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Research Progress on the Application of 'Tou San Xue' Zhigu Bone Puncturing Needling for the Treatment of Non-specific Low Back Pain

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Abstract: ***Nonspecific low back pain (NLBP) is a high-incidence condition in clinical orthopedics, rehabilitation, and acupuncture departments, accounting for 90%-95% of all low back pain patients, with an unclear etiology. After excluding specific spinal diseases and radicular pain, it is characterized by pain in the lumbar and sacroiliac regions as the core manifestation. Some patients may develop a chronic course, accompanied by lumbar stiffness and limited mobility, severely affecting daily work and quality of life [1]. According to relevant data, the annual prevalence of NLBP in China is 20.88%-29.88% [2]. The lifetime prevalence of NLBP is 40%-70%; the proportion of middle-aged patients seeking medical attention is higher than that of younger patients [3]. Current research proves that clinical treatment primarily uses exercise therapy as the main rehabilitation method [4-6]. Acupuncture therapies: local acupuncture, fire needle, electroacupuncture, etc., mostly focus on local lumbar and back acupoints. Although they can relieve pain by dredging local meridians, their intervention is insufficient for low back pain caused by abnormal central nervous system regulation and overall mechanical imbalance. The guideline clinical construction process and experience summarization are slow, and the progress of diagnostic scale research needs further exploration [7]. NLBP affects patients' physical and mental health, quality of life, and social activities, so exploring safer, more effective, economical, and convenient treatment methods for this disease is a focus of discussion in the medical field. Although the term "nonspecific low back pain" is not directly recorded in ancient medical texts, it belongs to the categories of "low back pain" and "bi syndrome". Analyzing the current research status of modern medicine on the TCM disease differentiation distribution of NLBP and the patient volume in our hospital's outpatient department, the study includes patients who meet the TCM disease differentiation of "low back pain" after excluding factors [8]. The bone-reaching needle technique is a characteristic TCM applicable technology proposed by Dr. Zou Dehui, which is a new type of acupuncture technique with "needle tip reaching the bone" or "needle body touching the bone" as the core operation.***

Keywords: Non-specific low back pain, Low back pain, Acupuncture, Zhigu Bone Puncturing Needling**.**

1. Overview of Nonspecific Low Back Pain

Nonspecific low back pain (NLBP) refers to low back pain with an unclear etiology, excluding specific spinal diseases and radicular pain, and is a type of disease primarily manifested as pain in the lumbar and sacroiliac regions [9]. Among these, low back pain is closely related to nonspecific low back pain [10]. Currently, the selection of acupoints for acupuncture treatment of NLDP mostly concentrates on local lumbar and back acupoints (such as Shenshu BL23, Dachangshu BL25, Weizhong BL40). Although it can relieve pain by dredging local meridians, its intervention is insufficient for low back pain caused by abnormal central nervous system regulation and overall mechanical imbalance. Precisely because a standardized treatment system has not been formed, various treatment methods have limitations [11]. Therefore, finding a new type of acupuncture method is crucial. The bone-reaching needle technique emphasizes respiratory guidance, movement to the affected area, intention to the affected area, and qi to the affected area, showing significant efficacy for NLBP caused by factors such as mental state, local muscles, tendons, ligaments, and respiratory abnormalities [12].

2. Modern Medical Understanding of Nonspecific Low Back Pain (NLBP)

2.1 Physiological Structure of the Lower Back

The lumbar spine is composed of five individual bones, each with complex structures including vertebral body, spinous process, transverse process, vertebral foramen, and intervertebral foramen. These structures collectively give the lumbar spine important functions of support, stability, and protection of the spinal cord and nerves.

2.2 Epidemiological Study of Nonspecific Low Back Pain (NLBP)

Statistically, NLBP can lead to disability, with approximately 11-12% of the population becoming disabled and 23% progressing to chronic low back pain [13]. Moreover, 84% experience low back pain in their lifetime, with chronic low back pain ranking among the top three and top five in terms of morbidity and disability rates for all diseases, respectively [14]. Furthermore, NLBP is a symptom that can occur across all age groups, with adolescents having a significantly lower incidence of NLBP than middle-aged and elderly patients [15]. The high incidence and disability rates of NLBP impose a heavy economic burden on society. According to European surveys, the average annual cost per person in European countries is 1322 euros, and the cost shows a linear and continuous upward trend [16]. Chinese research indicates that medical expenses for NLBP also increase due to its recurrent nature and poor prognosis [17]. NLBP patients, due to long-term recurrent pain episodes, often require the help of painkillers, and the abuse of painkillers can further lead to symptoms developing into chronic nonspecific low back pain [18].

2.3 Etiology and Pathogenesis of Nonspecific Low Back Pain (NLBP)

Currently, the pathogenesis of NLBP is not entirely clear, with studies suggesting its etiology involves multiple levels and sites including biomedical, social-behavioral, and psychological states for analysis. Therefore, after reviewing the literature, it is summarized from the following aspects:

1) Dynamic Characteristics of Brain Functional Networks in NLBP Patients

Changes in brain structure and functional connectivity are evident in NLBP patients. Research has found that NLBP patients have increased thickness in the ventrolateral prefrontal cortex (VLPFC), while the cortical thickness of the left anterior cingulate cortex (ACC) is reduced, and pain intensity is positively correlated with its thickness [19]. In terms of functional connectivity, the degree of functional linkage between higher-order cognitive networks (such as the frontoparietal network FPN and dorsal attention network DAN) and lower-order sensorimotor, auditory, and visual networks decreases in NLBP patients. The research of Jia Runhui et al. [20] further points out that the whole-brain CNE of low back pain patients is significantly lower than that of the healthy control group, and brain regions with reduced functional flexibility are mainly concentrated in the frontal cortex, temporal cortex, subcortical areas, and occipital cortex.

Chronic low back pain patients exhibit thalamocortical dysrhythmia during pain exacerbation, with increased activity frequency in the VL/VPL nuclei, PoCG, and the default mode network (DMN) [21]. The cerebellum also plays an important role in low back pain-related changes, with alterations in its functional connectivity involving motor control and cognition [22]. Notably, the fluctuating experience of pain is closely related to the activity of specific networks. For example, chronic pain intensity is positively correlated with the activity of the salience network (SN) and local pontine networks, and negatively correlated with the activity of the DMN [23]. Furthermore, the DMN is positively correlated with the patient's pain duration and is regulated by neurofeedback processes [24].

2) Neural Conduction Factors

The neuromuscular system is responsible for maintaining and stabilizing spinal posture, and the central nervous system can regulate and control muscle activity patterns. RUDOLF et al. [25] found that neuromuscular endplates (located at the nerve terminals at the junction of nerves and muscles) are simultaneously innervated by multiple somatic nerve fibers and sympathetic nerve fibers [26]. During an NLBP episode, muscle and fascial spasms trigger MTrPs reactions, transmitting disruptive signals that lead to central nervous system sensitization, resulting in characteristic local pain hypersensitivity and characteristic local twitch responses of MTrPs. This vicious cycle of "spasm-ischemia-pain" can cause abnormal skeletal muscle tension and local biomechanical imbalance [27].

Decreased neural control over lumbar muscles can lead to disturbances in the muscle control system. If the compensatory response of the neuromuscular system persists long-term, it can gradually induce adaptive changes in the central nervous system. As the central nervous system is the core regulator of muscle contraction, changes in its functional state can further affect the normal contraction rhythm, strength, and coordination of muscles throughout the body, leading to an overall imbalance in muscle contraction function [28]. Research indicates that the shear wave velocity and Young's modulus values of bilateral multifidus muscles can evaluate the stiffness and biomechanical imbalance results of the multifidus, and using different detection methods for quantitative analysis of neural conduction has research value [29].

3) Muscle Coordination Factors

Spinal stability requires the maintenance of both vertebral bodies and synergistic muscles [30]. In maintaining lumbar stability, the core muscle groups play a key role and can be further divided into stabilizing muscle groups and mobilizing muscle groups. Stabilizing muscle groups are represented by the multifidus, along with other rotator muscles, diaphragm, transversus abdominis, pelvic floor muscles, etc. These muscle groups primarily serve to stabilize the spinal structure. Mobilizing muscle groups include the erector spinae, psoas major, rectus abdominis, intertransversarii, quadratus lumborum, etc, which together with the stabilizing muscle groups regulate and coordinate the stability and motor performance of the lumbar spine [31].

NLBP patients, due to their lifestyle, have varying degrees of muscle imbalance issues, leading to disuse atrophy or hypertonic spasticity, primarily resulting in spinal instability. The research of Chen Yunxin et al. [32] shows that the representative multifidus muscle plays a crucial role in the stability of the lumbar structure. Contracture of the multifidus can lead to an imbalance in the external balance of the spine, producing some mechanical stimuli that generate pain. Research points out [33] that by assessing muscle contraction strength, motor unit recruitment number, combined with the flexion-relaxation ratio (FRR), flexion-extension ratio (FER), and coordinated contraction rate to judge the coordination degree of lumbar back agonist and antagonist muscles, the functional changes of lumbar muscles can be effectively evaluated. Similarly, core stability training can effectively activate muscles, increase motor unit recruitment numbers, improve the RMS values of the erector spinae and multifidus muscles to varying degrees, and significantly enhance their muscle function [34].

4) Fascia and Ligament Factors

The thoracolumbar fascia of the lower back and lower back ligaments (such as supraspinous ligament, interspinous ligament, iliolumbar ligament, intertransverse ligament, etc.) are closely adjacent anatomically, synergistic functionally, and mutually influential when injured, jointly maintaining lower lumbar fixation: on an anatomical level, the medial edge of the superficial layer of the thoracolumbar fascia fuses with the supraspinous ligament, the deep layer fuses inferiorly with the origin of the iliolumbar ligament, and the middle layer's medial edge tightly combines or interweaves with the

interspinous and intertransverse ligaments, forming a "fascia-ligament-bone" connection network. Ligaments, as passive static stabilizing structures, limit excessive lumbar flexion, extension, and other abnormal movements through their own tension. The thoracolumbar fascia, as a dynamic stabilizing structure, wraps the core muscle groups, transmits muscle force, cushions impact, assists ligaments in dispersing force, and together maintains the physiological curvature and stability of the lumbar spine, while also protecting nerves and soft tissues. Research [35] indicates that releasing the lumbar and abdominal fascia can promote local capillary and lymphatic microcirculation to promote the remodeling of the capillary network, dilute exudative fibrinogen, improve muscle adhesions, and achieve pain relief. After releasing the thoracolumbar fascia, lumbar muscle function is improved. Therefore, treatment needs to address both, improving fascial structure through physical therapy, rehabilitation training, etc., to restore overall lower back stability.

5) Intervertebral Disc Factors

The intervertebral disc is located between adjacent vertebrae, constituting a key structure for spinal movement and load-bearing, composed of three parts: the outer tough annulus fibrosus, the central elastic nucleus pulposus, and the cartilaginous endplates connecting the vertebrae at the upper and lower ends. Physiologically, the intervertebral disc primarily bears weight, transmits mechanical loads, and cushions shocks to the spine from activities like walking and jumping through the elastic deformation of the nucleus pulposus and the tension of the annulus fibrosus, protecting the spinal cord and nerve roots from impact. The anterior and posterior longitudinal ligaments attach and surround the intervertebral disc, jointly maintaining the normal physiological curvature and motor function of the spine. Degenerative changes in the intervertebral disc can cause NLBP. Research has found [36] that Sema3A regulates DRG neuron apoptosis, induces DRG nerve fibers to invade the inner layer of the annulus fibrosus, nucleus pulposus, or endplate, thereby regulating nerve and microvascular innervation. In the process of chronic intervertebral disc disease, the joint space narrows, the physiological curvature of the lumbar spine shows abnormal changes, further compressing the dural sac and spinal cord, causing the annulus fibrosus to thicken and coarsen, increasing the risk of rupture, leading to protrusion of the intervertebral disc nucleus pulposus, and ultimately resulting in lumbar disc herniation.

6) Sacroiliac Joint-Related Factors

Sacroiliac joint-related factors are closely related to NLBP. The anterior sacroiliac ligament and posterior sacroiliac ligament together form a complex ligamentous network. This network enhances the structural integrity of the sacroiliac joint, maintains normal joint mechanical balance, and provides key stability for the junction area between the pelvis and lumbar spine [37]. When this ligamentous network experiences decreased elasticity, laxity, or injury due to strain, degeneration, trauma, etc., it leads to instability of the sacroiliac joint, producing corresponding inflammatory factors. The research of Deng Yuguang et al. [38] proves that inflammatory factors interleukin, tumor necrosis factor (TNF)-α, and interferon (INF)-γ have diagnostic value in nonspecific chronic low back pain.

7) Psychological Factors

NLBP has a long course and recurrent episodes, and patients affected by pain develop anxiety, depression symptoms, lose confidence in the disease, which is also detrimental to treatment. The research of Lu Xuefang et al. [39] proves that negative emotions may be related to the chronicization of pain or a higher degree of disability, and the higher the pain intensity and the more frequent the episodes in low back pain patients, the higher their scores and proportions of pain catastrophizing, depression, and anxiety. Although it is believed that the effectiveness of psychological intervention in low back pain treatment is insufficient and lacks stable psychological rehabilitation opportunities [40]. However, the research of Sun Wenjiang et al. found that the pain intensity and course of NLBP patients have a significant correlation with psychological stress and the degree of social support. Psychological stress and social support rehabilitation are considered important means for pain rehabilitation [41].

2.4 Modern Medical Treatment of Nonspecific Low Back Pain (NLBP)

Research indicates that the etiology of NLBP involves multiple levels and sites including biomedical, social-behavioral, and psychological states. Simultaneously, multidisciplinary collaboration and coordinated diagnosis and treatment from physical, behavioral, and psychological perspectives are needed [42-44]. The most recommended treatment for NLBP is exercise therapy. Exercise therapy is the main method for NSLBP rehabilitation treatment, systematically increasing the strength reserve of the spinal core muscle groups through scientific training and rehabilitation means. This process not only provides a more solid structure for the spine but also needs to simultaneously focus on the stability enhancement of intrinsic muscle groups, ensuring their collaborative efficiency for subtle spinal movements, effectively enhancing spinal stability, optimizing lumbar function, reducing pain perception, and ultimately helping to improve quality of life [45]. Apart from exercise therapy, other therapies include physical factor therapy (thermotherapy and cryotherapy), braces and foot orthotics, rehabilitation therapy, drug therapy: such as muscle relaxants (e.g., eperisone hydrochloride, etc.), antidepressants (but currently there are few related studies), opioid drugs (tramadol, codeine), topical NSAIDs preparations (e.g., flurbiprofen, diclofenac, etc.) [46], and traditional exercise training, which also alleviate symptoms to a certain extent and improve patients' joint range of motion.

3. Traditional Chinese Medicine's Understanding of Nonspecific Low Back Pain (NLBP)

3.1 Disease Name Analysis

There is no disease name for NLBP in TCM; according to its clinical symptoms, it can be classified into the categories of "low back pain," "bi syndrome," "sinew injury disease", etc. in TCM. The earliest record of this disease is in the Yellow

Emperor's Inner Canon, using low back pain as the disease name. The Maiyao Jingwei Lun says: "The waist is the residence of the kidney; if turning and shaking are impossible, the kidney will be exhausted". The Ci Yaotong Lun says: "The hengluo vessel causes people to have low back pain".

3.2 Analysis of Etiology and Pathogenesis

Many physicians believe that the pathogenesis of NLBP mostly involves the liver, spleen, and kidney, deficiency of qi and blood, leading to pain due to lack of nourishment; or external pathogens taking advantage to obstruct, leading to pain due to obstruction [47]. Chao Yuanfang's Zhubing Yuanhou Lun discusses "kidney channel deficiency, invaded by wind-cold," "strain damaging the kidney, movement injuring the channels and collaterals, again invaded by wind-cold, qi and blood striking each other," etc., believing that kidney qi deficiency or strain followed by invasion of external pathogens leads to bi disease. Danxi Xinfa proposes "low back pain is mainly due to damp-heat, kidney deficiency, blood stasis, sprain, and phlegm accumulation," and divides its pathogenesis into two categories: deficiency and excess. Deficiency patterns are often attributed to the kidney, while externally contracted pathogenic factors commonly include wind, cold, and dampness, each with unique pathogenic characteristics, and often intermix during the pathogenic process, forming a pathological state of "wind-cold-dampness evils" combining to cause disease, significantly obstructing the flow of qi and blood in the lumbar channels and collaterals, thereby inducing low back pain. Strain and trauma are important acquired factors leading to low back pain. Both damage the lumbar channels and collaterals, causing internal stasis of blood and obstruction of channels and collaterals, thereby inducing low back pain with the pathogenesis of "obstruction causing pain," which can be specifically divided into two situations: chronic strain and acute trauma. Constitutional insufficiency, aging and physical decline, and sexual overstrain, among other factors, damage kidney essence, causing the lumbar collaterals to lose warmth and nourishment, inducing low back pain with the pathogenesis of "lack of nourishment causing pain."

3.3 TCM Treatment Methods

Mainly consider the treatment methods for low back pain using herbal formulas and acupuncture, organizing representative physicians' ideas in chronological order: Eastern Han period: Zhang Zhongjing's Treatise on Cold Damage and Miscellaneous Diseases sets up six formulas including Mahuang Tang and Ganjiang Lingzhu Tang for six etiologies, laying the foundation for pattern differentiation and formula use; Wei, Jin, Northern and Southern Dynasties period: Xiaopin Fang records Tao's Shenqi Fang and Bixiao Jisheng San, etc. , for treating kidney deficiency type low back pain; Sui and Tang periods: Sun Simiao's Beiji Qianjin Yaofang records formulas for treating low back pain such as Duhuo Jisheng Tang and Duzhong Jiu Fang; Jin and Yuan physicians each had their emphasis: Zhang Congzheng's dampness-expelling method, Liu Wansu and Zhu Danxi based their theories on kidney deficiency, Li Dongyuan discussed low back pain based on the spleen and stomach as the root; Ming Dynasty Zhang Jingyue's Jingyue Quanshu Yaotong details kidney deficiency differentiation types, Li Shizhen's Bencao Gangmu supplements medicinal herbs for low back pain; Qing Dynasty Ye Tianshi et al. created "chronic pain entering the collaterals" using insect drugs, Wang Qingren's Yilin Gaicuo established Shentong Zhuyu Tang, and Yizong Jinjian systematically divides into five types and clarifies formulas and herbs [48]. The Zhenjiu Dacheng from the Ming and Qing periods discusses the types of acupuncture in more detail by differentiation.

4. Elaboration of the Bone-Reaching Needle Technique

The bone-reaching needle technique is characterized by touch reaching the affected area, needle reaching the affected area, intention reaching the affected area, movement reaching the affected area, and qi reaching the affected area. It is a new type of acupuncture therapy that typically selects acupoints at bone edges to treat diseases. This article explores its therapeutic effects by the conceptual framework of the bone-reaching needle technique, starting from researching classical content and modern theories, exploring the connections between acupoints and meridians, periosteum and fascia, galea aponeurotica and superficial/deep cranial periosteum, acupoints and brain regions, and acupoints and periosteum.

4.1 Classical Exploration of the Association Between Acupoint Names and Properties

The acupoint Shenting (GV24) is also known as "Tianting," first seen in Zhenjiu Jiayi Jing. It belongs to the Governor Vessel meridian and is simultaneously the convergence point of the Stomach, Bladder, and Governor Vessel meridians. In TCM theory, the Governor Vessel governs the qi and blood of all yang meridians in the body, the Stomach meridian governs reception and decomposition, and the production of qi and blood, the Bladder meridian governs the exterior of the body and regulates water passage, and the qi and blood of the three yang meridians converge at the Governor Vessel, hence Shenting acupoint possesses the characteristics of these three meridians. When manipulating the Shenting acupoint, it can not only directly dredge the Governor Vessel meridian qi, regulating issues related to the Governor Vessel pathway such as head, face, and mental conditions, but also indirectly harmonize the qi dynamic of the whole body by regulating the qi and blood flow of the three yang meridians, achieving the effects of regulating the spirit to stop pain, and regulating qi and harmonizing blood to stop pain.

The acupoint Baihui (GV20) is also known as "Sanyang Wuhui," first seen in Zhenjiu Jiayi Jing. It belongs to the Governor Vessel meridian and is the convergence point of the Bladder, Gallbladder, Stomach, Small Intestine, Triple Burner meridians and the Governor Vessel. TCM believes that the Baihui acupoint is located at the vertex, being the "meeting of all yang" and the "upper transport of the sea of marrow," related to the Governor Vessel pathway, governing the qi and blood of all yang meridians in the body, and closely connected to the brain and marrow. Manipulating the Baihui acupoint can dredge Governor Vessel meridian qi to raise yang and stop pain, while simultaneously regulating the qi and blood of the five meridians, achieving the effects of regulating meridians to stop pain and awakening the spirit to stop pain.

The acupoint Qiangjian (GV18) is first seen in Zhenjiu Jiayi Jing. It belongs to the Governor Vessel meridian and is an important point for the infusion of Governor Vessel meridian qi between the vertex and the occipital region. Although there are no records of convergence with other meridians, the Governor Vessel runs along the spine, reaching the vertex, and Qiangjian is a key location connecting the brain and spinal cord and the Governor Vessel pathway, a crucial acupoint for regulating the meridian qi of the posterior occipital region and connecting the brain and spine. Manipulating the Qiangjian acupoint primarily achieves the effect of unblocking collaterals to stop pain by dredging the local Governor Vessel meridian qi.

4.2 Characteristics of the Bone-Reaching Needle Technique

The bone-reaching needle technique, under the guidance of TCM theory, achieves the purpose of dredging meridians, harmonizing qi and blood, and balancing sinews and bones by stimulating bones and periosteum.

Dredging Meridians: The bone-reaching needle technique emphasizes the needle tip reaching the bone surface or the needle body advancing close to the bone, directly stimulating the periosteum and deep fascia [49]. The periosteum can connect the internal and external body, infuse and irrigate qi and blood, and sensitively react to disease. Stimulating the periosteum can quickly obtain qi, amplify the propagation effect, and regulate the whole body through meridian conduction. NLBP is considered related to sinews and bones. The bone-reaching needle technique can dredge meridians, regulate yin and yang, regulate meridians to stop pain, and guide meridian qi and blood to balance.

Regulating Spirit and Guiding Qi: The bone-reaching needle technique operation emphasizes “intention reaching the affected area” and “qi reaching the affected area” for both practitioner and patient. Lingshu·Jiuzhen Shier Yuan: “The essence of needling is that when qi arrives, it is effective... meet it or follow it, harmonize it with intention”. The practitioner needs to focus intention on the needle tip, quietly guide and gather qi, lead qi with intention, so that qi reaches the affected area to attack pathogens and eliminate disease; the patient, through focusing intention on the propagation sensation and breath regulation training, guides qi to the affected area, accelerates meridian qi propagation, thereby soothing emotions and accelerating the transfer and elimination of pain. This concept of simultaneous mind-body regulation embodies the importance of “treating the spirit” in TCM [50].

Movement Posture: The bone-reaching needle technique operation emphasizes “movement reaching the affected area”, instructing the patient to perform active or passive movement after needling, while paying attention to the degree of lumbar pain, range of motion in flexion-extension and rotation, or with walking to observe gait, which is a method to enhance efficacy [51]. Research shows that acupuncture can effectively improve the effectiveness for acute nonspecific low back pain, improve patients’ lumbar ROM and total effective rate, and has high safety [52].

5. Modern Research Exploration of the Bone-Reaching Needle Technique

5.1 Anatomical Localization of Acupoints

Shenting acupoint (GV24): Located 0. 5 cun directly above the midpoint of the anterior hairline, corresponding to the anterior part of the frontal bone. Subcutaneously, it corresponds to the frontalis muscle and branches of the ophthalmic division of the trigeminal nerve.

Baihui acupoint (GV20): Located at the intersection of the midline of the vertex and the line connecting the apexes of both ears, corresponding to the middle part of the parietal bone. Subcutaneously, it corresponds to the galea aponeurotica, branches of the parietal branch of the trigeminal nerve, and branches of the greater occipital nerve.

Qiangjian acupoint (GV18): Located 3 cun directly below the Baihui acupoint, corresponding to the junction of the posterior part of the parietal bone and the occipital bone. Subcutaneously, it corresponds to the main trunk of the greater occipital nerve.

5.2 Association Between Acupoint Localization and Brain Functional Network Function

The anatomical region of the Shenting acupoint corresponds to the medial prefrontal cortex. This region has neural fiber connections with core nodes of functionally abnormal networks in low back pain, such as the frontoparietal network (FPN) and default mode network (DMN), including the medial prefrontal cortex (MPFC) and dorsolateral prefrontal cortex (DLPFC). In low back pain patients, DMN connectivity of MPFC and DLPFC decreases, and functional flexibility of the frontal cortex is reduced [53]. Acupuncture at the Shenting acupoint can regulate the subcutaneous nerves of the forehead, indirectly regulating the overall neural electrical activity of the frontal lobe, inhibiting pain signal transmission.

The anatomical region of the Baihui acupoint corresponds to the middle-upper part of the postcentral gyrus of the parietal lobe, which is a core component of the sensorimotor network (SMN) [53]. Stimulation of the Baihui acupoint can directly regulate the sensory area of the lumbar back in the postcentral gyrus through subcutaneous nerves, thereby reducing pain.

The anatomical region of the Qiangjian acupoint corresponds to the posterior parietal lobe and anterior occipital lobe. The posterior parietal lobe is adjacent to the core region of the dorsal attention network (DAN). The DAN in low back pain patients affects the regulation of attention on sensory signals; simultaneously, the functional flexibility of the occipital cortex is also reduced. Acupuncture at the Qiangjian acupoint can act on the greater occipital nerve to regulate the DAN, regulate the neural activity of the occipital lobe, and can relieve radiating low back pain.

5.3 Periosteal Effect

1) The Structural Characteristics of Periosteum are the Basis for Effect Initiation

The structural characteristics of periosteum are the foundation for all subsequent effects, with specific associations as follows: A large number of mechanosensitive pressure receptors are distributed on periosteal fibroblasts, which can not only directly receive stimuli such as pressure, stretching, and vibration brought by acupuncture and respond quickly but can also activate intercellular information communication, serving as the first signal-receiving unit for "acupuncture effect initiation, integration, transduction, and cascade amplification, " providing initial signals for subsequent bioelectrical and neural responses [54]. Simultaneously, periosteum, as a connective tissue fluid crystal system, possesses "good bioelectrical conductivity" [55]. This is a key prerequisite for the subsequent "conversion of mechanical energy into bioelectric current" and "long-distance transmission of bioelectric current". When the needle body and connective tissue friction and winding establish a mechanical coupling relationship, this characteristic also provides the condition basis for the effect of twisting and rotating needle manipulation; lacking this characteristic, the bioelectrical effect cannot form and conduct. Periosteal tissue is rich in polymodal receptors (PMR) and nerve endings, serving as a bridge connecting "local stimulation" and "neural conduction". When the needle reaches the bone, it creates strong pressure on the stimulated area, generating "shock waves" or piezoelectric effects, and these stimuli need to be converted into neural signals through PMR and nerve endings to be further transmitted to the.

2) Bioelectrical Biomechanical Effects are the Core Link for Signal Conversion and Transmission

Bioelectrical biomechanical effects (potential difference, local current, piezoelectric effect, etc.), with bone "a volume conductor containing charged particles," after the periosteum is stimulated by acupuncture, a potential difference will form locally, affecting the displacement of charged particles and generating local currents. This current can, on one hand, directly affect the cerebral cortex composed of neuronal cell bodies, producing widespread physiological effects; on the other hand, it also provides the electrical signal basis for the generation of the piezoelectric effect. Relying on the "good bioelectrical conductivity" of periosteum, its process of "mechanical coupling → effect → conversion of mechanical energy into bioelectric current" is the main source of the piezoelectric effect: twisting and rotating needle manipulation converts mechanical energy into bioelectric current, not only inducing local piezoelectric effects but also transmitting signals throughout the body through "long-distance transmission, " providing a "signal carrier" for neural conduction [56].

3) Neural Conduction is the Key Pathway for Achieving Analgesic Efficacy

Neural conduction is based on periosteal structural response and bioelectrical effects. The stimulation generated by the piezoelectric effect can directly excite PMRs in the periosteum, thereby accelerating signal conduction in unmyelinated C fibers and myelinated Aδ fibers—these two types of fibers are the "channels" transmitting local signals to the central nervous system [57]. The signals conducted by nerve fibers, upon reaching themain centre, activate the "pain signal processing system," by inhibiting "excessive excitation of nociceptive neurons," ultimately producing and realizing the "analgesic effect, "as described above in the narrate ofn terms of the functional structure of the cerebral cortex.

6. Research Significance

In conclusion, the 'Tou San Xue' Zhigu Bone Puncturing Needling technique presents a highly innovative and theoretically sound approach to the treatment of non-specific low back pain. By shifting the therapeutic focus from the peripheral site of pain to the central nervous system, it addresses the complex neurophysiological and biomechanical dysfunctions that underpin this challenging condition. While further high-quality research is imperative to substantiate its efficacy, this method holds considerable promise as a powerful new tool in the quest to provide lasting relief for the millions of individuals suffering from chronic low back pain.

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