



Nasal septum deviations in newborns: Literature review

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Abstract. Nasal septal deviations in newborns (NSDN) represent a relevant and relatively underexplored problem in neonatal otorhinolaryngology. Anatomical and functional features of the nasal cavity in newborns determine the high clinical significance of even minor deformities of the septum, which can lead to impaired nasal breathing, difficulty in sucking and breastfeeding, the development of hypoxia and negatively affect the adaptation and general physical development of the child. The purpose was to analyse and systematise contemporary scientific literature data on the aetiology and pathogenesis, clinical manifestations, and diagnostic methods and therapeutic tactics for nasal septal deviation in newborns. An analytical review of scientific publications has been conducted, including original clinical studies, review articles, and dissertations on the anatomical and physiological features of the nasal septum in newborns, the mechanisms of its deformity, and the results of conservative and surgical treatment. The analysis showed that deformities of the nasal septum in newborns can develop both in the antenatal period due to the specifics of intrauterine development, and intranatal – as a result of birth trauma. It was revealed that the clinical manifestations of NSDN vary from minimal functional disorders to severe obstruction of the nasal passages. Long-term consequences of septal deformities can contribute to the development of chronic inflammatory diseases of the nasal cavity and paranasal sinuses, malocclusion, and the development of persistent rhinological pathology at an older age. Contemporary diagnostic methods allow detecting NSDN in the early stages of life, and therapeutic approaches are focused on individualised, mostly gentle tactics, considering age and degree of deformity. NSDN, despite their relatively low prevalence, have significant clinical and prognostic significance. This necessitates the early detection of this pathology, an interdisciplinary approach, and an informed choice of therapeutic tactics to prevent functional disorders and long-term complications

Keywords: infant; birth trauma; neonatal otorhinolaryngology; diagnosis; treatment

Introduction

As noted by S.K. Swain [1], the treatment of NSD in childhood presents significant difficulties for otorhinolaryngologists, primarily due to concerns about the possible negative impact of surgical correction on the growth and development of the middle zone of the face (rhinomaxillary complex). A similar opinion

was shared by other researchers, who emphasised the need for a cautious approach to nasal septum interventions in paediatric practice, especially at an early age [2,3]. In this regard, wait-and-see tactics often prevail in clinical practice, even in the presence of pronounced anatomical changes.

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A number of studies indicate that underestimating the effect of septal deviation on nasal breathing in newborns and young children can lead to the development of persistent functional disorders, including chronic nasal obstruction, oral respiration, and secondary changes in the rhinomaxillary complex [4,5]. Moreover, current data on the outcomes of early correction indicate that with gentle and anatomically oriented techniques, the intervention does not have a significant negative effect on the growth of the facial skeleton [2]. Nasal septal deviation in newborns is one of the poorly studied but potentially clinically significant conditions of present-day paediatric otorhinolaryngology. In current clinical practice, nasal septal deformity is conventionally associated primarily with adolescence and adulthood, which largely determined the limited attention to this pathology in the neonatal period. As a result, the issues of early diagnosis, clinical interpretation, and the prognostic significance of NSDN remain insufficiently developed [1].

Review by S. Erdogdu [4], based mainly on the analysis of classical and early publications, reflected the objectively existing shortage of research on nasal septal deviation in newborns. The researcher emphasised the fragmentary nature of the available data, the significant variability in the frequency of detected deformities, and the lack of unified diagnostic criteria, which significantly complicates the comparison of the results of various studies and the development of evidence-based clinical recommendations. These conclusions are generally consistent with the results of epidemiological and clinical studies of the last two decades, in which the incidence of NSDN varied in a wide range (from 1.5 to 20%) depending on the examination methods used, the timing of the examination, and the interpretation of diagnostic findings [6-9].

However, the limitation of the review by S. Erdogdu [4] noted the insufficient integration of contemporary research data using improved clinical and instrumental diagnostic methods, and the lack of critical comparison of contradictory results regarding the role of antenatal and intranatal factors in the development of nasal septum deformities. A number of studies over the past 10-20 years have demonstrated statistically significant correlations of NSDN with the features of the course of pregnancy and childbirth, body weight, and head circumference of the newborn, and the method of delivery, while other studies do not confirm the leading role of birth trauma, which indicates the multifactorial nature of pathogenesis and the need for a differentiated approach to interpreting clinical data.

Despite historically wide fluctuations in prevalence estimates (from 2.9% to more than 30% in various samples) and contradictory data on risk factors, contemporary research continues to confirm the high incidence of NSDN in newborns and the role of mechanical stress during childbirth. The cross-examination study by D. Jyoti *et al.* [10] reported that nasal septal deviation

was identified in 29% of newborns examined in the first days of life, and that birth trauma, high birth weight, and primiparity were associated with an increased incidence of septal deformities. S. Erdogdu [4] noted in a prospective study that nasal septal deviation was observed in 12% of the examined newborns, and there were no significant differences between the incidence of deformity and the sex of the child or the age of the mother, but there was a connection with difficult childbirth, the number of previous births, gestation period, weight, and head circumference. During a clinical examination, an otorhinolaryngologist evaluates the patency of the nasal passages, asymmetry and protrusions of the septum using anterior rhinoscopy or instrumental methods such as probing and a "strut test" to determine the depth of penetration of the instrument.

Thus, there remains a need in the literature to systematise existing data on the prevalence, aetiology, clinical course, diagnosis, and treatment of NSDN, which is the purpose of this review. The purpose of this study was a systematic analysis of the literature on NSDN, with an emphasis on aetiological factors, pathogenesis, clinical manifestations, diagnostic methods, and therapeutic management strategies. The analysis of the included publications was carried out in accordance with the objectives of the review, which included: investigating the aetiological factors and mechanisms of development of nasal septal deviation in the neonatal period; evaluating existing classifications of deformities; characterising clinical manifestations and diagnostic methods; systematising approaches to the treatment and management of NSDN; and identifying existing knowledge gaps and identifying promising areas for further research.

Materials and Methods

This review was based on a systematic analysis of scientific publications devoted to the aetiology, pathogenesis, clinical manifestations, diagnostic methods, and therapeutic tactics for nasal septal deviation in newborns. The literature analysis covered the period from 1972 to 2025. The choice of this time interval was conditioned by the fact that it was during this period that significant progress took place in the development of neonatal otorhinolaryngology, contemporary methods of endoscopic visualisation of the nasal cavity were introduced, and views on the role of birth trauma and intrauterine factors in the development of nasal septum deformities in newborns were revised.

The search and selection of scientific publications were carried out in the leading international and national bibliographic databases: PubMed, Scopus, Web of Science, eLibrary, and Google Scholar. The search strategy was based on the use of keywords and their logical combinations in English, including: "nasal septum deviation", "septal deformity", "neonates, newborns", "birth trauma", "paediatric otorhinolaryngology", etc. The review included original scientific research

presented by clinical, observational, and retrospective papers, including studies analysing the outcomes of early conservative and surgical treatment. In addition, analytical and systematic reviews were considered, including dissertation research containing summarised data and clinically significant conclusions on the issue under study. Experimental studies have been used to a limited extent and have been considered primarily in the context of the pathogenetic mechanisms of the development of nasal septum deformities.

Additionally, a manual search was performed through the literature lists of relevant publications to identify sources that were not indexed in these databases. In the process of systematisation, preliminary selection and analysis of literary data, auxiliary tools based on artificial intelligence technologies were used exclusively to optimise information search and material structuring. The criteria for including sources in the review were: compliance with the research topic; publication in English; availability of clearly described diagnostic and therapeutic algorithms; sufficient completeness of the presented clinical data; and scientific reliability and practical significance of the conclusions. Publications with insufficiently described methodology, studies with an extremely small sample without statistical substantiation of the results, and sources that have not passed scientific review were excluded from the analysis. The data were selected and interpreted considering the level of evidence and their applicability in contemporary clinical practice of neonatal age.

Consideration of aetiological factors and mechanisms of development of nasal septal deviation in the neonatal period

The issues of nasal septal deviation in newborns were the subject of active study mainly in the second half of the 20th century, which is reflected in a number of fundamental studies on the aetiology, pathogenesis, clinical manifestations, and management tactics of this pathology [11-18]. These studies have laid the foundation for ideas about the role of birth trauma, intrauterine factors, and mechanical influences during childbirth in the development of nasal septum deformities in newborns. However, in the following decades, the number of publications on this topic decreased significantly, which led to a limited number of research and review papers. The classification of NSDN has historically been based on empirical observations and descriptive schemes proposed in the early and mid-20th century. Classical approaches serve as the basis for understanding morphological variants of deformities and their potential connection with aetiological factors, but they have limitations due to the lack of recent prospective analyses.

L.P. Gray [19] identified two main types of nasal septum deviations in newborns: anterior nasal deformity and combined septum deformity, which can occur

both in isolation and in combination. The researcher considered these changes as a consequence of different variants of foetal pressure during pregnancy and childbirth. The authors of the current study partially agree with this classification, since it reflects clinically observed types of deformities, but it did not consider possible impact of connective tissue dysplasia and individual anatomical features of the septum, which may limit the prognostic value of the proposed scheme. In parallel with this, P. Stoksted & U. Schønsted-Madsen [14] proposed a more detailed classification, distinguishing three types of deformities: fixed deviations caused by intrauterine trauma and prone to self-correction; deformities that occur during childbirth and require reposition; changes related to pressure and “modelling” of the foetal head that need therapeutic correction. The researchers recommended the use of specialised examination methods to diagnose these changes. The positive aspects of this classification include an attempt to link morphological changes with aetiological factors and the prognosis of spontaneous correction. However, it should be noted that the classification is not supported by prospective data and does not consider long-term treatment outcomes, which reduces its practical applicability in current clinical practice.

The issues of the prevalence of NSDN and the factors influencing their development have repeatedly been the subject of epidemiological research over the past two decades (2003-2023). The data indicate variability in the frequency of detection of NSDN, reflecting differences in survey methods, age assessment criteria, and population characteristics of the samples. In particular, A.S. Harugop *et al.* [6], conducted a prospective study of 250 newborns on the 2nd day of life using the “strut test” (Gray’s rods) and nasal septal deviation was detected in 49 children, which is approximately 20% of the sample.

Some conclusions of A.S. Harugop *et al.* [6] can be agreed upon, since the proposed “strut test” demonstrated high simplicity and objectivity of measurement, which is important in a neonatal population with limited opportunity for full active cooperation. The proportion of revealed deformities (~20%) is comparable with the data from other retrospective series, in which the prevalence of NSDN ranged from 10% to 30%, depending on the diagnostic method (for example, endoscopy, clinical rhinoscopy, or instrumental testing) [4,10]. This is consistent with the observation that even moderate septal abnormalities in newborns are not a rare phenomenon.

L.P. Gray [20] conducted a large-scale comparative study that included both neonatal observations (2,380 Caucasian newborns) and morphological analysis of 2,112 skulls of adults from five ethnic groups (Europeans, Indians [Asians], Chinese, Africans, and Australian Aborigines), and 918 mammals, including 266 primates, 457 other placental and 185 marsupials. In newborns,

a straight nasal septum was detected in 42% of cases, a curved one in 27%, and a twisted one in 31%. Deformity of the anterior cartilaginous region was observed in approximately 4% of newborns. A similar distribution of shapes was observed among adult skulls: straight septum – 21%, curved – 37%, twisted – 42%. L.P. Gray [20] also proposed a method of nasal testing in newborns using 6x2 mm test rods, which allowed quantifying anatomical abnormalities.

Critical analysis of the study by L.P. Gray [20] showed that it has indisputable value for understanding the morphological diversity of the nasal septum and the possible influence of congenital deformities on the further development of the facial skeleton. However, a number of limitations should be considered: the rod testing method mainly evaluates the anterior part of the nose and does not reflect a complete picture of the entire septum, and in the sample of newborns there is no detailed stratification by obstetric factors such as birth trauma, foetal position and type of delivery, which limits the possibility of identifying cause-and-effect relationships. In addition, a comparison with the morphology of adult skulls and mammals illustrates evolutionary and ethnic differences, but does not directly predict clinical ones.

F. Jeppesen & I. Windfeld [11] conducted one of the largest classical prospective observations of the condition of the nasal septum in newborns, revealing cartilage dislocation in 1.45% of 9,707 living newborns during routine examination and in 3.19% during in-depth rhinological assessment of 907 children. The researchers made an important conclusion about the dominant role of mechanical influences in the antenatal and intranatal periods: two thirds of the cases were most likely associated with intrauterine trauma or early labour, and the remaining third with trauma caused by internal rotation of the foetal head. F. Jeppesen & I. Windfeld [11] noted a more frequent occurrence of dislocations in primiparous women and in multiparous women with a prolonged second stage of labour, and the absence of spontaneous correction without reposition using the Metsenbaum method, which showed good results in their series.

B. Jazbi [12], summarising the data of clinical observations, described in detail the aetiology and pathogenetic mechanisms of NSDN, emphasising the leading role of birth trauma and mechanical factors during childbirth. The researcher also presented diagnostic approaches and possibilities of early corrective treatment using specialised instrumental techniques. Overall conclusions by B. Jazbi [12] remain relevant, as contemporary research confirms the importance of mechanical stress during childbirth as one of the key factors in the development of septal deformities [4,10]. However, methodology by B. Jazbi [12] has limitations: there is no standardisation of instrumental measurements and control of related factors (for example, foetal

position or obstetric tactics), which makes it difficult to compare directly with more recent prospective studies.

Contemporary epidemiological data have confirmed that mechanical factors of childbirth remain significant in the development of nasal septum deformities in newborns, however, the frequency of detection of NSDN in later studies varies and often depends on the diagnostic algorithm. For example, A.S. Harugop *et al.* [6] showed a prevalence of approximately 20% when using the “strut test”, and D. Jyoti *et al.* [10] found comparable proportions in institutional screening. These are higher scores compared to the results by F. Jeppesen & I. Windfeld [11] may reflect differences in examination methods, and the greater sensitivity of instrumental approaches compared to purely clinical rhinoscopy used in early studies.

It is critically important to note that the classical study by F. Jeppesen & I. Windfeld [11] was limited by the lack of standardised instrumental criteria and stratification (grouping) by influencing factors, and focusing on morphological features without a longitudinal assessment of functional outcomes. Contemporary studies emphasise the need to use objective techniques (nasal endoscopy, rhinometry) and consider concomitant perinatal factors to more accurately assess the prevalence and clinical significance of NSDN. Thus, the findings by F. Jeppesen & I. Windfelds [11] remain fundamental to the historical context, but require interpretation in the light of contemporary approaches to the diagnosis and analysis of risk factors.

A prospective study by K.S. Na *et al.* [7], which included 131 women and their newborns, used an otoscope for rhinoscopy in combination with a cotton swab test to detect nasal septum deformities. The researchers set the frequency of NSDN at 11.5%. When analysing factors potentially influencing the formation of deformities, such as the age and parity of the mother, obstetric history, duration of labour and the second period, type of delivery, body weight and gestational (intrauterine) age of the child, no statistically significant dependencies were found. These results suggest that intrauterine and birth mechanical effects may not be the leading factors in the development of all types of neonatal nasal septum deformities.

It is important to critically assess that the limited sample size and the diagnostic method used (otoscope and cotton test) may underestimate the frequency of NSDN and not reflect more subtle or functionally significant changes in the septum. Compared to larger-scale studies such as by F. Jeppesen & I. Windfeld [11] and L.P. Gray [20], where rhinoscopy and instrumental tests with a more detailed morphological assessment were used, indicators provided by K.S. Na *et al.* [7] look understated. Studies of the last 10-20 years, for example, by A.S. Harugop *et al.* [6] and D. Jyoti *et al.* [10], confirmed a higher prevalence of NSDN (up to 20%), which indicated the need to standardise

diagnostic methods and consider instrumental factors in epidemiological assessments.

In a prospective study by K. Uygur *et al.* [8], which included 195 mothers and 200 newborns (including 10 twins), using anterior rhinoscopy, it was found that nasal septal deviation were mainly observed in children born through the natural birth canal, while among newborns after cesarean section, the frequency of deformities was significantly lower. The researchers noted a statistically significant correlation between the frequency of NSDN and the features of the course of pregnancy and childbirth, the method of delivery, and the circumference of the newborn's head ($p < 0.05$). Based on these data, it is proposed to conduct a thorough rhinological examination in newborns with prolonged labour, enlarged head circumference, and after natural delivery.

A critical analysis of the study showed that K. Uygur *et al.* [8] made an important contribution to understanding the influence of obstetric factors on the development of NSDN. The diagnostic method – anterior rhinoscopy – limits the possibility of detecting latent or functionally significant deformities, especially in the posterior parts of the septum. The results are somewhat at odds with the data provided by K.S. Na *et al.* [7], who did not reveal a statistically significant dependence of NSDN on obstetric factors, and with the observations of A.S. Harugop *et al.* [6], where the frequency of deformities was also comparable with epidemiological estimates. These differences can be explained by both methodological features and differences in samples and diagnostic criteria, which highlights the need for standardised approaches and multicentre research in this area.

A prospective study by A. Bhattacharjee *et al.* [9], conducted at the Silchar Medical College Hospital from September 2002 to August 2003, examined 200 newborns aged 0-4 days. The researchers identified a nasal septal deviation in 29 children (14.5%). The greatest risk of deformities was observed in newborns with high birth weight, in children born through the natural birth canal from first-time mothers (55%), and in cases of foetal position disorders in utero, mainly with pelvic presentation (45%), and prolonged labour. Based on these data, the researchers emphasised the significant role of antenatal and intranatal factors in the development of NSDN and recommended early detection and screening in the neonatal period for timely correction and prevention of possible long-term complications.

Critical evaluation of the study by A. Bhattacharjee *et al.* [9] showed its value for identifying risk factors for the development of NSDN, however, the limitation of the study should be considered: a relatively small sample size (200 newborns) and the lack of long-term dynamic follow-up, which makes it difficult to assess the progression of deformities with age. The results are generally consistent with the data by K. Uygur *et al.* [8], confirming the influence of the method of delivery and

the body weight of the newborn on the frequency of NSDN, but differ from the observations of K.S. Na *et al.* [7], where no statistically significant association with obstetric factors was found. These discrepancies emphasised the need to standardise diagnostic methods and conduct prospective studies involving several clinical bases to clarify the effect of perinatal factors on the morphogenesis of the nasal septum.

According to A.S. Yunusov & M.R. Bogomilsky [5], the development of nasal septal deviations is conditioned not only by the influence of antenatal and intranatal factors, but also by a hereditary predisposition, including structural features of the facial skeleton, configuration of the nasal cavity, and individual growth variants of cartilage and bone structures. The researchers pointed out the possibility of intergenerational transmission of certain forms of nasal septum deformities, which is consistent with the concept of genetically determined morphotypes of the facial skull. A similar opinion was confirmed in the research by T.E. Hughes *et al.* [21], devoted to the investigation of the heritability of craniofacial and dental characteristics, which showed that similar facial and occlusal (bite-related) features are often found in siblings, and are also transmitted from parents to offspring, even in unrelated families.

However, it should be noted that most of the studies considering the genetic component of NSD are mainly descriptive in nature and are not supported by molecular genetic or large-scale population studies. The publications emphasised that hereditary factors are most likely realised through their influence on the growth and remodelling (restructuring) of the cartilage and bone tissue of the nasal septum, and on the general patterns of craniofacial development, however, isolated “risk genes” for nasal septum deformities have not yet been identified. This distinguishes NSDN from a number of other craniofacial abnormalities for which the genetic markers (indicators) have been studied in more detail.

Comparison of data by A.S. Yunusov & M.R. Bogomilsky [5], based on the results of recent research, concluded about the multifactorial nature of nasal septal deviation, in which a hereditary predisposition forms the anatomical basis, and antenatal and intranatal effects act as trigger (provoking) factors of clinical manifestation (manifestations of the disease). The insufficient representation of genetically oriented research highlighted the relevance of further interdisciplinary (joint specialists of different profiles) work involving methods of medical genetics, craniofacial morphometry, and long-term clinical observation.

In a comparative study by L.F. Grymer & B. Melsen [22], performed on 41 pairs of identical twins, showed that deformations of the anterior nasal septum, represented mainly by cartilaginous tissue, were detected in 22% of the examined, while changes in the posterior (bony) septum were recorded in 74% of individuals. Analysis of the intrapartum distribution of

deformities demonstrated a low degree of concordance (consistency of indicators) for anterior cartilaginous changes, which allowed considering them as predominantly exogenous and probably related to mechanical and traumatic effects in the antenatal and intranatal periods. On the contrary, the high frequency and relative symmetry of posterior bone deformities within twin pairs indicate a significant role of the patterns of normal growth and remodelling of the rhinomaxillary complex, realised with the participation of both genetic and epigenetic (regulatory) factors of gene expression. However, the limited sample size and the lack of dynamic follow-up in neonatal and childhood do not allow extrapolating (extending) the data obtained to the clinical course of nasal septal deviation, however, the study by L.F. Grymer & B. Melsen [22] remains an important argument in favour of a differentiated approach to the interpretation (assessment of the condition) of cartilaginous and bony deformities of the nasal septum.

Thus, the researchers emphasised that both genetic and epigenetic factors play a significant role in the development of nasal septal deviation in newborns; however, a number of studies have shown that this pathology can be hereditary, since in families with diagnosed nasal septal deviation in parents, similar changes are often detected in newborns. The researchers noted that most dislocations of the nasal septum tend to recover spontaneously within a few days, but severe deformities lead to functional, anatomical, cosmetic, and even systemic disorders. Special attention was paid to the importance of newborn screening, which allows timely detection of pathology and reduces the risk of complications [9].

To summarise, the development of NSDN is a multifactorial process based on intrauterine mechanical effects, obstetric conditions of delivery, and the influence of the order of delivery. The high heterogeneity of prevalence data highlights the need for standardisation of diagnostic criteria, and the introduction of early screening (examination) programmes in the neonatal period is an important area for the prevention of respiratory disorders and ensuring optimal growth of the facial skeleton. Along with this, it should be noted that the frequency and aetiological factors of NSDN remain insufficiently studied to date. This determines the relevance of further research in this area, which is important not only for paediatric otorhinolaryngology in the Republic of Uzbekistan, but also for international clinical practice.

Characteristics of clinical manifestations and diagnostic methods

The clinical manifestations of NSDN cover a wide range of symptoms associated with impaired nasal breathing. As noted by S.K. Swain [1] and A.S. Erdogdu [4], in such children, difficulty in nasal breathing can be both permanent and manifest itself mainly during feeding and crying, which leads to difficulty sucking and,

often, refusal to breastfeed. Such functional disorders are accompanied by snoring, episodes of sleep apnoea, severe irritability, and sleep disorders. A.S. Erdogdu [4] emphasised that with significant deformation of the septum, frequent regurgitation (return of stomach contents) and insufficient body weight gain were observed, which was associated with a restriction of adequate food intake.

An objective examination, including anterior rhinoscopy and testing of the patency of the nasal passages, revealed asymmetry of the nasal passages, difficulty in passing the probe through one of the halves of the nasal cavity, and the presence of mucopurulent discharge during congestion [1,6]. The importance of early detection of NSDN is emphasised by the physiological feature of newborns as obligate (obligatory) nasal breathers, which makes compensatory breathing through the mouth impossible when nasal flow is obstructed [7,20]. Critically, it should be noted that existing studies are limited by small samples and the variability of diagnostic methods: for example, A.S. Harugop *et al.* [6] used the "strut test", which allowed to evaluate mainly the anterior part of the septum, whereas S.K. Swain [1] and A.S. Erdogdu [4] relied on clinical and instrumental observations, but also did not fully cover the posterior region. This limited the possibility of a standardised assessment of the severity of deformities and a predictive interpretation of their functional consequences. A comparison of data from different researchers indicates the need to unify diagnostic criteria and systematise observations to develop recommendations for the early detection and correction of NSDN.

Clinical manifestations of respiratory disorders in newborns are characterised by high variability and polymorphism. According to S. Blackburn [23] and J.M. Richard *et al.* [24], the severity of symptoms depends on the degree and duration of hypoxia, the time of its occurrence – antenatal, intranatal, or postnatal – and on concomitant pathology. It should be borne in mind that research on this topic is limited to small cohorts and a variety of diagnostic criteria, which makes it difficult to compare data and form unified clinical recommendations.

The most characteristic manifestations in newborns with nasal septum deformity are signs of respiratory disorders, including tachypnea (over 60 respiratory movements per minute), retraction of intercostal spaces, involvement of auxiliary muscles in breathing, moaning type of breathing, and perioral or generalised cyanosis [6,11,19]. These symptoms reflect the development of respiratory failure and, based on the clinical picture, may mimic neonatal respiratory distress syndrome or congenital choanal atresia, making it necessary to conduct a thorough differential diagnosis [25]. A critical analysis of existing studies has shown that most of the data is based on limited cohorts and non-standardised

diagnostic criteria, which makes it difficult to compare results and form standardised approaches. Simultaneously, current prospective observations confirm that early detection of respiratory disorders associated with septal deviation is key to preventing secondary complications such as impaired sucking, delayed physical development, and increased frequency of respiratory infections.

The main method of initial examination for suspected nasal septum deformity in newborns is anterior rhinoscopy, which allows visualising the position of the septum, identifying the presence of its displacement or dislocation, and assessing the condition of the nasal passages [11,19]. In some cases, palpation using a probe or a button probe is used to clarify the mobility and fixation of cartilaginous structures, which increases the information content of the examination and facilitates the diagnosis of latent deformities. A critical analysis of existing techniques has shown that although anterior rhinoscopy is an affordable and safe procedure, it is limited by the assessment of the anterior septum and may underestimate posterior or combined deformities, which is confirmed by comparative studies using computed tomography and acoustic rhinometry [26,27]. This indicates the need for an integrated approach to the examination, including a combination of visual, palpatory, and instrumental methods for a more accurate assessment of the anatomy of the nasal septum in newborns.

Modern imaging methods, including endoscopy of the nasal cavity, provide a more detailed understanding of the morphology of the septum and the nature of the deformity, allowing the clinical picture to be recorded for subsequent dynamic observation [28]. Critically, it should be noted that endoscopy provides high resolution of the anterior and middle parts of the nasal septum, however, the assessment of the posterior sections remains limited, and the procedure itself requires special training and experience of an otorhinolaryngologist. Comparative studies have shown that the combination of endoscopy with acoustic rhinometry or computed tomography significantly improves diagnostic accuracy and allows objective documentation of the progression of deformities in newborns [26,27].

Advanced imaging methods for nasal septal deviation in newborns

In recent years, endoscopy of the nasal cavity has been considered as one of the most informative imaging methods for nasal septal deviation in newborns. Even the classical studies by L.P. Gray [19] emphasised that clinical examination and anterior rhinoscopy do not allow an adequate assessment of the posterior nasal septum, where clinically significant deformities are often localised. Similar conclusions were drawn by P. Stoksted & U. Schønsted-Madsen [14], who pointed out the limited diagnostic capabilities of standard examination and the need for more accurate imaging

methods to detect dislocations and fixed deviations of the septum in newborns.

Studies have also shown that endoscopic examination of the nasal cavity allows visualising in detail the degree and nature of the deformation, the condition of the cartilaginous part of the septum, and concomitant changes in the mucous membrane. K. Uygur *et al.* [8], using anterior rhinoscopy in combination with instrumental methods, demonstrated a higher detection of deviations and dislocations of the nasal septum in newborns, especially during natural delivery. In subsequent studies, I. Tasca & G.C. Compadretti [30], T. Aziz *et al.* [31] and other researchers emphasised that video endoscopy contributes to a more accurate differentiation of transient and stable forms of deformity and can be used as a method of dynamic observation in the early neonatal period. However, there is a lack of standardised video endoscopic criteria for assessing nasal septal deviation in newborns, and a limited number of prospective studies on the prognostic value of the detected changes, which underlines the need for further development of this diagnostic area.

I. Teul *et al.* [26] analysed the nasal cavity with bone structures and septum on CT scans of 105 spontaneously aborted fetuses (57 male and 48 female) aged 12 to 40 weeks of pregnancy. The purpose of the study was a morphometric assessment of the development of the nasal cavity using tomographic scanning methods and the identification of anatomical variations. The use of computed tomography in newborns with nasal septum deformities was limited due to radiation exposure and was carried out mainly when concomitant anomalies of the facial skeleton were suspected. Despite the limited number of direct studies of computed tomography (CT) in newborns with septal deformities, computed tomography is widely considered in the literature as an informative method for assessing the anatomy and variations of the nasal septum, especially in the paediatric population and when planning surgical interventions [26].

The diagnosis of NSDN is based on a combination of clinical assessment with the growing use of instrumental techniques. During a clinical examination, an otorhinolaryngologist evaluates the patency of the nasal passages, asymmetry and protrusions of the septum during anterior rhinoscopy or using probe/strut methods to check how far the instrument penetrates. For example, the study by A.S. Harugop *et al.* [6] examined 250 newborns on the 2nd day of life using the "strut test" and observed the NSDN in ~20%. In this case, the rods extending up to the 4 cm mark were considered normal, while the tool stuck up to this mark indicated the presence of a deviation of the partition on the corresponding side.

Instrumental methods allow clarifying the anatomy and functional disorders of the nasal cavity. Acoustic rhinometry allows quantifying the minimal cross-sectional area (MCA) and the volume of the anterior

part of the nasal cavity, which is especially important when comparing between the sides and during dynamic observation. Studies conducted, for example, by M. Baczek *et al.* [32], demonstrated the standard values of MCA and the volume of the anterior part of the nose in newborns 2-4 days old, which allowed creating control standards and using them to assess the functional state of the nasal septum. A comparison of the results of acoustic rhinometry with imaging methods was also described. B. Mamikoglu *et al.* [27] demonstrated that acoustic rhinometry has moderate sensitivity (~54%) and specificity (~70%) for detecting anterior septal deformity, while a statistically significant correlation was found between the minimum transverse area and signs of deviation on CT.

Overview data provided by T. Aziz *et al.* [31] emphasised that acoustic rhinometry, rhinomanometry, and peak nasal inspiratory flow are practical methods

for assessing nasal patency, including in the paediatric population, due to their relative simplicity and minimal requirements for patient cooperation. L.P. Gray [19] noted the need for early diagnosis and correction of nasal septal deviation in children, emphasising that untimely treatment may contribute to the development of chronic upper respiratory tract pathology. It is also worth noting the rare cases when early surgical intervention (closed reduction) in the first weeks of life was used with good results, especially with pronounced nasal septal deviation or with significant respiratory/nutritional disorders [3]. The differential diagnosis of NSDN is a key point, since the symptoms of nasal obstruction may be similar in different congenital and acquired pathologies. Below are the main conditions that should be considered, and methods to distinguish them from the true nasal septal deformity are shown in Table 1.

Table 1. Main pathologies to be differentiated

Pathology	Clinical features / distinguishing features
Choanal atresia / choanal stenosis	In case of bilateral atresia, respiratory failure immediately after birth, which increases during feeding; when trying to insert a probe through the nostril, the probe does not pass; visualisation: endoscopy and CT scans demonstrate the absence of choanal patency
Nasal stenosis (piriform aperture stenosis, CNPAS)	Narrowing in the anterior part of the nasal cavity, manifests itself as respiratory obstruction, especially during feeding; may be accompanied by other abnormalities of the facial skeleton (for example, holoprosencephaly*). Diagnosis is confirmed by CT scan of the face
Foreign bodies, tumours, cavities, dermoids, encephalocele, gliomas	They are more common in unilateral obstruction, discharge, and sometimes visual bulges or masses; imaging + CT / magnetic resonance imaging (MRI) is necessary to assess the nature and connection with the cranial base
Acute/chronic rhinitis of newborns, mucosal oedema, shell hypertrophy	Obstruction is often variable, associated with infection, secretion; symptoms may decrease with conservative therapy; there are no signs of anatomical deformity on imaging
Trauma of childbirth: haematomas, subluxation of the cartilaginous part of the septum	Birth history, presence of local swelling, possible visible asymmetry in the first few days; visual assessment and palpation; time allows differentiation – traumatic changes often regress partially or require corrective treatment

Note: *holoprosencephaly – defect in the development and separation of the structures of the forebrain and face that occurs in the early stages of embryonic development (approximately weeks 3-4 of pregnancy)

Source: [28,33-38]

Various clinical tests are used to initially assess the patency of the nasal passages and identify functional disorders in newborns. An attempt to insert a nasal probe or catheter allows the presence of a mechanical obstruction to be determined, while the simplest cold spatula test – fixing condensation on a cold spatula under the nostril – serves as a guideline for assessing passive airflow [37,39]. Additionally, the use of Metsenbaum's symptom is recommended, in which the asymmetry of the nostrils may indicate a deformation of the septum, and the Jeppesen and Windfeld test, based on pressure on the tip of the nose, followed by monitoring changes in the shape and patency of the nostrils, allows assessing the mobility of cartilaginous structures [17]. Critically, it should be noted that although these methods

are available and non-invasive, their accuracy is limited: the results may depend on the researcher's experience, the child's condition at the time of the examination, and the anatomical features of the nasal cavity. Contemporary research highlights the need to combine these tests with instrumental methods – endoscopy or rhinometry – to increase the objectivity of diagnosis and more accurately assess the degree of deformity and its functional consequences.

Endoscopic examination of the nasal cavity in newborns provides an opportunity to evaluate in detail the morphology of the nasal septum and identify related anatomical features that may affect breathing. With its help, it is possible to determine the degree of nasal septal deviation, the presence of strictures and complete

choanal obstruction, and to assess the volume of adenoid tissue and identify the presence of pathological masses [28,33]. The key advantage of endoscopy is the visual documentation of the condition of the nasal cavity, which provides the possibility of dynamic observation and an objective assessment of the effectiveness of treatment. However, it should be critically noted that the method requires some operator experience and may be limited in cases of severe discomfort of the child or anatomical features of the nasal cavity, which emphasises the need for an integrated approach using additional instrumental and clinical examination methods.

X-ray examination methods, including CT and, if necessary, MRI, play a key role in the diagnosis of severe anatomical anomalies of the nasal cavity in newborns. They are particularly important when there is suspicion of choanal atresia, stenosis of *apertura piriformis*, neoplasms, or encephalocele with intracerebral connections to the nose [37]. CT provides high spatial resolution and accurate visualisation of bone and cartilage structures, which allows clarifying the topography of pathological changes and planning surgical intervention. MRI, in turn, is preferable in assessing soft tissues and identifying intracerebral connections. It should be critically noted that X-ray methods are not the primary tools in typical cases of neonatal nasal septal deformities and are more often used as an adjunct to clinical and endoscopic evaluation. Their use requires a balanced approach, considering the radiation exposure in newborns and the need to minimise invasive interventions.

Analysis of the temporal course and dynamics of symptoms allows for differential diagnosis of neonatal nasal breathing disorders. With nasal septal deviation, clinical manifestations are more often gradual or relatively stable, whereas with choan atresia, the deficiency of air exchange is expressed immediately and significantly. Symptoms of rhinitis, on the contrary, show an oscillatory dynamics directly related to the activity of the inflammatory process. In addition, the association of congenital anomalies should be considered. Choanal atresia is often detected in combination with genetic syndromes, such as CHARGE, which requires a comprehensive approach to examination [35]. Congenital piriform stenosis is often accompanied by developmental disorders of the midline of the face, including signs of holoprosencephaly and the presence of a single central incisor of the upper jaw, which emphasises the need for an early and thorough assessment of concomitant pathology for the correct choice of treatment tactics [28]. It is critically important to note that ignoring these signs can lead to diagnostic errors and delayed correction of respiratory disorders.

Generalisation of contemporary approaches to the treatment and management of newborns with this pathology

The management of newborns with nasal septal deviation is determined by the severity of the clinical

manifestations, including the degree of nasal obstruction, the effect on feeding and breathing at rest or during sleep, and the presence of complications such as haematomas and septal abscesses, and related abnormalities. B. Jazbi [12] and S.K. Swain [1] emphasised that most anatomical NSDNs have limited clinical significance and are often partially or completely compensated as the facial skeleton grows, which justifies a predominantly conservative approach with dynamic observation. An important component is maintaining the patency of the nasal passages and preventing possible complications, including infections and secondary obstruction. Furthermore, the classical methods of early correction described by S.K. Swain [1] and F. Jeppesen & I. Windfeld [11], suggested manipulations during the first few days of life, when the anatomical structure of the nose is most malleable, and the intervention is easier for children to tolerate than 1-2 weeks after birth. The manipulation is performed without anaesthesia, with a careful pulling of the nose upward with a gauze swab and the insertion of the instrument along the base of the nasal passage, followed by a gentle lifting or rotation of the elevator until a characteristic click indicates the reposition of cartilage [4]. Critically, it should be noted that although early interventions can be effective in severe deformities, the academic literature of the last 10-15 years [7-9] has emphasised the need for individual assessment of indications, since overly aggressive intervention in children with mild and functionally compensated NSDN may be unjustified and potentially lead to damage to the growing cartilage.

Conservative therapy of newborns with nasal septal deviation includes dynamic follow-up with regular evaluation by a paediatrician and an otorhinolaryngologist, training of parents in methods to facilitate nasal breathing, such as the use of saline solutions and drops, and adjusting feeding techniques and monitoring body weight gain and severity of symptoms of obstruction. S.K. Swain [1] and B. Jazbi [12] noted that in the absence of severe respiratory failure and with satisfactory nutrition of children, surgical intervention in the neonatal period is usually not required. This approach ensures the patient's safety, prevents potential injuries to growing cartilage structures, and allows evaluating the natural dynamics of deformation compensation as the facial skeleton forms. The research by K.S. Na *et al.* [7], K. Uygur *et al.* [8] and A. Bhattacharjee *et al.* [9] emphasised that an individual approach to indications and regular clinical evaluation are key factors for optimal management of children with NSDN, especially at an early age, when anatomical structures remain highly malleable.

A haematoma of the nasal septum poses a serious threat to the viability of cartilage tissue and can cause necrosis followed by permanent deformity. In paediatric practice, such conditions require timely drainage

followed by local tamponage and the appointment of antibacterial therapy. Untimely or incomplete treatment significantly increases the risk of septal abscess and late anatomical deformities. Contemporary guidelines and reviews, including recommendations on nasal injuries in children, have emphasised that early intervention is a key factor in preventing long-term functional and cosmetic complications [41]. However, limited data on the incidence of complications in newborns has been noted in the literature, which indicates the need for further prospective studies to develop standardised management protocols.

The literature describes methods of conservative correction of the shape of the nasal septum and nasal pyramid in newborns, including the use of nostril retainers and soft splint containers. These approaches allow carefully maintaining the patency of the nasal passages and partially correct the anatomy without undergoing radical surgery. Despite the positive clinical observations published in the form of individual clinical cases and small series, the efficacy and safety of such methods remain insufficiently studied, and there are no standardised application protocols. Nevertheless, they represent a potentially useful alternative to immediate surgery, especially for minor anatomical deformities and in the absence of severe respiratory failure [42].

Surgical intervention in newborns, including septoplasty or other corrective manipulations, is a rare practice and is performed with great caution. As noted by R. Bishop *et al.* [2], surgical correction is indicated mainly in cases of life-threatening respiratory disorders, persistent nasal obstruction, chronic aspiration, insufficient weight gain, or combined anatomical abnormalities requiring immediate correction. In most cases, interventions are postponed until a later age, when the formation of the nasoseptal skeleton is completed, which minimises the risk of damage to the growth zones. The review emphasised the need for an individualised approach to choosing the time and volume of surgery, considering the combination of clinical manifestations and anatomical features of each child, and the potential long-term consequences of the intervention for the development of the facial skeleton [2].

Effective management of newborns with a curved nasal septum requires a multidisciplinary approach, including the participation of an otorhinolaryngologist, paediatrician or neonatologist, and, if necessary, an orthodontist, plastic surgeon, and radiologist. According to current clinical guidelines, a key aspect is regular monitoring of the child's condition with an assessment of nasal breathing, feeding technique, and growth dynamics of the facial skeleton, accompanied by documentation of changes, including photographs and, if necessary, functional tests. In addition, the researchers emphasised the importance of informing parents about the potential long-term consequences of pathology and discussing options for child management tactics [41].

This comprehensive approach enables not only timely detection of complications and monitoring the effectiveness of conservative or surgical interventions, but also reduces the risk of developing late functional and aesthetic disorders.

Identification of unresolved issues and areas for further research

Despite the long-term interest in the problem of nasal septal deviation in newborns, many aspects of this pathology remain insufficiently studied. Over the past 40-50 years, there has not been a unified view on the aetiopathogenesis of congenital and early postnatal nasal septum deformities, in particular, on the relationship between the role of intrauterine factors, and birth trauma. Classical observations by L.P. Gray [19] and P. Stoksted & U. Schönsted-Madsen [14] emphasised the multifactorial origin of these deformations, however, contemporary research still demonstrates the heterogeneity of interpretations and classification approaches. A significant unresolved issue remains the determination of the clinical significance of the detected deviations. There are no unified criteria that can reliably differentiate transient, self-correcting forms from deformities that potentially affect nasal breathing, feeding, and the further development of the rhinomaxillary complex. Prospective studies by K. Uygur *et al.* [8] have shown a connection between deviations and dislocations of the nasal septum with the specific features of the course of pregnancy and childbirth, however, the long-term consequences of the identified changes remain insufficiently studied. In general, the analysis of the literature indicates the need for further prospective and interdisciplinary research aimed at clarifying the natural course of nasal septal deviation in newborns, developing standardised diagnostic criteria and substantiating differentiated management tactics. Of particular importance is the investigation of the influence of early nasal septum deformities on the growth of the facial skeleton and the development of orthodontic pathology in subsequent age periods.

Despite the considerable amount of accumulated data, the problem of nasal septal deviation in newborns remains controversial and includes a number of unresolved issues. To date, the mechanisms of aetiopathogenesis of this pathology have not been definitively clarified, in particular, the ratio of the role of intrauterine influences and intranatal factors in the development of nasal septum deformities. The effect of hereditary predisposition and dysplastic changes in connective tissue on the morphogenesis of the nasal septum, and their contribution to the stability or progression of the identified abnormalities, has not been sufficiently studied. The question of optimal timing and objective criteria for early diagnosis of nasal septal deviation, especially considering the anatomical and physiological features of the neonatal

period, remains open. The clinical significance of minimal anatomical abnormalities of the nasal septum continues to be discussed, which are often interpreted as a variant of the norm, but can potentially affect the function of nasal respiration and the processes of postnatal adaptation. The degree of influence of the nasal septal deviation on the development of respiratory function and the growth of the upper jaw in early ontogenesis has not been sufficiently determined. The issue of indications for early, including neonatal, correction and its safety, and the validity of intervention in the absence of pronounced clinical manifestations, remains controversial. A limited amount of data is also presented on the long-term results of both conservative and surgical treatment initiated at an early age, which makes it difficult to objectively assess the effectiveness of various therapeutic tactics.

An analysis of long-term clinical and anatomical observations presented in available literature sources has shown that information about the natural course of nasal septal deviation detected in the neonatal period remains fragmentary and largely contradictory. A number of publications indicate the possibility of spontaneous correction of deformities as the facial skeleton grows, while other researchers emphasise the tendency for septal abnormalities to persist or progress with age, especially in the presence of chronic nasal breathing disorders. Generalisation of the presented data allowed formulating a hypothesis that the nasal septal deviation, diagnosed in newborns, in the future may act as a potential predisposing factor for the development of a nasal septal deviation in older children. Furthermore, it is emphasised that existing publications do not contain a sufficient number of prospective studies with long-term dynamic follow-up, which currently does not allow establishing a causal relationship between neonatal deformities and the subsequent development of rhinological pathology. Due to the identified limitations of the evidence base, this review systematises a list of key unresolved issues reflecting priority areas for further research, including the investigation of factors of deformity progression, their impact on craniofacial growth processes, and substantiation of indications and timing of early therapeutic interventions.

Conclusions

The analysis and generalisation of literature data helped to achieve the goal of the study, which consisted in a comprehensive assessment of the aetiopathogenesis, clinical significance, diagnostic approaches and tactics for the management of nasal septal deviation in newborns. It has been established that the development of NSDN is multifactorial in nature and is conditioned by the combined influence of intrauterine mechanical influences, foetal position characteristics, and birth factors, including compression and traction loads during delivery. It has been shown that hereditary

predisposition and dysplastic changes in connective tissue can play a modifying role, determining the variability of morphological manifestations and the resistance of the nasal septum to deforming influences.

The analysis confirmed that early diagnosis of nasal septal deviation is possible already in the neonatal period when using a clinical examination in combination with age-appropriate instrumental methods. It has been revealed that even minor anatomical abnormalities of the nasal septum in newborns are not always clinically indifferent, since they can disrupt nasal breathing, affect acts of sucking and sleeping, and in the long term – contribute to the emergence of an imbalance of the rhinomaxillary complex and the development of the upper jaw. An analysis of the literature data indicates the potential impact of chronic nasal breathing disorders on the processes of craniofacial growth, which gives the problem of NSDN an interdisciplinary significance.

It has been established that the tactics of managing newborns with a nasal septal deviation should be individualised. Conservative observation remains justified in the absence of pronounced functional disorders, whereas early correction can be considered in strictly selected patients with significant respiratory obstruction. However, the relative safety of gentle interventions is emphasised while observing the anatomical and physiological principles of neonatal age. Despite this, the analysis of long-term treatment outcomes indicates a lack of systematic data, which limits the possibility of an unambiguous assessment of the effectiveness of various approaches.

Based on the generalisation of literature data, the authors hypothesised that the nasal septal deviation, detected in the neonatal period, may in the future be a potential predisposing factor for the development of a nasal septal deviation in older children. Confirmation of this hypothesis requires prospective studies with long-term dynamic follow-up. In this regard, a number of unresolved issues have been identified, reflecting key areas of further research, including the investigation of the long-term morphofunctional consequences of NSDN, factors of deformity progression, and the development of standardised protocols for the diagnosis, monitoring, and treatment of newborns with this pathology, considering the interdisciplinary interaction of otorhinolaryngologists, neonatologists, and orthodontists.

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Conflict of Interest

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