

Review began 01/07/2025
Review ended 01/13/2025
Published 01/14/2025

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DOI: 10.7759/cureus.77451

Effectiveness of Occlusal Splints in the Management of Temporomandibular Disorders: Comparisons of Treatment Approaches and Digital Versus Conventional Fabrication Techniques

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Abstract

This research explores the types and effectiveness of occlusal splints in managing temporomandibular disorders (TMDs). TMDs encompass a range of musculoskeletal and neuromuscular conditions affecting the jaw, causing pain, limited movement, and discomfort. Occlusal splints, also known as bite guards, are commonly used in dentistry to alleviate TMD symptoms by relaxing jaw muscles, preventing joint trauma, and protecting teeth. This research examines various splint types, including stabilization splints, anterior bite planes, and repositioning appliances, and analyzes their fabrication methods, indications, and contraindications. Additionally, it investigates the effectiveness of splint therapy in reducing pain, improving jaw function, and managing specific TMD conditions. The research also delves into the comparison of conventional, milled, and 3D-printed splints, considering their accuracy, fabrication time, cost-effectiveness, and patient satisfaction. Finally, it addresses potential complications associated with splint use and concludes by emphasizing the importance of occlusal splint therapy as a noninvasive and effective treatment option for TMD management.

Categories: Dentistry, Pain Management

Keywords: bruxism, conventional splint, digital splint, muscle relaxation appliances, occlusal splints, splint fabrication techniques, tmd pain management

Introduction And Background

Introduction and background

Temporomandibular disorders (TMDs) comprise multiple musculoskeletal and neuromuscular disorders affecting the muscles involved in chewing, while a singular TMD specifically refers to a type or aspect of this condition, such as myofascial pain. TMDs, as a collective, are characterized by pain in specific areas of the face and around the ears, or by limitations or disruptions in jaw movement, degenerative and inflammatory conditions of the temporomandibular joint (TMJ), and TMJ disk displacements [1,2]. Commonly observed signs and symptoms in cases of TMD include pain that might radiate to the eyes, shoulder, and neck, discomfort, auditory changes (such as clicking or grating sounds), restricted or asymmetrical movement of the jaw, headaches, tinnitus - all of which can potentially impact an individual's overall wellbeing [1,3,4].

Occlusal splint therapy can be described as “the art and science of establishing neuromuscular harmony in the masticatory system by creating a mechanical disadvantage for parafunctional forces with removable appliances.” These tools are referred to as bite guards or intra-oral appliances. They are frequently employed to help relax the muscles in the jaw, prevent trauma to the temporomandibular joint, and protect the teeth [5,6]. Compared to surgical treatment for TMD, traditional soft occlusal splint treatment is considered a safe, effective, and conservative treatment approach [7].

Conventional techniques for fabricating occlusal splints typically involve vacuum injection molding or the application of acrylic resin, sometimes using a combination of both. Nonetheless, with the development of computer-aided design (CAD) and computer-aided manufacturing (CAM), the production of occlusal splints has become automated through milling technology. This enables the manufacturing process to be seamlessly integrated into a fully digital workflow [8], which serves to broaden the scope of options by incorporating innovative approaches to splint fabrication [9].

Review

Materials and methods

How to cite this article

Albagieh H, AlWazzan A K, Alhelal F A, et al. (January 14, 2025) Effectiveness of Occlusal Splints in the Management of Temporomandibular Disorders: Comparisons of Treatment Approaches and Digital Versus Conventional Fabrication Techniques. Cureus 17(1): e77451. DOI 10.7759/cureus.77451

A search of the reported literature up to 2024 focusing mostly on recent literature, was conducted using “PubMed,” “Google Scholar” databases, and manual search.” The MeSH terms and keywords in the search criteria were “Temporomandibular Disorders (TMDs)” “Occlusal Splints” “Bruxism” “TMD Pain Management” “Muscle Relaxation Appliances” “Splint Fabrication Techniques” “Conventional Splint” “digital splint”. The search was confined to English-language publications. Articles included in this paper were chosen due to their relevance to the subject matter; otherwise, they were excluded.

Epidemiology

TMD is a prevalent orofacial pain condition that is not of dental origin. However, determining the exact prevalence of TMD at a population level is a topic of ongoing debate. A study done by Ryan et al. suggests that the prevalence of TMD reaches its highest point between the ages of 25 to 45. It has also been observed that women tend to experience TMD more frequently than men. Additionally, the presence of psychosocial factors can contribute to a higher prevalence and increased intensity of TMD symptoms. Furthermore, there is evidence to suggest that the prevalence of TMD has been rising in the general population over the past decades. This indicates a growing number of individuals affected by TMD-related issues [10].

Etiology

Occlusal splint therapy serves several goals in dental treatment. Firstly, it aims to protect intra-oral tissues in patients who exhibit oral parafunction, such as teeth grinding or clenching. By providing a protective barrier, the splint helps prevent excessive wear on the teeth. Secondly, occlusal splints are utilized to stabilize an unstable occlusion, ensuring a harmonious bite. In patients experiencing stress-related pain symptoms, such as tension headaches and muscular neck pain, the splint aids in relaxing the jaw muscles. Another crucial aspect of occlusal splint therapy is the elimination of occlusal interferences that may disrupt normal jaw function. Moreover, before undergoing extensive restorative treatment, occlusal splints are employed to assess the effects of occlusion changes to the TMJ and jaw muscle function [5].

The primary indication for fabricating an occlusal splint is to safeguard the teeth from attrition caused by bruxism, a condition characterized by teeth grinding or clenching. Additionally, splints are commonly used in the management of TMDs and associated symptoms such as tension headaches, as well as pain in the cervical, neck, and oral/facial regions [5]. While occlusal splints have various indications, there are certain contraindications to consider. They are not recommended for individuals with severe skeletal discrepancies or significant vertical discrepancies that may require alternative treatment approaches [1,5].

Common types

The primary objective of occlusal splint therapy is to safeguard the TMJ discs against dysfunctional forces that have the potential to cause perforations or permanent displacements. In addition, the treatment aims to enhance the function of the jaw muscles, alleviate associated pain, and establish a stable and balanced occlusion [5]. There are several appliances that help achieve this goal:

Flat-Plane Stabilization Appliance (Michigan Splint)

Also known as the gnathological splint or muscle relaxation appliance, this appliance is usually fabricated for the upper arch to improve facial esthetics and minimize interference with speaking; some practitioners have suggested that it could be fabricated for the lower arch as well. According to the American Academy of Orofacial Pain guidelines, the purpose of a stabilization appliance is to “provide joint stabilization, protect the teeth, redistribute occlusal forces, relax the elevator muscles, and decrease bruxism.” Among the various types of occlusal appliances, the muscle relaxation appliance is the most commonly used and, when properly fabricated, has minimal adverse effects on oral structures [3].

Anterior Bite Plane: Traditional Anterior Bite Plane

These appliances are crafted in a horseshoe shape with palatal coverage, featuring an occlusal table that extends over six to eight anterior maxillary teeth. Advocates recommend the use of such appliances in the treatment of TMDs based on their ability to prevent clenching as well as the engagement of posterior teeth in both functional and para-functional activities. If worn exclusively during nighttime, the likelihood of an adverse effect such as posterior teeth overeruption is extremely low [3].

Anterior Repositioning Appliance (Orthopedic Repositioning Appliance)

The primary purpose of this appliance is to adjust the maxillomandibular relationship by positioning the mandible in a more forward position. An acrylic guiding ramp is integrated into the anterior third of the maxillary appliance, guiding the mandible into the desired forward position upon closure. The main objective of using repositioning appliances for patients is to maintain proper alignment of the TMJ on the disc, thereby preventing the joint from putting pressure on the retrodiscal tissue, which could result in significant pain [3].

Effectiveness

The treatment of TMD can be effectively achieved through both hard and soft occlusal splint therapies. However, it has been observed that soft splint therapy tends to lead to earlier improvement of certain TMD symptoms. It is generally recommended to undergo a minimum three-month period of splint therapy to experience positive outcomes in terms of alleviating TMD symptoms. Consequently, one study reinforces the utilization of splint therapy as a viable approach for managing myofascial pain dysfunction (MPD) and TMDs in patients diagnosed with anterior disk displacement and reduction [4].

The utilization of occlusal splint therapy has demonstrated its effectiveness in diagnosing and managing a range of disorders affecting the masticatory system [5]. The insertion of an occlusal splint brings about a change in the resting position, leading to an increase in the occlusal vertical dimension that extends beyond the free space. This new resting position promotes enhanced muscle efficiency during contact and decreases muscle activity during postural functions. Consequently, the increased vertical dimension lowers the amount of muscular effort needed, resulting in muscle and TMJ relaxation. The outcomes of one study that conducted a comparative analysis between a soft occlusal splint and muscle relaxants along with analgesics for managing MPD. The study found that occlusal splint therapy was more effective than pharmacological treatment in reducing pain, relieving muscle tenderness, and addressing TMJ clicking [4,11]. Similarly, electromyography of the masticatory muscles has determined that occlusal splint therapy for MPD improves the signs and symptoms of TMD [4,12]. Findings of some studies corroborate their results, demonstrating that occlusal splint therapy serves as a conservative treatment approach that effectively reduces pain and muscle tenderness while improving jaw opening [4,13].

A study by Grillo et al. compared acupuncture and a flat occlusal plane appliance (OS) in the treatment of myogenic TMD in 40 women. They found that both treatments were equally effective in reducing pain intensity and increasing mouth opening. In other words, both acupuncture and the OS appliance were able to reduce the symptoms of TMD, namely pain and limited jaw movement. The participants in the study were randomly allocated to either the acupuncture group or the OS group, so the results are likely to be reliable. This study suggests that both acupuncture and the OS appliance can be used to treat TMD effectively. The best treatment for an individual patient will depend on their individual preferences and circumstances. For example, some patients may prefer acupuncture, while others may prefer the OS appliance. It is important to discuss the risks and benefits of each treatment with the patient before making a decision [14,15].

A study by de Felício et al. measured the effects of orofacial muscle activity therapy (OMT) in the treatment of patients with concomitant painful joints and TMDs. They randomized patients into four groups: OMT, occlusal splint (OS), untreated TMD control, and asymptomatic control. At the beginning of the study, there were no significant differences between the OMT group, OS group, and untreated TMD control group. However, after 120 days, the OMT group showed better results than the OS group. Specifically, the OMT group had a decreased frequency of headaches, increased jaw range of motion, decreased Helkimo Index, and decreased occurrence and severity of signs and symptoms. The control group didn't show any significant changes over time. In conclusion, the study suggests that OMT may be a more effective treatment for patients with concomitant painful joints and TMDs than an occlusal splint [14,16]. The Helkimo Clinical Dysfunction Index (HCDI) is a widely utilized tool for the clinical diagnosis of TMDs. It provides a straightforward and efficient method for evaluating limitations in mandibular movement [17].

While occlusal splints are generally safe and effective, it's important to consider potential complications. These can vary depending on the splint type. For example, full-coverage splints may increase the risk of snoring and obstructive sleep apnea (OSA), while maxillary advancement splints (used to treat OSA) can cause changes in bite and facial structure. Complications are often associated with full-time splint use, so part-time wear is generally recommended. Additionally, a splint that is too thick can interfere with speech, swallowing, or lip closure [18-23].

To minimize complications and maximize effectiveness, advancements in splint fabrication have emerged. Traditionally, splints were made using conventional methods involving physical impressions and models. However, digital dentistry now offers computer-aided design and manufacturing (CAD/CAM) techniques like milling and 3D printing. [24]

These digital approaches offer several advantages. They are often more time-efficient and produce better-fitting, more comfortable splints [25]. Milling, which carves the splint from a material block, offers high accuracy but can be time-consuming. On the other hand, 3D printing, which builds the splint layer by layer, is faster and more cost-effective but may have limitations in accuracy and durability [26].

Comparison of conventional, milled, and printed occlusal splints:

TMDs are a common cause of orofacial pain and dysfunction. Treatment often involves occlusal splints to alleviate symptoms and protect teeth from wear. Traditionally, these splints were fabricated using conventional methods, but with the advent of digital dentistry, CAD/CAM techniques, such as milling and 3D printing, have become increasingly popular [24]. Milling has been the preferred method for CAD/CAM production, and 3D printing has emerged as a viable alternative. It often offers greater energy efficiency and

can create complex shapes that are difficult or impossible to achieve with traditional milling techniques (burs) [27]. The digital approach is more time efficient and often results in a better-fitting and more comfortable splint compared to traditional methods [25]. The digital systems are increasingly supplanting traditional manufacturing methods [27].

A conventional occlusal splint is fabricated using a multi-step process that involves taking a physical impression of the patient's mouth, which is then used to create a physical model. An occlusal splint is then created using the model [28]. Digital splints are fabricated using CAD/CAM technology. This involves using an intraoral scanner to take a digital impression of the patient's mouth, which is then used to create a digital model. The splint is then designed using CAD software and fabricated using CAM technology, such as 3D printing or milling [24].

Milling is a subtractive method that involves carving the splint out of a prefabricated block of material. It offers high accuracy but can be time-consuming and generates material waste while 3D printing works by additive technique which builds the splint layer by layer from a liquid resin. It is more cost-effective and faster than milling, but its accuracy and durability have been questioned [26].

Digital splints, especially those fabricated using milling, have shown comparable or superior accuracy to conventional splints [26]. Digital splints offer higher precision and reproducibility compared to conventional methods [28]. Comparing the workflow, the digital workflow can be more time-efficient, as impression-taking is faster than the conventional way, even for the dental technician, as it reduces the number of steps involved in the fabrication process. The conventional workflow is more time-consuming, especially for the dentist, due to the need for physical impressions and adjustments. Digital workflows can significantly reduce the laboratory time required for splint fabrication [29]. The digital workflow can be more cost-effective in the long run, as it reduces material waste and labor costs [24]. However, the initial investment in digital equipment, such as intraoral scanners and milling machines or 3D printers, can be substantial [26]. The cost of materials for digital splints can be comparable to or higher than conventional materials [26]. Both digital and conventional splints have demonstrated similar clinical efficacy in reducing TMD pain and improving jaw function [30]. Patients generally report high satisfaction with both types of splints, with some studies indicating a preference for digital splints due to increased comfort during the impression-taking process [30].

Milled splints generally exhibit higher accuracy (trueness) compared to 3D-printed splints, especially when printed in a horizontal position. This is attributed to the fewer layers required in horizontal printing, reducing cumulative inaccuracies. On the other hand, 3D-printed splints demonstrate higher precision (reproducibility) than milled splints when printed in a vertical position. This suggests that additive manufacturing may offer more consistent results compared to the milling process [28,31].

Accuracy is also affected by material selection; the choice of resin can significantly influence the accuracy of 3D-printed splints. This can also be affected by measurement methods, different software applications and measurement methods can yield varying results when assessing splint accuracy [31].

Comparing mechanical features for both types, milled splints generally exhibit superior mechanical properties compared to 3D-printed splints. The printing angle can significantly impact the strength and durability of 3D-printed objects [32]. Both milled and 3D-printed splints can achieve a clinically acceptable fit, although milled splints may require more adjustments initially [29]. 3D-printed splints show comparable wear resistance to milled splints. However, 3D-printed splints may be more prone to fracture compared to milled splints, especially under high occlusal loads [8].

One study indicates that participants generally report high satisfaction with both 3D-printed and milled splints, with no significant difference between the two [25].

Conclusions

Occlusal splint therapy is a minimally invasive, conservative treatment approach for TMDs. It is effective in relieving TMD symptoms, such as pain, clicking, and popping in the jaw joint, as well as headaches and muscle tension in the neck and shoulders. There are several different types of occlusal splints available, and the best type for a particular patient will depend on their individual needs and the severity of their TMD.

Digital and conventional splints are both effective treatment options for TMDs. Digital workflows offer advantages in terms of accuracy, precision, time efficiency, and patient comfort. However, the cost of digital equipment remains a consideration. Both 3D-printed and milled splints are viable options for the treatment of TMDs. Milled splints may offer higher initial accuracy, while 3D-printed splints are more cost-effective and faster to produce.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

- Lakshmi M, Kalekhan S, Mehta R, Bhangdia M, Rathore K, Lalwani V: Occlusal splint therapy in temporomandibular joint disorders: an update review. *J Int Oral Health*. 2016, 8:639-45.
- Ohrbach R, Dworkin SF: The evolution of TMD Diagnosis: past, present, future. *J Dent Res*. 2016, 95:1093-101. [10.1177/0022034516653922](https://doi.org/10.1177/0022034516653922)
- Alqutaibi AY, Aboalrejal AN: Types of occlusal splint in management of temporomandibular disorders (TMD). *J Arthritis*. 2015, 4:1000176.
- Seifeldin SA, Elhayes KA: Soft versus hard occlusal splint therapy in the management of temporomandibular disorders (TMDs). *Saudi Dent J*. 2015, 27:208-14. [10.1016/j.sdentj.2014.12.004](https://doi.org/10.1016/j.sdentj.2014.12.004)
- Yadav S, Karani JT: The essentials of occlusal splint therapy. *International Journal of Prosthetic Dentistry*. 2011, 2:12-21.
- Crout DK: Anatomy of an occlusal splint. *Gen Dent*. 2017, 65:52-9.
- Srivastava R, Jyoti B, Devi P: Oral splint for temporomandibular joint disorders with revolutionary fluid system. *Dent Res J (Isfahan)*. 2013, 10:307-13.
- Schmeiser F, Baumert U, Stawarczyk B: Two-body wear of occlusal splint materials from subtractive computer-aided manufacturing and three-dimensional printing. *Clin Oral Investig*. 2022, 26:5857-66. [10.1007/s00784-022-04543-5](https://doi.org/10.1007/s00784-022-04543-5)
- Nassif M, Haddad C, Habli L, Zoghby A: Materials and manufacturing techniques for occlusal splints: A literature review. *J Oral Rehabil*. 2023, 50:1348-54. [10.1111/joor.13550](https://doi.org/10.1111/joor.13550)
- Ryan J, Akhter R, Hassan N, Hilton G, Wickham J, Ibaragi S: Epidemiology of temporomandibular disorder in the general Population: a systematic review. *Adv Dent & Oral Health*. 2019, 10:555787. [10.19080/ADOH.2019.10.555787](https://doi.org/10.19080/ADOH.2019.10.555787)
- Tang Y, Li H, Chen Y, Zhu L, Kang H: Effect of different splint thicknesses on occlusal function and temporomandibular joint sounds: a clinical report. *Open J Stomatol*. 2018, 8:326-37. [10.4236/ojst.2018.812031](https://doi.org/10.4236/ojst.2018.812031)
- Daif ET: Correlation of splint therapy outcome with the electromyography of masticatory muscles in temporomandibular disorder with myofascial pain. *Acta Odontol Scand*. 2012, 70:72-7. [10.3109/00016357.2011.597776](https://doi.org/10.3109/00016357.2011.597776)
- Suvinen T, Reade P: Prognostic features of value in the management of temporomandibular joint pain-dysfunction syndrome by occlusal splint therapy. *J Prosthet Dent*. 1989, 61:355-61. [10.1016/0022-3913\(89\)90145-5](https://doi.org/10.1016/0022-3913(89)90145-5)
- Orzeszek S, Waliszewska-Prosol M, Ettlin D, et al.: Efficiency of occlusal splint therapy on orofacial muscle pain reduction: a systematic review. *BMC Oral Health*. 2023, 23:180. [10.1186/s12903-023-02897-0](https://doi.org/10.1186/s12903-023-02897-0)
- Grillo CM, Canales Gde L, Wada RS, Alves MC, Barbosa CM, Berzin F, de Sousa Mda L: Could acupuncture be useful in the treatment of temporomandibular dysfunction?. *J Acupunct Meridian Stud*. 2015, 8:192-9. [10.1016/j.jams.2014.12.001](https://doi.org/10.1016/j.jams.2014.12.001)
- de Felício CM, de Oliveira MM, da Silva MA: Effects of orofacial myofunctional therapy on temporomandibular disorders. *Cranio*. 2010, 28:249-59. [10.1179/crn.2010.033](https://doi.org/10.1179/crn.2010.033)
- Alonso-Royo R, Sánchez-Torrelo CM, Ibáñez-Vera AJ, et al.: Validity and reliability of the Helkimo Clinical Dysfunction Index for the diagnosis of temporomandibular disorders. *Diagnostics (Basel)*. 2021, 11:472. [10.3390/diagnostics11030472](https://doi.org/10.3390/diagnostics11030472)
- Al-Moraissi EA, Farea R, Qasem KA, Al-Wadeai MS, Al-Sabahi ME, Al-Iryani GM: Effectiveness of occlusal splint therapy in the management of temporomandibular disorders: network meta-analysis of randomized controlled trials. *Int J Oral Maxillofac Surg*. 2020, 49:1042-56. [10.1016/j.ijom.2020.01.004](https://doi.org/10.1016/j.ijom.2020.01.004)
- Zhang SH, He KX, Lin CJ, Liu XD, Wu L, Chen J, Rausch-Fan X: Efficacy of occlusal splints in the treatment of temporomandibular disorders: a systematic review of randomized controlled trials. *Acta Odontol Scand*. 2020, 78:580-9. [10.1080/00016357.2020.1759818](https://doi.org/10.1080/00016357.2020.1759818)

20. Deshpande RG, Mhatre S: TMJ disorders and occlusal splint therapy--a review . *International Journal of Dental Clinics*. 2010, 2:22-9.
21. List T, Axelsson S: Management of TMD: evidence from systematic reviews and meta-analyses . *J Oral Rehabil*. 2010, 37:430-51. [10.1111/j.1365-2842.2010.02089.x](#)
22. Magdaleno F, Ginestal E: Side effects of stabilization occlusal splints: a report of three cases and literature review. *Cranio*. 2010, 28:128-35. [10.1179/crn.2010.018](#)
23. Ramfjord SP, Ash MM: Reflections on the Michigan occlusal splint . *J Oral Rehabil*. 1994, 21:491-500. [10.1111/j.1365-2842.1994.tb01164.x](#)
24. Somogyi A, Végh D, Róth I, Hegedüs T, Schmidt P, Hermann P, Géczi Z: Therapy for temporomandibular disorders: 3D-Printed splints from planning to evaluation. *Dent J (Basel)*. 2023, 11:126. [10.3390/dj11050126](#)
25. Rabel K, Lüchtenborg J, Linke M, et al.: 3D printed versus milled stabilization splints for the management of bruxism and temporomandibular disorders: study protocol for a randomized prospective single-blinded crossover trial. *Trials*. 2024, 25:589. [10.1186/s13063-024-08437-7](#)
26. Abad-Coronel C, Ruano Espinosa C, Ordóñez Palacios S, Paltán CA, Fajardo JI: Comparative analysis between conventional acrylic, CAD/CAM milled, and 3D CAD/CAM printed occlusal splints. *Materials (Basel)*. 2023, 16:6269. [10.3390/ma16186269](#)
27. Haugli KH, Alkarra D, Samuelsen JT: Digital manufacturing techniques and the in vitro biocompatibility of acrylic-based occlusal device materials. *Clin Oral Investig*. 2024, 28:312. [10.1007/s00784-024-05707-1](#)
28. Cameron AB, Tong K, Tadakamadla S, Evans JL, Abuzar M: Effect of build orientation on the trueness of occlusal splints fabricated by three-dimensional printing. *J Oral Sci*. 2023, 65:261-4. [10.2334/josnurd.23-0115](#)
29. Patzelt SB, Krügel M, Wesemann C, et al.: In vitro time efficiency, fit, and wear of conventionally- versus digitally-fabricated occlusal splints. *Materials (Basel)*. 2022, 15:1085. [10.3390/ma15031085](#)
30. Piskin B, Yılmaz Savaş T, Topal SC, et al.: Comparison of efficacy and usability of custom mandibular advancement devices fabricated with the conventional method and digital workflow: A pilot clinical study. *J Prosthodont*. 2024, 33:123-31. [10.1111/jopr.13720](#)
31. Marcel R, Reinhard H, Andreas K: Accuracy of CAD/CAM-fabricated bite splints: milling vs 3D printing . *Clin Oral Investig*. 2020, 24:4607-15. [10.1007/s00784-020-03329-x](#)
32. Maleki T, Meinen J, Coldea A, Reymus M, Edelhoff D, Stawarczyk B: Mechanical and physical properties of splint materials for oral appliances produced by additive, subtractive and conventional manufacturing. *Dent Mater*. 2024, 40:1171-83. [10.1016/j.dental.2024.05.030](#)