

Research Article

The Nociceptive Glio-Neural Complex as a Histoanatomical Substrate of Acupuncture Meridians?

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Abstract

Morphological evidence of peripheral glial cell involvement is lacking. Therefore, we investigated the presence of Schwann cells in acupuncture meridians. Eight legs of four



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unembalmed cadavers were used. Along the stomach meridian and a control meridian, quadrangular samples were taken from skin to the deep subcutaneous fascia and embedded in paraffin. 5 µm sections were stained for H&E and processed for immunolabeling using antibodies against S100 and NFP, respectively. In the stomach meridian, a large assembly of glial cells was detected at the border of the papillar layer of the dermis to the superficial layer of the subcutaneous tissue in both colorations. In contrast, no glial cells could be detected in the control area. The presence of glial cells in the stomach meridian is a morphological indication that they also contribute to the function of acupuncture.

Keywords

Acupuncture; nociceptive glio-neural complex; histoanatomical substrate of acupuncture

1. Introduction

Acupuncture is a well-known method of treatment and part of the traditional Chinese medicine [1]. Ever since research on acupuncture began, explanations and evidence for acupuncture meridians have been sought [1]. Many theories and scientific explanations exist [1-3], but no conclusive, complete explanation has yet been found. Some are focusing on the connective tissue [2, 4]. Maurer et al. [5] documented the involvement of fascias and the extracellular matrix. In addition, acupuncture is effective for individuals with chronic musculoskeletal headaches and pain from osteoarthritis. The treatment effects persist for some time and cannot be explained solely by placebo [6]. Acupuncture is effective for peripheral neuropathy [7]. Ciczek et al. [8] described various types of sensory nerve endings in acupuncture points. As axons do need a cover by glial cells, consequently, glial cells might also be a contributing structure for the function of Acupuncture as well [9].

Glial cells, also known as Schwann cells, are primarily cells of the supporting tissue and thus differ from nerve cells. The majority are myelinating glial cells, which, on the one hand, protect nerve cells and, on the other hand, facilitate faster conduction through the Ranvier's cord ring. Abdo et al. [9] have discovered a specialized type of cutaneous glial cells that have large extensions and thus form a network at the dermis-epidermis boundary of the skin that reacts sensitively to painful thermal, mechanical, and electromagnetic stimuli. These glial cells are closely connected to unmyelinated, pain-sensitive nerves and are therefore crucial for the transmission of all kinds of stimuli. An essential prerequisite for the survival of an organism is the ability to detect and react to negative stimuli. Current knowledge is that harmful stimuli directly activate nociceptive nerve endings in the skin. These glial cells are closely connected to unmyelinated, pain-sensitive nerves and are therefore of crucial importance for the transmission of stimuli of all kinds. Hind Abdo et al. discovered a special type of glial cell located in the skin (so-called nociceptive non-myelinating Schwann's cells) with extensive projections that form a mesh-like network at the subepidermal border. These cells mediate the damaging effect of thermal and mechanical stimuli. Abdo et al. [9] demonstrated a direct excitatory functional connection with sensory neurons and identified a previously unknown organ that plays an essential physiological role in the reception of noxious stimuli. As a result, these glial cells are closely linked to non-myelinated nociceptive nerves. These are mechanosensitive and

thermosensitive. Light amplifies the stimulus. These glial cells transport noxious stimuli to nerves and thus play a crucial role in all stimuli [9]. Non-myelinating Schwann cells are essential for the proper function of the peripheral nervous system [10, 11]. Previous scientific work has shown that the 'terminal' Schwann's cells that cover neuromuscular synapses thereby play an important role in the maintenance and repair of synapses [12]. Acupuncture is effective for individuals with chronic musculoskeletal headaches and pain from osteoarthritis. The treatment effects persist for some time and cannot be explained as a placebo effect alone [6]. Metabolic pathway activation by nuclear factor κ B-COX2 through non-myelinating Schwann cells is essential for the persistence of neuropathic pain in vivo [13]. Acupuncture plays a vital role in the treatment of peripheral neuropathy [7, 14]. Manual acupuncture and electromagnetic stimulation stimulate the parasympathetic nervous system, while laser acupuncture affects the sympathetic nervous system [15]. In addition, Acupuncture also influences sensory perception [15]. However, glial cells accompany all nerve fibers, whether autonomic or sensory, so they might play a role in the function of acupuncture.

The aim of this study was to investigate the arrangement and presence of Schwann's cells at acupuncture points or acupuncture meridians in comparison to placebo or control points.

2. Materials and Methods

The investigation was carried out at the Department of Anatomy and Cell Biology of the Medical University of Vienna. All samples were taken from bodies donated to science and teaching to the Department of Anatomy and Cell Biology under the strict rules of the donation program of the Institute and according to the Viennese burial law. All procedures performed in the study were in accordance with the ethical standards of the institutional committee and with the Helsinki Declaration and its later amendments or comparable ethical standards.

In total, eight legs of four unembalmed bodies donated to science were used. They were kept in the cooling room until and were taken shortly before sample collection, providing material as fresh as possible.

Parts of the skin and subcutaneous tissue, including the deep subcutaneous fascial layer, were removed by quadrangular incisions. All samples were embedded in paraffin. 5 μ m sections were stained for H&E and processed for immunolabeling using antibodies against S100 and NFP, respectively.

We divided the collected samples into two groups.

Group 1 included samples along the stomach meridian of the acupuncture points M 36-38 [16]. These samples were stained with HE-coloration. The staining followed the standard coloration protocol of the Institute of Anatomy of the Medical University of Vienna.

Group 2: parts of the skin were also removed on the side of the posterolateral part of the leg, where it was ensured that no meridian runs in this area. This was designated as the placebo/control group. These samples were stained with S100-coloration. The staining followed the standard coloration protocol of the Institute of Anatomy of the Medical University of Vienna.

Photos of these histological investigations were taken with a Nikon "Eclipse Ti" microscope equipped with a mmi-CellCamera 1.4.

3. Results

3.1 Group 1

Schwann cells were documented in dense linear formation in the superficial part of the subcutaneous layer at the border to the deep papillar layer of the dermis in both staining techniques (Figures 1a and 1b and Figures 2a and 2b) in the stomach meridian 36-38 area. We could not differentiate between the two Schwann cell types, either myelinating or non-myelinating.

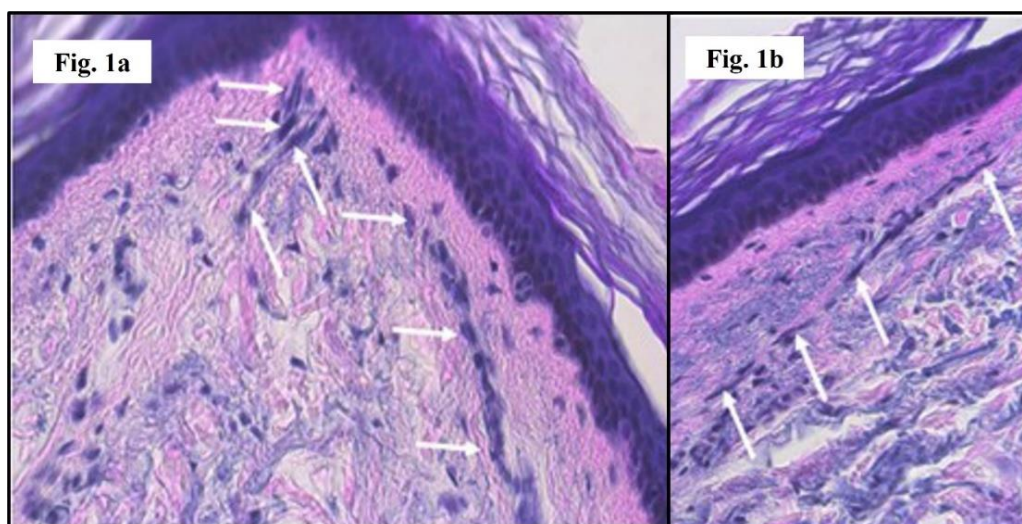


Figure 1 1a and 1b: HE- coloration documents Schwann cells (white arrows) at the border of subcutaneous tissue to the papillary layer of the dermis elevated from the stomach meridian.

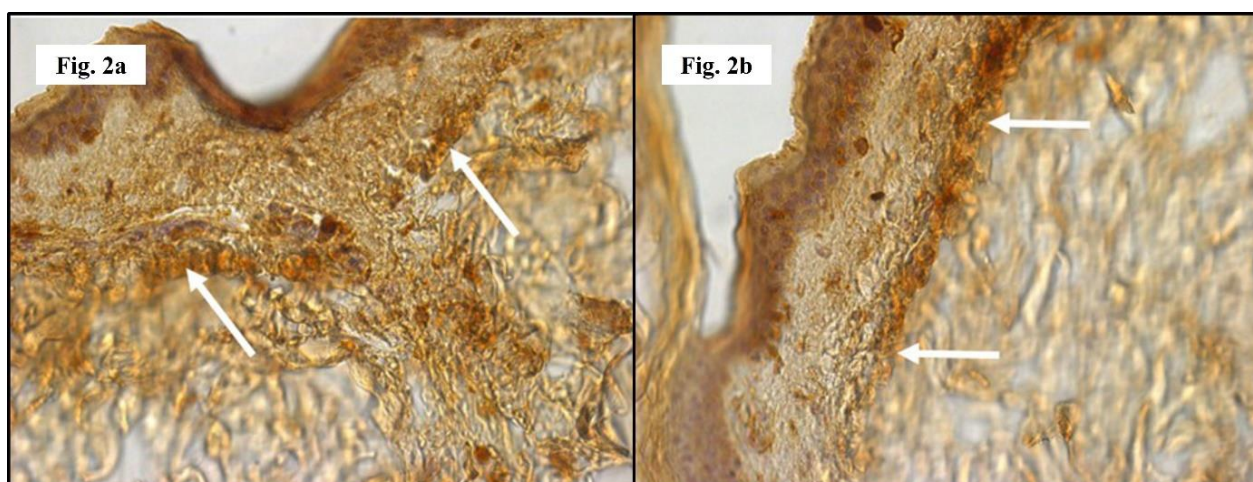


Figure 2 2a and 2b: S100- coloration documents Schwann cells (white arrows) at the border of subcutaneous tissue to the papillary layer of the dermis elevated from the stomach meridian.

3.2 Group 2

We detected no Schwann' cells along the "Placebo" line at all in neither HE (Figures 3a and 3b) nor S100 (Figures 4a and 4b) staining.

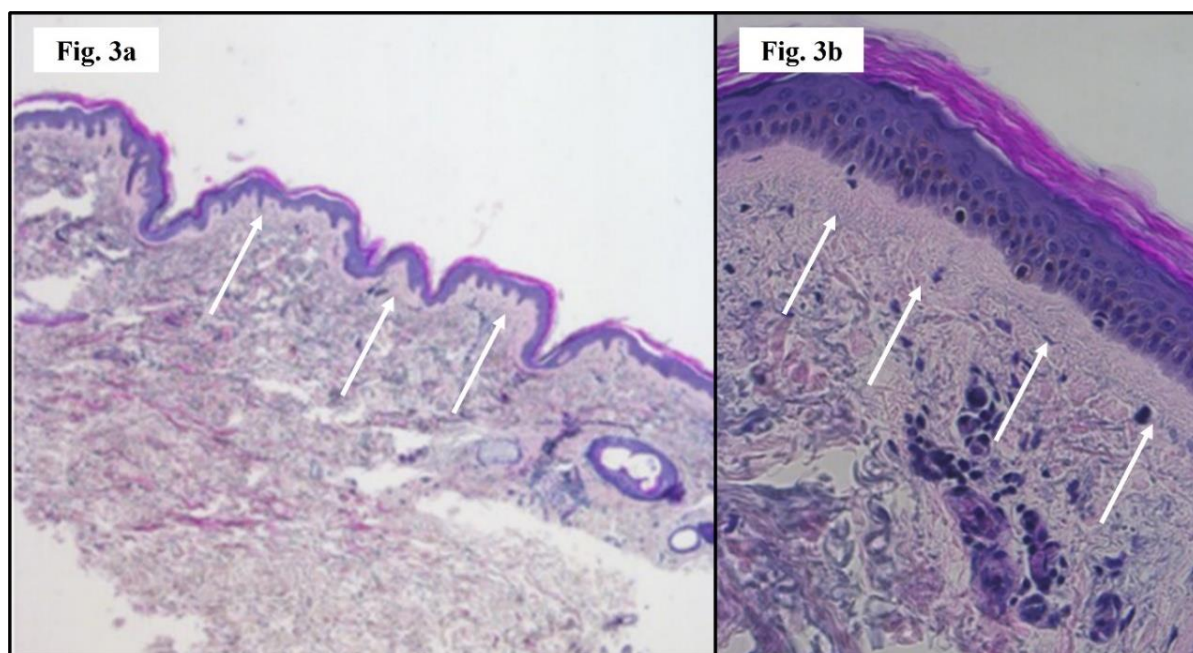


Figure 3 3a and 3b: HE- coloration shows no Schwann cells at the border of subcutaneous tissue to the papillary layer of the dermis (white arrows) elevated from the stomach meridian.

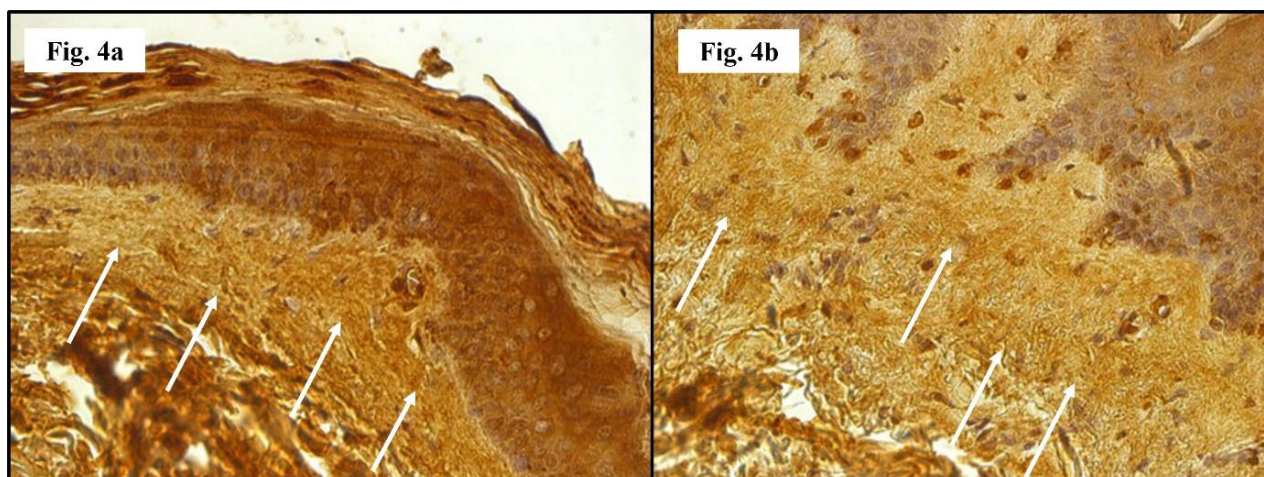


Figure 4 4a and 4b: S100- coloration shows no Schwann cells at the border of subcutaneous tissue to the papillary layer of the dermis (white arrows) elevated from the stomach meridian.

4. Discussion

The current investigation clearly shows an accumulation of Schwann cells along the investigated meridian, whereas no Schwann cells were visualized in our determined Placebo line. To our

knowledge, this is the first proof that such Glia cells are developed in large numbers along acupuncture meridians, and such acupuncture points are compared to control points. This supports the findings of Abdo et al. [9] and is a significant contribution, providing a morphological explanation for Acupuncture.

Acupuncture has a lasting effect on pain perception. As nociceptive fibers reach the dermis via free endings, they must be covered by Schwann cells [17, 18]. Unfortunately, histological textbooks do not clearly state where the glia of nociceptive fibers actually end [17, 18]. Anyway, the fact that we documented Schwann cells at the border between Dermis and subcutaneous tissue suggests that there may also be non-myelinated Schwann cells among those detected. The question arises whether these are mainly non-myelinated or myelinated Schwann cells. As myelinated Schwann cells are present mainly in efferent motoric nerve fibers [19, 20], we can assume that these represent non-myelinating Schwann cells surrounding afferent sensorial fibers or afferent and efferent autonomic fibers.

Non-myelinating Schwann cells appear to have a causal influence on polymodal nociceptors, which react to thermal, mechanical, and electromagnetic stimuli. Nerves only seem to respond meaningfully with the help of 'nociceptive' non-myelinating Schwann cells. Nociceptive non-myelinating Schwann cells, the glio-neural complex, and acupuncture appear to have the same effects on the pain stimulus and the peripheral nervous system. Skin conductance is greater in acupuncture points than in control points [19, 20]. As the receptors in the skin and deeper layers are part of the nervous system, a connection between nerve fibers, glial cells, electrostimulation, and skin conductance can be hypothesized.

Because of these results, we assume that the documented glia cells represent non-myelinating Schwann cells, which are located linearly in the area of the stomach meridian and probably other meridians. The course of the superficial layer of deep fascia is equally important for an acupuncture meridian [5]. It was concluded that Schwann's cells, the glio-neural complex, and the superficial layer of deep fascia form the histoanatomical substrate of the stomach meridian and presumably also of other meridians. However, the neurochemical and biological processes remain unknown. In addition, these results are an explanation of the function of physical medicine treatments using heat, mechanotherapy, and phototherapy. The 'nociceptive' non-myelinating Schwann cells also respond to heat, mechanical stimulus, and light [9], as acupuncture has a lasting effect in terms of reduced pain perception. Non-myelinating Schwann cells appear to have a causal influence on polymodal nociceptors, which react to thermal, mechanical, and electromagnetic stimuli. Nerves only seem to meaningfully respond with the help of 'nociceptive' non-myelinating Schwann cells. Nociceptive non-myelinating Schwann cells, the glio-neural complex, and acupuncture appear to have the same effects on the pain stimulus and the peripheral nervous system [21].

Moxibustion and acupressure are used on an equal footing with needle acupuncture. This also points to a connection with Schwann's cells, which also react to heat and pressure [21] and are involved in the promotion of peripheral nerve regeneration as well [22].

Even mast cells might be involved, too. In the context of Schwann cells, the significance of mast cells should also be briefly addressed. Mast cells have a wide range of functions. They play important roles in immunological responses, are essential components of all allergic reactions because they can take up, and process antigens. Concerning Acupuncture, it is indirectly activated by forces on the collagen network and releases mediators into the interstitial space [23]. They are found in the subcutaneous tissue as well and can trigger biological effects on adjacent cells, which might include

nerve cells and glial cells as well. With the release of multiple substances, they are involved in acupuncture analgesia [24]. Yin et al. [25] proved the connection between mast cells and nerve signals. The mast cells inhibited the acupuncture-induced nerve discharges. However, as we documented accumulations of glial cells at the acupuncture points, which surround the axons, we can hypothesize that Schwann cells might play a specific role. Li et al. [26] noted the complexity of mast cells' roles in anti-inflammatory function and in mechanisms of Acupuncture.

Summarizing, it is clear that the function of acupuncture is not dependent on a single parameter but on many different structures. It seems that the success of acupuncture is based on a complex reaction of a combined “teamwork” of connective tissue, nerve endings, extracellular matrix, Schwann cells, and even Mast cells.

5. Conclusion

Non-myelinating Schwann cells influence the polymodal nociceptors that react to thermal, mechanical, and chemical stimuli. Nerves seem to respond meaningfully only with the help of nociceptive non-myelinating Schwann cells. Nociceptive non-myelinating Schwann cells, the glioneural complex, and acupuncture have clear effects on pain stimuli and the peripheral nervous system. Due to the limited number of investigated specimens, we can conclude that there are differences in glial cell presence between the stomach meridian and predetermined “placebo” areas.

However, the final proof whether the documented glia cells are either non-myelinated or myelinated must be provided by additional immunohistochemical investigations.

Author Contributions

N.M.: sample and data collection, literature research, manuscript writing. H.N. and R.C.: sample and data collection, literature research. R.B. and R.C.: histological investigation and assessment. M.M. and E.G.: literature research, reviewing manuscript. G.F.: data assessment, literature research, manuscript writing, reviewing and editing.

Competing Interests

The authors declare that they have no conflicts of interest.

References

1. Zhuang Y, Xing JJ, Li J, Zeng BY, Liang FR. History of acupuncture research. *Int Rev Neurobiol*. 2013; 111: 1-23.
2. Langevin HM, Yandow JA. Relationship of acupuncture points and meridians to connective tissue planes. *Anat Rec*. 2002; 269: 257-265.
3. Kaptchuk TJ. Acupuncture: Theory, efficacy, and practice. *Ann Intern Med*. 2002; 136: 374-383.
4. Langevin HM, Churchill DL, Fox JR, Badger GJ, Garra BS, Krag MH. Biomechanical response to acupuncture needling in humans. *J Appl Physiol*. 2001; 91: 2471-2478.
5. Maurer N, Nissel H, Egerbacher M, Gornik E, Schuller P, Traxler H. Anatomical evidence of acupuncture meridians in the human extracellular matrix: Results from a macroscopic and microscopic interdisciplinary multicentre study on human corpses. *Evid Based Complement Alternat Med*. 2019; 2019: 6976892.

6. Dimitrova A, Murchison C, Oken B. Acupuncture for the treatment of peripheral neuropathy: A systematic review and meta-analysis. *J Altern Complement Med*. 2017; 23: 164-179.
7. Xie AX, Taves S, McCarthy K. Nuclear factor κ B-COX2 pathway activation in non-myelinating Schwann cells is necessary for the maintenance of neuropathic pain *in vivo*. *Front Cell Neurosci*. 2022; 15: 782275.
8. Cizek M, Szopinski J, Skrzypulec V. Investigations of morphological structure of acupuncture points and meridians. *J Tradit Chin Med*. 1985; 5: 289-292.
9. Abdo H, Calvo-Enrique L, Lopez JM, Song J, Zhang MD, Usoskin D, et al. Specialized cutaneous Schwann cells initiate pain sensation. *Science*. 2019; 365: 695-699.
10. Harty BL, Monk KR. Unwrapping the unappreciated: Recent progress in Remak Schwann cell biology. *Curr Opin Neurobiol*. 2017; 47: 131-137.
11. Balice-Gordon RJ. Dynamic roles at the neuromuscular junction. Schwann cells. *Curr Biol*. 1996; 6: 1054-1056.
12. Vickers AJ, Vertosick EA, Lewith G, MacPherson H, Foster NE, Sherman KJ, et al. Acupuncture for chronic pain: Update of an individual patient data meta-analysis. *J Pain*. 2018; 19: 455-474.
13. Morais N, Greten HJ, Santos MJ, Machado JP. Immediate effects of acupuncture on the mechanosensitivity of the median nerve: An exploratory randomised trial. *Acupunct Med*. 2018; 36: 132-138.
14. Lee NR, Kim SB, Heo H, Lee YH. Comparison of the effects of manual acupuncture, laser acupuncture, and electromagnetic field stimulation at acupuncture point BL15 on heart rate variability. *J Acupunct Meridian Stud*. 2016; 9: 257-263.
15. Baeumler PI, Fleckenstein J, Takayama S, Simang M, Seki T, Irnich D. Effects of acupuncture on sensory perception: A systematic review and meta-analysis. *PLoS One*. 2014; 9: e113731.
16. König G, Wancura-Kampik I. Band I. Praxis und Theorie der Neuen Chinesischen Akupunktur. München, Bern: Willhelm Maudrich Verlag Wien; 1979.
17. Lüllmann-Rauch R, Asan E. Taschenlehrbuch Histologie. 7th ed. Stuttgart, Germany: Georg Thieme Verlag; 2024.
18. Welsch U, Kummer W, Deller T. Histologie - Lehrbuch und Atlas. 6th ed. Amsterdam, Netherlands: Elsevier; 2022.
19. Reichmanis M, Marino AA, Becker RO. Electrical correlates of acupuncture points. *IEEE Trans Biomed Eng*. 1975; 22: 533-535.
20. Comunetti A, Laage S, Schiessl N, Kistler A. Characterisation of human skin conductance at acupuncture points. *Experientia*. 1995; 51: 328-331.
21. DU Y. Disease spectrum and strategy of acupuncture and moxibustion in treatment of encephalopathy. *Zhongguo Zhen Jiu*. 2024; 44: 367-371.
22. Ji Q, Shan F, Zhang B, Chen Y, Yang X, Gao F, et al. Acupuncture on "Huantiao" (GB30) and "Yanglingquan" (GB34) acupoints promotes nerve regeneration in mice model of peripheral nerve injury. *IBRO Neurosci Rep*. 2023; 15: 158-164.
23. Wang LN, Wang XZ, Li YJ, Li BR, Huang M, Wang XY, et al. Activation of subcutaneous mast cells in acupuncture points triggers analgesia. *Cells*. 2022; 11: 809.
24. Li Y, Yu Y, Liu Y, Yao W. Mast cells and acupuncture analgesia. *Cells*. 2022; 11: 860.
25. Yin N, Yang H, Yao W, Xia Y, Ding G. Mast cells and nerve signal conduction in acupuncture. *Evid Based Complement Alternat Med*. 2018; 2018: 3524279.

26. Li N, Guo Y, Gong Y, Zhang Y, Fan W, Yao K, et al. The anti-inflammatory actions and mechanisms of acupuncture from acupoint to target organs via neuro-immune regulation. *J Inflamm Res.* 2021; 14: 7191-7224.