Werner Schupp, Wolfgang Boisserée, Maria Tabancis, Julia Funke

Initial therapy of occlusion

Werner Schupp

Key words *occlusal splint, temporomandibular disorder (TMD), temporomandibular joint (TMJ)*

In most cases the initial treatment approach for a temporomandibular disorder (TMD) is an occlusal splint. The occlusal splint has to be regarded as a reversible therapeutic method. A definitive continuing treatment in orthodontics can only take place after the splint has delivered an improvement of the symptoms. As well as its use for the therapeutic approach, the occlusal splint can also be used as a diagnostic tool, as it allows determination of the physiological, three-dimensional position of the mandible. From this position, definitive orthodontic treatment can be started.

Introduction

The primary occlusal therapy in patients with temporomandibular disorder (TMD) and in patients with imbalance between the habitual occlusion (centric occlusion, CO) and the occlusion in physiological condyle position (centric relation, CR) aims to achieve a physiological repositioning of the mandible and the temporomandibular joints (TMJs) by means of occlusal adjustments using splints.

This means that all occlusal disturbances can be eliminated and a normalisation of the malfunction and all associated structures in the temporomandibular system (musculature, temporomandibular position, stress on the teeth and periodontal structures) and the entire organism (head, body, spinal and pelvic function) can occur.

Only when the splint therapy proves to be effective can irreversible measures such as orthodontic treatment be initiated.

The effectiveness of occlusal splints

When indicated after a comprehensive diagnosis and planned accordingly, occlusal splints have a scientifically proven efficacy[1-3]. The effectiveness of the occlusal splint also extends to the entire musculoskeletal system[4-8], not only the temporomandibular system.

Occlusal splints abolish occlusal errors and normalise neuromuscular dysfunctions. Furthermore, the three-dimensional jaw joint position can be reversibly redefined with the aid of the occlusal splint. For this, the occlusal splint has to be made of a hard material. Splints that are made of soft plastic, the interceptor, plastic occlusal splints filled with liquid and other prefabricated splints can be used for a max-

Werner Schupp, Dr. med. dent.
Private Practice for Orthodontics, Cologne, Germany.

Wolfgang Boisserée, Dr. med. dent.
Private Dental Practice, Cologne, Germany.

Maria Tabancis
Training Assistant, Private Practice, Cologne, Germany.

Julia Funke, Dr. med. dent.
Training Assistant, Private Practice, Cologne, Germany.

Correspondence to: Dr. Werner Schupp, Fachpraxis für Kieferorthopädie, Hauptstraße 50, 50669 Köln, Germany. Email: schupp@schupp-ortho.de

imum of a few days as tonus-reducing therapy of chewing musculature and for the decoupling of the occlusion[2,9].

If splint therapy is successful, clinicians then decide whether it is sufficient to continue wearing the splint only at night or if orthodontic, restorative or a combined orthodontic-restorative treatment is required[10,11].

Preconditions of occlusal corrections using splints

The indication is given after diagnostic evidence of an occlusal involvement in the dysfunctional process has been established according to the diagnosis of the temporomandibular system and the musculoskeletal system, and if necessary the radiological diagnosis.

The splints are worn constantly, i.e. day and night. In habitual intercuspation there should be no occlusal contact during the total duration of the functional treatment, otherwise a direct reprogramming of the neuromuscular system and an adjustment to the malocclusion may occur. Thus, a neurological adaptation to the prospective, initial therapeutic occlusion is possible.

Immediately after manual treatment and physiotherapeutic treatment[12] the splints are corrected.

COPA occlusal splints

Definition

Since the splint is made and adjusted in accordance with the musculoskeletal system, it can rightly be described as a craniomandibular orthopaedic positioning appliance (COPA), illustrating the orthopaedic nature of the device[9].

Design features of COPA splints

The splint is generally fabricated for the mandibular arch. This has significant advantages. On the one hand, the mandibular splint can be worn 24 hours a day, since speech and aesthetic appearance are not or are only slightly impaired. On the other hand, the examination and correction of the occlusion is much easier, since the patient and the practitioner can sit upright during treatment. Furthermore, a COPA in the mandible ensures that the two halves of the maxilla are not blocked.

The splints restore the posterior support in the premolar and molar areas and thus lead to a functional compensation of the static occlusion. To achieve anterior guidance during the dynamic occlusion the splint extends to the canines, which take the lead in protrusion and laterotrusion, with simultaneous disclusion in the lateral area.

As a rule, the mandibular incisors are not covered by the splint. In doing so, the occlusal therapy can support the recovery process of the frequently occurring TMJ compression. The mandible is allowed to adjust freely to a new horizontal position during the occlusal treatment without creating a new anterior tooth contact. Since the splint therapy is limited to 3 to 6 months, the risk of a change in the anterior teeth position plays a subordinate role[13].

However, it is also possible to incorporate the mandibular incisors into the splint design. In this case, this must not result in a contact on the anterior teeth, which in turn could lead to a retrusive impulse on the mandible.

Waxed-up splint designs can be differentiated from non-waxed-up designs on the basis of the occlusal relief. On the basis of overall design, removable and firmly attached splints can be differentiated. The indications depend on the respective treatment case.

Various possibilities of splint therapy

Removable splints

Removable splints are the most frequent treatment measures for the initial occlusal therapy. The main advantage lies in the reversibility of the procedure. As a practitioner, it is thereby possible to take only a prospective approach to the systemic process. If the treatment does not have sufficient therapeutic effect, it can be discontinued without having caused an irreversible effect on the system. Since the TMD has an elusive and difficult-to-understand etiopathogenesis, this treatment approach is, in most cases, the means of choice when a correction of the occlusion is indicated.

Non-waxed-up occlusal relief with stops and canine guidance

The most common splint used by the present authors is a splint manufactured for the mandible with a sublingual strap that does not cover the incisors. The maxillary palatal cusps have an antagonistic stop; the buccal cusps do not

have an antagonistic stop on the splint. The splint has a canine guidance, which also assumes control during the protrusion. The manufacturing is shown in Figs 1 to 10.

Waxed-up occlusal relief

After sufficient diagnostics have been performed, it is useful to 'offer' the neurological system the best possible occlusion. This can be achieved with a splint with a waxed-up occlusal relief including canine guidance, which has been designed according to the biodynamic concept. The splint with occlusal surface design may preferably be used, when the physiological position of the condyle can be reliably determined at the very beginning. Unfortunately, a change in the course of the therapy by means of COPA is more complex than in the case shown in Figs 1 to 10 without any waxed-up occlusal relief.

Immediately after normalisation of the neuromuscular functions and cessation of the complaints, the therapeutic centric and eccentric occlusal concept can be tested and successively improved by means of subtractive or additive measures.

Non-removable splints

Non-removable splints are usually inserted only after the initial, reversible occlusal therapy has been performed and the re-evaluation of the functional therapy has indicated further treatment of the occlusion to secure the new therapeutic centric position of the mandible.

Ideally, the firmly attached splints provide support for a unilaterally missing posterior vertical dimension. Due to the firm grip of the splints, the therapeutic occlusion can be tested and adjusted from the beginning for later orthodontic therapy or prosthetic reconstruction.

A particular advantage of non-removable splints is that they can be designed with minimal thickness. Therefore, the definite occlusion can be tested reliably for the subsequent orthodontic treatment and/or prosthetic treatment. Non-removable splints can preferably be used with anterior open bite, as in this case they may be locked or raised as little as possible posteriorly.

In the initial phase of the occlusal treatment non-removable, waxed-up splints are only indicated if the further therapeutic procedure is reliably predictable. In most cases, non-removable splints are occlusally designed as for the removable splints with non-waxed-up occlusal relief (see above).

Directly manufactured COPA-onlays

Directly manufactured COPA-onlays represent a special form of orthodontic therapy, as discussed later in this article.

It must be determined individually for each patient which of these splints is used. With the permanent interaction between the TMJs and the whole body in mind, it is important to thoroughly comprehend the changes caused by the treatment. Therefore, all changes must be accompanied therapeutically, preferably in an interdisciplinary network.

The initial splint therapy usually lasts 3 to 6 months. It can be considered successful if the symptoms of the patient are resolved or have significantly improved and the control of the occlusion's pattern shows no changes for the following two or three appointments.

Practical procedure

The centric bite, which has been assessed in respect to its effect on the musculoskeletal system[14], forms the basis for the dental cast analysis. It is used for verification of occlusal disturbances as the cause for diagnosed occlusion-related symptoms in the temporomandibular and musculoskeletal system. If an occlusal cause has been detected a splint therapy is indicated. Accordingly, a distinction must be made between a diagnostic and a therapeutic dental cast analysis.

After mounting the maxillary dental casts arbitrarily or kinematically, the mandibular dental cast is placed into the articulator with the manually tested centric or construction bite record in place. For dental cast analysis, a different pair of dental casts, which may be different in colour, is produced. This pair remains untreated for documentary and forensic reasons. It illustrates the initial situation or the start of treatment.

Next, the diagnostic dental casts are duplicated in differently coloured dental stone material and then mounted exactly analogue to the initial casts. The splints are produced using this pair; therefore, the initial dental casts are not damaged.

If further therapy is necessary, this must be discussed before the start of treatment and must be documented in the treatment and cost plan.

Plato and Kopp[12] state that a comprehensive reconstructive therapy is necessary in 50% of all patients with TMD after completed splint therapy[8].

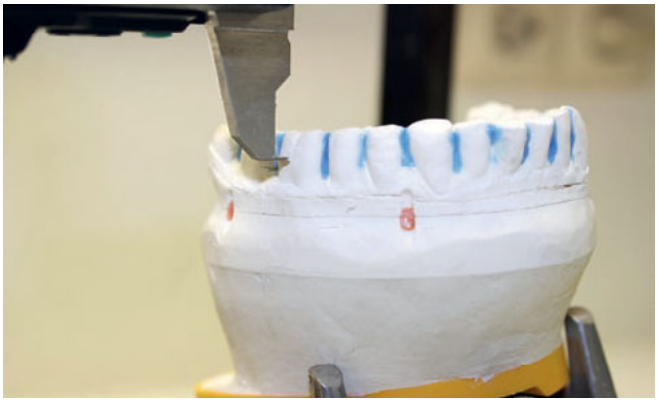
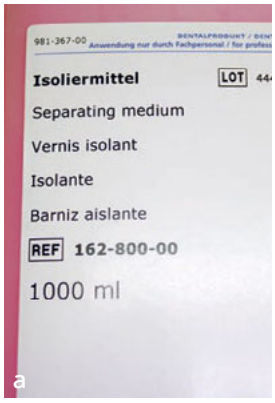


Fig 1 Measurement of the turning point.



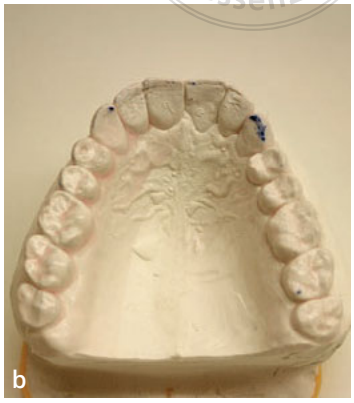


Fig 2a and b Separating the maxillary and mandibular plaster cast.

Contraindications and limitations of splint therapy

- Pronounced overbite combined with reclined maxillary central incisors: Under these conditions, the correct sagittal adjustment of the mandible would only be possible by means of a further rotation of the mandible. Therefore, orthodontic therapy combined with COPA-onlays is necessary in this case.
- Pronounced transversal crowding of the maxillary teeth with cross bite and tilting of the mandible: This situation also calls for functional joint therapy combined with simultaneous orthodontic treatment, or eventually surgical transversal development of the underdeveloped maxilla.
- Skeletal open bite, supraocclusion (Cave): The open bite can easily progress further. Under no circumstances may the splint be reduced in the posterior area. The bite should not be opened any further with the splint. Hence, a non-removable splint (see above) is appropriate in this case.
- Primary joint disorders: A splint therapy may lead to an aggravation of the joint complaints. A precise diagnosis as well as imaging procedures (digital volumetric tomography [DVT]/magnetic resonance imaging [MRI]), are required. If necessary, a surgical procedure should be applied.

The overall conclusion is that non-adjusted splints, especially those made from soft plastic, should not be used under any circumstances, although they are still frequently seen in general practice. Lechner[15] concluded in 2008 that "Whoever is still using these for the treatment of patients with craniomandibular dysfunction is, in my opinion guilty of medical malpractice".

The laboratory production of the COPA

If the mandibular arch shows a complete dentition, the occlusal surfaces are covered by the splint from the canines to the terminal tooth, while the mandibular incisors are generally not covered by the splint. In the anterior area, a lingual bow connects the right and left elements. On the lingual side, the splint extends beyond the clinical crowns to the gingival area in order to provide sufficient stability for the occlusal elements. However, these should be designed as flat as possible in order to ensure a good wearing comfort. On the buccal side, the splint covers the teeth of the premolars and molars to achieve a sufficient retention.

The single work steps are explained in Figs 1 to 10. For the plaster cast production the following steps are important:

- exact mixing in ratio of water and plaster;
- consistent mixing time in the vacuum mixing unit;
- 3 hours of dehydration and hardening;
- plaster class IV;
- preparation of the dental casts;
- removal of hard stone plaster pearls with the tip of an X-Acto knife.

Fig 3a and b Set of the acrylic resin.

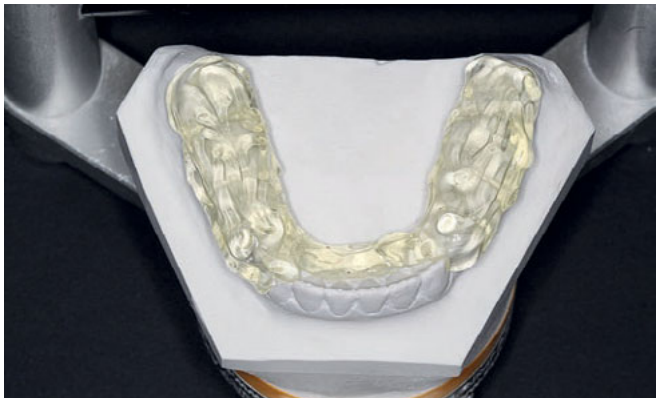


Fig 4 The state of the splint after acrylic resin is positioned all over the required surfaces.

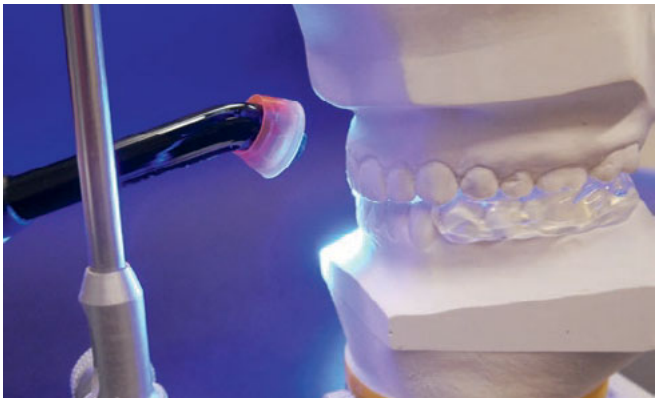


Fig 5 First hardening of the COPA material.

The manufacturing of the splints takes place with the plaster casts mounted in the articulator, in this case a SAM articulator (SAM 2P, SAM Präzisionstechnik, Munich, Germany).

The mounting of the casts was explained in the previous article "Continuing diagnostics and therapy of the temporomandibular and musculoskeletal system (TMS/MSS): The rest position of the temporomandibular joint (TMJ) and the therapeutic construction bite vs. the centric bite", published in the Journal of Aligner Orthodontics[16].

After mounting the plaster casts in the SAM articulator, the measurement of the turning point takes place (Fig 1). If significant undercuts exist, which would increase the friction of the splint, the interdental spaces are blocked out before continuing measurement. The margins of the splint follow the anatomical equator, which is marked with the aid of the parallelogram on the mandibular plaster cast. The splint should slightly overlap the tooth equator in order to ensure sufficient retention.

The dental surfaces of both plaster casts are separated with a separating medium (Ref 162-800-00, Dentaurum, Ispringen, Germany) (Fig 2).

The present authors use the Orthocryl LC Dentaurum (Ref 160-401-00) as material for this kind of splint (Fig 3). The maxillary part of the SAM articulator is lifted, so that the acrylic resin can be generously positioned on the required dental surfaces of the mandibular plaster cast (Fig 3b). This should slightly overlap the marked gingival margins to allow sufficient material for later finalising and polishing (Fig 4).

The maxillary part of the articulator is lowered so that dental impressions of the maxillary arch are produced in the acrylic resin. In order to fix the current state, the first hardening of the splint takes place using a dental curing light. The first hardening phase is completed after approximately 1 minute, when the maxillary plaster cast can be lifted up without the splint material adhering at it, but still being malleable (Fig 5).

Fig 6 Second hardening of the COPA material.

Fig 7 The state of the splint immediately after the completion of the light curing procedure.

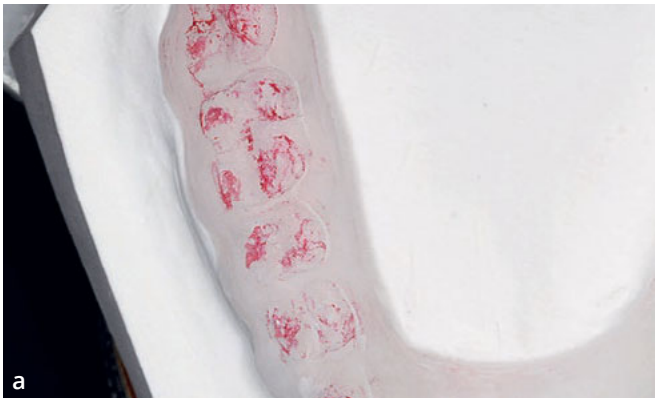


Fig 8a and 8b Assessment and correction of occlusal contact points.

Fig 9 The adapted occlusal contact points obtaining maxillary lingual stops to mandibular antagonists on posterior teeth.

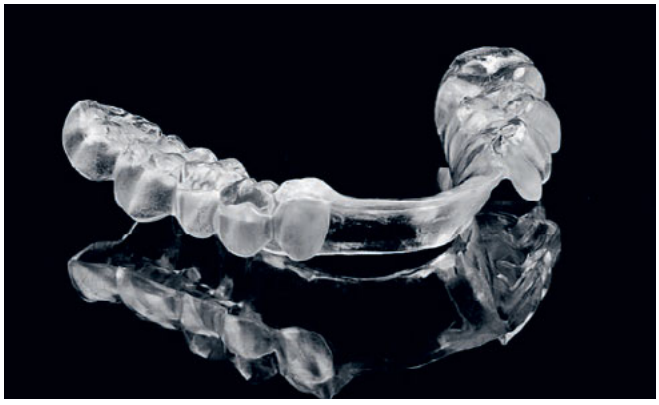


Fig 10 Completed COPA splint.

For the second hardening phase, the mandibular plaster cast is removed from the articulator and put into the light oven EyeVolution MAX (Dreve Dentamid, Unna, Germany). This procedure lasts about 10 minutes and takes place at a wavelength of at least 400 to 550 nm (Figs 6 and 7).

After finalising and polishing according to the predetermined gingival margin, the COPA-splint is airborne particle-abraded on the occlusal surface, so that the contacts can be better marked for the subsequent examination and finishing work. With both plaster casts mounted on the ar-

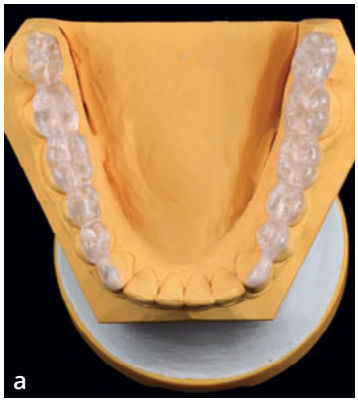


Fig 11a and b COPA-onlays are produced analogously (Reprinted from Boisserée and Schupp[10]).

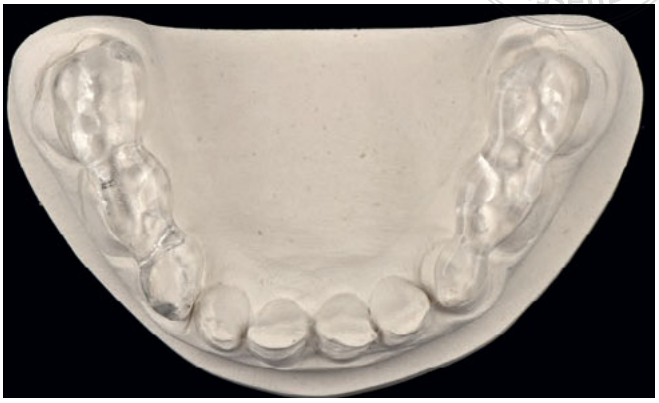
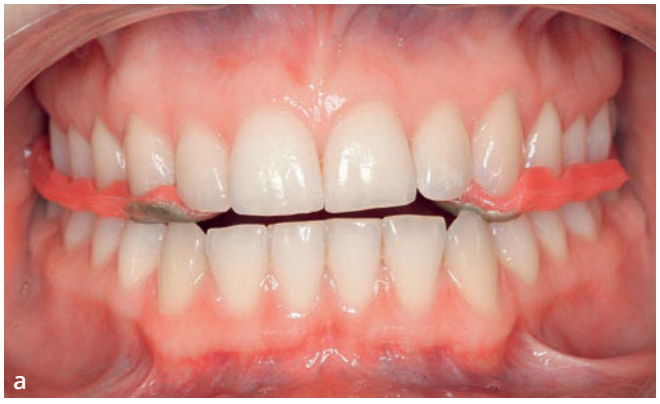


Fig 12 Dental cast of mandibular teeth in primary dentition with splint onlays (Reprinted from Boisserée and Schupp[10]).



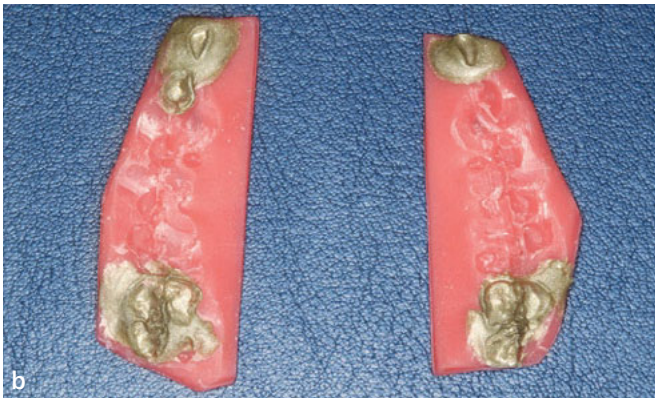


Fig 13a and b **a)** The therapeutic construction bite is tested in the patient's mouth. **b)** The therapeutic construction bite outside the mouth, made of Beauty Pink wax, extra hard (Integra Miltex, York, PA, USA) and aluminium wax (Reprinted from Boisserée and Schupp[10]).

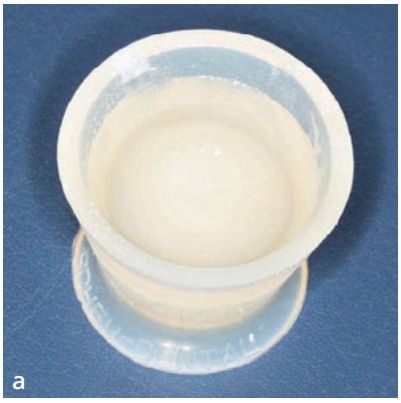
ticulator, the occlusal contact points are marked with black occlusion foil and contacts are repeatedly reduced (Fig 8). The aim is to obtain maxillary lingual stops that correspond with the mandibular antagonists in the splint. The process is repeated until all hyperbalances are removed and the occlusion appears to be stable (Figs 9 and 10).

Indication, manufacturing and integration of directly manufactured COPA-onlays

In cases with acute TMJ pathology such as localised pain, initial dislocation of the disc or a recaptured disc after complete dislocation of the disc, fixed splints are suggested, which are bonded from the mandibular canine to the mandibular terminal molar on each side (Fig 11). For an accompanying aligner treatment, COPA-onlays are often required on the molars. COPA-onlays can also be used in the primary dentition (Fig 12). For the manufacturing of COPA-onlays, a therapeutic construction bite is implied[16]. The fabrication and bonding procedure are illustrated in Figs 13 to 19.

Bonding process:

- The surface of the molars is cleaned and polished.
- The cleaned surface is airborne particle-abraded briefly with 50-µm aluminium oxide. Metal and ceramic surfaces are abraded for longer (Fig 16a).
- The enamel is conditioned with 33% phosphoric acid for 10 seconds, the acid is rinsed off and the surface air dried (Figs 16b and c).
- The bonding of the splints is carried out with a very thinly flowable bonding system, B (Maximum Cure un-



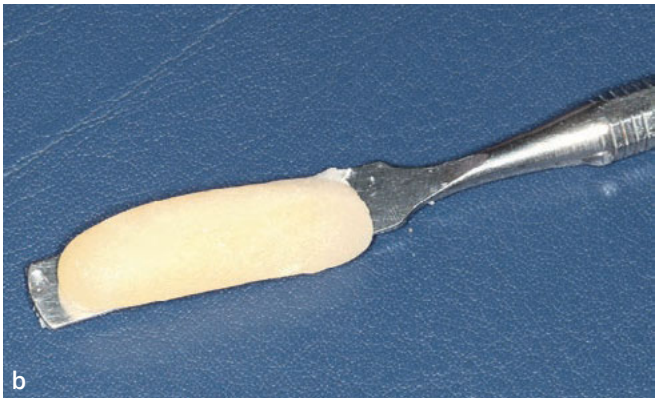
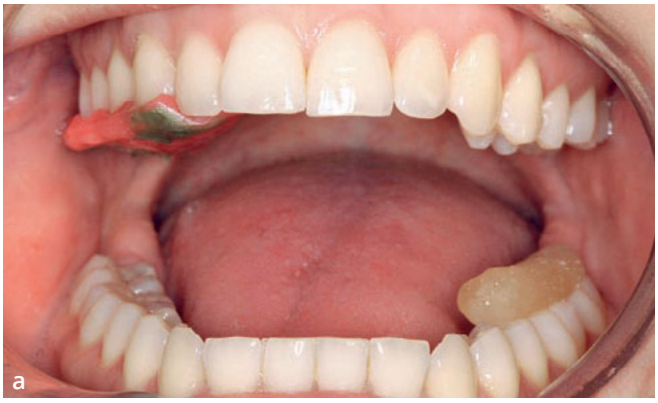


Fig 14a and b The autopolymerisation material is prepared; the dimensionally stable but still soft plastic can be used for the direct splint manufacturing (Reprinted from Boisserée and Schupp[10]).



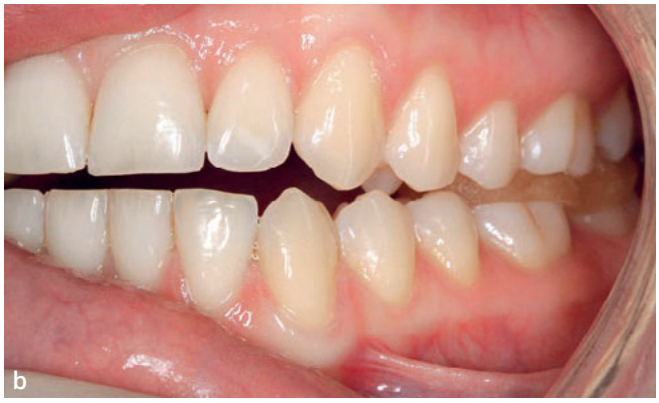
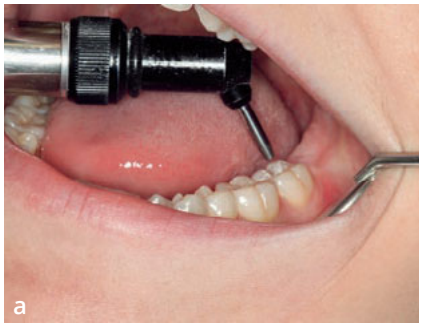
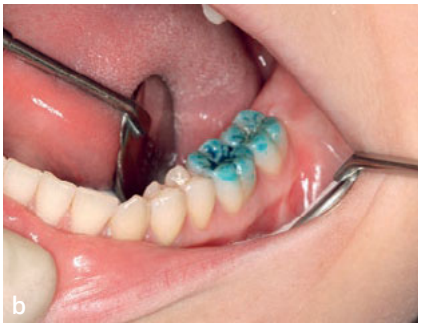


Fig 15a and b The therapeutic construction bite is incorporated in the maxilla; plastic is allied on the mandibular left teeth, as the patient is guided by the therapeutic construction bite into occlusion (Reprinted from Boisserée and Schupp[10]).

filled Paste A and B; Reliance Orthodontic Products, Itasca, IL, USA). The bottom of the splint is airborne particle-abraded and conditioned with a primer especially for plastic.

- The bonding material is applied and spread on the tooth and the base of a splint using a brush (Fig 17).
- The splint is inserted, held and the surplus bonding material is removed (Fig 18).
- When the bonding material is hardened, the edges of the splint and the interproximal spaces are cleaned (Fig 19).





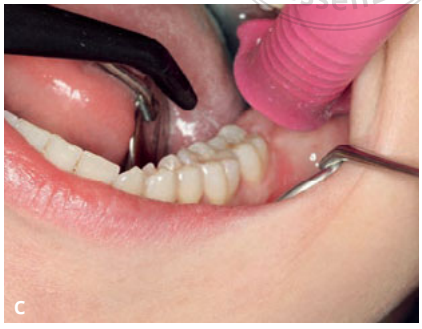


Fig 16a to c Preparatory measures before insertion of the splints. The occlusal surfaces are airborne particle-abraded with 50-µm aluminium oxide. The tooth surfaces are conditioned, rinsed with water and subsequently dried (Reprinted from Boisserée and Schupp[10]).

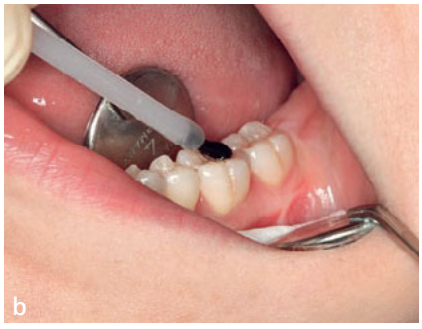
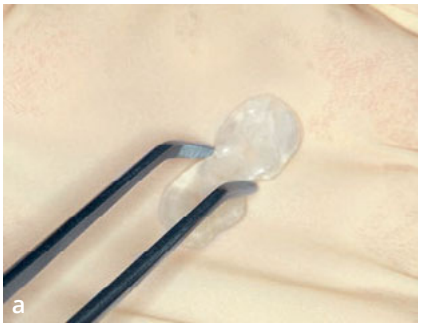


Fig 17a and b The thin-flowing bonding material is mixed and applied to the conditioned tooth surfaces as well as to the base of the splint (Reprinted from Boisserée and Schupp[10]).



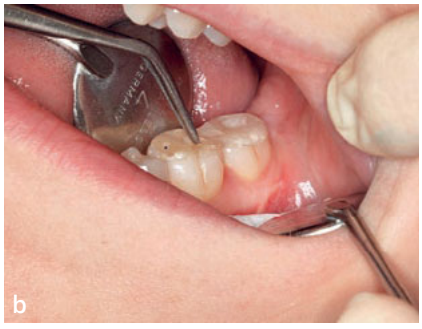


Fig 18a and b Insertion of the splint (Reprinted from Boisserée and Schupp[10]).

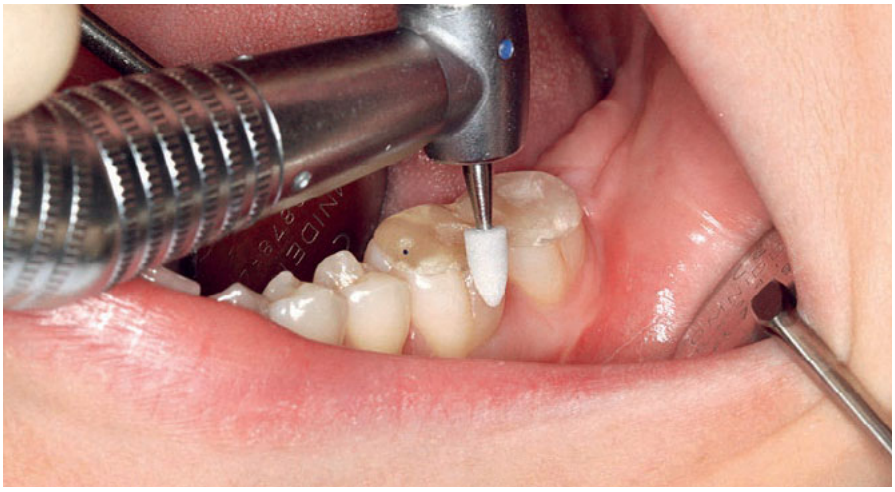


Fig 19 Polishing and removal of surplus bonding material (Reprinted from Boisserée and Schupp[10]).

Inserting, checking and correcting the removable splint

Insertion

The splint is checked for correct fit; it must not rock and should have a firm grip on the teeth. Uncomplicated removal should be possible by lifting the outer edges in the area of the canines. Once inserted, the splint should not be further adjusted. Instead, the practitioner has to rely on the correctness of the registration and the correct production of the splint.

The patient, or rather his/her neurological system, is given some time to adapt to the new therapeutic position. In the beginning the splint may be uncomfortable to wear, especially when the record has been prepared after manual pretreatment.

The first control

After 7 days, the bite splint is controlled for the first time, usually after manual pretreatment by a doctor of manual medicine or physiotherapist[12].

Between the manual therapy and the appointment in the dental practice, the patient uses an Aquilizer (Jumar Corporation, Prescott, Arizona, USA) or a Gelax Relax Bite Pad (Dentrade, Cologne, Germany), so he/she cannot bite in an incorrect occlusion. If this pretreatment does not occur, it is recommended to mobilise the TMJs before the session. In addition to the static occlusion, this session also concentrates on the dynamic occlusion and, if necessary, adjustment measurements can be taken.

As a rule, a follow-up appointment is scheduled 2 weeks later, also taking into account a pre-appointment with the doctor of manual medicine or physiotherapist.

With increasing normalisation of the neuromuscular functions and cessation of complaints, the future centric and eccentric occlusal concept is tested and adjusted by subtractive or additive measures.

Control protocol

Further controls, depending on the individual case, are carried out in weekly intervals up to the fourth or fifth week. A new functional analysis is carried out after 6 months at the latest for re-evaluation of the treatment.

A temporary aggravation of the symptoms is possible. This can be attributed to changed loading and changes in head and body posture. The complaints are therefore located in the area of neuromuscular regulation.

Occlusal evaluation and head posture

Since the head posture has an influence on the jaw relationship, during all corrective measures, it is important to maintain an upright posture and, in particular, a straight head position of the patient. A slight retroflexion can lead to a dorsal displacement of the mandible and to a reinforcement of retro-occlusal contacts.

One point of reference regarding the straight head position is the Frankfurt horizontal plane and the bipupillary line. In this reference position, the patient should be able to move reproducibly and without force out of the physiological rest position into the centric relation. The reproducibility of the occlusion can ultimately only be assessed by means of a dental magnifier.

Practical execution of the splint corrections

Small corrections can be made by direct grinding measures. The splint is taken out of the mouth in order to perform the grinding measures. Correction is carried out under magnification using a round diamond bur. Under certain circumstances, two occlusion foils are needed to support a uniform movement of the mandible.

First, the static occlusion (black occlusion foil) is ground. The contacts are never completely eliminated, but only reduced to the direction of the centric contact.

After a uniform occlusion has been reached, the correction of the dynamic occlusion is addressed. The protrusion is examined with blue occlusion foil, latero- and mediotrusion are marked with red occlusion foil. Particular attention should be paid to the correct guidance of the protrusion and laterotrusion over the canines and premolars and on interference-free movement.

Major corrections can only be carried out by remounting the splint in the articulator. For this purpose, the antagonistic teeth and the splint are first isolated with Microfilm (Kerr, Bioggio, Switzerland) and the surface is air dried. Bite Compound (GC, Leuven, Belgium) is heated and applied to the posterior area of the splint. Before inserting the splint

into the mouth, it must first be immersed in water at 56°C, so that the Bite Compound is not too hot and does not adhere to the opposing teeth.

The patient occludes while sitting upright with a straight head posture. After curing, the compound is cut back with an X-Acto knife and the occlusion is checked for uniform contacts. If necessary, the impressions are completely cut back and a new layer of Bite Compound is applied.

The new occlusion is checked on the musculoskeletal system. After remounting the splint in the articulator and subsequent split-cast control, the splint is successively ground.

Discussion

Occlusal splints have proven to be effective for reversible treatment of TMD. Furthermore, they should be used for the detection of the physiological TMJ position in the discrepancy between the centric occlusion and the centric relation[17]. The definitive orthodontic treatment can only be started when an unambiguous three-dimensional mandible position is defined. The initial splint therapy usually lasts 3 to 6 months.

As a result of the occlusal correction by means of the splint, there is a resultant effect on the musculoskeletal system[7,18-20]. If the splint therapy results in an improvement of health and if the occlusal contacts on the splint are clearly reproducible, the orthodontic aligner therapy can be started. In the case shown, it was possible to use parts of the splint as fixed bonded occlusal splints in the first course of orthodontic treatment[10,11,21]. Post-orthodontic retention by means of a bonded lingual retainer in the mandibular arch and a retention splint in the maxillary arch is advisable.

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