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BASICS OF FUNCTIONAL CLINICAL AND INSTRUMENTAL DIAGNOSTICS AND PRETREATMENT BEFORE FINAL ORAL REHABILITATION

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Abstract

Aim: The splint therapy is the most common and recommendable standard therapy for craniofacial pain. This type of therapy can obtain muscle relaxation and improvement of neuromuscular coordination. The aim of the article is to exemplify the clinical course of the dental diagnostics and splint therapy of patients with craniofacial pain.
Summary: A patient with craniofacial pain was treated using splint therapy. The therapeutic approach consisted in eliminating centric and eccentric occlusal disturbances, rebuilding lost support zones, and changing the mandibular motion pattern in order to improve muscle tone and neuromuscular coordination. Successful implementation required that, in centric relation and therefore in the splint position, the condyle-disc unit should be still largely intact and the interarticular space not constricted. As a result of the splint treatment, the patient was free of headaches, TMJ problems, and tinnitus, despite continuing work in a very intensive and responsible occupation. Recently, the patient reported not needing the splint at all during a sailing holiday in the Mediterranean.
Key learning points: This special type of splint therapy should be conducted in association with muscle massages and physiotherapy exercises, because the jaw relations must adapt to the premature contacts which arise on the splint at first.
Keywords: oral rehabilitation, instrumental diagnostic, craniofacial pain, splint therapy, centric relation

Introduction

In a healthy masticatory system, the interplay of cusps and fissures of antagonistic teeth is characterized by the fact that all movements, starting from an obvious habitual occlusion, can be performed without disturbances.
The temporomandibular joint also follows these growth-related, geometric patterns (Fig. 1). The corresponding sensory and motor functions of the neuromuscular system are adapted to these patterns, so that no interference occurs during the execution of any activities, e.g., chewing, swallowing, and speech (Fig. 2).[4,23,27,28]
The causes of functional disturbances, the so called craniomandibular disorders (CMD), can vary greatly and extend considerably into other medical disciplines. From the perspective of dentistry, masticatory functional disturbances are primarily caused by occlusal discrepancies if the latter are markedly outside the range of desmodontal tactility of 10 to 30 µm.[16,30] A crucial and often decisive exacerbating factor is the psycho-emotional stress ("grinding one's teeth"),[13,17] but orthopedic problems also influence the masticatory system[19,28]. Then, the neuromuscular functional processes can no longer be coordinated by the central nervous system, and typically result in frequent asymmetrical hyperactivity in the musculature. The effects are many and varied (Fig. 3).[6,7,9,21,25]
For instance, an epidemiological study on ca. 4000 subjects showed clear relationships between frequent headaches and tension in the masticatory muscles [(7)]. Hence, in diagnosing frequent headaches taking an interdisciplinary approach, it is also necessary to look for dental causes and consider dental therapy with, for instance, individual occlusal splints.[1,4,11,15] Possible failures should not be attributed to the method, but rather to the differential diagnostic exclusion of dental causes for a given disease/dysfunction. Current controlled studies conclusively show

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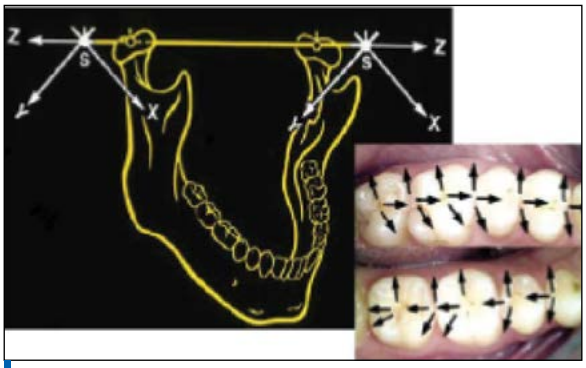


Figure 1. Biomechanics
The form and function of natural teeth and temporo mandibular joints are part of the physiological masticatory function. At the origin of each of the 3 arrows on all teeth lies a load-bearing opponent cusp at maximal intercuspation. Upon protrusive or lateral movements, the fissures marked with arrows are run through without contact. The joints are underlying the same geometric principles. Dentistry's foremost goal must be the maintenance of these occlusal structures or, if necessary, their restoration back to physiological function.

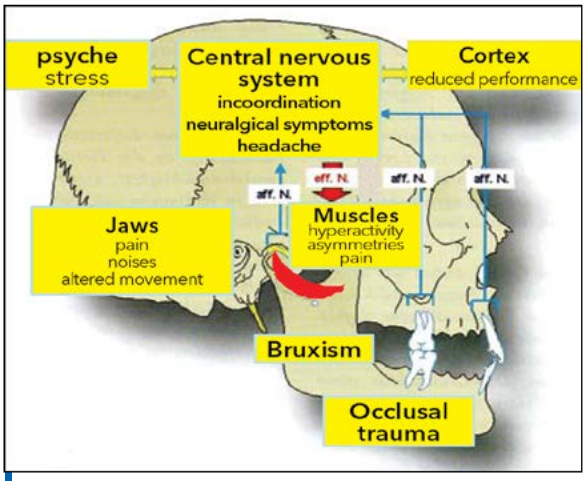


Figure 2. Physiology
In a healthy maxillofacial system, receptors in the area of the teeth, periodontium, muscles, and TMJ transmit the current situation via afferent nerve pathways (aff.n.) to the central nervous system (CNS). This includes information about the consistency of the food to be masticated. This sensory information determines the corresponding motor activity. Via efferent pathways (eff.n.), the appropriate motor activity is activated in the muscles, so that all masticatory functions can proceed in a coordinated manner. Physiological movement pathways of the TMJ and the individual anterior guidance are shown as dotted lines.

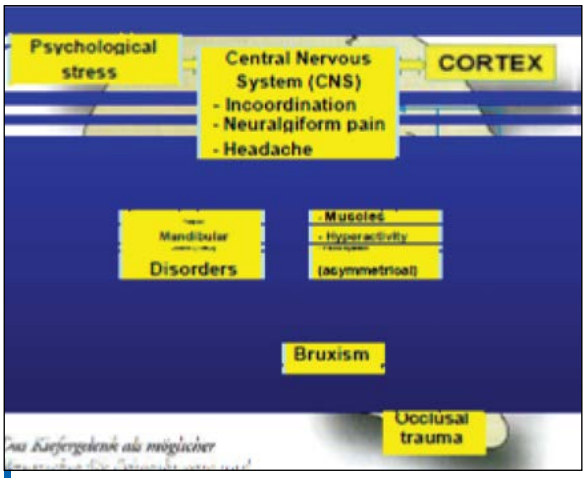


Figure 3. Pathology
Hyperactive musculature due to incoordinated signals from CNS is typical for a dysfunctional maxillofacial system. This can lead to bruxism and many other symptoms, e.g., tension headaches, tinnitus, neckache. The main causes are unnatural psychological burdens (stress) and/or occlusal trauma, for instance, due to malocclusion of the teeth or restorations/prostheses. About 50% of all patients with maxillofacial dysfunctions suffered simultaneously from psychoemotional stress and occlusal trauma when symptoms first manifested

that individually adjusted occlusal splints lead to significantly better muscle relaxation than do only vacuum-drawn, non-individualized splints, which thus must be regarded as largely obsolete.[8,10]

Case report
In the following, the case of a recent patient will be used to exemplify the fundamental clinical course of the dental diagnostics and splint therapy of patients with craniofacial pain. After reaching an initial diagnosis by a short clinical-screening-test[1,22,23] several functional-diagnostic steps in the following order have proven effective:

1. a) Anamnestic interview
The patient (female, 42 yrs, married, employed) reported to have suffered from massive tension headaches and occasionally tinnitus for the last 20 years, and that the intensity chiefly depended on stress. Neurological, ENT (ear-nose-throat), and orthopedic causes could not be diagnosed by the respective specialists. The patient had heard that dental causes could possibly be the root of the problem.

1. b) Clinical manual functional diagnostics[2,3]
The palpation of facial and shoulder muscles did not yield any abnormal (asymmetrical) findings (Fig. 4). Examination of mandibular mobility showed opening of circa 40 mm (incisal edge distance) with a slight deviation to the left. No muscle or TMJ pain occurred during this, nor during protrusion and lateral movements of the mandible, which could be performed without restrictions. Clicking or other sounds were also not detectable in the TMJ area, although the patient reported experiencing

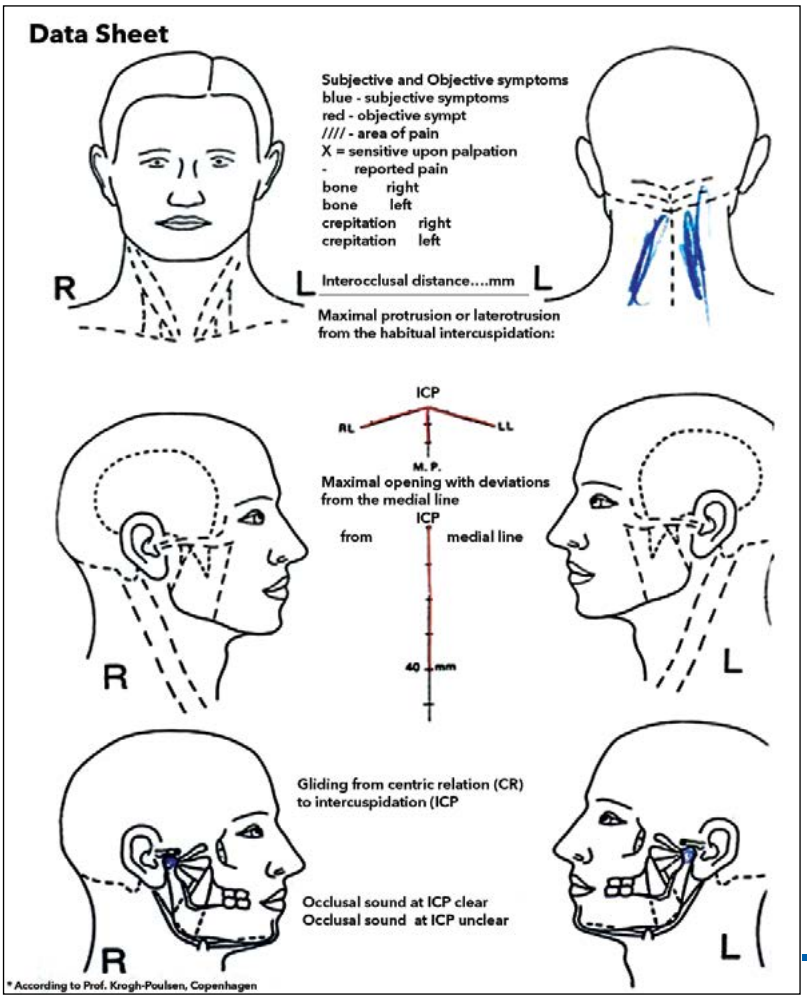


Figure 4. In the clinical-manual diagnosis, asymmetrical muscle conditions, disturbances in mandibular mobility, and abnormalities in the TMJ area are documented. On this Krogh-Poulsen data sheet, the subjective information from the patient is shown in blue and the dentist's findings in red. In the figure itself: subjective and objective symptoms; blue = subjective symptoms, red = objective sympt.; //// = painful area; x = sensitive upon palpation = reported pain; pain during stress, right/left; crepitation, right/left; interocclusal distance: .... mm. Maximal protrusion or laterotrusion from habitual intercuspation: Maximal opening with deviations from the medial line; gliding from centric relation (CR) to intercuspation (ICP); occlusal sound at ICP clear, unclear

Figure 5. Frequently, as with this patient, sensitive tooth cervices, wedge-shaped defects, recessions, and enamel cracks are indicative of para- or dysfunctions

Figure 6. On this side, wear facettes/attrition and cervical lesions are visible

both TMJ pain and tinnitus during particular stressful situations. The patient also reported having undergone orthodontic treatment between the ages of 11 and 16. The headaches began about 5 or 6 years after that, and had occurred regularly since then. She mentioned that she often clenched her teeth, and was surprised to learn that under physiological conditions, about 10 minutes of tooth contact per 24 hours was normal. Before having received this information and instructions in self-observation, she had thought constant contact of the teeth was normal. Generally speaking, any patient must learn to recognize and avoid her/his own stress situations, or at least

Figure 7. Intraoral findings were normal. The dentition was well cared-for, a few restorations were present, and there was an almost ideally-shaped maxillary dental arch

Figure 8. The mandible also exhibited a few restorations, but occlusal ab-normalities (facets, fracture) could be seen on molars 37 and 47 in the same area, where she had shown severe preliminary contacts after the "cotton-roll-test"

Figure 9. After touching preliminary contacts on her molars the patient could finally assume an evenly supported maximal intercuspation position

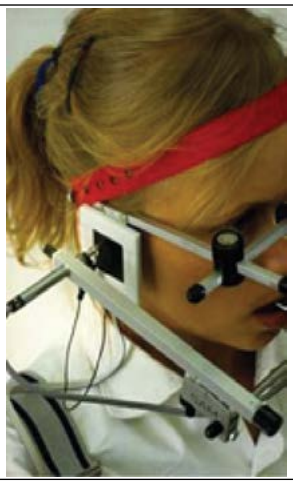


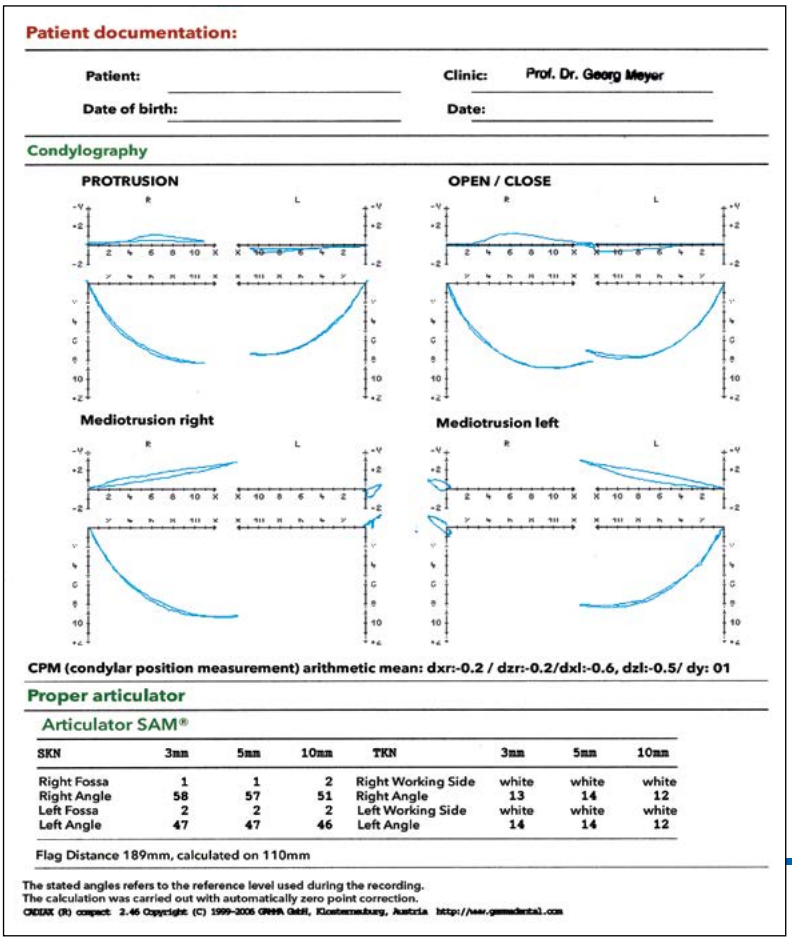
Figure 10. Since the clinical findings for the TMJ alone do not allow a definite diagnosis, electronic registration of the movement pathways was carried out

Figure 11. To conduct electronic registration in daily practice, we prefer the easy-to use Cadiax Compact system

learn not to clench his/her teeth at such times, because this can cause the muscle tension which triggers symptoms. To help patients recognize and avoid clenching their teeth, we give them 3 small, red adhesive dots as "reminders", for instance, to stick on their computer screen at work.[27] For many patients, it has proven helpful to lend them a video on relaxation exercises, muscle massage, and movement training.[14] It is also a means of testing a patient's willingness to cooperate.

1. c) Intraoral findings and clinical occlusal diagnostics

Intraorally, this patient exhibited tongue impressions, wear facets/attrition, enamel cracks, and pronounced wedge-shaped defects in the maxilla and mandible.[26] On the whole, these are clear clinical signs of stress and/or parafunctions


Patient documentation:

Patient: Clinic: Prof. Dr. Georg Meyer

Date of birth: Date:

Condylography

PROTRUSION OPEN / CLOSE

Mediotrusion right Mediotrusion left

CPM (condylar position measurement) arithmetic mean: dxr:-0.2 / dzr:-0.2/dxl:-0.6, dzl:-0.5/ dy: 01

Proper articulator

Articulator SAM®

SKN	3mm	5mm	10mm	TKN	3mm	5mm	10mm
Right Fossa	1	1	2	Right Working Side	white	white	white
Right Angle	58	57	51	Right Angle	13	14	12
Left Fossa	2	2	2	Left Working Side	white	white	white
Left Angle	47	47	46	Left Angle	14	14	12

Flag Distance 189mm, calculated on 110mm

The stated angles refers to the reference level used during the recording.
The calculation was carried out with automatically zero point correction.

Figure 12. The axiographic measurements showed undisturbed, almost ideal movement pathways of the TMJ upon protrusion, opening, and medio-trusion. On this basis, the Cadiax Compact calculates settings for nearly any articulator, in our case, for the Reference SL by GAMMA (Klosterneuburg, Austria). To conduct electronic registration in daily practice, we prefer the easy-to-use Cadiax. Compact system.

with occlusal causes (Figs. 5 and 6). With the exception of wisdom teeth, dentition was complete, the maxillary and mandibular dental arches were well-developed, and there were no primary positional anomalies. All molars bore partial crowns, one mandibular premolar had a gold inlay, but otherwise there were no restorations (Figs. 7 and 8). Maximal intercuspation was also clinically normal (Fig. 9). But after relaxing her chewing muscles by putting 2 cotton rolls, in the premolar region for about 2 minutes (Fig. 17) she showed preliminary contacts only in the area of her second molars indicating a discrepancy between centric relation and maximal intercuspation. Severe facets and a cusp fracture could be seen on the second lower molars of both sides (Fig. 8).

2. Instrumental TMJ diagnostics

Because this patient had reported having occasional TMJ problems, axiography was conducted (Fig.10).[23] For this, we routinely use the Cadiax Compact system by Gamma (Klosterneuburg, Austria) (Fig. 11). [28]

The device is simple to use and saves time, is very economically priced, and delivers (even without an additional computer) reliable data for both TMJ diagnostics and the adjustment of articulators by many different manufacturers. [23]

The electronic registration of the condylar pathways in this patient showed no abnormalities (Fig. 12).

3. a) Instrumental occlusion diagnostics in an articulator using a centric relation record

This patient exhibited marked clinical signs of occlusal interferences, confirmed by clinical occlusal diagnosis (cotton-roll-) test. After the temporomandibular joints were checked and nothing abnormal was found (see Fig. 12), the mechanical occlusion diagnosis was performed using an articulator and centric relation record.

Impression and Manufacturing casts

Carefully made dental stone casts from maxillary and mandibular impressions are required. Correctly mixed and processed alginate delivers adequate precision, provided that rim-lock trays are used with the correct adhesive (do not use perforated trays!). If the terminal teeth are within the range of the tray, an individual dam with, for instance a silicon material, is sufficient. If a terminal tooth lies outside the tray's range, an individual extension with a dam, e.g., of thermoplastic material, must be made. An individual palatinal stop must always be constructed for the maxillary tray, trimmed parallel to the dental arch to form an inner tray rim (Fig. 13). Shortly before inserting the impression tray, the occlusal surfaces of the teeth are coated with alginate; meanwhile, the assistant fills the tray. After removing the impression tray, excess alginate is generously trimmed off with a sharp knife in order to avoid unnecessary changes in dimension. Until pouring, the impression is stored

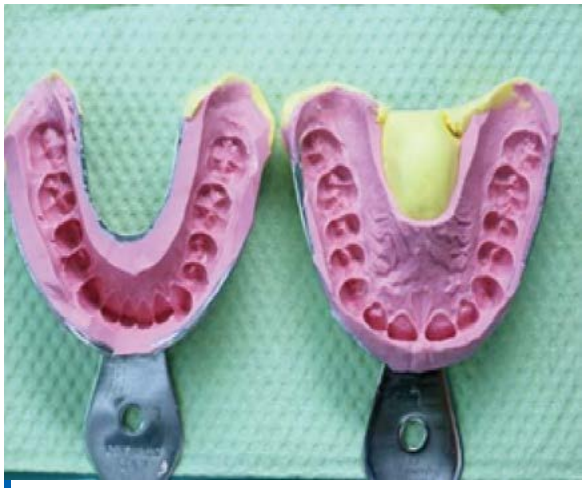


Figure 13. Carefully-made alginate impression with dammed and stopped Rim-Lock trays are essential for creating flawless working casts

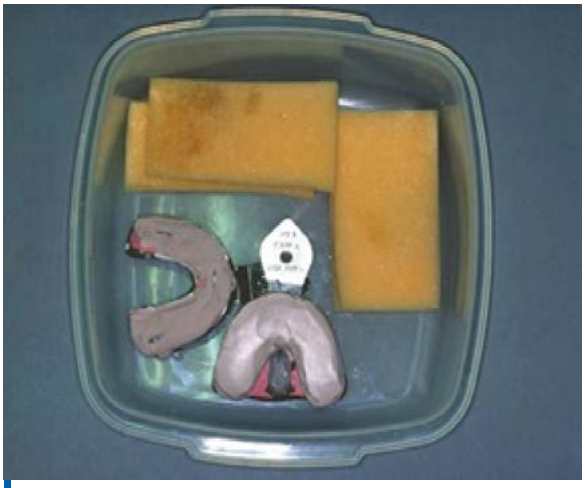


Figure 14. After pouring with dental stone, the models should be kept in a hygrophoree (air-tight plastic container) to harden

Figure 15. The completed casts of this patient fit tightly with no play in habitual position.

Figure 16. To prepare a centric relation record, the top side of a mounting tin foil plate is thinly coated with TempBond to take cusp impressions of the maxilla

in a hygrophore (e.g., air-tight plastic container with a damp sponge); it is never appropriate to wrap the alginate impression in wet paper towels or napkins, even for short-term storage. After pouring the impressions with dental stone, they should be stored in the hygrophore until the stone has hardened (Fig. 14), since this greatly improves the quality of the casts.[5]
In the habitual relation, this patient's finished casts fit tightly with no play, so that occlusal interferences were not discernable in this phase (Fig. 15). The casts are then mounted in the articulator and adjusted to the TMJ, as follows.

Centric relation record
Preparations are made for taking the centric relation record (synonym: bite registration). A mounting tin foil plate (or "Beauty Pink" wax) is cut to maxillary size, placed between the patient's teeth, and individually pre-formed through biting down with moderate force, creating a minimal opening of the bite. Next, the top and bottom surfaces of the mounting plate are coated with an adhesive polish. The top surface is then thinly coated with a eugenol liner (Temp Bond). Without using pressure, the plate is adapted to the maxilla, and held by two fingers in the area of the rows of teeth until hardening and removal (Fig. 16).
In preparation for taking the actual registration, the patient should sit upright and relaxed in the chair; the head should never be turned or stretched in any direction[20] To decouple occlusion and relax the muscles, slightly moistened cotton rolls are placed in the premolar region (Fig. 17)
In this case, a protrusion record for individually adjusting the horizontal condylar path inclination was not necessary, since the values for these angles (SKN) and the mediotrusion paths (TKN) were already available from the electronic registration (see Fig. 12).

Figure 17. Before taking the centric relation record, lightly moistened cotton rolls are inserted into the first premolar region to relax the patient's jaw muscles as much as possible

Figure 18. The registration plate is adapted to the maxilla. The mandible is gently (without force) rotated against the plate, upon the bottom side of which 4 aluwax drops were placed

Figure 19. After removing the plate, all 4 wax drops clearly showed impressions of mandibular cusps. When checking this on the patient, the mandible must reach these impressions repeatedly and without sliding off. If not, the last step in making the centric record must be repeated

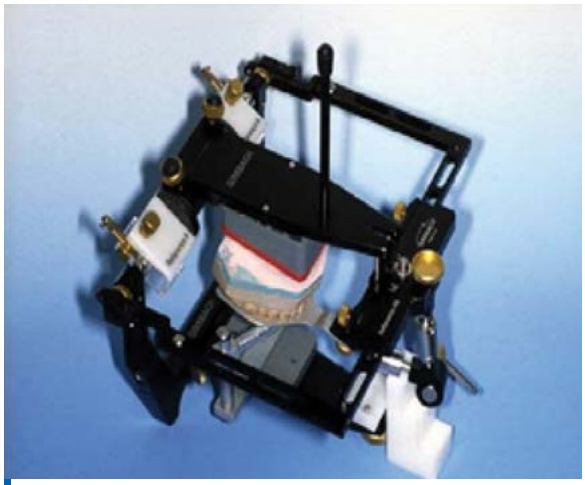


Figure 20. The anatomical transfer bow, with which the relation of maxilla and TMJs was registered, is fixed on the articulator. The maxillary cast is mounted accordingly

After removing the centric relation record, the casts mounted in the articulator showed a considerable discrepancy between the registered centric relation position (of the condyles) and the maximal intercuspation position of the teeth; premature contacts were visible in the molar area (Fig. 22) corresponding very well to what we had found clinically (cotton-roll-test). In habitual relation, the separated base of the maxillary cast indicates the presence of interference (Fig. 23). As a rule, malocclusions of this nature tend to lead to distraction effects in the TMJs with relatively moderate traumatization of these structures.

3. b) Confirmation of initial diagnosis: checking the centric relation record with therapeutic biteplates (centric splint)

Although the clinical findings from this patient – including the past orthodontic treatment which, as she said, was conducted without articulators adjusted for maxillomandibular relations – speak for the correctness of the observed occlusal interferences observed, but it was important to confirm the initial diagnosis with an interim splint therapy. The principle (centric splint) is very simple: The discrepancy found in the articulator is equilibrated through a custom-made bite-guard splint with equal support of all teeth (Fig. 24).

At this point, a warning is necessary: do not insert non-individualized splints, e.g., solely vacuum-drawn heat-treated polyvinyl sheets, because these tend to worsen the symptoms in the intermediate term[8]. With this particular patient, even more pronounced posterior premature contacts would result.

Asselmeyer has described the manufacturing of an appropriate bite-guard splint[5]. Composite is carefully and precisely added onto an

Figure 21. With the centric relation record in place, the mandibular cast is mounted on the articulator

Figure 22. After removing the record, a considerable occlusal discrepancy is obvious, which exactly corresponded to the clinical situation after the "cotton-roll-test"

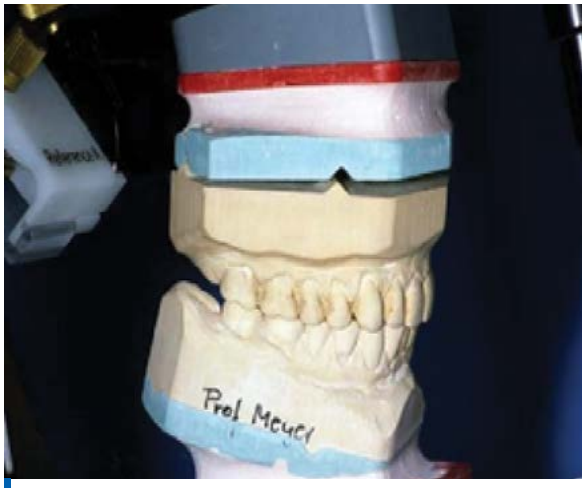


Figure 23. In the habitual relation, the separated base of the maxillary cast indicates strong premature contacts in the molar region

Figure 24. The bite-guard splint, individually constructed in the articulator, equilibrates the discrepancy between the centric and habitual relations (centric splint)

individualized vacuum-drawn heat-treated splint (which was first trimmed in the articulator to leave the smallest occlusal height possible) until the equal support of all posterior teeth results.

This occlusion concept corresponds to that of the Michigan splint by Ramfjord and Ash.[4] In contrast to natural teeth and restorations, the splint allows only the respective load-bearingcusps to contact, which antagonistically occlude with the splint. With a maxillary splint, this would involve just the buccal mandibular cusps, and with a mandibular splint, only the palatinal maxillary cusps would be involved (Figs. 25 and 26). **Fundamentally, maxillary and mandibular splints each have specific advantages and disadvantages.** This patient was given a maxillary splint, because this is the only one which can reconstruct an individual anterior tooth guidance which has a proven additional muscle-relaxing effect.[12,18] For this we use the Contour Curve Former (CCF, Whaledent International, New York, NY, USA), with which characteristics of anterior guidance can be formed to the individual patient (Figs. 27 and 28; see also Fig. 4).

Insertion of splint

The splint was inserted into the patient's mouth (Figs. 29 and 30). Attention must be paid to tension-free seating.

Exactly as in obtaining the centric record, the relaxed mandible is guided against the splint.

A disclosing paper 10 to 20 µm thick is used to check whether the load-bearing cusps produce even contacts on the splint; if necessary, corrections can be made with a milling cutter.

Subsequently, excentric movements are checked. In the initial phase, a slight canine guidance should be aimed for; in the present case, the individually formed anterior tooth guidance was checked and corrected.

The patient is advised to wear the splint as often as possible, especially at night, but not while eating

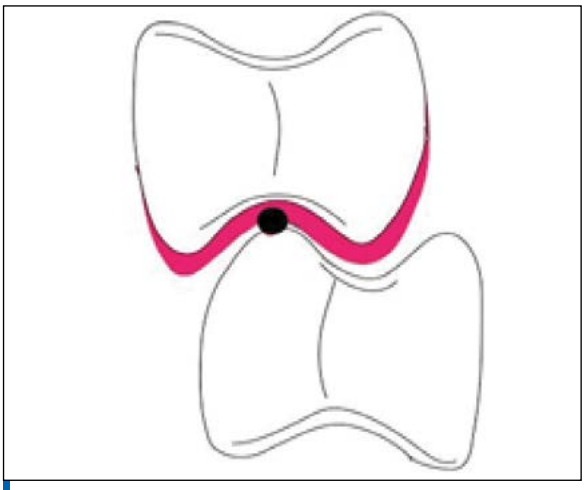


Figure 25. When a maxillary splint is used, only the supporting mandibular cusps may contact the splint

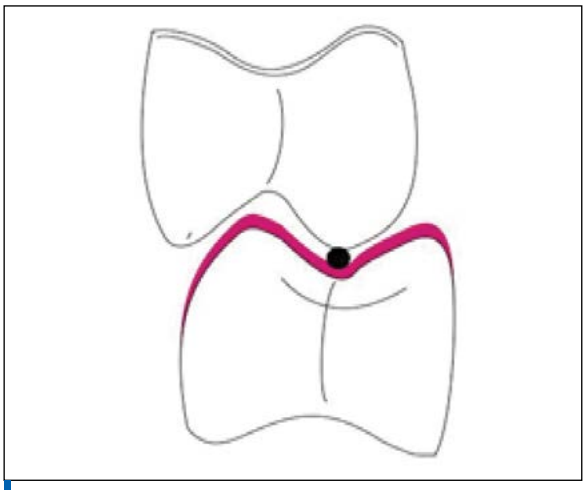


Figure 26. When a mandibular splint is used, only the supporting maxillary cusps should have contact points on the splint

Figure 27. On this splint, the individual contacts of the antagonistic cusps are evident. The surrounding regions are formed as shallow hollows with initial degrees of freedom in all directions. Anterior guidance was formed with the Contour Curve Former (CCF), which is only possible with maxillary splints

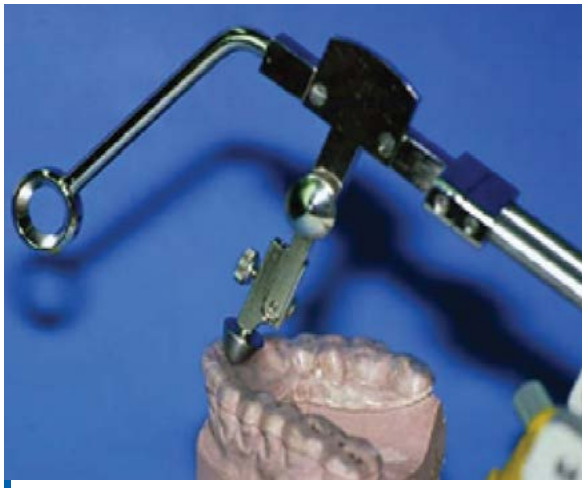


Figure 28. Using an auxiliary device for all conventional articulators (CCF), the characteristics of anterior guidance can be individually optimized for each patient

and not necessarily when speaking at length (lectures, etc.); the splint must be worn during periods of stress.

Re-examination and correction

The first re-examination must be conducted within the first 3 days if possible, or at least a telephone call should be made to the patient during this time. Within the next few weeks, several correction appointments are usually necessary, due to the fact that a change (improvement) of the mandibular position can be associated with increasing muscle relaxation, and the splint must be adjusted accordingly. In the present case, the patient was completely complaint-free within 3 months. She reported not being willing or able to do without the splint – at least when under stress. After about 6 complaint-free months, a new centric relation record was taken, which was then used to mount the casts in the articulator with the goal of a final occlusion analysis and further treatment planning. For instance, this could consist of orthodontic measures which can be simulated with a diagnostic set-up in the articulator. Plans for restorations can also be made in the articulator by diagnostic trimming and/or diagnostic waxing-up.

Glasses for the Dentition

In the end, the patient described here did not choose any of the options mentioned above. When needed (primarily at night and under stress), she simply inserts the splint.

As of the present day, she is free of headaches, TMJ problems, and tinnitus, despite continuing

Figure 29. Trying on the splint

Figure 30. A few weeks after starting splint therapy, the patient was free of headaches, TMJ pain, and tinnitus

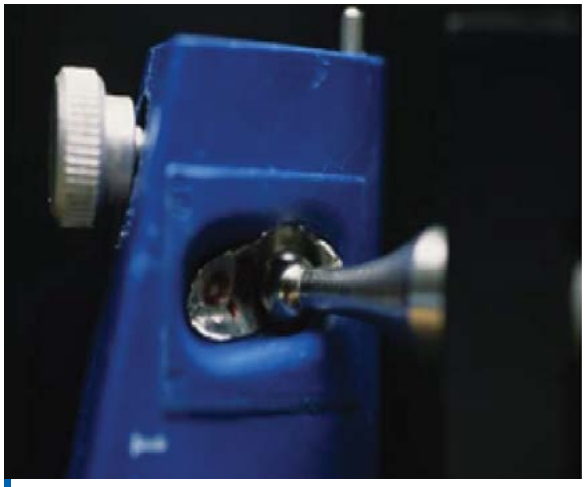


Figure 31. Decompression splint needs spaceholder of 0.8 mm in the condy-lar boxes of the articulator

Figure 32. The geometry of the decompression splint follows the manipulated geometry of the condylar boxes of the articulator

to work in a very intensive and responsible occupation. Recently, the patient reported not needing the splint at all during a sailing holiday in the Mediterranean.Stachniss therefore very appropriately termed the bite-guard splint "glasses for the dentition". [29]

Summary

The splint therapy presented here is the most common and recommendable standard therapy by far, which can primarily effect muscle relaxation and improvement of neuromuscular coordination [(24)]. However, successful implementation requires that, in centric relation and therefore in the splint position, the condyle-disc unit should be still largely intact and the interarticular space should not be constricted. The therapeutic approach consists in eliminating centric and eccentric occlusal disturbances, rebuilding lost support zones, and changing the mandibular motion pattern in order to improve muscle tone and neuromuscular coordination.[22] As a rule, it also leads to a more physiological positioning of TMJ structures with a positive, therapeutic effect. If TMJ pain persists nonetheless, targeted, geometric decompression of the very probably compressed articular structures should be performed. To this end, the splint described here can be modified into a decompression splint by inserting an approximately 0.8 mm space holder craniodorsally into the condylar box of the articulator on the side of the joint requiring decompression (also possible bilaterally)[24] (Figs. 31, 32). This yields a corresponding vertical increase of the splint, which in the patient can produce a ventrocaudal decompression of the compressed articular structures. It is strongly suggested that this special, often helpful type of splint therapy be conducted in association with muscle massages and physiotherapy exercises[14,27] because the jaw relations must adapt to the premature contacts which arise on the splint at first.

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Questions

Which is the normal range of desmodontal tactility?

❑ a. 10-30 µm;
❑ b. 100-300 µm;
❑ c. 1-3 µm;
❑ d. None of the above.

For how long did the patient suffer from massive tension headaches and occasionally tinnitus?

❑ a. 10 years;
❑ b. 20 years;
❑ c. 25 years;
❑ d. 35 years.

How large was the incisal edge distance of the patient?

❑ a. 5 mm;
❑ b. 25 mm;
❑ c. 40 mm;
❑ d. 60 mm.

How big should the space holder which is introduced into the splint to transform it into decompression splint be?

❑ a. 0 mm;
❑ b. 0.4 mm;
❑ c. 0.8 mm;
❑ d. 8 mm.