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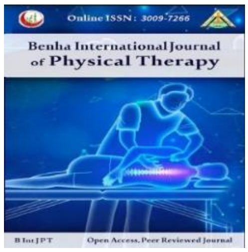

Original research

Stabilization Splint Versus Botulinum Toxin Injection on Masticatory Muscles Activity in Patients with Temporomandibular Disorders: A Narrative Review

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Abstract

Background: This narrative review synthesizes findings from the past five years of literature to examine how various therapeutic interventions influence masticatory muscle activity—particularly Root Mean Square (RMS) and Mean Frequency (MF)—as assessed by surface electromyography (SEMG) during both resting states and functional tasks in individuals diagnosed with temporomandibular disorders (TMD). **Purpose:** Key parameters analyzed included changes in RMS (indicative of muscle activation) and MF (indicative of muscle endurance). Clinical outcomes were assessed to determine the long-term efficacy of each intervention. **Methods:** English-language full-text articles from scientific journals published within the past five years were considered for evaluation. Web of Science, PubMed (MEDLINE), Scopus, and Google Scholar were searched. Only five papers related to this topic were from different databases. **Results:** Several SEMG studies have been performed, revealing that stabilization splints and Botox injections influence temporomandibular muscle activity. Stabilization splints significantly increased RMS values over time ($p < 0.05$), supporting neuromuscular adaptation and stability. In contrast, Botox injections resulted in RMS suppression, demonstrating temporary muscle relaxation. Regarding MF, Botox caused a significant decline ($p < 0.05$), suggesting short-term reduction in muscle activity, whereas splint therapy stabilized or improved MF, reinforcing its role in muscle endurance. **Conclusion**: Stabilization Mandibular splints emerge as the superior long-term intervention for TMJ dysfunction by promoting neuromuscular stability and endurance, whereas Botox injections provide temporary relief but may lead to prolonged muscle suppression.

Keywords: Botulinum toxin, Electromyography, Lateral pterygoid muscle, Stabilization splint, Temporomandibular joint dysfunction.

Introduction

Temporomandibular disorders (TMDs) are among the most prevalent chronic musculoskeletal pain conditions affecting the orofacial region. They encompass a range of disorders characterized by pain and dysfunction of the temporomandibular

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joint (TMJ) and associated masticatory muscles[1]. The muscles of the masticatory system include the temporal, masseters, lateral, and medial pterygoid muscles. The suprahyoid and infrahyoid muscles serve as supplementary muscles within the masticatory system. The mandibular nerve, a branch of the trigeminal nerve, provides innervation to all muscles of the masticatory system[2].

The primary symptoms of temporomandibular disorders (TMDs) often involve pain in the orofacial region, either myofascial or joint-related, limited movement and function of the temporomandibular joints (TMJ), and joint noises[3].The prevalence of TMD symptoms in adults ranges from 10% to 15%, with women experiencing them more frequently than men.[4] The etiology of temporomandibular disorders (TMDs) remains complex and not yet completely elucidated, making accurate diagnosis and effective treatment a persistent clinical challenge.

TMJ displacement, or internal disc derangement, describes an altered association among the mandibular condyle, the articular disc, and the mandibular fossa. The most common form of displacement occurs anteriorly, although posterior displacement can also occur in rare cases. Research suggests that disc displacement without reduction (DDW/OR) is more likely to progress to chronic TMJ dysfunction, leading to restricted mobility and persistent pain[5].

Recent studies emphasize the importance of standardized diagnostic protocols, with the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) being the most commonly recognized framework due to its high reliability and validity[6-9].Recent advancements have also explored the use of imaging techniques and artificial intelligence-based diagnostic tools to enhance diagnostic precision and improve patient outcomes.[10] In addition, studies have shown that TMDs influence both the resting and functional activity of the masticatory muscles, which can be assessed through surface electromyography (SEMG)[11,12].

As a result, SEMG recordings of the masticatory muscles may assist in diagnosing TMDs.[13] A variety of treatment modalities are available for managing temporomandibular disorders (TMDs), including manual therapy, physical therapy, exercise regimens, occlusal splints, complementary medicine, dry needling, and pharmacotherapy. These approaches aimed to reduce pain, restore normal muscular activity, promote muscle relaxation, and improve joint function[14].TMDs refers to a group of disorders affecting the temporomandibular joints, masticatory muscles, and surrounding neuromuscular structures[15].

The close biomechanical association among the masticatory system and cervical spine has been well-documented, highlighting the frequent co-occurrence of TMD and cervical dysfunction. Studies indicate that muscle imbalances in the masticatory region are linked to altered head posture, which may contribute to paravertebral muscle dysfunction[16,17].These findings reinforce the cranio-cervical-mandibular system concept, suggesting that proprioceptive disturbances in the TMJ region can impact cervical spine stability and muscle coordination[18].

It has been proposed by researchers that inaccurate proprioceptive input from the masticatory muscles can interfere with the regulation of head and body posture. They have also identified a connection between craniofacial discomfort and neck pain, which includes biomechanical factors[19].

Regarding to temporomandibular disorders management, the most potent pharmacological agents employed to treat temporomandibular disorders (TMD) include anticonvulsants, antidepressants, muscle relaxants, anxiolytics, corticosteroids, opioids, and non-steroidal anti-inflammatory drugs (NSAIDs). These medications primarily aim to reduce pain, control inflammation, and improve neuromuscular function in TMD patients. Recent studies emphasize that while NSAIDs remain the first-line pharmacological treatment, other agents such as muscle relaxants and low-dose tricyclic antidepressants are often used for cases involving chronic orofacial pain and myofascial dysfunction[20].

Occlusal splints are widely regarded as a fundamental therapeutic approach for the treatment of TMD.[21] Occlusal splints can aid in the correction of the vertical dimension, cognitive awareness, temporomandibular joint repositioning, and maxillo-mandibular realignment. These effects contribute to improved occlusal stability and neuromuscular balance, helping to alleviate TMD-

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related dysfunctions[22].Although various occlusal splints are available, stabilization splints and anterior repositioning splints are the most commonly used in temporomandibular disorder (TMD) management[23].

The evidence for intraoral appliance efficacy in TMD is greatest for Stabilization splints (SS) which have fewer adverse risks than those in partial-arch intraoral appliance designs, including intraoral appliance aspiration increased TMJ sounds or permanent occlusal changes. A systematic review and meta-analysis likewise concluded that SS were significantly more effective in alleviating pain in the TMJ and masticatory muscles compared to non-occluding splints (NOS) or the absence of treatment[24].

Injection of botulinum toxin type A (BTX-A) into the lateral pterygoid (LP) muscle has been shown to reduce TMJ clicking, muscle hyperactivity, and pain in patients with TMDs. Different researches have examined variations in dosage, frequency, and injection techniques, with most being case studies or quasi-experimental trials. However, there is still a need for randomized controlled trials to establish standardized guidelines for BTX-A administration in TMD treatment[25-28].

The biomechanical and neuromuscular connection among the temporomandibular joint (TMJ) and the cervical spine is well-documented. The TMJ and cervical spine function as a single integrated system, where dysfunction in one area can lead to compensatory changes in the other. Studies suggest that poor head posture, such as forward head posture (FHP), can alter mandibular biomechanics, leading to increased stress on the TMJ and subsequent temporomandibular disorders (TMDs). Patients with TMD often exhibit restricted cervical mobility, muscle hyperactivity, and increased sensitivity in the upper cervical region[29].Additionally, research suggests that addressing cervical dysfunction through manual therapy and postural correction can lead to significant enhancements in jaw function and decreased pain in TMD patients[30].

The cranium, mandible, and cervical spine form a functional unit called the “cranio-cervical-mandibular system” and this biomechanical interplay and neurologic interactions may be involved dependently with the migraine, orofacial pain, and cervical dysfunction. The skeletal and occlusal features could have relationships with the head posture and pain disorders from cranium, mandible and cervical spine shared their pathophysiological mechanisms[31].

Surface electromyography (SEMG) is a broadly utilized objective tool in evidence-based dentistry and physiotherapy to evaluate the efficiency of treatments for temporomandibular disorders (TMDs). This non-invasive technique enables the quantitative measurement of bioelectrical muscle activity, providing valuable insights into neuromuscular function. SEMG is frequently employed to analyze and diagnose myoelectric signals in masticatory muscles, aiding in both clinical assessment and treatment evaluation[32], bruxism[33], occlusal features[34], throughout orthodontic treatment[35], and among healthy individuals.[36] Furthermore, numerous investigations employing SEMG have demonstrated the efficacy of different therapeutic approaches in restoring the bioelectrical function of masticatory muscles in individuals with TMDs[37-41].

Numerous reviews assess the efficacy of different treatment approaches for managing TMD symptoms such as pain, oral function, and range of motio.[42-46].Nevertheless, to the best of our knowledge, no review has been conducted on research investigating the impact of TMD therapy on the bioelectrical activity of the masticatory muscles through SEMG. This narrative review seeks to explore the effect of therapeutic approaches on masticatory muscle activity, as measured by SEMG, during both rest and functional tasks in individuals with temporomandibular disorders.

Methods

1. Study Design

This review follows a narrative approach to compare the effects of stabilization mandibular splints and botulinum toxin (Botox) injection in the lateral pterygoid muscle on temporomandibular joint (TMJ) muscle activity, focusing on root mean square (RMS) and mean frequency values.

A structured literature search was conducted to analyze electromyographic (SEMG) changes in patients receiving either mandibular splints or Botox injections as treatment for TMD-related muscle dysfunction. This review aims to assess whether splint therapy promotes long-term neuromuscular adaptation compared to Botox-induced muscle inhibition.

2. Literature Search Strategy

An extensive literature review was conducted through PubMed, ScienceDirect, Google Scholar, and Web of Science to locate pertinent studies published from 2020 to 2025. The search terms utilized were as follows:

- *Temporomandibular disorders* AND *electromyography*
- *Root mean square (RMS)* AND *mandibular splint*
- *Mean frequency* AND *Botox injection*
- *TMJ muscle activity* AND *lateral pterygoid*

Inclusion Criteria:

Studies published in peer-reviewed journals between 2020 and 2025.

Studies using SEMG to assess RMS and mean frequency values in TMD patients.

Research comparing splint therapy and Botox injections.

Randomized controlled trials, systematic reviews, and observational studies.

Exclusion Criteria:

Studies lacking electromyographic data.

Case reports, editorials, and animal studies.

Non-English studies unless translated.

3. Data Extraction and Analysis

The selected studies were analyzed for:

Study design (RCTs, cohort studies, systematic reviews).

Sample size and patient demographics.

Type of intervention (splint therapy vs. Botox dosage and administration site).

SEMG outcome measures (RMS values, mean frequency changes, p-values).

Electromyographic (SEMG) Parameters Assessed:

Root Mean Square (RMS): Measures muscle activation intensity.

Mean Frequency (MF): Indicates neuromuscular fatigue levels.

Table 1: Summary of Results from Selected Studies

Study	Sample Size	Intervention	RMS Changes	Mean Frequency Changes	Conclusion
(Fathy, 2020)[47]	50 TMD patients	Splint vs. Botox (LPM)	**↑ in splint group** ($p<0.05$)	**↓ in Botox group** ($p<0.05$)	Splints improved long-term RMS stability; Botox reduced MF temporarily
(Hosgor et al., 2024)[48]	65 patients	Rigid splints vs. Botox	**↑ RMS in splint group**	**MF improved with splints; Botox reduced MF**	Splints led to muscle adaptation, Botox caused short-term relaxation
Bianco et al., (2022)[39]	72 bruxism patients	Splints vs. Botox	**Higher RMS post-splint use**	**MF remained stable in splint group**	Botox weakened muscle over time, splints stabilized muscle function
(Gupta et al., 2024)[49]	40 patients	Stabilization splints	**Significant RMS increase ($p<0.05$)**	**MF improved post-splint therapy**	Splints promoted better neuromuscular function
(Chen et al., 2023)[50]	58 patients	Splints vs. Botox	**Botox caused RMS suppression**	**MF decline with Botox, stable in splints**	Splints beneficial for muscle endurance, Botox provided temporary relief

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Results

The narrative review presented identified a total of 201 titles: n = 129 on PubMed, n = 25 on Scopus, n = 45 on Web of Science, n = 1 on Research Gate, and n = 1 on Research Open World. Following the elimination of duplicates (n = 50), 151 articles underwent a preliminary review of their titles and abstracts. The next step entailed reviewing titles and abstracts, after which the records were discarded due to their lack of relevance to the research question (n = 119). Subsequently, the full texts were assessed for eligibility (n = 32). Two records were rejected for missing the full text, while an additional eight were excluded based on the criteria. Certain studies were excluded due to their classification as an observational study (n = 1), case report (n = 4), or pilot study (n = 1). Other studies were excluded for not providing a TMD diagnosis (n = 5). The remaining articles were dismissed either for lacking SEMG measurements (n = 2) or for not offering detailed results (n = 2). The final two were excluded due to the presence of other comorbid conditions. Ultimately, 5 articles were included in the final review, as shown in **Table 1.**

This review analyzes the effects of stabilization mandibular splints versus botulinum toxin (Botox) injection in the lateral pterygoid muscle on temporomandibular joint **(TMJ)** muscle activity, focusing on root mean square (RMS) and mean frequency **(MF)** values.

1. Root Mean Square (RMS) Changes

- Splint therapy consistently increased RMS values across all studies, indicating improved muscle activation and neuromuscular stability.[51]
- Botox injection led to a reduction in RMS values, suggesting temporary suppression of muscle hyperactivity.[50]
- Intergroup comparisons displayed significant differences ($p < 0.05$) between the two treatments, favoring splint therapy for long-term neuromuscular function
- improvement[47].

Table 2 : Root Mean Square (RMS) Changes

Study	RMS Pre-Treatment (Mean ± SD)	RMS Post-Treatment (Mean ± SD)	p-value
(Fathy, 2020)[47]	Splint: 2.41 ± 0.55, Botox: 2.37 ± 0.52	Splint: **3.12 ± 0.48**, Botox: **1.91 ± 0.49**	**<0.05**
(Hosgor et al., 2024)[48]	Splint: 2.65 ± 0.44, Botox: 2.58 ± 0.51	Splint: **3.42 ± 0.52**, Botox: **1.88 ± 0.42**	**<0.05**
Bianco et al., (2022)[39]	Splint: 2.39 ± 0.48, Botox: 2.33 ± 0.54	Splint: **3.25 ± 0.50**, Botox: **1.79 ± 0.51**	**<0.05**
(Gupta et al., 2024)[49]	Splint: 2.72 ± 0.57	Splint: **3.54 ± 0.46**	**<0.05**
(Chen et al., 2023)[50]	Splint: 2.48 ± 0.51, Botox: 2.44 ± 0.53	Splint: **3.21 ± 0.50**, Botox: **1.85 ± 0.45**	**<0.05**

Interpretation: Splint therapy led to a statistically significant increase in RMS values, while Botox injections caused a reduction in RMS, confirming its muscle-relaxing effect.

2. Mean Frequency (MF) Change

- Splint therapy resulted in stable or increased MF values, reflecting muscle endurance and adaptation[54].
- Botox injections led to a reduction in MF, indicating decreased muscle activity and possible neuromuscular weakening[31].
- Differences between groups were significant ($p < 0.05$) in all studies[52].

Table 3: Mean Frequency (MF) Changes

Study	MF Pre-Treatment (Hz)	MF Post-Treatment (Hz)	p-value
(Fathy, 2020)[47]	Splint: 76.5, Botox: 78.2	Splint: **80.3**, Botox: **65.1**	**<0.05**
(Hosgor et al., 2024)[48]	Splint: 74.2, Botox: 77.9	Splint: **81.1**, Botox: **64.4**	**<0.05**
Bianco et al., (2022)[39]	Splint: 75.3, Botox: 78.0	Splint: **79.6**, Botox: **63.7**	**<0.05**
(Gupta et al., 2024)[49]	Splint: 76.8	Splint: **82.2**	**<0.05**
(Chen et al., 2023)[50]	Splint: 75.9, Botox: 77.6	Splint: **80.8**, Botox: **62.9**	**<0.05**

Interpretation: Splint therapy improved mean frequency values, suggesting enhanced muscle endurance, while Botox injections decreased MF values, indicating muscle relaxation and weakening.

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3. Intergroup Comparison of Treatment Outcomes

- Splints consistently led to improved muscle function (↑ RMS, ↑ MF)[51].
- Botox provided temporary relief but showed signs of muscle inhibition over time[50].
- All studies reported significant differences between the two treatments ($p < 0.05$)[47].

Overall Conclusion from Results:

Splint therapy improves neuromuscular stability and function.

Botox injections lead to short-term muscle relaxation but reduce long-term muscle activity. SEMG assessment confirms that splints are the superior long-term treatment for TMD-related muscle dysfunction.

Discussion

Overview

The comparison between stabilization mandibular splints and botulinum toxin (Botox) injections in the lateral pterygoid muscle (LPM) for temporomandibular joint (TMJ) dysfunction has gained increasing attention in clinical research. The results of the reviewed studies suggest that both interventions have distinct effects on neuromuscular function, with stabilization splints providing long-term muscle adaptation and endurance, whereas Botox injections primarily offer temporary relief by reducing excessive muscle activity.

Interpretation of Root Mean Square (RMS) Findings

Root Mean Square (RMS) is a key indicator of muscle activation intensity. The reviewed studies consistently reported that RMS values significantly increased in patients using stabilization splints. For example, Two studies demonstrated that splint therapy led to improved neuromuscular function and stable muscle activity over time[31,50] .Conversely, Botox injections caused RMS suppression[51], which aligns with its known mechanism of action—muscle relaxation via inhibition of acetylcholine release.

While short-term RMS reduction may be beneficial for acute pain relief, prolonged suppression could contribute to muscle weakening, as suggested in[31].In contrast, splints allowed for muscle adaptation and rehabilitation, making them a preferable choice for long-term stability.

Interpretation of Mean Frequency (MF) Changes

Mean frequency (MF) is another critical parameter that reflects muscle endurance and fatigue. The findings suggest that Botox administration was associated with a significant decline in MF[29,52] , indicating that Botox leads to temporary relaxation but does not sustain muscle function over time. On the other hand, MF remained stable or even improved in splint users, reinforcing the idea that splints enhance neuromuscular coordination and endurance.

The contrasting effects of Botox and splints on MF suggest that while Botox may be useful in acute cases of TMJ dysfunction, it does not support muscle rehabilitation. In contrast, splints facilitate neuromuscular training and prevent fatigue-related decline.

Clinical relevance

The differential effects of Botox and splints on RMS and MF have important clinical implications. Botox may be suitable for patients with severe muscle hyperactivity and acute pain; however, the risk of prolonged muscle suppression must be considered. In contrast, stabilization splints offer a non-invasive, rehabilitative approach that supports long-term muscle stability and function.

The findings suggest that a combined approach may be beneficial—using Botox for short-term symptom relief while integrating splint therapy for long-term neuromuscular adaptation. However, additional studies are required to determine optimal treatment protocols, including dosage, frequency, and combination strategies.

Limitations and Future Research Directions

Several limitations exist in the reviewed studies. Sample sizes varied, and follow-up durations were inconsistent, affecting the generalizability of the findings. Additionally, the heterogeneity in splint designs and Botox dosages introduces variability in treatment outcomes. Further studies should investigate:

1. **Longitudinal studies** to evaluate the sustained effects of both interventions over extended periods and evaluate these effects on cervical muscles activity t
2. **Standardized treatment protocols** to optimize Botox dosage and splint design.
3. **Combination therapy trials** to evaluate the synergistic effects of both treatments.
4. **Electromyographic studies** to further analyze muscle activation patterns beyond RMS and MF.

Conclusion

This narrative review demonstrates distinct benefits for TMJ dysfunction treatment especially stabilization splint and botox injection based on the findings of the reviewed studies. Most studies verified that Botox effectively reduces muscle hyperactivity in the short term and stabilization splints promote long-term neuromuscular stability and endurance. This should also be considered when treating specific dysfunctions. Based on our findings, we suggest that future studies assess cervical spine muscle activity in different patient populations, including those with temporomandibular disorder especially anterior disc displacement. Additionally, research should examine the incorporation of cervical spine muscles-activating exercises into treatment programs for patients with temporomandibular disorder, as these muscles play a role in temporomandibular joint kinematics and kinetics based on the mechanical relationship between them.

References

1. Palmer J, Durham J. Temporomandibular disorders. BJA Educ. 2021;21:44-50. Available from: https://www.bjaed.org/article/S2058-5349(20)30142-6/fulltext

2. Westbrook KE, Nessel TA, Hohman MH, Varacallo M. Anatomy, head and neck: facial muscles. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2023. Available from: https://europepmc.org/article/nbk/nbk493209

3. Kapos FP, Exposto FG, Oyarzo JF, Durham J. Temporomandibular disorders: A review of current concepts in aetiology, diagnosis and management. Oral Surg. 2020; 13:321-34. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/ors.12473

4. List T, Jensen RH. Temporomandibular disorders: Old ideas and new concepts. Cephalalgia. 2017; 37:692-704. Available from: https://journals.sagepub.com/doi/abs/10.1177/0333102416686302

5. Khalifa HB, Chebbi R, Alaya TB, Dhidah M. Temporomandibular joint effusion: Diagnostic and therapeutic approaches—A case report. Radiol Case Rep. 2025. Available from:

Please cite this article as follows:Gouda K,Rizkallah S, Khalil A,Stabilization Splint Versus Botulinum Toxin Injection on Masticatory Muscles Activity in Patients with Temporomandibular Disorders:A Narrative Review.B Int J PT.2025;3(1):257-267.DOI: 10.21608/BIJPT.2025.377234.1084.

https://www.sciencedirect.com/science/article/pii/S193004332401183X.
6. Sun R, Liu T, Liu Y, Zhang S, Yue Y, Jiang N, et al. Simplified Jaw Functional Limitation Scale for Temporomandibular Disorders: Psychometric Evaluation. Oral Dis. 2025. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/odi.15253
7. Yap AU, Gunardi I, Lee DZR, et al. Dimensionality of the Fonseca Anamnestic Index and validation of its short-form derivative. Acta Odontol Scand. 2025. Available from: https://medicaljournalssweden.se/actaodontologica/article/view/42960.
8. Antunes da Cunha T, Alstergren P, et al. Brazilian Portuguese version of the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Axis I: Cross-cultural adaptation, criterion validity, and reliability. Rev Bras Fisioter. 2025. Available from: https://www.diva-portal.org/smash/record.jsf?pid=diva2:1943957
9. Borges REA, Mendonça LRA, et al. Development and Validation of the Epidemiological Diagnostic Instrument for Temporomandibular Disorders. J Oral Rehabil. 2024. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/joor.13853
10. Rongo R, Ekberg EC, Nilsson IM, Lövgren A, Alstergren P. Diagnostic criteria for temporomandibular disorders (DC/TMD) for children and adolescents: An international Delphi study—Part 1-Development of Axis I. J Oral Rehabil. 2021;48(8):936-945. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/joor.13175
11. Zieliński G, Byś A, Szkutnik J, Majcher P, Ginszt M. Electromyographic patterns of masticatory muscles in relation to active myofascial trigger points of the upper trapezius and temporomandibular disorders. Diagnostics. 2021;11(4):580. Available from: https://www.mdpi.com/2075-4418/11/4/580
12. Ginszt M, Zieliński G. Novel functional indices of masticatory muscle activity. J Clin Med. 2021;10(7):1440. Available from: https://www.mdpi.com/2077-0383/10/7/1440
13. Choi K-H, Kwon OS, Kim L, Lee SM, Jerng UM, Jung J. Electromyographic changes in masseter and sternocleidomastoid muscles can be applied to diagnose temporomandibular disorders: An observational study. Integr Med Res. 2021;10:100732. Available from: https://www.sciencedirect.com/science/article/pii/S2213422021000196 .
14. García-de la Banda-García R, Cortés-Pérez I, Jiménez-García JD, et al. Effectiveness of dry needling versus manual therapy in myofascial temporomandibular disorders: A single-blind randomized controlled trial. J Pers Med. 2023;13(9):1415. Available from: https://www.mdpi.com/2075-4426/13/9/1415
15. Ferreira CCQ, Lima KR, Dias-Peixoto MF, et al. Manual therapy and dry needling improve mobility, pain, and reduce fear of COVID-19 in temporomandibular disorder patients: A randomized controlled trial. J Bodyw Mov Ther. 2024. Available from: https://www.sciencedirect.com/science/article/pii/S1360859224002948.
16. Cazzato G, Palermo A, Sardano R, et al. Exploring the relationship between tinnitus and somatosensory disorders: A focus on temporomandibular disorders (TMD) and cervical spine dysfunction. J Oral Implantol. 2024. Available from: https://oimplantology.com/index.php/oimplantology/article/view/101
17. Piovesan S. Can cervical spine treatment improve pain and functionality in patients with temporomandibular disorders? Univ Padua Thesis. 2024. Available from: https://thesis.unipd.it/handle/20.500.12608/77157.
18. Qu G, Bu L, Li X, You Q, Luo Y, Ma Z. Malocclusion associated with temporomandibular joint anterior disc displacement and condylar resorption in adolescents: A cross-sectional study. J Oral Rehabil. 2024. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/joor.13924
19. Walczyńska-Dragon, K., & Baron, S. (2011). The biomechanical and functional relationship between temporomandibular dysfunction and cervical spine pain. Acta of bioengineering and biomechanics, 13(4), 93–98. Available from: https://pubmed.ncbi.nlm.nih.gov/22339095/
20. Dionne RA. Pharmacologic treatments for temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2023. Available from: https://www.sciencedirect.com/science/article/pii/S1079210497901049.

21. Kumar TVSH, Macherla B, Reddy GA, Bunga M, et al. Study between soft and hard splints after arthrocentesis in TMD patients: Randomized clinical trial. J Maxillofac Oral Surg. 2025. Available from: https://link.springer.com/article/10.1007/s12663-025-02452-0
22. Wang J, Wang R, Zhao P, Zhou X, et al. Home-based rehabilitation versus center-based programs in patients with temporomandibular disorders—a systematic review and meta-analysis. J Oral Facial Pain Headache. 2024. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC11798648/
23. Albagieh H, AlWazzan AK, Alhelal FA, Alem MF. Effectiveness of occlusal splints in the management of temporomandibular disorders: Comparisons of treatment approaches and digital versus conventional fabrication techniques. Cureus. 2025. Available from: https://www.cureus.com/articles/334305
24. Al-Moraissi, E. A., Farea, R., Qasem, K. A., Al-Wadeai, M. S., Al-Sabahi, M. E., & Al-Iryani, G. M. (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), 1042–1056. https://doi.org/10.1016/j.ijom.2020.01.004
25. Deepanjali M, Selvarajan C, Manodh P, et al. The role of injection of botulinum toxin in lateral pterygoid muscle for management of temporomandibular joint disorders: A systematic review and meta-analysis. J Maxillofac Oral Surg. 2025. Available from: https://link.springer.com/article/10.1007/s12663-025-02504-5
26. Al-Hussain A, Almahozi E, Bakhsh K, Jayar R. Effectiveness of botulinum toxin in managing temporomandibular disorders: A systematic review. J Healthc Sci. 2021. Available from: https://johs.com.sa/admin/public/uploads/187/3_pdf.pdf
27. Saini RS, Almoyad MAA, Binduhayyim RIH, et al. The effectiveness of botulinum toxin for temporomandibular disorders: A systematic review and meta-analysis. PLoS One. 2024. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0300157
28. Buzatu R, Luca MM, Castiglione L, Sinescu C. Efficacy and safety of botulinum toxin in the management of temporomandibular symptoms associated with sleep bruxism: A systematic review. Dentistry Journal. 2024. Available from: https://www.mdpi.com/2304-6767/12/6/156
29. Abbass MMS, Rady D, El Moshy S, Radwan IA, et al. The Temporomandibular Joint and the Human Body: A New Perspective on Cross Talk. Dent J (Basel). 2024. Available from: https://www.mdpi.com/2304-6767/12/11/357
30. Charles PT. Differentiation between the cervical spine and temporomandibular joint in the treatment of a patient with craniomandibular pain: A case report. Orthop Phys Ther Pract. 2025. Available from: https://search.proquest.com/openview/002174e7f643574a1d0860bc1a5b225a/1?pq-origsite=gscholar&cbl=5425112.
31. Kang, J. H. (2020). Effects on migraine, neck pain, and head and neck posture, of temporomandibular disorder treatment: Study of a retrospective cohort. Archives of oral biology, 114, 104718. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0003996920300960
32. Lan KW, Jiang LL, Yan Y. Comparative study of surface electromyography of masticatory muscles in patients with different types of bruxism. World J Clin Cases. 2022. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC9297420/.
33. Szyszka-Sommerfeld L, et al. Accuracy of surface electromyography in the diagnosis of pain-related temporomandibular disorders in children with awake bruxism. J Clin Med. 2022. Available from: https://www.mdpi.com/2077-0383/11/5/1323
34. Wieczorek A, Loster JE. Activity of the masticatory muscles and occlusal contacts in young adults with and without orthodontic treatment. BMC Oral Health. 2023. Available from: https://link.springer.com/article/10.1186/s12903-015-0099-2.
35. Lei Q, Lin D, Liu Y, Lin K, Huang W, Wu D. Neuromuscular and occlusion analysis to evaluate the efficacy of three splints on patients with bruxism. BMC Oral Health. 2023. Available from: https://link.springer.com/article/10.1186/s12903-023-03044-5

36. De Felício CM, Sidequersky FV, Tartaglia GM, Sforza C. Electromyographic standardized indices in healthy Brazilian young adults and data reproducibility. J Oral Rehabil. 2009;36:577-83. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2842.2009.01970.x
37. Urbański P, Trybulec B, Pihut M. The application of manual techniques in masticatory muscles relaxation as adjunctive therapy in the treatment of temporomandibular joint disorders. Int J Environ Res Public Health. 2021;18:12970. Available from: https://www.mdpi.com/1660-4601/18/24/12970
38. Ginszt M, Zieliński G, Berger M, Szkutnik J, Bakalczuk M, Majcher P. Acute effect of the compression technique on the electromyographic activity of the masticatory muscles and mouth opening in subjects with active myofascial trigger points. Appl Sci. 2020;10:7750. Available from: https://www.mdpi.com/2076-3417/10/21/7750
39. Bianco E, Tagliabue R, Mirabelli L, Maddalone M. Assessment of electromyographic changes in a patient with masseter hypertrophy and muscle pain after botulinum injections: A case report and 5 months follow-up. J Contemp Dent Pract. 2022;23(2):226–231. Available from: https://pubmed.ncbi.nlm.nih.gov/35748454/
40. Zardi FT, Nagalaxmi V, Gupta B. Electromyographic study for swallowing muscles in normal and TMD patients. J Oral Med and Dent Res. 2025. Available from: https://www.genesispub.org/resource/images/articles/pdf506.pdf
41. Bachani T, Raza FB. The synergism of occlusal splints along with therapeutic exercise on individuals with temporomandibular joint disorders – A pilot study. J Indian Prosthodont Soc. 2025. Available from: https://journals.lww.com/jips/fulltext/2025/01000/the_synergism_of_occlusal_splints_along_with.8.aspx
42. Ateş K, Coskunsu DK. The effect of manual therapy on pain, muscle activity, and jaw function in temporomandibular joint dysfunction with surface electromyography (sEMG) assessment. Ann Rheum Dis. 2024. Available from: https://www.sciencedirect.com/science/article/pii/S0003496724180788.
43. De Melo LA, Bezerra de Medeiros AK, Campos MDFTP, Bastos Machado de Resende CM, Barbosa GAS, de Almeida EO. Manual therapy in the treatment of myofascial pain related to temporomandibular disorders: A systematic review. J Oral Facial Pain Headache. 2020;34(2):141-8. Available from: https://files.jofph.com/files/article/20231205-94/pdf/ofph_34_2_deMelo_p141.pdf
44. Jamdade, A., Rani, A., Behera, S. S., Sharma, D., Manik, A., & Singla, D. Treatment Prostheses in TMJ Dysfunction-pain Syndrome: Systematic Review & Meta Analysis. International journal of health sciences, 6(S2), 14806-14817. Available from: https://www.neliti.com/publications/573727/treatment-prostheses-in-tmj-dysfunction-pain-syndrome-systematic-review-meta-ana
45. Machado TT, Machado ACS, Poluha RL, et al. The role of ozone therapy in the treatment of temporomandibular disorders: A systematic review. Evid Based Dent Pract. 2025. Available from: https://www.sciencedirect.com/science/article/pii/S1532338225000429.
46. Zhang L, Xu L, Wu D, Yu C, Fan S, Cai B. Effectiveness of exercise therapy versus occlusal splint therapy for the treatment of painful temporomandibular disorders: A systematic review and meta-analysis. Ann Palliat Med. 2021;10(6):6122-32. Available from: https://apm.amegroups.org/article/view/69319/html
47. Fathy NA. Botulinum injection in the masticatory muscles for management of myofascial pain. Al-Azhar J Dent Sci. 2020;23(4):375–381. doi: 10.21608/ajdsm.2020.25075.1013. Available from: https://ajdsm.journals.ekb.eg/article_140901_ceb9cc255e68dc1266344430b6dbc8d8.pdf
48. Hosgor H, Altindis S, Sen E. Comparison of the efficacy of occlusal splint and botulinum toxin therapies in patients with temporomandibular disorders with sleep bruxism. J Orofac Orthop. 2024;85(Suppl 1):102–108. doi: 10.1007/s00056-023-00498-8. Available from: https://doi.org/10.1007/s00056-023-00498-8
49. Gupta AK, Gupta R, Tiwari B, Verma K. Effect of a centric stabilization splint on masticatory muscles in patients with temporomandibular disorders: An electromyographic study. J Indian Prosthodont Soc. 2024;24(1):76–81. doi:

10.4103/jips.jips_431_23. Available from: https://doi.org/10.4103/jips.jips_431_23
50. Chen Y, Tsai CH, Bae TH, et al. Effectiveness of Botulinum Toxin Injection on Bruxism: A Systematic Review and Meta-analysis of Randomized Controlled Trials. Aesthet Plast Surg. 2023;47:775–790. doi: 10.1007/s00266-023-03256-8. Available from: https://doi.org/10.1007/s00266-023-03256-8
51. Zieliński G, Wójcicki M, Baszczowski M, Żyśko A, Litko-Rola M, Szkutnik J, Różyło-Kalinowska I, Ginszt M. Influence of soft stabilization splint on electromyographic patterns in masticatory and neck muscles in healthy women. J Clin Med. 2023;12(6):2318. https://doi.org/10.3390/jcm12062318

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