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Conservative management of temporomandibular dysfunction: A literature review with implications for clinical practice guidelines (Narrative review part 2)

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ABSTRACT

The effective management of temporomandibular dysfunction (TMD) requires a thorough understanding of the pathoanatomic factors that drive the underlying condition. After reviewing the etiology associated with TMD in Part 1 of this narrative review, the temporomandibular joint capsule, articular disc and muscles of mastication emerged as key players. (http://dx.doi.org/10.1016/j.jbmt.2017.05.017) Part 2 focuses on conservative treatment strategies best able to reduce the pain and disability associated with TMD. A review of the literature revealed limited support of strengthening exercises targeting the muscles of mastication. There was also limited evidence for manual soft tissue work targeting muscles of mastication, which may be specifically related to the limited accessibility of the pterygoid muscles to palpation. For the reduction of pain, there was little to no evidence supporting splint therapy and electrophysical modalities, including laser therapy, ultrasound, TENs and iontophoresis. However, for the reduction of pain and disability, non-thrust mobilization and high-velocity, low amplitude thrust manipulation techniques to the TMJ and/or upper cervical articulations that directly and indirectly target the TMJ joint capsule were generally supported in the literature. Studies that used dry needling or acupuncture of the lateral pterygoid and posterior, peri-articular connective tissue also led to significant improvements in pain and disability in patients with TMD. Thus, the most effective conservative management of TMD seems to be techniques best able to impact anatomic structures directly related to the etiology of TMD, to include the joint capsule, articular disc and muscles of mastication, specifically the superior and inferior head of the lateral pterygoid.

1. Introduction

According to Shaffer et al., physical therapy is the preferred conservative approach for treating TMD (Shaffer et al., 2014), as it facilitates multi-modal treatment that addresses patient specific impairments (Guarda-Nardini et al., 2016). However, successful management requires treatment of anatomical structures that are consistent with the underlying condition. In this context, the muscles of mastication (Ariji et al., 2015; Hiraba et al., 2000; Murray and Peck, 2007; Murray et al., 2004; Peck et al., 2008; Pihut et al., 2016), joint capsule (Friedman, 1997; Mapelli et al., 2016; Saghafi and Curl, 1995) and cervical spine (Fernandez-de-Las-Penas et al., 2010; Guarda-Nardini et al., 2016; Jayaseelan and Tow, 2016; Mansilla-Ferragut et al., 2009) are high-value targets that likely require further consideration.

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2. Temporomandibular dysfunction and exercise

Given the reciprocal actions of the superior and inferior head of the lateral pterygoid (Desmons et al., 2007; Hiraba et al., 2000; Mahan et al., 1983; McNamara, 1973; Murray et al., 2004), it is plausible that decreased activity of the superior head agonist results in increased activity in the inferior head antagonist, a theory consistent with pain adaptation. Similarly, the decreased activity of the superior head could result in overuse of the inferior head, resulting in an energy deficit and setting the stage for muscle hypertonicity via the Vicious Cycle Model. Notably, both models result in overactive muscles of mastication, a problem further propagated by psychosocial factors (Peck et al., 2008). Perhaps this explains the limited evidence for strengthening muscles of mastication to treat TMD. That is, the purposeful activation of muscles that are already overactive (Lauriti et al., 2014; Tosato Jde et al., 2015) may not be advantageous and does not seem to be strongly supported by the literature (Mulet et al., 2007). Notably, a recent RCT by Bae et al. found masticatory relaxation exercises to be more effective for decreasing the pain and limited ROM associated with TMD than active exercises (Bae and Park, 2013).

The Rocabado exercise routine (Rocabado and Iglarsh, 1991), which addresses the rest position of the tongue, control of TMJ rotation during mouth opening, rhythmic stabilization of the mandible, head flexion stabilization, lower cervical retraction and shoulder girdle retraction is the most widely used exercise routine used by physical therapists to treat TMD (Shaffer et al., 2014). However, the only study that has examined its effectiveness concluded that that the exercise routine provided no additional therapeutic benefit to the rehabilitation process (Mulet et al., 2007; Shaffer et al., 2014). Kraus (Kraus, 1988, 2004) also proposed a 3-prong approach to TMD, including inhibition of excessive activity of muscles of mastication, mandibular neuromuscular control and isometric exercises to counter joint clicking, muscle asymmetry and spasms, but the regiment has never been studied or validated (Shaffer et al., 2014). According to a systematic review by Shaffer et al., '…no evidence exists to direct clinicians toward which exercises, if any, may be useful in the conservative management of TMD. Additionally, because many, if not most, patients with TMD over-recruit their muscles of mastication, it may be more advantageous to focus on relaxation techniques and patient education than therapeutic exercise' (Shaffer et al., 2014).

In a systematic review of 7 studies that investigated therapeutic exercises for TMD, which included stretching, relaxation, coordination, strengthening and endurance, Moraes et al. found exercises to be effective for the treatment of 'muscular TMD' (Moraes, 2013). However, the authors noted significant issues with internal validity and an over reliance on clinical experience (Moraes, 2013). Notably, all 7 studies included by Moraes et al. (Moraes, 2013) combined therapeutic exercise with other conservative procedures, making it difficult, if not impossible, to draw any firm conclusions about the usefulness of exercise for TMD. Therefore, it is not surprising that the most recent systematic review on TMD by Armijo-Olivo et al. reported 'great uncertainty' for the effectiveness of exercises in treating TMD (Armijo-Olivo et al., 2016). Although the investigators found 'promising' effects for manual therapy and manual therapy combined with exercise, the use of exercise alone was not superior to other conservative treatments for TMD (Armijo-Olivo et al., 2016). Perhaps the masticatory muscle weakness identified by many physical therapists is more likely the product of pain inhibition instead of true weakness. Given that both TMD pain and experimental jaw-muscle pain have been shown to result in decreased EMG activity during clenching, pain inhibition seems to play a role (Castroflorio et al., 2012; Pinho et al., 2000). As such, perhaps physical therapy outcomes would improve if more attention were placed on the pain associated with TMD instead of muscle weakness, the product of pain (Bae and Park, 2013; Moller et al., 1984).

3. Temporomandibular dysfunction and soft tissue release

A systematic review by Turp & Minagi reported a lack of validity and poor inter-examiner reliability for manual palpation of the lateral pterygoid muscle intra-orally and recommended that the procedure be abandoned (Turp and Minagi, 2001). However, with the exception of one lateral head radiograph on a single subject (Johnstone and Templeton, 1980), the 5 RCTs included by Turp & Minagi used cadavers, and the results may not be generalizable to live patients. Notably, a recent study by Stelzenmueller et al. found that palpation of the lateral pterygoid is 'basically feasible' in both live patients and cadavers with 'exact knowledge of muscle topography and the intraoral palpation pathway' (Stelzenmueller et al., 2016). However, the reliability of clinicians to follow the complex series of instructions required to negotiate the intraoral palpation pathway and bypass the medial pterygoid is unknown (Stelzenmueller et al., 2016). Moreover, while Stelzenmueller and colleagues demonstrate an ability to contact the lateral pterygoid with the tip of either digit three of five (Stelzenmueller et al., 2016), it is doubtful whether such limited contact would translate into meaningful clinical outcomes. Given the lack of inter-examiner reliability of localizing trigger points in the upper trapezius (Sciotti et al., 2001), a fully accessible muscle, it also seems highly unlikely that clinicians are able to reliably locate trigger points in the lateral pterygoid and needle them consistently, as a number of authors have claimed (Gonzalez-Perez et al., 2012, 2015).

The inaccessibility of the lateral pterygoid to palpation may also account for the limited evidence in the treatment of TMD with soft tissue mobilization (Miernik et al., 2012). The most recent systematic review and meta-analysis by Calixtre et al. reported a limited number of studies and low to moderate evidence that myofascial release and massage are better than control and moderate evidence that they are as effective as Botox injections in the masseter and temporalis muscle (Calixtre et al., 2015; Guarda-Nardini et al., 2012). However, given that a clinically relevant level of pain in the masseter muscles has only a minor impact in the performance of the masseter and temporalis (Manfredini et al., 2013; Shimada et al., 2015), manual soft tissue techniques targeting those muscles may not be useful for more than symptom relief. That is, manual soft tissue techniques may have a positive effect on more accessible muscles such as the temporalis and masseter, thereby improving symptoms associated with TMD, but they are unlikely to reach the pterygoid muscles that are not only more intimately related with the joint itself, but also more likely one of the primarily etiologic factors in TMD (Gauer and Semidey, 2015; Lafreniere et al., 1997; Liu et al., 1989; Scully, 2008, 2013).

4. Temporomandibular dysfunction and electrophysical modalities

Interestingly, McNeely et al. (2006) found no evidence to support the use of any electrophysical modalities commonly used by physical therapists such as pulsed radio frequency energy, biofeedback, laser therapy and TENS to reduce pain associated with TMD (McNeely et al., 2006). Since the ultrasound penetration half depth into a perpendicular muscle at 1 MHz and 3 MHz is 0.9 and 0.3 cm, respectively (Cameron, 2003), and laser intensity is reduced by 90% at a tissue depth of 1 cm (Ayyildiz et al., 2015), very little of the sound waves or energy likely reaches the TMJ or pterygoids. Notably, a number of systematic reviews have reported little to no evidence to support using ultrasound for musculoskeletal

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conditions (Robertson and Baker, 2001; Shanks et al., 2010; van der Windt et al., 1999), in general, to include TMD (Shaffer et al., 2014). Also, while the depth of penetration of TENs depends on the size and distance between surface electrodes (Cameron, 2003), Fuglevand et al. reported that only motor units of muscle fibers within 1–1.2 cm from the surface electrodes are influenced by the modality (Fuglevand et al., 1992). Thus, much like soft tissue techniques that have a limited ability to reach the pterygoids and TMJ capsule, the source of the problems according to Scully's model of TMD (Scully, 2008, 2013), electrophysical modalities likely provide very limited relief to patients suffering from TMD.

A number of studies have also considered the use of iontophoresis for treating TMD (Braun, 1987; Furto et al., 2006; Mina et al., 2011; Reid et al., 1994; Schiffman et al., 1996). While dexamethasone can be delivered to depths of up to 17 mm (Anderson et al., 2003a, 2003b), the absorption of the drug into target tissue is variable (Smutok et al., 2002). Clinically, studies that have used iontophoresis for TMD (Furto et al., 2006; Mina et al., 2011; Reid et al., 1994; Schiffman et al., 1996) report modest improvements in function but not pain (Shaffer et al., 2014; Wieckiewicz et al., 2015). In a case series of patients with TMD, Furto et al. used a multimodal approach that included iontophoresis with dexamethasone and concluded', patients with TMD who are treated with a rehabilitation program including manual physical therapy interventions plus exercise, with or without iontophoresis with dexamethasone, can demonstrate clinically meaningful improvements in disability and overall perceived change in a relatively short period of time' (Furto et al., 2006). Given that Reid et al. found iontophoresis to be no better than saline for the treatment of TMD (Reid et al., 1994), more evidence is required to fully justify the use of the modality, clinically.

5. Temporomandibular dysfunction and splint therapy

In a 2004 Cochrane review, Al-Ani et al. found insufficient evidence to support the use of splint therapy for the treatment of TMD (Al-Ani et al., 2004). After treating 80 consecutive patients with TMD, Niemela reported that splint treatment, counseling and masticatory muscle exercises were not more beneficial than counseling and masticatory muscle exercises alone. Similarly Nagata et al. found no added short-term benefit of splint therapy in TMD patients receiving multi-modal therapy, including self-exercise, cognitive therapy, self-management education and manipulation (Nagata et al., 2015). Quintus et al. further evaluated the long-term effect of splint therapy. After 1 year, 27.6% of TMD patients that received splint treatment and 37.5% of TMD patients that received counseling and instructions for increasing masticatory muscles exercises, respectively, reported 'very good' treatment effects (Qvintus et al., 2015). Even though 16/40 patients in the counseling and exercise group were switched to the splint therapy group because of painful symptoms associated with TMD, both groups experienced only a modest reduction in pain. Moreover, splint therapy did not outperform counseling and instructions for self-exercise (Qvintus et al., 2015).

6. Temporomandibular dysfunction and joint mobilization

Non-thrust, joint mobilization has been found to improve the extensibility of noncontractile tissue and increase range of motion while decreasing pain and disability via peripheral, spinal and supraspinal mechanisms (Bialosky et al., 2009; Shaffer et al., 2014). However, very few studies presently exist that have investigated the use of mobilization, independent of other conservative treatments, for TMD. Therefore, after reviewing systematic reviews, RCTs and clinical guidelines related to the use of mobilization for various musculoskeletal disorders, Bronfort et al. reported inconclusive evidence for the use of joint mobilization for TMD (Bronfort et al., 2010). Nevertheless, Taylor et al. used EMG to demonstrate a significant decrease in masseter activity and improved mandibular ROM following passive mobilization compared to sham (Taylor et al., 1994). Given the more intimate relationship of the superior and inferior head of lateral pterygoid to the TMJ capsule, joint mobilization may have an even stronger impact on these muscles.

The use of joint mobilization in combination with other conservative treatment has been evaluated in a number of studies on patients with TMD, and they have, almost without exception, reported significant improvements in pain and mandibular range of motion. In one study, Cameli et al. treated 36 patients with TMD with either splint therapy or TMJ mobilization and exercise (Carmeli et al., 2001). Joint mobilizations were progressively advanced from Grade I to Grade IV over 15 treatments, while exercises focused on active mouth opening, closing and lateral deviation X10 repetitions, 6 times per day. After 4 weeks of treatment, only the group receiving mobilization and exercise reported a significant between group improvement in pain and disability (Carmeli et al., 2001).

7. Temporomandibular dysfunction and joint manipulation

High-velocity low-amplitude (HVLA) thrust manipulation has been shown to increase afferent discharge rates of mechanoreceptors to quiet alpha motor neuron pool activity at the level of the spinal cord and subsequently decrease muscle activation levels (Colloca et al., 2004). A number of case studies have successfully used HVLA thrust manipulation to treat patients with TMD, reporting improvements in pain and disability (Ogawa et al., 2015; Rubis et al., 2014; Yabe et al., 2014). While Gotou et al. reported a significant improvement in condylar movement using JOG-HVLA thrust manipulation (i.e. combination of pivot closing, side-to-side and opening HVLA thrust techniques) to treat 34 patients with TMD and limited mouth opening (<35 mm) (Gotou et al., 2010), the most recent systematic review of only 2 medium quality studies on HVLA thrust manipulation of the TMJ by Alves et al. found insufficient evidence to support using the technique for patients with TMD (Alves et al., 2013).

Interestingly, there is considerably more evidence for manipulating the cervical spine (i.e. HVLA thrust manipulation) to treat symptoms associated with TMD.

Anatomically, the spinal aspect of the trigeminocervical nucleus overlaps with the dorsal horns in the upper cervical spine (Chua et al., 2012; Lin, 2014; Spadaro et al., 2014). Thus, nociceptive afferents from the anatomical structures in the upper neck can often be confused with trigeminal pain, to include the TMJ (Chua et al., 2012; Lin, 2014; Spadaro et al., 2014). Notably, Fernandez de-las-penas et al. reported a significant correlation in 25 patients with TMD and myofascial trigger points in the muscles of the neck and shoulder regions (Fernandez-de-Las-Penas et al., 2010). As such, manual techniques such as HVLA thrust manipulation that target the upper cervical spine region (i.e. C0-1, and C1-2) may also effectively inhibit pain and quiet hypertonic muscles of mastication, to include the pterygoids.

A recent systematic review by Calixtre et al. reported low to high evidence for the use of non-thrust mobilization or HVLA thrust manipulation of the cervical spine compared to control in the treatment of TMD (Calixtre et al., 2015). Monaco et al. found a significant increase in mouth opening and opening velocity per kinesiographic data following osteopathic manipulation in 28 children with TMD (Monaco et al., 2008). Moreover, Oliveira-Campelo et al. treated 121 volunteers with latent trigger points in the masseter and reported that a single session of either occipito-

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atlantal (C0-1) HVLA thrust manipulation or soft tissue release of the suboccipital muscles resulted in an immediate increase in pressure pain thresholds over the masseter and an improvement in mouth opening compared to control (Oliveira-Campelo et al., 2010). Mansilla-Farragut et al. also treated 37 women with chronic neck pain with a single session of bilateral OA HVLA thrust manipulation and demonstrated an immediate improvement in mouth opening and reduction in pressure pain thresholds over the sphenoid bone compared to control (Mansilla-Ferragut et al., 2009).

Taken together, these studies seem to demonstrate a clear connection between neck pain and the trigeminal nerve, which provides sensation to face, and specifically to the TMJ via the auriculotemporal branch of the mandibular branch of the trigeminal nerve and motor innervation to the muscles of mastication (Fernandez-de-Las-Penas et al., 2010; Moore and Dalley, 2006). While spinal manipulation targeting the upper cervical spine has been shown to improve pain and motor performance in patients with TMD, the longevity of the changes is presently unknown. However, given that Dunning et al. reported a significant improvement in neck pain, disability and motor performance of the deep cervical neck flexors 48-h following spinal manipulation at C1-C2 and T1-T2 compared to grade IV mobilization, the changes are likely not transient (Dunning et al., 2012).

8. Temporomandibular dysfunction and joint mobilization and/or manipulation

A recent systematic review by Martins et al. notes a general consensus in the literature and B-level of evidence supporting TMJ mobilization (or manipulation), a manual technique applied to the 'craniocervical mandibular system' and commonly combined with 'multi-modal therapy', for improving pain and ROM in patients with TMD (Martins et al., 2016). Moreover, the authors reported a large effect and a significant difference in active mouth opening and pain reduction of manual therapy compared to other active interventions, including home exercise, massage, usual care, sham treatment and splint therapy (Martins et al., 2016). Interestingly, a systematic review and meta-analysis by Armijo-Olivo et al. (2016) reported that mandibular, postural and cervical exercises were superior to other active conservative treatments for TMD (Armijo-Olivo et al., 2016). However, manual therapy, including manipulation and/or mobilization to the orofacial and C-spine, was effective when administered alone or in combination with exercise (Armijo-Olivo et al., 2016). In general, a 5 mm improvement in mouth opening is considered a clinically relevant change (Kropmans et al., 1999a, 1999b); while postural exercises and either jaw or jaw and cervical exercises reported a 5.54 and 5.94 mm improvement, respectively, manual therapy led to a 17.33 mm improvement (Armijo-Olivo et al., 2016; Kropmans et al., 1999a, 1999b). That is, the addition of exercises to manual therapy for the treatment of TMD did not seem to provide an added clinical advantage, suggesting that mobilization (or manipulation) may provide a key component of the intervention (Armijo-Olivo et al., 2016).

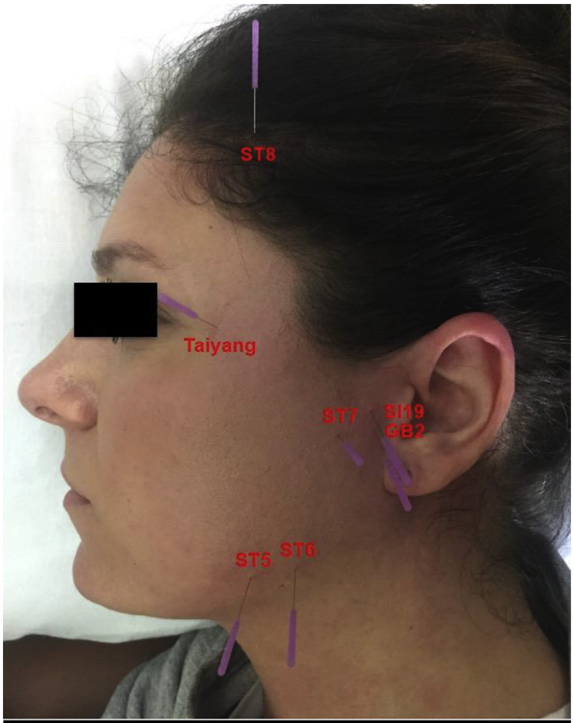
9. Temporomandibular dysfunction and needling modalities

While the terminology, philosophy and theoretical constructs differ between Western-based DN and traditional Chinese acupuncture, the procedure of inserting monofilament needles is similar (Dunning et al., 2014). Therefore, manual and electric DN are used synonymously with manual and electroacupuncture, respectively, throughout this section to describe needling procedures that penetrate the skin in the absence of medicine or injectate (Butts et al., 2016; Dunning et al., 2014).

While acupuncture specifically facilitates direct contact with the TMJ joint capsule and the superior and inferior heads of the lateral pterygoid muscle, many of the controlled trials that have attempted to treat TMD with acupuncture have reported modest outcomes (McNeely et al., 2006). A systematic review by List and Axelson did not support acupuncture for TMD more than occlusal appliances, behavioral therapy, exercise, posture training and pharmaceutical meds (List and Axelsson, 2010). Similarly, Jung et al. published a systematic review of 7 randomized control trials and found only limited evidence for the use of acupuncture for the symptomatic treatment of TMD (Jung et al., 2011). However, methodological issues stand out in the Jung et al., systematic review (Jung et al., 2011). First, a penetrating placebo was used in one of the 7 included, and this comparison treatment was likely not inert (Dincer and Linde, 2003). Second, only 1 of the 7 included trials considered needle manipulation, which is likely an important omission considering the soft-tissue (i.e. mechanotransduction) (Langevin et al., 2006, 2005, 2011) vascular (Sandberg et al., 2003; Yim et al., 2007), peripheral analgesic (Choi et al., 2013; Goldman et al., 2010; Takano et al., 2012) and central descending pain inhibitory effects (Lundeberg and Lund, 2007) that have been linked with needle manipulation (Kong et al., 2007; Zhou and Benharash, 2014). Third, in 4 of the trials, the longest outcome was following just one acupuncture session—likely an under dosing of the intervention (White et al., 2007, 2008). Fourth, and perhaps most surprising, was the fact that 60 of the 91 points needled across the 7 trials included in Jung et al. were in distal points of the hand (LI4, SI3 and SI2) instead of the muscles of mastication or the peri-articular connective tissue of the TMJ. In fact, only 13 of the 91 points were consistent with the masseter (ST6) and 6 of the 91 points were consistent with masseter and lateral pterygoid (ST7) (Jung et al., 2011). Similarly, a more recent study by Grillo et al. compared acupuncture with a flat occlusal plane appliance in 40 women with TMD and reported no between-group difference (Grillo et al., 2015). Yet, only 1 out of 10 acupoints used (i.e. SI19) was associated with the TMJ, and none penetrated muscles of mastication (Grillo et al., 2015).

Notably, La Touche et al. reported that local acupoints (i.e. acupoints anatomically positioned near the symptomatic TMJ) achieved the greatest pain reduction (La Touche et al., 2010). More specifically, 2 of the 4 randomized control trials included in the La Touche et al. systematic review produced both statistically significant and clinically meaningful changes in pain associated with TMD using acupoints ST6 (i.e. the lower, posterior border of the masseter muscle) and ST7 (i.e. the mandibular notch, one index finger forward of the tragus, within the deep masseter when inserted superficially and/or the lateral pterygoid muscle when inserted deeply) (La Touche et al., 2010.) (See Fig. 1).

Cho and Whang published a systematic review of 15 randomized control trials of 808 patients with TMD (Cho and Whang, 2010); however, in order to combat heterogeneity of various interventions, they qualitatively grouped patients instead of statistically pooling the data. Unlike Jung et al. (2011). 2 of the 3 most common acupoints used among the 14 trials were points consistent with the masseter and lateral pterygoid (ST6 and ST7). Notably, the authors concluded that there is moderate evidence that acupuncture is superior to non-penetrating placebo, wait list control, pharmaceutical treatment and physical therapy, to include ultrasound, massage and manual therapy, for the treatment of TMD. In a more recent systematic review of 21 studies, Porporatti et al. also reported significant improvements in pain, joint movement and oral function along with decreased hypertonicity of masticatory muscles secondary to acupuncture (Porporatti et al., 2015). As in Cho and Whang, Porporatti et al. found that ST6 and ST7 were 2 of



Acupoints	Associated Anatomy
ST5	Anterior aspect of distal masseter muscle
ST6	Posterior aspect of distal masseter muscle
ST7	Proximal masseter muscle, superficially Inferior head of lateral pterygoid muscle, deep
ST8	Anterosuperior temporalis muscle
Taiyang	Anteroinferior temporalis muscle
GB2	Posterior TMJ capsule
SI19	Posterior TMJ capsule

Fig. 1. Recommended needle insertion sites for the conservative treatment of TMD.

the 3 most commonly used acupoints for TMD. In addition, the authors suggested that the temporalis muscle also be needled at Taiyang (one index finger posterior of the lateral orbit of the eye) (Porporatti et al., 2015). Given that ST5 (lower, anterior border of the masseter) and ST8 (anterosuperior aspect of the temporalis) correspond to the masseter and temporalis muscle, respectively (Deadman et al., 2007), these acupoints may also be appropriate needle locations for patients with TMD (See Fig. 1).

While myofascial trigger points in the muscles of mastication can be a source of pain in TMD (Diracoglu et al., 2012; Gonzalez-Perez et al., 2012, 2015), there is a lack of robust, empirical evidence validating the clinical diagnostic criteria for identifying trigger points, as originally proposed by Travell and Simons (Simons et al., 1999; Simons and Travell, 1983) and Fischer (Fischer, 1988; Tough et al., 2007) (Sciotti et al., 2001). Nevertheless, the goal of needling trigger points associated with TMD requires clinicians to focus their needles on the key muscles of mastication (Diracoglu et al., 2012; Gonzalez-Perez et al., 2012, 2015). As a result, the limited number of studies that have investigated the use of myofascial trigger point (MTrP) dry needling to treat TMD have reported, in the main, positive outcomes in terms of statistically significant and clinically meaningful between-group reductions in both pain and disability.

Interestingly, McMillan et al. found that MTrP dry needling and simulated procaine, simulated MTrP dry needling and procaine, and simulated MTrP dry needling and procaine targeting trigger points in the masseter muscle resulted in modest and statistically equivalent changes in pain intensity and unpleasantness scores (McMillan et al., 1997). In contrast, Fernandez-Carnero et al. found a significant increase in pressure pain thresholds and maximal jaw opening compared to sham after needling trigger points in the masseter muscle (Fernandez-Carnero et al., 2010). Given that the authors performed deep dry needling into the masseter at a depth consistent with the trigger point, it would be interesting to know how often the medial and lateral pterygoid muscles were penetrated. Gonzalez-Perez et al. also performed MTrP dry needling once per week for 3-weeks on muscles of mastication with palpable trigger points in 36 patients with TMD but specifically targeted the inferior head of the lateral pterygoid at an insertion site consistent with the ST7 acupoint (Mesa-Jimenez et al., 2015). While the study did not include a control group, the authors reported a statistically significant within-group improvement in pain and jaw movement compared to baseline directly following treatment and at 6 months post treatment. In a more recent study by Gonzalez-Perez et al., the authors reported significant between-group reductions in pain and improvements in jaw movements that lasted up to 70 days following MTrP dry needling targeting the lateral pterygoid compared to control (methocarbamol/paracetamol every 6-h for 3-weeks) (Gonzalez-Perez et al., 2015). Collectively, these findings suggest that the masseter and temporalis play significant roles in TMD; however, and in large part, the primary etiology and the treatment focus for the pain and disability associated with TMD is likely the lateral pterygoid muscle (Scully, 2008, 2013).

While no studies have directly investigated the use of dry needling or acupuncture to improve the health of intra- and peri-articular aspects of the TMJ itself in patients with TMD, there is evidence to suggest that acupuncture may be useful for joint osteoarthritis (OA), mainly due to its ability to stimulate vasodilation and facilitate neovascularization (Ahsin et al., 2009; Li et al., 2009; Loaiza et al., 2002; Wu et al., 2010). A number of studies have shown improved blood flow to joints secondary to acupuncture may facilitate the recruitment of opioid producing immune cells required to reduce the level of inflammatory cytokines (Ahsin et al., 2009; Huang et al., 2007; Zhang et al., 2014). There is also limited evidence suggesting that acupuncture may stimulate an increase in hyaluronic acid, allowing the synovial fluid to better lubricate the joint (Li et al., 2009; Wu et al., 2010). Given Scully's mechanism of TMD (Scully, 2008, 2013), it may therefore be particularly advantageous to target traditional acupoints GB2 and SI19, as they are anatomically positioned directly over the TMJ posterior capsule (Deadman et al., 2007. (See Fig. 1).

10. Conclusion

There is limited evidence to support soft tissue release and strengthening exercises for the muscles of mastication in patients with TMD. For the reduction of pain associated with TMD, there is little to no evidence to support the use of electrophysical modalities and splint management. For the reduction of pain and disability in TMD, non-thrust joint mobilization and HVLA thrust manipulation to the TMJ and/or upper cervical articulations, and dry needling or acupuncture to the lateral pterygoid muscle and posterior peri-articular connective tissue may provide the most evidence-based approach for conservatively treating TMD.

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