REVIEW ARTICLE

Masticatory Myofascial Pain Syndrome: Implications for Endodontists

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ABSTRACT

Introduction: Masticatory myofascial pain syndrome can present similarly to other dental conditions in odontogenetic structures. Endodontists should be familiar with the symptomology and pathophysiology of masticatory myofascial pain syndrome to avoid misdiagnosis, incorrect treatment, and medicolegal repercussions. The aim of this review was to provide a foundational summary for endodontists to identify and correctly manage masticatory myofascial pain syndrome. **Methods:** A narrative review of the literature was performed through a MEDLINE search and a hand search of the major myofascial pain textbooks. **Results:** Masticatory myofascial pain syndrome is a musculoligamentous syndrome that can present similarly to odontogenic pain or refer pain to the eyebrows, ears, temporomandibular joints, maxillary sinus, tongue, and hard palate. Currently, the most comprehensive pathophysiology theory describing masticatory myofascial pain syndrome is the expanded integrated hypothesis. The most widely accepted diagnostic guidelines for masticatory myofascial pain syndrome are the Diagnostic Criteria for Temporomandibular Disorders; however, their diagnostic capability is limited. There is no hierarchy of treatment methods because each patient requires a tailored and multidisciplinary management aimed at regaining the muscle's range of motion, deactivating the myofascial trigger points, and maintaining pain relief. **Conclusions:** The pain patterns for masticatory myofascial pain syndrome are well-known; however, there is a lack of consensus on the most proper method of trigger point diagnosis or pain quantification. The diagnostic strategies for masticatory myofascial pain syndrome vary, and the diagnostic aids are not well developed. *(J Endod 2022;48:55–69.)*

KEY WORDS

Diagnosis method; masticatory myofascial pain syndrome; myofascial pain syndrome; myofascial trigger points; therapeutic guidelines

SIGNIFICANCE

A significant number of cases of dental pain presented to endodontists are nonodontogenic. It is particularly critical for endodontists to be aware of all aspects of orofacial pain and masticatory myofascial pain syndrome.

Endodontists are among the most often consulted dental specialists who must make correct diagnoses with respect to often complex dentoalveolar/orofacial pain conditions. Toothache is the most common orofacial pain complaint,[1] and a significant number of those complaints are referred pain from nonodontogenic conditions.[2,3] In fact, approximately 7% of cases that present to the endodontist's office are of referred pain.[4] It is also reported that 53%–62% of cases of persistent pain after root canal treatment are cases of nonodontogenic referred pain.[5] When inspected further, it was found that 80% of this nonodontogenic pain was due to myofascial pain syndrome.[5]

Myofascial pain syndrome is a soft tissue inflammatory condition that causes acute or chronic localized myogenous pain and stiffness.[6–8] The presence of musculoligamentous pain can be related to a variety of potential sources such as muscle tears, fibromyalgia, or joint dysfunctions such as temporomandibular disorders (TMDs).[6,7,9–11] Myofascial pain syndrome and its dental counterpart, masticatory myofascial pain syndrome (MMPS), can be diagnosed as musculoligamentous pain.[6,7,9–11] The lifetime prevalence of myofascial pain syndrome ranges from 25%–85% in the general population, with a predilection for 30- to 50-year-old women.[12–16] Up to 90% of pain clinic patients, 75% of fibromyalgia patients, and over 50% of TMD patients present with MMPS.[10,12–16] MMPS may present as positive bite tests and percussion sensitivity in any isolated tooth[3] and therefore could be easily

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misdiagnosed as acute apical periodontitis.[1,17] Diagnostic nerve blocks also stop the referral of pain, contributing to possible misdiagnosis.[1]

The burden of MMPS is significant to afflicted patients. When myofascial pain is misdiagnosed, patients continue to suffer clinically from high pain levels, poor mood, high pain disability, sleep problems, long-term sick leave, and a hindered quality of life.[1,18–20] That being said, as perhaps shown by the high prevalence of MMPS contribution to persistent pain after endodontic treatment, there is a gap of knowledge in the general understanding of MMPS.[17] This is partially due to limited and fragmented information presented in the dental literature on this topic. Therefore, it is incumbent on endodontists to improve their ability to differentiate between causes of odontogenic and nonodontogenic orofacial pain. Endodontists' awareness of the many aspects of orofacial pain in general and MMPS in particular is vital for streamlining patients' referral and treatment processes, avoiding unnecessary treatments, and mitigating the risk of iatrogenic damage and legal malpractice lawsuits.[21–23] Hence, the purpose of this review was to present a summary of MMPS to support endodontists and dentists in better identifying and managing MMPS.

METHODS

We navigated an OVID MEDLINE search and landmark textbooks[9,10,12,24–54] to answer the following questions:

- How do the current pathophysiological theories relate to myofascial pain?
- How does the myofascial pain present, how do the current theories relate to myofascial-referred pain, and what are the comorbidities associated with myofascial pain?
  - How is myofascial pain diagnosed?
  - What are the current myofascial pain management strategies, their efficacy, and their mechanism of action?

The search was conducted by 2 reviewers with the help of the institutional librarian. The search was performed by combining each topic heading in the review section with the phrase "myofascial pain syndrome." We used the hierarchy of evidence and level of processing framework outlined by Brignardello-Petersen et al.[55] In cases in which no guideline or preappraised resources were available, we followed the evidence hierarchy by searching for primary studies and considered observational studies for etiology-related portions, randomized controlled trials for therapy-related portions, and randomized controlled trials and cross-sectional studies for diagnosis-related portions.[55]

REVIEW

Pathophysiology of MMPS

MMPS can be a primary ailment or secondary to an underlying joint problem (eg, other TMDs) or other problem (eg, occlusal abnormalities).[8,10,12,30,36,37,56–59] Currently, there are 6 theories that use different pathophysiological pathways to explain the agreed outcome of contracted hyperirritated nodules called myofascial trigger points.[9,56,60–63]

1. Energy crisis theory: continuous sarcomere contraction and compression on local blood vessels limit oxygenation[10] and reduce adenosine triphosphate levels.[10,30,33,36,37,64] Consequently, adenosine triphosphate–dependent degradation of acetylcholine, which induces muscle contraction, is barred.[10,30,33,36,37,64] Active transport of calcium ions back into the sarcoplasmic reticulum is then restrained, hence increasing the already excessive sarcomere calcium ion concentration. The resultant continuous sarcolemma contraction causes continuous muscle contraction and myogenous pain development.[10,30,33,36,37,64]
2. Central sensitization: due to persistent Aδ and C-fiber muscle nociceptor sensitization, the now hyperalgesic dorsal horn releases prolonged neuronal discharges, generating abnormally severe responses even to mildly painful stimuli.[28,30,36,44,65] Expansion of the spinal cord's receptive field causes functional changes to the spinal cord and allodynia.[28,30,36,44,65] The regular diffuse inhibitory noxious control mechanism is substantially reduced during chronic pain, causing further disproportionate nociception and pain reactions.[30,36,44,65]
3. Electrophysiological hypothesis: spontaneous and sustained electrical depolarizations from the end plates near myofascial trigger points (ie, end plate noise) cause electrical activity that produce excessive amounts of acetylcholine, similarly to defective end plates. This leads to downstream effects on sodium channels and thus increases intracellular calcium concentrations.[66] Eventually, the resultant cascade induces prolonged muscle contractions 1000 times more intense than the average end plate output.[10,30,33,36]
4. Physical abnormality: organizational imbalance within muscle fiber filaments (A and I bands) and degenerative changes in the myofascial trigger points induce myofiber disintegration, glycogen accumulation, capillary damage, and mitochondrial changes within myofibrillar networks.[10]
5. Muscle spindle theory: repeated physical trauma causes α-adrenergic sympathomimetic compounds such as norepinephrine to stimulate the sympathetically controlled muscle spindle,[12,30] resulting in hyperactivity, chronic muscle tension, and pain.[12]
6. Expanded integrated trigger point hypothesis: this all-encompassing approach[30] (Fig. 1) hypothesizes that etiologic factors such as incorrect posture and parafunction cause muscle overload, increasing sympathetic drive and thus acetylcholine levels and sarcomere contraction.[30] Muscle overload also induces ischemia and hypoxia in muscle tissue,[30] causing decreased intracellular pH and increases in cytokines/neurotransmitters such as calcitonin gene-related peptide, bradykinin, tumor necrosis factor alpha, and hydrogen ions. These molecules also increase acetylcholine levels by interfering with acetylcholinesterase activity and increasing its receptor sensitivity, increasing sarcomere contraction muscle pain.[30]

Masticatory muscles are more equipped to handle fatigue and overload than most of the musculoskeletal system,[52] and the pathophysiologic processes of trigger point formation are independent from the stabilization of the lactic acid buildup. However, the activation mechanism of masticatory musculature may contribute to its susceptibility to MMPS.[52] The activation of most extremity muscles is thought to be homogeneous;[52] 1 synaptic input activates the muscle via sequential recruitment of all the motor neurons of a single motor unit.[52] The masticatory muscles, in contrast, have a heterogeneous activation; a single muscle is activated by more than 1 motor neuron unit, which receive different synaptic inputs and are activated differently depending on the specific action (eg, 6-motor units activate in 8 locations of the lateral pterygoid during horizontal jaw displacement).[52,67,68] This complexity increases the likelihood of individual or specific groups of muscle fibers to develop a trigger point via muscle fiber(s) overload.[69]

Presentation of MMPS

Unlike muscle spasms, which are generalized increased stiffness of the entire muscle, myofascial trigger points are located within stretched muscle fibers (taut bands) that when compressed cause referred or local pain

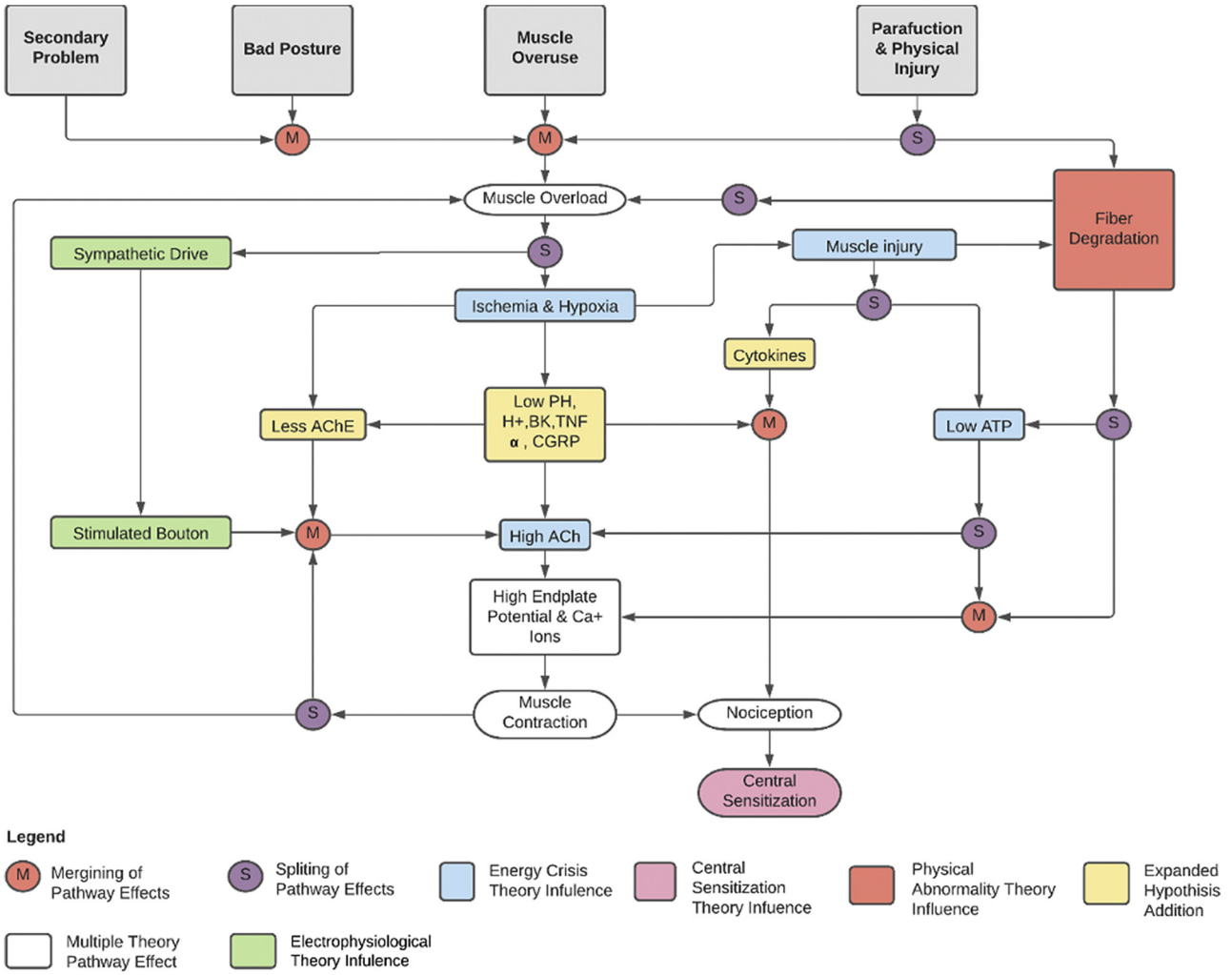

FIGURE 1 – Expanded integrated trigger point hypothesis. The expanded integrated trigger point hypothesis combines the electrophysiological hypothesis, the energy crisis theory, and the central sensitization theory. In this theory, physiological depolarization, ischemia and adenosine triphosphate starvation, histologic changes, and change of the dorsal physiology due to constant local trigger point nociception contribute to trigger point formation. In addition, trigger points are also identified by isolating the chemicals such as tumor necrosis factor alpha (TNF-a), bradykinin, and the calcitonin gene-related peptide, which partake in trigger point formation. Figure is prepared based on the information in references10, 30, 33, and 36.

(Fig. 2).[9,56,60,63,70] These points can be latent, occurring in the preclinical stage and existing asymptomatically unless palpated, or active, occurring in the clinical stage causing a nonprovoked or familiar pain that radiates across overlying subcutaneous and cutaneous tissue independent of stimulation.[6,30,53,56,61]

MMPS can present as trigger point pain or referred pain. Both active and latent myofascial trigger points are sensitized through physical stimulation, producing a nonlocalized, aching, deep, and steady pain[27,30,37] that can be sharp, numbing, radicular, or visceral.[32,27,45] This pain can cause muscle stiffness and reduce the range of motion, gradually causing muscle atrophy and disturbed motor function.[27,30,37,45]

MMPS may also present as referred pain[30] from visceral or somatic structures,[71,72] perceived in "targets," which are areas other than where the noxious stimulation is located.[12,71,72] The referral patterns (Fig. 1) are well established. For example, Wright[3] examined the referral patterns of 230 TMD patients and found that pain referral to the dentition was most prominent in mandibular molars and least in mandibular premolars and maxillary and mandibular anterior teeth.[3] Pain in these target areas is directly proportional to the level of original pain in the nociceptive area.[71,72] Occasionally, the patient may feel a cool sensation with or without sweating at the target location.[12,71] Referred pain theories build on the nociception pathway. In facial and dental nociception, the first trigeminal neurons, which collectively make up the trigeminal tract, transfer action potential stimulation through the trigeminal ganglion via afferent nerve fibers (C or Aϑ fibers).[26,28,41] They enter the brainstem and terminate at the subnucleus pars caudalis. The trigeminal tract releases neuropeptides at the subnucleus pars caudalis, which relays painful stimuli to projection neurons in the trigeminothalamic tract.[26,28,41] However, the ventral posterior nuclear complex of the thalamus uses third-order neurons to relay pain stimuli into the somatic sensory cortex where pain allocation and processing are completed.[26,28,41] Areas near the spinal cord feel pain via a similar pathway, except that the spinothalamic tract replaces the trigeminothalamic tract.[26,41] The following 2 main theories describe the patterns underlying mechanisms, although it is currently accepted that neither of the theories act exclusively:

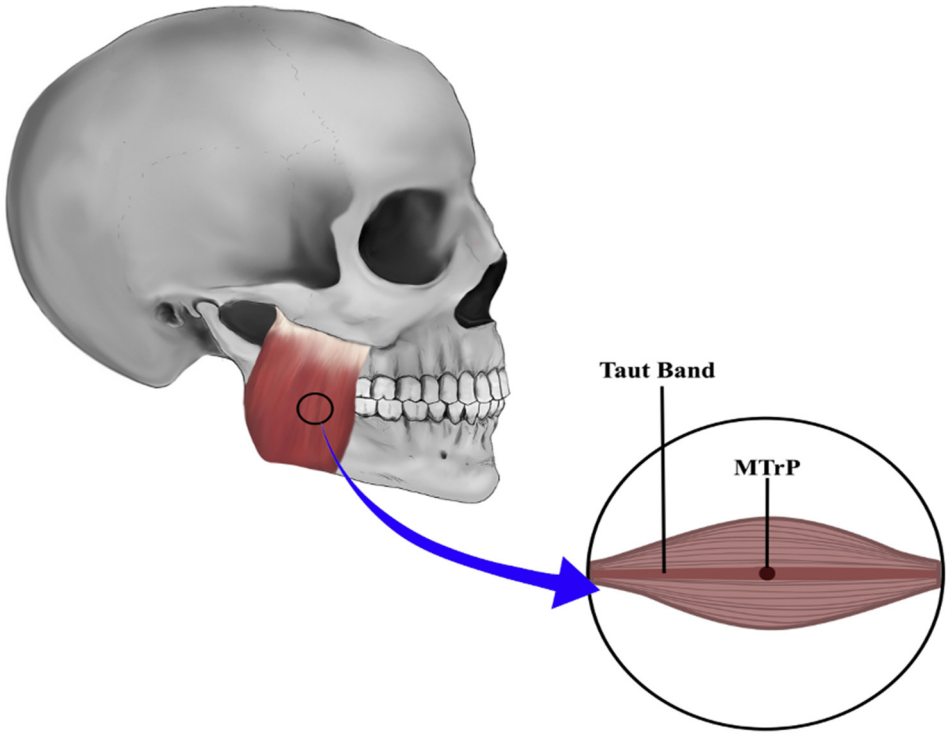

FIGURE 2 – An illustration of trigger points of a taut band within the masseter.

- Afferent nociceptor branching: for body parts that share a common neuron, the central nervous system might not be able to differentiate between the actual source of pain versus the site from which the pain originated (eg, a tender muscle referring pain into a nearby tooth).[12,73,74] However, evidence of somatic–somatic referred pain requires further research.[12,73,74]
- Convergence with central sensitization theory: pain innervated by the trigeminal cranial nerve largely relays in the subnucleus pars caudalis, where approximately half of the neurons in the region converge.[28,65] The density of nociceptors and the convergence of the neurons collectively cause the pain stimulus to be perceived by the somatic sensory cortex as originating from the most likely source rather than the actual site.[28,65,75] This is attributed to nociceptor sensitization hyperalgesia at the second-order neuron, developing into widespread hyperalgesia, affecting separate convergence points, and sensitizing components of the central nervous system.[28,65,75]

Comorbidities Associated with MMPS

Various comorbidities have been associated with MMPS including headaches, sleep disorders, depression, and physiological disturbances.[33,76–78] Headaches can present as long duration bilateral pain with tightening or pressing sensations in the frontotemporal region.[79] Although the pathophysiological mechanisms remain unclear, the international classification of headache disorders classifies them as secondary headaches, relating them to underlying ailments.[79,80] Up to 65% of patients suffering from myofascial pain syndrome have sleep disturbances, which are also strong comorbid predictors of depression.[33,77] Chronic pain, such as in MMPS, might be 1 of the sequelae of depression, sometimes manifesting solely from depression.[77,81] This might arise from interactions between the emotion-handling medial system and somatic pain–cognition centers, the thalamocerebral system, and the direct link between the nociceptive pathways and the parabrachial nucleus that leads to the fear-regulating amygdala.[44] In addition, patients with chronic pain display neuroplastic changes in brain regions that manage sensory (pain and non–pain related) and cognitive tasks.[20] These changes have a linear growth pattern associated with the longevity of the chronic pain condition.[20] There is also evidence of maladaptive responses to chronic pain via cognitive and emotional phenomena (eg, catastrophizing and rumination of the existing pain, feeling of vulnerability to injury, and fear of physical movement).[20]

Diagnosis of MMPS

Clinical examination follows a thorough review of the patient's pain history, presuming no other dentoalveolar issues are observed.[10,27,53,56,60,61,70,82,83] Despite the availability of different examination guidelines and consensus documents for MMPS diagnosis (eg, the Diagnostic Criteria for TMDs in dentistry),[60,82,84,85] a cornerstone of all guidelines is palpation,[60,82,84,85] which, via a compressive force, locates myofascial trigger point nodules and taut bands to elicit "familiar pain" and a local twitch response.[27,60,82] During palpation, the clinician also traces referred pain to its target and assesses the target point locations (Fig. 3*A–F*).[10,27,53,56,60,61,70,82,83] Some diagnostic aids (Table 1) and several palpation methods can be used (Fig. 4*A–C*). Once diagnosed, MMPS can be quantified (subjectively) through various scales (Table 2) that report sensations as quantifiable measurements.[27,42,50,51,93–96]

The process of diagnosis by elimination and the Diagnostic Criteria for TMDs have flaws. Given the already maladaptive cognitive and emotional associations of the condition, conducting multiple tests,[30] and possibly multiple dental procedures,[21,22] only to conclude that the pain is referred due to MMPS can trigger financial and emotional distress.[20] In the widely accepted Diagnostic Criteria for TMDs,[60,82] the MMPS diagnostic accuracy is not completely established.[82] Also, possibly

due to its extensiveness, clinicians often independently create parallel diagnostic forms,[96] causing variability between clinicians/institutions.

Management of MMPS

MMPS patient management should begin with empathetic[98] patient education[99] to support the patient's mental state.[27,32] Explaining the pain to the patient, and often their family, in biological/physiological terms is likely to reduce the patient's pain catastrophizing, fear-avoidance, unhealthy attitudes/behaviors and increase physical movement and utilization of health care support.[99] Next, a multiprofessional approach (dentists, physicians, psychologists, physiotherapists, chiropractors, and massage therapists)[100,101] should be used to regain range of motion,[102] deactivate trigger points,[103] and maintain pain relief.[101] Currently, there is no treatment hierarchy,[103] and multidisciplinary management is needed to provide personalized plans that best address patients' needs.[101,104] Non-pharmacotherapy intervention, pharmacotherapy, and cognitive behavior therapy[105] are the main management strategies used by health care teams and are briefly described as follows:

1. Nonpharmacotherapy intervention strategies: the main nonpharmacotherapy interventions are as follows:
   a. Acupuncture: classic acupuncture is an ancient treatment performed via shallow insertions of fine needles into specific points termed "Ah shi points" to affect the body's energy pathways, relieve pain, and loosen muscles.[29,43,106] Western medical acupuncture, in contrast, focuses only on specific "acupuncture treatment areas"[107] or myofascial trigger point locations (termed dry needling).[107,108] Acupuncture needles can be used as a stand-alone instrument (such as in classic acupuncture/dry needling),[108,109] stimulated via an electrical current,[107,110] or completely replaced by lasers.[107,110] The treatment durations can range from 20–30 minutes over 1/multiple sessions.[107] Acupuncture treatments induce physiological inhibition of the nociceptive pathway at the spinal dorsal horn.[107] A systematic review showed that (classic, trigger point, and laser) acupuncture therapy for MMPS was comparable with occlusal splints but better than placebo in pain reduction.[109] However, the authors did state that the available studies had small sample sizes, and further investigations are required to recommend any type of acupuncture with confidence. Additionally, a meta-analysis[108] of studies exploring dry needling for lower back pain reported it to be better than sham needling (placebo) at reducing functional disability and pain intensity at follow-up appointments.[108] Dry needling was also found to work faster and better than classic acupuncture in the immediate reduction of pain (5 minutes) and was significantly better at alleviating pain intensity and functional disability. However, at follow-up appointments, dry needling was observed to have the same effect as acupuncture in pain intensity and functional disability effects.[108] In another meta-analysis, electroacupuncture was found to be more effective than sham acupuncture for myofascial neck pain. The authors stated that the evidence used was weak.[111] Lastly, regarding laser acupuncture, a review that investigated laser acupuncture in dental applications found limited evidence that the acupuncture significantly improved the symptoms of acute and chronic TMDs, including masticatory myofascial pain; however, further investigations are required.[112]
   b. Electrical therapies: the main 2 electrical stimulation modalities are electrical muscle and nerve stimulations.[113] Electric/galvanic stimulations are low-frequency electrical monophasic pulses that release charges to alter neurologic polarity and decrease pain symptoms.[100,113] In this treatment, electrical stimulations are applied to the muscle with the trigger point or the related peripheral nerve.[113] A study comparing transcutaneous nerve stimulation and electrical muscle stimulation in 20-minute sessions of trapezius muscles with myofascial pain found that electrical nerve stimulation was effective in reducing pain intensity and increasing pain threshold in all patients regardless of their pain levels but did not suggest any reduction of muscle stiffness.[113] The study also found that electrical muscle stimulation was not able to increase the pain threshold but was able to reduce muscle tightness at all pain levels and pain intensities in mild to moderate pain.[113] Electrical muscle stimulation was also ineffective in changing pain thresholds, suggesting that a combination of both electrical therapies is most appropriate in myofascial pain management.[113] Another study found that, compared with placebo and control, galvanic stimulation for 20 minutes with exercise produced lower pain levels on a visual analog scale immediately after the procedures but not at the 15-day follow-up, suggesting only short-term pain relief.[100]
   c. Ultrasound therapy: molecular vibrations and heatwaves induce physical and chemical changes to help release myofascial trigger points.[114,115] It is useful in chronic myofascial pain syndrome, ligaments, muscles with reflex tension, scar tissue, and relatively thin muscular tissue but is contraindicated in areas of abnormal sensitivity, bleeding sites, and fresh thrombosis.[114] A systematic review reported that ultrasound therapy did not improve range of motion or pressure pain threshold but did ameliorate patients' pain immediately after treatment. However, the authors warn that the evidence is weak, and further studies are needed.[115]
   d. Helium–neon-based lasers: helium-neon lasers are visible red laser beams with a wavelength of 632.8 nm that do not heat human body tissues.[116] Albeit not fully established, several studies demonstrate their potential therapeutic effect.[43,103] A meta-analysis of 3 myofascial pain studies concluded that although better randomized control trials are needed to establish the effects of the helium–neon-based lasers on musculoskeletal and skin conditions, they seem to indicate better general therapeutic effects in terms of pain management than placebo.[117]
   e. Occlusal appliances: these vary in physical attributes (hard or soft splints), duration of wear (24-hour or nocturnal splints), and/or application location (anterior teeth or palatal coverage).[52] Significant data regarding base effect theories such as the cognitive-behavioral changes, reorganization of intramuscular usage habits hypotheses, and different effects of the occlusal appliance (such as the reversible reduction of muscle activity) are currently lacking.[52,118–121] Nonetheless, occlusal appliances are common elements of therapeutic regimens for various TMD treatments, including MMPS.[52,118–121]
2. Pharmacotherapy: multiple drugs (Table 3) are frequently used for pain, muscle spasms, sleep deprivation, and

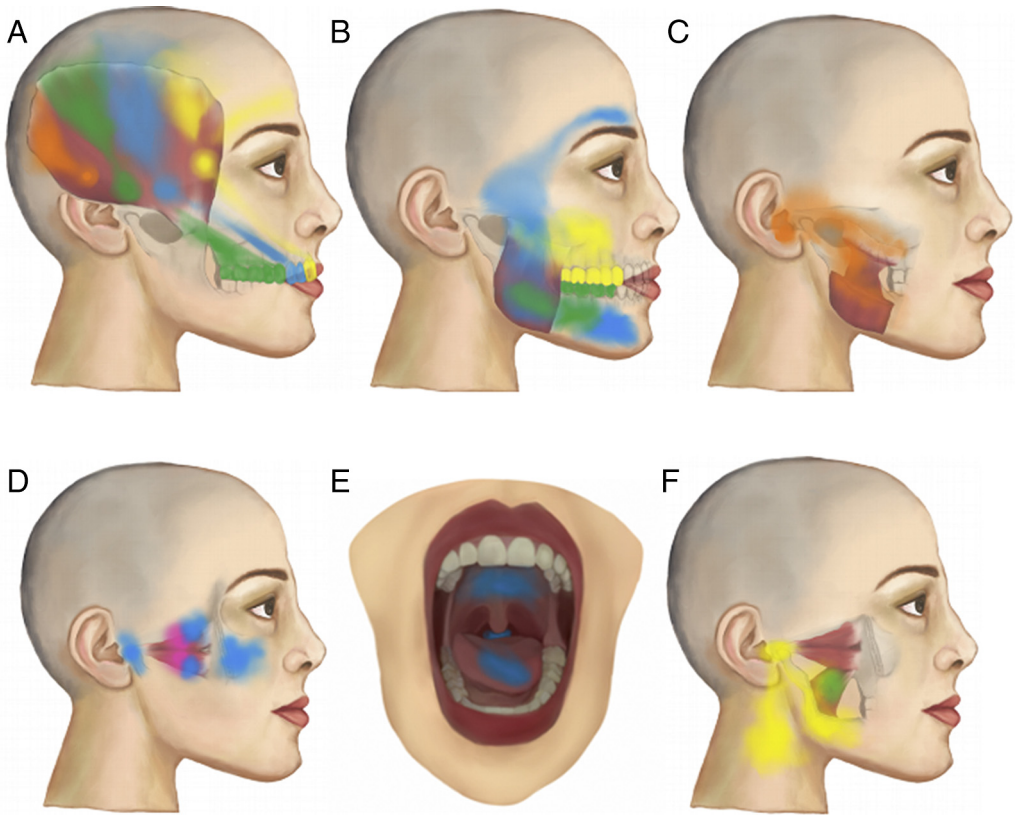

FIGURE 3 – Pain referral patterns. (*A*) The temporalis target patterns: the temporalis commonly refers pain to the maxilla, eyebrows, and temporomandibular joints. It can also present as temporal headaches or maxillary teeth hypersensitivity.[27,30,46] (*B*) The superficial masseter head target patterns: the superficial masseter commonly refers pain to the eyebrows, maxilla, anterior mandible, and upper/lower teeth.[27,30,47] (*C*) The masseter deep head target patterns: the deep masseter head commonly refers pain to the ears and the temporomandibular joint.[27,30,47] (*D* and *E*) The medial pterygoid target patterns: the medial pterygoid commonly refers pains (*D*) extraorally to the maxillary sinus, the temporomandibular joint, and behind the eyes[30] and (*E*) intraorally to the back of the mouth, the tongue, and the hard palate.[27,30,46] (*F*) The lateral pterygoid target patterns: the lateral pterygoid commonly refers pain deep within the ear and in the retromandibular areas.[27,30,46]

psychological disturbances associated with MMPS.[12,34] They can be administered orally or via injection. Intramuscular myofascial trigger point stimulation with a hypodermic needle or medication injection are the most common treatment modalities of myofascial pain syndrome.[12,29,43,126] These injections work primarily to mechanically disrupt the trigger point and dilute the inflammatory and nerve sensitizing agents, break feedback mechanisms, remove metabolites, and reduce postinjection soreness.[12,29,43,103]

a. Nonsteroidal anti-inflammatory drugs (eg, aspirin, ibuprofen, and diclofenac): these inhibit prostaglandin synthesis and cyclooxygenase enzymes.[12,34] Although theoretically ideal, treatment should be attempted with caution due to gastric and duodenal ulcers, bleeding disorders, severe heart failure, and concerns during pregnancy and breastfeeding.[25] Additionally, their availability over the counter adds an additional risk of double dosing.
b. Tricyclic antidepressants (eg, amitriptyline and clomipramine): these are relatively effective in managing MMPS/myofascial pain syndrome.[12,34,52] Amitriptyline hydrochloride's mechanism of action is not fully known; however, similar to clomipramine, it is shown to inhibit the membrane pump mechanism responsible for the reuptake of norepinephrine and serotonin and increase their concentrations in the synaptic clefts of the brain.[127]
c. Muscle relaxants (eg, cyclobenzaprine, baclofen, and benzodiazepines): these are considered common choices for pharmacologic management of MMPS[12,34,52] and are often used in combination with analgesics or nonsteroidal anti-inflammatory drugs.[12,34,52,128]
    1. Cyclobenzaprine is a skeletal muscle relaxant that is structurally related to the tricyclic antidepressant amitriptyline.[127] It is thought to relax skeletal muscle and reduce tonic somatic motor activity in the alpha- and gamma-motor systems.[129] In humans, cyclobenzaprine was found to relieve skeletal muscle spasm of local origin.[130]
    2. Baclofen is a muscle relaxant and an antispastic agent.[127] Although baclofen's mechanism of action is not fully known, current understanding suggests that it hyperpolarizes afferent spinal terminals and therefore inhibits the monosynaptic and polysynaptic reflexes at the spinal level.[127] Although baclofen is an analog of the putative inhibitory neurotransmitter gamma-aminobutyric acid, its clinical effects are unrelated.[127]
    3. Benzodiazepines can be classified in anxiolytic (eg, lorazepam), sedative (eg, diazepam), or anticonvulsants (eg, clonazepam) drug classes, or any combination thereof, and therefore can be used for multiple

TABLE 1 - Diagnostic Aids

Modality	Diagnostic strategy	Main advantages	Main disadvantages
Algometry	Press the algometer on vertical axis to the trigger point and correlate a pain response to algometer reading	Pain quantification in relation to pressure exerted[86]	Algometry is more painful than palpation and therefore less specific[86] No physical description of the trigger points
Magnetic resonance elastography	Locate taut bands by measuring their stiffness (vibratory displacements)[86]	Noninvasive	Cost Availability to clinicians Not looking at trigger points themselves
Ultrasonography	Identify changes in muscle tissue via echocardiographic detection of ultrasonic sound waves	Detect nonpalpable myofascial trigger points[87] Physical description in muscle Detect local twitch response[87]	Diagnostic accuracy not fully established Need training for use by most dental clinicians

indications, including anxiety, epilepsy, and muscle relaxation.[127,131] Generally, benzodiazepines work to increase neural inhibition by modulating gamma-aminobutyric acid receptors A and have been proven effective in animal testing.[127,131]

d. Anticonvulsants (eg, gabapentin and pregabalin): these molecules are ligands for the alpha-2-delta subunit of voltage-gated calcium channels, unrelated to the gamma-aminobutyric acid mechanism.[127] Gabapentin is commonly used by clinicians in the management of neuropathic pain.[127,132,133]
e. Selective neuronal potassium channel openers (eg, flupirtine): these demonstrate analgesic and muscle relaxant properties by acting as indirect N-methyl-D-aspartate receptor antagonists, ultimately inhibiting nociceptive impulse transmissions during neuronal excitation and suppressing polysynaptic reflexes.[125] Research on the clinical efficacy of this drug is still needed.[52,125]
f. Presynaptic neurotoxins: a growing base of literature is developing regarding the injection of botulinum toxin type A (eg, Botox; Allergan, Irvine, CA), a presynaptic neurotoxin that blocks the calcium ion–mediated release of acetylcholine at neuromuscular junctions in alpha and gamma motor neurons of muscle spindles.[102] The neurotoxin also works as an analgesic, partially by blocking neuropeptides (substance P and glutamate) and neurotransmitters at the central nerve terminals.[134] Over 3–6 months, 10–150 units of Botox are usually injected to reduce pain and increase mouth opening with minimal side effects.[102]
g. Steroids (eg, prednisolone): glucocorticoids are endogenous regulatory hormones that have anti-inflammatory and analgesic attributes and contribute to, among other functions, physiological stress regulation.[135] The steroids act via a series of interactions that ultimately decrease the level of prostaglandins and leukotrienes through the down-regulation of arachidonic acid and the cyclooxygenase enzyme.[135,136] Thus, chronic muscular pain is commonly treated with synthetic steroids.[136,137] However, frequent use of steroids, as with chronic conditions, can cause localized muscle atrophy and systemic side effects.[137]
h. Cannabis: a retrospective chart review found that 82% of patients who request treatment with medical cannabis for chronic pain were diagnosed with myofascial pain syndrome,[138] effectively elevating cannabis to the forefront of treatment possibilities for MMPS. The mechanism of action of cannabis is not yet fully understood; however, animal studies indicate that the cannabidiol in cannabis induces anxiolytic effects via its effect on 5HT1A, a serotonin receptor subtype.[139]
i. Opioids: opioids have been used to treat chronic pain conditions such as fibromyalgia; however, they are highly addictive and can lead to central nervous system suppression of respiration and should not be used for long-term conditions.[140,141] Their mechanism of action is multifaceted,[142]

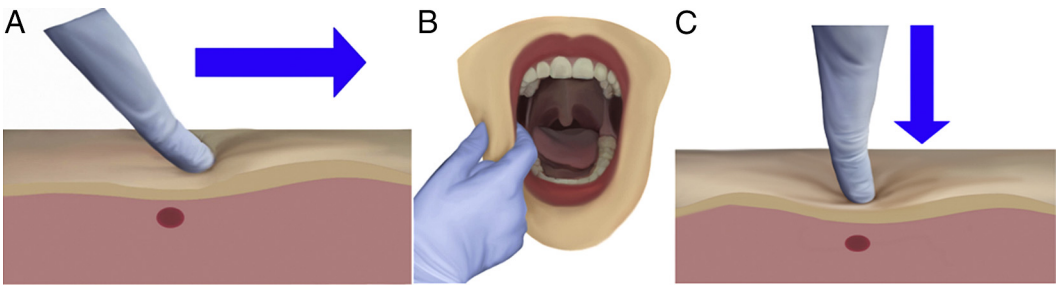

FIGURE 4 – Palpation techniques. (*A*) Flat palpation: the clinician uses the distal phalanx's soft bed to push the area's loose skin to 1 side in a smearing motion. The clinician then observantly roles the digit back, returning the skin to its original location while simultaneously feeling for any underlying muscle texture variation.[27] (*B*) Pincer palpation: the muscle of interest is placed between the soft beds of the distal phalanxes of the index and thumb followed by a rubbing motion that locates the taut band. This palpation is best suited for muscles of multiple access points, such as the masseter muscle.[27] (*C*) Deep palpation: the clinician uses the tip of his or her digit to press onto the muscle to elicit a pain response.[27]

TABLE 2 - Summary of Pain Quantification Techniques[35,88–92]

Pain scale	Description	Advantages	Disadvantages
Numeric rating	Rating of pain in a range between 2 numeric values (ie, 0–10)[42]	Simple and intuitive[42] Versatile[42]	Limited expression Hard to translate into clinical significance Cognition dependent
Visual analog scale	Demarcation of pain on an unmarked line[27,50,93]	Unlimited expression High sensitivity[94,95]	Motor function dependent Cognition dependent Low patient adherence Introduced bias risk
McGill Pain Questionnaire*	Juxtaposes descriptive phrases in groupings[27,50,91,92]	Multidimensional and comprehensive[31] Most used[31]	The numeric rating section of the questionnaire has the inherent disadvantages mentioned earlier. Significantly longer than the other scales
Patient reaction scale	Assesses the pain degree† in 4 distinct grades[27,51,96,97] at palpation pressure‡	Unfiltered and involuntary input	Patients may have variable reactions Subjective

*McGill Pain Questionnaire is available at: https://journals.lww.com/pain/Abstract/1975/09000/The_McGill_Pain_Questionnaire__Major_properties.6.aspx.
†0, no pain upon palpation; 1, no physical reaction, but there is a positive reaction when the patient is asked; 2, a mild spontaneous reaction; and 3, a marked physical reaction (eg, jump) or a grade 2 response before the full force of palpation has been reached.[51,96,97]
‡This test is dependent on subjective clinical palpation. This palpation is presumed to follow the research diagnostic criteria for temporomandibular disorders (palpation pressure of 1 kg).[82] However, it was reported that 57% of clinicians do not apply a palpation pressure within the acceptable 20% range (0.8–1.2 kg) as measured by applying palpation force to a digital scale repeatedly.[97] As the palpation pressure range of clinicians may exceed the suggested diagnostic criteria range, the patient reaction scale may be inaccurate.[97]

including antagonization of N-methyl-D-aspartate receptors,[142] which activates the descending serotonin and noradrenaline pain pathways from the brainstem.[142] However, the N-methyl-D-aspartate receptors may also result in neuropathic pain and the development of tolerance.[142]

No single hierarchy of medications can currently be recommended as a treatment pathway. Comparisons of pharmacologic treatment methods are available; however, they are limited by sample sizes and heterogeneity.

Studies on the role of nonsteroidal anti-inflammatory drugs in the management of MMPS/myofascial pain are lacking,[143] perhaps due to the chronic nature of the syndrome and short-term treatment usage recommendations of the drugs. However, current evidence suggests that nonsteroidal anti-inflammatory drugs have minimal to no therapeutic effects on MMPS.[12,34,52] Reviews on the topic suggest that they can be used as topical palliative treatment (eg, diclofenac sodium) in myofascial pain[143] and as supplemental therapy to muscle relaxants and tricyclic antidepressants in similar conditions (fibromyalgia).[128]

Regarding the use of injectable pharmacologic agents, a recent meta-analysis identified low-quality evidence that Botox is slightly more effective than no treatment for temporomandibular pain reduction at 1 month, but this difference was diminished at 3–6 months.[144] Also, a randomized clinical trial found that Botox was more beneficial than steroid (methylprednisolone) injections for trigger point pain alleviation when combined with appropriate physiotherapy.[137] However, a systematic review assessing various local anesthetics, prednisolone, saline, and Botox found that the injected substance is no better than intramuscular stimulation with a dry hypodermic needle.[145] This may perhaps indicate that the benefits of medicant injection therapies are mostly mechanical rather than due to the medicants themselves.[56] Muscle relaxants (cyclobenzaprine and clonazepam) were found slightly less effective than lidocaine injections by a Cochrane review in the treatment of myofascial pain.[130] However, the review did state that the evidence for this is weak, and further investigation is required.[130]

A systematic review on the use of anticonvulsants in orofacial pain found that gabapentin was better at pain intensity reduction than placebo group in a 12-week period but concluded that further investigation is needed to assess the use of anticonvulsants in MMPS.[146] Another clinical trial found that 37% of myofascial pain syndrome patients who were nonresponsive to tricyclic antidepressants were managed with gabapentin and achieved ≥50% decreased pain intensity.[133] Regarding cannabis treatment of MMPS, a Cochrane overview of systemic reviews concluded that the efficacy of cannabis-based medicines for myofascial pain is inconsistent.[147] The overview further stated that more study is required to establish the optimal dosage balancing efficacy, tolerability, and safety and urged health care providers to address the often unrealistic expectations of patients with chronic pain on the efficacy and safety of cannabis products.[147] Regarding opioids, clinical practice guidelines discourage long-term opioid therapy; in addition, a systematic review assessing opioid use for chronic back pain concluded that there is a significant risk of higher percentages of severe harm in opioid use for the management chronic pain.[140,141]

3. Cognitive behavioral therapy and self-modulated lifestyle modification: cognitive behavioral therapy effectively improves chronic orofacial pain and is recommended in most cases.[105] Cognitive behavioral therapy and self-modulated lifestyle modification aim to change patients' negative beliefs and attitudes into a factual appraisal of their condition[148] and to implement correct posture to treat and prevent myofascial trigger point formation.[27] Raja-yoga (a meditation therapy technique) and pranayama (a traditional form of breathing exercises) have been shown to decrease posttreatment pain, posttreatment inflammation, posttreatment anxiety, stress, and depression when combined with noninvasive treatments (pharmacotherapy, diet, and exercise) compared with noninvasive treatments alone.[149] Isotonic exercises of the muscles related to speech and mastication prescribed by speech and

TABLE 3 - Therapeutic Drugs Used for Managing Masticatory Myofascial Pain Syndrome

Drug class	Examples	Daily dosage (mg)	Reference
Nonsteroidal anti-inflammatory drugs	Acetylsalicylic acid	2500–4000	34
	Ibuprofen	2400	34
	Diclofenac	200	34
Muscle relaxants	Cyclobenzaprine	10	122
	Baclofen	30–75	34
	Benzodiazepines (diazepam)	5–15	34
Antidepressants	Amitriptyline	20–100	34
	Clomipramine	20–100	34
	Doxepin	30–150	34,123
Anticonvulsants	Gabapentin	1800–3600*	124
	Pregabalin	150–450†	123
Selective neuronal potassium channel openers	Flupirtine	300–600	34,52,125

*Used for neuropathic pain.
†Used in fibromyalgia.

physical therapists or relaxation techniques and stress management training prescribed by psychologists must be implemented for optimal results.[101]

CONCLUSION

MMPS is a common ailment with multiple comorbidities and symptoms. Endodontists must be familiar with its presentation to assess and diagnose patients correctly. The management of MMPS is multidisciplinary, revolving around identification of the syndrome and its trigger points. Interdisciplinary nomenclature and improvement to the existing evidence-based approach to diagnosis and management are needed. To this end, developing chairside, visual, minimally invasive, and easy-to-implement diagnostic aids can allow interdisciplinary standardization for improved identification, quantification, and management of myofascial trigger points. High-quality comparative studies evaluating patient-centered outcomes using different therapeutic modalities and more extensive research on the psychological aspects of MMPS and chronic pain are needed.

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