

SYSTEMATIC APPROACH TO ORAL SPLINTS – AN OPINION PAPER PART 1: FUNDAMENTAL ISSUES

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ABSTRACT

Oral Splints are controversially discussed in dentistry. Although scientific findings cannot yet provide a definitive statement on efficacy and mechanism of action, dentists apply occlusal splints in large numbers. This series of articles aims to bring together the discrepancy between findings based on studies and clinical reality. In addition, the contradictory terminology will be discussed.

A practicing dentist and his interdisciplinary team strive to provide the best possible treatment for the patient. Treatments focus on the long-term effect, using a causal therapeutic approach. Occlusal splints can be used in different situations. This requires the indication to be defined precisely, the parameters of the splint to be tailored to the individual patient, and a realistic picture, including a realistic prognosis regarding the expected effect, to be developed together with the patient.

KEYWORDS

Cranio-mandibular Disorder; Occlusal Splints; Positioning Splints; Re-Capturing Splints; Stabilization Splints.

1. INTRODUCTION

Oral Splints are controversially seen in dentistry. Practicing dentists use this therapeutic option frequently and regularly. [1,2] Academic opinion leaders reject the use of oral splints, citing the paucity of studies that show little evidence for these forms of therapy. [3] A constantly increasing number of Over-The-Counter devices (OTC) and similar commercially available devices indicate that consumers, affected persons, and unsatisfied patients demand these products a lot. [4] A wide range of other treatment methods, some of which are part of the so-called conventional medicine but others that go far beyond it, make it difficult to form a clear opinion and define the best way to relieve affected patients. [5,6]

Dental treatments aim to improve the patient's situation on the long term. Often, the patient requires intervention from the dental team because of a symptom such as pain. The approach is either causal or symptomatic. Causal therapy is preferable

in many respects. Dentists must take these situations seriously and are in charge of developing the best possible treatment. Any treatment requires an open mind without premature and preconceived diagnoses. An unbiased diagnosis needs systematic examinations and neutral conclusions. Weighing up the facts and the patient's preferences can now be combined with scientific evidence. The most suitable therapy will be implemented after weighing the risk-benefit profile. The dental team must consider scientific information (the evidence) and match all parameters while developing a treatment plan. However, if the evidence for a particular therapy (e.g., occlusal splints) is weak (low), the conclusion must not be to rule out this treatment method. The dentist's expertise and the patient's autonomous freedom of choice are equally important factors in evidence-based medicine. [7] (Fig. 1) Evidence-based medicine is the conscientious, explicit, and judicious use of current best evidence in making decisions about the care

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of individual patients. Low evidence should not be interpreted as a rejection of a therapy. Rejection implies the risk of harming a patient by withholding a possible helpful therapeutic regime. [8] Rejection requires evidence as well. A paradigm shift is methodically and ethically sound if a clear alternative exists and the evidence demonstrates the superiority of the alternative. [9,10,11]

This series of three articles discusses the discrepancy between scientific evidence and clinical expertise regarding occlusal splints (oral devices). If the main differences in the view on occlusal splints (scientific vs. practical) are understood, an improved application of occlusal splints, merging evidence with expertise and patients' characteristics to improve the patient's quality of life.

2. CONFUSING TERMINOLOGY

In medicine and dentistry, "splint" refers to measures to connect, stabilize, and fix two or more parts together to enable or improve the healing process. A rigid or flexible device maintains the corrected position of displaced parts to keep these parts in place. Such splinting devices usually restrict motions or immobilize joints. Splinting in dentistry refers to connecting two or more teeth, forming a rigid unit to reduce the mobility of the single tooth. [12]

In (muscle) physiology, a prolonged muscle contraction that inhibits or prevents movement of a body part is called muscle splinting, an involuntary contraction of a muscle (total or partially) to avoid particular movements causing severe pain sensations. The location of the pain to be avoided by the splinting is not necessarily located directly in the muscle but in the joints, joint capsules, ligaments, and tendons. Resistance to passive stretch of the muscle with partial muscle relaxation at rest is typical for such situations, also called protective muscle contraction. [13,14,15]

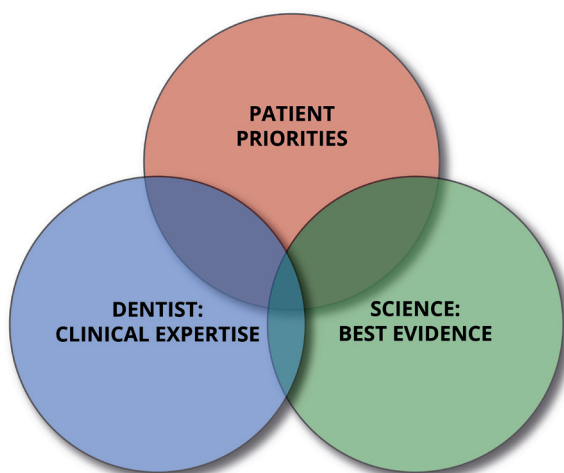


Figure 1. Evidence-based medicine (EBM). Scientific evidence is an important, but not the only element in decision making. Only the combination between the clinical expertise of the dental team and the patients' priorities allows the establishment of the best treatment strategy.

Today, the term splint is still used, although the main idea of occlusal splints is not to connect or to fix two parts. Occlusal splints are removable intraoral devices covering the occlusal surfaces and affecting the relationship of the mandible to the maxillae. Blocking mandibular movements and limiting TMJ movements are not intended by prescribing occlusal splints; here, the term splint should not be interpreted in a sense, as mentioned earlier, of fixing two or more moveable parts. [16]

The use of occlusal splints may include, but is not limited to, occlusal stabilization, initial therapy prior to extensive intervention, or prevention of wear of the dentition or damage to brittle restorative dental materials. Such occlusal appliances (occlusal splints) are designed in manifold variations. A unique and characteristic feature of occlusal splints is the artificial occlusion, allowing reversible alterations of dental structures and the interaction of upper and lower teeth. Oral splints allow alterations of mandibular position, vertical dimension, and joint position without irreversible changes in dental structures. [16] The terms occlusal splints, occlusal appliances, and occlusal splints are generally used as synonyms. The term night guard is misleading and should be used only for particular indications, which is usually the parafunctional activity of the patient. Such devices are used during sleep to avoid the adverse side effects of bruxing and clenching. Night guard implies that these devices should be used during sleep (during the night) only. Today, awake bruxism also requires attention, and such protection guards are also helpful during the awake state. Bruxism was (and sometimes still is) seen as a harmful movement disorder. On the other hand, the positive effects of these (physiological) occlusal functions are described: interrupting breathing suspension, increased salivation, better hormonal regulation, and stress relief. [17,18,19] The visualization of the tooth contacts, occurring due to grinding or pressing teeth in an awake or asleep state, helps the patient to understand these unconscious occlusal functions and supports the dental team in integrating this information into the diagnostic findings (not only "bruxing yes or no" but also which teeth, which segments of the dental arches are involved, correlated to other findings such as periodontal breakdown, chipping, class V lesions, pain, and alterations of mandibular movements). [18] Sleep bruxism is not only an issue for the adult. Clinical attention should be placed on children and adolescents to support the development of the stomatognathic system and occlusal functions. [20]

3. UNCLEAR INTENTIONS of ORAL SPLINTS

A general description for oral splints can best be the following one: Occlusal splints are removable devices, usually made of hard acrylic, covering the occlusal and incisal surfaces of all teeth in one dental arch and influencing the relationship of the upper

and lower jaw. The labels (names) for such devices that emerged over the last decades (1950 till now) are not uniform and often conflicting and, therefore, confusing. Unclear synonyms potentially provoke misunderstandings, leading to problems with the indication and application. [21,22]

The following (incomplete) list intends to illustrate this problem, particularly from the perspective of the reader of specialist articles and publications:

- Positioning:
- What should be positioned?
- From which position (start) to which position (desired)?
- Repositioning:
- What should be repositioned?
- From which position (start) to which position (desired)?
- Positioning and Repositioning:
- Are there differences in the intention and in the design of the splint?
- Are there differences in the meaning?
- Stabilization:
- What has to be stabilized?
- Why does something (mandible, jaw joints) have to be stabilized?
- What was the reason for becoming unstable?
- Are there particular and clinically relevant differences between Stabilization and Positioning?
- Is the stabilization an active (via splint elements) or a passive (via muscle coordination and relaxation) operation?

Names (labels) of splints refer to typical design features (e.g., mandibular advancement), may refer to the proposed effect (mandibular stabilization), or refer to particular diagnostic findings (disc re-positioning). Are these devices different to justify different names, or is it one type of splint, and further subdivisions do not lead to more clarity but create more misunderstandings? On the other hand, if this labeling makes sense and is helpful in clinical decision-making, are such differentiators recognizable in the evidence-based conclusions?

Four terms are often used concerning occlusal splints and may be considered to refer to fundamental intentions when using such oral devices.

- **Stabilization** usually refers to stabilizing the mandible. Occlusal structures (relief and particular elements) of the splint occlusal surface are used to implement the stabilization effect. A harmonization and improved coordination of the muscles of the chewing organ is a possible mechanism for stabilization or a positive effect of the achieved mandibular stability. The term stabilization splint is frequently used in clinical trials. [23, 24]
- **Relaxation** usually refers to relaxation of the (neuro-)muscular system. The relaxation effect of oral splints (Stabilization, Positioning) is often not explicitly mentioned but can probably be read between the lines. Relaxation techniques

seem to be the domain of non-splint therapeutic regimes. However, the effects of stabilization splints and applied relaxation techniques are not different; both show similar effectiveness in treating pain. [25] However, if the patient receives two or more therapies, and different disciplines are involved, the outcome of the therapy should be better compared to the outcome of a single therapy. (Fig. 2)

- Oral devices for short-term masticatory muscle relaxation can be summarized in one group with only partial occlusal contacts (often frontal teeth, but also premolars). Jig, anterior bite plate, and interceptor are familiar names.
- **Positioning** refers to Mandibular Position, including the Temporo-mandibular Joint (TMJ). An active positioning requires the fabrication of the splint in the programmed articulator. A passive positioning: the CMS System dominates over occlusion. The terms active and passive are used here from the dentist's perspective: active implies decision and construction elements, and passive means the dentist allows the stomatognathic system to position the mandible as soon as the splint separates the existing occlusion.
- **Re-capturing** refers to the articular disc in cases with partial or total anterior disc dislocation with reduction. A re-capturing occlusal device aims to bring the articular disc back into its physiological position in relation to the condyle. A re-capturing splint is applied to move the articular disc from partial or total displacement back to the physiological position in relation to the condyle. The terms Disc-Repositioning and Disc Re-Capturing are used synonymously. What is known today as internal derangement of TMJ structures has been described by W. Farrar in 1978: the condyle-disc relationship is temporarily (anterior Disc

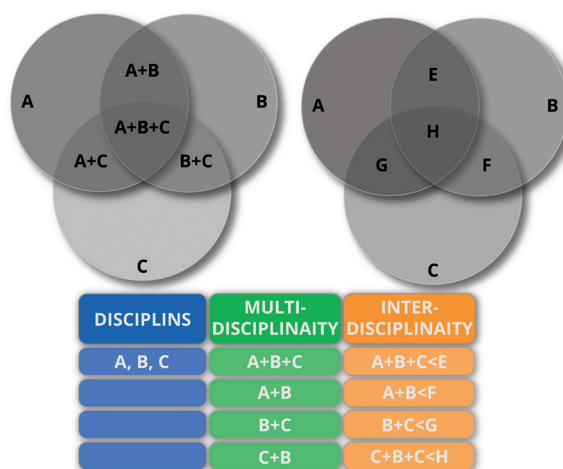


Figure 2. Multi- and Interdisciplinary treatments. In a multidisciplinary approach, the collaboration of disciplines leads to the sum of the effects of the disciplines. In an interdisciplinary collaboration, the concerted approach leads to an increased therapeutic effect. [adapted from: Slavicek G., Interdisciplinary - A Historical Reflection 2012, Int.J.Humanities&Social Science Vol.2/20].

Displacement with Reduction (aDDwR) or permanently (anterior Disc Displacement without Reduction (aDDwoR)) disturbed. In both situations, the articular disc is anteriorly positioned in relation to the condyle, with possible lateral or median shifts. The anterior dislocation of the disc remains during the opening movement in aDDwoR, with the condyle-disc relationship reduces during the opening in aDDwR. The reduction of the disc (during opening or excursive movements of the mandible) and the luxation of the disc (during closing or incursive movements of the mandible) are often accompanied by joint sounds, usually described as clicking noises. Clinically, the term reciprocal click is used to summarize the opening and closing sounds. Mandibular movements can be affected quantitatively and qualitatively; the mandibular range of motion (MROM) may be reduced for opening, protrusion, and laterotrusion, deviation, and deflections during mandibular movements can be described as well. The aDDwoR and reduced opening capacity are summarized as acute (often accompanied by joint pain) and chronic (often without joint pain, but with muscle pain, stiffness, or fatigue) locked joint (mouth) phenomena. [26,27]

Most occlusal devices used in clinical studies can be allocated to one of the above-mentioned terms.

4. The ORIGIN of MANY of TODAY'S COMMON NAMES for OCCLUSAL SPLINTS

The use of oral devices as therapeutical options in case of mandibular fractures goes back to the 1860s. [28] Ramfjord and Ash in the 1950s were one of the first to report the systematic use and description of occlusal appliances. [29,30] At that time, stabilization and splinting teeth were strategies in periodontal treatment by temporary splinting of the affected teeth using bonding techniques. Stabilization refers, in this context, to reducing tooth mobility. The so-called bite-planes represented an additional option for treating periodontal patients and reducing occlusal loads on mobile teeth. Occlusal trauma and periodontal stress due to bruxism were primary indications, intending to stabilize mobile teeth and prevent tooth migration. Positive effects of such devices on temporomandibular joint discomfort and muscle pain were observed (positive adverse events) and were subsequently used therapeutically. Before orthodontic re-positioning of migrated teeth, bite planes were used if permanent splinting was impossible. Ramfjord and Ash described maxillary bite-planes with flat occlusal surfaces, centric stops for all opposing teeth, and anterior and canine guidance for posterior disclusion in lateral and protrusive mandibular movements. "This appliance will decrease the occlusal load for single teeth and also decrease the total muscle activity." [29] The terms splinting, stabilization, positioning, and repositioning have emerged already, but they are based on dif-

ferent meanings and intentions.

Knowledge of the original texts by Ramfjord and Ash helps a lot to understand the nomenclature of occlusal splints in use today: **to splint** – to reduce occlusal forces affecting single teeth; **to stabilize** – reduce tooth mobility; **to reposition** – orthodontic movement of migrated teeth back to their original position. These terms are still in use, but the meaning and the target structures have significantly changed. Occlusal Splints are used to reduce and distribute occlusal forces better; Occlusal Splints are used to stabilize the mandible by alternating mandibular-maxillary relationship and to allow the neuromuscular system to reduce activity and to harmonize mandibular statics and dynamics; Occlusal Splints are used to (re-)position the mandible and to improve TMJ position, including the condyle-disc relation. [30]

Today, the term stabilization splint is frequently used. A splint is used to stabilize (but not immobilize) the chewing organ or parts of it if occlusion does not perform stabilization. [GPT-9] In the 1980s, the term stabilization splint became popular and refers to splints fabricated in semi-adjusted articulators to stabilize the mandible. Often, such splint designs are called Michigan splints. The upper and lower teeth are separated by a flat occlusal surface with centric contacts and anterior guiding elements (laterotrusive and protrusive). Indication for stabilization of the mandible is an unstable lower jaw due to occlusal deficits of an individual. Occlusal structures cannot stabilize the mandible. Today, the term "stabilization" with an occlusal splint implies the following intentions in the specialist literature: to develop a stable status, to maintain the stable status, to protect other parts of the stomatognathic system due to instability of the mandible, to secure and to reinforce elements of the craniomandibular system.

The Michigan type and similar splint designs are often applied in splint studies. Systematic reviews show that no clear evidence exists to support the provision of splints for the various subtypes of TMD or bruxism. However, the conclusions drawn from such meta-analysis are based on the studies, which used substantial differences in three crucial factors: 1) diagnoses, 2) splint type, and 3) outcome measurement/reporting. [3]

A common indication and inclusion criteria in clinical trials is pain, referring to the (Research) Diagnostic Criteria for Temporomandibular Disorders ((R) DC/TMD) for Clinical and Research Applications. [31] Pain is an unspecific symptom. Craniomandibular Disorder (CMD) is a collective term that summarizes signs and symptoms. Pain often goes along with dysfunction. The treatment needs of CMD patients are controversially discussed. Causal or symptomatic approaches are possible. Pathomechanism, especially the role of occlusion and occlusal function as a cause for CMD, is the subject of ongoing debate. [11,14,32] J.B. Costen described the effect of occlusal

alterations, loss of vertical dimension of occlusion, and reduction of lower facial height in 1934. [33] The description of this clinical picture, known today as Costen's syndrome, is a predecessor to today's CMD interpretation. Pain alone or combined with other signs and symptoms is often used as an inclusion criterion in (randomized) clinical trials of occlusal splints versus other therapeutic regimens. [22] The results are inconclusive and do not allow a final conclusion as to whether splints are superior to other forms of therapy. [35] Pain, dysfunction, and bruxism are often combined in these studies, which makes it difficult to quantify the effects. [36,37]

5. CONCLUSION: HOW to DEAL with THIS UNCLEAR SITUATION?

Rejection of (potentially helpful) splint therapy for individual patients due to a lack of scientific evidence carries the risk of withholding effective therapies and prolonging or worsening the patient's situation. Experimentation and trial and error approaches are contraindicated. A superficial diagnosis, often focused only on one symptom (pain or dysfunction), leads to symptomatic applications of oral devices that perform equally or even worse in direct comparison with other methods.

Oral splints are often indicated on the basis of symptoms and signs.

- Symptom: a subjective experience of a patient, not necessarily noticed by others
- Sign: objectively observed indicator of a medical condition, observed by the doctors, possibly noticed by the patients

Are occlusal splints causal or symptomatic? Often, the indication for oral splints is the combination bruxism and pain, without explaining in detail which treatment strategy is applied (a causal bruxism therapy or a symptomatic pain therapy). Oral Splints and limited mouth opening, oral splints and joint noises, oral splints and chewing muscle pain – are these causal or symptomatic approaches? Causal approaches are certainly preferable in modern dentistry. However, the causality of occlusion in the development and emergence of masticatory organ dysfunctions, mandibular dysfunctions, and myoarthropathies is still controversially discussed. There are two completely contradictory points of view for and against occlusal causality; the dentist has to make the decision based on systematic clinical and instrumental functional analysis. The goal of a splint therapy is a causal approach. Here, special attention has to be paid to the multifaceted problems of the patient. If the patient's situation does not allow a clear assignment to a particular discipline, or the diagnostic findings clearly show that more facets need to be considered, a one-splint therapy is very apt to fail. Patients with various problems should not fall between two stools (disciplines). (Fig. 3)

Occlusal splints are effective and efficient in treating patients in daily dental practice. However, the

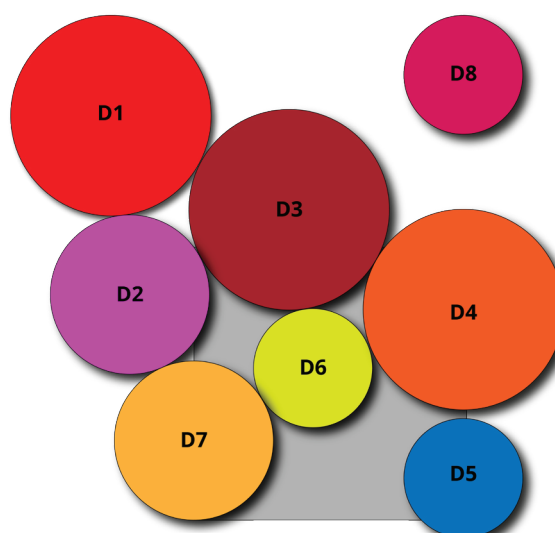


Figure 3. Interdisciplinary dentistry. The allocation of a patient to a special discipline is sometimes difficult, especially if the patient's problems affect several disciplines (indicated by the light grey area). This can complicate the coordination of diagnostic and therapeutic tasks. [adapted from: Slavicek G., Interdisciplinary - A Historical Reflection 2012, Int.J.Humanities&Social Science Vol.2/20].

scientific evidence of these positive effects still needs to be completed. From the authors' point of view, the following factors contribute significantly to this:

- one type of splint for (almost) all indications
- general splint parameters for each patient, without considering the individual patient's skeletal class and skeletal pattern
- only limited information regarding instructions for the patient how and when to use the appliance
- almost no information regarding follow-up (short-term check-up) and how to monitor the course of the treatment
- no information if the occlusal splint has to be adapted and equilibrated
- expectations are formulated in a very general manner (pain reduction)

The complexity of the stomatognathic system requires special attention. A classical gnathological triangle demonstrates the interaction between occlusion, TMJ and neuromuscular system. (Fig. 4) Nevertheless, the complexity of the masticatory organ is not reflected in this conclusive graphic. If the masticatory organ is understood as a cybernetic system, more complex interactions can be derived. The role of occlusion in this system is recognized less by separated independent factors (interference) and more by dynamic occlusal function (chewing, swallowing, speaking, grinding, clenching). (Fig. 5) Searching for similarities between the occlusal splints leads to two elements, both closely related to occlusion: the existing occlusion is (reversibly) changed, and the vertical dimension of the occlusion is increased. The craniomandibular system can stabilize, position, and relax without constantly conflicting with the existing occlusion. Splints usually lead to a new lower jaw posi-

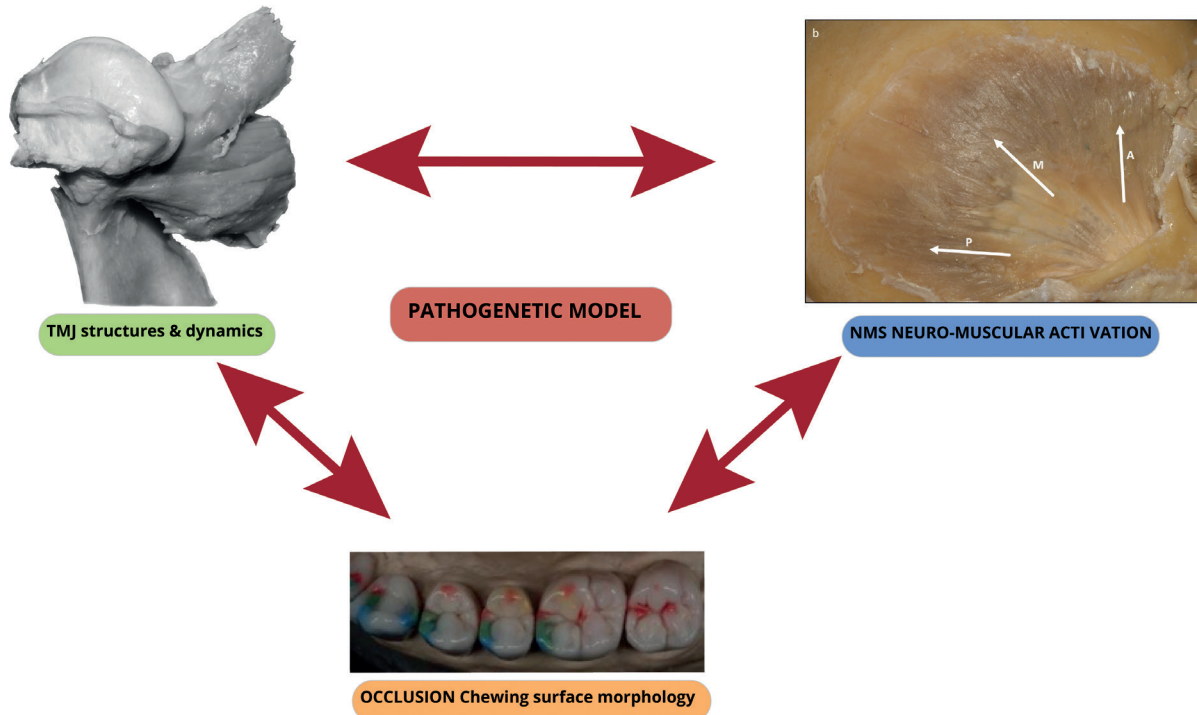


Figure 4. Mutual influences. The mutual positive and negative influences of the temporomandibular joint, musculature and occlusion are clearly recognizable and comprehensible in a pathogenetic model. However, linear relationships are simplifying and not capturing the fundamental complexity.

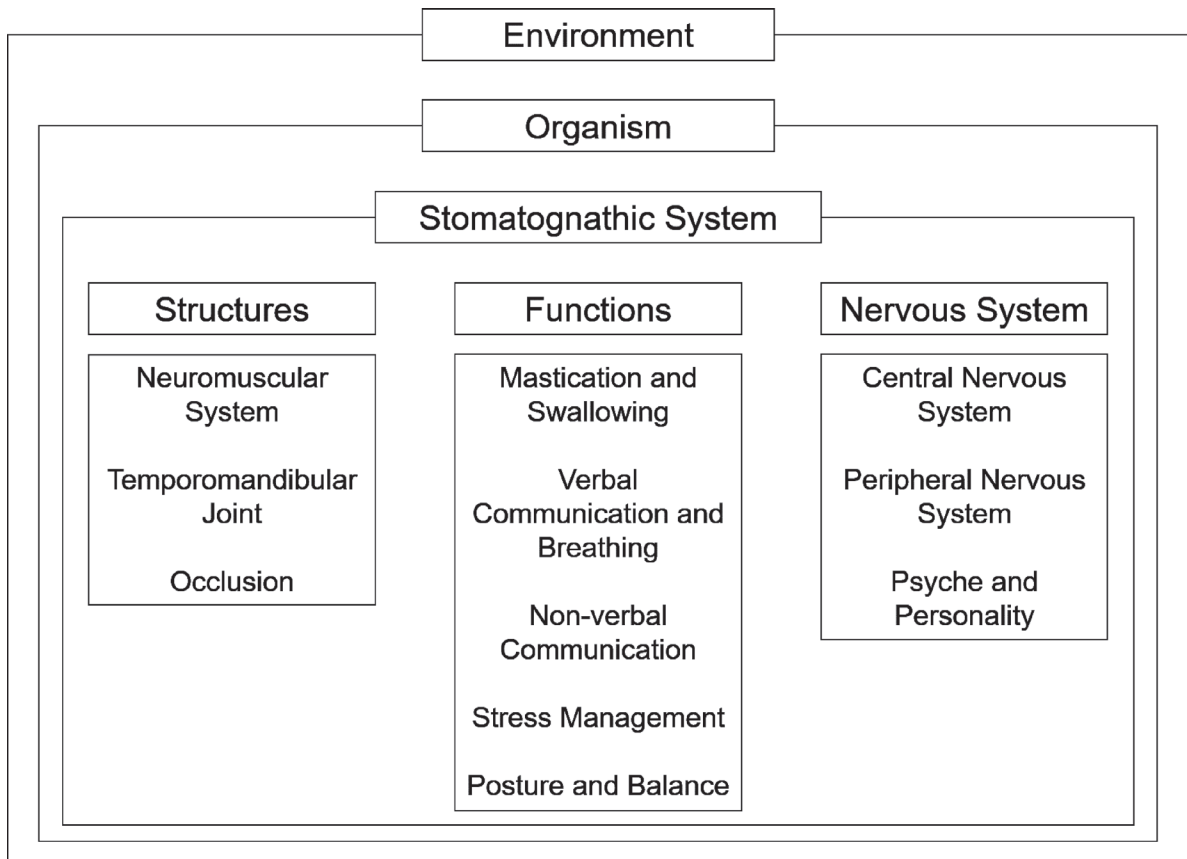


Figure 5. Cybernetic system. If the masticatory organ is viewed as an integrated part of the organism, the relationships of structures, occlusal functions and central/peripheral nervous system can be visualized. Psyche and personality are elements that cannot be ignored. [adapted from: Slavicek R. The Masticatory Organ, ISBN 3950126112, 9783950126112].

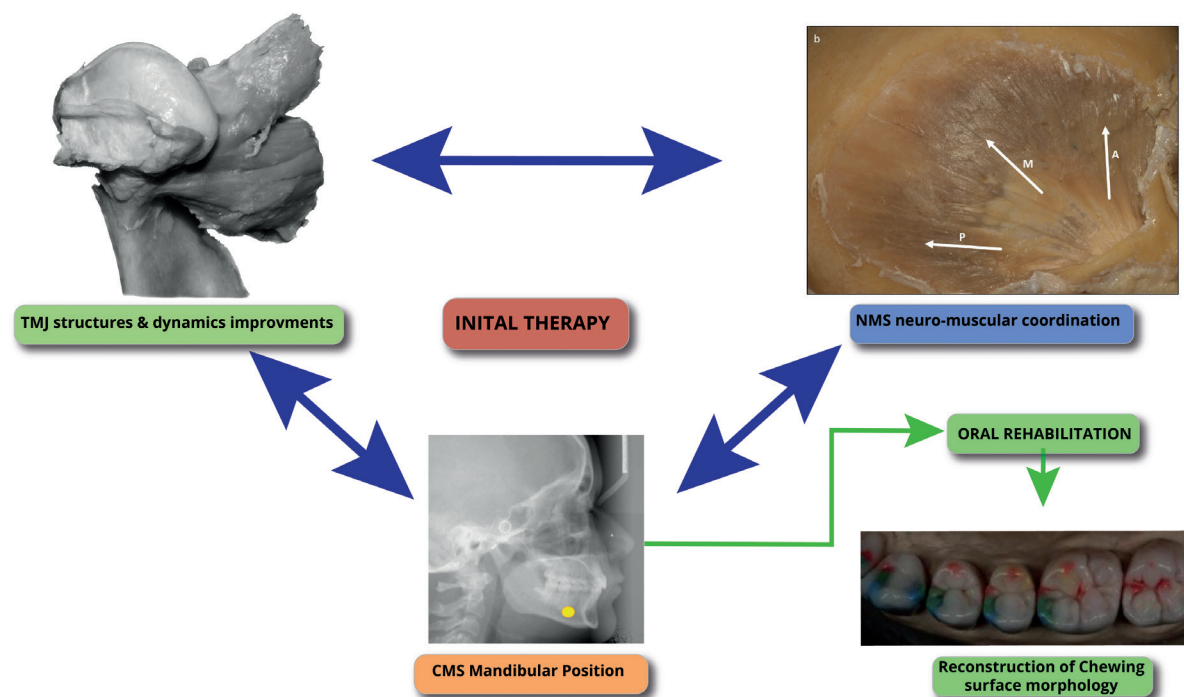


Figure 6. General splint effects. Most occlusal splints act via the occlusion, which is reversibly altered, including an increase in the vertical dimension of the occlusion. These alterations of occlusion allow the neuromuscular system to relax, harmonize better, and carry out the mandibular movements more cohesively. The jaw joint can assume a centered position without being placed in an unfavorable position by the occlusion..

tion. The existing occlusion remains unchanged. The subsequent oral rehabilitation task is to adapt the occlusion to optimally support this new lower jaw position and guarantee the long-term effect. (Fig. 6)

The beneficial effects of occlusal splints can be significantly increased by considering individual factors. The clinical application is based on adapting the splint in many ways to the individual patient's situation. These aspects are discussed and explained in part 2 and part 3 of this article series.

AUTHOR CONTRIBUTIONS

All authors contributed to the concept, writing, analysis, interpretation and critical revision of the manuscript.

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CV

Dr. Slavicek is an MD, specialized in Dentistry. He is currently Director of the Steinbeis Transfer Institute Biomedical Interdisciplinary Dentistry, Steinbeis University of Berlin. Since 2019, he has been CEO of Orehab Minds GmbH in Stuttgart, Germany. He graduated from the University of Vienna (medicine and dentistry), also specializing in Clinical Research at the same university (Master of Science). He attended additional postgraduate orthodontic training at the University of Aarhus (Denmark), with Prof. B. Melsen, and postgraduate gnathological training at University of Florida (USA), with Prof. H. Lundeen and Prof. C. Gibbs. He is an honorary member of the Italian Gnathological Society. He was awarded an honorary professorship by the Ukrainian Dental Society. He was visiting professor at the first medical state University in Moscow Sechenov (2014-2018).

Questions

1. Systematic reviews report the level of evidence for splints studies for the various subtypes of TMD or bruxism as follows:

- a. Strong;
- b. Low;
- c. Confirmed;
- d. Superior to alternative treatments.

2. Data from meta-analysis on occlusal splints often are unclear regarding the following parameters:

- a. Diagnosis;
- b. Splint type and outcome measure;
- c. Diagnosis, Splint type and outcome measure;
- d. Outcome measure.

3. Typical Splint types do not refer to one of the following items:

- a. Posteriorizing;
- b. Stabilization;
- c. Positioning;
- d. Anterior repositioning.

4. Which statement is incorrect regarding the term re-capturing?

- a. Re-Capturing refers to the articular disc;
- b. Re-Capturing refers to aDDwR;
- c. Farrar description of the pathomechanism of the reciprocal click with a recapturing and a luxation of the articular disc;
- d. Re-Capturing refers to the re-establishing the vertical dimension of occlusion.