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LETTER TO THE EDITOR

Physical rehabilitation for sensorineural hearing loss in childhood: Progress and challenges

Lu Zhang, Pu-Jue Huang, Xue Deng, Jiao Tang, Yang Zhai, Tao Wang

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Abstract

Early intervention for sensorineural hearing loss (SNHL) in childhood is crucial for auditory and language development. In recent years, innovative auditory stimulation techniques and speech therapy strategies, such as middle ear implants, cochlear implants, auditory brainstem implants, and midbrain implants, have provided new avenues for improving patient outcomes. Additionally, basic research advancements in cell reprogramming and regeneration, stem cell therapy, and targeted drug delivery offer promising approaches to meet the individualized needs of children with SNHL. However, many challenges and unresolved issues remain in the treatment of SNHL. This article comments on the case report, which describes a female pediatric patient with SNHL who underwent foot reflexology which led to the normalization of hearing thresholds. Reflexology is considered to have potential benefits in physical rehabilitation, but its efficacy in hearing restoration requires further scientific validation through rigorous clinical trials and large-scale prospective studies.

Key Words: Sensorineural hearing loss; Childhood; Physical rehabilitation therapy; Recent

advances in rehabilitation techniques; Reflexology

Core Tip: Physical rehabilitation for pediatric sensorineural hearing loss (SNHL) encompasses innovative approaches such as auditory stimulation and speech therapy, which are crucial for auditory and language development. Despite advancements in treatments such as middle ear implants and stem cell therapies, challenges in accessibility and efficacy persist. This article reviews the progress and challenges in physical rehabilitation for SNHL, emphasizing the need for further scientific validation of therapies to better address the individualized needs of children with hearing impairments.

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TO THE EDITOR

Hearing impairment in children is a serious issue that can lead to deficits in language, communication, social skills, and motor development[1]. The prevalence of moderate to severe hearing loss in children ranges from 1‰ to 6‰, with 10% of these cases being severe[2]. Sensorineural hearing loss (SNHL), conductive hearing loss, and mixed hearing loss are the three primary types of hearing loss, with SNHL being the most common type of permanent hearing impairment[3]. Early intervention for SNHL is crucial for a child's growth and development.

The etiology of SNHL remains unclear. Studies suggest that prolonged noise exposure, ototoxic drugs, infections, and trauma-induced inner ear inflammation and oxidative stress are significant mechanisms leading to hearing loss[4,5]. Current pharmacological treatments primarily focus on anti-inflammatory and antioxidant therapies. Glucocorticoids are the most widely used anti-inflammatory drugs and have shown efficacy in sudden SNHL caused by noise, ototoxic drugs, and viral infections, with a recovery rate of 38.4% in the study by Lu *et al*[6] following the administration of glucocorticoids. Despite some promising results in animal experiments, antioxidant treatments are not yet predominant in clinical practice[7,8]. Overall, pharmacological treatments have limitations, and there is no definitive effective drug therapy for most types of SNHL beyond some cases of sudden hearing loss.

In recent years, physical rehabilitation techniques for SNHL have rapidly developed, focusing on auditory stimulation, speech training, and early rehabilitation. However, these treatments have issues such as high costs, low public awareness, and the inability to address the root cause of hearing impairment. To complement existing treatments, researchers are exploring various potential therapies, such as gene therapy, stem cell therapy, and foot reflexology. Reflexology, as a non-invasive supplementary therapy, has shown effectiveness in relieving symptoms and improving quality of life in conditions such as cancer and multiple sclerosis (MS)[9]. However, there is limited research on its application in SNHL, and no large-scale studies have confirmed its direct positive impact on hearing restoration. High-quality clinical trials are needed to explore the applicability and efficacy of reflexology in SNHL to better meet the rehabilitation needs of children with this condition.

CURRENT STATUS OF PHYSICAL REHABILITATION TECHNIQUES FOR CHILDHOOD SNHL

Auditory stimulation-based physical therapy

Early auditory stimulation therapy is crucial for the development of hearing and language skills in infants with hearing impairments. Children who receive early intervention show better development in auditory performance, reading comprehension, speech clarity, and language perception than those who receive late intervention[10,11].

For children with SNHL unresponsive to drug therapy or with congenital SNHL, hearing assistive devices should be considered. These include hearing aids (air conduction and bone conduction), bone-anchored hearing aids, middle ear implants vibrant soundbridge (VSB), cochlear implants (CI), auditory brainstem implants (ABI), and auditory midbrain implants. Hearing aids can improve hearing by amplifying sound for those with residual hearing, but they may have limited comfort and speech recognition rates[12]. VSB, a semi-implantable middle ear device, offers stable and efficient signal transmission with higher comfort and fewer sound distortion issues, effectively improving or restoring hearing [13]. However, VSB has strict clinical indications[14]. CI is the most valuable physical therapy for patients with severe to profound bilateral SNHL[15]. For those with disrupted nerve pathways between the cochlear spiral ganglion and the central auditory pathways, ABI can directly stimulate the auditory regions of the brainstem to transmit sound signals to the auditory cortex.

Auditory stimulation therapies provide auditory information to children with SNHL, helping establish correct neural pathways in the brain's auditory processing areas for nearly normal speech and language development[1]. However, these therapies have high costs and limited accessibility. They also only restore hearing and require comprehensive interventions with other rehabilitation methods to further promote speech and language development in children with hearing impairments.

Speech training-based physical therapy

Early auditory development is the foundation for speech and language development in children, preceding the emergence of speech perception, speech production, and language development[16]. Speech training for auditory recognition, including word recognition and phoneme discrimination, helps children identify acoustic features of speech [17]. Combined with auditory stimulation therapies, individualized speech training (including auditory function training, speech and language function training, and speech therapy) is vital for promoting language development in children with hearing impairments. It improves language comprehension and expression, mitigating adverse language development outcomes[18].

However, speech training faces challenges. Children with hearing aids or CIs may have articulation disorders, reduced speech clarity, slower vocabulary acquisition, and reduced vocabulary compared to their peers[19]. Additionally, family members' lack of awareness and involvement in speech rehabilitation can negatively impact the child's auditory and language development[20,21].

Early rehabilitation-based physical therapy

Early rehabilitation emphasizes the importance of interdisciplinary collaboration centered around the family, involving specialists, audiologists, speech therapists, special education teachers, psychologists, and family members[22]. If family decisions negatively impact the development of children with hearing loss, professionals can help family members recognize these adverse consequences[23]. This comprehensive approach supports progress in multiple developmental areas, not just hearing and language. Early rehabilitation plans are tailored to individual hearing conditions and language development levels, including family guidance, social skills training, and cognitive development activities[24].

Early intervention plays a crucial role in the rehabilitation of children with SNHL. Utilizing auditory stimulation techniques, speech training, and interdisciplinary collaboration maximizes the potential for auditory and language development, enhancing treatment outcomes. As recognition of early intervention's importance grows and techniques improve, we can expect better support and improvement in the auditory and language development of children with SNHL.

RECENT ADVANCES IN REHABILITATION TECHNIQUES FOR CHILDHOOD SNHL

Cell reprogramming and regeneration

Researchers[25,26] are attempting to use reprogramming techniques to activate specific transcription factors, such as Myc and Notch1, to promote hair cell regeneration in the inner ears of adult mice. Such research supports the conversion of supporting cells into hair cells in animal models, potentially restoring hearing loss caused by hair cell loss. This method may help develop a clinically relevant approach for hair cell regeneration in mature non-transgenic cochleae, laying the foundation for future hearing restoration through hair cell regeneration.

Stem cell therapy

Stem cell therapy is another potential treatment for SNHL. Studies show that mesenchymal stem cells (MSCs) from various tissues can improve hearing function following single-dose injections[27,28]. MSCs can increase spiral ganglion neuron density, potentially repairing hearing damage. This may involve recruiting homing factors to the damaged area and inducing transdifferentiation into inner hair cells or neurons, or regenerating sensory hair cells to restore hearing [29]. In animal models, stem cell therapy has shown significant effects for SNHL, and some studies indicated that intravenous transplantation of human umbilical cord blood MSCs can restore hearing in deaf animal models[30].

Targeted drug delivery

Researchers have developed new gel formulations, such as AC102, for direct intratympanic injection to deliver drugs specifically to inner ear cells[31]. This method reduces systemic exposure and minimizes adverse side effects, providing a more precise treatment approach. It overcomes the limitations of traditional intratympanic drug injections, such as dexamethasone and type-1 insulin-like growth factor, which do not remain in the middle ear for long. Animal experiments have shown increased hair cell numbers and hearing restoration[32].

Targeted ion channel therapy

Researchers are developing therapies targeting specific ion channels to improve natural hearing in patients with permanent SNHL[33]. Many studies focus on the Kv3 family of channels, crucial for high-frequency sound processing. Noise exposure leads to hearing loss and tinnitus in mice and humans due to overactive auditory brainstem neurons, related to reduced Kv7.2/3 (KCNQ2/3) potassium channel activity. Non-specific KCNQ channel agonists such as RL-81 can prevent noise-induced tinnitus, showing potential as a new treatment for noise-induced hearing loss[34].

Gene therapy

Gene therapy is a significant innovation in treating SNHL, especially for hearing loss caused by specific gene mutations. The Otoferlin (OTOF)-GT project aims to restore hearing loss caused by *OTOF* gene defects by providing a normal *OTOF* gene. Results show that this gene therapy effectively treats childhood SNHL[35]. Additionally, research using special viral vectors, such as adeno-associated virus-mediated gene therapy for acquired hearing loss, has shown positive results, with future steps to verify its safety, sustained gene expression in non-dividing cells, target cell specificity, non-pathogenicity, and low immunogenicity[36].

The diversity and innovation in hearing treatment and rehabilitation offer more effective options for SNHL patients. However, these technologies are still in the research or preclinical stages, requiring further validation and development for clinical application. Each method has specific indications and limitations, necessitating a comprehensive evaluation of suitable treatment strategies based on individual patient conditions.

Foot reflexology

Foot reflexology involves applying gentle pressure to specific areas of the feet to trigger functional responses in the body [36]. Current research on its effectiveness for various diseases, including cancer, MS, diabetes, and SNHL, is mixed and requires comprehensive consideration and judgment. As a non-invasive supplementary therapy, reflexology's effectiveness varies across studies with varying quality.

A 2010 study concluded that there is no convincing evidence to support reflexology's effectiveness for any specific disease. However, some research suggests potential benefits in certain cases, such as pain relief, MS, diabetes, and pediatric conditions. Sajadi *et al*[37] reported positive effects of foot reflexology on managing constipation in 63 MS patients. Toledo *et al*[36] found that reflexology influenced muscle activation patterns and plantar pressure parameters in people with diabetic neuropathy. Miralizadeh *et al*[38] observed that palm and foot massage helped reduce respiratory distress in preterm infants receiving non-invasive ventilation. These studies indicate the potential benefits of reflexology, such as fatigue relief, anxiety reduction, acute or chronic pain management, improved sleep quality, and physiological improvements. They also provide insights into reflexology's possible physiological mechanisms, such as regulating blood flow to affect visceral organ function and stimulating the pituitary gland to release endorphins and enkephalins.

Although reflexology is considered to have certain benefits in improving symptoms and quality of life[9], these studies often have significant methodological limitations. Thus, evidence is insufficient to confirm reflexology's effectiveness and scientific validity. Research design challenges, particularly in achieving blinding, make it difficult to evaluate the therapy's effects accurately.

To date, research on reflexology's impact on hearing restoration is limited, and the existing evidence is primarily based on case studies or studies with design limitations. For instance, in the case report of a child with SNHL, hearing thresholds normalized after 24 weeks of foot stimulation, but the clinical trial lacked a control group[39]. Currently, there is no widely accepted scientific evidence that foot reflexology can directly influence hearing restoration.

CONCLUSION

While reflexology shows potential benefits in some areas, its effectiveness in hearing restoration remains unproven. Future high-quality research is needed to explore reflexology's role in hearing recovery and other diseases, providing a clearer theoretical foundation for this treatment method.

FOOTNOTES

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