CLINICAL SCIENCE

MORPHOLOGICAL DEVELOPMENT OF THE HIP IN NEWBORNS AND INFANTS WITH OR WITHOUT WIDE SWADDLING UP TO 8 MONTHS OF AGE

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Abstract

Developmental dysplasia of the hip (DDH) is one of the most common musculoskeletal disorders. Hip dysplasia occurs in approximately 1in 100 cases, which means it is ten times more common than hip dislocation. The physiological development of the hip during growth is determined by the central positioning of the femoral head within the acetabulum. Maintaining the hips in flexion and abduction positions in newborns is the most common recommendation for improving hip development.

The aim of this study was to assess the effects of wide swaddling on hip maturation and its morphological characteristics and development, specifically to determine whether wide swaddling influences hip maturation in the first 8 months of life. A prospective clinical stratified study was conducted, including male and female newborns and infants with type Ia, Ib, and IIa+ hips according to the Graf method. The subjects were divided into two groups. The first group consisted of 55 newborns and infants in whom wide swaddling was used (110 hips were followed). The second group consisted of 55 newborns and infants who were not swaddled (110 hips were followed). Wide swaddling consisted of an extra cloth diaper and one wide swaddle diaper.

Subjects were monitored with hip ultrasound according to the Graf method during the first weeks of life and every two months until eight months of age. For the bony roof, the results showed a natural improvement in the bony shape in infants without wide swaddling, which may indicate a positive trend in the development. The results indicated that even without wide swaddling, there was a natural improvement in bony shaping in a certain percentage of infants. For the bony rim, the results showed a natural improvement in infants without wide swaddling, which may indicate a natural developmental process. In both groups, progress was being made in the development of the ossification nucleus, indicating a natural process of improvement.

Improvement in the morphological characteristics of the hip was observed in the first months of follow-up of both groups, indicating spontaneous progression and maturation of hip

КЛИНИЧКИ ИСТРАЖУВАЊА

МОРФОЛОШКИ РАЗВОЈ НА КОЛКОТ КАЈ НОВОРОДЕНЧИЊА И ДОЕНЧИЊА СО И БЕЗ ШИРОК ПОВОЈ ДО 8-МЕСЕЧНА ВОЗРАСТ

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Клучни зборови: ехосонографија, развојна дисплазија на колк, широк повој

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Печатарски права: ©2026 Марина Комненовиќ, Зоран Божиновски, Милена Богојевска-Доксевска, Дејан Дамјановиќ, Игор Атанасовски. Оваа статија е со отворен пристап дистрибуирана под условите на нелокализирана лиценца, која овозможува неограничена употреба, дистрибуција и репродукција на било кој медиум, доколку се цитираа оригиналниот(ите) автор(и) и изворот.

Конкурентски интереси: Авторот изјавува дека нема конкурентски интереси.

Извадок

Развојната дисплазија на колкот (РДК) е едно од најчестите заболувања на мускуло-скелетниот систем. Дисплазијата на колкот се јавува кај 1од 100 новороденчиња, што значи дека е 10 пати почеста од дислокацијата на колкот. Физиолошкиот развој на колкот за време на растот е детерминиран од централната поставеност на феморалната глава во ацетабулумот. Задржувањето на колковите кај новороденчињата во положба на флексија и абдукција е најчестата препорака за подобрување на развојот на колкот. Беше спроведена проспективна клиничка стратифицирана студија во која беа вклучени машки и женски новороденчиња и доенчиња со тип Ia, Ib и IIa+ колк според методот на Граф. Испитаниците беа поделени во две групи: прва група од 55 новороденчиња и доенчиња кај кои беше користен широк повој (беа следени 110 колкови) и втора група од 55 новороденчиња и доенчиња кај кои не беше користен широк повој (беа следени 110 колкови). Широкиот повој се состоеше од дополнителна тетра пелена и една шведска пелена. Испитаниците беа следени со ултразвук на колковите според методот на Граф во првите недели од животот и на секои два месеци до осуммесечна возраст. За коскеното обликување, резултатите покажаа природно подобрување на коскениот кров кај децата без широко повивање, што може да укажува на позитивен тренд во развојот. Резултатите покажаа дека дури и без широко повивање има природно подобрување во обликувањето на коскениот кров кај одреден процент од доенчињата. За коскениот агол, резултатите покажуваат природно подобрување кај децата без широко повивање, што може да укажува на природен процес во развојот. Во двете групи беше забележан значителен напредок во развојот на осификационото јадро што укажува на природен процес на подобрување. Подобрување на морфолошките карактеристики на колкот беше забележано во првите месеци од следењето кај двете групи, што укажува на спонтана прогресија и созревање на колкот.

Introduction

Developmental dysplasia of the hip (DDH) is one of the most common disorders of the musculoskeletal system. Hip dysplasia occurs in 1in 100 newborns, which means that it is ten times more common than hip dislocation and is the result of abnormalities in the size, shape, orientation, and development of the femoral head or the acetabulum.[1,2] The femoral head and the acetabulum influence each other during growth and development, starting already in the prenatal period. The physiological development of the hip during growth is determined by the central positioning of the femoral head within the acetabulum. Maintaining the hips of newborns and infants in flexion and abduction is the most common recommendation for improving hip development.[3]In newborns, there is a certain degree of hip laxity after birth, and therefore swaddling in adduction and extension should not be used. Instead, safe swaddling with the lower extremities in abduction should be used.[4–9]

In 1959, Judet and Gielis placed all newborns preventively in hip flexion and abduction up to the age of 4 months. With hip flexion of 100°, intra-acetabular pressure decreases, and the dislocating force of the hamstrings is reduced. It is necessary to pay attention to the so-called Ramsey safe zone, which means that hip abduction should not exceed 70° so as not to interrupt the blood supply to the femoral head, thereby increasing the risk of avascular necrosis (AVN) of the hip. By positioning the hips in abduction and flexion, the femoral head becomes centered and acts as a stimulatory factor for the development of the acetabulum. Some abduction orthoses have a low rate of AVN but a high rate of skin ulcers due to pressure on the soft tissues. Wide swaddling allows free movement of the lower extremities while still improving the position of flexion and abduction required for better hip development and maturation, but it cannot be used as a treatment for an unstable hip.[10]

There are not many studies investigating the effect of wide swaddling on hip maturation. The aim of this study was to evaluate the effect of wide swaddling on morphological hip development.

Material and methods

A prospective clinical stratified study was conducted, including newborns and infants with type Ia, Ib, and IIa+ hips according to the Graf method. Subjects were divided into two groups. In the group that used wide swaddling, 55 newborns and infants (19 male and 36 female), with a total of 110 hips (right and left) were followed. In the group without wide swaddling, 55 newborns and infants (25 male and 30 female), with a total of 110 hips (right and left) were followed. In both groups, the progression of the appearance of the ossification nucleus and the morphological characteristics of the hip were assessed. Follow-up examinations were performed every two months until the age of 8 months.

Wide swaddling consisted of one additional cotton (tetra) diaper and a wide diaper placed over the standard hygienic diaper, and parents were instructed on its proper use. Subjects withoutwide swaddling, continued to

use only the basic hygienic diaper.

For each subject, a clinical history was taken, including fetal position during pregnancy, postural anomalies of the fetus, birth weight, and vitamin D_3 prophylaxis. Subjects who met the inclusion criteria, i.e. those with type I or type IIa+ hips according to the Graf method, were instructed to use wide swaddling 24 hours a day. The swaddle was removed only for changing the hygienic diaper and for bathing. Any subject, who after the age of 3 months, remained type IIa – according to the Graf method, or progressed to type IIb, was excluded from the study and treated according to standard protocols.

Inclusion criteria were:

- Newborns and infants with hip types Ia, Ib, and IIa+ according to the Graf method.
- Singleton pregnancy, cephalic presentation of the fetus, and full-term newborns.
- Newborns and infants younger than three months.
- Normal birth weight (2,500–4,000 grams).
- Negative family history of developmental hip dysplasia.
- Negative clinical findings for hip instability, including no adductor contractures and negative Ortolani and Palmén tests.
- Vitamin D_3 prophylaxis on a regular basis.
-

Exclusion criteria were:

- Newborns and infants who on hip sonographic examination were type IIb, IIc, IId, or type III or IV hips according to the Graf method.
- Twin pregnancy, breech positioning of the fetus, or premature birth.
- Newborns and infants older than three months.
- Low birth weight (under 2,500 grams).
- Positive family history of developmental hip dysplasia.
- Positive clinical findings for hip instability, adductor contractures, and positive Ortolani and Palmén tests.
- Subjects that did not take vitamin D_3 prophylaxis on a regular basis.

Evaluation of hip position, range of motion and clinical tests for hip instability (positive Ortolani and Palmen/Barlow tests) were made.

Hip range of motion, the angle of passive flexion and abduction of the hips in the supine position were measured in both groups. Ultrasound follow-up and measurements according to the Graf method were performed using a Resona I9 ultrasound device with a linear probe of 2.5–9 MHz, and hips were classified into the appropriate Graf type. The Alpha and beta angles were measured in each subject.

The morphological characteristics of hip development were also noted at each visit.

The first ultrasound examination according to the Graf method was carried out in the first weeks after birth. After that, newborns and infants were followed every 2 months until they progressed to type I hips according to Graf, i.e., up to 8 months of age.

The Graf method and classification also include a description of the anatomical structures of the hip. The

first structure described is the shape of the bony roof, which can be good, adequate, deficient, severely deficient, or poor. The second structure described is the bony rim, formed at the point where the bony roof changes from concavity to convexity; it can be angular, blunt/rounded, and flat.

The third structure described is the cartilaginous roof, which can be covering or displaced cranially or caudally. The fourth structure described is the presence of an ossification nucleus of the femoral head, which can be present or absent.

The time interval to hip maturation (transition from IIa to type I hip according to Graf) was measured, and the exponential development of the hip was followed up to 8 months of age. Type IIa+ hips according to Graf are physiologically immature hips, which in some cases achieve spontaneous evolution and maturation, but in other cases progress to type IIa-.

Results

The two groups were compared to determine whether there was a significant difference in hip development.

Table 1. Baseline characteristics by fixation type

Bony roof - good	First exam	15	6	15	6
	Second exam	14	22	14	22
Bony roof adequate	First exam	25	34	25	34
	Second exam	26	18	26	18
McNemar test		p=0.000	p=0.000	p=0.000	p=0.000

There was a significant improvement in bony shaping between the first and second examinations on both sides (right and left). Some subjects who were in the “adequate” category at the first examination progressed to the “good” at the second examination. The results indicated that even without a wide swaddling there was natural improvement in bony shaping in a certain percentage of infants.

Table 2. Baseline characteristics by fixation type

		Without swaddle right	With swaddle right	Without swaddle left	With swaddle left
Bony rim - rounded/ blunt	First exam	19	18	19	18
	Second exam	2	12	2	11
Bony rim - sharp	First exam	21	12	21	12
	Second exam	38	28	38	29
McNemar test		p=0.000	p=0.000	p=0.000	p=0.000

There was a significant improvement in the status of the bony rim between the first and second examinations on both sides (right and left). A large proportion of infants progressed from the "rounded" category to the "sharp" category. The results showed natural improvement in the bony rim in infants without wide swaddling, which may indicate a positive trend in the development.

Table 3. Progression of the ossification of nucleus

		Without swaddle right	With swaddle right	Without swaddle left	With swaddle left
Absent ossification nucleus	First exam	36	36	35	35
	Second exam	13	17	11	16
Present ossification nucleus	First exam	4	4	5	5
	Second exam	27	23	29	24
McNemar test		p=0.000	p=0.000	p=0.000	p=0.000

There was a significant improvement in the formation of the ossification nucleus between the first and second examinations on both sides (right and left) in both groups. This was confirmed by McNema test (p = 0.000). There was significant progress in the development of the ossification nucleus in both groups, which may indicate a natural process of improvement.

Discussion

Type IIa+ hips according to Graf are physiologically immature hips, which in some cases achieve spontaneous evolution and maturation, but in other cases progress to type IIa. According to Graf, these physiologically immature hips must be followed by ultrasound until they progress to type I hips. The question remains whether, in this type of hip, preventive interventions can achieve faster development and maturation, since a certain degree of flexion and abduction has a stimulatory effect on hip development. With the application of wide swaddling, greater hip flexion and abduction are achieved, allowing better positioning of the femoral head in the acetabulum and actin as a stimulus for its development. The study by Raba A.A. *et al*. focused particularly on type IIa hips, pointing out that it is not possible to determine which hips will deteriorate and which will have spontaneous evolution, and this requires further investigation. However, as an independent warning factor, they emphasized that if the alpha angle at the first examination was less than 55 degrees, the hip had a negative predictive value.[11]

By introducing a protocol of ultrasound examinations according to the study by Bialik V, it becomes possible to distinguish two types of pathological hips: hips that will develop normally in the following months and hips that will progress to true dysplasia, potentially up to dislocation of the hip joint.[12]

In the study by Klisic *et al.*, the benefit of wide diapering was particularly emphasized, with a reduction in prevalence within 4 years, as well as a reduction in the incidence of surgical treatment. [13–15]

According to the results of the study by Wei Chun Lee *et al.*, in which 33 subjects used a wide diaper and 37 did not, it was concluded that the wide diaper had an effect on hip development in physiologically immature hips, while the effect of wide diapering in true dysplasia was not proven. The effect of the wide diaper has not been fully verified, since to prove that hip development is not due to natural spontaneous evolution and maturation, more than 31 subjects in each group are needed to achieve statistical significance > 0.8.1

According to the study by Harcke *et al.*, conducted on 30 newborns with suspected and documented DDH, it was shown that in subjects swaddled in adduction and extension, hip instability or dislocation progressed. In contrast, in subjects who were swaddled in a safe position, i.e., with a wide diaper, there was no change in hip stability.[16]

The study by Watanabe *et al.*, based on 18 years of clinical experience with DDH, showed that the use of diapers that hold the hips in flexion not only reduced the incidence but also the severity of DDH in childhood, indicating their effectiveness in preventing DDH.[17]

In this study, type I hips were included to determine whether the use of wide swaddling would lead to better hip maturation, while type IIa+ hips, which are physiologically immature, were selected to see whether the use of wide swaddling would lead to faster and better hip development. The results obtained so far have indicated that in both groups hip development shows progressive growth, i.e., spontaneous evolution.

Regarding morphological characteristics and the appearance of the ossification nucleus, it was determined that in most subjects the ossification nucleus was already present at the second examination, regardless of which group they belonged to, with significant further progress, indicating that the appearance of the ossification nucleus was also an independent, spontaneous process of hip maturation over time. In terms of the bony roof and bony rim, there was a higher percentage of better maturation in the group using wide swaddling, especially in the first months of its use. However, it cannot be excluded that this might have been spontaneous progression and hip maturation, since a similar progression was seen in the group without wide swaddling. All these results indicate that there is spontaneous maturation of type IIa+ hips over time, as well as spontaneous maturation in type Ia and Ib hips over time, and that this progression is similar for both types of hips. According to the study by Pellegrin M. *Et al.*, wide swaddling did not improve the position of abduction and flexion of the hips and therefore did not influence hip development, while the “caretaker’s side” carrying position of the newborn (baby-wearing in a sling with hips abducted 60 degrees and flexed 100 degrees) had a greater effect on hip development.4 Swaddling in extension and adduction of the lower extremities increases the rate of hip instability.[4] In the study by Sandeep Vaidya *et al.*, two groups of patients were compared: one swad-

dled in a so-called restrictive swaddle in extension and adduction, and the other swaddled in a so-called safe position. The results showed that using the restrictive position, the incidence of developmental dysplasia increased, whereas in the safe position, the incidence of DDH decreased.[5]

In the study by Bing Liu *et al.*, it was found that there was a progressive hip maturation in the first 3 months of life, whereas between 4–6 months there was a stagnation in hip development, i.e., reaching a plateau; it was also noted that hip development showed sex-related differences.[18]

Tegnander A. *et al.* conducted a study in which they followed a group of newborns and infants for 3 years who had normal clinical findings but suspicious-looking ultrasound findings for hip dysplasia. The conclusion of this study was that these patients did not require immediate treatment, because there was spontaneous resolution of hip dysplasia in most of them. Delaying treatment in some subjects with persistent dysplasia did not affect the outcome.[19-20]

The process of natural evolution and progression of developmental hip dysplasia as assessed by ultrasound were established by a population study in which subjects were followed using the Graf ultrasound method. The study determined that hips noted as healthy on the first ultrasound examination remained type I in almost 100% of cases, though development of dysplasia is still possible; whereas hips noted as physiologically immature at 4 weeks of age later progressed to type I without treatment.[21]

The degree of femoral head coverage and the age of the patient at the time of the first ultrasound examination have a significant impact on the decision about further treatment.

Conclusion

The ossification nucleus showed spontaneous appearance in both groups. In relation to the bony roof and bony rim, the results were similar in both groups, indicating independent hip maturation. An improvement in the morphological characteristics of the hip was observed in the first months of follow-up in both groups.

These results show that hip maturation is an independent process of progression during the first months of life, and that wide swaddling does not affect it.

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