ABSTRACT

Dissertation submitted for the degree of Doctor of Philosophy (PhD) in specialty 8D10102 – "Medicine"

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entitled "Improving the Diagnosis of Developmental Dysplasia of the Hip in Children in the Antenatal Period and Its Treatment in the Postnatal Period"

Relevance of the topic:

Developmental dysplasia of the hip (DDH) is one of the most diverse and common congenital abnormalities of the musculoskeletal system in children. Its prevalence ranges from 1.5 to 25.0 cases per 1,000 children, depending on the population studied and the diagnostic criteria used.

The exact causes of DDH are unknown. However, several important contributing factors have been identified, including a combination of genetic predisposition and environmental influences, multiple pregnancy, fetal breech presentation during pregnancy, and sex-related predisposition (the female-to-male incidence ratio is 6–7:1).

These circumstances may also be related to the lack, to date, of methods for the earliest possible identification of markers of the dysplastic process in the hip joint, including during the antenatal period.

Despite the continuing development and introduction of early diagnostic methods for DDH, improved diagnostic equipment in healthcare institutions, and the availability of specialized personnel, untreated cases or sequelae of inadequate conservative treatment provided during infancy are still observed in children aged six years and older.

Therefore, this issue remains highly relevant and requires further development of methods for the earliest possible detection, prevention, and treatment of DDH in order to improve outcomes in affected children.

Aim of the study: to improve the effectiveness of diagnosis and treatment of children with DDH by introducing prenatal ultrasound markers and a newly developed abduction splint.

Study populations:

1. Intervention group (50 patients): children who underwent antenatal screening and children with DDH treated using the developed abduction splint (aged 0–3 months).
2. Control group (50 patients): children with DDH treated using conventional methods (aged 0–3 months).
3. Pregnant women in the third trimester (146 women).

Subject of the study:

Antenatal ultrasound diagnosis, the developed orthopedic splint, and the method of its use in the conservative treatment of DDH in children.

Study objectives:

1. To identify potential ultrasound markers of fetal DDH in the third trimester of pregnancy;
2. To develop an abduction splint and evaluate its effectiveness in treating DDH in children during the first year of life;

3. To analyze the outcomes of conservative treatment using the developed splint compared with devices traditionally used to treat DDH;
4. To establish an algorithm for antenatal and postnatal patient management.

Scientific novelty of the findings

1. For the first time in Kazakhstan, the study demonstrated the feasibility of using the fetal bony coverage index during the antenatal period for early diagnosis of DDH ("Method for Prenatal Ultrasound Diagnosis of Hip Dysplasia," copyright certificate No. 57982 dated 14 May 2025; Appendix A).

2. A new algorithm for early diagnosis of DDH during antenatal ultrasound screening was developed ("Algorithm for Early Antenatal Diagnosis and Postnatal Treatment of Children with Hip Dysplasia," copyright certificate No. 59264 dated 5 June 2025; Appendix A).

3. A new type of abduction splint was developed for treating young children with DDH (Republic of Kazakhstan utility model patent No. 5658 dated 28 May 2020). Its advantages include ease of manufacture and use, with no need to replace the device as the child grows (Appendix B).

4. New statistically significant evidence was obtained regarding the advantages of the developed abduction splint introduced into clinical practice. Its use was associated with a statistically significant reduction in invasive interventions (closed and open reductions): no such procedures were recorded ($p=0.047$), and with a shorter overall treatment duration ($p<0.05$).

Scientific and practical significance

The study optimized the earliest possible detection of antenatal markers of DDH and substantiated the benefits of early use of the developed abduction splint as part of comprehensive treatment in young children.

Main propositions submitted for defense

1. Antenatal ultrasound screening of fetal hip joints in the third trimester, including measurement of the α and β angles according to Graf, makes it possible to identify ultrasound signs of hip immaturity and define a group at risk of DDH. A strong positive correlation was established between the bony coverage index (BCI) and Graf α angle on the left ($\rho=0.881$; $p<0.001$) and right ($\rho=0.859$; $p<0.001$), as well as a moderate correlation with the β angle on the left ($\rho=0.321$; $p<0.001$) and right ($\rho=0.342$; $p<0.001$). Thus, the BCI measured during antenatal fetal hip ultrasound in the third trimester serves as an additional quantitative marker of hip maturity.

2. The use of the developed abduction splint as part of early conservative treatment of DDH reduced mean treatment duration from 40.6±5.8 to 33.9±6.3 days (16.5%; $p=0.03$) compared with conventional methods.

3. The author-developed abduction splint improves clinical and functional treatment outcomes in DDH: the proportion of "excellent" and "good" outcomes increased significantly by 18 percentage points ($p=0.046$). No closed or open reduction was required in the intervention group (0%), whereas reduction was required in 8% of control patients ($p=0.047$).

Implementation in clinical practice

The developed orthopedic splint and treatment method were introduced at City Polyclinic No. 4 (municipal state enterprise with the right of economic

management), Astana, and Ak-Zhan Medical Center LLP, Astana. The main findings are used in teaching senior medical students, interns, and residents of the general medicine and pediatrics faculties at the Department of Pediatric Surgery, Astana Medical University, Astana (Appendix B).

Dissemination and appraisal of the work

The dissertation materials and main findings were presented and discussed at:

1. The Republican Forum of Pediatric Surgeons of Kazakhstan with international participation, "Innovative Technologies in Pediatric Surgery," dedicated to the 85th anniversary of Professor K. S. Ormantayev, Doctor of Medical Sciences, Academician of the National Academy of Sciences of Kazakhstan and founder of pediatric surgery in Kazakhstan, Shymkent, 5–6 May 2022.

2. An extended interdepartmental meeting of the Department of Pediatric Surgery, Astana Medical University, on 12 October 2026.

Seven publications were produced on the dissertation topic: one article in a Scopus-indexed journal, three articles in journals recommended by the Committee for Quality Assurance in Science and Higher Education, and three conference/congress abstracts. One patent and two copyright certificates were obtained.

Personal contribution of the author

The author independently formulated the aim and objectives and developed the study protocol. Primary clinical and diagnostic data were collected, and an electronic database was created for subsequent analysis. The author performed statistical analysis, described the findings, and formulated the scientific propositions, conclusions, and final dissertation summary. The author also actively participated in preparing scientific publications in journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of Kazakhstan and in international peer-reviewed journals, as well as in developing presentation materials for international scientific conferences.

General description of study materials and methods

The dissertation research was carried out according to a developed plan for patient examination and treatment.

Approval was obtained from the Local Ethics Committee of Astana Medical University (Protocol No. 8 dated 9 June 2020).

Based on the nature of the data collected and analyzed, the study was divided into five stages:

Stage I – a search and review of contemporary literature on the epidemiology, classification, etiology, pathogenesis, antenatal and postnatal diagnosis, and conservative and surgical treatment of DDH in children. Searches were performed in international scientific and medical databases including PubMed, Elsevier, Cochrane Library, TripDatabase, BMJ Best Practice, Google Scholar, eLIBRARY, and the Russian Science Citation Index (RSCI).

Stage II – development and clinical evaluation of an abduction splint for treating DDH.

A utility model patent was obtained (Republic of Kazakhstan Patent No. 5658, dated 28 May 2020, “Splint for the Treatment of Hip Dysplasia in Children”; Appendix A). Documentation confirming the device’s implementation in clinical practice was completed (Appendix B).

Stage III – development and clinical evaluation of antenatal ultrasound examination of the fetal hip in the third trimester, identification of diagnostic criteria, and development and clinical evaluation of the bony coverage index.

A certificate of registration in the State Register of Rights to Copyright-Protected Objects was obtained on 14 May 2025, No. 57982 (Appendix C).

Stage IV – development of an algorithm for early antenatal diagnosis and postnatal treatment of children with DDH.

A copyright registration certificate was obtained for entry in the State Register of Rights to Copyright-Protected Objects on 5 June 2025, No. 59264 (Appendix D).

Stage V – comparative assessment of the effectiveness and outcomes of the proposed conservative treatment using the developed splint versus devices traditionally used for treating DDH.

Study design: a retrospective–prospective, nonrandomized, controlled clinical study.

The study included 146 pregnant women and 100 children diagnosed with DDH. Patients were allocated to groups according to the treatment method used. The intervention group comprised 50 patients who underwent antenatal screening and were treated with the developed orthopedic splint; the control group comprised 50 patients who received conventional treatment. Patients and pregnant women were recruited at the outpatient departments of City Children’s Hospital No. 2, Perinatal Center No. 1, and City Polyclinic No. 4, all municipal state enterprises with the right of economic management.

The assessment period for diagnostic and treatment effectiveness began in the third trimester of pregnancy and extended through the postnatal period up to the age of three months.

Conclusions

1. The bony coverage index is a reliable antenatal ultrasound marker of fetal hip maturity and correlates significantly with the Graf hip type ($r=0.467$ on the right; $r=0.426$ on the left; $p=0.01$).

2. Comprehensive management incorporating antenatal ultrasound screening, early postnatal confirmation of the diagnosis, and timely initiation of conservative treatment was significantly associated with a 6.7-day reduction in mean treatment duration, from 40.6±5.8 days in the control group to 33.9±6.3 days in the intervention group ($p=0.03$).

3. Use of the developed abduction splint was associated with a statistically significant increase in the proportion of “excellent” and “good” treatment outcomes from 70% in the control group to 88% in the intervention group, an increase of 18 percentage points (relative increase, 25.7%; $p=0.046$). Unsatisfactory outcomes decreased from 6% to 0%, while the need for closed or

open reduction decreased from 8% to 0%: closed reduction from 6% to 0% and open reduction from 2% to 0% (p=0.047).

4. A comprehensive algorithm for antenatal and postnatal management of children with DDH was developed and implemented, ensuring continuity between prenatal risk-group identification, early postnatal diagnostic confirmation, serial ultrasound monitoring, and individualized conservative treatment. Clinical evaluation of the algorithm demonstrated a significant 16.5% reduction in treatment duration (p=0.03).

Practical recommendations

1. The developed comprehensive algorithm, incorporating antenatal ultrasound diagnosis and early postnatal treatment, is recommended for use in clinical practice.
2. The developed orthopedic splint is recommended for conservative treatment of DDH in children younger than three months.