INDONESIAN JOURNAL OF PROSTHODONTICS

CASE REPORT

Integration of leaf gauge technique in the digital fabrication of stabilization splint for temporomandibular disorder: A case report

Alexander Justin,[1] Syafrinani,[2]* Ricca Chairunnisa[2]

Keywords: Arthralgia, Disc displacement with reduction, Leaf gauge, Local myalgia, 3D printing

ABSTRACT

Temporomandibular disorder (TMD) is a multifactorial musculoskeletal condition characterized by jaw pain, limited mandibular movement, and joint sounds. A common subtype is disc displacement with reduction (DDWR), often accompanied by local myalgia and arthralgia. Stabilization splints are a standard treatment modality, with 3D printing offering benefits such as precision, efficiency, and reduced clinical time. However, the effectiveness of splint therapy depends on accurate recording of the mandibular-maxillary relationship, which can be reliably achieved using a leaf gauge. To report the management of a TMD case involving DDWR, myalgia, and arthralgia in an adolescent patient using a leaf gauge to establish centric relation during the fabrication of a 3D-printed stabilization splint. An 18-year-old male presented with right-sided jaw pain and clicking upon mouth closure. History revealed parafunctional habits, including unilateral mastication and academic stress. Diagnosis was confirmed via DC/TMD Axis I and II, along with clinical and radiographic assessment, indicating DDWR with myalgia and arthralgia. Treatment includes behavioral treatment, infrared light therapy, and fabrication of a stabilization splint. Centric relation was determined using a leaf gauge to ensure accurate mandibular positioning. The use of a leaf gauge in this case facilitated precise centric relation, enhancing the efficacy of the 3D-printed stabilization splint. This approach contributed to significant symptom improvement and underscores the value of integrating analog tools within digital workflows in TMD management. (IJP 2025;6(2):130-135)

Introduction

The temporomandibular joint (TMJ) is one of the most complex joints in our body. The temporomandibular joint (TMJ) is an articulation between the mandibular condyle and the mandibular fossa of the temporal bone. These two bony structures are separated by the articular disc, which functions as an intra-articular cushion to prevent direct contact between the bone surfaces. The TMJ is classified as a compound joint. Anatomically, a compound joint involves at least three bony elements, but in the TMJ, only two bones directly contribute to the formation of the joint.[1]

Temporomandibular joint dysfunction (TMD) is a complex musculoskeletal condition that can cause jaw pain, limited movement of the joint, and/or other related structures.[2] According to the Glossary of Prosthodontic Terms (GPT), the definition of TMD is a condition that causes abnormal, incomplete, or impaired function of the temporomandibular joint and/or the masticatory muscles. Irritation of the auriculotemporal nerve and/or the chorda tympani nerve, which arises from the tympanic plate, may be caused by changes in anatomical relationships and temporomandibular joint dysfunction associated with loss of occlusal vertical dimension, loss of posterior tooth support, and other malocclusions.

These disorders can cause a series of clinical manifestations, including headache, tinnitus, otalgia (pain around the ear), hearing disturbances, and glossalgia (pain in the tongue). This condition reflects the complex involvement between the stomatognathic system and the cranio-mandibular neuroanatomical structures.[3] Among the intraarticular disorders of the temporomandibular joint (TMJ), disc displacement with reduction (DDWR) is the most common condition, with a prevalence of up to 41% of TMD diagnoses.

Disc displacement with reduction (DDWR) is characterized by the displacement of the articular disc from its normal position when the jaw is at rest, which returns to its original position during mandibular movement, typically accompanied by a clicking sound upon mouth opening.[4] The correlation between temporomandibular joint pain, termed arthralgia, and the position of the articular disc remains a controversial topic in the scientific literature. Although most cases of disc displacement with reduction (DDWR) are asymptomatic, the occurrence of intra-articular inflammatory processes may trigger pain sensations. This indicates that disc displacement does not directly cause pain in all cases; rather, the involvement of local inflammatory mechanisms may contribute to the pathogenesis of pain symptoms in some patients.[5,6]

Treatment for cases of disc displacement with reduction (DDWR) generally consists of patient education such as advising the patient to minimize excessive mouth opening—along with physical self-regulation (PSR) techniques and/or the use of an occlusal splint.[4] A study conducted by Conti, et al.[7] (2006) treated 57 patients with disc displacement with reduction (DDWR) using occlusal splints, and

1Specialist Program in Prosthodontics, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia
2Department of Prosthodontics, Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia

*Corresponding author: syafrinani@usu.ac.id

DOI 10.46934/ijp.v6i2.316

Table 1. Examination of Pain Intensity and Palpation of Masticatory Muscles and TMJ (0 = no pain, 1 = discomfort, 2 = pain)

Examination	Region	
	Right	Left
Temporalis	Ant : 1 Med : 1 Post : 1	Ant : 0 Med : 0 Post : 0
Tendon temporalis	1	0
Lateral pterygoid	2	0
Masseter	Superior : 1 Middle : 1 Inferior : 1	Superior : 0 Middle : 0 Inferior : 0
Regio submandibula	0	0
Sternocleidomastoideus	Posterior : 0 Anterior : 0 Klavikula : 0	Posterior : 0 Anterior : 0 Klavikula : 0
Splenius Capitis	-	-
Trapezius	0	0
Maximum pain-free mouth opening (mm)	30 mm	
Maximum mouth opening with pain (mm)	35 mm	
Maximum assisted mouth opening (mm)	37 mm	
Lateral movement	5 mm	10 mm
TMJ pain	2	0
TMJ noises	Open : - Close : Kliking	Open : - Close: - -
Headache	-	-
Tinitus	-	
Static Occlusion	Right : Klas I Angle (molar relationship) Left : Klas I Angle (molar relationship) Overbite : 2 mm Overjet : 2 mm	
Dynamic Occlusion	Group function	
Midline deviation maximum mouth opening during	Deviation to the right during mouth closure	

Table 2. Post-treatment assessment of pain intensity and palpation of masticatory muscles and TMJ (0 = no pain, 1 = discomfort, 2 = pain)

Examination	Region	
	Right	Left
Temporalis	Ant : 0 Med : 0 Post : 0	Ant : 0 Med : 0 Post : 0
Tendon temporalis	0	0
Lateral pterygoid	0	0
Masseter	Superior : 0 Middle : 0 Inferior : 0	Superior : 0 Middle : 0 Inferior : 0

Figure 1. Frontal and lateral profile

Figure 2. Intra-oral examinations

reported a significant improvement in both pain intensity and clicking sounds of the temporomandibular joint (TMJ).

Muscle-related disorders constitute the largest subgroup among the various diagnoses of temporomandibular disorders (TMDs). Scientifically, this condition encompasses a range of manifestations, including myalgia and myofascial pain, which serve as the primary etiologies of non-odontogenic orofacial pain. The predominant prevalence of muscle disorders highlights the critical role of neuromuscular factors in the pathophysiology of TMD.[8] According to a recent meta-analysis, the most effective therapeutic approaches include counseling, occlusal splint therapy, and jaw exercises, as well as heat/light therapy or physiotherapy. This multimodal approach has demonstrated superior efficacy in alleviating pain symptoms, improving mandibular function, and modulating psychosocial factors that contribute to masticatory muscle disorders.[9,10]

Since its initial introduction in the early 1980s through the CEREC system, Computer-Aided Design and Computer-Aided Manufacturing (CAD-CAM) technology has undergone rapid development and has been widely adopted—particularly through 3D printing fabrication methods—not only in the field of restorative dentistry, but also across all branches of dental medicine. This technological innovation has enabled chairside restorations to be performed entirely under the clinician's supervision, offering numerous advantages such as cost efficiency and significantly reduced production time. The fabrication of occlusal splints using a fully digital workflow offers several advantages over conventional techniques. One of its primary benefits is the significantly reduced fabrication time and minimal risk of contamination, making it a more efficient and practical option in modern clinical practice. However, the success of the splint is highly dependent on the accuracy of the centric relation, which can be effectively achieved through the use of a leaf gauge.[10]

Centric relation (CR) can be recorded using two primary techniques: bimanual manipulation and the anterior device technique. One of the instruments employed in the anterior technique is the leaf gauge. The leaf gauge functions by relaxing the lateral pterygoid muscle, thereby allowing the mandibular condyles to assume a passive and stable centric relation position. This is achieved through the stimulation of mandibular elevator muscles (such as the masseter and temporalis), which help position the mandible physiologically without involving muscles that could induce deviation or abnormal pressure on the temporomandibular joint. Clinically, this technique is advantageous for obtaining a more accurate and reproducible CR position.[11]

Case Report

Case Presentation

Figure 3. Panoramic radiography imaging Panoramic

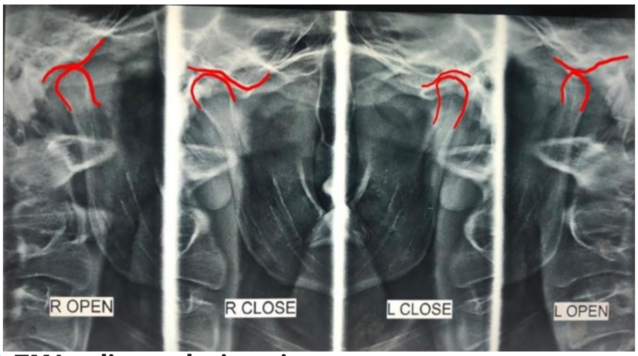

Figure 4. TMJ radiography imaging

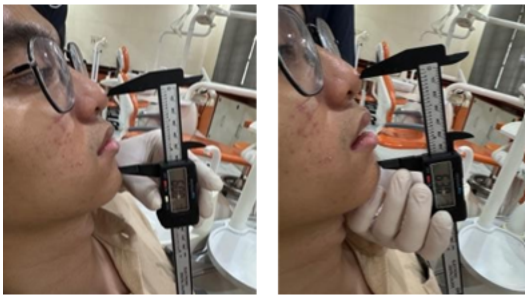

Figure 5. Freeway space (3mm)

Figure 6. Custom leaf gauge

Figure 7. Centric relation determination with leaf gauge technique

An 18-year-old male patient figure 1 presented to the Dental and Oral Hospital, University of North Sumatra (RSGM USU) with a chief complaint of dull pain and occasional discomfort in the right jaw, particularly in the preauricular region. Anamnesis revealed that the pain typically occurred during periods of stress and increased activity over the past six months. The patient also reported several parafunctional habits, such as chewing and sleeping predominantly on one side.

Prior to initiating treatment, a comprehensive examination was performed, which included an assessment of the masticatory muscles and temporomandibular joints (TMJ) through palpation, intraoral photography, TMJ and panoramic radiographic imaging, as well as Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Axis I and II evaluations.

Radiographic Analysis figure 3: Impacted teeth identified: 18, 28, 38, and 48; No pathological abnormalities detected; From the TMJ radiographic findings, the following observations were made: Closed Mouth Position: Right side: The condyle appears larger than the left condyle, with the mandibular condyle positioned within the glenoid fossa. Left side: The mandibular condyle is positioned within the glenoid fossa.

Open Mouth Position: Right side: The condyle appears larger than the left condyle, with the mandibular condyle positioned anterior to the articular eminence. Left side: The mandibular condyle is positioned more anterior to the articular eminence compared to the right condyle.

Based on the comprehensive clinical evaluation, the patient was diagnosed with disc displacement with reduction, local myalgia, and arthralgia, conditions that were primarily associated with psychological predisposing factors and parafunctional habits contributing to the development of temporomandibular disorder (TMD). The prognosis was considered favorable, as the patient demonstrated good cooperation, motivation to undergo treatment, and a willingness to modify detrimental habits. Other contributing factors, such as occlusal discrepancies and dental crowding, were identified, and orthodontic treatment was planned to correct tooth alignment.

Treatment began with preliminary therapy, including scaling and root planing, followed by determination of the patient's freeway space using a caliper figure 5. The splint fabrication process commenced with the creation of a custom leaf gauge, made from panoramic radiographic film measuring 4 × 10 cm with a thickness of 0.2 mm per layer. The number of layers for the leaf gauge was adjusted according to the patient's freeway space figure 6.

The patient was instructed to bite on the leaf gauge while performing protrusive and retrusive mandibular movements. When the mandible reached the retruded position, the patient was asked to gently maintain the bite for 30 seconds to 1 minute. This proce-

DOI 10.46934/ijp.v6i2.316

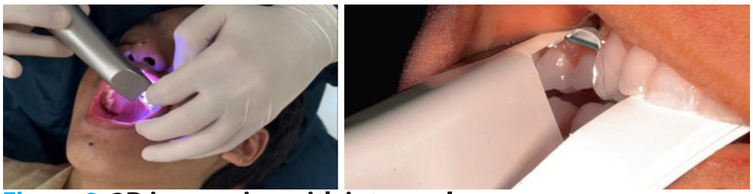

Figure 8. **3D impression with intra oral scanner**

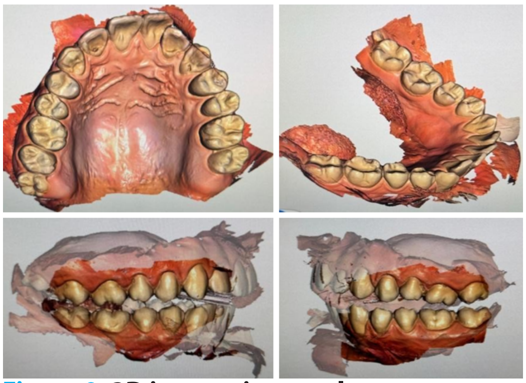

Figure 9. **3D impression results**

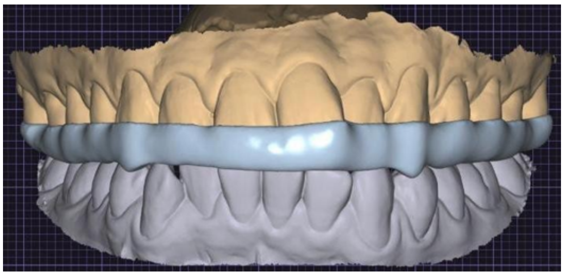

Figure 10. **Occlusal splint 3D design**

Figure 11. **Insertion of the occlusal splint and verification of canine guidance**

Figure 12. **Heat therapy with infrared light**

dure was repeated two to three times figure 7. Subsequently, while the patient maintained the biting position on the leaf gauge, a 3D digital impression was obtained using an intraoral scanner figure 8.

Following the 3D digital impression, the scanned data were sent to the laboratory for 3D printing fabrication of the occlusal splint, designed with a thickness of 3 mm corresponding to the patient's freeway space and incorporating a canine-guided occlusal scheme figure 10. During the second visit, the splint was inserted for intraoral adjustment and verification figure 11. The patient was also provided with adjunctive light/heat therapy using an infrared lamp applied to the right temporomandibular joint region figure 12.

A follow-up evaluation was conducted 1–2 weeks after splint insertion to assess muscle condition, mouth opening, and joint sound. After two weeks, a re-evaluation was performed, including an examination of the masticatory muscles and occlusion, while the patient continued to wear the stabilization splint continuously throughout the day. The patient reported improved comfort and a notable reduction in pain around the TMJ region. After one month of follow-up, the patient no longer experienced pain or clicking sounds in the temporomandibular joint table 2.

Discussion

The temporomandibular joint (TMJ) is anatomically and functionally classified as the most complex synovial articulation within the human musculoskeletal system. The articular surfaces of this joint are in direct contact with the articular disc, an avascular structure that derives its nutritional supply from the synovial fluid.[12] Dislocation of the temporomandibular joint (TMJ) disc is a disorder characterized by an abnormal displacement of the articular disc in relation to the mandibular condyle and the mandibular fossa. One subtype of temporomandibular disc displacement is disc displacement with reduction (DDWR). During mandibular opening, the articular disc undergoes repositioning over the condylar head, thereby restoring a physiologically aligned articular relationship. The asynchrony between disc translation and condylar motion may result in audible acoustic phenomena, typically perceived as clicking, snapping, or popping sounds, which are commonly detected during the mandibular opening phase.[6]

The etiological factors of disc displacement with reduction (DDWR) and arthralgia are predominantly associated with abnormal biomechanical forces exerted on the mandibular condyle, which may progressively alter the morphology and function of the articular tissues. These pathological changes disrupt the physiological relationship between the condyle and the articular disc.[12] Bruxism, psychological stress, clenching, oral parafunctional activities, mandibular trauma, excessive masticatory activity, morphological alterations of the articular eminence and joint surfaces, insufficient

DOI 10.46934/ijp.v6i2.316

intraarticular lubrication, structural modifications of the articular disc, degenerative joint disorders, hyperactivity of the lateral pterygoid muscle, ligamentous injury, abnormal dental occlusion, mandibular hypoplasia, posterior tooth loss, deflective occlusion, and joint hypermobility are all potential risk factors that may contribute to the development of disc displacement with reduction (DDWR).[13,14] These factors, either individually or synergistically, can induce biomechanical and neuromuscular imbalances within the stomatognathic system, thereby increasing the susceptibility to articular disc displacement and contributing to functional disturbances of the temporomandibular joint.

Management of the patient's psychological factors can be achieved through the implementation of Physical Self-Regulation (PSR) techniques, which aim to promote systemic relaxation, thereby alleviating pain symptoms and functional disturbances. Patients are instructed to eliminate deleterious habits such as clenching or grinding, practice diaphragmatic breathing, maintain proper head posture (avoiding tilting), allocate dedicated relaxation periods twice daily, and ensure a comfortable sleeping position to support neuromuscular balance and recovery.[15] A study conducted by Aggarwal et al. demonstrated that the combination of Physical Self-Regulation (PSR) therapy and patient education effectively alleviates orofacial pain symptoms, highlighting the synergistic benefits of integrating behavioral and educational interventions in TMD management.[16]

The management of DDWR cases is contingent upon the patient's clinical complaints. In patients presenting with disc displacement with reduction accompanied by clicking but without additional symptoms, occlusal therapy is generally not indicated, and patient education is recommended. However, in cases where DDWR is associated with pain, the use of a stabilization occlusal splint may be warranted. An occlusal splint is a therapeutic device fabricated from acrylic resin, designed to cover the occlusal surfaces of one dental arch while establishing controlled and precise occlusal contacts with the antagonist arch.

The eccentric guidance of this splint is selectively configured on the canines (canine guidance) to prevent posterior interferences during lateral and protrusive mandibular movements, thereby reducing occlusal load on the masticatory muscles and temporomandibular joint structures. The stabilization splint in centric relation (CR) is designed to provide uniform occlusal contacts when the mandibular condyles are positioned anterosuperiorly, supported by the articular disc and articulating with the posterior slope of the articular eminence, representing a musculoskeletally stable and physiologically optimal position.[1,10]

An engram is a pattern of muscle activity stored in memory that can induce mandibular deviation, leading to errors during the recording of centric relation (CR). A muscle deprogrammer is a device used to eliminate these engrams and consistently position and stabilize the condyles in centric relation. Muscle deprogramming is achieved by placing the deprogrammer, such as a leaf gauge, in the anterior region, thereby preventing posterior occlusal contacts.[17] This approach allows the lateral pterygoid muscles to relax, enabling the mandibular condyles to assume an accurate centric relation (CR) position. Muscle relaxation eliminates abnormal traction forces on the condyles, thereby allowing the temporomandibular joints to achieve a stable and physiologically optimal articulatory position.[18]

Conventional impression-taking presents several challenges. Patients with mucosal undercuts or interdental spaces may cause distortion of the impression material during tray removal. Such complications impair the fabrication of a precise splint and hinder the attainment of an accurate impression. These issues can be mitigated through 3D digital impression techniques, which offer advantages such as enhanced precision, greater efficiency, and a reduction in the number of patient visits required.[19] This approach enables the clinician to fabricate splints with high accuracy and reduced production time. It can be implemented in the clinical setting as a novel, standardized method for digitally-based splint fabrication.

Conclusion

The implementation of a digital workflow using an intraoral scanner and 3Dbased splint design facilitates the rapid and precise fabrication of the device while minimizing distortions commonly encountered with conventional techniques. The leaf gauge functions as an effective deprogrammer, promoting relaxation of the lateral pterygoid muscles and allowing the mandibular condyles to achieve a musculoskeletally stable and physiologically accurate centric relation (CR) position. The use of the leaf gauge in centric relation determination has been shown to contribute significantly to the successful fabrication of 3D-printed stabilization splints in TMD cases.

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DOI 10.46934/ijp.v6i2.316