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Splints: Decoded

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Splint therapy is a proven modality for alleviating the pain of many types of temporomandibular disorders and bruxism, though questions still remain regarding how splints work. Despite the predictable results of the therapy in treatment of temporomandibular dysfunction, it is still considered by many clinicians as a mysterious treatment as the physiology of treatment response is less understood. The purpose of this article is to provide an understanding of various aspects of splint therapy like how splints work, what are the various splint types and their uses, functions of a splint how to ensure their proper design, fabrication, and adjustment.

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I. Introduction

Splint therapy may be defined as the art and science of establishing neuromuscular harmony in the masticatory system and creating a mechanical disadvantage for parafunctional forces with removable appliances. A properly constructed splint supports a harmonious relation among the muscles of mastication, disk assemblies, joints, ligaments, bones, teeth, and tendons.[1]

Types of splints:
Okeson classified splints as:[2]
1) Stabilization appliance/ Muscle relaxation appliance used to reduce muscle activity.
2) Anterior repositioning appliances (ARA)/ Mandibular orthopedic repositioning appliance (MORA)

Other types:
a) Anterior/Posterior bite plane
b) Pivoting appliance
c) Soft/ resilient appliance (silicone)

Dawson classified splints as:[3]
1. Permissive splints/ muscle deprogrammer.
2. Non-permissive splints/ Directive splints
3. Pseudo permissive splints (e.g. Soft splints, Hydrostatic splint)

1.**PERMISSIVE SPLINTS**:[1]

A permissive splint allows the teeth to move on the splint unimpeded, which in turn allows the condylar head and disk to function anatomically. Examples of permissive splints include bite planes also called as Anterior midpoint contact splints (anterior jigs, Lucia jig, anterior deprogrammer) and stabilization splints also called as Full contact splints (flat plane, Shore, Tanner, superior repositioning, and centric relation splint)

Anterior midpoint contact splints: (fig 1)

Anterior midpoint contact permissive splints are designed to disengage all teeth except incisors.[4] EMG studies by Becker has shown that molar contact allows 100% clenching force; cuspid contact permits approximately 60% maximum clenching force; and incisor contact minimizes elevator muscle clenching force to 20% to 30% of maximum clenching force.[5]Therefore, muscle clenching forces are reduced significantly when contact is isolated exclusively on the incisors. This type of splint, inserted during parafunctional movements, provides an immediate reduction of occlusal forces, and prevents their destructive impact on the masticatory system, which results in preventing/minimizing the effects of wear on the teeth.[(5,6)] Bite plane therapy may be used when a muscle disorder is suspected Muscle disorders are initiated by hyper occlusion; bite planes separate the teeth, allowing the muscles to relax. It is mainly recommended in patients with acute or chronic muscle pain

if the plane splint is without effect. The width of the midpoint contacting platform is limited to the width of the two lower incisors, measuring 8-10mm. Anterior midpoint contact permissive splints include nociceptive trigeminal inhibition (NTI) splint, Lucia Jig

FIG 1 Anterior Midpoint contact splint

Fig 2 Stabilization splint

Stabilization splints:(fig 2)

These types of splints are commonly used for treatment of masticatory dysfunction signs and symptoms such as muscular pain, TMJ pain, clicking, crepitus, limitation of motion and incoordination of movement. The stabilization splint provides: adaptation of the craniomandibular structures by raising the vertical dimension, occlusal stability, neuromuscular reprogramming and condylar self-positioning within the articular fovea, elimination of dysfunction symptoms and signs of degenerative joint diseases. This type of splint is constructed with even posterior contact in centric relation with condyles seated, separation of posterior teeth in protrusive or lateral excursions. It can cover maxillary or mandibular dentition. [(7)]

In a study Carraro and Caffese (1978) described the response of 170 TMJ patients treated with a full coverage stabilization splint. 82 % of subjects responded favorably to the splint therapy. Symptoms of TMJ pain, muscle pain or dysfunction all improved. 37 % of patients were cured and 45 % improved. Pain symptoms were significantly more likely to be cured than dysfunction symptoms, clicking being the most difficult dysfunctional symptom to eliminate. [(8)]

2. **NON-PERMISSIVE SPLINTS:**

A nonpermissive splint has a ramp or "indentations" that position the mandible inferiorly and anteriorly and secure it there. An example of a nonpermissive splint is a repositioning splint (anterior repositioning appliance [ARA]) (Fig.3) and a mandibular orthotic repositioning appliance (MORA). These types of splints are also called as directive splints. Directive splints guide the mandibular condyles away from the fully seated joint position when a painful joint problem is present. Such splints prevent full seating of the joints by guiding the mandible into a forward posture on closure into the occlusal splint.

Anterior Repositioning splints: (fig 3)

Anterior disk displacement is functionally classified as displacement with or without reduction. Displacement with reduction is clinically characterized by reciprocal clicking. To treat this disorder, Farrar in 1971 suggested the use of a splint that positioned, the mandible anteriorly in order to maintain the disk in a normal relationship to the condyle.[9] This method of treatment has been widely adopted since then. If complete reduction is possible but not maintainable, a directive splint is used to position the condyle in the disk to prevent it from slipping back past the posterior band.[10]

In cases with severe retrodiscal trauma with edema, directive splint is used to hold the condyle forward to prevent compression of the retrodiscal tissues. The patient should be weaned off the splint as early as possible to avoid irreversible fibrotic contracture of the superior lateral pterygoid muscle.[3]

Fig 3 Anterior repositioning splint

Posterior Bite Plane Appliance (Mandibular Orthopedic Repositioning Appliances: MORA)[11]

These appliances made to be worn on the lower arch. The design consist of a bilateral hard acrylic resin table, creates a disocclusion of the anterior teeth, located over the mandibular molars and premolars and connect with a lingual metal bar. These appliances intended to produce vertical dimension and horizontal maxillomandibular relationship changes. Posterior bite plane appliances were supposed to produce an "ideal" maxillomandibular relationship, and should be followed by occlusal procedures to maintain that relationship permanently. The major concern regarding posterior bite plane design is that occlusion only on posterior teeth that allow overeruption of the anterior teeth or intrusion of the opposing posterior teeth, eventually lead to a posterior open bite.

Fig 4: posterior bite plane appliance

PIVOT SPLINTS: Distraction splint(fig 5) Treating an injured or painful articulation with traction is common in physical medicine.[12] Pivot is a hard-acrylic splint that covers one arch and usually has a single posterior tooth contact in each quadrant. This contact is usually established as far posteriorly as possible. The proposed effect is that the condyles are pulled downward upon clenching on the pivot, thereby relieving traumatic load and giving the disc freedom to reassume a normal position. Unloading is desirable in patients with internal derangements and intracapsular inflammations[11]. But studies[13][14] have concluded that there is no distractive effect on the TMJ by occlusal pivots and instead of that can actually lead to compression of the joint, As in

craniofacial configuration of most patients the elevator muscle lies on or posterior to the most distal tooth, therefore contraction of the closing muscles does not result in joint unloading. The closing vector must be anterior to the pivot for distraction to take place. A modified version of this appliance with a unilateral pivot placed in the posterior region so that when the mandible close on this pivot this will load the contralateral joint and slightly distract the ipsilateral joint. Unfortunately, a potential adverse effect with the use of this modified appliance may cause occlusal changes as a posterior open bite in pivot area.

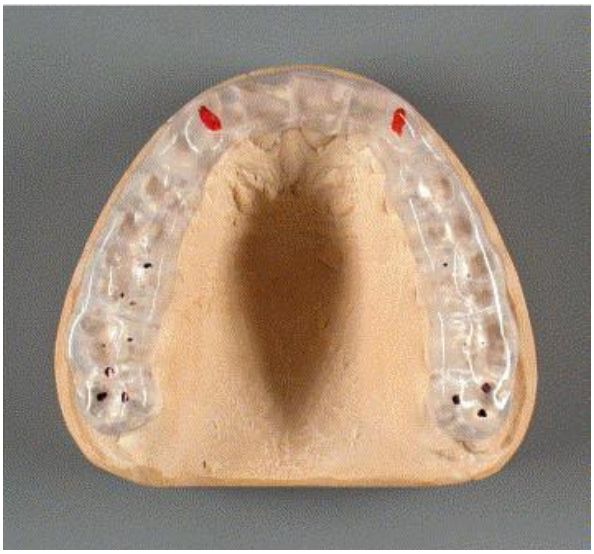

Fig 5 Pivot splint

Pseudo Permissive Splints:

Soft splints and hydrostatic splints (Aqualizer) are considered as pseudo-permissive splints, as their functions are extremely different than those of the permissives. These splints can exacerbate bruxism, possibly due to premature posterior contacts related to the fact that these splints cannot be balanced[(15)].

Soft rubber splint: (fig 6)

This appliance is generally made of a resilient material (2 of polyvinyl sheet). This splint should be worn only at night and generally produces symptomatic relief within 6 weeks. The soft splint is less likely to cause significant occlusal changes that are occasionally noted with hard occlusal splints. They are used to reduce symptoms of joint dysfunction or myalgia, to prevent bruxism and clenching and as a protective device in athletes. But these appliances can exacerbate the bruxism probably due to the inability to achieve balanced occlusal contacts.[(15)]

Fig 6 soft rubber splint

Hydrostatic splint: (Commercial name: Aqualizer)

It employs water to balance the biting pressure, to treat malocclusion and to relieve TMJ pain and symptoms associated with TMDs. This unique appliance was designed by Lerman [(16)]over 30 years ago. The Aqualizer®

applies a physical law of nature called Pascal's Law, meaning that when you bite down on the Aqualizer®, the fluid is evenly distributed across the entire bite. Use of Aqualizer™ is indicated in TMJ pain, headache, neck and shoulder pain and stiffness, orthodontic-triggered muscle pain during treatment, pre-surgical differential diagnoses, post-surgical pain and inflammation. It has flexible fluid layer that equalizes all bite forces by preventing tooth to tooth contact .The Aqualizer™ has unique water system that immediately optimizes biomechanics, supports the jaw in a comfortable position, removes the teeth from dominance, placing bite and body in harmony, straightens the bite to maximize other structures, enables systemic function and balance, allows the body to naturally balance itself, finds perfect occlusal balance after starting the treatment immediately .[17]

Summary of various types of splints and their uses

TYPE OF SPLINT	USES
BITE PLANE SPLINT: anterior jig, Lucia jig, NTI	- Treatment of muscle disorders, especially myospasms, that originates from an occlusal condition. - Parafunctional activity associated with unfavorable posterior tooth contacts
STABILIZATION SPLINT: Flat plane, Shor, Tanner, Centric relation splint, superior repositioning.	- treatment of Muscle and joint pain from occlusal contact discrepancies or parafunctional habits. - mandibular position deprograming. - Vertical dimension alteration
REPOSITIONING SPLINT: anterior repositioning splint, orthopedic positioner	- To treat disc-interference disorders. - In patients with joint sounds such as single or reciprocal clicks. - Inflammatory disorders. - To unload the TMJ or stretch the joint.

PIVOT SPLINT: Distraction splint	- For the treatment of symptoms related to degenerative joint diseases.
SOFT SPLINTS:	- To reduce symptoms of joint dysfunction or myalgia, to prevent bruxism and clenching and - as a protective device in athletes. - Emergency appliance - Extremely sensitive posterior teeth due to chronic sinusitis.
HYDROSTATIC SPLINTS: Aqualiser	- TMJ pain, headache, neck and shoulder pain and stiffness - orthodontic-triggered muscle pain during treatment - pre-surgical differential diagnoses - post-surgical pain and inflammation.

Functions of Splints:

a) **Relaxation of muscles**:

Studies have shown that lateral pterygoid muscle is hyperactivated whenever there is tooth interference in the centric relation arc of closure, and elevator muscle gets hyperactivated whenever there is tooth interference due to extrusive mandibular movements. This elevator muscle hyperactivity is reduced by eliminating the posterior excursive contacts by anterior guidance. Muscle relaxation is obtained with the use of occlusal splints by providing a platform for the teeth, so as to allow the equal distribution of tooth contacts and by immediate posterior tooth disocclusion in all movements using anterior guidance.

b) **Seating the condyle in CR**:

When the superior belly of lateral pterygoid muscle is in full extension due to minimal positioning muscle hyperactivity the condyle/disc assembly seats in CR. Temporomandibular joint is a load bearing joint especially during parafunctional activities and forceful biting or mastication.[(18)(19)]The temporalis and masseter muscles are the main elevator muscles to exert maximal force, while loading, when lateral pterygoid muscle and disc is totally relaxed in its physiological position. Any type of hyperactivity of lateral pterygoid muscles due to occlusal stimuli pulls the disc anteromedially towards the origin of muscles resulting in displacement of condyle/disc assembly, which leads to the damage of disc, muscles ligaments and condyle head. The overloading of condyle/disc assembly which can be acute or chronic, out of physiological limits lead to the development of TMD. Now the function of splint is to provide the occlusion with the properly relaxed elevator muscles which in turn allows the condylar disc to remain in anterosuperior position over the CR as physiological position. In case when there is pain of the joint due to the inflammation the condyles are placed in anterior inferior position till symptoms of pain subside so as to achieve CR.

c) **For providing diagnostic information:**

Splint therapy is a useful diagnostic tool for restorative dentistry. Wearing a splint gives the information about the TMD status, bruxism habits and wear pattern. Whenever splint is given to a patient the splints show wear pattern which can be reintroduced in natural dentition after stopping the splint therapy. Different people show different occlusal schemes depending upon the chewing habits which varies with people having horizontal grazing pattern and vertical chopping bite.Wear patterns obtained on splints gives information about the envelope of function, neutral zone, axial loads, occlusal configuration, choice of material to be used, cusp heights and shapes and guidance angulations to be introduced in restoration. Splint therapy also reveals the anatomical and physiological status of the TMJ.

d**) It protects teeth and other structures from Bruxism**:

Bruxism is defined as "grinding or clenching of teeth at other times than for the mastication of food". Lots of studies has been done to find the force of bruxers and all the studies revealed the nocturnal force of clenching is always much higher than the normal day clenching.The average clenching force in humans has been recorded 162 lbs./sq. Inch while as it is 6 times more in bruxers. As per the study carried out by the Holmgren[20],the splints do not stop the bruxism habit but it distributes the force uniformly, thus reducing its harmful effects on the dentition and the TMJ. Before doing the restorative treatment, bruxism should be identified and the signs and symptoms should be encountered.

e) **Tomitigate periodontal ligament proprioception:**[1]

Each tooth root is covered by periodontal ligament, these periodontal ligaments of each tooth send nerve messages to the central nervous system. They indicate the amount of force on individual teeth and can trigger the muscle to change pattern in order to protect teeth from overload. The function of splint is to provide uniform contacts,by covering over a large surface of teeth. and thereby redistributing the force. To obtain uniform contacts and balance, regular adjustment and modification of splints is required.

f) **To stabilize unstable occlusion**:

Occlusal splints have been shown to reduce the symptoms of TMJ dysfunction and are thought to relieve the neuromuscular responses caused by occlusal interferences. [21]The literature has shown that tooth interferences to the CR arc of closure activate the lateral pterygoid muscles.[21,22] The clinical benefits of anterior guidance were demonstrated by Williamson and Lundquist.[23] A splint limiting excursive contacts to the anterior teeth shut down the masseter and anterior temporalis activity that normally occurred with posterior tooth contact. Williamson and Lundquist concluded that anterior guidance was necessary to reduce muscle activity. Even 50μm occlusal interferences can initiate changes in coordinated muscle activity.

g) **To promote jaw muscle relaxation in patients with stress related pain symptoms like tension headache and neck pain of muscular origin**:

Headache is observed in many TMD patients.[24] The effectiveness of splint therapy in reducing head and neck pain and muscle hyperactivity is well documented by Manna A et all.[25] It has also been demonstrated by Shankland that hyperactive temporalis muscles are responsible for tension headaches as well as creating noxious stimulus for sympathetic vascular changes that provoke migraines.[4]

A specific anterior deprogrammer known as the nociceptivetrigeminal inhibition (NTI) appliance has been approved by the FDA for the prevention of medically diagnosed migraine headache pain.

II. Splint selection

WHICH MATERIAL: HARD VS SOFT SPLINT? [11]

Commonly there are two different materials, based upon consistency, which are used in the fabrication of occlusal appliances. There are hard acrylic resin Occlusal appliances that are either self-cured (by chemical reaction) or heat cured, resulting in hard and rigid tooth-borne and occlusal surface. In other hand, there are soft or resilient occlusal appliances, the soft appliance is somewhat flexible and pliable tooth-borne and occlusal surface. A third variation of material known as dual laminated, as its occlusal surface consists of hard acrylic resin and the tooth-borne surface consist of a soft material. This produces an occlusal appliance with advantages of a soft material (fitting well and providing comfort for the supporting teeth), and an adjustable occlusal surface of the hard-acrylic resin.

Hard acrylic resin occlusal appliances have several advantages over the soft appliances; hardness and resistance of the acrylic resin enable easily and quickly adjustments, easily repaired, the fit of a hard-acrylic resin is more accurate, methods of fabrication are more reliable and greater longevity, more color stable, less food debris accumulation and more durable than that of the soft version. In contrary, the adjustment of soft material is more difficult and often results in a less adequate occlusal scheme. And these appliances are more susceptible to wearing that in turn result in occlusal changes.[26]

Form economic point of view the soft occlusal appliance compared with the hard appliances are of low cost. Soft occlusal appliances recommended by some investigators for the reduction of both muscular and arthrogenous TMD symptoms. However, in an electromyography (EMG) crossover study by Okeson, between hard and soft occlusal splints involving ten bruxism subjects, the authors found that majority of subjects experienced a significantly reduced nocturnal muscle activity with the use of hard occlusal appliances.In comparison, the soft occlusal appliances significantly reduced muscle activity in only one participant and caused a statistically significant increase in EMG activity in most of the participants.[15]According to another EMG study done by Savabi O et al, after the immediate insertion of a soft occlusal appliance during maximum clenching it was found that the masseter muscle activity was increased.[27]

MAXILLARY OR A MANDIBULAR SPLINT?

If teeth are missing, the splint is usually made in the jaw where most teeth are lost to increase the stabilizing effect by creation of additional occlusal points.

In case of significantly increased incisor overjet, as in case of severe Angle Class II, an occlusal splint on the maxillary arch is preferred because it is difficult to achieve proper anterior contacts and guidance with a mandibular splint.[26] In class III cases and in cases with deep curve of Spee, mandibular splint is preferred.[28] Mandibular occlusal splint also offers the advantage of encouraging a better rest place for tongue (which is anterior palate).

The type of bruxism habits dictates whether the splints should be given in upper or lower arch. Usually the maxillary guard with all the teeth in contact should be given in the patients clenching isometrically. The mandibular splint is more effective if the parafunctional movement is in or protrusive direction. Canine guidance is to be given in the patients having lateral parafunctional

movement, where the anterior teeth are relieved. [29] . Mandibular appliances are the popular choice for active patients who wear splints 24 hours per day, as they do not show or affect speech as much as maxillary appliances. On the other hand, the maxillary appliance is an attractive choice for night wear, as all of the teeth are in contact with equal intensity.It is appropriate for the patient to have a mandibular appliance for day wear and a maxillary appliance for the night.[1]

MAXILLARY ARCH	MANDIBULAR ARCH
CLASS I & CLASS II MALOCCLUSION	CLASS III MALOCCLUSION
DEEP BITE	PRONOUNCED CURVE OF SPEE
ISOMETRIC CLENCHING	PARAFUNCTION IN PROTRUSIVE DIRECTION
USUALLY FOR NIGHT WEAR	FOR 24 HR WEAR

WHICH TYPE OF SPLINT?[29]

If the patient reports bruxism and headaches but no TMD, the use of a full-coverage splint at night, in which acrylic covers an entire arch of teeth, is often adequate to protect the teeth.

When a muscle disorder is suspected in TMD patients, bite plane therapy may be used. Muscle disorders are initiated by hyper occlusion; bite planes separate the teeth, allowing the muscles to relax. Full-coverage stabilization splints, which are flat plane splints covering the entire dental arch, can also be used, and may be the treatment of choice for unreliable patients.

If combination of muscle and disc disorders are identified (i.e. clicking of TMJ with muscle pain), stabilization splints are the treatment of choice. They provide long-term wear that is usually needed. They also cover the entire dental arch, ensuring that the covered teeth do not move.

If advanced disc and muscle disorders are identified (jaw locking and/or noises, painful joints), stabilization splints are the treatment of choice which must be balanced to accommodate the specific needs of the patient.

In acute trauma anterior repositioning appliance for 7 to 10 days is required to keep the condyle away from the retrodiscal tissues so that the inflammation can subside.

CONDITION	TYPE OF SPLINT ADVISED
Bruxism and headaches but no TMD	Full coverage splint (stabilization splint)
Muscle Disorder	Bite plane therapy (Ant. Midpoint contact splint)
Combination of muscle and disk disorders	Stabilization splints
Acute trauma	Anterior repositioning splints

MAINTENANCE AND RECALL:[1]

The splint must be continually monitored and adjusted. When the muscle relaxes and/or inflammation subsides, the position of the teeth on the splint changes. When readjustment on the splint to the CR position is accomplished, the teeth and condyle/disk assembly achieve neuromuscular harmony. This explains why patients

feel some initial relief from almost anything put in their mouths yet stop improving after the initial 1 to 2 weeks. If the interferences on the splint are continually chased by rebalancing into CR, the patient will grow comfortable and stay that way.

The majority of splint wearers need to be seen more often than every 2 weeks for initial adjustments. A suggested protocol would include adjustmentsat 24 hours, 54 hours, 7 days, 2 weeks, and 1 month after seating. When no movement on the splint is seen at adjustment appointments and symptoms arereduced, the intervals between adjustments can be extended as long as any reversal of symptoms is countered with an immediate adjustment appointment.

After 3 months with no changes on the splint, a comfortable musculature, and no pain on loading, the patient is ready for evaluation of phase II therapy ((additive or subtractive occlusal therapy, restorative dentistry, orthodontics, maxillofacial surgery, and segmental alveolar surgery.)

III. Conclusion

Splints can be valuable diagnostic and treatment aid if carefully selected, properly made, adjusted and maintained, butcomplete knowledge of the appliances is essential for the splint therapy to be of benefit to our patients. The negative effects of splints may be subtle, but these splints are not beneficial to patients if they are poorly adjusted at delivery and left without arranging for regular maintenance visits.

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