

# Clinical and Pathophysiological Features of Coordination Disorders in Sensorineural Hearing Loss in Children

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**Abstract** Sensorineural hearing loss in children is often combined with coordination disorders due to anatomical and functional proximity of auditory and vestibular analyzers in the inner ear. The study of pathophysiological mechanisms of coordination disorder development in sensorineural hearing loss in childhood is important for early diagnosis, disease course prognosis, and development of comprehensive rehabilitation programs.

**Keywords** Sensorineural hearing loss, Coordination disorders, Children, Vestibular system, Postural balance, Inner ear, Auditory analyzer, Vestibular rehabilitation

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## 1. Introduction

The most frequent reason for visits to combined pediatric examination offices of neurologist and otolaryngologist is sensory pathology - hearing loss (total or partial), which particularly in this age period affects subsequent speech development, intellectual abilities, and additionally influences the formation of motor and coordination abilities [1]. According to recent WHO data, the prevalence of congenital and early acquired hearing loss ranges from 1 to 3 cases per 1000 newborns, and in the presence of genetic predisposition or perinatal risk factors, the disease increases several-fold [2].

However, in recent years, research in the field of hearing loss in children has ceased to exist in the narrow understanding of the existing system, with increasing attention paid to the combination of hearing reduction with vestibular and static-coordination disorders, which often accompany sensorineural hearing loss and exacerbate overall child development disorders [3].

Specialized studies have established that damage to peripheral parts of the auditory analyzer in some cases is accompanied by structural-functional changes of the vestibular apparatus [4]. According to foreign research, more than 50% of children with sensorineural hearing loss show various forms of vestibular dysfunction, manifesting as delayed formation of static-locomotor skills - such children have difficulty holding their head, lag behind functional norms: sit late, stand late, experience difficulties in maintaining balance and movement precision, walking [5].

These disorder symptoms are masked as general motor underdevelopment and remain underestimated in clinical practice, especially in early stages. Accordingly, studying and determining coordination and static parameters in children with hearing loss is of fundamental importance for comprehensive assessment of central [6].

Modern research indicates a close relationship between the degree of hearing loss and severity of balance and coordination disorders, where researchers believe that even with minor hearing insufficiency in children, it is possible to detect disruptions in proprioceptive connections and slowing of sensorimotor integration, which correspondingly negatively affects motor function formation and spatial adaptation ability [7].

Besides debatable questions raised regarding the disease: severity level and character of clinical symptoms, instrumental diagnostic methods acquire special value in identifying and quantitatively assessing these disorders, among which stabilometry, computer posturography, videonystagmography, video head impulse test, vestibular evoked myogenic potentials, MRI (with analysis of structural changes in vestibular nuclei and cerebellum) are considered informative, allowing not only to assess the level of disorders but also to monitor the process of effective treatment-rehabilitation and prevent secondary deviations (in motor and speech development) [8].

All this emphasizes the necessity of in-depth study of a comprehensive clinical-diagnostic and therapeutic approach aimed at early detection of static-coordination disorders, with clarification of disease mechanisms for prevention of secondary neurological complications.

**The aim of this study** is to investigate and assess static-coordination balance in children with sensorineural hearing loss.

## 2. Material and Methods

The study material consisted of children with sensorineural hearing loss, aged 8 to 15 years. Clinical and instrumental examination was conducted at the Multidisciplinary Clinic of Samarkand State Medical University, departments of pediatric neurology, otolaryngology department, outpatient clinic of MC SamSMU; during the period 2023-2025. In total, more than 270 children with hearing loss were examined during this period, but 82 children were selected for the study: 47 patients included in the main group and 35 patients comprising the comparison group. The difference between main and comparative groups included the presence of static-coordination signs (in the main group of children).

Depending on the level of hearing disorder degree from the total number (82 patients): 43 patients with first and second degree hearing loss, where children responded to sound at a distance of more than 2.5-3.5 meters; 39 patients with third and fourth degree hearing loss, where children respond to sound originating no more than 3 meters away. Additionally, it should be noted that bilateral hearing loss from the total number of children comprised 54 patients, and unilateral hearing impairment 28 children.

Research methods were conducted in stages: primarily, patients' parents answered questionnaire questions (where they emphasized information about pregnancy period, childbirth, neonatal period; hereditary predisposition to the disease; possible risk factors for sensorineural hearing loss development); clinical-neurological examination; audiologist examination; hearing loss level determination was studied by standard audiometric analysis method; to identify vestibular insufficiency, vestibular and cerebellar tests were used (mainly all types of nystagmus); Ultrasound duplex scanning (USDS), for simultaneous assessment of vascular structure and character/velocity of blood flow. Statistical processing of research results was conducted on a personal computer using application programs.

## 3. Research Results

In the first stage of the study, patients' parents (98% were mothers of children participating in the study) underwent interviews with questionnaire card completion. During history taking, it was noted that most mothers during this pregnancy consulted clinics at their place of residence with various symptoms indicating the presence of some health instability factors, with the highest percentage being diagnosed urogenital infections during pregnancy: TORCH infections (chlamydia/cytomegalovirus/herpes), in more than 65% of cases. Second, in percentage ratio, an unfavorable factor was diffuse goiter, in more than 55% of cases. No less important harmful conditions during pregnancy were identified: gestosis (at different pregnancy terms, in 77% of cases; fetoplacental insufficiency with chronic fetal hypoxia in 36% of cases.

The birth period should be noted separately: in 40% of cases, symptoms of labor activity deviation were noted, for example, rapid or precipitous labor (56%), prolonged labor

(33%); use of cesarean section delivery assistance - 28% of cases. From the total number of examined children, more than 17% of children were born premature and underweight. The main question during parent interviews was the presence of relatives with hearing loss in the family; it turned out that more than 60% of relatives in the first and second generation had cases of hearing impairment, indicating a high percentage of predisposition to the disease. In 13% of cases, mothers during pregnancy, or children after birth (due to infection), used antibiotics (ototoxic, aminoglycosides).

Thus, unfavorable factors during pregnancy, birth period, postnatal period, most likely influenced underdevelopment of sensitive hair cells of the inner ear cochlea, which subsequently led to sensorineural hearing loss.

The main criterion for inclusion in the study, as noted above, was characteristic clinical features of sensorineural hearing loss, confirmed by an audiologist and audiometry method. In accordance with the set goal, it was necessary to determine the level of static-coordination disorders in children with sensorineural hearing loss. But the complexity of identifying changes lay in the fact that all children naturally initially showed speech underdevelopment syndrome (various levels according to hearing loss severity), and consequently reduced cognition. In 100% of cases, general speech underdevelopment was noted (complete absence or insufficient vocabulary, defects in word pronunciation). Additionally, children often showed aggression, unwillingness to communicate, alienation.

The next stage of the study was vestibulometry, according to which the main group of patients consisting of 47 children was determined. In this group, all children showed a descriptor indicating the character of central vestibular syndrome, distinguished by signs of non-systemic dizziness, balance and coordination disorders of different severity degrees.

Using scales to determine quantitative-qualitative disorders of static-coordination disturbances allowed identifying the following signs. True nystagmus was noted only in 2 patients, which was associated with central nervous system damage (natal cervical spinal cord trauma), literature data by Utaganova G.Kh. (2010) confirm these percentage indicators. Nystagmus detected using special glasses (Bartela) revealed atypical asymmetric horizontal nystagmus in 10% of cases, mainly fine-amplitude. In the same group (main), a distinctive feature was the determination of positional nystagmus, i.e., depending on head position identifier, again depending on the nature of disturbance in the posterior cerebral artery area or insufficiency (anomaly, in the form of Chiari symptom), in the posterior cranial fossa area.

Nystagmus had the character of horizontal oscillation, fine-amplitude frequency (in more than 63% of cases). A distinctive property of such nystagmus is preservation of oscillatory movements during head position changes, which again indicates circulatory disturbance in the posterior cranial fossa. In several cases, so-called "cervical" nystagmus, as in previous cases, was short-term and depends on head rotation. Such behavior can be explained by the presence of pathological natal lesions in the cervical spinal cord, which is

confirmed by literature data (Utaganova G.Kh., 2010).

Additionally, the presence of such nystagmus is accompanied by dizziness (in cases when the child can vocalize), or according to the mother, the child develops vomiting urges, indicating a significant problem of impact in vestibular and vascular pathology development. In this group, 61% of children had unilateral hearing loss, with nystagmus detected during head changes, especially rapid position changes from vertical to horizontal or sharp head rotation (test Coutorn), it should be considered that nystagmus in this test was noted toward the healthy ear, indicating labyrinth damage, the pathomechanism being related to organ destruction.

Balance level was checked by standard methods, one of which is Romberg position. Analysis of results showed in 92% of cases, children in the main group had balance disturbance, and when the procedure was complicated (eye closure), more intense balance deviation was revealed, and since patients during the procedure stood unsteadily and the body took a position with backward inclination, we can confidently speak about cerebellar insufficiency condition leading to such result.

According to "finger-nose" test results, in 100% of cases overshooting was noted, additionally in children with unilateral hearing loss, overshooting was revealed on both sides. In two patients (previously noted CNS damage), balance disturbance was noted without special research methods, constant and stable, indicating the presence of a pathological process in the posterior cranial fossa, accordingly this criterion indicates severe disturbance.

Thus, the character and severity degree of static-coordination disorders are interdependent on the degree of hearing insufficiency. All indicators of changes in static-coordination function showed changes with emphasis on vascular insufficiency in the posterior cranial fossa area, which became the basis for more detailed study of this zone, for which patients needed to be examined by ultrasound duplex scanning method for cerebral blood supply level.

Analysis results showed, in most cases, central (magistral) type of circulation, with the asymmetry coefficient index (same-name vessels) being very insignificant. A significant pathological change was the closure of connection in the Circle of Willis, this process was noted in 59% of cases; developmental anomaly in the form of absence of anterior, posterior (on both sides) communicating arteries was found within 5-6%; in 1 patient, vertebral artery hypoplasia (up to 2 mm) was revealed.

That is, in patients (main group) brain hemodynamic disorders were revealed, the most demonstrative deviations were pathological changes at the craniovertebral junction level, which is confirmed by literature data of foreign scientists (I.V. Rychkova, 2007, Abramova M.F., Pykov M.I., 2024), additionally directly correlated with clinical-neurological symptoms - vestibulo-atactic. As noted, during clinical examination of patients and testing, the most significant changes in vertebral artery blood flow were noted in tests with sharp head turns.

Based on data presented in tables and comparison of previously conducted questionnaires, clinical-neurological features, instrumental indicators of audiometry, static-coordination tests and cerebral hemodynamics indicators in children with sensorineural hearing loss, the obtained results indicate that pathological neurological symptoms develop gradually with progressive disease course, while the brain blood flow indicator is in direct predetermination from perfusion pressure level and inversely correlates with brain vascular resistance, indicating direction of adequate blood supply with their metabolic needs.

## 4. Conclusions

Thus, the study result showed that absence or minimal enhancement of linear blood flow velocity according to USDS data in children with sensorineural hearing loss can be considered a prognostically favorable fact. Sensorineural hearing loss in children is characterized by diversity of clinical-neurological manifestations, including speech disorders, cognitive and cognitive function disorders, social maladjustment. Leading clinical signs of central nervous system involvement in congenital sensorineural hearing loss are static-coordination system disorders, whose severity correlates with the degree of hearing reduction, character of structural changes and patient age. The revealed changes in brain blood flow can be considered as one of the key pathogenetic factors in coordination disorder formation in sensorineural hearing loss in children, and the obtained data confirm the necessity of a comprehensive clinical-instrumental approach to assessment and correction of static-coordination disorders in children with sensorineural hearing loss.

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