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NARRATIVE REVIEW

Pathoanatomical characteristics of temporomandibular dysfunction: Where do we stand? (Narrative review part 1)

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A B S T R A C T

Temporomandibular dysfunction (TMD) is a complicated and multifactorial condition that affects the temporomandibular joint (TMJ) and muscles of mastication, resulting in pain and disability in 5–12% of the population. The condition involves genetic, anatomic and hormonal factors and is propagated, in part, by trauma, habitual activity, psychosocial components and occlusal variation. Yet, the exact etiology of TMD is still unknown and the most strategic conservative management of the condition is still a topic of debate. The purpose of this paper, the first of a two part series, is to provide greater insight into the pathoanatomical factors associated with TMD. Consistent with Scully (2008, 2013), degenerative changes seem to disrupt the relationship between the TMJ capsule, articular disc and muscles of mastication. The resulting position of the articular disc coincides with three primary classifications of TMD: Type 1 (muscle disorders), Type 2a/b (disc displacement with and without reduction), and Type 3 (any joint pain). Given the association of the lateral pterygoid with both the joint capsule and articular disc, the superior and inferior head seem to play a key role in TMD. Both heads undergo biological changes associated with the vicious cycle, pain adaptation and integrated pain adaptation, making the muscle a key pain generator associated with TMD. Clinicians must understand the pathoanatomic features associated with TMD so as to choose appropriate treatment strategies, leading to optimal short and long-term outcomes. While the former is discussed in part 1 of this narrative review, the latter will be considered in part 2.

1. Introduction

Temporomandibular dysfunction (TMD) is a complicated and multifactorial condition that affects the temporomandibular joint (TMJ) and muscles of mastication, resulting in pain and disability (Mujakperuo et al., 2010). According to the National Institute of Health and Cranial Research, the prevalence of temporomandibular dysfunction (TMD) ranges from 5 to 12% (Ariji et al., 2015; Murray and Peck, 2007). While the exact etiology of TMD is still unknown, genetic (Pihut et al., 2016), anatomic (Murray et al., 2004; Peck et al., 2008) and hormonal factors (Hiraba et al., 2000; Saghafi and Curl, 1995) seem to predispose the joint to problems (Friedman, 1997; Pihut et al., 2016). While a number of studies have also identified trauma, habitual activity and occlusal variation as being precipitating factors for TMD, there also seems to be a strong psychosocial component that propagates the condition (Jayaseelan and Tow, 2016; Mapelli et al., 2016). TMD is a complex condition, and the pathoanatomical factors associated with its etiology require further consideration.

2. Muscles of mastication

The primary muscles of mastication are the masseter, temporalis and medial and lateral pterygoids. The masseter is attached to the maxillary process of the zygomatic bone and the zygomatic arch proximally and the angle and ramus of the mandible distally (Marieb and Hoehn, 2010). It primarily elevates and protracts the mandible (Moore and Dalley, 2006). While the temporalis also elevates the mandible, its proximal and distal attachments to the temporal fossa of the temporal bone and the coronoid process and anterior border of the ramus of the mandible, respectively, are better suited for retracting rather than protracting the mandible (Marieb and Hoehn, 2010; Moore and Dalley, 2006). Deep to the

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temporalis and masseter, the medial pterygoid further assists with mandibular elevation and protrusion via its attachments to the lateral pterygoid plate and medial surface of the ramus of the mandible (Marieb and Hoehn, 2010; Moore and Dalley, 2006). While the medial pterygoid also facilitates side-to-side grinding movements (Moore and Dalley, 2006), the synergistic actions of the temporalis, masseter and medial pterygoid vertically close the jaw during mastication (Marieb and Hoehn, 2010; Moore and Dalley, 2006).

In contrast, the lateral pterygoid is divided into two heads, both of which are intimately related to the TMJ. Classically, the superior head of the lateral pterygoid runs from the infratemporal crest of the sphenoid bone and inserts onto the anterior aspect of the articular disc (Stelzenmueller et al., 2016). Based on the attachments of the superior head, a number of researchers have suggested that it may contract to pull the disc forward during mandibular depression (Hiraba et al., 2000; Juniper, 1984; Reichert and Stelzenmuller, 2008; Schunke et al., 2006), consistent with the position of the mandibular condyle (Manfredini, 2009; Stelzenmueller et al., 2016). Given this function, hyperactivity of the superior head of the lateral pterygoid could easily be implicated in anterior disc displacement (Bakke et al., 2005; Taskaya-Yilmaz et al., 2005).

However, based on the relatively small number of superior head fibers directly attached to the articular disc (Carpentier et al., 1988) compared to the condylar neck and the limited number of studies demonstrating superior head activation during mandibular depression (Gibbs et al., 1984; Hiraba et al., 2000; Mahan et al., 1983; Manfredini, 2009; McNamara, 1973; Murray and Peck, 2007; Murray et al., 2004; Wood et al., 1986), some researchers have suggested an alternative function. The nonelastic quality of the ligaments connecting the disc to the condyle and the biconcave shape of the disc also makes it unlikely that the disc is able to migrate from the superior aspect of the condyle, making tracking unnecessary (Manfredini, 2009). Notably, the posterior aspect of the disc attaches to the posterior capsule via retrodiscal tissue, which maintains posteriorly directed traction via its superior layer as the disc moves anteriorly with jaw opening (Manfredini, 2009). The attachment of the disc anteriorly to the superior head may, therefore, passively drag the disc forward in concert with the actions of the inferior head during mandibular depression, while its primary purpose may be to counter the retrodiscal traction and provide an anterior braking force to the disc as it moves posteriorly into the condyle during mandibular elevation (Manfredini, 2009).

The inferior head of the lateral pterygoid runs from the lateral plate of the pterygoid process to the condylar process of the mandible (Bakke et al., 2005; Benninghoff, 2004; Schmolke, 1994; Stelzenmueller et al., 2016; Taskaya-Yilmaz et al., 2005; Usui et al., 2008). Classically, bilateral inferior head activation is responsible for mandibular depression and protrusion (Gibbs et al., 1984; Hiraba et al., 2000; Mahan et al., 1983; McNamara, 1973; Murray and Peck, 2007; Murray et al., 2004; Wood et al., 1986), functions that have been confirmed by single-motor-unit recordings conducted by Phanachet et al. (Phanachet et al., 2001, 2002). That is, the bilateral contraction of the inferior head works with the suprahyoid digastric muscles (Marieb and Hoehn, 2010; Stelzenmueller et al., 2016) to pull the mandible anteriorly and inferiorly out of the fossa during jaw opening (Miloro, 2004). Notably, while the masseter, temporalis, medial pterygoid and superior head of the lateral pterygoid all seem to be primarily active during mandibular elevation, the inferior head of the lateral pterygoid and the digastric muscles are the primary players during mandibular depression (Monemi et al., 1999; Peck et al., 2000).

While a number of studies support the notion that the superior head is primarily active during mandibular elevation and the inferior head is active during mandibular depression (Desmons et al., 2007; Hiraba et al., 2000; Mahan et al., 1983; McNamara, 1973; Murray et al., 2004), investigations using EMG have suggested a more synchronous relationship for the two heads (Hannam and McMillan, 1994; Murray et al., 2004). By incorporating image guided EMG electrode placement via computer tomography, Murray et al. discovered more overlap between the superior and inferior head of the lateral pterygoid than previously thought (Murray et al., 2004). In fact, the authors cite three unique regions of the superior head of the lateral pterygoid, a medial region that fires consistent with the inferior head (i.e. during mandibular depression, protrusion and contralateral excursion), a lateral region that is active during mandibular elevation, retrusion and ipsilateral excursion and a middle region that exhibits firing patterns consistent with both the superior and inferior head (Murray et al., 2004; Phanachet et al., 2001). Therefore, EMG electrodes mistakenly placed in the middle region would certainly suggest the superior and lateral pterygoid were functionally similar when, in fact, that appears to not be the case (Murray et al., 2004).

Notably, the ipsilateral activation of the superior and inferior head of the lateral pterygoid has also been implicated in ipsilateral and contralateral jaw movements, respectively (Murray et al., 2004). In doing so, the inferior head may provide horizontal forces required for mastication and parafunctional activities (Murray et al., 2004; Widmalm et al., 1987; Wood et al., 1986). The inferior head seems to progressively increase in activity with horizontal excursion of the mandible in the contralateral direction (Murray et al., 2004; Uchida et al., 2002). Importantly, while some activity of both the superior and inferior head of the lateral pterygoid has been shown to occur with intercuspal jaw clenching, this action may be an effort to stabilize the condyle and prevent slippage in the posterior direction (Murray et al., 2004; Widmalm et al., 1987). Alternatively, the superior head may be firing to tension the articular disk, thereby maintaining the position of the condyle (Murray et al., 2004). Thus, while the masseter, temporalis and medial pterygoid provides the forces required for mastication in the vertical plane, the inferior head of the lateral pterygoid seems to facilitate horizontal forces. The reciprocal actions of the superior and inferior heads in the horizontal plane further suggest a role in fine motor control of the mandible during jaw movements (Murray et al., 2004; Phanachet et al., 2001, 2002).

3. The lateral pterygoid: two distinct muscles

Treating the superior and inferior head of the lateral pterygoid as one or two muscle continues to be a source of debate in the literature (Hannam and McMillan, 1994; Murray and Peck, 2007; Murray et al., 2004). Perhaps the best argument for two functionally distinct lateral pterygoid muscles is their neural innervation (Desmons et al., 2007). According to Kim et al. the superior head is innervated by the buccal nerve, while the inferior head is innervated by the mandibular nerve trunk (Kim et al., 2003). While different fiber orientations of a multi-penniform muscle could alternatively explain various complex actions of a single muscle (Desmons et al., 2007; El Haddioui et al., 2005), the unique neural innervation and activity during both jaw opening and closing suggests that a 2 muscle system is more likely (Aziz et al., 1998; Juniper, 1981, 1984; Liu et al., 1989). Notably, the masseter and medial pterygoid have the same muscle fiber structure and only fire during mandibular elevation (Desmons et al., 2007).

4. Etiology of temporomandibular dysfunction with anterior disc displacement

While TMD is a complex condition with a multi-factorial