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OCCLUSAL SPLINTS, RETAINERS AND THE RELATION BETWEEN THEM – A REVIEW ARTICLE

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Abstract: This article reviews different types of occlusal splints and retainers, and current trends of their creation by digital technologies. They were systematically searched by key words, single or combined. The key words were: bruxism, retainer, modification of occlusal splints, modification of retainers, 3D printing, CAD/CAM. It was used peer-reviewed articles published in Google scholar until July 2023. The articles were in English with available at least abstract with clear conclusion part. Paid for the reader articles are not included in the review. In this article are presented main and additional types of occlusal splints, different types of retainers and their modifications, the contact point between splints and retainers and their digital creation.

Keywords: Occlusal splints, retainers, digital technologies, CAD/CAM technology, 3D printing.
Field: Medical Sciences and Health

Occlusal splints:

Bruxism, a common parafunctional habit, arises from a variety of factors including biological, physiological, and exogenous influences. It can significantly impact individuals' quality of life by leading to dental issues such as tooth wear, frequent dental restoration fractures, and orofacial pain. Clinically, it manifests through symptoms like muscle fatigue in the masseter area, temporomandibular joint pain, ear discomfort, tingling sensations, soreness, or a sense of teeth instability. Despite its prevalence, there isn't a definitive and cost-effective clinical method for diagnosing bruxism with reliable diagnostic and technical validity [Koyano]. Two types of bruxism are recognized: static (involving compression only) and dynamic (involving compression and horizontal movements). It can occur during both daytime (primarily static clenching) and nighttime (dynamic grinding) [Okeson]. The term "splint," according to orthodontic terminology, refers to various devices, appliances, or apparatus employed to stabilize or support teeth or bones. These devices resist motion or displacement of fractured or injured structures [Jacobson]. In the literature, two main categories of splints are described: Okeson splints and Stabilization appliances. The latter category includes Anterior Repositioning Appliances (ARA) or Mandibular Orthopedic Repositioning Appliances (MORA) [Okeson]. Additional types encompass Anterior/Posterior bite planes, Pivoting appliances, and Soft/Resilient appliances made from materials like silicone [Moin, Dhannawat]. Dawson's classification further breaks down splints into permissive splints/muscle deprogrammers, non-permissive splints/directive splints, and pseudo-permissive splints (e.g., Soft splints, Hydrostatic splints) [Dhannawat, Dawson].

The stabilization splint is primarily used to address symptoms related to masticatory dysfunction, encompassing issues like muscle pain, temporomandibular joint (TMJ) pain, clicking, crepitation, restricted movement, and coordination difficulties. This type of splint is typically recommended for continuous wear, except during meals, and can be positioned on either the upper or lower jaw [Al-Ani]. On the other hand, a repositioning splint is employed to address alterations in intermaxillary relationships and muscle function. Joint clicking could result from swift changes in disc or condyle positions during condylar translation. The classic repositioning splint involves placing a vestibular arch on the frontal teeth area, with smooth surfaces distally [Wiliamson]. Anterior bite splints, featuring a horizontal plane at the front, are worn on the upper jaw and only occlude with the lower front teeth. They are used to manage muscular dysfunction and disturbances in occlusal relationships. Additionally, they can serve orthodontic purposes for treating deep bites [Farha]. Posterior bite splints, with a bilateral distal horizontal plane, are crafted for the lower jaw, often with both halves connected by a metal connector. They are indicated for addressing lower third

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of the face height loss and disarticulation of both jaws [Gelb]. In cases of painful articulation accompanied by a sensation of traction, a pivot splint is advised. It is constructed with a single contact of the distal teeth [Hamlin]. Soft splints are typically commercially manufactured. They are utilized to prevent trauma in sports and, to a lesser extent, treat bruxism and parafunctional habits. Some variants are thermoformed, offering elasticity and covering the entire tooth surfaces [Wright]. A recent study focused on the efficacy of anterior repositioning splints (ARS) revealed an impact on dental anomalies. These splints are designed by moving the lower jaw forward to attain a Class I position between the molars, with a 5 mm gap between the premolars. This movement positions the joint disc correctly, a placement that endures even after treatment, fig. 1 [Al Ouran]:

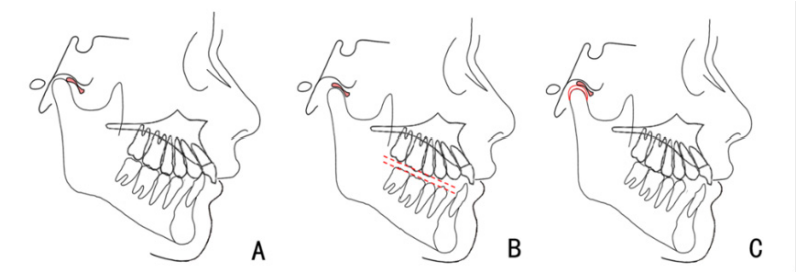

Figure 1. Change the position of the articular disc: A - before treatment; B - protrusion of the lower jaw with the correct position of the articular disc; C - final result of repositioning splint treatment [Al Ouran]

In a comparative study, the activity of the anterior temporalis and masseter muscles was measured using electromyography (EMG) while wearing hard and soft splints. The results indicated that wearing hard splints led to a decrease in EMG activity in both muscles compared to no splint, especially in the anterior temporalis muscle during maximum clenching. On the other hand, wearing soft splints resulted in a slight increase in activity in both muscles, with a greater impact on the masseter muscle. The decrease in temporalis muscle activity relative to masseter muscle activity could contribute to the therapeutic effect of both hard and soft splints, although the decrease was more pronounced with hard splints [Al Ouran]. Another perspective suggests that the use of rigid occlusal bite plates might not be highly effective in reducing overall signs of bruxism, but it could help mitigate deviations in mouth opening [Respero]. Infrared thermography can also be employed to register muscle activity. When achieving balance after wearing splints for one to three months, a decrease in registered temperature is naturally observed due to the conditions created for reducing joint inflammation and muscle overload [Taneva]. In certain cases, antidepressant therapy can be considered. In one investigation, patients were treated with a tricyclic antidepressant (Amitriptyline HCl, 10 mg/day) for three months. The study concluded that occlusal splint therapy might be more effective than tricyclic antidepressants in bruxism treatment [Alkan]. Other researchers propose combining occlusal splints with cognitive-behavioral treatment, which includes techniques like problem-solving, progressive muscle relaxation, nocturnal biofeedback, and training for relaxation and enjoyment. These combined approaches have shown significant reductions in sleep bruxism activity, self-assessment of bruxism activity during sleep, psychological distress, and an increase in positive stress-coping strategies [Ommerborn].

Retainers:

The retention phase in orthodontic treatment is crucial for preventing teeth from reverting to their original positions [Melrose]. Sustaining teeth in their corrected alignment post-orthodontic treatment is challenging due to influences from periodontal, gingival, occlusal forces, growth-related factors, and natural aging changes. Since orthodontics cannot accurately predict which patients will experience relapse, who will remain stable, and the extent of potential relapse, practitioners must approach all patients as potentially high-risk for relapse. Therefore, advocating for long-term retention is recommended [Blake, Littlewood, Joondeph]. Retainers are devices utilized after active orthodontic treatment to preserve treatment outcomes while hard and soft tissues remodel, or skeletal growth completes. These can be categorized as fixed or removable retainers. Removable retainers can be taken out by patients for thorough oral hygiene and part-time wear as required. However, certain situations mandate continuous retainer wear to minimize relapse risk, often necessitating the use of fixed retainers [Johnson]. Among globally used removable retainers, the Hawley-type retainers (with acrylic baseplate and wire labial bow) and thermoplastic retainers are prevalent. Vacuum-formed retainers are more effective than Hawley

retainers in maintaining the alignment of maxillary and mandibular labial segments. This superiority is especially significant in the mandibular arch when addressing single tooth displacement, fig. 2 [Rowland].

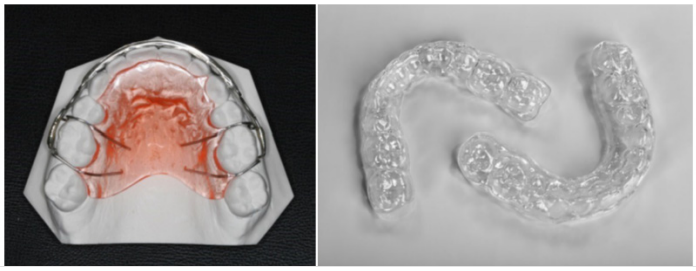

Figure 2. Hawley style removable retainer and Clear thermoplastic removable retainers [Rowland]

The Begg retainer, also known as the Wrap-around Retainer, is a variant of the Hawley retainer. A typical Begg design consists of a wire arch (labial bow) with adjustment loops at the canines, contoured closely to the second molars [Sahoo]. In a comparison between Essix and Begg retainers, more individuals wearing Essix retainers reported comfort and acceptable appearance, whereas those with Begg retainers found them more suitable for biting and chewing. Both types allowed some degree of post-treatment tooth relapse, with minimal clinically significant differences over a 6-month period [Kumar]. A modified Essix retainer can address tongue thrusting habits. This version incorporates a rigid stainless-steel wire on the palatal surface. Known as tongue cribs, these retainers prevent patients from practicing tongue thrusting or thumb sucking, thereby reducing the risk of relapse, fig. 3 [Thakur].

Figure 3. Essix retainer with tongue crib [Thakur]

A fixed retainer technique was introduced for the precise application of the modified 3-3 multistrand wire retainer described by Zachrisson. This lingual retainer or splint is minimally invasive to dental tissue and can be removed reversibly [Becker]. Another method involved etching the inner side of cast fixed partial denture frameworks to create a retentive mechanism. The etched metal ceramometal restoration was then bonded to the enamel surface using acid etching technique. Enhanced resin-bonded retainers offer innovative, conservative, and practical alternatives to traditional fixed prosthodontics [Liyaditis]. In terms of occlusion, research demonstrated that the Hawley retainer led to a significant increase in occlusal contacts on posterior teeth while maintaining anterior contacts. Conversely, the clear overlay retainer showed no significant change in either anterior or posterior contacts during retention. The retentive characteristics of these two retainers differ: the Hawley retainer permits relative vertical movement (settling) of posterior teeth, while the clear overlay retainer maintains teeth in their debanding position [Sauget]. The impact of retainers on speech is also crucial and can be evaluated using tools like Speech Analyzer [Hotori]. Sound distortion was noted in both the Hawley retainer group and the vacuum-formed retainer group, with more noticeable changes in articulation seen in the Hawley retainer group [Wan]. Similar studies found that the Hawley retainer had a more pronounced effect on articulatory movements in consonant-vowel combinations compared to the Essix retainer. Voice onset time in the Hawley group was shorter than normal, indicating rapid articulatory movement in the alveolar region [Atik].

Bruxism and Orthodontics:

Occlusal splints and orthodontic retainers indeed share similar designs but serve different purposes. Dealing with orthodontic patients with parafunctions like bruxism can be challenging. Research indicates

that around 38% of children at an average age of 8.1 years exhibit bruxism symptoms. Children with psychological disorders are 3.6 times more likely to have bruxism. A history of bruxism in either parent increases the likelihood of their child having bruxism by 1.8 times. Nighttime drooling is associated with a 1.7 times higher likelihood of bruxism, while sleep-talking children are 1.6 times more likely to brux [Cheifetz]. Sleep bruxism was observed in 27.3% of patients awaiting orthodontic treatment. Among those undergoing treatment, 36.4% had sleep bruxism before treatment, and 25% continued to experience it after receiving an orthodontic appliance. Of those who had bruxism prior to treatment, 75% reported that it ceased after the appliance was placed [Prado]. The modified Hawley mechanical retainer is simple and practical. It not only retains optimal corrective effects in patients with tooth clenching or bruxism after orthodontia but also effectively treats these conditions [Wen-Xian]. Invisible orthodontic devices differ from oral appliances commonly used in temporomandibular disorder (TMD) patients, as they are neither as rigid as conventional appliances nor as soft as over-the-counter devices [Wassel]. A study investigated the short-term effects of invisible orthodontic retainers on sleep-time masticatory muscle activity (sMMA) in 19 healthy individuals in a home environment. The study found that sMMA parameters did not significantly change over the four recording nights, suggesting that invisible orthodontic retainers do not have substantial effects on sMMA in healthy individuals during the short term [Manfredini]. Digital methods can be employed to combine an occlusal splint and a retainer, allowing for various occlusal surface designs such as raised to antagonist cusp tips, raised to antagonist plane, and raised ramp [Shopova, Shopova, Shopova].

Digital technologies:

In recent years, the field of dental medicine has experienced a significant shift towards constant innovation and the adoption of more efficient methods, largely driven by digitalization [Shopova]. Digital dentistry is a subset of teledentistry methods, which proved to be a valuable option during the COVID-19 pandemic [Shopova]. Around the world, modern materials and construction methods have garnered interest from dental professionals. The current technological landscape, along with the array of materials available, offers practitioners the flexibility to choose methods or combinations thereof based on patient conditions and preferences. Research in contemporary dentistry frequently incorporates digital technologies, although the application of specific materials related to these new technologies requires further investigation [Zaharia, Bakova]. Various digital methods can be effectively combined, such as articulators, facebows, cone-beam computer tomography, axiographs, and digital smile design [Taneva, Shopova, Kasnakova, Shopova]. Traditional vacuum-formed retainers are progressively being replaced by those made on 3D printed models rather than gypsum models. The shift is due to the demonstrated advantages in accuracy and stability offered by digitally produced working models compared to their analog counterparts. As a result, these models are now employed to craft numerous other orthodontic appliances, including aligners, expanders, and braces indirect fixation transfers [Sweeney, Kim, Darroudi]. Modern software applications enable the creation of various types of splints and retainers tailored to specific clinical cases. The integration of digital tools is transforming the field, offering enhanced precision, convenience, and customization for both dental professionals and patients. Notable software platforms in this domain include Exocad, 3Shape, and Sirona [exocad.com, 3shape.com, sicat.com], as shown in figure 4.

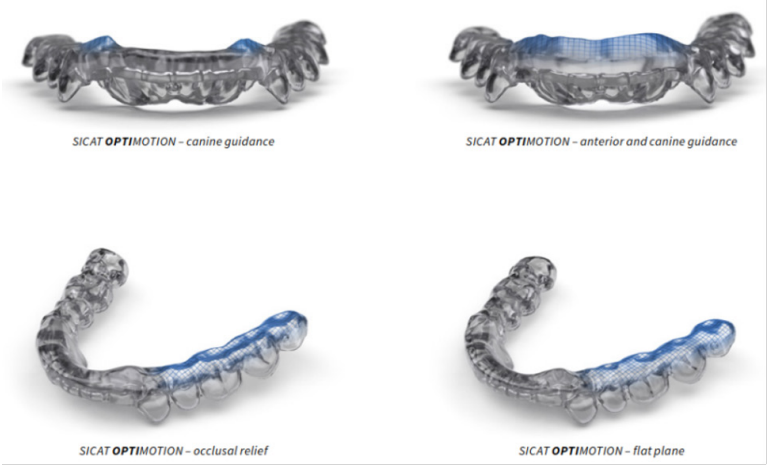

Figure 4. Different types of splints made by 3D technology (Sicat function, Dentsply, Sirona) [www.sicat.com/products/functional-dentistry/optimotion]

Splints and retainers in dentistry can be fabricated using different technological methods such as 3D printing or CAD/CAM milling. CAD/CAM technology, with historical mentions dating back to 1957, involves cutting objects from monolithic blocks or disks, and it gained official recognition in the literature by 1994 [Avinash, Edelhoff]. On the other hand, 3D printing technology aims to streamline construction intermediaries, creating objects layer by layer from soft materials, thus reducing costs and improving various aspects of dental practice, from models to maxillofacial prostheses [Zaharia, Bakova]. Creating 3D virtual retainers through user-friendly software presents an exciting prospect that could transform contemporary dental practice. This method offers simplicity, speed, accuracy, and patient satisfaction, potentially shaping the landscape of orthodontic appliance design in the digital orthodontic era [Nasef].

Conclusion:

Occlusal splints play a significant role in treating temporomandibular joint (TMJ) and masticatory system dysfunctions. By covering tooth surfaces, they protect against mechanical friction and prevent loss of hard tissues. Hard or soft braces help correct occlusal disharmony, immobilize teeth, and alleviate bruxism symptoms.

The Essix retainer, with its thin foil and aesthetic appeal, is almost invisible during speech and smiling. However, its mechanical properties are not entirely satisfactory, often necessitating frequent replacement. While printed retainers are not yet widely utilized in orthodontic practice, they possess potential advantages, even though they are less than 1 mm thick and can influence lower jaw positioning with beneficial effects.

Digital technologies enable precise design, ensuring equal offset between tooth surfaces and the inner surface of the splint. They also allow for pre-inspection in central occlusion and articulation. These technologies reduce the time required for scanning (typically 1 to 2 minutes for a full jaw scan) and enhance patient comfort during the initial clinical stage, as compared to traditional intraoral impressions that may induce nausea and discomfort when placing impression material in the mouth. As the field of dentistry continues to embrace digital advancements, new possibilities for treatment and patient care emerge.

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