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Application of Brain Imaging Technology in the Study of Acupuncture Mechanism and Disease Curative Effect

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Abstract: Research back ground: Acupuncture and moxibustion is a treatment method passed down for thousands of years, and it is still considered "unscientific" despite significant clinical efficacy. In the scientific research of acupuncture and moxibustion, how to promote the "modernization of acupuncture and moxibustion" has become a frontier field, combining modern imaging and acupuncture treatment, and further visualization research has become a trend. The literature on" imaging and acupuncture" in 2022 was collected from the database of "China National Knowledge Network", and the endnoteX9.1 software was imported to screen the literature on MRI technology and acupuncture combined with the research perspective. Through the analysis and summary of the literature on acupuncture MRI in the past five years, the changes of image data before, during and after acupuncture treatment of diseases were combined with acupuncture efficacy. This article explores the scientific nature of MRI technology in the visualization of acupuncture mechanism and therapeutic effect. In the acupuncture treatment of dominant diseases such as stroke, pain and mental diseases, MRI technology can confirm the imaging changes of patients before and after treatment, and further clarify the acupuncture mechanism of the central system and peripheral nerves, which is conducive to the application of acupuncture imaging in clinical practice and improve the clinical curative effect of acupuncture.

1. Acupuncture imaging has emerged as a result

Acupuncture therapy has been passed down in China for thousands of years and has shown remarkable therapeutic effects in clinical practice. It is particularly effective for certain diseases, which are the advantageous diseases of acupuncture treatment. However, due to the unclear

mechanism of its effects and the lack of data evidence, it has not been scientifically recognized. With the development of imaging, techniques such as transbrain imaging have been widely used to clarify the therapeutic effect and mechanism of acupuncture, which is conducive to the explanation of the mechanism of acupuncture effect and thus promotes the popularization of acupuncture therapy worldwide. Acupuncture imaging emerged as the Times required. In 2005, Professor Xu Jianyang first proposed the concept of "acupuncture imaging" and discussed its classification, research contents and methods [1].

With the support of national policies for the revival of traditional medicine, more and more researchers have embarked on the path of "modernization of acupuncture", and the cross-integration of multiple disciplines has become a trend.

2. The application of brain imaging technology in the field of acupuncture

In the field of acupuncture imaging, brain imaging technology has many cutting-edge studies in both the exploration of the mechanism of acupuncture and clinical treatment. The commonly used brain imaging techniques in research and clinical practice include: calcium imaging, laser speckle contrast imaging, photoacoustic imaging, near-infrared spectroscopy imaging, and two-photon in vivo imaging, etc [2].

These technologies all have some advantages and disadvantages. Therefore, when studying the different mechanisms and effects of acupuncture, different imaging techniques can be selected to make the research more accurate and achieve twice the result with half the effort. Calcium imaging has high spatial resolution and can be used for long-term monitoring, but it has the problem of shallow observation. It is mostly used in the field of neuroscience to observe the activities of glial cells and neurons. Combining it with acupuncture research can further explain the connection between acupoints and brain functions, and illustrate the mechanism of acupuncture on the neural pathways of the human body [3][4][5]. Similar is laser speckle contrast imaging. Its image resolution is high. The advantage is that it has a large monitoring area, can monitor the blood perfusion of local tissues in real time, and display the blood supply situation at the lesion site. It is a non-contact imaging method. The disadvantages are invasive operation and shallow imaging depth. This technology can be applied to study the specificity of acupuncture manipulation [6][7]. If one is to study the therapeutic mechanism of acupuncture or the sensitization reaction of acupoints, or the role of acupoints in the central system, photoacoustic imaging, near-infrared spectroscopy or two-photon in vivo can be adopted [8][9][10]. No matter which imaging method is used, it indicates that the combination of acupuncture and modern technology has become mainstream in today's scientific research, and a certain number of achievements have been made in the research progress of this field.

3. A brief description of the Classification of Acupuncture Imaging and the Principle of MRI

Acupuncture imaging is classified into holistic acupuncture imaging, acupuncture organ imaging, acupuncture cell and molecular imaging, acupuncture immunoimaging, etc. according to different research levels. According to different disciplinary branches, they are classified as: acupuncture X-ray imaging, acupuncture CT imaging, acupuncture MRI imaging, acupuncture ultrasound imaging, acupuncture radionuclide imaging, etc. The author aims to focus on studying the current application status of acupuncture MRI imaging in the mechanism of acupuncture and the therapeutic effect of the dominant diseases treated.

MRI(Magnetic Resonance Imaging)acquires the characteristics of biological tissues and functions through signals emitted by hydrogen atoms in the human body. It features no radiation, no trauma, and high resolution, and is widely used in clinical practice. This article is based on the

"China National Knowledge Infrastructure" database and combines "acupuncture", "electroacupuncture", "abdominal acupuncture", "body acupuncture", etc. with "MRI", "acupuncture imaging", "magnetic resonance imaging", "spin imaging" as the main subject words. From the establishment of the professional database to 2024, a total of 2,870 documents related to "Imaging and Acupuncture" have been retrieved, including 1,198 Chinese journal articles, 687 dissertations, 184 conference papers, and 801 foreign journal articles.

Judging from the number of published articles, the period from 2001 to 2008 was the exploration stage for researching this topic. As time goes by, the period from 2009 to 2022 was the explosive growth stage of research topics so far, showing a spiral upward trend and setting off a wave of enthusiasm. See Figure 1.

From the analysis of the current research topics in acupuncture imaging, most of the research directions are in the clinical observation research stage, and the research scope is concentrated on the brain. The main theme is to study the impact of acupuncture on the central nervous system, with a focus on diseases such as migraine and cerebral infarction. See Figure 2.

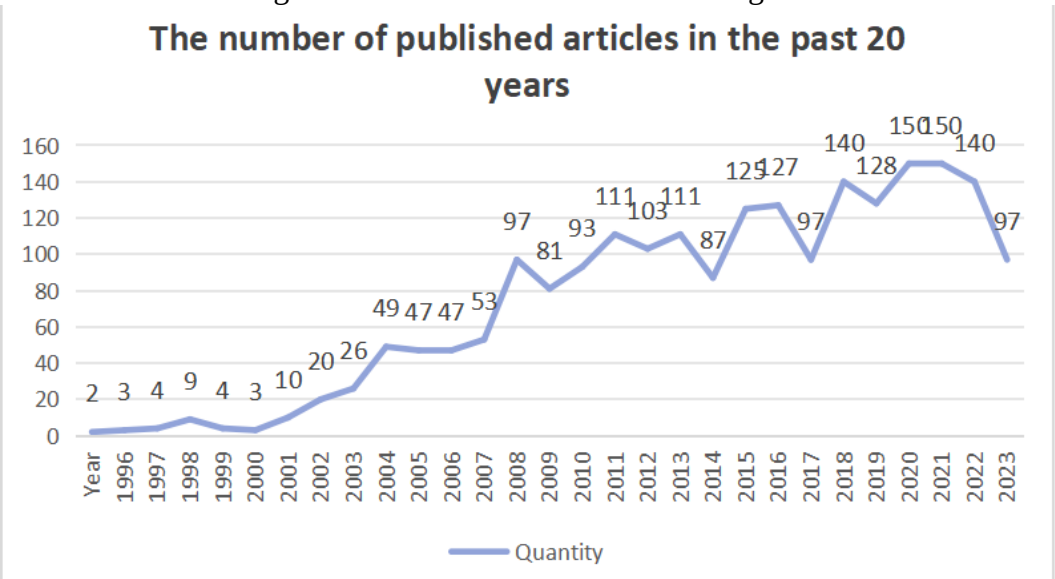

Figure 1 Year distribution map of literature combining MRI and acupuncture

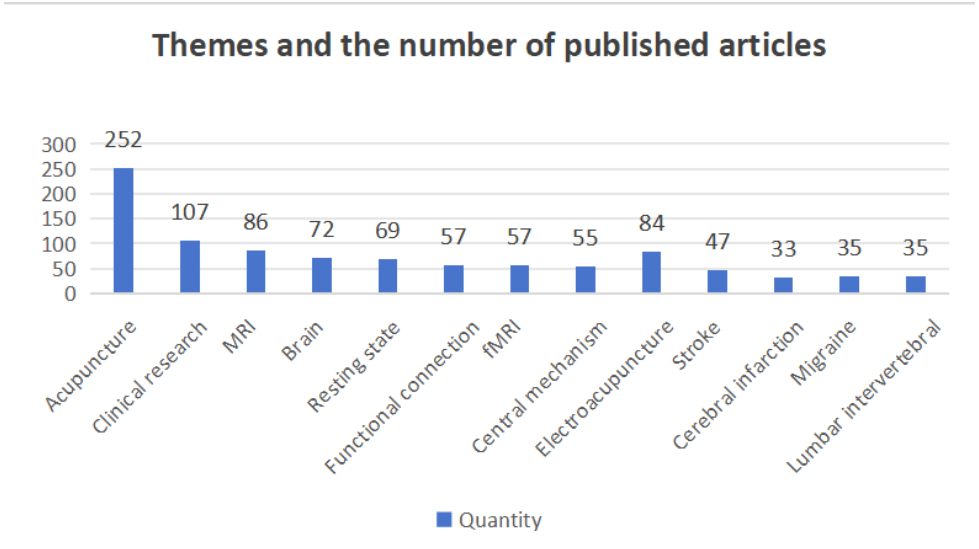

Figure 2 The subject distribution of the literature combining MRI and acupuncture

4. Research on the Application of Brain Imaging in Acupuncture Treatment of Dominant Diseases

4.1 MRI technology is applied to the mechanism of acupuncture effect

Research on the modernization of acupuncture has emerged both at home and abroad. A project similar to electroacupuncture therapy, named "Stimulating Peripheral Nerves to Treat Diseases", has been launched at the National Institutes of Health in the United States. Meanwhile, domestic scholars also organized and established the first International Symposium on the Brain Effects of Acupuncture Points. At the first conference in 2012, Professor Fang Jiliang affirmed that the research on brain function imaging of acupuncture points is a successful example of integrated traditional Chinese and Western medicine imaging studies, and hoped to use this new technology to provide more convincing evidence for the scientific nature of the acupuncture mechanism [11]. A large amount of literature data indicates that when needling the meridians and acupoints, different effects will be produced in the brain functional areas. That is shown in figure 3. In the research related to acupuncture and the brain, experts such as Rong Peijing, Fang Jiliang, and Yu Yutian have sorted out and summarized the mechanisms of neural regulation and the effects of acupuncture from the perspectives of traditional Chinese medicine and modern medicine, which is helpful for understanding the influence of acupuncture on the central regulation and peripheral operation mechanisms [12].

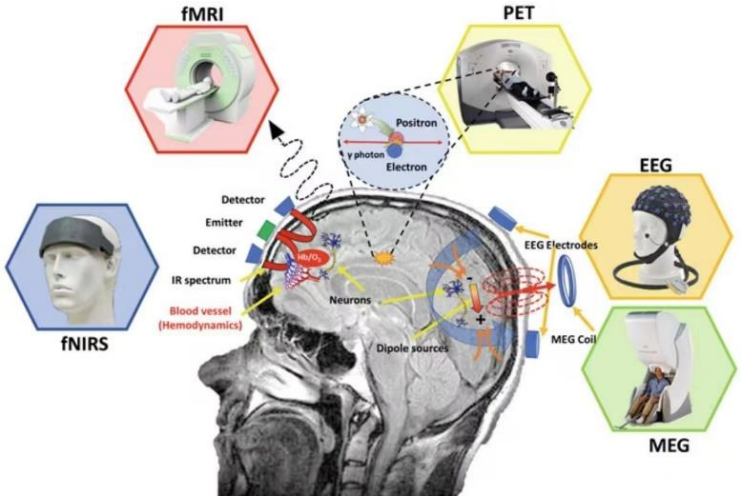

Figure 3 Brain Networks and Their functions

In acupuncture treatment, obtaining qi is the main indicator of therapeutic effect. Through the group comparison of real and fake needles, the real needle was stimulated to obtain qi. Observed in the resting state through functional magnetic resonance imaging (fMRI), the limbic - paratoral cortical network played an important regulatory function [13]. In addition, in the research on the acupuncture techniques for obtaining qi, the lifting manipulation technique has the strongest impact on the central nervous system, followed by the combined technique of lifting, inserting and twisting, with the twisting technique being the weakest [14]. Whether one gets qi or the quality of the qi is achieved through the acupuncture technique of the doctor. In other words, it is to change by altering the stimulation amount of acupuncture, that is, the direction, depth, application and corresponding symptoms of acupuncture at the same acupoint. This is the acupuncture manipulation quantitative theory proposed by Academician Shi Xuemin [15]. When applying the technique, brain functional imaging can be connected to show the changes in brain effects before and after acupuncture by observing cells. The model example is shown in Figure 4. The "dose-effect" relationship remains a

hot topic in current acupuncture research. Hu Jianping et al. needled the Neiguan point through different methods, and fMRI showed changes in different brain functional areas, or different signal intensities and areas of common brain functional activity areas [16]. Yu Huijuan, on the other hand, generated different amounts of stimulation through various methods such as different durations of stimulation, different frequencies of electroacupuncture, and whether acupuncture was performed or not. In the study, patients with diarrhea-predominant irritable bowel syndrome were treated. Functional magnetic resonance imaging showed that the main activated brain regions were concentrated in the lateral prefrontal cortex, primary somatosensory cortex, insula, anterior cingulate gyrus, etc. It also proved that different stimulation amounts would produce different acupuncture effects [17].

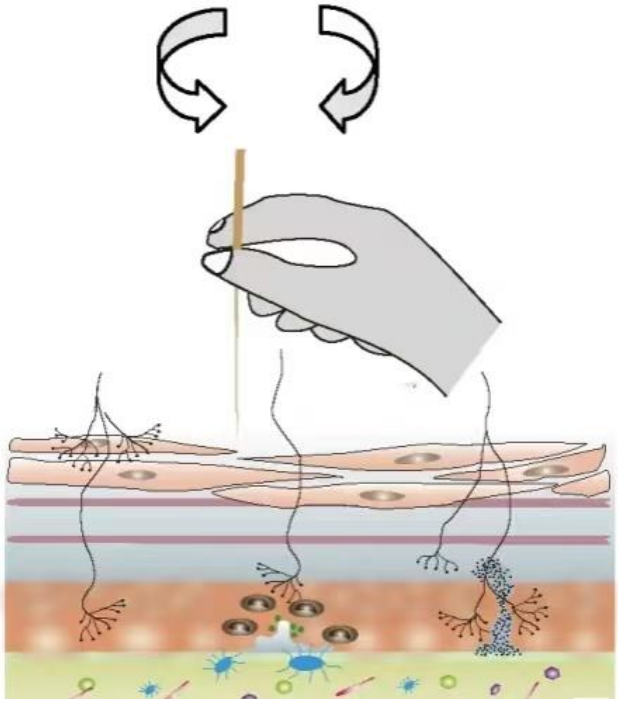

Figure 4 The brain effect model during acupuncture manipulation

4.2 Research on the Brain Effects of Acupuncture on Dominant Diseases

Based on technology, scholars have also attempted to further study the disease types where acupuncture treatment is advantageous through imaging means. This is an attempt and phased achievement of scholars in the field of modern acupuncture research.

4.2.1 Stroke

Acupuncture treatment has obvious clinical efficacy in both the early intervention and later recovery of stroke. Han Xiao from Beijing University of Chinese Medicine, by applying the complex network analysis method of graph theory and conducting a comparative study of whole-brain functional magnetic resonance images between stroke patients and healthy individuals, has summarized the pathological characteristics of brain function in stroke patients. And analyze and explain the mechanism of acupuncture intervention in reshaping brain function after stroke [18]. Coincidentally, Jiang LAN focused on patients with stroke accompanied by hemiplegia. The results, through statistical analysis, revealed that acupuncture could promote homotopy function on both sides of the brain. It achieves the effect of restoring the hemiplegic affected limb by regulating various brain functions related to sensations and emotions in the body [19]. Gong Zhigang, Fu Zhihui

and others conducted in-depth research on the group of patients with hemiplegia after stroke who were identified as having phlegm blocking the meridians syndrome. Functional magnetic resonance scanning was performed in the non-acute stage, and the images of the cortical spinal tract in the brain were reconstructed in three dimensions. It was proved that needling the relevant acupoints during treatment could have the effect of eliminating dampness and resolving phlegm. At the same time, it was concluded that acupuncture has a significant effect on restoring the functions of the upper limb and hand on the hemiplegic side, but has a limited effect on the recovery of the lower limb [20]. Yang Fuxia, Hou Dongmei and others also used corticospinal tract images to study patients with cerebral infarction. The results show that transferring the Tongdu acupuncture method can promote the recovery of patients with cerebral infarction, thereby improving the motor function of the patients [21].

4.2.2 Pain disease

Dong Xiaohui, Zhou Jun and others summarized the cases in recent years from the perspective of neuroimaging of the therapeutic effect of acupuncture migraine. Acupuncture analgesia is currently the field with the most extensive and in-depth research in acupuncture. Scholars predict that perhaps with the popularization of artificial intelligence, various factors affecting the therapeutic effect of acupuncture can be further studied, thereby screening out more effective and safe methods for clinical treatment, which can save medical resources, improve therapeutic effects and reduce treatment costs [22]. Reality shows that this prediction is gradually advancing, and applying imaging technology to the field of acupuncture treatment is precisely a major breakthrough.

4.2.3 Mental disorders

Acupuncture is also a good option for the treatment of mental disorders. Major Depressive Disorder (MDD) Depression is a disorder of mood and emotion. Brain imaging indicates that this manifestation is related to abnormal activation of the default network and the prefrontal lobe [23]. MDD falls within the categories of depression syndrome, zonal restlessness, lily disease, epilepsy, and plum kernel qi in traditional Chinese medicine. He Jiakai from the China Academy of Chinese Medical Sciences has conducted research on the clinical efficacy of acupuncture in relieving depression. He was the first to propose a new type of non-invasive physical therapy for relieving depression. This is called "percutaneous cranial - auricular point electrical stimulation(Trans cutaneous Electrical Cranial-Auricular Acupoints Stimulation, TECAS). Clinical research has proved that this physical therapy has a regulatory effect on the inflammatory abnormal brain regions of depression [24]. This is a major practical application of acupuncture imaging. In addition, Chen Ying, Sun Jingqing and others studied the clinical brain functional imaging of patients with migraine comorbid with anxiety and depression. This study indicates that acupuncture can alleviate patients' pain and symptoms related to anxiety and depression by increasing the functional activity of the right middle frontal gyrus of patients [25].

5. The Deficiencies and Prospects of Acupuncture Imaging

The visualization research process on the mechanism of acupuncture at home and abroad has progressed slowly. The main reason is the lack of theoretical basis and scientific explanatory means for the mechanism of acupuncture action. After more than two decades of development, acupuncture imaging has become a distinctive study in the integration of traditional Chinese and Western medicine. How to find modern data evidence for the scientific nature of traditional Chinese medicine has become a breakthrough point. Yin Tao, Teng Yuke and Zeng Fang summarized the current status of previous acupuncture neuroimaging research from four aspects: "specificity of

meridian and point effects", "mechanism of acupuncture effects", "influencing factors of acupuncture effects" and "Prediction of acupuncture therapeutic effects based on neuroimaging characterization" [26]. It explains the rationality, scientificity and possibility of the development of this discipline from the data level.

In the existing research, acupuncture imaging has developed rapidly, especially the research on the combination of brain imaging technology and acupuncture treatment has achieved phased progress. The flaws lie in the lack of uniformity in the experimental design. During the operation, there are deficiencies such as difficult control of experimental conditions, a relatively small sample size, individual differences among subjects, and different data analysis methods. The above multiple factors have led to significant differences in the research results, and it is still impossible to form a relatively unified conclusion [27].

6. Conclusion

In diseases such as stroke, pain disorders and mental disorders where Western medical treatment methods are limited, acupuncture has obvious advantages in effect. This was confirmed by the researchers in the visualization study of acupuncture treatment through MRI technology. However, acupuncture imaging has not been widely promoted and applied in actual clinical practice. There is still a long way to go for acupuncture imaging to move from the scientific research level to the clinical application level.

Perhaps with the continuous development of neuroimaging technology, integrating the development of multiple interdisciplinary fields such as brain functional imaging techniques, neurophysiology, and molecular biology, it has become possible to conduct multimodal verification in these fields. The uniformity and scientificity of the research are achieved through various approaches such as the expansion of the research content, the optimization of the experimental plan, and the rationalization and precision of data processing. At present, in the field of acupuncture, there is still considerable research space in areas such as the specificity of acupuncture techniques, acupoint sensitization, and the exploration of acupuncture mechanisms. The application of modern imaging techniques is to further reveal the approaches of acupuncture treatment. The main purpose of MRI technology is to further explore whether the peripheral stimulation of acupuncture has an impact on the central system and how it generates brain effects on the premise of improving clinical symptoms. In the future, by revealing the above issues, the clinical efficacy and safety of acupuncture treatment can be improved. While legitimizing acupuncture treatment through modern technological means, it also provides better guidance for optimizing clinical application and enhancing the clinical efficacy of acupuncture.

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