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The Mechanism of Action and Clinical Research Progress of Intradermal Heat Needle Therapy in Orthopedic Diseases

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Abstract: *Intradermal heat needle therapy, as a conservative treatment approach and an alternative to surgical intervention, has gained significant recognition in the research community since 2018 for its demonstrated efficacy in improving cognitive functions. Both domestically and internationally, there has been a notable increase in research outcomes related to the understanding and application of intradermal heat needle therapy in orthopedic diseases. The integration of intradermal heat needle therapy with various treatment modalities has also become increasingly diverse. This review synthesizes the clinical applications and mechanisms of action of intradermal heat needle therapy in orthopedics, highlights the deficiencies in existing research, and proposes corresponding solutions*

Keywords: *intradermal heat needle therapy; Mechanism of Action; Clinical Progress; Review*

1. Introduction

Intradermal heat needle therapy is a novel acupuncture tool that combines traditional moxibustion with modern technology[1]. Compared to traditional moxibustion, intradermal heat needle have overcome the issue of non-adjustable temperatures. By utilizing an electric heating wire within the needle core, precise temperature control is achieved, allowing the temperature in the needling area to be adjusted between 40 and 60 degrees Celsius. The needle tip generates heat while the shaft remains at room temperature, enabling denser needle placement and more effective heat transfer to the affected area. This promotes local blood circulation and accelerates tissue metabolism, achieving anti-inflammatory and analgesic effects. intradermal heat needle have demonstrated significant clinical efficacy in treating pain caused by acute and chronic soft tissue injuries and bone and joint pain disorders. Furthermore, due to their high safety, ease of operation, and long-lasting effects, intradermal heat needle hold broad prospects for clinical application[2, 3].

Intradermal heat needle therapy, a traditional Chinese acupuncture treatment, stimulates the body's meridians and acupoints to promote local blood circulation and metabolism, thereby alleviating pain and restoring the function of damaged areas. Research by Zou Qiping et al.[2, 3]indicates that intradermal heat needle is primarily applied to conditions such as Lumbar Disc Herniation (LDH), Ankylosing Spondylitis (AS), periarthritis of the shoulder, and Knee Osteoarthritis (KOA), affecting muscles, soft tissues, and bones. They have demonstrated therapeutic advantages in treating these conditions and are widely used in clinical practice. Especially in recent years, due to their side effect-free nature and significant therapeutic effects, intradermal heat needle have become one of the important means for treating bone and joint diseases, suitable for clinical use in many county and even city-level hospitals.

Intradermal heat needle can be used to treat various bone and joint diseases, such as fractures, periarthritis of the shoulder, osteoarthritis, Lumbar Disc Herniation (LDH), spinal diseases, Ankylosing Spondylitis (AS), and so on. Among these, the effects of intradermal heat needle on fractures and soft tissue injuries are more significant than those of traditional acupuncture therapies. Therefore, this study provides a detailed description of the mechanisms of action of intradermal heat needle and the progress in clinical research.

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2. Mechanism of Action

Intradermal heat needle therapy affects disease treatment by targeting biomarkers like β-catenin and IL-6, reducing inflammation, regulating collagen expression, and influencing MMPs, TNF-α, VEGF, RANKL, and RANK levels, as detailed in this article.

2.1 Intradermal heat needle inhibit the generation of inflammatory factors.

Zhang Zhihui et al. [5] found that intradermal heat needle therapy, by reducing neuronal excitability and muscle tension, can modulate inflammatory responses, specifically by inhibiting IL-6 expression to delay Ankylosing Spondylitis (AS) progression.

Sun Zhuoli et al.[6]conducted a study combining the use of intradermal heat needle, Sanbi Tang, and needle knife therapy for the treatment of periarthritis of the shoulder. The study found that this method effectively reduced the levels of inflammatory factors, alleviated patient shoulder joint pain, and promoted the recovery of joint function.

Chen Zhili et al. [6] found that combining thermal acupuncture with polarized light therapy significantly reduced MMP-3 and MMP-7 levels in LDH patients. This treatment reduced inflammation by easing nerve and blood vessel compression, decreasing nerve stimulation, and alleviating muscle spasms, with the experimental group showing lower MMP levels than the control group.

Liu Wu et al. [6] found that combining intradermal heat needles with extracorporeal shock wave therapy was more effective in reducing serum levels of SP and TNF-α than shock wave therapy alone for lumbar and back myofascial inflammation. This combined approach also promoted inflammation resolution. Additionally, Wang Cuiping et al.[9] reported that adding intradermal heat needles to anti-rheumatic drug treatment significantly lowered inflammatory markers like CRP and ESR in AS patients.

2.2 Other mechanisms of action:

(1) Intradermal heat needles downregulate the expression of wnt1 and β-catenin in the annulus fibrosus and upregulate the expression of Axin. Zhuang Jin'gang et al.[10] found that intradermal heat needles treat lumbar degenerative diseases by regulating the expression levels of factors related to the β-catenin signaling pathway. However, this mechanism still needs further exploration.

(2) Intradermal heat needles can upregulate the expression of type I collagen and downregulate the expression of matrix metalloproteinase 3 and osteopontin. Zhu Shiqiang et al.can repair the microstructure of subchondral bone by increasing the expression of type I collagen and reducing the expression of matrix metalloproteinase 3 and osteopontin.

(3)Intradermal heat needles can reduce MMP-9 and VEGF levels. Mei Qiu'an et al.[11] found that intradermal heat needles can reduce MMP-9 and VEGF levels, and through improving the local nerve pain threshold of the knee joint, eliminating inflammatory factors, dredging meridians, and relieving muscle tension, they have an excellent analgesic effect.

(4) Intradermal heat needles reduce serum ESR, CRP, and RF levels. Hou Haikon et al. [13] treated AS patients with warm yang and intradermal heat needle therapy. After treatment, the levels of serum ESR, CRP, and RF were significantly reduced, and the experimental group significantly reduced the effects on serum ESR, CRP, and RF levels.

(5) Zhang Song et al.[14] demonstrated that intradermal heat needle therapy, along with needle knife treatment, effectively lowers serum levels of substance P (SP) and 5-hydroxytryptamine (5-HT), particularly benefiting pilots by reducing these markers, improving waist mobility, and strengthening joint function, thus enhancing treatment outcomes.

(6) Zhang Zhi et al.[15]found that combining intradermal heat needle therapy with traditional Chinese medicine steaming for KOA treatment significantly reduced IL-1β, IL-6, and MMP-3 levels, particularly in the treatment group, indicating the efficacy of this combined approach in decreasing these inflammatory markers.

(7) He Xiaoyan et al.[16] found that intradermal heat needle therapy can increase OPG expression and decrease RANKL and RANK levels in rabbit KOA, thus inhibiting osteoclast activity and

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preventing disease progression.

(8) Intradermal heat needles can inhibit the expression of Caspase-3 and Caspase-9 Wan Chao et al.[17] found that intradermal heat needle therapy showed significant efficacy in a rat model of KOA, possibly by reducing the expression of apoptosis-related proteases Caspase-3 and Caspase-9, thereby reducing apoptosis of chondrocytes caused by injury and playing an important guiding role in the repair of KOA rats' injuries.

Intradermal heat needles can affect a variety of mechanisms of action, but further verification is needed in some mechanisms of action. In addition, there are many gaps in the mechanisms of action of intradermal heat needles, and it is recommended that future research can fill in this part of the mechanism of action.

3. Clinical Application

3.1 Intradermal heat needle treatment for cervical spondylosis

The occurrence of spondylosis is due to degenerative changes in the intervertebral discs of the neck, which break the dynamic and static balance between the soft tissues and vertebrae of the neck, leading to pathological changes such as disc herniation, calcification of ligaments, and hyperplasia of vertebral bone. These changes may stimulate or compress the cervical nerve roots, sympathetic nerves, spinal cord, and blood vessels, resulting in a series of related symptoms and signs that form a syndrome[18]. Dong Xianghui et al.[19] found that intradermal heat needles were effective in treating cervicothoracic syndrome, especially when needling the fascial and muscle layers. Duan Chao et al.[20] believed that intradermal heat needles and electroacupuncture were both effective for cervical spondylosis, but intradermal heat needles were superior to electroacupuncture. Wang Minghua[21] found that the efficacy of intradermal heat needles was higher than that of Western medicine. Sun Zhuolai et al.[22]found that combining Sanbi Tang, intradermal heat needles, and "T"-type needle knife technique effectively treats cervical spondylosis radiculopathy, enhancing therapeutic effects, relieving pain quickly, and improving cervical spine function, making intradermal heat needles indispensable in treatment.

3.2 Intradermal heat needles or combined with other methods for the treatment of periarthritis of the shoulder

Periarthritis of the shoulder, or frozen shoulder, is a musculoskeletal condition causing intermittent pain near the deltoid insertion, often disrupting sleep and limiting shoulder joint movements like abduction and rotation[23]. Clinical manifestations, including pain around the shoulder joint and limitations in active and passive movements[24], cause inconvenience to the patient's life. Studies have shown that the incidence of periarthritis of the shoulder in the population is 2% to 5%[25], and it is on the rise[26]. Tian Huanghua et al.[27] found that the combination of intradermal heat needles and dexmedetomidine had excellent anesthetic and analgesic effects during spinal anesthesia surgery, which can effectively improve the clinical anesthetic effect. Fu Biaobin et al.[28] used intradermal heat needle release technique to treat periarthritis of the shoulder and effectively alleviated patient pain. Zhang Yingying et al.[29]found that intradermal heat needle therapy was more effective than moxibustion for frozen shoulder, needing fewer sessions, causing less pain, and was highly recognized by patients.Cao Yue et al.[30] used intradermal heat needle therapy combined with continuous passive motion to treat periarthritis of the shoulder, and the results showed that intradermal heat needles could reduce patient pain, improve shoulder joint function, and restore shoulder joint movement. Ren Zhengqiang et al.[31] used intradermal heat needles combined with needle loosening treatment, and patients generally recognized and continued to promote in clinical practice. Zeng Mingjun[32] treated frozen shoulder under the guidance of musculoskeletal ultrasound, solving the subjectivity and uncertainty in conventional treatment. Single treatment is not as effective as combined treatment with intradermal heat needles. Therefore, this study recommends combined treatment with intradermal heat needles and other therapies for periarthritis of the shoulder.

3.3 Intradermal heat needles combined with other methods for the treatment of knee osteoarthritis

KOA is a common chronic joint disease characterized by degenerative changes in articular cartilage and secondary osteophyte formation, eventually leading to joint deformity and loss of function[33, 34].

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Li Jien[35] used intradermal heat needle Release technique to observe KOA and found that intradermal heat needles could effectively relieve discomfort symptoms, control the further development of the disease, and reduce the incidence rate, without affecting various indicators of vital signs. The methods of treating KOA with intradermal heat needles combined with other methods are varied, and all cases show the efficacy of KOA treatment. For instance, Zhang Zhi et al.[15] used intradermal heat needles in conjunction with traditional Chinese medicine steaming, Mei Qiu'an et al.[12]integrated intradermal heat needles with Huoxue Qi Bi drink, and Wan Chao et al.[36] employed intradermal heat needles along with joint cavity irrigation.These methods can improve the range of motion of the patient's knee joint, effectively reduce knee joint pain, and have a good therapeutic effect on KOA. Therefore, the use of intradermal heat needle combined treatment methods is feasible and effective.

3.4 Intradermal heat needle treatment for ankylosing spondylitis

AS is a chronic inflammatory autoimmune disease mainly involving the sacroiliac joints and spinal joints, accompanied by severe deformation, bending, and rigidity of the spinal joints. It can also cause varying degrees of bone loss and bone destruction in patients, leading to osteoporosis. If not treated in time, the lesion can involve the waist, chest, and cervical spine, severely affecting people's daily activities and life[37, 38].

Cheng Ling et al.[39] studied the impact of "nursing impact on pain and quality of life after intradermal heat needle treatment for ankylosing spondylitis" and found that this method could reduce the pain level of patients with AS. Zhang Zhihui et al.[40] found that 45°C was the most effective temperature for treating AS. Wang Junwei et al.[41] found that intradermal heat needle therapy had good clinical efficacy and safety in the treatment of middle and late stages of AS, especially in improving spinal joint activity, reducing pain, reducing disability rate, and delaying disease progression, the efficacy of intradermal heat needle therapy was significantly better. Zhan Chao[42] observed 48 patients with AS and found that intradermal heat needle therapy could reduce pain symptoms to a certain extent and improve the patient's condition.In conclusion, since intradermal heat needles are effective for AS, it is recommended that their use be promoted among patients with AS.

3.5 Intradermal heat needle treatment for lumbar disc herniation

LDH is a clinical syndrome with lower back and leg pain as the main symptoms, characterized by degeneration of the nucleus pulposus in the intervertebral disc, destruction and rupture of the annular tissue structure, and protrusion of the central part of the intervertebral disc through the peripheral annulus, causing compression of the nerve roots and cauda equina[43]. The incidence of LDH in China is between 8% and 25%[44], and the quality of life of patients is severely reduced[45], which is a focus in clinical practice.

Liu Yalin et al.[46] found that the total effective rate of intradermal heat needle therapy for the disease was 97.43%, significantly reducing pain symptoms. Mao Jianyu et al.[47] used fascial intradermal heat needle therapy for late LDH, which can significantly reduce patient symptoms, reduce the recurrence rate, and help patients return to normal daily activities. In a study of 90 patients with LDH, Gong Hui et al.[48] found that intradermal heat needle therapy was highly effective, significantly improving lumbar function, reducing pain levels, and enhancing patients' quality of life.

4. Discussion

Intradermal heat needles, a traditional Chinese therapy with centuries of history, are controversial due to safety concerns, especially when misused, leading to adverse reactions like infection and pain. It's crucial to use them under the guidance of qualified doctors and avoid sharing to prevent complications. Patients with certain conditions, such as heart or liver disease, epilepsy, or bleeding disorders, should consult doctors before use. Post-treatment, patients should rest and maintain proper nutrition. When used correctly, intradermal heat needles can effectively treat specific diseases.

At present, the application of intradermal heat needles in clinical practice is becoming more and more extensive. Some studies[20, 21, 27, 30, 31, 35, 40, 42, 48] have shown that intradermal heat needles can effectively alleviate the symptoms of musculoskeletal pain and improve the patient's quality of life. In addition, intradermal heat needles can also be used to treat pain syndrome, neurasthenia, cardiovascular diseases, etc. Reviewing the application of intradermal heat needles in clinical practice in recent years,

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whether used alone or in combination with other treatment methods, the therapeutic effect has been affirmed. However, the scope of diseases treated with intradermal heat needles is mostly concentrated in the field of pain, and the types of diseases are relatively limited. This phenomenon is likely related to the theoretical frameworks adopted by current scholars.

Although the application of intradermal heat needles in clinical practice is increasing, their mechanisms of action still need further research and discussion. Future research can be conducted at the molecular level, neurobiology, and other levels to reveal the mechanisms of action of intradermal heat needles more deeply and improve their clinical application effects. At the same time, the clinical application of intradermal heat needles also needs to be further standardized to ensure the safety and effectiveness of treatment.

In summary, as a safe and effective acupuncture therapy, intradermal heat needles have been used to treat a variety of diseases. The efficacy of intradermal heat needles is influenced by various factors, including the selection of acupoints, the length of the course, the depth of needling, and the frequency of needling. To ensure the safety and effectiveness of treatment, the clinical application of intradermal heat needles needs further standardization. Future research also needs to explore the mechanisms of action of intradermal heat needles in depth to improve their efficacy in orthopedic clinical applications.

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