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Comparative and Expansive Study on Diagnosis Methods of Myofascial Trigger Point

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Abstract: ***Background:*** *Myofascial trigger points (MTrPs) are hyperexcitable areas in the skeletal muscle or fascia that cause muscle pain and dysfunction due to overuse, trauma, or neurological abnormalities. MTrPs are associated with palpable contracture nodules in tight bands. Various diagnostic methods exist for MTrPs; however, standard diagnostic criteria and procedures have yet to be established by international scholars. This lack of consensus can lead to confusion with other diseases.* ***Aims:*** *The objective of this systematic review is to survey the literature on MTrPs and myofascial pain syndrome (MPS). This paper analyzes evidence of MPS and MTrPs production and pain occurrence using electromyography, imaging, and biomarkers. Additionally, it identifies recent diagnostic methods for MTrPs and provides the latest evaluation and diagnostic criteria for MPS and MTrPs. The authors propose some accurate and easy-to-use diagnostic indicators and methods suitable for front-line clinicians.* ***Methods:*** *Literature published from February 2000-2023 was searched through PubMed and Google Scholar using the following search terms: myofascial trigger points, myofascial pain syndrome, diagnostic, ultrasound, electromyography, genetic and molecular biology.* ***Results:*** *Currently used diagnostic methods include physical examination, MTrPs partition table, ultrasonography, electromyography, and biomarkers. This paper thoroughly evaluates the advantages and disadvantages of various diagnostic methods and introduces some emerging methods, such as elastography and immunomarker analysis.* ***Conclusions:*** *Standardized, systematic, and reproducible diagnostic methods and procedures have not yet been developed for MTrPs, and the pathogenesis of MTrPs is still under investigation. In the future, specific biomarkers, genetic testing technology, and artificial intelligence-assisted diagnosis may become acceptable diagnostic tools.*

Keywords: Myofascial trigger point, Diagnosis, Myofascial pain syndrome, Chronic pain, Biomaker, Pain assessment**.**

1. Introduction

MTrPs and MPS are clinical conditions that have been of significant concern and confusion for decades. The hallmark of MPS is usually considered to be the finding of single or multiple MTrPs at the site of painful discomfort: a hard nodule palpable over a tight band [1]. The prevalence of cell phone and computer usage has surged in recent times due to advances in electronic technology and rapid-paced lifestyles. However, extended periods of using electronic devices are likely to increase the occurrence of MPS and trigger point pain [2,3]. Despite the increasing number of targeted treatment options for it, most clinicians are not as successful as they think, and the diagnosis still relies on the subjective diagnostic criteria proposed by Simons et al [4]. Specific objective diagnostic markers are not yet established. Studying its pathogenesis and related tissue structures can aid in developing more specific methods of diagnosis and adjuvant tests.

2. Epidemiology:

Muscle pain is a widespread occurrence, caused by degenerative aging lesions, disease-induced strain, injury, and overuse in daily activities, and this is a common reason for patients to perform self-body care and to visit hospital pain units. Most pain is usually associated with MPS caused by activation of MTrPs. All types of people can suffer from MPS, but those who regularly participate in high-intensity sports and whose bodies have experienced motor function deterioration due to aging are more susceptible, and almost all orthopedic conditions induce pain in this category [5-10]. Chronic pain is one of the most common reasons for people to visit the clinic, with myofascial pain syndromes accounting for approximately 30%-85% of pain clinics and the increasing financial stress associated with the long duration of pain, which also affects people's daily work life to some extent [11].

3. Overview:

3.1 MTrPs

Travell first introduced the term "MTrPs" in 1952 [12]. These trigger points are located at areas of hyperstimulation in muscle, fascia, or joint junctions, where localized muscle pain is determined to be deep palpable taut bands [13]. MTrPs are defined by Travell and Simons [4] as "a point of hyperstimulation, usually located within the taut band of skeletal muscle or within the myofascia, that is painful when compressed and can cause characteristic pain, motor dysfunction, and autonomic phenomena". Previously, MTrPs were referred to as "fibrositis" or "myofibrosis", terms that describe inflammation or abnormal enlargement of connective tissue lining the muscle, accompanied by chronic muscle pain. When pressure is applied to the trigger point, the pain produces referred pain around or adjacent to the palpated area, and a local twitch response (LTS) occurs when the trigger point is strongly pressed or needled. This twitch response occurs in the proximal or distal muscles, which is a characteristic feature of activated myofascial trigger points [14].

3.2 Activation and Potential Trigger Points

Numerous studies have demonstrated that the activation of MTrPs in skeletal muscle is associated with several pain syndromes [15-17]. For many clinicians and researchers, the detection of one or more MTrPs is necessary to ensure the diagnosis of MPS. Clinically, MTrPs can be classified as either latent or active [5,14]. Active MTrPs are characterized

by spontaneous pain in specific pain patterns in surrounding tissues as well as distant sites. The strong electrochemical signal produced by active MTrPs exacerbates patients' instinctive pain discomfort, mimicking prior painful experiences [18]. Nonetheless, underg MTrPs may remain present on the body, and applying pressure to these MTrPs can cause local pain at the nodal site even when no spontaneous pain is experienced [5,14,19]. Such pain may also be due to MTrPs resulting from prior muscle injuries or from other diseases [4,20]. Both latent and active MTrPs can lead to muscle dysfunction and limited range of motion [14,18].

In summary, the presence of MTrPs not only results in structural changes within the local skeletal muscles, but also changes in the intrinsic biochemical environment, resulting in the inability of sensory receptors to recognize and transmit the correct information, which in turn leads to sensory impairment in the body. For novice doctors, locating one or multiple MTrPs on muscle tension bands is a challenging task that requires a significant amount of time and practice to hone palpation skills [21]. Therefore, developing visual and easily identifiable diagnostic criteria is essential.

4. Diagnosis

4.1 Distribution Map of MTrPs

MTrPs are regional pains that are located in muscles and fascia, and can be found throughout the body. However, their distribution has specific characteristics: 1) Muscle-specific: MTrPs are usually found in specific muscles, such as the psoas major, biceps, gluteus medius, and other muscles that are subject to high daily physical loads or are easily overused; 2) Multi-point distribution: Multiple MTrPs may exist in a single muscle, and these points may interact with each other and together cause pain or discomfort; 3) involvement pain: involvement pain is not limited to the local area where the myofascial trigger point is located, different muscle tissues and myofascial trigger points may cause involvement pain in different areas, but the area involved is often fixed [4,18]. For example, MTrPs in the back muscles may cause pain in the arms or legs, while MTrPs in the palms of the hands may be associated with pain in upper extremity areas such as headache or neck pain. To expedite localization of MTrPs, a relevant atlas according to the site of pain can be consulted (Figure 1).

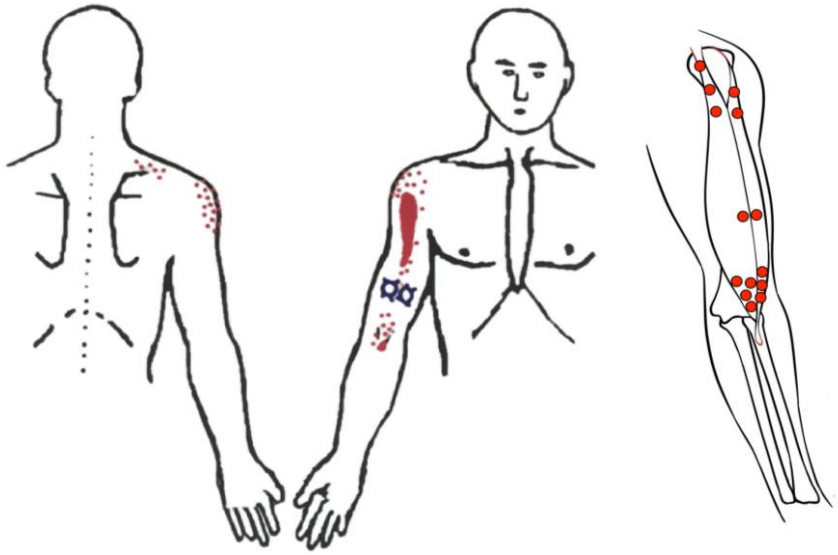


Figure 1: The approximate distribution of MTrPs in the biceps muscle and the location of the involvement pain were described

4.2 Physical Examination

Through literature search, the authors have identified three physical examinations which are highly accurate for localizing MTrPs: pressure points with nodules, involvement pain, and local twitch response (LTS).

4.2.1 Pressure points with nodules

The pressure point of MTrPs is typically located in the tensest or most shortened portion of the muscles and fascia. The area is palpated using the index finger to apply pressure, and determine the presence of a significant local pain response. Additionally, considerations must be given to the following: 1) size and morphology of the pressure point, which may vary depending on the site and may include characteristics such as hard nodes or palpable striated bands; 2) the extent of pain radiation, whereby MTrPs pressure points may cause painful responses in surrounding muscles and nerves, requiring detection to determine the primary area; and 3) the degree of pain intensity at the pressure point, which must be measured for further evaluation [1,4,22].

4.2.2 Involvement pain

Referred pain is defined as radiating pain or discomfort around a tender point. This type of pain can manifest in various ways: 1) radiating pain, which can spread from the pressure point to adjacent muscles, nerves, bones, and other areas, creating a broad area of discomfort; 2) conductive pain, which can be transmitted through nerve pathways to cause pain or discomfort in the distribution area of the nerve; 3) reflex pain which can lead to muscle tension or contraction in the muscles near the pressure point, resulting in pain or discomfort [23,24]. It's worth noting that some trigger points may have referred pain at the location of other MTrPs, causing them to mask potentially painful trigger points in these muscles. Referred pain caused by MTrPs can also mimic

the symptoms of other conditions, such as nerve root pain and arthralgia, so great care is necessary during the diagnosis process.

4.2.3 LTS

LTS is usually a local muscle twitch response that can be elicited at the point of rapid pressure or pinprick trigger, or a sudden and brief muscle twitch or pulsation at the pressure point. This response occurs due to stimulation of the pressure point, which is the most sensitive area for active MTrPs. The LTS phenomenon, which is different from the spontaneous contraction of surrounding healthy muscle tissue, can manifest as strips running along the intramuscular trigger point of skeletal muscle or in muscle fibers away from the trigger point location, but within the same muscle [14,25]. The diagnosis of LTS is more challenging than the previous two methods and requires greater patience and clinical experience.

4.3 Ultrasonic Examination

The literature on the use of ultrasound for precise localization of MTrPs is growing. Ultrasound imaging provides reliable data for accurate localization and assessment of not only muscle tissue but also fascial status and trigger point location, thereby improving diagnostic speed and accuracy through objective characterization and quantitative measurements [26-28]. Different ultrasound imaging techniques offer varying presentations of MTrPs, and using imaging techniques facilitates the clinician's ability to locate MTrP trigger points, thereby reducing the duration of patient suffering and shortening pain time through less burdensome diagnostic procedures. Through a literature review, the authors identified three commonly used imaging methods for locating and diagnosing MTrPs: conventional grayscale imaging, Doppler imaging, and sonoelastography.

4.3.1 Gray-scale US

MTrPs typically appear in ultrasound (US) images as a focal hypoechoic region with heterogeneous internal texture [1,22]. Kumbhare et al [29] identified significant differences in speckle characteristics between healthy and myofascial painful individuals in quantitative ultrasound of the trapezius muscle, while Sikdar et al. [30] observed that ultrasound techniques could differentiate between myofascial tissue containing MTrPs and normal myofascial tissueMTrP morphology is highly variable, with spherical, oval, and banded shapes being the most commonly encountered in clinical practice [30]. In the human body, muscle fibers are not unidirectional and exist in multiple layers. Aging causes changes in the deep myofascial structure, leading to morphological changes at the joints where MTrPs occur. Abnormalities in the local structure can cause force transmission to neighboring tissue structures, making muscle tissue susceptible to non-correct ultrasound images due to the complex muscle direction [31-34]. For beginners, it is recommended to move the probe slowly over the painful area to accurately depict small changes in muscle echotexture. In suspicious cases, a gentle tilt of the probe can avoid muscle tissue pseudo-hypoechoic associated with anisotropic artifacts. The small tilt of the probe over the hypoechoic nodes optimizes its ultrasound visibility and effectively reduces the "interference effect" of connecting branches [35].

4.3.2 Doppler

Differences in blood flow patterns were observed between active myofascial trigger points (MTrPs) and potential MTrPs, with a higher proportion of positive resistive index (RI) in active MTrPs (69%) compared to potential MTrPs (16.7%) [30]. This reflects the presence of a vascular bed of greater resistance in active MTrPs [30]. Doppler Flow Imaging (CDFI) examinations of MTrPs also yielded similar results. In the CDFI examination, two of the 14 blood flow signals were absent, five were one or two punctate signals, four were three punctate or one thin, short blood flow signals, and three were one or more larger, longer blood flow signals. These findings suggest that blood flow in and around MTrPs was higher than in corresponding normal muscle sites, which had no blood flow signal [36].

Sikdar et al. [37] found that blood flow waveforms near activated MTrPs showed increased systolic velocity, reversal of blood flow, and negative diastolic velocity. Computational modeling identified two factors that may contribute to these observed waveforms: an increase in vascular lumen volume, and an increase in outflow resistance due to muscle contracture at the MTrP compressing the capillary/venous bed, external compressive pressure exerted by muscle decompression adjacent to it pressing against each other, local vasoconstriction due to inflammation, or external pressure exerted by the use of an ultrasound transducer during imaging [37].

4.3.3 Sonoelastography

Sonoelastography, a technique combining ultrasound imaging with tissue elastography, is used to detect the hardness and deformation characteristics of various tissues in the human body. The Mechanical Heterogeneity Index (MHI) is computed from the ratio of the elastic modulus between the softest and hardest regions within the tissue and it measures the mechanical heterogeneity of tissues. A higher MHI value indicates more pronounced mechanical heterogeneity within the tissue.

In 2008, Sikdar et al. [38] demonstrated the feasibility of using vibroacoustic elastography for the localization of myofascial trigger points (MTrPs). The researchers employed two techniques to induce vibration in the superior trapezius muscle: an external massager and asking the subject to hum lightly. Image analysis showed that MTrPs were firmer than the surrounding tissue, with approximately a 27% reduction in vibration amplitude. When the external massager was used, there was a similar reduction in vibration amplitude in both active and latent MTrPs [30,38]. Turo et al. [39] observed a decrease in mechanical heterogeneity index after dry needling, indicating a change in MTrP status. Sonoelastography offers a new detection method with high application value for the quantitative identification of MTrPs [40,41].

4.4 Electromyogrphy

Electromyography (EMG) is a common diagnostic tool for

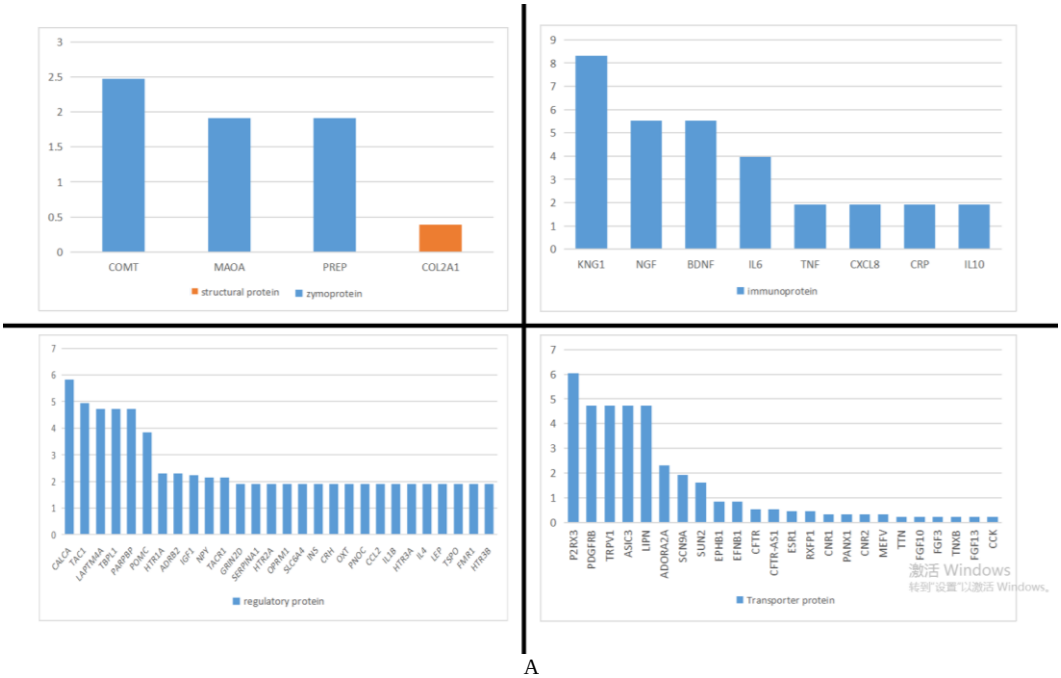
examining nerve and muscle function using electronic instruments to record bioelectrical signals produced during muscular rest or contraction. EMG can be used to determine the functional status of peripheral nerves, neurons, neuromuscular junctions, and muscles themselves. Moreover, it can clarify diagnostic criteria for abnormal electromyography of MTrPs [42,43].

Various studies have demonstrated that MTrPs cause abnormal increases in muscle action potentials, leading to muscle contraction and pain. David R. et al. [44] found spontaneous EMG activity at 1-2 mm around the MTrPs, while sustained spontaneous electrical activity was confined around the MTrPs. When the probe was located 1 mm forward or backward of the MTrPs, the activity disappeared. Furthermore, when the probe reached the MTrPs, patients consistently reported episodes or worsening of pain [44]. Jiang et al. [45] used surface electromyography to examine the core muscle groups of patients with myofascial pain syndrome in the low back and found that abnormalities in electromyography led to abnormal muscle contraction or stretching, which increased muscle fatigue and pain. Additionally, Huang et al [46] found significantly higher myoelectricity at the site of MTrPs in an animal model than in normal rats at the same site. Michał et al [47] suggested that pain due to MTrPs causes changes in surface electromyography, which protects the tissue from further damage by reducing muscle activity to limit movement.

Hoffmann's reflex (H-reflex) is a reflex pathway involving both the spinal cord and peripheral nervous system. Liu et al. [48] noted enhanced H-reflex electromyographic activity in muscles affected by MTrPs compared to normal muscles, suggesting that muscle spindle may play a critical role in the pathological mechanism of MTrPs. Similarly, David et al. [44] suggested that the persistent presence of MTrPs could lead to changes in neuroplasticity at the level of the dorsal horn, resulting in amplified pain sensations (i.e., central sensitization) with a tendency to extend beyond its original boundaries (i.e., receptive field expansion).Huang et al. [49] through quantitative EMG assessments, that the abnormal end-plate noise wave amplitude and end-plate spike frequency were significantly higher in the model group than in the control group. Moreover, the acetylcholine content was significantly higher in the model group than in the control group, indicating that over-produced acetylcholine caused these myoelectric abnormalities [49].

4.5 Biomaker

Proteins are essential molecules that play various biological roles, including providing structural support, catalyzing enzymatic reactions, transporting substances, providing immune protection, regulating cellular processes, transmitting signals, and storing energy. MTrPs can disrupt intracellular processes such as protein metabolism, transcription, translation, and degradation, leading to alterations in the type and level of proteins produced. Identification of specific proteins expressed in MTrPs as biomarkers is crucial for accurate diagnosis and treatment of the disease. In this study, the authors compiled a list of proteins associated with MTrP pathogenesis and found that IL-6 is the central protein in MTrPs through PPI protein interaction network analysis (Figure 2-B). This finding suggests that MTrP development has a strong link to cellular signaling, immune response, and inflammatory response. The remaining expressed protein species can be broadly categorized into five types: structural proteins, enzyme proteins, regulatory proteins, immune proteins, and transport proteins (Figure 2-A). These proteins have various functions that impact the structure, stability, sensitivity, and pain onset of MTrPs and can either promote or inhibit inflammatory responses, affect myofascial tissue injury, repair, development, and regulation of neuronal function and participate in the formation and regulation of neural networks (Table 1). These proteins can contribute to the development of contracture nodules, tenderness, hypertonic bands, and hypersensitive areas in MTrPs through direct or indirect means. However, this study did not find any MTrP-specific protein markers. The following studies are related to proteins highly associated with MTrPs.



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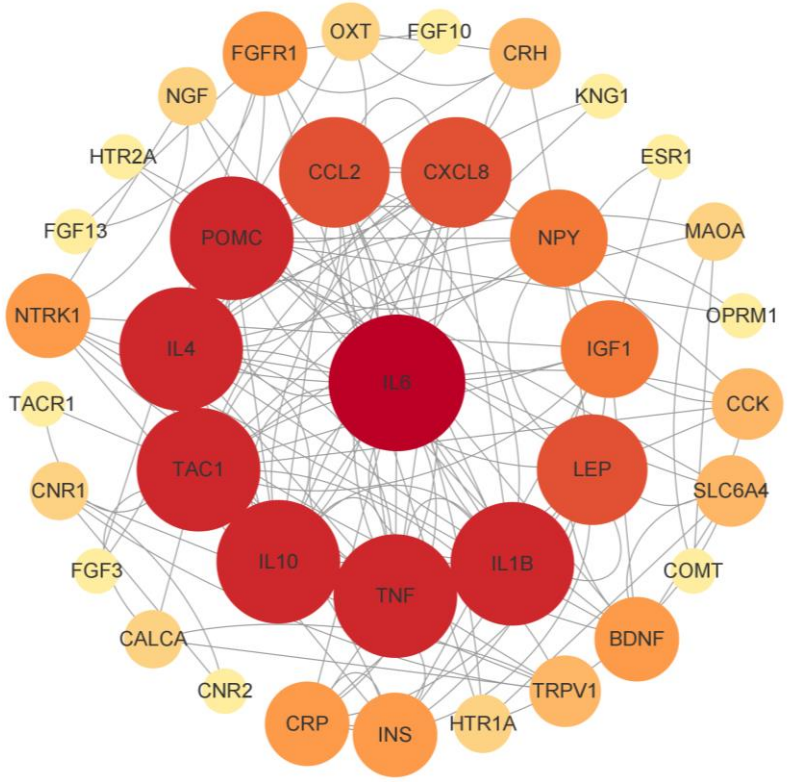

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Figure 2: Figure 2-A shows the various classes of proteins in descending order of their relevance to MTrPs, and Figure 2-B shows the MTrPs-associated protein PPI protein interactions. Data from Genecard

Table 1: MTrPs highly correlated expressed proteins

Name	Full name	Function
COL2A1	Collagen Type II Alpha 1 Chain	Influence the structure and stability of MTrPs
COMT	Catechol-O-Methyltransferase	Affects MTrPs sensitivity and pain onset
MAOA	Monoamine Oxidase A	Causes the onset and exacerbation of myofascial pain
PREP	Prolyl Endopeptidase	Affects myofascial pain perception and sensitivity
CALCA	Calcitonin Related Polypeptide Alpha	Influence the inflammatory response of myofascia and the development of trigger point pain
HTR1A	5-Hydroxytryptamine Receptor 1A	Inhibits C-fiber activity and reduces pain perception and sensitivity at MTrPs
TAC1	Tachykinin Precursor 1	Mediating the release of inflammatory mediators in muscle and tendon tissue to influence pain sensitivity in the MTrPs region
IL10	Interleukin 10	Promotes repair and regeneration of muscle tissue and improves tissue damage and repair in the MTrPs area
BDNF	Brain Derived Neurotrophic Factor	Promotes neuronal growth and synapse formation, improves neuronal function and protects neurons
TNF	Tumor Necrosis Factor	Promotes infiltration of inflammatory cells and activation of fibroblasts
P2RX3	Purinergic Receptor P2X 3	Modulates neuronal excitability, enhances pain transmission and promotes inflammatory response
EPHB1	EPH Receptor B1	Regulates the growth and development of myofascial tissue and participates in the formation and functional regulation of neuronal networks
TNXB	Tenascin XB	Extracellular matrix construction and cell adhesion in myofascial tissue

4.5.1 Structural protein

Structural proteins play a crucial role in maintaining stability of cell and tissue structures, providing morphological stability and support. These proteins typically possess a relatively stable three-dimensional structure and are involved in forming complex structures, such as the nucleus, cytoplasm, cell membrane, and organelles. Examples of structural proteins include myofibrillar proteins, collagen, and skeletal proteins. COL2A1 is a gene that encodes the α1 chain of type II collagen, a connective tissue protein that plays supportive and protective roles mainly in connective tissues like cartilage, vitreous, and viscera [51]. Abnormal expression of type II collagen at the joint site can induce degenerative disease of the articular cartilage and trigger MTrPs located around the joint [52]. Moreover, several studies have indicated that disruption of COL2A1 during type II collagen assembly can accelerate damage to joint tissues and induce production of MTrPs [53].

4.5.2 Zymoprotein

Enzyme proteins catalyze biological reactions and can accelerate such reactions, including digestive, metabolic, and transport enzymes. The structure and function of enzyme proteins are influenced by various factors, such as temperature, pH, and ionic strength, which can affect the plasticity of neurons and lead to overtransmission of pain signals, resulting in chronic pain in MTrPs.

Catechol-O-methyltransferase (COMT) is an enzyme that primarily catalyzes the degradation of dopamine into 3,4-dihydroxyphenylacetic acid (DOPAC) in the brain and other tissues, thereby reducing neurotransmitter concentrations and biological reaction products [54]. The expression of the COMT gene variant has been found to affect the degree of chronic pain [55,56]. In 2020, Xu et al. [57] validated further that variants in COMT lead to alterations in pain sensitivity.

Prolyl endopeptidase (PREP) is a pain sensitivity-related protein that functions mainly in the central nervous system [58]. PREP degrades various neuropeptides associated with pain, such as norepinephrine, oxacrine, and hormone-releasing hormone, affecting the modulation of neurons by these neuropeptides and facilitating or inhibiting the transmission of pain signals [59]. Additionally, PREP is highly specific and accurate for chronic pain and can serve as a biomarker [60].

Monoamine oxidase A (MAOA), which is primarily involved in regulating the metabolism of several neurotransmitters, including norepinephrine, serotonin, and dopamine [61], may be associated with cortical pain [62]. However, the relationship between MAOA and pain in MTrPs is complex, and its specific mechanisms require further investigation.

4.5.3 Regulatory protein

Regulatory proteins play a significant role in regulating gene expression and biochemical responses in cells, leading to the development and maintenance of pain. In the pain sensory pathway, regulatory proteins modulate neuronal excitability or mediate pain messaging, influencing pain perception. These proteins are produced in local tissues and secreted by inflammatory cells, contributing to pain onset.

CALCA is a protein that encodes the calcitonin gene, also known as procalcitonin gene. The degradation of CALCA has been shown to relieve pain [63]. CALCA produces calcitonin-related peptides (CGRP), increasing sensitivity to painful stimuli and modulating musculoskeletal pain through peripheral and central nervous system actions [64-66].

The HTR1A gene encodes 5-hydroxytryptamine 1A receptors, which play an important role in pain regulation. These receptors are widely distributed in regions associated with pain in the central nervous system, such as the posterior horn of the spinal cord, the thalamus, and the gray matter [67]. HTR1A receptors modulate pain perception thresholds and can reduce pain perception. Antagonizing these receptors may increase pain responses and exacerbate pain perception [68,69].

The TAC1 (tachykinin 1) gene encodes substance P, a neuropeptide that enhances pain signal transmission and perception, promotes pain production, and plays an important role in pain transmission and perception [70]. Substance P facilitates the transmission of pain signals in the posterior horn of the spinal cord, aggravating pain perception [71,72]. deletion of the Tac1 gene product may trigger a broader cellular response to compensate for the absence of an important component of the nociceptive pain transmission system [73].

4.5.4 Immunoprotein

Immunoproteins play multiple roles in pain. Production and release of immunoglobulins can impact the transmission and processing of pain signals, while certain types of immunoglobulins are believed to be analgesic. Immunoglobulin applications have been used in pain treatments, such as the use of monoclonal antibodies against certain pain receptors to reduce or block pain signaling.

Interleukin-10 (IL-10) has anti-inflammatory and immunomodulatory effects, which play an important role in reducing or eliminating inflammation-induced pain. [74] IL-10 inhibits the production of multiple cytokines and immune cells during the inflammatory response, reducing nociceptive sensitivity and decreasing pain threshold [75,76].

The use of BDNF, a brain-derived neurotrophic factor that plays a crucial role in neuronal survival, differentiation, and growth and development, as a pain-related biomarker is significant. A negative correlation between BDNF and pain pressure thresholds in patients with fibromyalgia has been observed by Zanette et al. [77]. Deitos et al. [78] found elevated BDNF and TNF-αlevels in chronic widespread pain compared to other chronic conditions such as osteoarthritis and endometriosis, but without significant structural pathology. A recent study showed that higher serum levels of BDNF were associated with lower inhibition of intracortical motor cortex in MPS patients compared to healthy populations, suggesting the potential use of BDNF as a substitute for cortical de-inhibition in MPS [78].

4.5.5 Transporter protein

Transporter proteins are proteins that help transport substances within a cell by binding to molecules, transporting them through transmembrane or plasma membrane channels from inside or outside the cell. When tissues experience inflammation or injury, relevant channels activate, causing ions to flow into neurons and excite them, resulting in pain signaling.

P2RX3 is an ion channel receptor primarily found in sensory neuron terminals and the central nervous system. It responds to changes in extracellular ATP concentrations by opening or closing the channel to regulate ion entry and exit, transmitting pain signals [79]. Pain responses to thermal, chemical, and mechanical stimuli were significantly reduced in P2RX3 knockout mice [80]. Specific P2RX3 antagonists have been shown to effectively reduce pain levels in some pain models [81].

EphB1 is a tyrosine kinase receptor protein encoded by the EphB1 gene that acts as a cell surface receptor, binding with ligands to activate tyrosine kinase activity through the transmembrane region, triggering downstream signaling pathways. Researchers found that EphB1 expression was elevated in biopsies from MPS patients' MTrPs sites of the oblique muscle, and p-EphB1 levels were significantly correlated with pain intensity [82].

TNXB is a non-collagenous protein present in connective tissue and vascular walls, playing roles in regulating collagen fibril formation and structure, interacting with other connective tissue proteins, and functionally regulating the vascular wall, tissue regeneration, and tumorigenesis. Huijing et al [83] found that TNX deficiency altered myotransmitter pathway properties in tenascin-X knockout mice, directly affecting muscle function. Mutant TNXB expression leads to a range of pain according to another study [84].

5. Conclusions and Research Prospects

The theory of MTrPs originates from recent Western medicine and is mostly used in the management related to pain problems, but for its diagnostic method the diagnosis is still based on the subjective feeling of the patient, supplemented by objective examination. Reference charts and physical examinations of MTrPs and MPS are an intuitive way for physicians to understand the sensation and degree of pain from the patient's perspective and thus better individualize treatment. It also does not require the use of overly expensive instruments or equipment, making it less costly and more popular in areas where medical resources are scarce. However, pain perception is a subjective feeling, and without extensive experience and expertise, physicians are prone to subjective misdiagnosis, resulting in a high rate of misdiagnosis of pain. And nowadays, since there is no unified evaluation standard for diagnosis of MTrPs, different doctors often have different diagnoses for the same kind of pain, which lacks standardization. Therefore, having only reference charts and physical examinations is more detrimental than beneficial to the development of the discipline, which cannot become a standardized, systematic, and reproducible discipline.

Diverse ultrasound imaging techniques provide physicians with visualized and diversified diagnostic tools for MTrPs, with the advantages of precise localization, non-invasiveness, immediate feedback, and good reproducibility. However, the diagnostic criteria for MTrPs imaging in the literature are based on single or multiple high signals at painful muscle fibers, and not much research has been conducted on the differential diagnosis of conditions that present similarly to MTrPs under ultrasound imaging, such as muscle inflammation and ligament injury. At the same time there are other shortcomings: the high technical requirements of the operator, the influence of the patient's body size, muscle density, and fat content, and other factors.

As an auxiliary examination, electromyography (EMG) can help physicians evaluate muscle function and treatment efficacy to a certain extent. EMG offers the advantages of being simple to operate, high sensitivity, and rapid response. However, the lack of standardization in diagnostic criteria for MTrPs makes it difficult for physicians to determine the cause of abnormal EMG responses and differentiate them from other muscle abnormalities. In most studies, abnormal EMG responses were found in the site with MTrPs compared to the normal site, but the cause of EMG abnormalities remains unclear. Additionally, EMG has limitations, such as susceptibility to interference, poor localization ability, and lack of visual representation

Protein markers are an emerging diagnostic tool that can assist in the diagnosis of myofascial trigger points by detecting specific protein levels in patients. Compared to ultrasound and electromyography, protein markers have several advantages such as easy detection, non-invasiveness, high sensitivity, and comprehensive analysis. However, current research on protein markers of MTrPs is still in the preliminary stage, and the correlation between specifically expressed proteins and highly expressed proteins is insufficient to help identify MTrPs specifically. Highly expressed proteins similar to other inflammatory and painful diseases can only identify proteins relating to the clinical manifestations of MTrPs, which cannot explain the mechanism of MTrPs production accurately. Protein markers also have the following limitations: a) They are costly and time-consuming to detect, and not yet widely used in some areas; b) Although protein markers can diagnose myofascial trigger points, their ability to predict risk requires further research and validation.

Objective diagnosis techniques such as ultrasound, electromyography, biomarkers, and other objective manifestations have many advantages, including high accuracy, repeatability, fast diagnosis, reduced patient pain, and simplified treatment. These techniques enable physicians to further clarify the cause and severity of pain through multiple tests, thereby improving the accuracy and reliability of the diagnosis. In combination with the patient's subjective response, objective diagnosis can simplify the treatment process, leading to faster analysis of pain, development of a more targeted treatment plan, and lessened patient suffering. However, objective diagnosis requires a high degree of professionalism in the use of expensive equipment and technology. Additionally, objectifying certain pains is challenging since it requires combining subjective and objective measures. Results from objective diagnosis require consideration of the patient's medical history and clinician's professional knowledge since a lack of comprehensive analysis can mislead the diagnosis.

Currently, there is no standardized process-based diagnostic procedure for physical examination or objective diagnostic markers. However, the authors believe that future directions for diagnosing MTrPs should include the following:

1) A standardized and repeatable diagnostic process is necessary for the effective diagnosis of MTrPs. This requires subjective diagnosis during consultation based on patients' descriptions and clinicians' preliminary diagnoses, followed by objective examinations to confirm the point of occurrence and cause of MTrPs. To ensure a more targeted and efficient treatment plan, biomarkers as well as patients' chief complaints and clinician expertise should be taken into account.

2) Objective diagnosis: As medical technology continues to advance, it is imperative to incorporate additional methods for objectively assessing MTrPs. For instance, UR techniques can precisely locate the site of MTrPs leading to a significant improvement in diagnostic accuracy.

3) Discovery and application of biomarkers: Alterations in biomarkers have the potential to anticipate or indicate disease

conditions. In-depth investigation and analysis of biomarkers can facilitate the establishment of precise diagnostic indicators for pain, ultimately resulting in swift and precise pain diagnosis.

4) Research and application of transcriptomics: Comparative analysis of gene expression patterns between healthy tissues and MTrPs, identifying differentially expressed genes, and scrutinizing their regulatory networks can offer valuable insights into the underlying mechanisms of MTrPs, thereby establishing a crucial conceptual framework for diagnostic, therapeutic, and pharmacological interventions.

5) Research and application of metabolomics: Metabolomics offers insights into variations in metabolite levels within an organism at a given time or under specific circumstances, providing vital data for the early diagnosis, treatment, and prognostic assessment of MTrPs.

6) Intelligent auxiliary diagnosis: Owing to the constant advancement of artificial intelligence technology, intelligent auxiliary diagnosis is emerging as a prospective approach for pain diagnosis. By harnessing machine learning, big data analytics, and other cutting-edge technologies, the nature and intensity of pain can be rapidly and accurately ascertained through extensive data analysis and comparison.

7) Development of comprehensive treatment plan: Effective pain management necessitates a comprehensive approach that takes into account diverse factors such as pain classification, patient characteristics, physical condition, and more. Moving forward, tailored treatment plans will become more prevalent for distinct pain syndromes, resulting in enhanced therapeutic outcomes.

In conclusion, the future development of MTrPs diagnosis will pay more attention to objectivity, standardization and intelligence, and will integrate a variety of technical means, aiming to improve diagnostic accuracy and therapeutic effectiveness.

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