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

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ABSTRACT

Background 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.

Objectives This series of articles aims to bring together the discrepancy between findings from studies and clinical reality. In addition, the contradictory terminology will be discussed.

Conclusion The practicing dentist and his interdisciplinary team strive to provide the best possible treatment for the patient. The 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

Orthognathic Surgery; Titanium miniplates; Plate removal; Risk factors; Infection.

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 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 in 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 the 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)

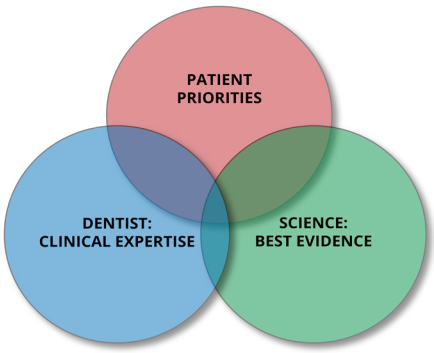

Figure 1. Evidence-based medicine (EBM). Scientific evidence is an important, but not the only element in decision making. Only the combination between the clinical expertise of the dental team and the patients' priorities allows the establishment of the best treatment strategy.

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Evidence-based medicine is the conscientious, explicit, and judicious use of current best evidence in making decisions about the care 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 [9-11].
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

TIn 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 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 [13-15].
Today, the term splint is still used, although the main idea of occlusal splints is not to connect and 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. [Sleep medicine] On the other hand, the positive effects of these (physiological) occlusal functions are described: breathing suspension and increased salivation [17, 18], hormonal regulation, and stress relief [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 described as follows: 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?

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- Are there differences in the meaning?
- Stabilization:
- What has to be stabilized?
- Why does something has 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 splint), may refer to the proposed effect (mandibular stabilization splint), or refer to particular diagnostic findings (disc (re-) positioning splint). 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 neuromuscular 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 therapeutical 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)

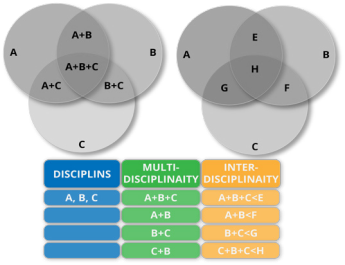

Figure 2. Multi- and Interdisciplinary treatments. in a multidisciplinary approach, the collaboration of disciplines leads to the sum of the effects of the disciplines. In an interdisciplinary collaboration, the concerted approach leads to an increased therapeutic effect. [adapted from: Slavicek G.,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

* 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. 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 here used 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 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 restored during the opening in aDDwR. The reduction of the disc and the luxation of the disc are often accompanied by joint noises, 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.

The length of the plates in the mandible was used as an indicator for the advancement of the lower jaw. A BSSO with plate lengths of 8 mm or less was considered as a small advancement (574 patients), while plate lengths of more than 8 mm were considered as a big advancement (573 patients). In the patient group with a small advancement 31 patients needed plate removal, 41 patients in the big advancement group (P=.221). Of the 1147 patients

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with a lower jaw osteotomy, 86 patients had a rotation of the mandible. Patients with a rotation of the lower jaw had more plates removed than patients with a symmetrical osteotomy (P=.010).
According to the patient files 47 out of 1252 patients smoked (3.8%). Only 2 of these 47 patients had plates removed (2.6%, P=.965). Smoking was more frequent among female patients (70.2%), versus 29.8% for male patients.

4. THE ORIGIN OF MANY OF TODAY'S COMMON NAMES FOR OCCLUSAL SPLINTS

The first systematic use and description of occlusal devices dates back to Ramfjord and Ash in the 1950s [28,29]. At that time, stabilization and splinting teeth were strategies in periodontal treatment.
The splinting was not performed with occlusal devices but as temporary splints using bonding techniques. Stabilization refers, in this context, to reducing tooth mobility. An additional option for treating periodontal patients and reducing occlusal loads on mobile teeth was called bite-planes. 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" [28]. The terms splinting, stabilization, positioning and repositioning have emerged already, but they are based on different 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 [29].
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. 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 are not able to 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 (R)DC/TMD criteria [30]. 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, 31]. J.B. Costen described the effect of occlusal alterations, loss of vertical dimension of occlusion, and reduction of lower facial height in 1934 [32]. 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 [34]. Pain, dysfunction, and bruxism are often combined in these studies, which makes it difficult to quantify the effects [35-37].

5. CONCLUSION

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

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symptomatic applications of oral devices that perform equally or even worse in direct comparison with other methods.

A causal approach is required in contemporary dentistry. However, the causality of occlusion in the development and emergence of masticatory organ dysfunctions, cranial Mandibular Dysfunctions, and Myoarthropathy 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 made to multifaceted problems of the patient. If the patient´s situations 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 problem should not fall between two stools (disciplines). (Fig. 3)

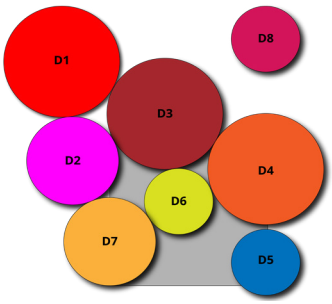

Figure 3. Interdisciplinary dentistry. The allocation of a patient to a special discipline is sometimes difficult, especially if the patient´s problems affect several disciplines (indicated by the light grey area). This can complicate the coordination of diagnostic and therapeutic tasks. [adapted from: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

Application of occlusal splints for individual patients is effective and efficient in treating patients in daily dental practice, not only to reduce or eliminate symptoms, but also to serve as basis for oral rehabilitation [37]. However, the 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 who 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. Successful therapeutical regimes require a clear and systematic clinical sequence of dental diagnostics followed by an initial splint therapy [37,38] 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.

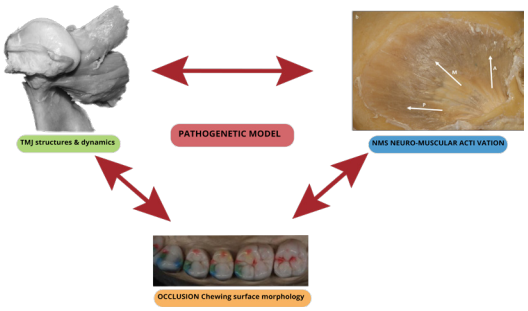

Figure 4. Mutual influences. The mutual positive and negative influences of the temporomandibular joint, musculature and occlusion are clearly recognizable and comprehensible in a pathogenetic model. However, linear relationships are simplifying and not capturing the fundamental complexity.

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 position.

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).

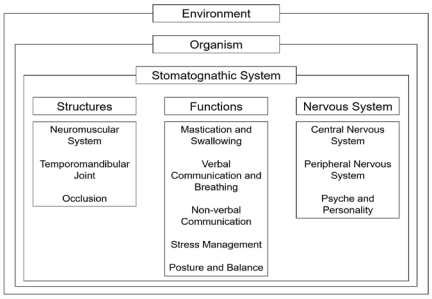

Figure 5. Cybernetic system. If the masticatory organ is viewed as an integrated part of the organism, the relationships of structures, occlusal functions and central/peripheral nervous system can be visualized. Psyche and personality are elements that cannot be ignored. [adapted from: Slavicek R. The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

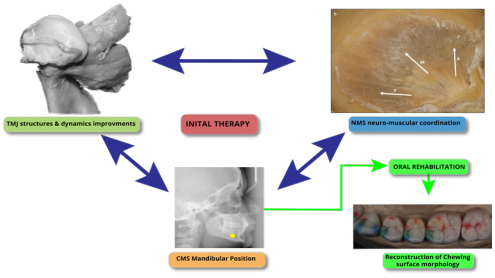

Figure 6. General splint effects. Most occlusal splints act via the occlusion, which is reversibly altered, including an increase in the vertical dimension of the occlusion. These alterations of occlusion allow the neuromuscular system to relax, harmonize better, and carry out the mandibular movements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

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The beneficial effects of occlusal splints can be significantly increased by considering individual factors. 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.

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AUTHOR CONTRIBUTIONS

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

CONFLICT OF INTEREST

Authors declare that there is no conflict of interests.

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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.