As early as 1884, the Deutsche Monatsschrift für Zahnheilkunde published a report by the German dentist Ritter on the successful use of an occlusal appliance for the treatment of myofacial pain. Yet, since that time, the role of occlusal disturbances as etiologic or consequential factors causing excessive hyperactivity of the head and neck muscles still has not been fully understood. Neither has the issue of what a physiologic occlusion really looks like been resolved.

Most clinicians believe that occlusion is the primary or secondary factor contributing to temporomandibular disorders (TMD), whereas a few others see no connection between malocclusion and TMDs. Of course, it is true that in many patients the management of temporomandibular disorders is a multidisciplinary task and thus more a medical than just a dental challenge. Nevertheless, the diagnostics and treatment of malocclusion rank among the primary objectives of our profession.

Two different types of clinical experience might help to partially explain the controversy surrounding occlusion, and not least of all because this experience provides a key to understanding how to pretreat temporomandibular disorders with occlusal appliances. Clinical experience has shown that even a dentist with less expertise in the diagnosis and therapy of TMDs can achieve a success rate of 50% to 60% in treating TMD patients. If we wish to increase the success of the therapeutic outcome, then this demands a diagnosis-related and variable therapeutic approach and thus automatically requires specialization in this field of dentistry. But the fact remains that, at least based on our current state of knowledge, we are not able to help all TMD patients.

Any evaluation of a therapeutic method must also account for the fact that some patients have symptoms that are subject to periodic fluctuations. Pain increases and then decreases, and that is only partially dependent on the therapy. The lessening of symptoms coincidentally accompanying the initiation of an occlusal pretreatment is all too often misinterpreted as resulting from the therapy chosen. This “period of glory” for successful healing tends to be rather limited. The occlusion appears to have been stabilized, but suddenly the symptoms come back with more intensity. The forensic problems are obvious, particularly once the occlusion has been unnecessarily or irreversibly changed by selective equilibration of definitive prosthetic restorations. A poor example of an attempt at selective equilibration is shown in Fig 1.

A proven test method for correcting occlusion without irreversibly altering the teeth, at least for the present, is the specific application of occlusal appliances or interocclusal splints (Fig 2-4). The effectiveness of treating TMDs with these removable devices is quoted in the literature as being between 50% and 90%.

To select the proper occlusal splint for a patient, a dentist must first identify the major etiologic factor causing the disorder. The importance of a thorough history, examination, and diagnosis cannot be emphasized enough. Which factors, such as malocclusion, parafunction, or trauma, play an important role? How can they be treated, and what are the chances that these factors can be permanently eliminated?

It is important to realize that treatment with an occlusal appliance can only be truly successful when the temporomandibular disorder is caused or
Fig 1 Extreme negative example of an attempt at selective grinding to stabilize maximum intercuspation.

Fig 2 Full-arch hard acrylic maxillary appliance in situ.

Fig 3 All posterior contacts in maximum intercuspation are achieved by the mandibular buccal tips.

Fig 4 Equilibration appliances provide an even and simultaneous contact for all premolars and molars in the patient’s centric relation.
made worse by mandibular displacement or excessive parafunctions that are triggered or intensified by occlusal disturbances. For instance, bruxism that is not occlusally triggered cannot be treated by occlusal correction. In this case, an interocclusal splint can help minimize dental attrition and periodontal overload.

Much controversy exists over the exact mechanism by which occlusal appliances reduce symptoms. Most authors agree that they alter muscle activity and that this leads to a decrease in myogenous pain. Normalizing muscle activity also reduces the forces exerted on the temporomandibular joint (TMJ) and other structures within the masticatory system and alleviates the associated symptoms such as arthrogenous or dental pain, but it is not yet fully understood which specific features of an appliance normalize muscle function.

It is unfortunate that many clinicians construct and apply an occlusal device and, as symptoms resolve, interpret this as confirmation of their predetermined diagnosis. They then immediately direct long-term treatment toward the feature of the masticatory system that they believe the appliance has affected. In some instances they may be right, but in other cases this treatment may be quite inappropriate.

For example, as with any kind of treatment, a placebo effect can also result. We know that certain temporomandibular disorders respond favorably to such treatment. A positive placebo effect may result from the competent and reassuring manner in which we approach the patient and provide the therapy. This favorable doctor-patient relationship, accompanied by an explanation of the problem and reassurance that the appliance will be effective, often leads to a strong influence on the patient's emotional state, which may be the significant factor responsible for the placebo effect. This effect is normally greatest during the initial treatment phase.

Although occlusal appliances may have some diagnostic value, conclusions regarding the rationale for their success should not be drawn too hastily. Before any treatment plan is begun, ample evidence must be available that the treatment will benefit the patient. For example, extensive occlusal therapy is not normally proper treatment for parafunctional activity associated with high levels of emotional stress.

The use of removable appliances is often considered to be a risk-free treatment technique, since the necessary occlusal corrections are not performed on the patient's own teeth. This results in the false conclusion that all stomatognathic changes caused by the temporary insertion of an appliance would be reversible. However, pretreatment with occlusal splints that is not diagnosis-related, is uncontrolled, and extends over too long a period can cause a range of pathologic and irreversible changes in the masticatory organ.

1. Progression of caries and periodontitis. The defective design of base and retaining elements of the appliance can lead to unnecessary plaque accumulation and direct mechanical irritation of the periodontium. The patient must be told the importance of systematic and careful oral hygiene and care of the appliance.

2. Irreversible alteration of craniomandibular structures. Iatrogenic damage can naturally result from the use of a contraindicated appliance or from deficient design of the base, particularly if it is worn for a prolonged period. Changes in the position of the teeth and TMJ remodeling especially can lead to a total loss of the patient's maximum intercuspation.

3. Increased occlusal perception. If the splint is worn for too long, a patient can develop an increased occlusal perception, particularly those with psychologic problems. The patient's responses can be verified with a simulated occlusal correction as a placebo. However, the ability of the patient to experience minor and sometimes barely detectable premature contacts as vexing occlusal interferences can make it extremely difficult to give the patient definitive treatment.

4. Conversion of psychologic disorders. If the primary cause of the craniomandibular dysfunction is a psychologic disorder, any treatment that does not causally consider the patient's psyche can lead to conversion of the psychologic disorder to organic suffering. Over the course of protracted occlusal therapy, the mentally ill patient is thus strengthened by the dentist in the belief that the "malocclusion" is the true cause of all the problems. It then becomes
virtually impossible to treat the patient by the causal approach of psychotherapy.

Types of splints

Many different types of interocclusal splints have been suggested for the management of TMDs, the most common being occlusal appliances primarily for normalization of muscle function and appliances primarily for alteration of condylar position.\(^4,6-8\)

Splints for muscle relaxation or normalization of muscle function

Two types of splints can be differentiated according to their occlusal design: the anterior bite-plane device and the equilibration appliance. The anterior bite-plane device is a hard acrylic appliance worn over the maxillary teeth, providing contact only with the mandibular anterior teeth or premolars. It is primarily intended to disengage the posterior teeth, thus eliminating their influence on the function of the masticatory system. The splint used by Ritter in 1884 to treat myofacial pain was a type of anterior bite-plane device.\(^1\)

The main indications for the appliance are muscle disorders caused by centric or eccentric premature contacts on the posterior teeth. Major complications can arise when this appliance is worn continuously for several days, as the unopposed posterior teeth have the potential to supraerupt. When this occurs and the appliance is removed, the anterior teeth no longer contact, and the result will be an anterior open bite.

Another problem can occur in the TMJ. The artificial loss of posterior tooth support may lead to condylar displacement and compression of articular tissues. Therefore, the anterior bite-plane device must be closely monitored and used only for short periods. But in most cases, the same treatment effect can be accomplished with the equilibration appliance. This appliance is generally used to improve muscle function to harmonize mandibular movement patterns, and to establish a stable and reproducible neuromuscularly determined centric relation. Equilibration appliances are especially used in the case of loss of posterior tooth support, deflective occlusal contacts, and/or inadequate anterior guidance. Therefore equilibration appliances can also be helpful for patients experiencing retrodisclitis secondary to trauma. Unlike an anterior bite-plane device, the equilibration appliance provides an even and simultaneous contact of all premolars and molars in the patient's present centric relation (Figs 3 and 4).

The full-arch hard acrylic equilibration appliance can be used in either arch, but maxillary placement normally provides a better adjustment of anterior guidance (Figs 5 and 6). It is also more versatile, allowing opposing contacts to the achieved in all skeletal and molar relationships. The major advantages of the mandibular appliance are that it is easier for the patient to speak with it in place, and for some patients it is less visible and thus more esthetic (Figs 7 and 8).

Many methods have been suggested for the fabrication of occlusal appliances. One, which the author prefers, begins with precise casts mounted on an articulator. In this phase of preparation, it is important to develop and record the patient's best momentary centric relation, knowing that this treatment position is normally not identical to the definitive centric relation. Centric relation can only be achieved with normalization of muscle function. There is no manipulation technique available that could record centric relation at the first attempt. For an improved fit of the appliance, a two- or three-segment sprinkle-on fabrication technique is preferable. Each section is allowed to polymerize completely before the next section is applied. Anterior guidance of the occlusal device is normally reconstructed with anterior guide pin, a previously determined guide table, or the Contour-Curve-Former (CCF).\(^5,6\)

Occlusal design of a maxillary appliance

All posterior contacts in the centric occlusion of the appliance will be achieved by the mandibular buccal cusp tips, as it is shown in Fig 9 (black dots). The patient should be able to close virtually without force and feel all premolars and molars contacting evenly and simultaneously. With an increase in
Figs 5 and 6  Maxillary occlusal splints normally provide a better adjustment of anterior guidance. A mandibular splint is to be preferred when the patient’s anterior guidance will not be altered definitely.

Figs 7 and 8  Mandibular appliances normally offer more comfort for the patient. It is easier to speak with it in place and for most patients it is less visible.

Fig 9  Typical occlusal design of a maxillary equilibration appliance with anterior guidance.
Fig 10  Occlusal diagnostics and treatment should be controlled while the patient is sitting in an upright position with the head kept straight.

Adjustments of maximum splint intercuspation
Each alteration of muscle activity or change in head or body posture can lead to an altered mandibular position and vice versa. For occlusal splint adjustments, this functional relationship of occlusion, mandibular position, and head and body posture must be taken into account. The mandible is at the mercy of the head and neck muscles. Both occlusal diagnostics and occlusal therapy should be carried out or at least controlled while the patient is sitting or standing in an upright position with the head kept straight (Fig 10). All occlusal contacts should be carefully refined so they will occur on nearly flat surfaces with equal occlusal force. After each occlusal adjustment, the patient should be able to close and feel all teeth contacting evenly and simultaneously. It is also important that the mandibular incisors and canines move freely over the occlusal surface of the appliance. All eccentric contact lines depicted by these teeth should be smooth and continuous. Of course, irregular pathways and initial contacts need adjustment.

Monitoring
Due to normalization of muscle function, a kind of mandibular autorepositioning takes place until the maxillomandibular relationship has been stabilized. Therefore, the occlusion of the appliance should be monitored regularly during the initial period. Without continuous adjustments of the splint occlusion, especially in the first 2 or 3 weeks at intervals of 2 to 5 days, this centering process will stop. New excessive parafunctions may then occur and jeopardize the success of treatment. Thus, the main principle of occlusal treatment of muscle symptoms is the continuous adaptation of maximum splint intercuspation to the three-dimensional changes in the maxillomandibular relation resulting from a gradual muscular relaxation process. The result will be a neuromuscularly determined and a more stable centric relation.

Occlusal pretreatment chosen primarily for normalization of muscle function will last an average of 2 to 3 months. Patients showing no positive response to occlusal improvement within 3 to 4 weeks should be carefully re-evaluated. If the occlusion of the patient seems to be a major etiological factor for
TMD, the equilibration appliance should be worn day and night particularly in acute cases. Part-time use of the appliance must be considered in cases of stress-related bruxism. Then the appliance only needs to be worn during occlusally active periods. To reduce myogenous pain and improve muscle function, an additional home physiotherapeutic program with self-massage and heat or ice application can also be of benefit, even as a pedagogical measure. From the first day, the patient must understand that cooperation and compliance are essential for treatment to be successful. In other cases, it is more sensible to combine occlusal pretreatment with professional physical therapy. If this approach is taken, occlusal corrections of the appliance must be made on the same day and always after physiotherapy.

The physiotherapeutic effect has to be utilized for occlusal stabilization.

**Anterior positioning appliance**

In contrast to equilibration appliance therapy, successful treatment of joint noises and some inflammatory articular disorders can often be achieved only by establishing a therapeutic condylar position. This orthopedic treatment position of the mandible has to be defined and established by the operator. Clinicians must be aware that this kind of treatment can only be successful if the therapeutic position chosen is also an acceptable position for the masticatory muscles. Temporomandibular disorders cannot be treated contrary to the mechanisms of the neuromuscular system. Any occlusal treatment that does not consider this as a matter of fact will necessarily fail. Generally, the anterior repositioning or positioning appliance encourages the mandible to assume a position more anterior and/or inferior than the intercuspal position. Its goal is to provide a better condyle-disc relationship in the fossae so that normal or improved function will be re-established. Like the equilibration appliance, the positioning appliance is a full-arch hard acrylic device that can be used in either arch. The occlusal design is also very similar to that of an equilibration appliance. The difference with this appliance is the anterior guiding ramp for the incisors or retrusive facets for the first premolars (see Fig 9). Especially in the first days of therapy, this ramp or these facets are helpful for programming the neuromuscular system to the anterior treatment position of the mandible. Disocclusion of all posterior teeth is guaranteed if the mandible falls into a more backward position.

**Indications for a repositioning appliance**

Originally, the indication for a repositioning appliance was anterior disc displacement with reduction. The treatment position that must be chosen by the operator is the most backward position of the mandible in which the condyle-disc unit is still intact. During all movements to and from this position, no clicking or pain should occur. In any case, consequences of definitive treatment must be discussed with the patient prior to the treatment of the anterior disc displacement, since repositioning therapy normally results in irreversible changes in the occlusion. A typical change is the development of posterior open bite. This result often requires complete mouth rehabilitation or extensive orthodontic treatment. This can raise the cost of treatment considerably. In most cases described in the literature, long-term success with the recaptured disc could not been realized. This led to the recommendation that pain-free clicking should not be treated occlusally. When analyzing the failures of repositioning therapy, several reasons become apparent.

1. Reciprocal joint clicking during opening and closing movements is often interpreted as clear evidence of anterior disc displacement. However, this kind of clicking can also be caused by other pathologies that cannot be eliminated by an anterior position of the mandible.
2. The actual morphology of the disc is not taken sufficiently into account. The morphology of the posterior band especially has an influence on the stability of the recaptured disc. If the posterior band is already flattened, a stable condyle-disc unit cannot be achieved. Axiographic tracings recorded under manipulated loading of the articular tissues can help evaluate the
biomechanical quality of the disc (Figs 11 and 12).

3. The etiologic factor causing the anterior disc displacement, such as bruxism or other eccentric parafunctions, is not diagnosed and/or eliminated sufficiently by pretreatment, therefore clicking will recur sooner or later.

Since the goal of eliminating all joint symptoms by the chosen anterior position of the mandible often cannot be achieved completely, we have to consider that eliminating pain is far more important than reducing joint noises. If a displaced condyle led to painful inflammation of the retrodiscal tissue an recapturing the disc is not possible or indicated.
A slightly anterior or inferior positioning of the condyle is often sufficient to eliminate joint pain and to enhance adaptation of the damaged tissue. Once this adaptation has occurred, the condyle can function on the now fibrous structures of the bilaminar zone that attach to the posterior band of the displaced disc (Figs 13 and 14). Repositioning or positioning devices in particular lead to an orthopedic alteration of the condylar position. Therefore, this method may only be applied by an operator who has profound experience in the diagnosis and treatment of articular dysfunction. Otherwise, the risk of therapeutic failure is too high.

Conclusion

When correctly indicated and when the correct application techniques are used, occlusal appliances are powerful tools for treating temporomandibular disorders, especially when combined with specific physiotherapeutic measures. Occlusion is important, but how much occlusion is individually necessary depends on the patient, not on the dentist.

Key words

Occlusal appliance, occlusal splint, anterior positioning appliance, temporomandibular disorders.

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