A comparative study. J Am Dent Assoc 1971;84:624–628.
100. Minagi S, Okomoto M, Shimamura M, Sato T. Palatal plate of different designs for the suppression of masseter muscle activity during sleep. A challenge to the concept of placebo splint. J Oral Rehabil 2002;29:882–883.
101. Whitney CW, Dworkin SF. Practical implications of noncompliance in randomized clinical trials for temporomandibular disorders. J Orofac Pain 1997;11:130–138.
102. Schulz KF, Grimes DA. Allocation concealment in randomized trials: Defending against deciphering. Lancet 2002;359:614–618.
103. Schulz KF, Grimes DA. Epidemiology series: Blinding in randomized trials. Hiding who got what. Lancet 2002; 359:696–700.
104. Moore RA, Gavaghan D, Tramer MR, Collins SL, McQuay HJ. Size is everything—Large amounts of information are needed to overcome random effects in estimating direction and magnitude of treatment effects. Pain 1998;78:209–216.
105. Dao TTT, Lavigne GJ, Feine JS, Tanguay R, Lund JP. Power and sample size calculations for clinical trials of myofascial pain of jaw muscles. J Dent Res 1991;70: 118–122.
106. Dworkin SF, LeResche L, DeRouen T. Reliability of clinical measurement in temporomandibular disorders. Clin J Pain 1988;4:89–99.
107. Price DD, McGrath PA, Rafii A, Buckingham B. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain 1983;17:45–56.
108. Guyatt GH, Sackett DL, Cook DJ. Users' guides to the medical literature. II. How to use an article about therapy or prevention. B. What are the results and will they help me in caring for my patients? JAMA 1994;271:59–63.
109. Dworkin SF. Behavioral characteristics of chronic temporomandibular disorders: Diagnosis and assessment. In: Sessle BJ, Bryant PS, Dionne RA (eds). Progress in Pain Research and Management. Vol 4: Temporomandibular disorders and related pain conditions. Seattle: IASP Press, 1995:175–192.

CRITICAL COMMENTARY 1

APPLICATION OF PRINCIPLES OF EVIDENCE-BASED MEDICINE TO OCCLUSAL TREATMENTS FOR TEMPOROMANDIBULAR DISORDERS: ARE THERE LESSONS TO BE LEARNED?

Glenn Clark, DDS, MS
Director
Center for Orofacial Pain and Oral Medicine
Professor of Diagnostic Sciences
USC School of Dentistry
925 West 43th Street (Rm B-14)
Los Angeles, California 90089
E-mail: gtc@usc.edu

The focus article[1] performs an admirable review of the literature on occlusal-based treatments for temporomandibular disorders (TMD). The noteworthy accomplishment of this article is that the method used by the authors to select only high-quality articles for review is fully described, logical, and appropriate. Specifically, they were looking for evidence-based articles that had reasonable quality with regard to experimental design and objective research outcomes. Another noteworthy feature is that the authors include good descriptions of how some of the control therapies, which are usually presumed to be nonactive therapies, might be able to produce an active therapeutic result. For example, they note that palatal splints have been used as a control or nonactive treatment, but this method may instead be an active device that is fully able to influence and reduce jaw muscle hyperactivity. The final positive comment is that these authors appropriately discuss the limitations of any research study in which subjects are not randomly assigned to a treatment procedure. The authors point out that most prior studies claiming randomization have not adequately described the methods used. Inadequate randomization may result in inequality and heterogeneity of the treatment groups. They also appropriately point out that a potential confounding factor in the attempt to find a suitable treatment approach will be etiology of the disease. They note that, unfortunately, TMD are not categorized by etiology, which is a substantial limitation. Moreover, current diagnostic systems, which depend on signs and symptoms and joint imaging, do not identify etiology.

The critical points about this review are that the authors do not explain fully why they suggest that patients with muscle problems should be separated from those with temporomandibular joint (TMJ) problems in future research. While this recommendation has good face validity, it is not clear that this distinction is so easily made. For example, if all TMJ clicking patients who have a predominantly muscular pain disorder and just happen to have joint noises are to be excluded, this specification process might eliminate a large portion of the population. Another example is that most muscle pain patients also have joint tenderness; again, this would make the specification process intrusive and highly exclusive. While this dilemma is solved by simply including all patients and then sorting them out afterward to see if any cluster of symptoms is unduly affected by the therapy being tested, the problem here is that a calibrated examination must be performed blind to subject (control versus patient) and treatment time (before/during/after) status.

A second critical issue is the authors' conclusion regarding the efficacy of occlusal treatment for TMD. While I agree and believe the literature strongly supports the concept that occlusal adjustment is not a logical therapeutic approach for chronic, spontaneous-onset TMD, this conclusion is not so clear for occlusal appliance therapy and TMD symptoms. Certainly occlusal appliances have their limitations as an intervention, but the issue comes down to how occlusal appliances are used. If they are expected to cure TMD, then the data suggest they have a weak efficacy at best. If, however, they are used as a management method to protect teeth that are sore or worn, or to make a patient more aware of a destructive behavior, they have clear merit. In general, in considering the treatment efficacy of occlusal appliances, the discussion can be divided into 2 components: *(1)* Are

occlusal appliances a cure for the TMD problem? and *(2)* Are occlusal appliances a reasonable method of providing help and protection for some selective TMD patients? The authors do not address this distinction, and this is largely because prior research has not examined the utility of these devices as a therapeutic aid. A logical conclusion to reach for the efficacy of occlusal appliances would be that as a bite guard that prevents abnormal tooth attrition and/or reduces individual tooth loading, and sometimes changes clenching behaviors, these devices have merit. It would be illogical to suggest that these devices stop a strong, long-term sleep bruxism behavior, that they put a loose TMJ disc back in place, or that they resolve arthritic destruction of the TMJ.

References

1. Forssell H, Kalso E. Application of principles of evidence-based medicine to occlusal treatments for temporomandibular disorders: Are there lessons to be learned? J Orofac Pain 2004;18:9–22.

CRITICAL COMMENTARY 2

APPLICATION OF PRINCIPLES OF EVIDENCE-BASED MEDICINE TO OCCLUSAL TREATMENTS FOR TEMPOROMANDIBULAR DISORDERS: ARE THERE LESSONS TO BE LEARNED?

Iven Klineberg
Professor of Prosthodontics
Head, Jaw Function and Oro-facial Pain Research Unit
Faculty of Dentistry
University of Sydney, Australia
Fax: +61-2-9845-7192
E-mail: IvenK@dental.wsahs.nsw.gov.au

The authors of the focus article[1] are to be commended for their commitment to the principles of evidence-based medicine (EBM) with their critical appraisal of the evidence linking occlusion and temporomandibular disorders (TMD).

EBM is succinctly defined by the authors as the "systematic, explicit, and judicious use of best evidence in patient care." However, a more complete explanation of EBM[2] includes a combination of *(1)* the application of the best available clinical research evidence with *(2)* the clinical experience and expertise of the clinician *(3)* in addressing the patient's specific concerns.

Recognition of the application of EBM for dentistry is as crucial for the clinical practice of dentistry as it is for medicine. The presence of 2 dental journals that are wholly committed to the promotion of an evidence-based approach—*The Journal of Evidence-Based Dentistry* and *The Journal of Evidence-Based Practice*—attests to this, as does the emergence of texts that provide evidence-based critiques of dentistry[3] and orofacial pain.[4] Given that this has been an emerging requirement for dentistry for more than a decade,[5,6] the term *evidence-based dentistry* or the more generic term *evidence-based practice* (EBP) is more appropriate.

TMD and the Biologic Basis of Dentistry

A critical rethinking of the management of TMD in clinical practice is crucial to the continuing emergence of dentistry as a biologic discipline. The reputation of dentistry depends on the provision of a service for patients that recognizes contemporary treatment methods and acknowledges developing clinical research evidence to support "mainstream" dental practice. A fundamental change in the management of TMD is needed to continue the evolution from dentistry's mechanical traditions and the anecdotal evidence or clinical opinion (the "expert

view") that continues to guide much of TMD management,[7] and the authors recognize this need. The concerns for TMD diagnosis and management were comprehensively documented by the National Institutes of Health Technology Conference Statement on management of TMD,[8] which has become the benchmark statement on TMD and is acknowledged in this article.

Quality of Clinical Research

The authors emphasize the hierarchy of clinical research evidence, led by randomized controlled trials (RCTs) and systematic reviews. This is not to deny the role of case reports and case series[9] as a means of reporting new disease entities or innovative clinical treatment methods. However, further progress in the particular condition or treatment requires appropriate follow-up study.

The authors recognize the RCT as the gold standard for assessment of efficacy of treatment. Where trials are not randomized, the treatment effect may be significantly enhanced ("up to 40%"). It is also a concern that the quality of study design, even for RCTs, is not standardized; this undermines validity by inadequate concealment in management of bias.[5,10] Inconsistent quality of data from varying research methodologies compromises the quality of meta-analyses and systematic reviews and creates a major problem for assessment of TMD research.[11] Dao et al[12] provided explicit recommendations for power and sample size in clinical trials. It is hoped that this advice will be applied to future clinical trials in addressing the requirements for study design.

TMD and Musculoskeletal Pain

The focus article clearly describes TMD controversies and recognizes that varied treatment methods report success and patient improvement, but that prospective studies are needed with standardized outcome measures for study and control groups. The article focuses on the role of occlusal factors in TMD. The authors identify Costen's syndrome, which drew attention to an occlusal etiology. The reasoning behind the preoccupation with the occlusion in dentistry is not surprising, since restoration of the occlusion continues to be a mainstream need in dental practice.

This focus in traditional dental curricula and dental practice with restoration of the occlusion, supported by the mechanical nature of much of what is needed in restorative and prosthodontic treatment, has not surprisingly led to a transfer of this approach to management of TMD. This does not excuse the reluctance of some clinicians to move away from these mechanical associations. The authors emphasize that the relationship between occlusion and TMD is "weak or nonexistent" and that management therapies should be reversible according to each patient's needs.

Efficacy of Occlusal Treatments

Evidence-based treatment for TMD is considered in detail in the article, which recognizes the varying quality of clinical trials of TMD therapy, noting that fewer than 5% were RCTs. The problem is compounded by the poor quality of most RCTs. Notwithstanding these difficulties, the authors have completed a systematic review of RCTs and also have outlined appropriate methodologic aspects to be incorporated into future RCTs.

The authors conclude that, based on the available evidence, occlusal adjustment is, at best, no better than control treatment and that occlusal splint therapy may be of benefit in management of TMD. They have acknowledged the difficulty in comparing studies because of their heterogeneity in design, outcome measures, and study duration.

The authors also conclude that definitive statistical results concerning the efficacy of stabilization splints for myofascial pain could not be justified. The clinical importance of studies on stabilizing occlusal splints is considered on the basis of the number needed to treat (NNT), eg, for a 50% reduction in worst pain experience comparing "active" and "passive" splints. The NNT was calculated from the studies of Ekberg et al[13,14] as 6 for joint pain and 4.3 for muscle pain. This result suggests a modest therapeutic value and is only marginally different from the comparisons of VAS scores by Dao et al[15] and Raphael and Marbach,[16] which described minimal outcome differences. The authors support the conclusion that, since the data modestly support the effectiveness but not the efficacy of stabilization splints, they should be seen only as an adjunct to orofacial pain management.

The authors also conclude that RCTs that reported on occlusal adjustment could not be scrutinized following EBP principles because of their low quality. On the basis of published research, there is no evidence to justify the use of occlusal adjustment.

Ethics in Clinical Research

In critically reviewing the literature on TMD, the authors struggle with the heterogeneity of study design, a preponderance of poor-quality studies (including RCTs), and an acknowledgment that the data was in general confusing. We could ask, where have the ethics of clinical research gone, and how has a commitment to professional ideals for quality let us down so badly? The answer is complex and has many facets. Of importance are limitations in research training and in research as a desirable and necessary component of the educational process; an obvious limitation in necessary funding; and the continuing preoccupation of universities to, not unreasonably, require publications as an indicator of scholarship.

There needs to be a rethinking of these priorities as a general requirement for dentistry. More specifically, the research process needs to be reconsidered. Emanuel et al[17] defined ethical requirements for clinical research, which are listed below and might form a useful starting point in the reassessment of study design.

1. The research must be of value in enhancing knowledge of health issues.
2. The research must be methodologically rigorous.
3. The subjects selected must be representative of the population and selected objectively.
4. There must be a favorable risk-benefit ratio.
5. There must be independent review of the research proposed.
6. Informed consent is essential.

Equally important, Benatar and Singer[18] have defined a "standard of care" for research subjects, which also ought to be acknowledged.

Conclusions

The authors of the focus article have applied the principles of EBP in their assessment of the role of occlusal therapy in management of TMD. Their conclusions are a sobering reminder of the need for careful planning of clinical study design to ensure that quality clinical trials allow the proposed outcomes. This baseline information is essential to ensure that the dental research community addresses the need for directing TMD management in practice by focusing on an evidence-based approach. EBP needs to become the cornerstone of clinical decision-making, and dental curricula need to emphasize these principles.

In addition to the evidence presented by the authors, it is appropriate to acknowledge the following:

1. As with all chronic conditions, TMD show regression to the mean.[19] This contributes to the exacerbations and remissions described by TMD patients and other musculoskeletal pain patients.
2. Placebo effects are an important and positive component of clinical treatment and research.[20] Placebo effects influence outcomes for any treatment and together with regression to the mean are responsible for successful outcomes that may be attributed to treatment effect. This needs to be addressed for pain treatment by appropriately designed RCTs.
3. Visual analog scales need to be correctly applied in pain studies for description of both the intensity and affective dimensions of the pain experience.[21]
4. Finally, colleagues wishing to maintain the link with the occlusion for all components of clinical dentistry should not feel disenfranchised, since the following identify a significant role for the teeth and the occlusion in dental practice: *(1)* determination of occlusal vertical dimension (OVD), lower face height, esthetics of individual teeth and tooth arch arrangement, and postural jaw position through the role of OVD on physiologic jaw muscle length; *(2)* influencing psychosocial factors of facial profile, orofacial comfort for biting, psychosocial well-being, and the relationship between completeness of the dental status and body self-image; and *(3)* functional components of masticatory efficiency, mastication and swallowing, and speech.

It is clear that even without a role in TMD etiology, the occlusion retains an important role in most aspects of dental practice.

References

1. Forssell H, Kalso E. Application of principles of evidence-based medicine to occlusal TMD treatments: Are there lessons to be learned? J Orofac Pain 2004;18:9–22.
2. Sackett DL, Rosenberg WMC, Gray JAM, Hayes RB, Richardson WS. Evidence based medicine: What it is and what it isn't. It's about integrating individual clinical expertise and the best external evidence. Br Med J 1996;312:71–72.
3. Walther W, Micheelis W (eds). Evidence-Based Dentistry. Cologne, Germany: Deutscher Zahnärzte Verlag DÄV-Hanser, 2000.
4. Zakrzewska JM, Harrison SD (eds). Pain Research and Clinical Management. Vol 14: Assessment and management of orofacial pain. Amsterdam: Elsevier Science, 2002.

5. Antczak AA, Tang J, Chalmers TC. Quality assessment of randomised control trials in dental research. I. Methods. J Periodontal Res 1986;21:305–314.
6. Antczak AA, Tang J, Chalmers TC. Quality assessment of randomised control trials in dental research. II. Results. J Periodontal Res 1986;21:315–321.
7. Greene CC. The etiology of temporomandibular disorders: Implications for treatment. J Orofac Pain 2001;15: 93–105.
8. Management of temporomandibular disorders. NIH Technology Assessment Conference Statement. J Am Dent Assoc 1996;127:1595–1603.
9. Vandenbrouke JP. In defense of case reports and case series. Ann Intern Med 2001;134:330–334.
10. Schulz KF, Clamers I, Hayes RJ, Altman DG. Empirical evidence of bias. Dimensions of methodological quality associated with estimates of treatment effects in controlled trials. JAMA 1995;273:408–412.
11. Antczak-Bouckoms AA. Epidemiology of research for temporomandibular disorders. J Orofac Pain 1995;9: 226–234.
12. Dao TTT, Lavigne GJ, Feine JS, Tanguay R, Lund JP. Power and sample size calculations for clinical trials of jaw muscles. J Dent Res 1991;70:118–122.
13. Ekberg EC, Vallon D, Nilner M. Occlusal appliance therapy in patients with temporomandibular disorders. A double-blind controlled study in a short-term perspective. Acta Odontol Scand 1998;56:122–188.
14. Ekberg EC, Vallon D, Nilner M. The efficacy of appliance therapy in patients with temporomandibular disorders of mainly myogenous origin. A randomised, controlled, short-term trial. J Orofac Pain 2003;17:133–139.
15. Dao TTT, Lavigne GJ, Charbonneau A, Feine JS, Lund JP. The efficacy of oral splints in the treatment of myofascial pain of the jaw muscles: A controlled clinical trial. Pain 1994;56:85–94.
16. Raphael KG, Marbach JJ. Widespread pain and the effectiveness of oral splints in myofascial face pain. J Am Dent Assoc 2001;132:305–316.
17. Emanuel EJ, Wendler D, Grady C. What makes clinical research ethical? JAMA 2000;283:2701–2711.
18. Benatar SR, Singer PA. A new look at international research ethics. Br Med J 2000;321:824–826.
19. Whitney CW, Von Korff M. Regression to the mean in treated versus untreated chronic pain. Pain 1992;50: 281–285.
20. Turner J, Deyo RA, Loeser J, Von Korff M, Fordyce W. The importance of placebo effects in pain treatment and research. JAMA 1994;271:1609–1614.
21. Price DD, McGrath PA, Rafii A, Buckingham B. The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. Pain 1983;17:45–56.

CRITICAL COMMENTARY 3

APPLICATION OF PRINCIPLES OF EVIDENCE-BASED MEDICINE TO OCCLUSAL TREATMENTS FOR TEMPOROMANDIBULAR DISORDERS: ARE THERE LESSONS TO BE LEARNED?

Maria Nilner, DDS, Odont Dr
Professor
Department of Stomatognathic Physiology
Faculty of Odontology
Malmö University
SE-205 06 Malmö, Sweden
Fax: +46-40-6658420
E-mail: maria.nilner@od.mah.se

The authors of the focus article[1] state that *evidence-based medicine* (EBM) is "the systematic, explicit, and judicious use of best evidence in patient care." They state that in practice, "EBM means the integration of individual clinical expertise with the best available evidence, moderated by patient circumstances and preferences." The authors express an intention to elucidate and discuss the application of EBM in the most controversial treatment methods for temporomandibular disorders (TMD), ie, occlusal treatments, including occlusal adjustment and splint therapy. To be able to treat patients according to the rules of EBM, a treating dentist must have knowledge about the scientific standards of treatments for TMD. Today, it is obvious for dentists claiming to be lifelong learners that there are lessons to be learned when applying principles of EBM to occlusal TMD treatments. The article is thereby an important paper, which the authors also underscore.

Clinicians like to believe that what they are doing for their patients is for the patients' own good. There are, however, instances when clinical intervention has been more detrimental than beneficial, for example, when patients with periodontal problems were subjected to uncomfortable surgery with exposed bone, which resulted in a loss of periodontal support. These results were presented in a meta-analysis.[2] Other treatment methods that have been questioned are extraction of asymptomatic third molars on a massive scale.[3] These examples clearly show the importance of EBM.

Many clinicians encounter patients who request a treatment that they have read about in the newspaper or sensational press. Still, the patients have the right to expect a high standard of care from the dentist. Achieving these standards forces dentists to engage themselves in lifelong learning. Since large numbers of research articles in the area of dentistry are published every year in over 500 journals related to dentistry, it is easy to understand that it is impossible for the clinicians to be up to date in all areas of dentistry. Moreover, if clinicians study articles on TMD treatment, they are seldom educated in research methodology and are therefore unable to be sufficiently critical of the published data. High-quality review articles are for that reason of the utmost importance for the treating clinician. This cannot be overstated, but it also puts a great responsibility on the authors of review articles, as the responsibility of the reviewers is to discuss all the evidence available at the time.

In 1999 the authors of this high-quality systematic review presented a systematic review of occlusal treatment for patients suffering from TMD.[4] In that review article, it was concluded that "the use of occlusal splints may be of some benefit in the treatment of TMD" but that "the evidence for the use of occlusal adjustment is lacking." These statements present a clear picture of the available evidence. It was also expressed that there is an obvious need for well-designed controlled trials to analyze current clinical practices. The call for well-designed controlled studies has been heard, and in this new review article, another 2 articles on splint therapy are included,[5,6] but no additional studies on occlusal adjustment as a treatment modality in the management of patients suffering from TMD have been published. It seems that the status of occlusal adjustment as a mode of treatment in patients suffering from TMD has been settled according to the well-written review article by De Boever et al.[7]

Regarding splint therapy, Raphael and Marbach[5] concluded that patients with myofascial face pain with only local pain experience pain reduction when treated with oral splints, compared to patients with widespread pain. The conclusion in the 2003 study by Ekberg et al[6] was that the stabilization appliance was more effective in alleviating symptoms and signs in patients with TMD of mainly myogenous origin than a control, nonocclusal appliance. The stabilization appliance was therefore recommended for the therapy of these patients. Only patients with localized pain were included in that study. In the section "Clinical Implications and Future Perspectives" of the focus article, it is stated that "although final answers to the question about the efficacy of splint therapy cannot be given at the moment, the latest studies have provided some further support for their use. The recommendation may still remain valid until the question is solved through new high-quality randomized controlled trials" (RCTs). It is not difficult to agree with this statement, but surprisingly, another conclusion is expressed in the abstract: "Occlusal splint studies yielded equivocal results. … the results do not justify definite conclusions about the efficacy of splint therapy. Their clinical effectiveness to relieve pain also seems modest when compared with pain treatment methods in general."

Under the heading "Systematic Review of RCTs of Occlusal Treatments," another objective for the focus article is expressed, ie, to evaluate the effectiveness of occlusal treatments for the symptoms of TMD. To be able to do so, long-term follow-up studies must be available. The continuation of 1 RCT acknowledged in the present article as well as in the earlier review[4] (on both occasions rated with a score of 0.71) has been published as a long-term follow-up study at both 6 and 12 months that focused on the alleviation of signs and symptoms.[8] This study lends further support to stabilization appliance therapy but unfortunately, since it was published in 2002, is not included in the focus article. The conclusion about splint therapy and its effectiveness in the abstract of the focus article would probably have been expressed in another way if the above-mentioned study had been included. A long-term follow-up study of an RCT of pain treatment[8] cannot, because of ethical aspects, keep the groups intact. Still, these kinds of studies are of the utmost importance in our ability to judge the effectiveness of stabilization splint therapy.

In the cited article by Antczak et al,[9] the therapeutic procedure is discussed and it is stated that the procedure must be described in sufficient detail to allow a comparison with other studies. The authors of the focus article seem to have accomplished the comparisons. However, important discussions are

Table 1 Studies of Stabilization Splints (with a Quality Score ≥ 0.5 as a Measure of Adequate/Good Quality) That Are the Basis for the Conclusions in the Focus Article

Studies	Sampling of patients	No. of patients	Diagnosis	Pain (acute/ chronic)	Pain rating	Use of splint	Additional tx during trial
Rubinoff et al[10]	Recruitment through a newspaper notice	28 total; 13 tx 15 control	Myofascial pain dysfunction	Unknown	Daily pain (scale 0–5) CS 3.6 ± 0.78 NS 2.1 ± 0.9	24 h*	Moist heat home exercise
Dao et al[11]	Recruitment through announcement	60 total; 22 tx, 20 AC, 19 PC	Myofascial pain	Chronic	VAS (1–10); 3.5 at rest; 4.0 postexercise; quality of life	Tx and AC: 24 h*; PC: 30 min/visit	—
Ekberg et al[8,13]	Patients referred to a specialist clinic	60 total; 30 tx, 30 control	TMD of arthrogenous origin	Chronic	Verbal scale: 93% moderate to very severe; VAS (0–100): worst pain > 70	At night	—
Raphael and Marbach[5]	Referrals and recruitment of referrals	63 total; 32 tx, 31 control	Myofascial pain and widespread pain	Chronic	VAS (0–10): mean pain level 4.5 ± 1.8	At night	Soft diet, moist heat, massage, exercise, NSAIDs
Ekberg et al[6]	Patients referred to a specialist clinic	60 total; 30 tx, 30 control	TMD of myogenous origin	Chronic	Verbal scale: 97% moderate to very severe; VAS (1–100): worst pain > 70	At night	—

*Except for cleaning and meals.
CS = conventional splint; NS = nonoccluding splint; tx = active treatment; AC = active control; PC = passive control; NSAIDs = nonsteroidal anti-inflammatory drugs.

missing. The studies that evaluated treatment with stabilization splints and that had the highest scores (above 0.5) include different treatment regimens (Table 1). In the studies by Rubinoff et al[10] and Dao et al,[11] the splints in the active treatment groups were worn day and night, and in the other studies they were worn only at night. Additional treatments were also performed. The different ways of wearing the splints, as well as the additional treatments, probably created different therapies, which surprisingly was ignored in Forssell and Kalso's comparison. What these differences mean we do not know. However, studies examining the raising of bites with the help of splints have found new resting positions for the mandible[12] after splint insertion. Another aspect of using the splint day and night is that of comfort. It is not difficult to imagine a patient's reluctance to comply fully. No study has proven that the wearing of a splint night and day is the most effective in the treatment of TMD. Differences in ways of recruiting patients, numbers of patients, diagnoses, and information given to the patients are important parameters to take into account when evaluating the results of treatment (see Table 1 for differences between the highly scored studies).

The focus article's section "Is There Evidence of Efficacy for Occlusal Treatments?" includes important discussions about drawing conclusions regarding the efficacy of a particular treatment. Referring to Antczak et al,[9] the authors decided to set a cutoff point of 0.5 for the quality score, which removed 14 of 20 studies from consideration. Of the 6 remaining studies, 5 evaluated treatment with stabilization splints and 1 assessed treatment with the soft splint. It soon becomes obvious how difficult it is to devise a good method for scoring quality, as the method used could have included studies that did not have, eg, selection description, blinding, or description of withdrawals but still had a score above 0.5. A call for other and new tools for evaluation of the quality of a study seems appropriate. In the excellent article by Kalso et al[14] it is stated that high quality does not necessarily mean that a trial of adequate design can answer the question posed, and therefore the issue of validity must be discussed. To assess validity, 2 of the most important inclusion criteria are suggested to be adequate: baseline pain intensity and adequate number of patients in each group. According to the importance of these criteria, Table 1 was created to get an overview of the strength in the studies regarding these and other important parameters.

To answer a question proposed[15] to the reader of systematic reviews: Were differences in individual study results explained adequately? I would say no! First of all, 3 different treatments were evaluated: *(1)* stabilization splint used 24 hours a

day, *(2)* stabilization splint used only at night, and *(3)* soft splint. The number of patients in 4 of the studies with stabilization splints is adequate; the patients, however, were recruited in different ways, which probably cannot be neglected in the evaluation of treatment outcome. Patients referred to a specialist clinic because of TMD problems are probably quite different from patients recruited through announcements. To be able to judge the efficacy and effectiveness of treatment, these parameters are of great importance.

Number needed to treat (NNT) was calculated for a 50% reduction of worst pain in 2 RCTs.[6,13] Since these trials did not include continuous measurements of visual analog scale scores, NNT of the change in pain according to the verbal scale would be of more interest. If patients who reported that they got better, got much better, or were symptom-free in both studies are considered, NNT values of 2.3[6] and 3[13] will result, which are well in accordance with the pain relief seen in drug studies.[16]

In conclusion, I agree with the authors of the focus article that EBM is an important part of health care and will have a major influence on decisions about acceptable treatment methods in the future. I think, however, that a review must clearly express the type and strength of the evidence of efficacy of the treatment evaluated, in accordance with the principles of EBM. After my analysis of quality and validity of the RCTs, I suggest the following about occlusal treatments for TMD, in accordance with the guidelines of McQuay and Moore[17]:

- Treatment of patients suffering from TMD of mainly myogenous origin by means of occlusal adjustment alone must be regarded as ineffective at evidence level II.
- The treatment with stabilization splints used at night for patients suffering from TMD of both arthrogenous and myogenous origin seems appropriate, at evidence level II.
- A stabilization splint used day and night is not more effective than a control splint in patients suffering from myofascial pain, at evidence level II.
- The level of evidence for the use of a soft splint in the treatment of patients with masticatory muscle pain is III, as the number of patients in the single available study[18] is too small.
- There is a need for an ongoing discussion about the tools for evaluating both the quality and the validity of RCTs and review articles.

References

1. Forssell H, Kalso E. Application of principles of evidence-based medicine to occlusal TMD treatments: Are there lessons to be learned? J Orofac Pain 2004;18:9–22.
2. Antczak-Bouckoms A, Joshipura K, Burdick E, Tulloch JFC. Meta-analysis of surgical versus nonsurgical methods of treatment for periodontal disease. J Clin Periodontol 1993;20:259–268.
3. Song F, Landes DP, Glenny A-M, Sheldon TA. Prophylactic removal of impact third molars: An assessment of published reviews. Br Dent J 1997;182:339–346.
4. Forssell H, Kalso E, Koskela P, Vehmanen R, Alanen P. Occlusal treatments in temporomandibular disorders: A qualitative systematic review of randomised controlled trials. Pain 1999;83:549–560.
5. Raphael KG, Marbach JJ. Widespread pain and the effectiveness of oral splints in myofascial face pain. J Am Dent Assoc 2001;132:305–316.
6. Ekberg EC, Vallon D, Nilner M. The efficacy of appliance therapy in patients with temporomandibular disorders of mainly myogenous origin: A randomized, controlled, short-term trial. J Orofac Pain 2003;17:133–139.
7. De Boever JA, Carlsson GE, Klineberg IJ. Need for occlusal therapy and prosthodontic treatment in the management of temporomandibular disorders. Part I. Occlusal interferences and occlusal adjustment. J Oral Rehabil 2000;27:367–379.
8. Ekberg EC, Nilner M. A 6- and 12-month follow-up of appliance therapy in TMD patients: A follow-up of a controlled trial. Int J Prosthodont 2002;15:564–570.
9. Antczak AA, Tang J, Chalmers TC. Quality assessment of randomized control trials in dental research. I. Methods. J Periodontal Res 1986;21:305–314.
10. Rubinoff MS, Gross A. McCall WD. Conventional and nonoccluding splint therapy compared for patients with myofascial pain dysfunction syndrome. Gen Dent 1987;35:502–506.
11. Dao TTT, Lavigne GJ, Charbonneau A, Feine JS, Lund JP. The efficacy of splints in the treatment of myofascial pain of the jaw muscles: A controlled clinical trial. Pain 1994; 56:85–94.
12. Rivera-Morales WC, Mohl ND. Relationship of occlusal vertical dimension to the health of the masticatory system. J Prosthet Dent 1991;65:547–553.
13. Ekberg EC, Vallon D, Nilner M. Occlusal appliance therapy in patients with temporomandibular disorders. A double-blind controlled study in a short-term perspective. Acta Odontol Scand 1998;56:122–128.
14. Kalso E. Five easy pieces on evidenced-based medicine (1). Eur J Pain 2000;4:217–219.
15. Oxman AD, Guyatt GH. Guidelines for reading literature reviews. Can Med Assoc J 1988;138:697–703.
16. Sommer C. Pharmakologische Behandlung orofazialer Schmerzen. Schmerz 2002;16:381–388.
17. McQuay HJ, Moore RA. An Evidence-Based Resource for Pain Relief. Oxford: Oxford University Press, 1998.
18. Wright E, Anderson G, Schulte J. A randomized clinical trial of intraoral soft splint and palliative treatment for masticatory muscle pain. J Orofac Pain 1995;9:192–199.

AUTHORS' RESPONSE TO CRITICAL COMMENTARIES

Heli Forssell, DDS, PhD
Eija Kalso, MD, PhD

We thank Drs Clark,[1] Klineberg,[2] and Nilner[3] for their criticism and valuable comments on our article on the evidence-based management of temporomandibular disorders (TMD). The commentaries raise important new issues on this topic, such as Dr Klineberg's discussion on research ethics. All 3 authorities seem to agree on the main issue of our focus article, ie, the importance of evidence-based knowledge in the TMD field. If experts in different parts of the world recognize the importance of high-quality clinical studies of TMD, we can expect the future to bring new evidence to guide the decisions of clinicians who treat TMD patients. In the following, we will briefly comment on some of the main issues raised in the commentaries.

Dr Clark and Dr Klineberg address the heterogeneity of TMD problems and discuss how this should be handled in treatment studies. We suggested that future studies should define the diagnosis more clearly (eg, joint or muscle pain) rather than lumping everything under the term TMD. It is obvious that at least acute joint pain and muscle pain have different pathophysiologic mechanisms, and presumably, they respond differently to treatments. The best way to handle this problem would be to use the Research Diagnostic Criteria for TMD,[4] which allow a patient to receive multiple diagnoses on the somatic axis.

Results from long-term follow-up studies are indeed important, as mentioned by Dr Nilner. She paid attention to one recently published long-term follow-up of a randomized controlled trial (RCT) that lent support to the effectiveness of stabilization appliance therapy.[5] The long-term follow-up results of both this study and 4 others mentioned in our previous systematic review[6] had to be excluded from the efficacy analysis because of randomization violations.

Despite the many difficulties discussed in our text, we wanted to follow the rules of evidence-based medicine (EBM) and base our conclusions about the efficacy of occlusal treatments on the evidence provided by the RCTs. Unlike Dr Nilner, we found it impossible to draw definite conclusions about the evidence-based efficacy of stabilization appliances. When 2 high-quality studies[7,8] show different results, we have to conclude that the issue remains unsettled.

Dr Clark's conclusions about the efficacy of occlusal appliances—that they prevent abnormal tooth attrition and/or reduce individual tooth loading and sometimes change clenching behaviors—cannot be substantiated by published evidence. None of the RCTs on splint therapy used tooth attrition or clenching behaviors as outcome measures.

What endpoints should be used to calculate number needed to treat (NNT)? We used the example of a 50% reduction in pain intensity, rather than the outcomes suggested by Dr Nilner, as this outcome has been used in the vast majority of published studies in pain medicine. The use of the same endpoint enables comparisons across studies and between different treatments. However, any NNT based on small patient populations (fewer than 500) should be treated with caution.[9]

Finally, we fully agree with Dr Klineberg's statement that EBM should be implemented by considering the best available research evidence, along with the clinical experience of the clinician and, most importantly, the individual patient's needs. The main criticism toward EBM seems to be based on the fear that EBM as such would dictate how clinicians should treat their patients. It is important to understand that EBM is a good tool to be used to guide decisions when delivering optimal clinical care to the patients. Research-based evidence will be vital for the reputation of any area of clinical practice, as stated by Dr Klineberg.

References

1. Clark G. Critical commentary 1. Application of principles of evidence-based medicine to occlusal TMD treatments: Are there lessons to be learned? J Orofac Pain 2004;18:23–24.
2. Klineberg I. Critical commentary 2. Application of principles of evidence-based medicine to occlusal TMD treatments: Are there lessons to be learned? J Orofac Pain 2004;18:24–27.

3. Nilner M. Critical commentary 3. Application of principles of evidence-based medicine to occlusal TMD treatments: Are there lessons to be learned? J Orofac Pain 2004;18:27–30.
4. Dworkin SF, LeResche L. Research Diagnostic Criteria for Temporomandibular Disorders: Review, Criteria, Examinations and Specifications, Critique. J Craniomandib Disord Facial Oral Pain 1992;6:301–355.
5. Ekberg EC, Nilner M. A 6- and 12-month follow-up of appliance therapy in TMD patients: A follow-up of a controlled trial. Int J Prosthodont 2002;15:564–570.
6. Forssell H, Kalso E, Koskela P, Vehmanen R, Puukka P, Alanen P. Occlusal treatments in temporomandibular disorders: A qualitative systematic review of randomized controlled trials. Pain 1999;83:549–560.
7. Dao TTT, Lavigne GJ, Charbonneau A, Feine JS, Lund JP. The efficacy of oral splints in the treatment of myofascial pain of the jaw muscles: A controlled clinical trial. Pain 1994;56:85–94.
8. Ekberg EC, Vallon D, Nilner M. The efficacy of appliance therapy in patients with temporomandibular disorders of mainly myogenous origin. A randomized, controlled, short-term trial. J Orofac Pain 2003;17:133–139.
9. Moore RA, Gavaghan D, Tramer MR, Collins SL, McQuay HJ. Size is everything—Large amounts of information are needed to overcome random effects in estimating direction and magnitude of treatment effects. Pain 1998;78:209–216.