Educational Administration: Theory and Practice
2024, 30(1), 3181-3189
ISSN: 2148-2403
https://kuey.net/
Research Article

# 3d Printed Occlusal Splint Versus Conventional Occlusal Splint Review Of Literature

Maaz Vohra[1], Nabeel Ahmed[2*]

[1]Postgraduate Student, Department of Prosthodontics and Implantology Saveetha Dental College And Hospitals Saveetha Institute Of Medical And Technical Sciences Saveetha University Chennai-600077, Tamil Nadu, India; Email: maazvohra390@gmail.com
[2*]Associate Professor Department of Prosthodontics and Implantology Saveetha Dental College And Hospitals Saveetha Institute Of Medical And Technical Sciences Saveetha University Chennai-600077, Tamil Nadu, India; Email: nabeel.5610@gmail.com

**Citation**: Maaz Vohra, (2024) 3d Printed Occlusal Splint Versus Conventional Occlusal Splint Review Of Literature, *Educational Administration: Theory and Practice*, 30*(1)* 3181-3189
Doi: 10.53555/kuey.v30i1.7067

## ANATOMY OF TEMPOROMANDIBULAR JOINT

The TMJ is characterized as a ginglymoarthrodial joint, a term originating from "ginglymus," signifying a hinge joint allowing movement primarily in a backward and forward direction within a single plane, and "arthrodia," denoting a joint that facilitates gliding motion between surfaces. Both the right and left TMJ collectively form a bicondylar articulation, resembling an ellipsoid type of synovial joint akin to the knee joint . This joint shares common attributes with synovial joints, such as the presence of a disk, bone, fibrous capsule, synovial fluid, synovial membrane, and ligaments.Nevertheless, what sets this joint apart and renders it distinctive is the fibrocartilage covering its articular surface, deviating from the typical hyaline cartilage found in other joints. The dynamics of movement are not solely dictated by the bone structure, muscles, and ligaments but are also influenced by the occlusion of the teeth. This unique aspect arises from the fact that both joints are connected through a singular mandible bone, preventing independent movement (Ahmad and Schiffman, 2016).

### • Articular Surfaces

### 1.Mandibular Component

The condylar process, an ovoid structure atop a slim mandibular neck, measures 15 to 20 mm in width and 8 to 10 mm anterior to posterior. When the elongated axes of two condyles converge medially, they form an angle of 145° to 160° around the basion, located at the anterior boundary of the foramen magnum. Condylar morphology varies among individuals and age groups, influenced by developmental factors, adaptive remodeling, malocclusion, and trauma. Assessment of condylar morphology is possible through axial and coronal MR imaging (Caruso *et al.*, 2017).

### 2.Cranial Component

The articular surface of the temporal bone is situated on the inferior aspect of temporal squama anterior to the tympanic plate. Various anatomical terms of the joint are elaborated below,
(a) Articular eminence: Transverse bony structure at the zygomatic base, impacting the condyle and disk during jaw movements.
(b) Articular tubercle: Small, elevated bony protuberance at the outer end of the articular eminence, attaching to the lateral collateral ligament.
(c) Preglenoid plane: Concave articular area extending forward from the articular eminence's summit.
(d) Posterior articular ridge and postglenoid process: Resulting from tympanosquamous suture division, creating a ridge (posterior articular) and a cone-shaped prominence (postglenoid) anterior to the external acoustic meatus.
(e) Lateral edge of the mandibular fossa: Elevated feature connecting the articular tubercle to the postglenoid process.
(f) Medial narrowing of the fossa encircled by the ento-glenoid process, forming the medial glenoid plane (Al-Saleh *et al.*, 2016).

### • Articular Disc

The TMJ's crucial anatomical element is the biconcave-shaped articular disk, positioned between the mandibular condyle and the temporal bone. It facilitates hinging and gliding motions, with distinct regions: a 2 mm anterior band, a 3 mm posterior band, and a 1 mm intermediate band. The bilaminar region, behind the disk, has upper elastin-rich temporal lamina attached to the postglenoid process, hindering disk displacement during yawning. The inferior lamina merges with the joint capsule and condylar neck. An expansive pad amid layers deters disk rotation and aids in recoil during closing. On sagittal MR imaging, the disk, with low signal intensity, is posteriorly attached to the bilaminar zone. The anterior band aligns with the condyle, and the posterior band and retrodiscal tissue are evident during mouth opening.

- **Fibrous Capsule**

The fibrous capsule, a slender sheath, encases the entire joint, extending from the cranial articular surface's periphery to the mandibular neck. It attaches to the cranial base, following a path from the articular tubercle to the mandibular fossa's outer edge, then to the postglenoid process, posterior articular ridge, medial margin of the temporal bone at its junction with the greater wing of the sphenoid, and anteriorly to the preglenoid plane, enclosing it within the joint cavity.

- **Temporomandibular Joint ligament complex includes**

a.Collateral Ligaments of the Bilateral Jaw Joints
b.Sphenomandibular Ligament
c.Stylomandibular Ligament

- **Muscular Components**

Understanding the nomenclature and function of TMJ-related muscles is crucial, as issues often involve these muscles. Proximity to the joint allows masticatory muscles to work cohesively, ensuring optimal jaw function through coordinated contractions and relaxations. In a relaxed state, these muscles operate harmoniously with other TMJ components. Originating on the cranium, spanning to the mandible, and inserting on it, masticatory muscles play a vital role in diverse jaw movements. Abductors (temporalis, masseter, medial pterygoid) facilitate jaw opening, while lateral pterygoid muscles serve as key abductors. Additionally, muscles for forward movement (protrusion) can engage in lateral movement (Santana-Mora *et al.*, 2021).

## DISORDERS OF TEMPOROMANDIBULAR JOINT

Anatomically, the disc plays a central role, being part of the articulating surfaces within both the lower and the upper joint compartment. Nevertheless, the disc became the central issue in diagnostic classifications. Disc displacements appeared to explain many of the clinical signs and symptoms displayed by patients and since then played a central role in the diagnosis of TMDs (Chang *et al.*, 2018)

| | | |
|---|---|---|
| ARTICULAR DISORDERS | 1.Congenital or Developmental | 1.First or second branchial arch disorders<br>2.Condylar hyperplasia<br>3.Idiopathic condylar resorption |
| | 2.Disc derangement disorders | 1.Displacement with reduction<br>2.Displacement without reduction<br>3.Perforation |
| | 3.Degenerative joint disorders | 1.Inflammatory<br>2.Non inflammatory |
| | 4.Trauma | 1.Contusion<br>2.Intracapsular hemorrhage<br>3.Fracture |
| | 5.TMJ hypermobility | 1.Joint laxity<br>2.Subluxation<br>3.Dislocation |

| | | |
|---|---|---|
| | | |
| | 6.TMJ hypomobility | 1.Trismus<br>2.Fibrosis<br>3.Ankylosis |
| | 7.Infection | |
| | 8.Neoplasia | |
| MASTICATORY MUSCLE DISORDERS | 1.Myofascial pain disorder | |
| | 2.Local myalgia | |
| | 3.Myositis | |
| | 4.Myospasm | |
| | 5.Myo Fibrotic contracture | |
| | 6.Neoplasm | |

*Classification scheme adapted from the guidelines of the American Academy of Orofacial Pain.TMJ denotes temporomandibular joint.*

## DIFFERENTIAL DIAGNOSIS

Several conditions can resemble temporomandibular joint disorder (TMD), including dental issues like cavities or infections, oral conditions such as herpes or ulcers, muscular issues like clenching or bruxism, injuries, sinusitis, salivary gland disorders, neuralgia (trigeminal, postherpetic, glossopharyngeal), giant cell arteritis, headaches, and cancer-related pain. Autoimmune diseases like lupus, Sjögren's syndrome, and rheumatoid arthritis can also exhibit TMD-like symptoms (Schiffman *et al.*, 2014).

## INVESTIGATIONS FOR TMD

Diagnosing TMD relies on patient history and physical exams, mainly focusing on jaw movement and pain in areas like the preauricular, masseter, or temple region. If pain persists without being affected by jaw movement, other orofacial issues should be considered. Sounds, like clicking, may occur in TMD but also in 50% of asymptomatic cases. A large 25-year study (n=4,528) found common symptoms like facial pain (96%), ear discomfort (82%), headache (79%), and jaw issues (75%). Other symptoms may include dizziness or neck, eye, arm, or back pain. Chronic TMD is pain lasting over three months. Physical exam findings supporting TMD diagnosis include abnormal jaw movement, reduced range of motion, masticatory muscle tenderness, pain with dynamic loading, bruxism signs, and neck/shoulder muscle tenderness. Clicking, crepitus, or TMJ locking may accompany joint dysfunction (Gauer and Semidey, 2015). Single-click during mouth opening suggests anterior disk displacement; a second click during closure is disk displacement with reduction. Closed lock occurs when the displaced disk blocks mouth opening . Crepitus in TMD may relate to osteoarthritis. Reproducible TMJ tenderness indicates intra-articular derangement, while masseter, temporalis, and neck muscle tenderness may distinguish myalgia or referred pain. Deviation of the mandible during mouth opening may signal anterior disk displacement. When history and physical examination results are inconclusive in diagnosing TMD, imaging can provide additional insights. While not commonly used, various imaging methods can offer more information on potential TMD causes. Initial studies typically involve plain radiography (transcranial and transmaxillary views) or panoramic radiography, revealing visible acute fractures, dislocations, or severe degenerative joint disease. Computed tomography is more effective than plain radiography for assessing subtle bone changes (Garstka *et al.*, 2023). Magnetic resonance imaging is the preferred method for a comprehensive joint evaluation in TMD patients, showing a 78% to 95% correlation with joint morphology in symptomatic cases, but false positives occur in 20% to 34% of asymptomatic patients. It is usually reserved for persistent symptoms, ineffective conservative therapy, or suspected internal joint issues. When magnetic resonance imaging is not readily available, ultrasonography, a noninvasive and cost-effective technique, can diagnose internal derangement of the TMJ (Kapos *et al.*, 2020).

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) is a set of standardized criteria used for the diagnosis and classification of temporomandibular disorders (TMD). These criteria were developed to ensure consistency and reliability in research studies related to TMD. The RDC/TMD includes both Axis I and Axis II criteria:

**Axis I**: Physical Diagnosis

**1. Group I - Muscle Disorders:**

- Ia: Myofascial Pain
- Ib: Myofascial Pain with Limited Opening
- Ic: Myofascial Pain with Disc Displacement
- Id: Myofascial Pain with Disc Displacement and Reduction
- Ie: Myofascial Pain with Disc Displacement and Without Reduction

**2. Group II - Disc Displacements:**

- IIa: Disc Displacement with Reduction
- IIb: Disc Displacement without Reduction
- IIc: Disc Displacement with Reduction and Limited Opening
- IId: Disc Displacement without Reduction and Limited Opening

**3. Group III - Arthralgia, Osteoarthritis, and Osteoarthrosis:**

- IIIa: Arthralgia
- IIIb: Osteoarthritis
- IIIc: Osteoarthrosis

**4. Group IV - Other TMD:**

- IVa: Subluxation
- IVb: Traumatic Arthrosis
- IVc: Neoplasia

**Axis II: Psychosocial and Disability Assessment**

**1. Psychological Status:**

- I. Depression
- II. Non-specific Physical Symptoms

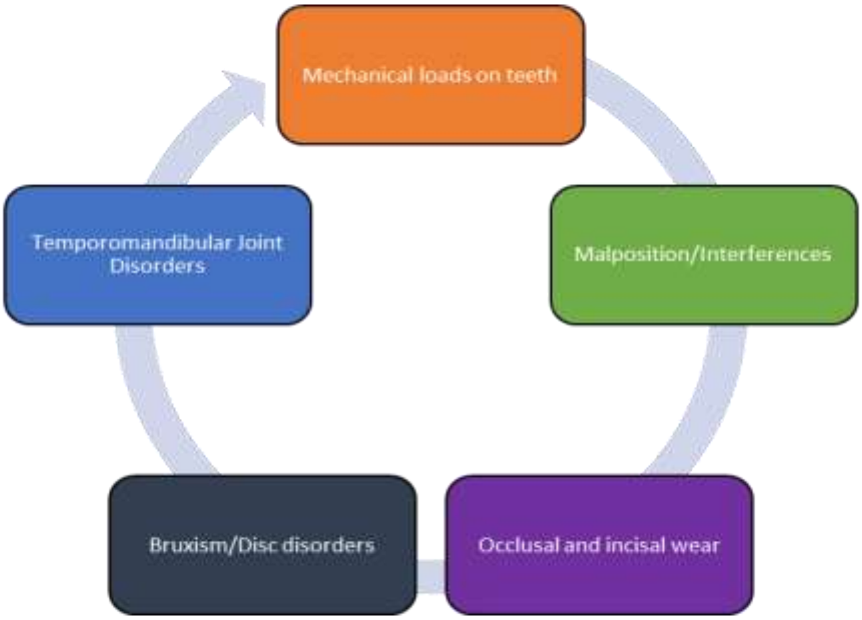
**2. Disability Assessment:**

- Graded Chronic Pain Scale (GCPS)
- Jaw Disability Checklist (JDC)

These criteria help clinicians and researchers to systematically categorize and diagnose various TMD conditions based on clinical and psychosocial factors. It is important to note that the RDC/TMD has been revised, and the updated version is referred to as the DC/TMD (Diagnostic Criteria for Temporomandibular Disorders). The DC/TMD includes modifications and improvements to enhance diagnostic accuracy and clinical utility (Schiffman *et al.*, 2014).

## TOOTH WEAR AND TEMPOROMANDIBULAR JOINT DISORDERS

Tooth wear is a natural process that happens over time, but it can become problematic if it accelerates due to various factors. There are four main types of tooth surface loss: attrition (from functional and parafunctional habits), abrasion (mechanical processes), erosion (chemical processes), and abfraction (mechanical loading leading to wedge-shaped defects). Identifying the cause of severe tooth wear is crucial for proper treatment and preventing further damage. Temporomandibular joint disorders can also impact tooth wear or tooth wear can impact temporomandibular joint health. Understanding these types of tooth surface loss helps in choosing the right treatment and preventing more harm to the teeth (Mickeviciute, Baltrusaityte and Pileicikiene, 2017).




*Tooth wear and Temporomandibular Joint Disorders*

## 4.6.CENTRIC RELATION AND TEMPOROMANDIBULAR JOINT DISORDERS

The Ackee and Piper classification: It is a method of classifying centric relation, which is the most retruded position of the mandible that can be reproducibly achieved(McNamara Jr. JA, Seligman DA, Okeson JP., no date). The classification is based on the relationship between the condyles and the articular eminences of the temporomandibular joint (TMJ) in centric relation. According to the Ackee and Piper classification, there are three types of centric relation:
Type I: The condyles are in the most superior position on the articular eminences, with the discs interposed between the condyles and the eminences.
Type II: The condyles are in a slightly inferior position on the articular eminences, with the discs still interposed between the condyles and the eminences.
Type III: The condyles are in a significantly inferior position on the articular eminences, with the discs displaced anteriorly or medially.
Temporomandibular Joint Disc disorders are closely related to centric relation, and treatment approaches like Occlusal splint focuses on disc positioning with respect to condyle (Dzingutė *et al.*, 2017; Mickeviciute, Baltrusaityte and Pileicikiene, 2017).

## MANAGEMENT OF TEMPOROMANDIBULAR JOINT DISORDERS

Treatment for TMD is only necessary in 5% to 10% of patients, with 40% experiencing spontaneous symptom resolution. In a prolonged follow-up study, 50% to 90% of patients achieved pain relief through conservative therapy. Managing TMD effectively often involves a multidisciplinary approach. Initial treatment objectives should prioritize the alleviation of pain and improvement of dysfunction (Dimitroulis, 2018).

## • NONPHARMACOLOGIC MANAGEMENT

The initial suggested approach for managing TMD involves supportive patient education. Additional measures encompass jaw rest, a soft diet, moist warm compress application, and engaging in passive stretching exercises. Immobilizing the TMJ has demonstrated no positive outcomes and might exacerbate symptoms due to muscle contractures, fatigue, and diminished synovial fluid production.

### 1.Physical Therapy.

The available evidence, although not robust, suggests a potential benefit of employing physical therapy to alleviate symptoms associated with TMD. Both active and passive techniques, such as scissor opening with fingers or utilizing medical devices, aim to enhance muscle strength, coordination, relaxation, and range of motion. Despite a lack of solid evidence, specialized physical therapy modalities like ultrasound, iontophoresis, electrotherapy, or low-level laser therapy have been employed in TMD management. Addressing underlying comorbid conditions increases the probability of success in TMD management.

### 2.Acupuncture.

Acupuncture is progressively employed in managing myofascial TMD, with sessions spanning 15 to 30 minutes, and an average of six to eight sessions. Findings from two systematic reviews indicate that acupuncture serves as a plausible supplementary approach for achieving short-term pain relief in individuals experiencing painful TMD symptoms.

### 3.Biofeedback.

Biofeedback, according to a Cochrane review, is endorsed for both short- and long-term pain control in individuals with symptomatic TMD when compared to standard management. Patients are advised on behavioral changes, including stress reduction, maintaining good sleep hygiene, eliminating parafunctional habits like teeth grinding and chewing on objects like pencils or ice, and avoiding excessive mandibular movements during activities such as yawning, tooth brushing, and flossing. Additionally, cognitive behavior therapy is recommended for effective pain management in TMD patients (Busse *et al.*, 2023).

### • PHARMACOLOGIC MANAGEMENT

The pharmacological management of TMD relies heavily on expert opinions, with various classes of medication aimed at addressing the underlying pain. A Cochrane review assessed nonsteroidal anti-inflammatory drugs (NSAIDs, encompassing salicylates and cyclooxygenase inhibitors), benzodiazepines, anti-epileptic agents, and muscle relaxants. The initial pool of 2,285 studies was narrowed down to 11 for qualitative synthesis. However, the authors concluded that there is inadequate evidence to either support or refute the effectiveness of any drug in treating TMD (Ouanounou, Goldberg and Haas, 2017; Busse *et al.*, 2023).

### • OCCLUSAL SPLINTS AND ADJUSTMENTS

Occlusal splints are believed to mitigate or avert degenerative forces impacting the TMJ, articular disk, and dentition. These devices might be advantageous for individuals experiencing severe bruxism and nocturnal clenching. Systematic reviews present contradictory findings regarding the most effective occlusal device for alleviating symptoms of TMJD. Seeking dental advice is crucial to identify the optimal occlusal device. However, adjusting occlusion, such as grinding enamel surfaces to enhance dentition, does not offer any benefits in managing or preventing TMD (Zhang *et al.*, 2020).

### OCCLUSAL SPLINT AS A TREATMENT OPTION

### a.HISTORY

The original inventor of the forerunner of modern splints will probably never be known. With the development and patenting of vulcanite rubber in 1855, Charles Goodyear provided dentists with a material that could be molded for many different oral applications. One of the early medical uses of vulcanite was by dental surgeons for splinting of broken jaw bones. In November 1862, Thomas Gunning, a practicing surgeon, used vulcanite to fabricate a custom fitting splint to treat himself for a broken jaw. He wore the splint for two months and discarded it when he considered himself healed. Another dentist, James Bean, working independently from Gunning, used a vulcanite device for jaw fractures while in the service of the Confederate Army. His splint had cup-like depressions to fit over the crowns of teeth.In 1887, twenty-five years after Gunning's development, Kingsely, published an article discussing the use of soft vulcanized rubber to make an obturator. Then in 1888, Farrar discussed the use of a splint to disarticulate the teeth for the purpose of increasing the eruption of selected teeth. He also recognized the changes in what he calls the inferior maxilla and its articulation. Karolyi, a German, introduced an occlusal splint in 1901 for the treatment of bruxism. Since that time, a variety of different splint designs have been developed and treating theories postulated. Hawley, in 1919, and then Monson, in 1921, each suggested that bruxism led to a loss of occlusal vertical dimension, which gave rise to occlusal disorders. The use of a removable bite plane to extrude posterior teeth was advocated. Several years later, in 1925, Washburn published an article discussing the history and evolution of occlusion. Articles by Goodfriend in 1933, Costen in 1934 and Block in 1947 suggested treatment modalities to increase vertical dimension for the treatment of TMD symptoms. Sved,in 1944, was using appliances to extrude posterior teeth to increase vertical dimension. To this day, our therapies continue to carry forward many of these pioneers' treatment concepts.

### b.Hard vs Soft splint

Posselt and Wolff, in 1963, undertook a study to compare the effectiveness of hard and soft bite plates to manage bruxism. They concluded that the hard bite guards were slightly more effective for managing these disorders. That same year, Gecker and Weill discussed the use of soft splints for bruxism because they believed this material produced less trauma on the teeth. In 1974, Dawson,29 suggested the use of soft appliances to cushion the posterior teeth in subjects with chronic sinusitis. Thorp,30 in 1975, described a technique of combining hard and soft (Molloplast B) material to produce an appliance to use in the treatment of bruxism. Writing in 1978, Block and Laskin found that resilient appliances were effective in treating TMJ dysfunction symptoms with complete or almost complete joint reduction. They reported that 74% of their patients had total or almost complete remission of non-specific TMD symptoms after six weeks.Also, in 1987, Okeson, compared the use of hard splints with soft splints in a pool of patients showing nocturnal bruxism. He concluded that the hard splints significantly reduced this hyperactivity of the muscles, while the soft splints did not.

### c.Methods for fabrication of occlusal splint

#### 1.Vacuum Pressing technique

After impressions and bite registration, a thermoplastic sheet is vacuum-pressed onto the models, forming the splint. This method ensures accurate fit, reduces processing time, and provides an effective solution for managing temporomandibular joint disorders.

#### 2.Using heat cure acrylic resin

After impressions and jaw relation, occlusal bite is recorded using 2-4 mm thick wax. This occlusal bite is flasked and de waxed. Using heat cure acrylic in the dough stage the de waxed flask is packed under compression. Heat is used to cure this packed acrylic resin. Following completion of curing, the splint obtained is trimmed and polished.

#### 3.3-D printing

3D printed occlusal splints are fabricated layer by layer using additive manufacturing technology. This precise and customizable technique allows for intricate designs, ensuring a comfortable and accurate fit for patients experiencing temporomandibular joint disorders.

### 4.8d. Fabrication of Occlusal splints using CAD/CAM technology:

The history of CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) in dentistry can be traced back to the 1970s when the first computer systems were used for designing and manufacturing dental restorations. However, it wasn't until the 1980s that CAD/CAM technology began to gain wider acceptance in the dental field.

In 1985, the first commercially available CAD/CAM system for dental applications, called CEREC (CEramic REConstruction), was introduced by Sirona Dental Systems. This system used a chairside scanner and a milling machine to produce ceramic inlays, onlays, and crowns in a single visit.

Over the next few decades, CAD/CAM technology continued to evolve and improve, with advancements in software, hardware, and materials. In the 1990s, 3D printing technology began to emerge, which allowed for the production of more complex and intricate dental restorations.

In recent years, CAD/CAM technology has become increasingly popular in dentistry, with many dentists and dental laboratories incorporating it into their workflow as it allows for faster, more accurate, and more predictable fabrication of dental restorations, reducing the need for traditional dental impressions and improving patient outcomes.

Occlusal splint fabrication can benefit from CAD/CAM technology in various ways. The use of digital scanning and 3D modeling in CAD/CAM technology enables highly accurate and precise fabrication of Occlusal splints (Alam *et al*., 2022; Juntavee, Juntavee and Srisontisuk, 2023). Studies have demonstrated that CAD/CAM-fabricated occlusal splints have superior tooth adaptation and fit compared to those made with traditional methods (Jafar Abdulla *et al*., 2021; Giannetti *et al*., 2022). The process of fabricating occlusal splints with CAD/CAM technology is also more efficient and faster, allowing for the entire process to be completed in a single visit. The computer-controlled milling process of CAD/CAM technology ensures predictability and consistency, which reduces the risk of errors.

3D printing and milling are two popular techniques used in CAD/CAM (computer-aided design and computer-aided manufacturing). Here are some more details on each technique:

#### 3D Printing:

3D printing involves creating a physical object from a digital model by depositing successive layers of material(Alam *et al*., 2022; Izdebska-Podsiadły, 2022). In the case of the occlusal splint, 3D printing can be used to create restorations using a clear acrylic resin. The 3D printing process involves slicing the virtual 3D model of the restoration into thin layers, which are then printed layer-by-layer using a 3D printer. The 3D printer typically uses a photo-polymerization process, in which a light source is used to cure the resin in the desired shape.

#### Milling:

Milling involves cutting away material from a block of acrylic resin using a milling machine, guided by a digital model of the restoration. The milling machine typically uses a high-speed rotating tool to remove material from the PMMA block until the desired shape is achieved (Arora, Ahmed and Maiti, 2022; Ellakany *et al*., 2023). The milling process is computer-controlled, which ensures that the restoration is accurately and consistently fabricated to the design specifications.

Studies have compared the two techniques for fabricating restorations. While 3D printing is a relatively new technology in the field of dentistry, some studies have shown that 3D-printed restorations have similar clinical performance and adaptation compared to milled PMMA restorations (Kane and Shah, 2023). However, milling has been the gold standard technique for many years, and numerous studies have demonstrated its accuracy, precision, and consistency (Giannetti *et al*., 2022). While 3D printing technology offers advantages such as reduced material waste and increased design flexibility, milling has the advantage of being a well-established and widely used technique with a high level of accuracy and consistency(Ellakany *et al*., 2022).

## EVALUATION OF TREATMENT SUCCESS

Success of any treatment modality in TMJ disorders can be evaluated using T scan, Joint Vibration analysis and Pain reduction (VAS score).

### 1.T scan

The T-Scan offers an objective method for evaluating dynamic dental occlusion, utilizing computerized analysis to eliminate subjective errors from paper marking and remain unaffected by saliva. This digital occlusion analysis device employs a pressure-sensitive bite transducer and an arch-shaped recording sensor to real-time record and assess tooth contact, force, and timing. T-Scan provides graphical representations in two or three dimensions for occlusal data, allowing the calculation of occlusal force distribution, interference, and relative force for each interference. It records patient parameters, including the center of force, confirming occlusal force symmetry. The T-Scan system determines key aspects such as the first contact between maxillary and mandibular teeth, maximum biting force, maximum intercuspation, and the mandibular occlusal position where maxillary and mandibular cusps fully interpose. Maximum intercuspation is crucial in orthodontic evaluations, defining jaw relationships in various dimensions. Through translating qualitative data into quantitative parameters, the T-Scan system offers a precise way to assess the timing sequence and magnitude of occlusal contact force.In TMJ (Temporomandibular Joint) treatment, T-Scan plays a valuable role by providing precise information on occlusal forces and timing of tooth contacts during biting and chewing. This data helps in assessing and adjusting the patient's bite, contributing to the diagnosis and effective management of TMJ disorders and related symptoms. The T-scan system’s advantages include not only its objectivity and reproducibility but also its ability to identify occlusal changes over time. This system measured parameters that time-related factors, occlusal papers, and occlusal indices could not. Furthermore, this method is currently the only one accessible for investigating the dynamic properties of occlusion (Alhammadi *et al.*, 2022)

### 2.Joint Vibration analysis

Analyzing the temporomandibular joint (TMJ) through vibration analysis is a quantitative procedure that measures the intensity and frequency distribution of vibratory waves emitted by the joint during its entire range of motion. The recording of tissue vibrations is detailed, extending down to approximately 1 μm. Joint Vibration Analysis (JVA) operates on principles of motion and friction. When surfaces come into contact and experience rubbing, it induces vibrations. The extent of surface roughness directly correlates with the magnitude of vibration, and accelerometers are employed to capture and measure this vibration.Alterations in the joint surface, such as those resulting from tissue degeneration, tears, or disc displacements, are believed to generate increased friction and more pronounced vibration. Distinct disorders may yield unique vibration patterns or identifiable "signatures" within the joint and examination of these vibrations helps in distinguishing different temporomandibular disorders (TMD). Two companies currently market instruments that are used for the assessment of JVA: BioResearch and Myotronics. The instrumentation marketed by Myotronics is presented on their website as the K7 evaluation system, although the website shows a K-7 ESG Electrosonograph. No specifications were found on the US Food and Drug Administration website15 for this component. The US Food and Drug Administration approves the BioResearch JVA (Abad-Coronel *et al.*, 2023)..

### 3.VAS score

Visual Analog Scale (VAS) scoring is a subjective pain assessment method used in TMJ treatment. Patients rate their pain levels on a graduated scale, typically ranging from 0 to 10, with 0 being no pain and 10 being the worst pain imaginable. VAS scoring helps clinicians evaluate pain intensity, monitor treatment effectiveness, and adjust management strategies accordingly.

## REFERENCES

Abad-Coronel, C. *et al.* (2023) ‘Comparative Analysis between Conventional Acrylic, CAD/CAM Milled, and 3D CAD/CAM Printed Occlusal Splints’, *Materials*, 16(18). Available at: https://doi.org/10.3390/ma16186269.

Ahmad, M. and Schiffman, E.L. (2016) ‘Temporomandibular Joint Disorders and Orofacial Pain’, *Dental clinics of North America*, 60(1), pp. 105–124.

Alam, M. *et al.* (2022) ‘Comparative evaluation of fracture resistance of anterior provisional restorations fabricated using conventional and digital techniques - An study’, *Journal of Indian Prosthodontic Society*, 22(4), pp. 361–367.

Aldosari, L.I.N. *et al.* (2023) ‘Prevalence of temporomandibular disorders among psychoactive substances abusers: A systematic review and meta-analysis’, *Journal of oral rehabilitation*, 50(9), pp. 894–901.

Alhammadi, M.S. *et al.* (2022) ‘Skeletal and dentoalveolar effects of class II malocclusion treatment using bi-maxillary skeletal anchorage: a systematic review’, *BMC oral health*, 22(1), p. 339.

Al-Moraissi, E.A. *et al.* (2020) 'Effectiveness of occlusal splint therapy in the management of temporomandibular disorders: network meta-analysis of randomized controlled trials', *International journal of oral and maxillofacial surgery*, 49(8), pp. 1042–1056.

Alomar, X. *et al.* (2007) 'Anatomy of the temporomandibular joint', *Seminars in ultrasound, CT, and MR*, 28(3), pp. 170–183.

Al-Saleh, M.A.Q. *et al.* (2016) 'MRI and CBCT image registration of temporomandibular joint: a systematic review', *Journal of otolaryngology - head & neck surgery = Le Journal d'oto-rhino-laryngologie et de chirurgie cervico-faciale*, 45(1), p. 30.

Armijo-Olivo, S. *et al.* (2016) 'Effectiveness of Manual Therapy and Therapeutic Exercise for Temporomandibular Disorders: Systematic Review and Meta-Analysis', *Physical therapy*, 96(1), pp. 9–25.

Arora, O., Ahmed, N. and Maiti, S. (2022) 'Comparison of the marginal accuracy of metal copings fabricated by 3D-printed resin and milled polymethyl methacrylate - An study', *Journal of advanced pharmaceutical technology & research*, 13(Suppl 1), pp. S238–S242.

Attanasio, R. (1997) 'Intraoral orthotic therapy', *Dental clinics of North America*, 41(2), pp. 309–324.
Beddis, H., Pemberton, M. and Davies, S. (2018) 'Sleep bruxism: an overview for clinicians', *British dental journal*, 225(6), pp. 497–501.

Bonjardim, L.R. *et al.* (2009) 'Association between symptoms of temporomandibular disorders and gender, morphological occlusion, and psychological factors in a group of university students', *Indian journal of dental research: official publication of Indian Society for Dental Research*, 20(2), pp. 190–194.

Bozhkova, T. and Shopova, D. (2022) 'T-Scan Novus System in the Management of Splints-Pilot Study', *European journal of dentistry*, 16(2), pp. 454–457.

Busse, J.W. *et al.* (2023) 'Management of chronic pain associated with temporomandibular disorders: a clinical practice guideline', *BMJ* , 383, p. e076227.

Capp, N.J. (1999) 'Occlusion and splint therapy', *British dental journal*, 186(5), pp. 217–222.
Caruso, S. *et al.* (2017) 'Temporomandibular Joint Anatomy Assessed by CBCT Images', *BioMed research international*, 2017, p. 2916953.

Dimitroulis, G. (2018) 'Management of temporomandibular joint disorders: A surgeon's perspective', *Australian dental journal*, 63 Suppl 1, pp. S79–S90.

Dylina, T.J. (2001) 'A common-sense approach to splint therapy', *The Journal of prosthetic dentistry*, 86(5), pp. 539–545.

Dzingutė, A. *et al.* (2017) 'Evaluation of the relationship between the occlusion parameters and symptoms of the temporomandibular joint disorder', *Acta medica Lituanica*, 24(3), pp. 167–175.
Ellakany, P. *et al.* (2022) 'Influence of CAD/CAM Milling and 3D-Printing Fabrication Methods on the Mechanical Properties of 3-Unit Interim Fixed Dental Prosthesis after Thermo-Mechanical Aging Process', *Polymers*, 14(19). Available at: https://doi.org/10.3390/polym14194103.

Ellakany, P. *et al.* (2023) 'Comparison of the color stability and surface roughness of 3-unit provisional fixed partial dentures fabricated by milling, conventional and different 3D printing fabrication techniques', *Journal of dentistry*, 131, p. 104458.

Ferneini, E.M. (2021) 'Temporomandibular Joint Disorders (TMD)', *Journal of oral and maxillofacial surgery: official journal of the American Association of Oral and Maxillofacial Surgeons*, 79(10), pp. 2171–2172.

Ferreira, M.C. *et al.* (2018) 'Association between chewing dysfunctions and temporomandibular disorders: A systematic review', *Journal of oral rehabilitation*, 45(10), pp. 819–835.

Garstka, A.A. *et al.* (2023) 'Accurate Diagnosis and Treatment of Painful Temporomandibular Disorders: A Literature Review Supplemented by Own Clinical Experience', *Pain research & management: the journal of the Canadian Pain Society = journal de la societe canadienne pour le traitement de la douleur*, 2023, p. 1002235.