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REVIEW ARTICLE

Marma Chikitsa through the Lens of Neuroscience: Neuroplasticity and Neuroglial Perspectives

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ABSTRACT

Marma Chikitsa is a traditional Ayurvedic therapeutic approach based on stimulation of specific anatomical sites considered vital because of their structural and functional significance. From a contemporary perspective, these regions may contain combinations of neural, vascular, muscular, fascial, and connective-tissue structures capable of generating sensory input. Neuroscience has established that peripheral sensory stimulation can influence neural activity at spinal, subcortical, and cortical levels and that repeated neural activity may contribute to functional and structural plasticity. Neuroglial cells, including astrocytes, microglia, and oligodendrocytes, also participate in synaptic regulation, neural homeostasis, and activity-dependent plasticity. This review explores *Marma Chikitsa* through the concepts of somatosensory signaling, neural processing, neuroplasticity, and neuroglial interaction. Direct mechanistic evidence linking Marma stimulation with neuroplastic or neuroglial changes remains limited; therefore, evidence from related somatosensory and acupuncture research is considered supportive rather than direct evidence. A cautious neuroscientific framework is proposed in which peripheral stimulation may influence neural signaling and, with repeated stimulation, potentially contribute to adaptive neural changes. This framework provides a basis for future experimental investigation of *Marma Chikitsa* using neurophysiological, neuroimaging, and neurobiological methods.

1. INTRODUCTION

Marma are described in Ayurveda as vital anatomical sites associated with important structural components and functional significance. *Sushruta Samhita* describes *Marma* in relation to *Mamsa, Sira, Snayu, Asthi,* and *Sandhi* and emphasizes their association with *Prana*. A total of 107 *Marma* sites are described in the classical tradition, distributed throughout the body.[1,2]

Marma Chikitsa involves therapeutic stimulation of these anatomically significant regions. Although its classical explanation is rooted in Ayurvedic concepts, contemporary anatomy provides an opportunity to investigate the neural and sensory characteristics of these regions. Peripheral tissues contain sensory receptors and afferent fibers capable of transmitting mechanical, thermal, and nociceptive information to the central nervous system.[3,4]

Neuroscience demonstrates that neural circuits are not static. Sensory experience and repeated neural activity can produce functional and structural changes within the nervous system, collectively referred to as neuroplasticity.[5,6] Such changes may involve synaptic strength, neuronal excitability, axonal organization, and activity-dependent myelination.

Neuroglial cells also participate in neural function and plasticity. Astrocytes regulate the synaptic environment, microglia contribute to synaptic remodeling, and oligodendrocytes are involved in activity-dependent changes in myelination.[7]

However, direct evidence demonstrating that *Marma* stimulation produces specific neuroplastic or neuroglial changes is currently limited. Therefore, the present review examines *Marma Chikitsa* through established neuroscientific concepts and proposes a cautious framework for future investigation.

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1.1. Aims and Objectives

1.1.1. Aims

The aim of the study was to explore *Marma Chikitsa* from a contemporary neuroscientific perspective, with particular focus on neuroplasticity and neuroglial mechanisms.

1.1.2. Objectives

1. To examine the anatomical and neurophysiological basis of *Marma.*
2. To explore its possible relationship with neural signaling and neuroplasticity.
3. To identify current evidence gaps and potential directions for future research.

2. METHODOLOGY

A narrative literature review was undertaken using relevant literature retrieved from PubMed/MEDLINE, Scopus, and Google Scholar, along with classical Ayurvedic texts and published literature on *Marma Chikitsa*. The search focused on the anatomy and physiology of *Marma*, somatosensory stimulation, neural signaling, neuroplasticity, neuroglial mechanisms, and related neuromodulatory approaches. Relevant peer-reviewed articles, reviews, and classical references were considered. Literature directly relevant to the proposed neuroscientific framework was prioritized, while evidence from related modalities was used only as supportive evidence and not as direct evidence for Marma-specific effects.

3. CLASSICAL FOUNDATION OF *MARMA*

In Ayurveda, *Marma* are described as vital anatomical sites where different structural components converge and where injury may produce serious or life-threatening consequences. *Sushruta Samhita* describes Marma in relation to *Mamsa, Sira, Snayu, Asthi,* and *Sandhi* and emphasizes their association with *Prana*. A total of 107 Mar*ma* sites are described in the classical tradition.

The therapeutic use of *Marma* is based on stimulation of these sites according to the intended clinical purpose. From the classical perspective, *Marma* is therefore not merely a localized anatomical point but a site of functional and vital significance. This distinction is important when attempting to interpret *Marma* through contemporary anatomical and neuroscientific concepts.

4. CONTEMPORARY ANATOMICAL PERSPECTIVE OF *MARMA*

From a contemporary anatomical perspective, *Marma* regions may contain combinations of neurovascular, musculoskeletal, and connective-tissue structures. Depending on their anatomical location, these may include muscles, blood vessels, peripheral nerves, fascia, periosteum, and joints. Such structural relationships may provide a basis for understanding the sensory and physiological responses associated with stimulation of these regions.

Peripheral nerves are particularly relevant because stimulation of tissues supplied by sensory afferents can generate signals that are transmitted toward the central nervous system. Muscles and fascia also contain sensory receptors involved in mechanosensation and proprioception. Vascular structures may contribute to local hemodynamic and autonomic responses.

However, anatomical proximity should not be interpreted as evidence of a specific therapeutic mechanism. Contemporary anatomical interpretation of *Marma* is therefore best considered a framework for identifying potential neural and sensory substrates that can be investigated experimentally (Figure 1).

5. SOMATOSENSORY BASIS OF *MARMA* STIMULATION

Stimulation of peripheral tissues activates sensory receptors that detect mechanical, thermal, and potentially noxious stimuli. These receptors transmit information through peripheral sensory afferent fibers toward the central nervous system. Somatosensory afferents include functionally diverse fibre populations, including Aβ, Aδ, and C fibers, which differ in their conduction properties and sensory functions.

Mechanical stimulation of the skin and underlying tissues can activate low-threshold mechanoreceptors and other sensory afferents. Their signals are conveyed through peripheral nerves to the spinal cord and subsequently through ascending somatosensory pathways for higher-order processing.

From this perspective, stimulation of a *Marma* region may be considered a form of peripheral sensory input capable of engaging somatosensory pathways. However, the specific neural response produced by *Marma* stimulation and whether it differs from stimulation of other anatomical sites remain to be established experimentally (Figure 2).

6. NEURAL PATHWAYS AND CENTRAL PROCESSING

After entering the spinal cord, somatosensory signals are processed through ascending neural pathways that transmit information from the periphery toward higher centres of the central nervous system. These pathways involve multiple spinal and supraspinal relay stations, allowing sensory information to be progressively integrated and modulated before reaching the cerebral cortex.

The thalamus serves as a major relay and processing center for sensory information reaching the cerebral cortex. From the thalamus, somatosensory signals are conveyed to cortical regions including the primary and secondary somatosensory cortices, where information related to touch, pressure, and other sensory modalities is further integrated and interpreted.

Importantly, sensory processing involves reciprocal communication between thalamic and cortical networks rather than a simple one-way transmission. Such interactions allow incoming sensory information to be modified according to ongoing neural activity and contextual demands.

Therefore, repeated peripheral stimulation may influence neural activity across multiple levels of the somatosensory system. Whether *Marma* stimulation produces a distinct pattern of central neural processing, however, remains an open question requiring direct neurophysiological and neuroimaging studies.

7. NEUROPLASTICITY

Neuroplasticity refers to the capacity of the nervous system to modify its functional and structural organization in response to experience, sensory input, learning, environmental demands, or injury. Plastic changes may occur at several levels, including synaptic strength, neuronal excitability, dendritic organization, axonal connectivity, and cortical representation.

Activity-dependent plasticity demonstrates that neural activity can modify the properties and organization of neural circuits. Repeated or patterned

sensory input may therefore contribute to adaptive changes within sensory networks. Structural plasticity can involve alterations in synaptic and neuronal architecture. Sensory systems also demonstrate activity-dependent changes in axonal organization and spinal circuit function.[8,9] These findings provide a biological basis for investigating whether repeated peripheral stimulation could influence neural organization.

In the context of *Marma Chikitsa*, repeated patterned sensory input capable of engaging activity-dependent neural processes. These processes may be investigated as a possible mechanism underlying the proposed therapeutic effects of *Marma Chikitsa*. However, this remains a hypothesis, and direct evidence demonstrating specific neuroplastic changes following *Marma* stimulation remains limited (Figure 3).

8. NEUROGLIA AND NEURAL PLASTICITY

Neural plasticity is not mediated by neurons alone. Neuroglial cells actively participate in the regulation and adaptation of neural circuits. Astrocytes contribute to synaptic regulation, neurotransmitter homeostasis, metabolic support, and modulation of neuronal activity.

Microglia participate in synaptic surveillance, synapse elimination, and synaptic remodeling. Their activity can influence the formation and modification of neural connections.

Oligodendrocytes contribute to myelin formation and maintenance, while changes in myelination can occur in relation to neural activity. Activity-dependent myelination has therefore been proposed as an additional mechanism of neural plasticity.

These findings support a broader concept in which neural adaptation results from interactions between neurons and glial cells rather than from neuronal changes alone.[10,11]

For *Marma Chikitsa*, this provides a potential mechanistic perspective: Peripheral sensory stimulation may alter neural activity, while repeated neural activity could theoretically engage neuron–glia interactions. Nevertheless, direct evidence demonstrating Marma-induced neuroglial changes is currently limited and requires experimental confirmation (Figure 4).

9. *MARMA CHIKITSA* AND THE PROPOSED NEUROSCIENTIFIC FRAMEWORK

Based on established principles of somatosensory physiology and neural plasticity, a conceptual framework can be proposed to investigate the possible neuroscientific basis of *Marma Chikitsa*. The proposed sequence is:

Marma stimulation → peripheral sensory receptor activation → afferent neural signaling → spinal and supraspinal processing → central neuronal activity → neuron–glia interactions → possible neuroplastic adaptation → potential functional effects

Within this framework, peripheral stimulation may activate sensory receptors and afferent fibers, generating neural signals that are processed at spinal and supraspinal levels. Modulation of this sensory input may influence the processing and integration of sensory information within neural networks. Conceptually, this may be related to the proposed *reset* aspect of *Marma Chikitsa*, where "reset" is used descriptively to refer to possible modulation of sensory and sensorimotor processing rather than to a specific, established neural event.

With repeated or patterned stimulation, neural activity may engage activity-dependent mechanisms associated with synaptic and structural plasticity. Neuroglial cells may also contribute to these processes through the regulation of synaptic function, metabolic support, immune signaling, and myelination.[12-14] Thus, the proposed framework connects peripheral sensory input with central processing, neuroplastic adaptation, and neuron–glia interactions.

Research on somatosensory stimulation has demonstrated its potential to modulate central sensory processing and brain network activity.[12,13] These findings provide a broader neuroscientific context for exploring the possible mechanisms of *Marma Chikitsa*.

The proposed framework provides a basis for investigating the possible relationship between *Marma Chikitsa*, somatosensory processing, and neuroplasticity. However, the specific neural pathways and neuroglial responses associated with *Marma* stimulation remain insufficiently understood. Further experimental and clinical studies are required to examine these mechanisms and establish their physiological relevance.

Therefore, this framework should be regarded as hypothesis-generating rather than as evidence of a *Marma*-specific neuroplastic or neuroglial mechanism. It provides a conceptual basis for investigating how *Marma* stimulation may interact with peripheral sensory signaling, central neural processing, and neuroplastic mechanisms (Figure 5).

10. CONTEMPORARY CLINICAL AND NEUROSCIENTIFIC EVIDENCE

Contemporary clinical research has explored *Marma Chikitsa* across musculoskeletal, pain-related, neurological, sleep-related, and other functional conditions. At Pt. Khushilal Sharma Government (Autonomous) Ayurveda College & Institute, Bhopal, *Marma Chikitsa* has been a subject of sustained clinical and academic investigation, with 33 research works completed**,** alongside clinical studies, pilot studies, and case reports across diverse clinical conditions.

The department's research and clinical experience encompass several categories of disorders, including musculoskeletal disorders (osteoarthritis, frozen shoulder, lumbar spondylosis, low back pain, cervical spondylosis, trapezius myalgia, piriformis syndrome, tennis elbow, and plantar fasciitis); neurological and pain-related disorders (sciatica, migraine, headache, cerebral palsy, ulnar neuritis, paralysis, facial palsy, Parkinson's disease, and carpal tunnel syndrome); sensory disorders (tinnitus and sinus-related headache); sleep-related and stress-associated complaints (insomnia and stress-related symptoms); Lifestyle-related disorders (pre-hypertension and prediabetes). Published pilot studies, clinical investigations, and case reports provide additional documentation of research in selected conditions.[14-20]

Institutional records report a cumulative Outpatient Department benefited of 63,321 patients up to 2026, reflecting the extensive clinical application of *Marma Chikitsa* at the institute.

From a neuroscientific perspective, *Marma* stimulation may activate peripheral sensory receptors and afferent pathways, with subsequent processing at spinal, subcortical, and cortical levels. Repeated sensory input and neuron–glia interactions represent potential areas for investigation; however, these mechanisms have not yet been established specifically for *Marma Chikitsa.*

11. PROPOSED HIERARCHICAL NEUROANATOMICAL PATHWAY OF *MARMA* STIMULATION

Mention in flow chart 1.

Potential Mechanistic Consideration: Neuron–glia interactions may be investigated across central nervous system processing levels, but their specific involvement in *Marma Chikitsa* remains unestablished.

Related somatosensory research, particularly acupuncture neuroimaging studies, has reported changes in brain activity and functional connectivity. A 2026 review also discussed findings involving brain networks, neural oscillations, and neurochemical processes, while highlighting methodological limitations and the need to distinguish association from causation.[21] These findings may be considered a related neuroscientific context for understanding *Marma Chikitsa,* but they do not constitute direct evidence of its underlying mechanisms.

Overall, the department's clinical and academic experience, together with emerging neuroscientific research, provides a rationale for further systematic investigation of *Marma Chikitsa.* Future studies using standardized protocols, appropriate clinical outcomes, and objective physiological and neuroscientific measures may help clarify its clinical effects and possible underlying mechanisms.

12. DISCUSSION

12.1. Ayurvedic-Neuroscientific Correlation

The classical *Ayurvedic* understanding of *Marma* is closely associated with the concept of *Prana*. According to *Sushruta Samhita* (Sharira Sthana 6/16), *Marma* sites involve the convergence of *Mamsa*, *Sira*, *Snayu*, *Asthi*, and *Sandhi*. The text further states "*Teṣu svabhāvata eva viśeṣeṇa prāṇāḥ tiṣṭhanti*" (*Sushruta Samhita*, Sharira Sthana, 6/35), indicating the special importance attributed to *Prāṇa* at these sites in classical *Ayurvedic* understanding. *Charaka Samhita* also describes ten *Pranayatana* (vital seats of *Prana*) (*Charaka Samhita*, Sutra Sthana, 29/3), highlighting the importance of vital structures in the *Ayurvedic* understanding of life. Within this framework, *Marma Chikitsa* is understood in relation to *Vata*, *Pitta*, and *Kapha* and the maintenance of *Tridosha* balance.

These classical concepts should not be directly equated with any single modern anatomical structure, nerve, neurotransmitter, or neuroglial cell. Similarly, *Marma* cannot be defined solely by the presence of a nerve or blood vessel at a particular anatomical location. Ayurveda and modern neuroscience represent distinct conceptual frameworks; therefore, their correlation requires the investigation of measurable physiological phenomena rather than a direct equivalence between their terminologies.

The *Ayurvedic* concept of balance may be cautiously explored in relation to modern concepts of neural homeostasis and autonomic regulation.[22] *Marma* stimulation may potentially influence sensory processing and autonomic responses, while its possible association with neuroplastic changes and neuron–glia interactions warrants further investigation. Thus, a neuroscientific perspective provides a complementary framework for investigating the measurable sensory, neural, autonomic, and neuroplastic responses associated with *Marma Chikitsa*, without assuming mechanisms that have not yet been established experimentally.

13. RESEARCH GAPS AND FUTURE DIRECTIONS

Future studies should objectively examine the neural responses associated with standardized *Marma Chikitsa.* Clinical outcomes may be combined with appropriate neurological and brain-imaging methods to assess changes associated with treatment. Repeated assessment may help determine whether such changes persist with treatment. Further research should explore possible neuroplastic and neuroglial involvement, which currently remain hypotheses rather than established mechanisms. A stepwise approach from clinical assessment to appropriate neurological investigations may help clarify the neural effects of *Marma Chikitsa.*

14. LIMITATIONS

The principal limitation of the present review is the limited availability of direct mechanistic evidence on *Marma Chikitsa* and neuroplasticity. Much of the neuroscientific evidence discussed is derived from general somatosensory research or related modalities such as acupuncture.

The clinical application of *Marma Chikitsa* highlights the need for a universally standardized protocol addressing stimulation techniques, frequency, duration, and disease-specific *Marma* points. Variations in stimulation techniques and the absence of validated treatment parameters also present challenges in clinical application. Furthermore, objective assessment of therapeutic outcomes remains an important consideration.

The proposed relationship between *Marma* stimulation, neuroplasticity, and neuroglial activity therefore remains hypothetical until supported by controlled experimental studies.

15. CONCLUSION

Marma Chikitsa can be examined through contemporary neuroscience by considering the sensory and neural processes associated with peripheral stimulation. Peripheral sensory input can engage established somatosensory pathways, while repeated neural activity can produce functional and structural plastic changes. Neuroglial cells also contribute to synaptic regulation, neural homeostasis, and activity-dependent adaptation.

Accordingly, a possible neuroscientific framework suggests that *Marma* stimulation may influence peripheral sensory signaling, central neural processing, and potentially activity-dependent neural adaptation. Various clinical studies on *Marma Chikitsa* have reported positive outcomes in different disorders, providing a basis for further exploration of its possible relationship with neuroplasticity and neuroglial interactions.

Future controlled studies are needed to identify and evaluate suitable neurological assessment and brain-imaging techniques for investigating *Marma Chikitsa*. Such studies may help determine whether these proposed mechanisms can be experimentally demonstrated and clarify the possible relationship between classical *Marma Chikitsa* and contemporary neuroscience.

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17. AUTHORS' CONTRIBUTIONS

All the authors contributed equally in design and execution of the article.

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19. ETHICAL APPROVALS

This study is not required ethical clearance as it is a review study.

20. CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

21. DATA AVAILABILITY STATEMENT

The data analyzed in this review were obtained from publicly available sources, including peer-reviewed articles, observational studies, and surveys accessible through databases.

22. DISCLAIMER/VIEW AND OPINIONS

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***Marma* Stimulation**

(Targeted Mechanical Pressure)

⬇

Peripheral Sensory Receptors and Afferent Pathways

Mechanoreceptor activation

Sensory input transmitted through primary afferent fibers

⬇

Spinal Cord Processing

Dorsal horn transmission and local modulation

⬇

Subcortical Neural Structures

Processing through brainstem and thalamic networks

Potential modulation of sensory and autonomic signaling

⬇

Cortical Integration

Somatosensory cortex and higher-order brain networks

Integration of sensory information

Flow chart 1: Hierarchical neuroanatomical pathway of marma stimulation

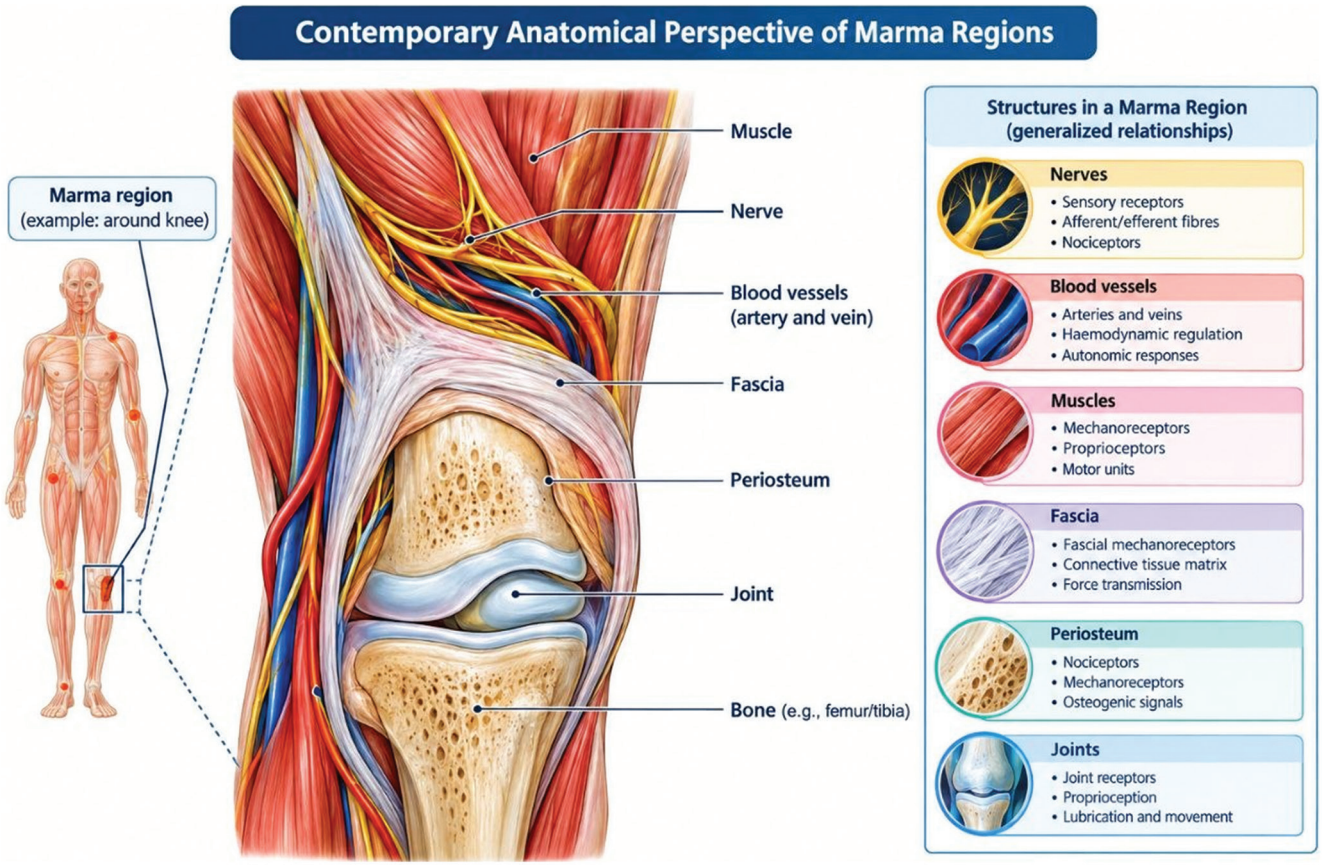

Figure 1: Contemporary anatomical perspective of *Marma* regions showing generalized relationships with neural, vascular, muscular, fascial, and connective-tissue structures

Figure 2. Proposed Somatosensory Pathway of Marma Stimulation

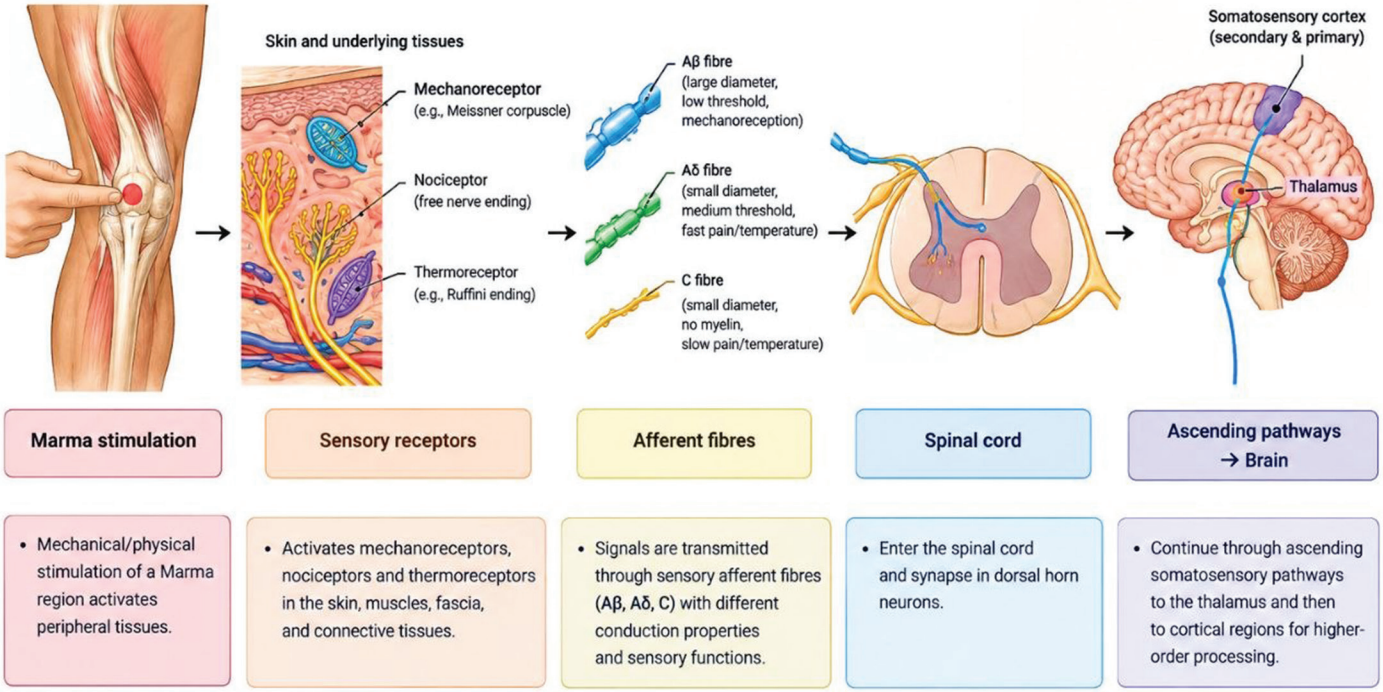

Figure 2: Proposed somatosensory pathway of *Marma* stimulation: peripheral stimulation → sensory receptors → afferent fibers → spinal cord → ascending pathways → brain

Figure 3. Conceptual Representation of Neuroplasticity

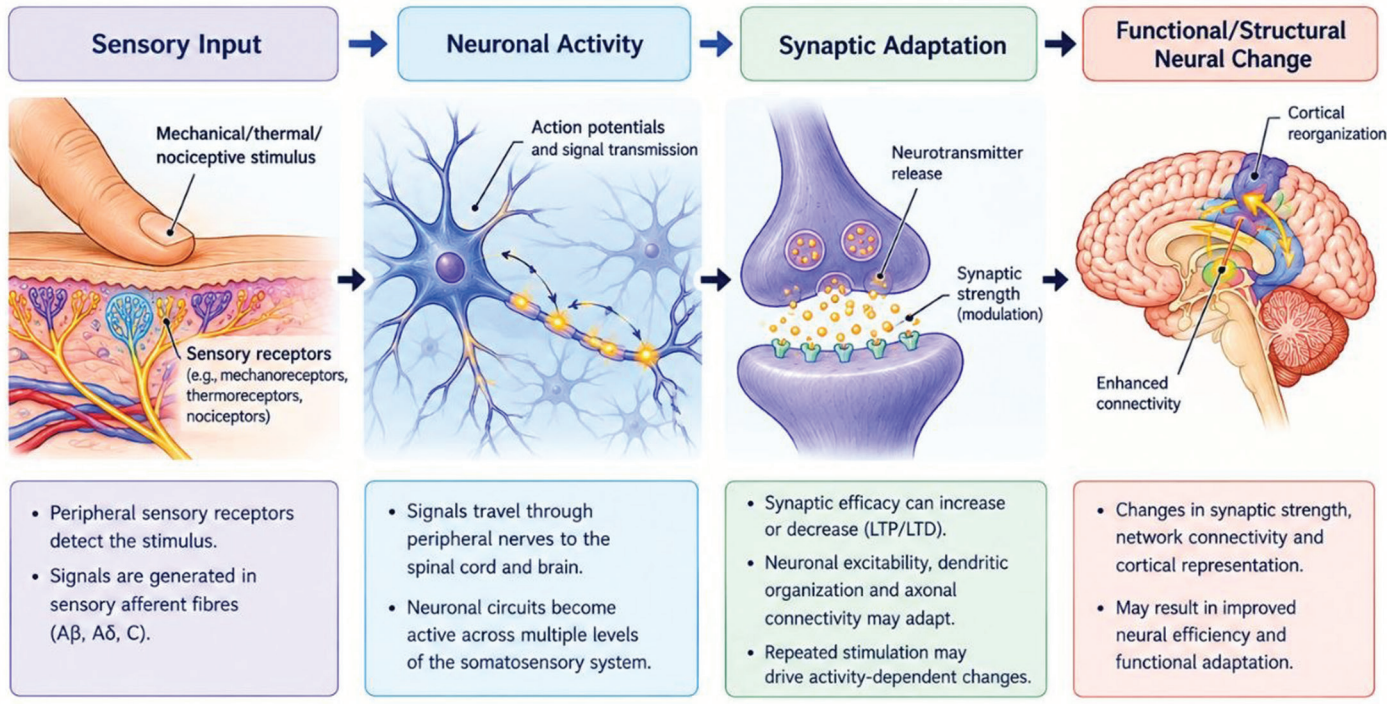

Figure 3: Conceptual representation of neuroplasticity: Sensory input → neuronal activity → synaptic adaptation → functional/structural neural change

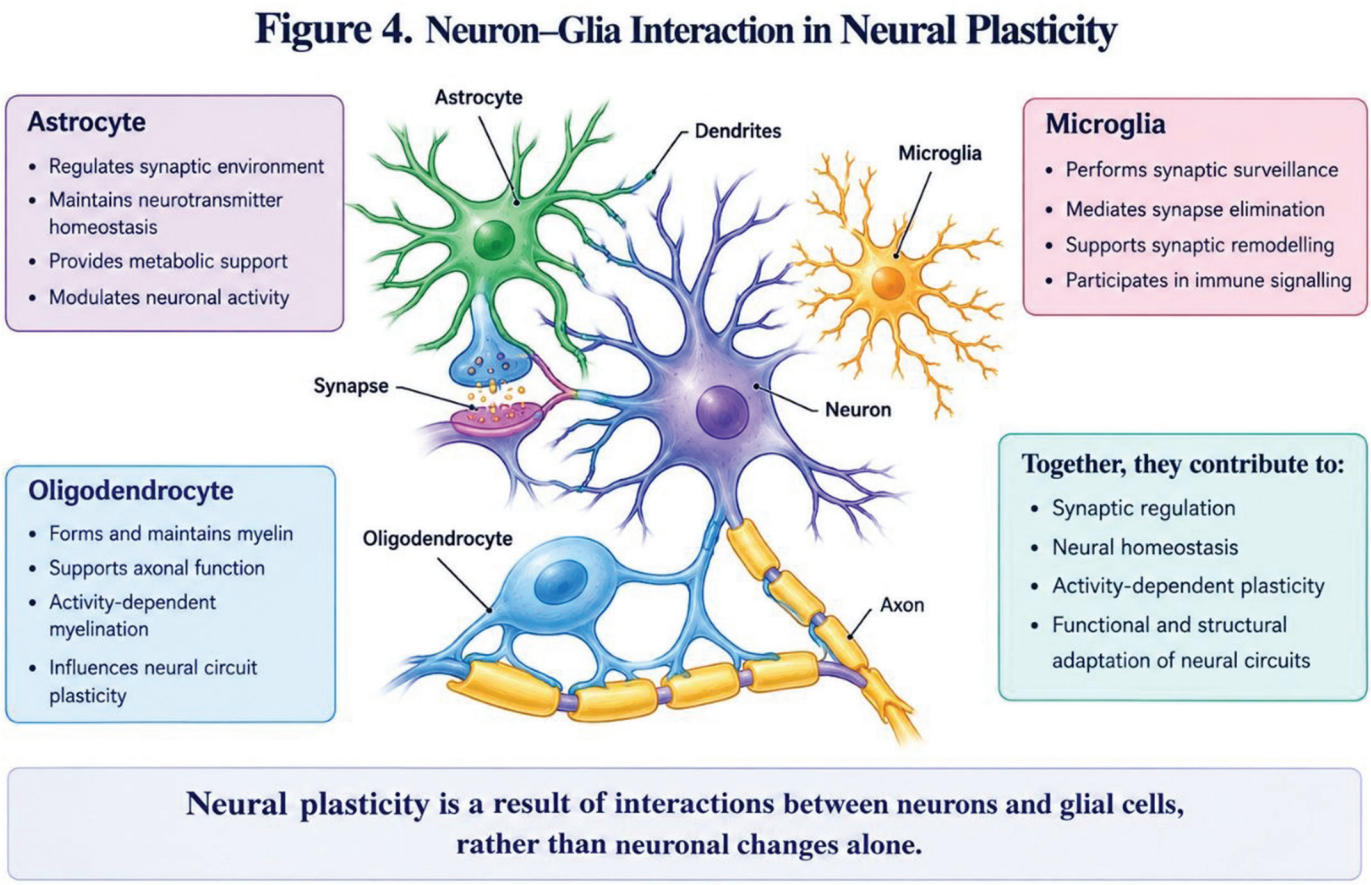

Figure 4: Neuron–glia interaction in neural plasticity showing the proposed roles of astrocytes, microglia, and oligodendrocytes

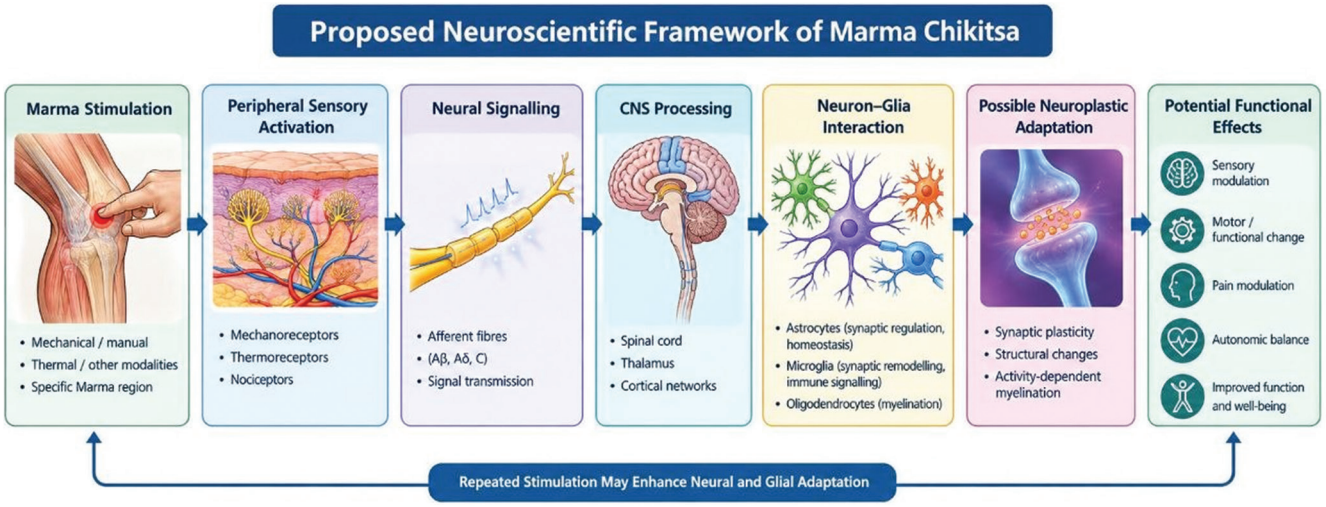

Figure 5: Proposed neuroscientific framework of *Marma Chikitsa: Marma stimulation* → peripheral sensory activation → neural signaling → central nervous system processing → neuron–glia interaction → possible neuroplastic adaptation