

Current Status and Prospects of Transcutaneous Acupoint Electrical Nerve Stimulation-Based Therapy for Pediatric Blepharospasm

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Abstract: Blepharospasm is a common eyelid movement disorder that, although more prevalent in the elderly, also affects children and can significantly impair their visual function and quality of life. Conventional treatments such as medication and botulinum toxin injections have limitations, including high recurrence, strong dependency, and obvious side effects. In recent years, transcutaneous acupoint electrical nerve stimulation (TAENS), a non-invasive therapy integrating modern neuroelectrophysiology with traditional acupuncture theory, has attracted increasing attention in pediatrics. This paper reviews the pathophysiology of blepharospasm from both modern medicine and Traditional Chinese Medicine (TCM) perspectives, and systematically analyzes current research progress, acupoint selection, treatment protocols, and therapeutic outcomes of TAENS in pediatric blepharospasm. The study highlights TAENS's unique advantages in improving efficacy, safety, and treatment compliance in children. Furthermore, it identifies current limitations such as small sample sizes, inconsistent protocols, and a lack of long-term follow-up, and proposes future research directions and technical innovations. This work provides theoretical and practical support for expanding treatment options for pediatric blepharospasm.

Keywords: Blepharospasm; Children; Transcutaneous acupoint electrical nerve stimulation; Non-invasive acupuncture

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1. Introduction

Blepharospasm is a focal movement disorder characterized by involuntary, repetitive contraction of the orbicularis oculi muscle, clinically manifested as frequent blinking, eyelid tightness, visual fatigue, and even functional blindness. While it is more common in older adults, the incidence among children has been gradually increasing in recent years, especially under conditions of visual strain, autonomic imbalance, or psychological stress. Pediatric cases are often underdiagnosed or misdiagnosed due to subtle and atypical symptoms, which may impair

both visual and psychological development, warranting clinical attention. Current treatment options, including anticholinergic medications, botulinum toxin injections, and neuromodulation procedures, are not always suitable for children due to side effects, the need for repeated injections, pain, and dependency risks. Therefore, there is an urgent need for a safer, non-invasive, and more acceptable treatment method with proven efficacy. Transcutaneous acupoint electrical nerve stimulation (TAENS) combines modern electrical stimulation techniques with traditional Chinese meridian theory. By applying low-frequency microcurrents to specific acupoints, TAENS activates local neural responses and central regulatory mechanisms, aiming to unblock meridians, balance qi and blood, and relieve muscle spasms. Compared with traditional acupuncture, TAENS is painless, repeatable, and more acceptable for children. It has shown promise in pediatric conditions such as tic disorders and hemifacial spasm. This study aims to systematically review the application of TAENS-based therapy for pediatric blepharospasm, analyzing its mechanisms, commonly used acupoints, therapeutic outcomes, and current limitations. By integrating TCM syndrome differentiation with modern neural regulation, it proposes optimized pathways for future research and clinical application, offering a safe and effective intervention strategy for children.

2. Pathogenesis and understanding of blepharospasm in Western and Chinese medicine

2.1. Pathophysiological mechanisms in modern medicine

Blepharospasm is a focal dystonia caused by dysfunction in the central nervous system, resulting in involuntary, episodic contractions of the orbicularis oculi muscles that may severely affect daily functioning and visual capacity ^[1].

Modern neuroscience indicates that hyperexcitability of motor neurons in the facial nerve (cranial nerve VII) plays a central role in blepharospasm. As illustrated in **Figure 1**, the facial nerve branches into five divisions—temporal, zygomatic, buccal, marginal mandibular, and cervical—after exiting the skull base, innervating key facial muscles such as the orbicularis oculi, frontalis, zygomaticus, and orbicularis oris. Dysfunction in excitatory and inhibitory neural circuits leads to sustained muscle contraction, presenting clinically as eyelid closure, frequent blinking, and even facial twitching and asymmetry. Abnormalities in the basal ganglia–thalamus–cortex pathway, which regulates voluntary motor control, are considered core mechanisms ^[2]. Functional MRI studies show hyperactivation in regions such as the frontal lobe, putamen, and cerebellum in patients with blepharospasm, indicating a disruption in higher-order motor regulation. Peripheral factors, including ocular dryness, fatigue, or light sensitivity, may further exacerbate muscle activity through trigeminal–facial nerve reflex loops, forming a central–peripheral feedback cycle. Some patients also exhibit comorbid symptoms such as tinnitus, headache, or emotional disturbances, implicating the autonomic and limbic systems in disease modulation. In summary, blepharospasm is a multifactorial condition involving central dysregulation, facial nerve conduction abnormalities, local neuromuscular hyperactivity, and environmental triggers. Understanding these mechanisms provides a foundation for multi-target intervention strategies, including neuromodulation therapies like TAENS ^[3].

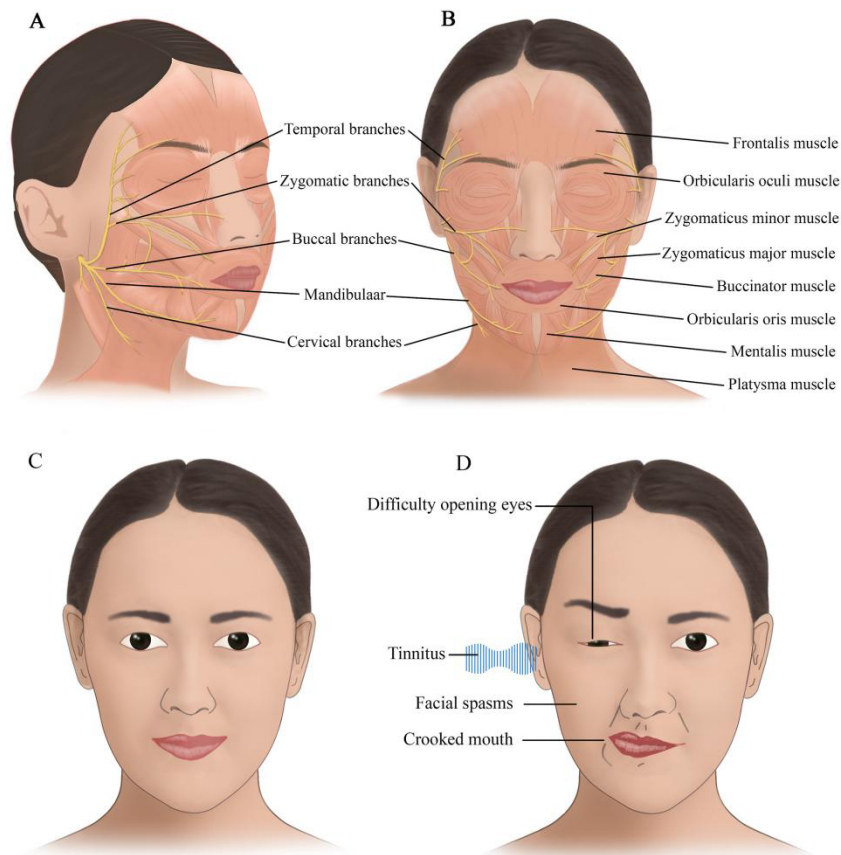


Figure 1. Schematic of facial nerve branches, facial musculature, and typical manifestations of blepharospasm

2.2. Pathogenesis from the perspective of traditional Chinese medicine (TCM)

Although there is no exact equivalent to “blepharospasm” in TCM terminology, its clinical features—such as eyelid twitching, visual blur, and facial asymmetry—are found under disease categories like eye tremors, inability to open eyes, wind-induced deviation, and facial paralysis. Ancient medical texts such as *Zhubing Yuanhou Lun*, *Yinhai Jingwei*, and *Zhengzhi Zhunsheng* attribute its causes to external wind invasion, liver qi stagnation, spleen deficiency with dampness, or kidney essence deficiency. First, external wind and internal liver wind are key pathogenic factors. Wind is known in TCM to be mobile and variable, easily disturbing the upper orifices. When wind-cold invades the face and blocks meridians, qi and blood become stagnant, resulting in eyelid tremors or tightness. Children, with their inherently active liver yang and fragile constitutions, are particularly susceptible to wind-fire agitation triggered by emotional disturbance, overstimulation, or poor diet. Second, spleen deficiency and dampness accumulation can impair the meridian network. The spleen governs transport and transformation. If its function is weak due to congenital deficiency or chronic illness, dampness accumulates and obstructs the yangming meridians, leading to heaviness and disordered eyelid movement. Third, kidney essence deficiency and poor nourishment of sinews may also contribute. The kidneys nourish the marrow and sinews. Insufficient kidney qi weakens muscular control, especially in developing children, resulting in involuntary facial twitching. In TCM, blepharospasm is often a complex interplay of wind, phlegm, heat, and deficiency, with pathogenic factors affecting the liver, spleen, and kidney systems ^[4]. Treatment emphasizes root-strengthening and symptom relief, focusing on calming liver wind, tonifying the spleen, eliminating dampness, and nourishing sinews and blood. Combining acupoint regulation with non-invasive TAENS may effectively activate meridian qi, aligning with the

TCM principle: “when qi flows, pain ceases and function is restored.”

3. Overview of transcutaneous acupuncture and TAENS technology

3.1. Development of transcutaneous acupuncture

With the deep integration of modern medical technology and traditional Chinese meridian theory, transcutaneous acupuncture and transcutaneous acupoint electrical nerve stimulation (TAENS) have emerged as key directions in the development of non-invasive traditional Chinese medical therapies. These techniques apply superficial stimulation to specific acupoints without penetrating the skin, activating local neural responses and meridian conduction. They combine the advantages of traditional acupuncture and modern neuromodulation, making them especially suitable for populations such as children who are less tolerant of conventional acupuncture^[5].

Transcutaneous acupuncture originated from traditional methods like plum-blossom and dermal acupuncture, emphasizing the principle of “non-penetrating stimulation that harmonizes qi and unblocks meridians.” With technological advances, modern devices have integrated low-frequency electrical modules to enhance biological effects. Compared to traditional needling, transcutaneous acupuncture is non-invasive, repeatable, and minimally painful, making it more suitable for treating pediatric neurological and functional disorders. Studies have shown promising effects in regulating neuromuscular excitability, improving local blood flow, and enhancing acupoint activation, positioning it as an important extension of external traditional Chinese medicine^[6].

3.2. TAENS principles and operational methods

Transcutaneous Acupoint Electrical Nerve Stimulation (TAENS) refers to the application of low-frequency pulsed current at specific intensities to body surface acupoints to activate meridian conduction and local neural responses, thereby achieving analgesic, sedative, and autonomic regulatory effects. As shown in **Figure 2**, a typical TAENS device consists of self-adhesive electrode pads, electrode wires, and a pulse control unit. During treatment, the practitioner selects appropriate acupoints (e.g., Jingming, Zanzhu, Taiyang) based on the child’s condition, applies the electrodes, and sets the pulse frequency (usually 1–20 Hz), intensity, and waveform. Each session typically lasts 15–30 minutes^[7].

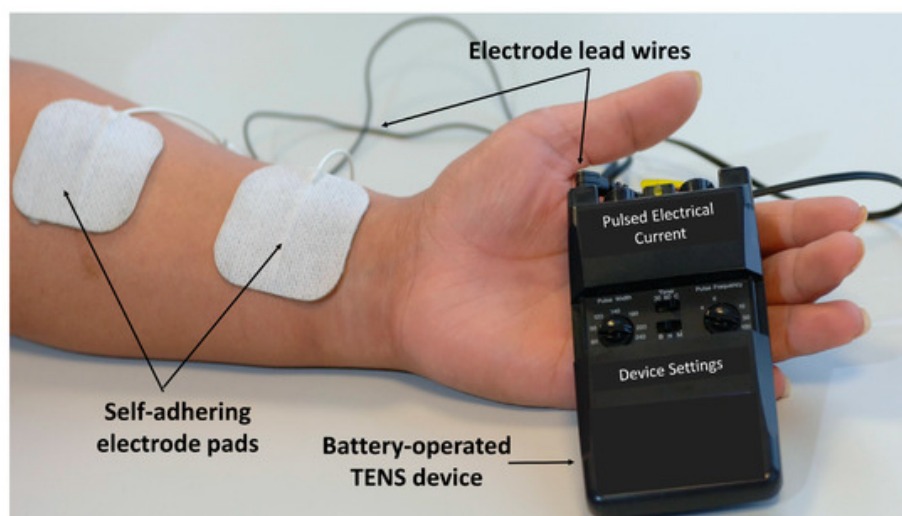


Figure 2. Components and operational diagram of the TAENS device

The therapeutic mechanism of TAENS primarily follows the “skin–acupoint–nerve–central” pathway: electrical stimulation activates skin receptors and nerve endings beneath the acupoints, transmitting signals via the facial or trigeminal nerve to the central nervous system, regulating excitability in areas such as the thalamus and brainstem. This helps to correct the abnormal contraction rhythm of eyelid muscles. Compared to traditional acupuncture, TAENS avoids needle-related pain and fear, significantly improving pediatric compliance, and offers a safe, effective non-pharmacological intervention for facial nerve dysfunctions like pediatric blepharospasm^[8].

4. Current research on transcutaneous acupuncture for pediatric blepharospasm

4.1. Overview of domestic and international studies

As attention to pediatric functional neurological disorders grows, non-pharmacological interventions are increasingly applied in clinical practice. Among these, minimally invasive neuromodulation techniques such as transcutaneous acupuncture and TAENS have become research hotspots. Although epidemiological studies on pediatric blepharospasm remain limited, literature on non-invasive treatments is gradually increasing, particularly focusing on interventions for facial spasm, eyelid dysfunction, and tic disorders^[9].

In China, multiple clinical and experimental studies have preliminarily confirmed the potential of TAENS in modulating facial nerve function and relieving eyelid muscle spasms. Some studies apply low-frequency stimulation to traditional facial acupoints such as Taiyang, Jingming, and Zanzhu, reporting improvements in eyelid opening, reduced blinking frequency, and decreased muscle electrical activity. Preliminary clinical trials with small sample sizes indicate that transcutaneous acupuncture, without reliance on sedatives or botulinum toxin, can effectively enhance eyelid muscle regulation and is superior to traditional acupuncture in safety and compliance among children. Internationally, research has focused on non-invasive treatments for facial palsy, eyelid myokymia, and facial dystonia. Rehabilitation centers in the U.S., Germany, and Japan have widely adopted TENS/TAENS devices for facial muscle function training and neural rehabilitation. These studies emphasize TAENS’s influence on neuroplasticity and motor unit recruitment. For example, guidelines by the American Physical Therapy Association highlight the effectiveness of transcutaneous nerve stimulation in alleviating pediatric facial muscle spasms, particularly for patients unsuitable for medication or invasive procedures. Moreover, foreign studies place greater emphasis on objective and quantitative metrics—such as eyelid closing pressure, eye-tracking data, and quality of life (QOL) scores—enhancing the scientific rigor and comparability of results^[10].

However, several common limitations remain across domestic and international research: Small sample sizes and a lack of multicenter randomized controlled trials (RCTs); Inconsistent stimulation parameters, including frequency, intensity, and duration; Insufficient long-term follow-up to assess sustained efficacy during pediatric development; Lack of standardized acupoint selection and localization, limiting reproducibility and inter-institutional application. In summary, while the clinical use of transcutaneous acupuncture—particularly TAENS—for pediatric blepharospasm is still in the exploratory stage, its non-invasiveness, safety, and high acceptance offer strong development potential. With the standardization of study design, advancement of smart therapeutic devices, and deeper investigation into pediatric neuromodulation mechanisms, TAENS is expected to become an important adjunctive intervention in managing childhood blepharospasm.

4.2. Efficacy observations and safety assessment

Current clinical evaluations of transcutaneous acupuncture—especially TAENS—in treating pediatric

blepharospasm focus on therapeutic effectiveness and adverse event monitoring. Although the number of studies is still limited, preliminary findings suggest that TAENS can effectively relieve symptoms, restore function, and improve the quality of life in affected children.

In terms of efficacy, several small-scale clinical trials and case series have demonstrated varying degrees of improvement after 1–2 treatment courses (10–15 sessions per course, about 20 minutes each). Common indicators include: Alleviation of eyelid-opening difficulty, with increased palpebral fissure width; Significant reduction in blinking frequency, with EMG showing decreased muscle activity; Decrease in frequency and intensity of involuntary facial muscle twitches (e.g., orbicularis oculi, orbicularis oris); Improved physician or caregiver subjective scores (e.g., Modified Ashworth Scale, visual analog scores); Behavioral assessments (e.g., FACES, PEDI) showing enhanced attention and social interaction post-treatment. A prospective study conducted at a tertiary hospital in China reported that in comparison to a control group receiving only routine warm compresses, the TAENS intervention group showed a 36% reduction in eyelid closing frequency—significantly higher than the control’s 12%. Follow-up data also indicate that some patients maintained improvements for weeks to months post-treatment, suggesting sustained neuromodulatory effects.

In terms of safety, transcutaneous acupuncture and TAENS are generally well tolerated due to their non-invasive nature and adjustable intensity, making them especially suitable for younger or emotionally sensitive children. Most studies reported no serious adverse events, with only mild discomfort observed in some cases, such as: Localized skin redness or mild itching at the electrode site; Initial anxiety or irritability in first-time patients; Rare allergic reactions to electrode adhesives, which resolved after discontinuation. Compared to botulinum toxin injections—which can cause complications like ptosis, diplopia, or local weakness—TAENS offers a safer profile. Its simplicity also enables trained family members to assist with home-based treatment, improving treatment frequency and compliance. Nonetheless, stratified studies targeting age-related differences in nerve development, acupoint responsiveness, and electrical current tolerance are still lacking. Future research should aim to optimize stimulation parameters while ensuring safety. Additionally, incorporating multimodal evaluation tools such as imaging, electromyography, and behavioral scales can help establish a standardized efficacy assessment system, providing a more comprehensive understanding of treatment outcomes.

5. Key acupoints and treatment protocol analysis

5.1. Commonly used acupoints and their neuroanatomical basis

In the application of transcutaneous acupuncture and TAENS for pediatric blepharospasm, the selection of acupoints must consider both traditional meridian theory and modern neuroanatomical pathways. Commonly used facial acupoints include Jingming (BL1), Zanzhu (BL2), Sizhukong (SJ23), Taiyang (EX-HN5), Yangbai (GB14), and Sibai (ST2), primarily distributed along the Foot Taiyang Bladder Meridian, Foot Yangming Stomach Meridian, and Hand Shaoyang Triple Energizer Meridian. Jingming, located at the inner canthus, is close to the superior trochlear nerve and the medial part of the orbicularis oculi, making it effective for relieving eyelid spasms and difficulty in opening the eyes. Zanzhu and Sizhukong, located at the eyebrow area, are near the infra-trochlear and frontal branches of the facial nerve, and help modulate upper eyelid muscle tone. Yangbai targets the superior margin of the orbicularis oculi, while Taiyang lies near the main trunk of the superficial temporal nerve, important for regulating overall facial muscle excitability. From a neuroanatomical perspective, these acupoints are located along the distribution areas of the facial nerve and its branches, especially the zygomatic, buccal, and mandibular

branches, which innervate the orbicularis oculi, zygomaticus, and orbicularis oris muscles—precisely the regions involved in blepharospasm. Electrical stimulation delivered through these acupoints reaches local nerve endings, modulates neuromuscular excitability, relieves spasm, and influences central regulation through reflex pathways, contributing to systemic therapeutic effects. Therefore, scientific acupoint selection based on both meridian theory and neuroanatomy not only aligns with the principle of “meridian-guided needling” in TCM but also provides a modern foundation for neuromodulatory treatment design.

5.2. Treatment frequency, course, and combination therapy

Clinical experience suggests that the effectiveness of TAENS for pediatric blepharospasm is closely related to the frequency and duration of stimulation. Most studies apply low-frequency pulses (1–20 Hz) for 15–30 minutes per session, 2–4 times per week, with 10 sessions per course. A typical treatment plan includes 2–3 courses, with noticeable improvements emerging after the first and stabilizing after the second. Stimulation parameters are generally set at the maximum tolerated current below the comfort threshold, avoiding discomfort from overstimulation. Symmetric biphasic waveforms are commonly used to enhance muscle responsiveness while minimizing skin irritation. Throughout treatment, physicians should assess eyelid mobility, facial muscle tension, and blinking frequency to adjust parameters accordingly. In combination therapy, TAENS may be integrated with TCM methods such as herbal hot compresses, eye function training, or emotional-behavioral interventions to enhance therapeutic outcomes. Some studies have also combined TAENS with acupuncture, massage, and light therapy, reporting synergistic effects. For children with comorbid anxiety or tics, psychological counseling may further reduce muscle tone imbalance. In summary, tailoring the frequency and plan of treatment while combining multi-modal interventions can enhance recovery rates and compliance, promoting both functional and neurological rehabilitation in pediatric patients.

6. Pediatric-specific considerations and treatment optimization

6.1. Compliance and cooperation challenges in children

In treating pediatric blepharospasm, compliance and cooperation significantly impact therapeutic outcomes. Due to immature cognitive development, children often have a limited understanding of their condition and treatment, leading to fear or resistance, especially with facial procedures like acupuncture or electrical stimulation. Younger or more emotionally sensitive children may cry, resist, or even terminate treatment prematurely. TAENS, being non-invasive, painless, and gentle, is generally better tolerated than traditional needling. However, the sensation of electrode patches, electrical stimulation, and the duration of sessions may still pose psychological burdens for some children, affecting their engagement and treatment continuity. To improve cooperation, individualized and child-friendly approaches are essential. Pre-treatment explanations using simple language and demonstrations can reduce fear. During sessions, distraction strategies such as cartoons or parental presence can ease tension. For anxious or hyperactive children, shorter sessions with lower stimulation intensity may help them gradually adapt. Medical staff should also maintain effective communication with caregivers to build trust and encourage home support, creating a calm and positive treatment atmosphere. Improving the overall treatment experience and emotional acceptance can significantly enhance adherence and the clinical efficacy of TAENS.

6.2. Personalized treatment pathways

Pediatric blepharospasm presents with considerable individual variation in clinical symptoms, pathogenesis, and

response to treatment. Developing personalized treatment pathways is essential for maximizing effectiveness and safety. Differences in developmental stage, neuromuscular sensitivity, disease duration, and psychological state must be considered, as standardized protocols may not yield optimal outcomes and may even induce resistance or symptom aggravation.

Personalized plans should consider: Age and neurodevelopmental stage — Younger children may benefit from low-frequency, low-intensity, short-duration sessions combined with family-based rehabilitation. Older children can gradually progress to stronger stimulation paired with EMG feedback or behavioral training. Symptom profiles — For difficulty in eye opening, Jingming and Zanzhu are prioritized. Frequent blinking may warrant added use of Yangbai or Taiyang. For comorbid tics, distal calming acupoints like Fengchi and Hegu may be included. Dynamic adjustment — Treatment plans should be adaptable based on ongoing efficacy evaluation and emotional state monitoring. A closed-loop “assessment–intervention–feedback” model helps ensure alignment with the evolving needs of each child. Through scientific and systematic personalized treatment planning, therapeutic precision, sustainability, and family satisfaction can be significantly enhanced.

7. Challenges and future prospects

Although transcutaneous acupuncture and TAENS have shown promise in treating pediatric blepharospasm, current research remains in its early stages and faces several limitations. Firstly, sample sizes in clinical studies are generally small, with a lack of high-quality randomized controlled trials, weakening the strength of clinical evidence. Secondly, there is no consensus on treatment parameters or acupoint combinations, and differences in frequency, duration, and intensity limit comparability and wider application. Moreover, insufficient attention has been given to developmental differences across pediatric age groups, and personalized treatment strategies are underdeveloped. Most studies rely on subjective outcome measures, with few incorporating objective tools such as EMG or eye-tracking analysis. The underlying mechanisms of TAENS also remain to be fully elucidated. Looking ahead, future research should focus on multicenter collaborations to conduct rigorous clinical trials and develop standardized protocols tailored to age groups. The integration of wearable intelligent TAENS devices could enable home-based treatment and remote monitoring, improving compliance and treatment reach. Multimodal assessment tools—such as electromyography, facial motion tracking, and QOL evaluations—will contribute to a more comprehensive understanding of efficacy and help optimize therapeutic strategies. With continued progress, TAENS has the potential to become a safe, accessible, and personalized intervention for pediatric blepharospasm.

8. Conclusion

As a non-invasive, safe, and child-friendly intervention, transcutaneous acupuncture and TAENS provide a novel therapeutic option for pediatric blepharospasm. Current studies indicate that TAENS can effectively alleviate eyelid spasms, improve facial muscle function, and have few side effects, making it suitable for broader pediatric applications. However, challenges such as small-scale research, lack of standardization, and unclear mechanisms persist. Future efforts should focus on strengthening clinical trials, developing standardized treatment pathways, and advancing personalized therapeutic approaches to promote the integration of TAENS into pediatric neurorehabilitation.

Disclosure statement

The authors declare no conflict of interest.

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