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Prevention of congenital dislocation of the hip

The Swedish experience of neonatal treatment of hip joint instability

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Figures

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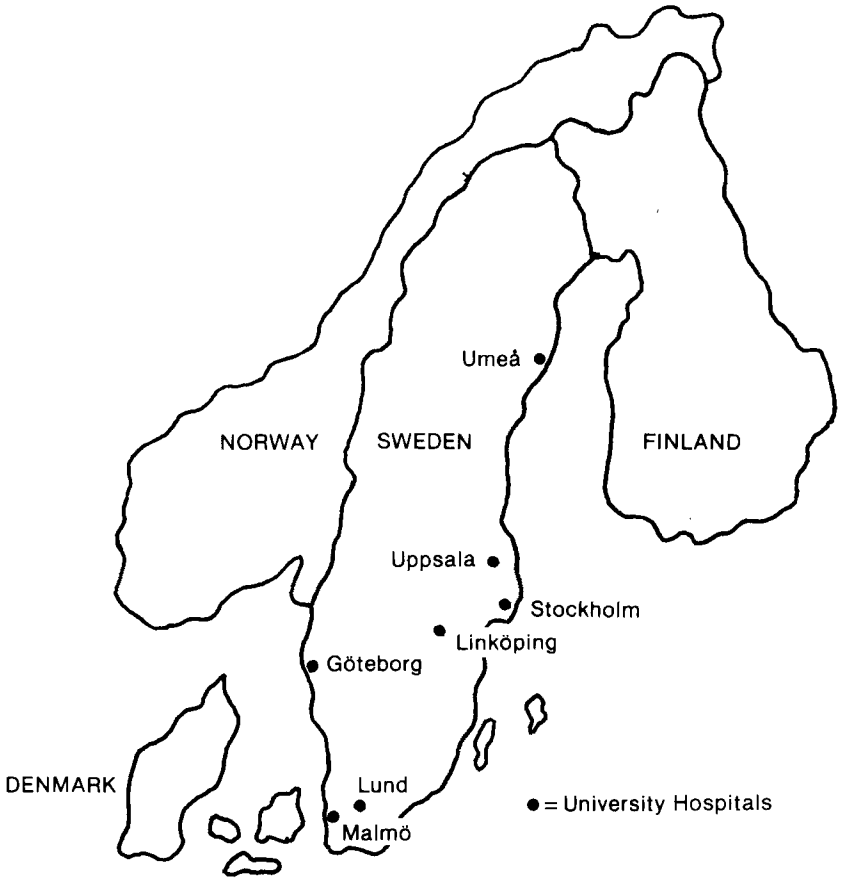


Fig. 1. Sweden 1981 (from "Statistical Abstract of Sweden 1981" and from the National Board of Health and Welfare).
Population: 8,317,937
Live births 97,064
Obstetric departments: 57
Obstetric wards in small hospitals: 25
Deliveries in hospitals: nearly 100 % (9 births at home in 1969)
Paediatric consultants examining the newborns and their hip joints: at all obstetric departments and wards
Infants examined 4 times during their first year of life at Child Health Centres: nearly 100 %
Orthopaedic departments: 36
Small hospitals where newborns with hip joint instability are also treated by orthopaedic surgeons: 10

Definitions

CDH — congenital dislocation of the hip joint, has long been used in the literature to designate dislocation or subluxation. This term has also been employed to cover instability of the hip occurring during the first months of life, as well as hip joint dysplasia, demonstrated radiographically. Thus CDH is a composite expression of all these different changes in the hip joint.

Dislocation — the femoral head is displaced and has passed the cartilaginous edge of the acetabulum — the limbus — and therefore lies outside the acetabulum (Fig. 2 a).

Subluxation — the femoral head is more or less markedly displaced but has not passed the limbus. Usually it is combined with radiographically visible dysplasia of the ossified acetabulum (Fig. 2 b).

Dysplasia — the changes observed at radiography:

a) of the acetabulum: its angle is greater than normal — a shallow acetabulum. The lateral edge is less distinct and less mineralized than in a normal acetabulum (Fig. 2 c).

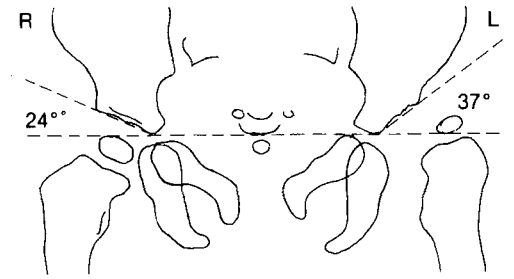
b) of the femoral head: this appears smaller, sometimes irregular and less mineralized. The mineralization is delayed.

Instability of the hip joint — hip joint laxity: the femoral head is not fixed against the centre of the acetabulum but can be moved to varying extents superio-posteriorly into, or in rare cases, out of the acetabulum. In newborns this may occur as a "preluxation" — a state of readiness for dislocation. After the first few weeks it is a symptom of subluxation or, rarely, of a reducible dislocation.

Early-diagnosed CDH — the above conditions diagnosed during the neonatal period (the first month of life), i.e. in Sweden usually at the routine examination during the first week of life.

Late-diagnosed CDH — cases discovered after the neonatal period.

Note! CDH cases due to malformation, such as arthrogryposis and other teratological syndromes, are not included in the material in this book.



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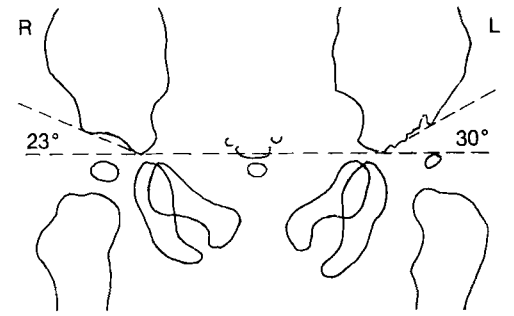

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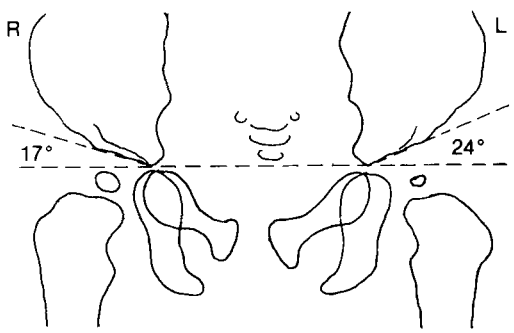

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Fig. 2. Definitions. Left hip: a. Dislocation, b. Subluxation, c. Dysplasia.

Introduction

A challenge: "Early treatment of hip joint dislocation is the main prerequisite of successful correction. I believe that many of these cases could be restored to normal if the condition were discovered neonatally and immediately treated with an abduction splint".

Roser, at the German conference of surgeons in 1878.

Congenital dislocation of the hip (CDH) is a classical orthopaedic condition with a fascinating history. Attempts to reduce the dislocation were of no avail until the new era of treatment began at the end of the nineteenth century with Lorenz's primarily successful results. However, his dogmatic opinion that reduction is best performed at the age of 2—3 years hindered early diagnosis and treatment up to the 1930's—1940's.

Paediatricians took little interest in CDH until the 1950's, when systematic examinations and treatment of hip joint instability were initiated.

After a few years of screening newborns for hip joint instability I recommended this procedure to all paediatric consultants at the obstetric hospitals all over the country in 1953. My work of spreading information on and organizing early diagnosis and treatment, which has been kept up since that time, has provided me with the experience upon which this book is based.

The fact that in Sweden all children are born in hospitals and that those with CDH are treated at orthopaedic departments gave a unique possibility of studying the effects of early diagnosis in this country.

In this book I shall describe the screening of newborns and results of early treatment. Some follow-ups are reported and reasons for failure of treatment are discussed. The gradual decrease in the number of CDH cases diagnosed at a late stage, collected from all orthopaedic departments, is demonstrated. From a late follow-up the results of treatment of such cases are reported.

The organization of hip joint examination of newborns and also of children at Child Health Centres will be described in detail. These examinations have now been recommended by the National Board of Health and Welfare (1980). A detailed description of the examination technique will also be given, with comments.

The organization of the treatment of hip joint instability in newborns will be dealt with and practical instructions for orthopaedic surgeons and parents will be given. This model of treatment has recently been recommended by the Swedish Orthopaedic Society (1982).

Limited abduction of the hip joint, which is one of the main symptoms of late-diagnosed CDH, creates a problem of diagnosis and treatment at the ages of 1—6 months, when unspecific, limited abduction may be encountered. This will be discussed in a separate section.

Since radiographic examination is important in the diagnosis and treatment of CDH, some sections will be devoted to this aspect.

Finally, some problems of current interest will be discussed, for example over-diagnosis in newborns and the still frequent cases of CDH at the age of 2—4 months in spite of the high frequency of hip instability of newborns. Are they being overlooked at birth?

This book will present our experiences and results from a long period of work on CDH, and the achievements in the prevention of dislocation (Fig. 3).

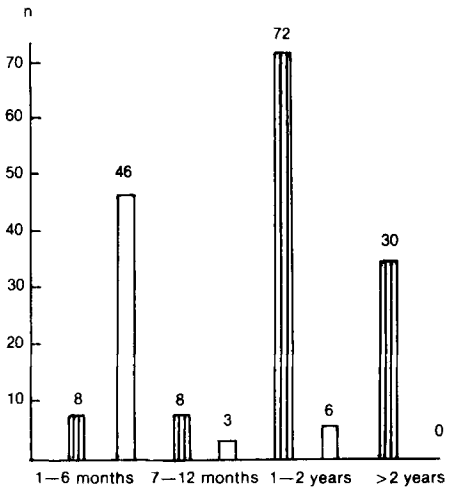


Fig. 3. Results of efforts towards early diagnosis of CDH in Sweden. Late-diagnosed CDH at all orthopaedic departments. Age at diagnosis.

▥ 1948: 118 cases, before hip joint examination of newborn had been initiated.
□ 1979: 55 cases, after 30 years of work on early diagnosis.

The book is intended as a monograph for postgraduate teaching in orthopaedics and paediatrics. The problems concerning CDH are, I believe, the same throughout the world, and it is therefore my hope that the work may also be useful to individuals and organizations concerned with the prevention of this condition in other countries.

Kurt Palmén
Varberg, January 1984

History

The old history of dislocation

Dislocation of the hip joint was referred to as early as in the oldest medical documents. Even Hippocrates (460—370 B.C.) gives a detailed description of dislocation of various joints and mentions that a dislocation of the hip may be congentital, caused by an injury to the mother's abdomen. He also writes: "It is said that the Amazons provoked a dislocation in their male children shortly after birth, sometimes in their knees, sometimes in their hips, naturally with the intention of making them lame so that the males should be incapable of carrying out any action against the females" (Löwegren, 1909).

Hippocrates also gives detailed directions concerning the manual reduction of various dislocations, with or without means of assistance. Fig. 4 shows an illustration from the 16th century of the "bench of Hippocrates" — which is mainly reminiscent of a mediaeval implement of torture!

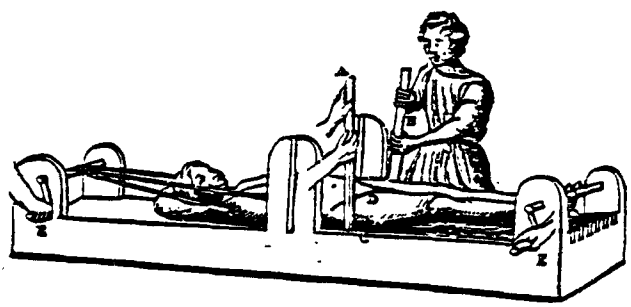


Fig. 4. The bench of Hippocrates illustrated by Andreas a Cruce, Officinia Chirurgica Venetiis, 1596. Reduction of a dislocated hip joint (from Hart, 1952).

In writings from the 16th and 17th centuries occasional references are made to dislocations of the hip joint. Ambroise Paré in Paris, the "father of surgery", note in 1578 that hip dislocation may be hereditary. He also mentioned that a shallow acetabulum impedes retention of the femoral head at reduction.

The first post-mortem pathological-anatomical description of a dislocated hip joint was given by Paletta in Vienna in 1783, concerning a bilateral dislocation in a boy aged 15 days.

Dupuytren's dissertation on hip joint dislocation, written in Paris in 1826, is well-known. He described the underdeveloped acetabulum at dislocation and remarked that treatment had no prospect of success.

It is generally held that the first definite case of successful reduction of a dislocation of the hip joint was that reported by Pravaz in Lyon in 1836, in a 7-year-old boy with unilateral dislocation. Pravaz first applied traction for 8—10 months. After the reduction the child lay flat for two years on a carriage and only then was allowed to start using a wheeled walking chair.

At that time the treatment was not started until the age of 4—12 years and the results were consequently disappointing, although a reduction was sometimes primarily achieved.

During the middle decades of the 19th century new interest in dislocation of the hip joint arose, owing to the establishment of orthopaedic hospitals, providing schools for the surgeons of the time. The famous French school was started in Montpellier by Delpech, an orthopaedic pioneer, and was carried on by Pravaz in Lyon and Guèrin in Paris. Prolonged traction therapy preceding attempts at reduction was used in the 1860's to 1880's in England (Brodhurst 1866, Adams 1888), and in the U.S.A. (Brown 1885).

During the last three decades of the 19th century surgical operations were introduced for correction of dislocations, by Guèrin, König and Paci (1888) and Hoffa (1897). These consisted in deepening of the acetabulum with a view to facilitating retention of the femoral head, a method also used by Lorenz (1895). However, the results were disappointing. Infections, sometimes fatal, were not unusual and subsequent joint contractures occurred. Many warned against the operations, and the late results were always discouraging (Deutschländer 1908).

The year 1895 was a notable year in the history of orthopaedics, when Lorenz in Vienna published his method of closed reduction of dislocation. His great experience of many hundreds of operative reductions helped him to develop his method in accordance with the suggestions of Paci in Paris (1888). The latter proposed that in the case of traumatic dislocation the reduction over the posterior edge of the acetabulum be performed in one session under general anaesthesia. He also stressed the importance of achieving optimum retention of the femoral head in the acetabulum. In this way the acetabulum would be reshaped. Fixation was accomplished by plaster-of-Paris, as a rule at 90° abduction, "Lorenz's first position".

With the discovery of X-rays in 1895 the primarily encouraging results could be verified and Lorenz's method quickly became widespread. This development was met with great enthusiasm and this ancient orthopaedic problem was considered to be finally solved.

Since Lorenz, strangely enough, had not seen any dislocation in newborns, he was of the opinion that this condition occurred later in life and was due to an inherited "anlage". He introduced the term "so-called congenital dislocation of the hip joint". He maintained that reduction was best performed at the age of 2—3 years. Subse-

quently patients were treated according to this principle in many places and most often showed good primary results. However, the materials were heterogeneous and the times of observation short (e.g. Lange, 1906).

Lorenz's great experience is evident in a monograph published in 1920. He reported that excellent results were obtained in 57 % of 477 treated unilateral dislocations and in 53 % of 290 bilateral cases, but he gave no figures concerning either the age at treatment or the age at follow-up. He still considered that the best results of reduction were achieved at an age of 2—3 years (Lorenz 1920).

Somewhat later, at a follow-up of dislocations treated in 1891—1910, Stephens (1928) observed functional and anatomical healing in fewer than 15 % of the patients.

A brief review of the earlier Swedish work is given below.

Early diagnosis and treatment

Froelich (1932) in Nancy pointed out well before 1910 that a dislocation can be diagnosed already during the first week of life and be reduced by abduction of the flexed hips. He and his pupils Hoffman and Vuillaume advocated early treatment. Froelich reported on his experiences at the conference of French surgeons in 1911. Joachimsthal (1908) and Peltesohn (1920) were also advocates of early diagnosis and treatment. The latter suggested that the hip joints of all newborns be examined.

However, early treatment was still not generally accepted, owing to opposition of the leading orthopaedic surgeons, first and foremost Lorenz.

Hilgenreiner (1935) in Prague described his 10-year experiences of treating 157 cases of dislocation in infants — the two youngest at the age of 2 months. He considered that the sound of reduction and redislocation was especially easily perceived at the age of 3—6 months and that treatment was best started at the age of 4—6 months. He favoured an abduction splint.

In northern Italy, where in many areas dislocation was frequent, Putti (1929, 1933) introduced early treatment in Bologna. The first 24 cases were presented at the orthopaedic conference in London in 1929, and in his publication of 1933 he reported on 119 treated cases of what he called "preluxation". This diagnosis was made when an X-ray showed an incerased acetabular angle but still no subluxation. The youngest patient was 34 days old and the oldest 16 months. The treatment consisted of hip abduction achieved by a pillow placed between the flexed legs. Of the 119 cases, 113 were stated to be completely cured. Putti considered that all infants should be treated immediately after diagnosis, even if this were on the first day of life. Enthusiastically, he therefore suggested that all newborns ought to be X-rayed!

Ortolani (1937, 1948), a paediatrician in Ferrara in northern Italy, started to apply the principle of early diagnosis and treatment in about 1935. His diagnostic criterion was the "click" which occurs when the femoral head, if subluxated or dislocated, slips back into the acetabulum on abduction of the legs, flexed at the hip joints. For treatment, he used a pillow to keep the hip joints flexed and abducted. Since about 75 % of the children in his district were born at home, he trained nurses to examine the hip

joints as early as possible when making home visits. He organized a "diagnostic and prophylactic centre for dislocation of the hip joint" and treated about 200 infants annually.

He described his experience in many publications, including a monograph in 1948 (in Italian). Gradually his work gained attention in other countries and he became the eponym of the Ortolani method.

It is of interest from the historical viewpoint that Ortolani's examination method had already been described in exactly the same way in 1912 by Le Damany in France (Fig. 5). But the latter author did not realize its importance and the method fell into obscurity.

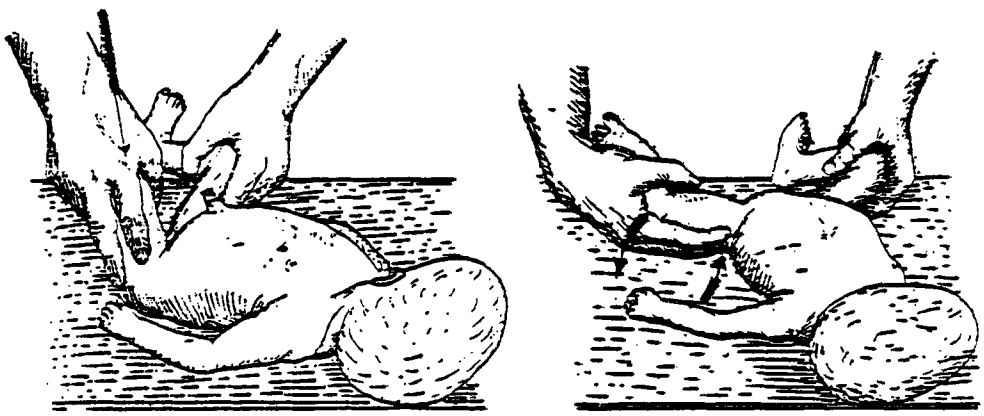


Fig. 5. Hip joint examination. Le Damany (1912).

In Czechoslovakia, Frejka (1941) in Brno proposed that infants a) with CDH in the family, b) born in the breech presentation, or c) with limited abduction should undergo hip treatment. He used the same type of pillow as Ortolani. It is known as a Frejka pillow and is used in many countries, including Scandinavia.

In the U.S.A. the paediatrician Chapple (1935) pointed out that CDH was also a major paediatric problem to which not enough attention had been paid earlier. He reported that he had treated three infants with a hip spica before the age of 3 months, with encouraging results. Hart (1950, 1952), a surgeon at the University of Minnesota, U.S.A., described Ortolani's method of examination and treatment. He suggested in his monograph that examination of the hip joint be performed on newborns and infants so that "congenital dysplasia" could be treated as early as possible.

No systematic examination of the hip joints in all newborns seemed to have been carried out at the obstetric hospitals before 1950, at which time I started such examinations (Palmén 1953). During the 1950's reports appeared on routine examinations of newborns in several countries, e.g. in Würzburg, West Germany (Burger 1953), in Bergen, Norway, (Walther and Moe 1954), in Salt Lake City, U.S.A. (Coleman 1956), and in Zürich, Switzerland (Geschwend 1959).

Early Swedish works

The first Swedish treatise on dislocation of the hip was written as early as in 1855 in the form of an academic dissertation "Om medfödd luxation af Höftleden" (On Congenital Dislocation of the Hip Joint) by Carl Axel Rosborg. This work was based on a treatise written by Carnochan in New York in 1850: "A treatise on the etiology, pathology and treatment of congenital dislocation of the head of the femur".

Rosborg stated that the femoral head of the newborn is not deformed, and that it is spherical except for a slight flattening of its inner segment which presses against the ilium. He described how pathological changes gradually occur both in the acetabulum and the femoral head, and eventually also in the femoral neck, resulting in coxa vara. He wrote: "The disease is always unnoticeable in the newborn and becomes evident only when the child starts walking".

Concerning treatment he described, as the first published case of a reduced dislocation, Pravaz's above-mentioned patient from 1836. The treatment consisted of preliminary traction of the same kind as is used nowadays. A strap attached to a leather brace around the leg led over a pulley at the foot of the bed to two weights, which were gradually increased. If the traction did not give effective results, tenotomy was performed, usually on the gluteus medius muscle (according to the method of Guèrin). When the femoral head was located somewhat below the anterior iliac spine, reduction had been achieved. If this was successful, it was important to try to maintain the position of the femoral head, and this was accomplished by means of two upholstered wooden boards, attached to the bed, and shaped after the body. When the patient temporarily had to leave his bed, a tightly fastened girdle was used. After a period of 5—6 months movement exercises were started and after another 4—5 months the child was allowed to start walking with the help of a go-cart. This prolonged treatment in bed in hospital, very often for more than a year and followed by a long period of further treatment, was the traditional form of therapy for dislocations — with slight modifications, e.g. plaster, for about 100 years. What a physical and psychological strain upon the children and their parents! Rosborg did not report on any treated cases of his own in his dissertation.

Patrik Haglund was "the grand old man" of Swedish orthopaedics during the first decades of the 20th century. During the years 1910—1935 he worked at the "Vanföreanstalten" (the Institute for the Disabled) in Stockholm, at the time one of Sweden's four establishments for handicapped children and adults and also an orthopaedic department. Haglund was our first professor of orthopaedics. He treated dislocations of the hip joint by means of a modified variation of Lorenz's method. Like Lorenz, he considered that the most propitious time for starting treatment was at the age of 2—3 1/2 years.

As a young student of medicine in Uppsala in the middle of the 1930's, at which time teaching in orthopaedics was non-existent at that university, I attended Haglund's lectures for some weeks. From him we learnt about Lorenz's old opinions, which up to that time had hindered early diagnosis and treatment of CDH.

Haglund was succeeded by Henning Waldenström, who in about 1937 started treat-

ing CDH as soon as the diagnosis was established and who considered the best time for reduction to be before the age of one year.

Erik Severin, one of Waldenström's collaborators and later a professor of orthopaedics in Göteborg, was the first to carry out an extensive and thorough follow-up of patients with CDH, and published his findings as a dissertation in 1941. He collected all CDH cases treated at the "Vanföreanstalten" in Stockholm from 1913 to 1932. The year 1913 is the first year from which all X-ray films have been preserved — the earliest ones as glass slides. The observation time was at least 5 years.

Out of 757 cases, the 330 in whom reduction was successful were followed up — more than 50 % of those examined at the hospital were too old for effective reduction! Twenty of the 330 had died before follow-up and 4 could not be examined for other reasons. There remained 306 patients with 417 reduced hip joints. None of these had been treated before the age of one month, but 13 % were treated before the age of 2 years and 36 % at 2—3 years. At that time reduction was performed without preceding traction therapy or tenotomy and usually the legs were fixed in Lorenz's first position — with the hips in 90° flexion and 90° abduction.

The follow-up revealed that only 4 % had an anatomically normal joint, another 7 % had slight changes and 74 % showed a more or less pronounced dislocation. The prognosis was more favourable when early reduction had been performed and severe changes of the femoral head and neck were rare in patients who had undergone reduction before the ages of 2 years (Severin 1941).

Waldenström and Severin were thus convinced of the importance of early diagnosis and treatment and somewhat modified the principles of treatment: reduction as soon as the diagnosis is made, treatment with a hip spica for about 6 months, and the joints in 90° flexion and 60—70° abduction.

Severin thus advocated early diagnosis and in 1939 he treated the first patients before the age of one year — two children at 10 months. During the following 10 years there were occasional infants in whom CDH was diagnosed from shortening of the leg or as a secondary finding at an abdominal X-ray.

In the teaching of *paediatrics* no mention was made of diagnosing dislocation of the hip joint until routine hip examinations of newborns was initiated at the beginning of the 1950's. Until that time CDH was an orthopaedic disease.

Aetiology

Heredity

It was recognized for a long time that mothers with dislocation of the hip joint often had children who limped (Ambroise Paré, 1678), that the disease was many times more common in girls and that the frequency was much higher in certain areas. In 1784 Camper claimed that 125 persons in a Dutch village limped because of dislocation.

The interest in heredity in association with CDH was aroused during the last decade of the 19th century and at the beginning of the 20th, when Mendel had formulated the laws of heredity. As a rule a CDH frequency of 20—30 % was found in relatives — of whom 3—4 % in the immediate family. Idelberger (1951) studied the frequency of CDH in twins and found a concordance in 10 out of 29 monozygote pairs, but only in three of 109 dizygote pairs.

A study of the high frequency of CDH among Lapps living in the north of Sweden has been reported by Mellbin (1962) (see below).

Among 407 patients with late-diagnosed CDH, described later on, CDH was found in the immediate family in 40 cases (10 %), and among other relatives in 65 cases (16 %). The latter figure is uncertain, however.

We know that patients with dislocation due to malformation — so called teratological cases — very rarely have members of the immediate family or other relatives with the same condition. There are exceptions, however, e.g. in arthrogryposis, where concordance of CDH in monozygote twins has been observed, as well as in occasional cases in siblings (Wynne-Davies, 1973).

According to the modern concept of the common type of CDH, it is a multifactorial disease caused by interactions between endogenous and exogenous factors (Carter 1973). Thus it is considered that

- activity of several genes predisposes to the disease
- environmental influences, intrauterine and postnatal, may then work as triggers.

The following factors may interact:

- intrauterine mechanical factors, breech position
- breech position
- female sex
- first-born child
- birth in a certain season
- hip joint laxity caused by hormones
- familial generalized joint laxity

Intrauterine mechanical factors, breech position

We know of old that the breech position considerably increases the risk of instability of the hip joint in newborns, which later may be followed by dislocation. The breech position is most likely due to several combining factors. According to one of the theories belated flexion of the knee joints makes the fetus remain in its earlier position, with the legs stretched at the knee joints and the hip joints flexed maximally and inwardly rotated — the feet towards the ears — "the position of dislocation" (Wilkinson 1963). However, in most cases the fetus has bent its legs by flexing the knee joints by the 6th—7th month and is thereby able to kick and move more freely and to turn around into the cephalic position (Fig. 6). The belated flexion of the knee joints may be physiologically conditioned but may also have a neurological origin, e.g. in spina bifida.

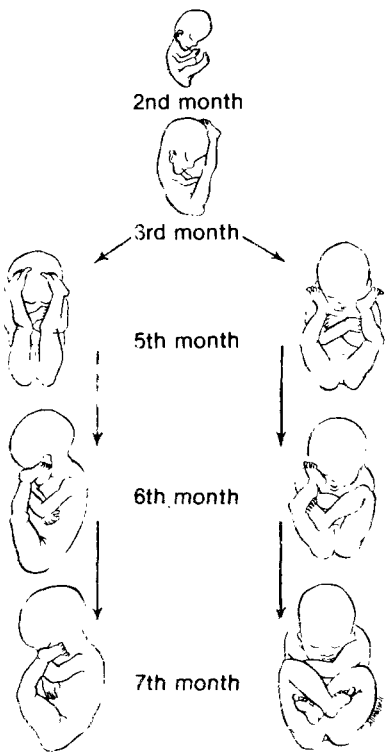


Fig. 6. The development of breech malposition in utero (Wilkinson 1963, by permission). "The left side shows the persistent medial rotation breech posture. The right side shows the pre-version folding of the more common lateral rotation breech posture."

In Scotland Wynne-Davies (1970) found breech presentation or version in 18 % of 192 newborns with instability of the hip joint, and the same frequency in 397 late-diagnosed CDH cases.

In my first material of 12,400 examined newborns, instability of the hip joint was 6.8 times as common in those who were born in the breech position, with a frequency of

11.4 %, compared to 1.9 % in the whole material. The low frequency of children born with a breech presentation among the late-diagnosed CDH cases of recent years, 6 % of 407 cases, is worthy of note. This is perhaps due to the fact that instability of the hip joint after birth in the breech presentation sometimes is more pronounced and thereby easier to diagnose.

Oligohydramnios caused by renal malformations with oliguria or anuria, Potter's syndrome, is the source of different fetal deformities. Dunn (1971 a) has described 12 such cases, infants who died shortly after birth. All of them had changes of the hip joint ranging from slight instability to dislocation. He also found in another material (Dunn 1971 b) that 10 out of 11 newborns whose mother's amniotic membranes had ruptured more than one week before delivery (mean interval 50 days, range 9—133 days) showed musculo-skeletal deformities similar to those in Potter's syndrome. Thus, insufficient space in the uterus, for varying reasons, may give rise to fetal deformities, e.g. plagiocephaly, torticollis, oblique mandible, talipes calcaneo-valgus and postural scoliosis (Mau 1973, Dunn 1974). The frequency of these deformities increases in the presence of hip instability and dislocation (Dunn 1976).

In Dunn's opinion, some other intrauterine conditions may explain other birth characteristics:

The increased frequency of sinistral CDH may be due to the fact that the fetus more often lies with its back against the mother's left side. In the usual cephalic position the left leg will be placed posteriorly and adducted by pressure against the mother's spine, all of which may affect the hip joint unfavourably.

The increased frequency of CDH in first-borns may be explained by the fact that in a woman having her first baby the uterine cavity is flattened by a stronger tone of the abdominal muscles, thus subjecting the fetus to an increased pressure.

Birth in a certain season

In the 1950's a considerable seasonal variation in the time of birth of children with CDH in Japan, Hungary and England was reported (Nagura 1955, Pap 1956 and Record and Edwards 1958, respectively). In these series 28—43 % of the children were born in December—February. This seasonal variation was ascribed to differences in the heaviness of the clothing — in winter the movements of the child's legs were restricted.

In my large material from 1961 of 1,313 late-diagnosed cases of CDH and 816 newborns with hip joint instability, clear differences were found between observed and expected values for the individual months of the year (Andrén and Palmén 1963). The observed frequency curves showed the crest of the wave in September—November and the trough in March—May, i.e. about 3 months earlier than in the other series referred to above. It was of interest that the variation in our curves was the same for the newborns with hip instability as for the late-diagnosed cases of CDH, as well as for both sexes.

Since one of the aetiological factors of hip joint instability in newborns is a hormonal pelvic instability (Andrén 1960), we proposed that the seasonal variation in the birth dates of patients with CDH may be due to seasonal influences on the hormonal interrelationships.

Hip joint laxity caused by hormones

It was demonstrated at an early date that pelvic relaxation could be induced in guinea-pigs by injecting them with oestrogen and progesterone. However, the effects occurred only in females.

Carter (1973) held a theory that there is a probable specific, sex-determined quality in female ligaments which may be one of the explanations of the higher CDH frequency in girls.

Wilkinson's experiments with rats is interesting (1963). Legs of rats aged 6—8 weeks were fixed with the hip joints flexed and inwardly rotated, equivalent to the human frank breech presentation. None of the animals showed dislocation of the hip. But if they were first injected with oestrone followed by progesterone, the females, but not the males, developed general joint laxity and atraumatic dislocation of the hip joints. In veterinary medicine similar experiments have been performed with the same results (Langenskiöld A and Sarpio O 1957).

Andrén (1960) demonstrated that the newborn's pelvis is influenced by hormones; thus, newborns with instability of the hip displayed radiographically demonstrable instability of the symphysis pubis during their first week of life. Earlier hormone investigations have shown that fetuses and newborns are able to break down certain oestrogens that cannot be decomposed by the mothers (Diczfalusy et al 1957). It has also been proved that newborn girls secrete more oestrogens than boys for a slightly longer period (de Blieck and Schwers 1958).

Oestrogen is metabolized into oestriol in fetuses and newborns. The oestriol is excreted in the urine during the first days of life. Oestrone and oestradiol-17ß have strong relaxing effects on pelvic tissues and on the hip joint capsule and ligaments. Attempts have therefore been made to demonstrate an increased secretion of these hormones in infants born with instability of the hip.

Andrén and Borglin in Malmö (1961) found in such an investigation that in some newborns with hip instability there was an increased secretion of oestrone and oestradiol after injection of oestradiol, in comparison with healthy newborns. In another study (1961) these two authors compared the urinary contents of oestrogen in 11 newborns with instability of the hip joint with those in 26 healthy newborns. Conjugated oestriol was abundantly secreted by both groups during the first two days. Oestrone and oestradiol 17-ß were sparse in the healthy group, whereas many — but not all — of the newborns with instability of the hip secreted considerably more.

These results, however, were not verified in two subsequent studies (Thieme, Wynne-Davies et al 1968, Aarskog et al 1966).

● The hypothesis of hormonal influence is highly probable, but has not been proved beyond doubt experimentally. The examined material has been small and the difficulties in collecting the daily urine and in performing the sensitive hormone analyses may have been partly responsible for the conflicting results.

Familial, generalized joint laxity

This condition was described as far back as in 1916 by Finkelstein. It has been shown by Carter and Wilkinson (1964) that laxity of this kind is one of the predisposing factors of CDH. In more pronounced cases of such joint laxity there are also recurrent dislocations of the patella and the shoulder joint (Carter and Sweetnam 1958).

In a few cases there is generalized joint laxity owing to some connective tissue diseases such as the Ehler-Danlos syndrome, Larsen's syndrome, Marfan's syndrome and mucopolysaccharoidosis (Morquio's type). Hip joint dislocation is relatively frequent in association with these rare diseases.

From a methodical examination of joint laxity in five joints (Fig. 7), Carter and Wilkinson (1964) considered that generalized joint laxity could be said to exist if more than three pairs of joints were affected.

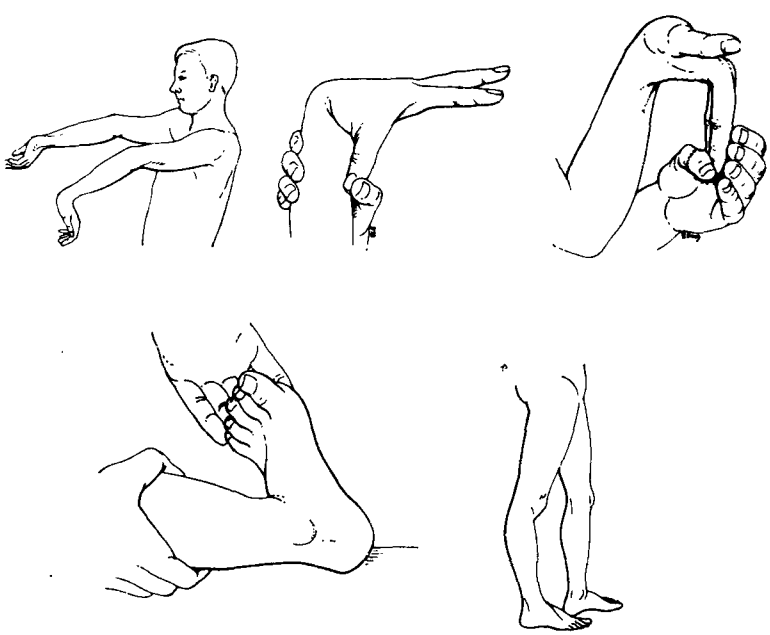


Fig. 7. Generalized joint laxity (from Wynne-Davies 1973, by permission).

The authors found that of 88 children aged 5—14 years with CDH, 48 % had generalized joint laxity, compared to 7 % in a control group. In the control group, 145 schoolboys and 140 schoolgirls, there was no significant difference between the sexes.

Of girls with CDH about a third and of boys over three-quarters showed laxity. In 14 familial cases of CDH (parent or sibling affected) the incidence of joint laxity was high — in the boys five out of seven, and in the girls four out of seven.

- It was concluded that persistent generalized joint laxity, which is often familial, is an important predisposing factor to CDH, especially in boys.

  At a Swedish follow-up, Fredensborg (1975) found that 110 children aged 8—16 years, who had been treated for hip instability in the neonatal period, showed a strongly significantly increased joint laxity in four out of five examined pairs of joints.
- The same author has also shown that the contents of collagen in the umbilical cord of 10 newborns with pronounced instability of the hip joint were significantly lower than in the same number of corresponding controls.

Primary acetabular dysplasia

The old prevailing opinion of Lorenz and others was that dislocation started gradually when the child began to walk, and was due to a congenital "anlage" — a restrictive influence on the growth of the joint, first and foremost of the acetabulum. When performing a post-mortem on a 12-day-old girl with bilateral dislocation, Hilgenreiner in Prague (1925) found a strongly inclined acetabulum. He considered this to be the reason for the dislocation, a congenital "Hemmungsbildung" of the whole joint. He suggested the name "dysplasia", which could occur with or without dislocation. Interest has since been focused on the question whether such an acetabular dysplasia, observable as an abnormally large angle at radiography, is primary or secondary.

Great pains have been taken in attempts to measure the acetabular angle, with a view to obtaining standard values even for newborns. An angle larger than a certain value has been referred to as representing dysplasia. Putti (1935) even suggested that all newborns should be X-rayed with a view to early diagnosis. This was also done in some centres but without concrete results (e.g. Caffey et al 1956).

Howorth (1977) was one of the first (1932) to propose that dysplasia may be secondary. He reasoned that subluxation would lead to changes in pressure on the acetabulum and the femoral head and that the changes would disappear after treatment.

In animal experiments it was found that skeletal changes, of the same kind as in CDH in infants, occur quickly, after about one week (Smith at al 1958, Langenskiöld and Sarpio 1957).

The diagnosis dysplasia has often been made on uncertain or erroneous grounds. At radiography a misleading projection of the acetabulum, due to a rotated pelvis, may increase the angle (see Fig. 25).

Is there any indication that acetabular dysplasia is a genetic condition? Wilkinson and Carter (1960) have held this opinion, on the basis of observed considerable vari-

ations in size of the acetabular angle and the fact that in 40 % of the unilateral cases of dislocation there has been a large angle — a "dysplasia" — on the opposite side.

At a radiographic investigation of the hip joint, Wynne-Davies (1970 a) measured the CE angles (see Fig. 9) of both parents of children with late-diagnosed CDH. She found smaller angles than in a control group — in mothers of girls with late-diagnosed CDH the difference was significant at a level of 1 %, and in the fathers of boys with late-diagnosed CDH at a level of 5 %. This was also confirmed in Yugoslavia by Strinović (1978).

- The above two investigations are very interesting and it seems probable that the anatomical appearance of the acetabulum, with its reduced CE angle, may have a genetic basis, and, together with other factors promote the development of CDH. It is open to discussion, however, whether such a potential disposition should be called a "primary acetabular dysplasia".

Postnatal factor

An environmental factor which after birth acts as a powerful trigger of the development of CDH is the practice of swaddling infants from the very day of birth, with their legs stretched and adducted. It is well known in different parts of the world that in areas where children are wrapped up in this way the frequency of CDH is very high. Remarkable effects have been noted when this exogenous factor has been discontinued.

In Sweden Mellbin (1962) studied the frequency of CDH among Lapps, a small ethnic group of people inhabiting the northern parts of the country, previously nomadic. According to ancient tradition the mothers kept their children in a "komsion", a boat-shaped cot covered with fur, during the first year (Fig. 8). In this cot the child lay, its legs wrapped up and totally extended and adducted. In 173 families with 813 living children the frequency of CDH was 2.5 %. All the 20 cases were to be found among the 426 girls (4.7 % of them). Most of these children, according to Mellbin, had probably been kept in the "komsion". It is of interest that 50 % of the CDH cases had not been treated, owing to the fact that they lived in isolated settlements and to religious conceptions prevailing at the time. Nowadays the Lapps are domiciled, and their children are born in hospital, wear nappies and are able to move their legs freely. In my compilation of the late-diagnosed CDH cases from all the orthopaedic departments from 1973 to 1979 (see later on), I found no patient with definite Lapp relations. In the last three years the parents have been asked about this in a questionnaire.

Among the North-Canadian Indians the mothers have of old carried their infants on their backs, strapped to a cradleboard, with the legs extended and adducted. Salter (1968) found that the frequency of CDH was 10 times as high when such a cradleboard was used. Among 2,032 children carried in this way there were 250 cases of CDH (12.3 %), compared to 17 cases among 1,347 children (1.2 %) for whom the cradleboard was not used. In areas where the mothers refused to discontinue the use of cradleboards, they were recommended to shorten by half the bag in which the children were

Fig. 8. A Lapp woman with her child in a "komsion". (Photograph from the Lapp Museum in Arjeplog, a gift from the head, E. Wallquist, M.D.)

placed. The legs then assumed a position of hyperflexion of the hip and knee joints. Salter discovered that by this simple means the frequency of CDH decreased tenfold.

In mountain regions in Georgia in the Soviet Union, the infants have been nursed by tradition in an Oriental cradle, a "beshik", with the legs extended and wrapped up. Furthermore, a tube is placed between the infant's legs to drain the urine, which adds to the negative effects by pressing the femoral heads outwards. Dogodnadse (1973) in Tbilisi found a frequency of CDH of 3—4 % in areas where the cradle was used, while dislocation was unknown in districts where it was not in use and where the children were able to move their legs freely.

Material

Hip joint instability in newborns

My first contact with hip joint instability of newborn infants was an article by Hart (1950) in Minnesota, U.S.A., where he mentioned Ortolani's examination method, by means of which instability can be detected even neonatally and treatment with an abduction pillow can be started. This aroused my interest and in August 1950 I began to use this method when examining all newborns at the hospital of Falköping, where I was chief physician of the paediatric hospital and consultant to the department of obstetrics. This hospital was the central hospital for about 125,000 inhabitants and its annual rate of births was about 1,200—1,300. In December 1950 I found the first case of instability of the hip joint and as far as I know this was the first case diagnosed in this way in Sweden. At about the same time some isolated cases of dislocation in newborns were discovered by limited abduction (Oldfelt and Magnusson 1952). My case, which was demonstrated at the staff-meeting of the hospital, was regarded chiefly as a curiosity. The girl displayed bilateral, pronounced instability of the hip joints on abduction. An X-ray showed no definite dislocation — at that time we knew nothing about radiographic examination of the hips in newborns — but I treated the girl with a simple abduction splint for 4 months. Later radiographic examination showed a moderate difference in the sizes of the nuclei of the femoral heads, but at the age of 18 months the development of the joints was normal.

The experiences of four cases during the first year showed that treatment of instability gave positive results, whereas one patient who was not treated showed a dislocation at radiography after 2 months.

Since I was unable to find any literature on systematic examination of newborns or treatment of cases of instability of the hip joints, I decided to begin this procedure.

In December 1952 I sent a letter to those Swedish obstetric departments which at that time had paediatric consultants, i.e. 21 hospitals with about 32,000 births annually — about one-third of the births of the whole country — recommending that hip joint examination of newborns be introduced. I described Ortolani's method of examination.

Treatment of all cases of instability of the hips was recommended even if the findings at radiography were uncertain or "negative".

As an abduction splint, a simple wooden board was proposed, onto which the child

should be fixed for 3 months. If treatment was needed for more than 3 months a Frejka abduction pillow was recommended.

The cases should be recorded on special cards for subsequent compilation.

In addition, I planned to study the effects of the diagnosis and treatment of newborns on the frequency of late-diagnosed CDH in all the orthopaedic hospitals.

The hip joint examination of newborns was described in "Svenska Läkartidningen" (Palmén 1953) together with our experiences during the first years. Hip examination of newborn infants was now recommended to all obstetric departments, even to those without a paediatric consultant. The importance of examining the hip joints at the health check-ups at the Child Health Centres, especially during the first year of life, was stressed. It was also pointed out that limited abduction was the main symptom of subluxation/dislocation after the neonatal period.

Diagnosis at the obstetric department

The author's material during the first 10 years 1950—1960 (Palmén 1961).

The material consisted of 12,394 examined newborn infants (Table I), of whom I personally had examined about 11,000; the rest were examined by carefully instructed colleagues at the paediatric department. All the newborns were examined by Ortolani's method. In 1956 this method was supplemented by a subluxation provocation (see Fig. 14). At this time the newborns were, as a rule, examined only once during one of the first few days of life. Uncertain cases were examined several times during the first week.

Table I. Results of the author's first 10 years of examining newborns.

Year	Total	Instability per thousand newborns	
		Ortolani	Subluxation provocation
1950—1955	5,813	2.4	
1956—1960	6,581	4.9	3.6
Total	12,394		

Birth characteristics of the cases with instability of the hip joint: girls 82 %, boys 18 %, born in a breech presentation 11 % — a frequency 6.8 times as high as in the total population of infants.

Diagnosis at the obstetric departments of the whole country up to 1963

As mentioned above, routine examination of the hip joints were started in 1953 at the 26 departments which at that time hade a paediatric consultant for health examination of all newborn infants. Gradually other departments acquired consultants and in 1963 about 75 % of all children were born in these 45 hospitals. The rest were born in 85 smaller hospitals and units without consultants. The results of these examinations are given in Table II.

Table II. Diagnosed hip instability in newborns born in 1953—1963.

Year	Total[1]	Examined[2]		Instability	
		n	%	n	%
1953	108,811	33,681	*31*	32	*1.0*
1956	106,690	47,520	*45*	76	*1.6*
1959	103,569	68,570	*66*	216	*3.2*
1963	109,866	81,931	*75*	534	*6.5*

1. Number of children born alive, excluding those who died during the first week.
2. Number of newborns in the obstetric departments where examination of the hips was a routine.

Comments:

During the first years the frequency of instability of the hips was 1.0—1.6 per thousand. From 1957 onwards this number increased, due to intensification of the method of examination by the introduction of subluxation provocation. Interest was stimulated by the issue of copies of a new article in "Svenska Läkartidningen" (Palmén 1957), along with an announcement from the National Board of Health and Welfare recommending hip joint examination of all newborns. In 1961 the interest was possibly stimulated by my thesis on this subject.

The frequency of instability of the hips varied considerably at different departments, in 1963 from 1.4 to 29 per thousand. This was certainly due to the inadequate experience of many examiners. In order not to overlook any case, uncertain ones were probably included. I had pointed out in the instructions, however, that crepitations in the hip joints are unspecific.

Treatment

The author's cases diagnosed in 1950—1974

During these years about 28,000 children were born at the hospital where I was a paediatric consultant. I examined them all as a rule on their 1st—4th day of life, except

about 3,500, who were born during my holidays and examined by well-informed locum tenentes.

174 cases of hip instability were diagnosed, i.e. 6.2 per thousand. Since initially I was not convinced that instability of the hip joint was indeed a form of "preluxation", I tried at first to treat only every second case.

As my experiences from the first five cases led me to treat *all* subsequent cases, they will be briefly mentioned here:

1) A girl with bilateral hip joint instability. Abduction splint for 4 months. Normal hip joints at follow-up.

2) A boy, unstable left hip joint, no treatment. The left nucleus of the femoral head was ossified later. At follow-up a normal hip.

3) A girl with unstable right hip, abduction splint. Arthrography at one month: no dislocation. Then Frejka pillow. At 4 months dislocation, plaster. Developed necrosis of the femoral head. At 9 years slight coxa magna et vara.

4) A girl, unstable left hip joint. X-ray uncertain, no treatment. X-ray at 3 months: dislocation of left hip joint. Plaster for 6 months. At 9 years normal hip joints.

5) A boy, left hip joint unstable, no treatment. At 1 month hip again unstable, abduction splint for 4 months, later normal X-ray.

In all these cases the instability of the hip joints disappeared within the first week and the first X-ray was uncertain. At the time we had no satisfactory technique for radiographic examination of newborns and no experience in evaluating the films. After these findings I treated all cases immediately after diagnosis, except for a series which will be described below. We used a wooden board to which we fixed the legs with the hips flexed 90—110° and abducted 80—90°. The Frejka pillow was also used if the treatment lasted for more than 3 months.

The treatment and results are reported in my dissertation (Palmén 1961). Some figures from the first follow-up may be given:

The first 39 patients were followed up in 1961 after at least 3 years of observation. Thirty-four patients showed normal hip joints. Two patients displayed slight signs of dysplasia of the femoral head, which I considered was likely to disappear. In one patient there was more pronounced dysplasia, also of the acetabulum, and later on an osteotomy was performed. Two infants had slight changes after "necrosis" (irregular ossification) of the femoral head.

- Thus it was judged that all but one patient had or would develop normal joints.

This treatment of newborns also showed very good results later on. The very few cases in which the initial treatment was inadequate seemed to be due mainly to the mothers' incapacity to follow the instructions.

Cases not treated or treated for a very short time

In the 1960's we discussed the need for primary treatment of all cases of hip instability, including the slight ones, where the instability would disappear in one or a few days. In some places in other countries these cases were not being treated (Sinios 1963).

During that decade I therefore carried out a trial in which some such cases were either not treated or were treated for a very short period, ranging from a few days to 4 weeks. These infants were then followed up carefully, and the results are summarized here:

A. Of 20 untreated patients and 8 patients treated for 2—6 days, 17 had no radiographic signs of dysplasia, and 11 had slight symptoms during the first year or, in a few cases, during the first years — mostly delayed ossification of the nucleus of the femoral head. The subsequent development of these hips was considered to be normal, however. In one patient treatment was started again after 3 weeks because of limited abduction, and subsequently the hip development was normal.

B. Short treatment of 2—4 weeks was tried in 21 other patients from birth, and stability was achieved within one week. It was necessary to re-treat two of these patients, one because of instability and the other because of limited abduction with slight subluxation. At follow-up normal joints were seen. One other patient developed an avascular necrosis with coxa vara.

Conclusions:

- In most cases of slight-moderate instability of the hip joint, disappearing during the first week of life, the hip joint develops normally without or with only a short period of treatment.
- In some cases, however, treatment must be recommenced.
- Radiographic signs of dysplasia may persist for a long time.
- These findings gave reason to recommend treatment for 6 weeks to 3 months in all cases of hip instability in newborns.

Follow-up of cases treated in Malmö

At the Department of Orthopaedic Surgery in Malmö, von Rosen started in 1953 to treat newborns who had been diagnosed as having instability of the hip joint by the paediatric consultant at the obstetric department. The first eight cases, occurring during 1953—1955, were treated with abduction splints of different kinds and the results of the first follow-up after 1—3 years (von Rosen 1956) were not completely satisfactory. In 1956 a new type of splint was therefore introduced, the "von Rosen splint", plus a strict schedule of treatment, with very good results.

After a relatively long period a follow-up study of the patients treated during 1956—1964 was made by Fredensborg (1975). The material initially comprised 119 cases of hip instability among 30,280 newborns (=3.9 per thousand). Among these

119, four infants with other syndromes, 1 infant who died and 3 emigrants were excluded. The follow-up therefore comprised 111 children, 16 % of whom were boys.

All newborns had been examined by Ortolani's method and from the middle of 1963 also according to Palmén's subluxation-provocation technique. The diagnosis was also verified radiographically.

All patients were treated with a von Rosen splint, the majority for 3 months. The children were bathed once a week in the orthopaedic department by experienced staff and their mothers were not allowed to remove the splint for nursing care at home. A physician checked the treatment every second week. The follow-ups took place at the ages of 6 and 12 months and at 3, 5 and 7 years. Radiographic examinations were performed at these same intervals and at the later follow-ups.

In two infants the initial treatment was unsuccessful. In one of them a short, 2-week treatment was tried and redislocation occurred after 2 more weeks. In the other infant slight acetabular dysplasia was observed at 7 months and subluxation at 1 year. In both cases the hip joint developed normally after treatment.

Among children born during the same period there were two cases of late-diagnosed dislocations (0.07 per thousand). Both were diagnosed at 18 months.

At follow-up the average age of the children was 10 (8—16) years. In addition to the general configuration of the hip joints on the radiographs, the centre-edge, CE angle (Wiberg 1939) was measured (Fig. 9). The sphericity of the femoral head was also judged by a spherical index, SI, introduced by Fredensborg (Fig. 10).

The radiographic findings were compared with those in a control material of 222 children equally distributed as to age and sex, who had been examined radiographically for other reasons.

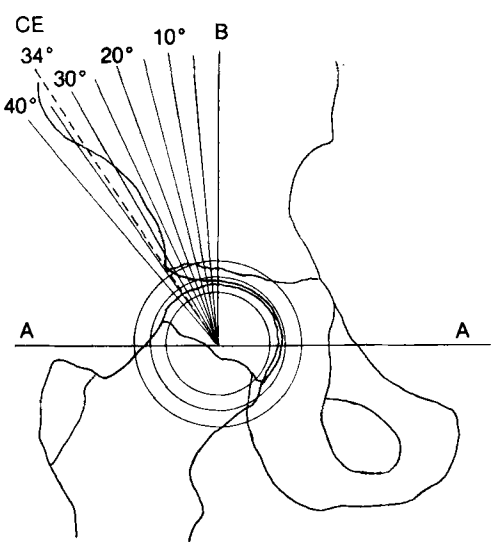


Fig. 9. The centre-edge (CE) angle of the acetabulum (Wiberg 1939) in a 10-year-old normal girl.

A — a line drawn through the centres of the femoral heads (in a case of subluxation this line has to be drawn at right angles to the sagittal midline — the longitudinal axis).

B — a line at right angles to the A line.

CE angle — the angle between B and a line drawn through the outside bony edge of the acetabulum (CE = *C*entre — *E*dge).

The CE angle according to Fredensborg (1975): Children aged 14 years or less — normal $\geq 20°$, uncertain 15—19°, pathological $< 15°$.

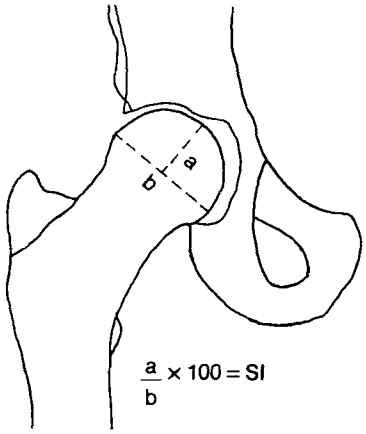


Fig. 10. The spherical index (SI) of the femoral head (Fredensborg 1975, by permission). Line *b* denotes the maximum width of the femoral head and line *a* the maximum height measured from this line. In the control material of 222 children aged 8 years or more, SI was 35 or more, in most children 40—46.

Results

The distribution of the CE angles and that of SIs among the study material were identical to those in the controls. No lateral differences in CE angles or in SIs were found between the stable and the unstable hip joints in the unilateral cases. There were two deviant cases:

One girl with bilateral instability of the hips was treated for 10 weeks, and at the age of 2 years she showed avascular necrosis of the femoral head and metaphysis. At 8 years of age she had a somewhat flatter and wider femoral head and a slightly wider femoral neck. One girl with unilateral subluxation had slight dysplasia of the acetabulum without subluxation, and a CE angle of 15°, the lowest limit, at the age of 10 years. However, in both cases the CE angle and SI were within the limits of the control material.

Cases where early treatment was unsuccessful or insufficient

While collecting late-diagnosed CDH cases from all the orthopaedic departments, I also asked for reports on patients in whom neonatal treatment had not been satisfactory. During the years 1973—1979 copies of case records of 65 such cases, about 10 annually, were collected. The records and X-rays were studied, with the following results:

All patients showed unstable hip joints when examined on one of the first days of life. The initial treatment consisted of von Rosen's splint in half of the cases, a Frejka pillow in one-third and other splints in the remainder. von Rosen's splint was used to a greater extent during the later years.

During the check-ups the only clinical symptom of unsuccessful treatment was in most cases limited abduction, and only a few patients showed persistent hip instability.

According to the radiographic signs the patients were divided into two groups:
Group I: Forty patients showed signs of *subluxation,* more or less pronounced — the majority before or at the age of 6 months and a few at one year of age. The renewed treatment consisted of plaster in 33 cases and other splints in the rest.
Group II: Twenty-five exhibited *dislocation.* In 15 patients dislocation was observed after 3 weeks to 2 months, in nine patients at 3—6 months and in one patient at the age of one year. In 13 patients the dislocation was reducible but in the other 12 patients open reduction had to be performed, as the dislocation was non-reducible under anaesthesia or after traction therapy. Nine of these patients had been treated primarily with a Frejka pillow and 3 with a von Rosen splint.

A further follow-up of the whole material has not been made, as the follow-up time is still too short in many cases, but the radiographic changes described in Table III were observed at the latest X-ray after the secondary treatment — at 2—4 years of age:

Table III. Radiographic changes at follow-up after secondary treatment.

	Group	
	I	II
Avascular necrosis of femoral head-neck	1	3
Pelvic osteotomy	1	4
Rotation osteotomy of the femur	1	3

Group I subluxation and group II dislocation at follow-up after the first treatment.

Discussion

There were several reasons why the primary treatment was unsuccessful. The material is small, but the fact that nine of the 12 patients who had to undergo open reduction had been treated primarily with a Frejka pillow may indicate that this therapy is less effective. In a study from Göteborg Hansson (1980) found less successful results with use of a Frejka pillow compared to treatment with a von Rosen splint.

On the other hand, half of the whole material were treated with a von Rosen splint. In most cases, however, information on the treatment routine was lacking, but in a few cases there was definite information in the case records that the mother had removed the splint when washing the child.

It is possible that some patients had primary dislocations that had not been reduced. In a few cases it was noted in the case records that at a subsequent check-up the child "showed an oblique position in the splint".

During the same period I was informed of three infants with non-reducible dislocations at birth, none of which were due to malformation. After traction therapy for 8 days and 4 weeks respectively, reduction was successful in two of these cases. In the third case the primary reduction was thought to be successful, but dislocation was observed after 7 weeks of treatment in a von Rosen splint. Traction therapy was not

successful and at the age of 5 months open reduction revealed that the iliopsoas tendon was constituting an obstacle.

A slack treatment routine is probably the main reason for unsuccessful primary treatment. Strict organization, experienced and capable doctors and meticulous information to the mothers concerning the treatment are all essential. The very good results obtained with use of the von Rosen splint in Malmö under these conditions, as reported above, confirm this assumption.

This study shows that the following points are of crucial importance for achievement of optimum results when treating CDH in newborns:

- A correct diagnosis. A radiographic examination should be performed if a non-reducible dislocation is suspected. Arthrography is of value for confirming that the dislocation has been reduced after traction therapy.
- Application of a splint which meets the demands for reliability.
- Assurance that reduction has been performed in the position in which the child is placed in the splint. An experienced orthopaedic surgeon will be able to feell this, and there is no need for a radiographic examination in cases of neonatal hip joint instability.
- The splint must be bent so as to prevent re-dislocation within the range of motion of the legs.
- The mother must be instructed not to remove the splint when nursing the child until permission is given.
- The orthopaedic surgeon must make one or two check-ups during the treatment.
- Cases of non-reducible dislocation, as well as those of high-grade instability, where retention of the femoral head in the acetabulum is poor, should be referred to a paediatric orthopaedic surgeon at a regional hospital.

Late-diagnosed CDH cases

In order to determine whether organized early diagnosis and treatment of unstable hips in newborns gave a lower frequency of late-diagnosed CDH, the late-diagnosed CDH cases treated at all the orthopaedic departments during the years 1948—1960 were collected. Teratologic cases were excluded, as well as children born abroad. This material was published in my dissertation of 1961, from which some figures are extracted (Palmén 1961).

Table IV. CDH cases *treated* before examination of newborns had begun.

Treated in years	Total	Age at diagnosis		
		1—11 months	1—2 years	>2 years
1948	118	16	72	30
1949	103	19	60	24
1950	101	14	50	37
1951	106	14	67	25
1952	119	17	71	31
Total	547	80	320	147

Table V. Children *born* in 1950—1952 with late-diagnosed CDH

Born in year	Age at diagnosis					
	1—6 months	7—11 months	1—2 years	2—3 years	3—8 years	Total
1950	1	1	44	19	13	78
1951	2	6	57	18	10	93
1952	10	6	54	17	8	95
Total	13	13	155	54	31	266

During the three years 1950—1952 335,192 children were born alive, and the frequency of late-diagnosed CDH was 0.8 per thousand. Of these, 86 % were girls and 14 % were boys. In 36 % the left hip was affected, in 31 % the right hip and 33 % were bilateral.

The frequency of male cases was higher than that of today, 14 % compared with only 9 %. The same is true for the bilateral cases, 33 % compared with 7 % today.

- Most children had *dislocations* — 87 % of the total material and 95 % of the children diagnosed after the age of 6 months. The high frequency of dislocations compared with subluxations was probably due to late diagnosis. Thus, early subluxation will often develop into dislocation.

Cases from all the orthopaedic departments in 1948—1979

Cases of late-diagnosed CDH reported from all orthopaedic departments are listed in Fig. 11.

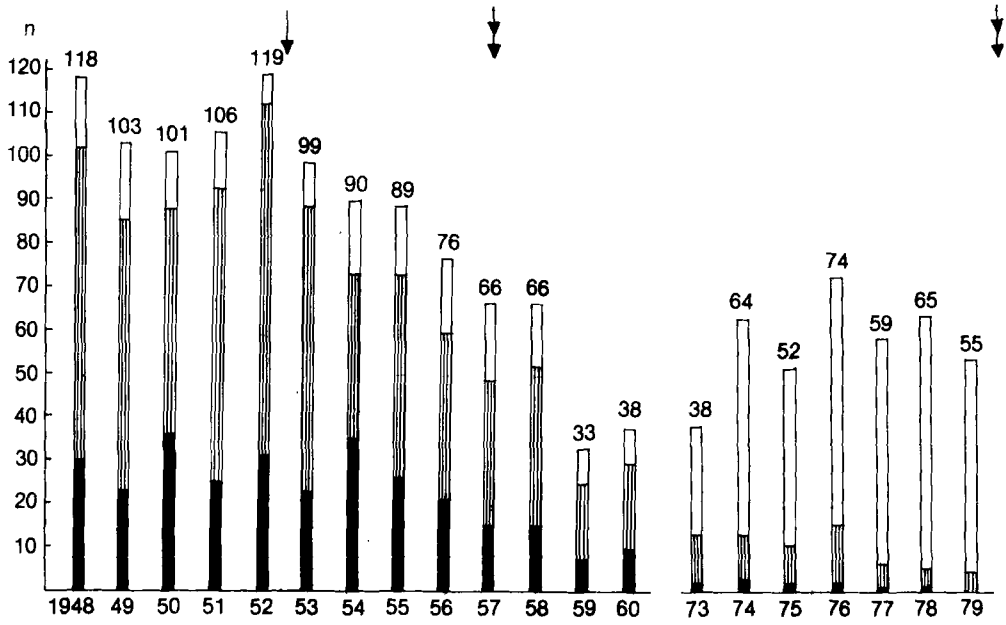


Fig. 11. Children with late-diagnosed CHD treated at all orthopaedic departments in 1948—1979.

▭ diagnosed at 1—11 months
▤ " " 1—2 years of age
▬ " later than 2 years of age

→ Recommendation to the paediatric consultants to examine the hips of newborns (1952).
→→ Recommendation from the National Board of Health and Welfare to examine all newborns (1957, 1980).

Comments

The frequency of late- diagnosed cases decreased after the recommendation had been made to the paediatric consultants to examine all newborns with respect to hip joint instability. In 1957, in accordance with my proposal, the National Board of Health and Welfare recommended to all the maternity hospitals and smaller units that the hip joints of all newborns be examined. This resulted in a further decrease in late-diagnosed cases of CDH.

It is interesting that up to 1958 only 17 % of the cases were referred to the orthopaedic departments from Child Health Centres. Possibly the examination of newborns was considered an effective means of finding all CDH cases, and all children did not undergo hip examinations at the Child Health Centres. At least 10 years elapsed before the interest in examining the hips of all children was aroused at all Child Health Centres.

From about 1961 to 1973 the compilation of all late-diagnosed CDH cases was discontinued. However, owing to a reported increase in such cases at the age of 2—4 months in the beginning of the 1970's, annual compilation of late-diagnosed cases was recommenced and has since been continued. The case records from the orthopaedic departments and the radiographs have been studied. Questionnaires have been sent to the parents in order to collect information concerning the hospital of birth, birth characteristics, family history of CDH, and when and how the diagnosis was suspected, among other things.

Analyses of the material have been sent out to the orthopaedic departments every year. The Child Health Centres of each county have been informed about the results by their chief physicians at several of the annual meetings of their association.

To provide a picture of the present-day problems, some figures from the last 7 years are given in Table VI:

Table VI. Children with CDH diagnosed late at various ages during 1973—1979.

Age at diagnosis	Late CDH		Dislocation		Subluxation		Dysplasia only	
	n	%	n	%	n	%	n	%
1—6 months	303	74	37	12	190	63	76	25
7—11 months	33	8	15	45	16	48	2	6
1—2 years	60	15	53	75	18	25		
>2 years	11	3						
Total	407	100	105	26	224	55	78	19

Comments

- Even in recent years the number of cases diagnosed at ages of 1—6 months of life has remained approximately the same.
- Cases diagnosed after the age of one year are now rare — in the last 2 years there have been only 6 per year. In 1979 no patient was diagnosed after the age of 2 years.
- Thus, during the last 2 years 90 % of the late-diagnosed cases of CDH have been diagnosed before the age of 1 year.
- During the last 2 years 71 % of the total number of cases have been diagnosed at the age of 1—4 months at the Child Health Centres.
- The frequency of boys is notably small, 9 %. This is markedly lower than the figure of 14 % in the material of late CDH cases before 1953.
- Very few of the children, 6 %, are born in the breech presentation, but this is about 3 times as high as the total percentage of births in this position.

- The frequency of bilaterial cases is also very low — 7 %. In the material of 1950—1952, 33 % were bilaterial, and among the newborns with instability of the hips no fewer that 47 % were bilateral.

The differences between these frequencies might be due to the following:

- Hormonal influence, which will affect the girls more and both sexes bilaterally, may increase the instability, which then might be easier to diagnose during the first days of life.
- The effect of the breech position before birth perhaps makes the instability more pronounced and thus facilitate diagnosis in newborns.

Heredity

The questionnaires to the mothers included a question about CDH cases in the family. The results are given in Table VII.

Table VII. Family heredity for CDH among 407 late-diagnosed cases.

	Mother	Father	Sister	Brother	Total
n	8	3	25	4	40
%	*2*	*0.7*	*6*	*1*	*9.3*

Follow-up examinations

Hip joint instability in newborns with subluxation — even slight ones — may develop into a dislocation, sometimes fairly quickly. In some cases acetabular dysplasia with subluxation may also persist without symptoms until adulthood. Therefore, in our attempts to prevent dislocation of the hip, we tried to find and treat the late-diagnosed cases as early as possible.

- The importance of this is based on the supposition that early treatment gives the best result.

In an earlier investigation, late-diagnosed cases of CDH in children born in 1963 and treated at all the orthopaedic departments were followed-up after 4—10 years (Palmén and von Rosen 1975), and the findings are given in Table VIII.

Table VIII. Follow-up of 27 children with late-diagnosed CDH *born* in 1963.

Diagnosis at follow-up	n
Normal joints	5
Practically normal joints	9
Subluxation + acetabular dysplasia	8
Sequelae of vascular necrosis	3
Deformity after pelvic osteotomy	1
Dislocation (not treated)	1

The results of the treatment were not entirely satisfactory owing to the late diagnosis (in 70 % of the cases after 1 year of age) and the fact that 74 % were dislocations.

Only five patients had been treated with traction before reduction. Since we have been able during the latest decade to diagnose an increasing number of cases at an early stage, it was of interest to study the results of a group born later.

Children with late-diagnosed CDH born in 1976

and reported from all orthopaedic departments were therefore investigated. This is the latest group to be followed up for at least 4 years.

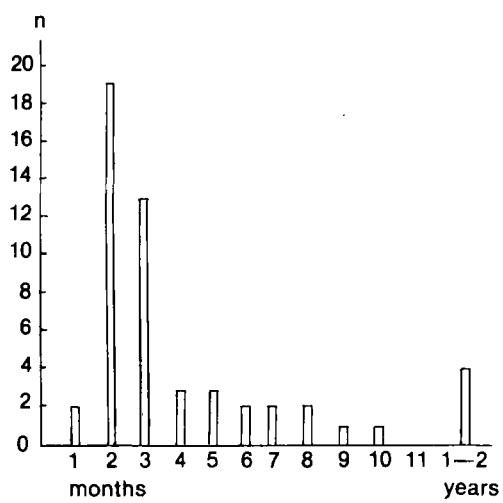


Fig. 12. Fifty-two cases of late-diagnosed CHD, born in 1976. Age at diagnosis. Four-fifths were diagnosed between 1 and 6 months.

Material

52 cases, 48 girls and only 4 boys (8 %);

CDH in the immediate family: in 4 cases CDH in older sisters;

Born with a breech presentation: 5 cases;

Unstable hip joint at the first examination during the first days of life, but negative at a check a few days later, and therefore not treated early: 8 cases.

Age at diagnosis: see Fig. 12.

Diagnosis:	dislocation	11
	subluxation	38
	acetabular dysplasia without dislocation	3

Bilateral cases: only 5, including one dislocation.

Treatment: plaster or Hexelite in 3 patients, von Rosen splint in 8, Camp splint in 2 and Frejka pillow in 1 patient.

Reduction under anaesthesia, without previous traction therapy or tenotomy	36
Traction therapy before reduction (also tenotomy in 3 cases)	9
Adductor tenotomy before reduction	7

Follow-up (Tables IX and X).

All children except five were followed up after 4—5 years with a radiographic examination. The parents of these five children did not want them to have a further X-ray examination, as the latest one at the age of 18 months to 2 1/2 years had shown a completely normal hip joint (in 4 patients) or very slight dysplasia (in one patient).

Table IX. Follow-up of all late-diagnosed cases of CDH *born* in 1976

Radiographic follow-up	Start of treatment, n of cases			
	1—6 months	7—11 months	1—2 years	%
Normal joints	33	3	0	*69*
Slight dysplasia of acetabulum and/or femoral head	3	0	1	*8*
Acetabular changes after osteotomy of the pelvis	0	0	2	*4*
Sequelae of avascular necrosis of the femoral head and neck	6	3	1	*19*

Table X. Treatment before reduction in patients with avascular necrosis.

	n
No traction therapy and no tenotomy	8
Traction therapy alone	1
Tenotomy alone	1

Discussion

In the current discussion on the treatment of late-diagnosed CDH, particular attention has been paid to the risk of necrosis of the femoral head, avascular necrosis.

We have long known that the risk of this complication is especially serious if treatment is started after the neonatal period and during the subsequent months. Chiari (1953) treated 198 infants with CDH aged between 3 weeks and 3 months. Forty-three per cent of the 49 patients in whom reduction was performed under general anaesthesia because of limited abduction showed necrosis of the femoral head. Among the 149 patients in whom reduction was possible without anaesthesia this condition was found in only 5 %. No cases of femoral head necrosis were noted at the follow-up of the 249 children who had been treated from the neonatal period.

The problems concerning avascular necrosis have been examined by Salter et al (1969) in an experimental and clinical study. They distinguish between a "temporary irregular ossification" of the femoral head, which may simulate fragmentation, when the growth is accelerated after reduction, and "avascular necrosis". Irregular ossification has a favourable prognosis. It may disappear completely or cause a slight coxa magna, which will persist for several years.

Avascular necrosis develops when there is a total interruption of the blood supply to a part or the whole of the femoral head during the treatment. The causes of this are *iatrogenic,* and it may sometimes occur also in the normal hip joint in unilateral cases. Severe cases will show pronounced, persistent changes such as coxa magna, coxa plana, marked coxa vara and a very short, broad femoral neck.

Salter et al (1969) demonstrated that the prognosis improved in children treated before the age of 18 months and when traction therapy and tenotomy were used before reduction. Earlier 30 % had developed avascular necrosis, while this frequency decreased to 15 % during the subsequent 5-year period. During the next 5-year period, when, furthermore, plaster had been used with more than 90° flexion and considerably less abduction than 90°, only 5 % showed avascular necrosis, with relatively slight changes.

In the material of my study avascular necrosis with persistent changes was observed in 19 %. These 10 cases illustrate the increasing risk of this complication if reduction is performed:

at an early age, 2—6 months,
when hip abduction is restricted,
without preceding traction therapy and tenotomy,
with fixed immobilization of the hip joints at 90° abduction
(see Case reports I—III, Fig. 13).

Summary of the follow-up of the 52 children with late-diagnosed CDH born in 1976:

40 were diagnosed before the age of 6 months, only 8 after 1 year,
11 had dislocations, the others had subluxations, a few dysplasia alone,
37 were diagnosed at routine examinations at Child Health Centres,
34 were not treated before reduction, either with traction or with tenotomy,
8 were treated with traction,

- 40 (77 %) had normal joints or dysplasia, which is liable to disappear,
- 10 (19 %) showed sequelae of avascular necrosis of the femoral head and neck.
- Only in 3 cases was osteotomy of the pelvis performed — none when diagnosed before 6 months.

Conclusions

- Early treatment of late-diagnosed CDH cases results in a completely normal joint development in most cases.
- The risk of avascular necrosis is still not negligible.
- This risk can be limited by adequate early treatment — traction therapy and tenotomy.
- No patient in whom treatment was started before the age of 6 months and in whom traction therapy was performed before reduction showed avascular necrosis.
- Acetabular dysplasia, which necessitates osteotomy of the pelvis, can be avoided by early diagnosis and treatment.

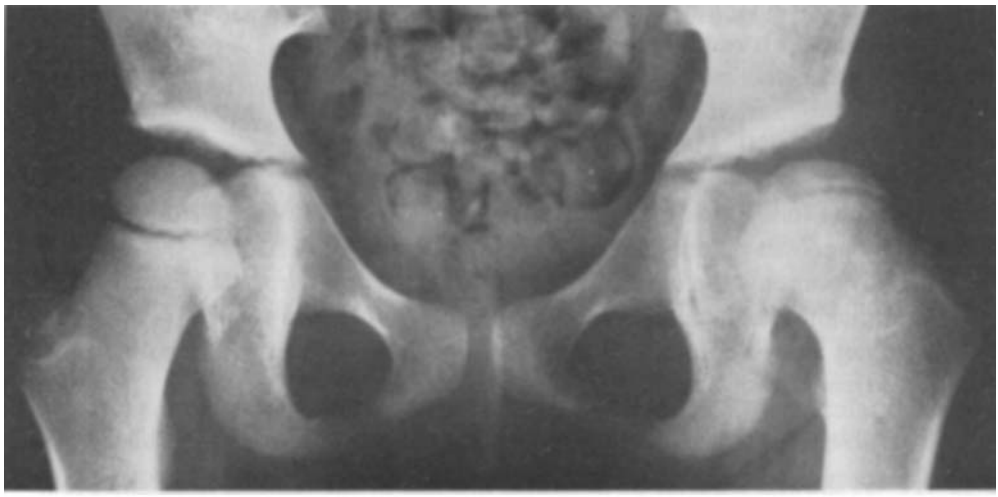


Fig. 13: I—III. Case reports. Avascular necrosis of the hip joint.
I. 760630, J.J. At the age of one week hip joints normal. At 2 1/2 months instability of the left hip joint. X-ray: left acetabular angle 45°, subluxation, right 30°, normal. Reduction easy, therefore no traction therapy and no tenotomy. Treatment: von Rosen splint for 3 months. At 15 months: avascular necrosis of the left femoral head. Later on the metaphysis also deformed. At 4 years and 7 months: radiographic follow-up: coxa vara and magna (Figs).

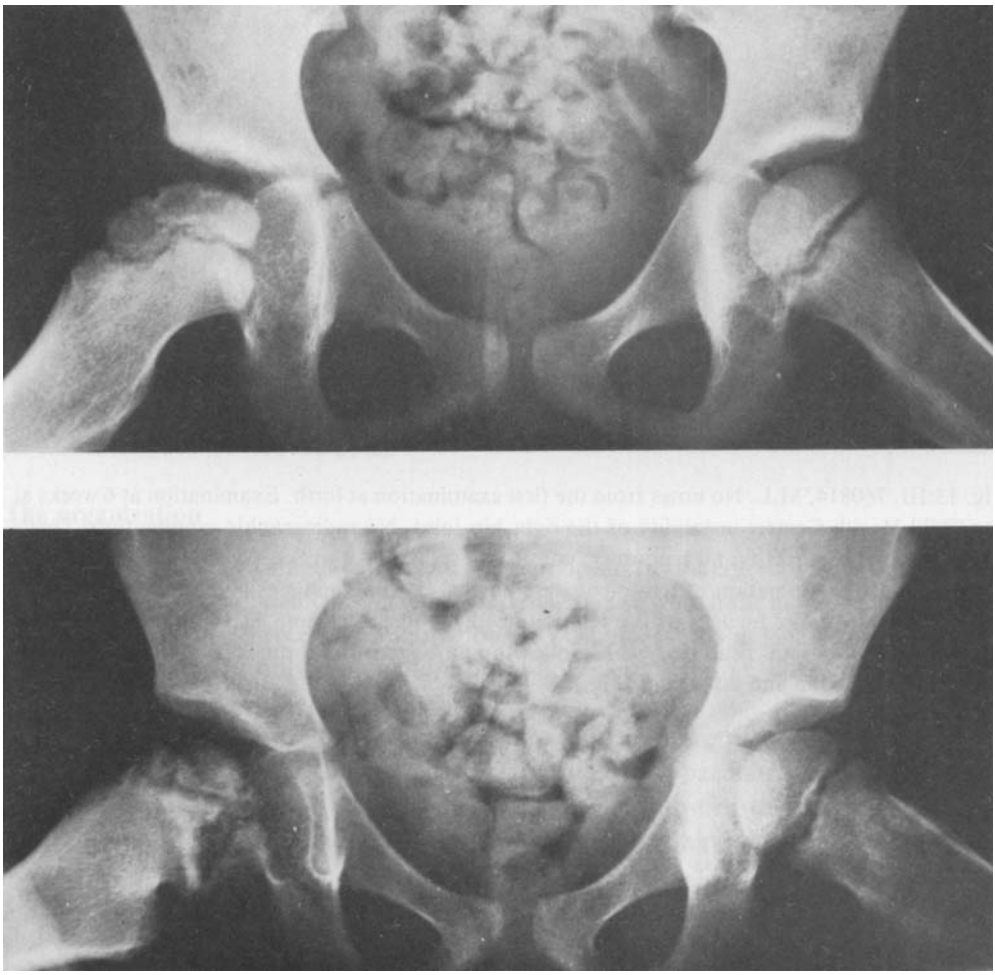


Fig. 13:II. 760930, N.S. Older sister: preluxation at birth. Hip joint instability suspected at birth, but at a second examination nothing abnormal observed, as at the first examination at the Child Health Centre. At 3 1/2 months limited abduction of the right hip joint. Radiographic examination: dislocation of the right hip joint. Treatment: reduction relatively easy under general anaesthesia (no traction therapy, no tenotomy). Plaster for only 3 months because of dermatitis. Later on avascular necrosis of the femoral head and neck. Follow-up at 4 1/2 years: sequelae of necrosis (Figs).

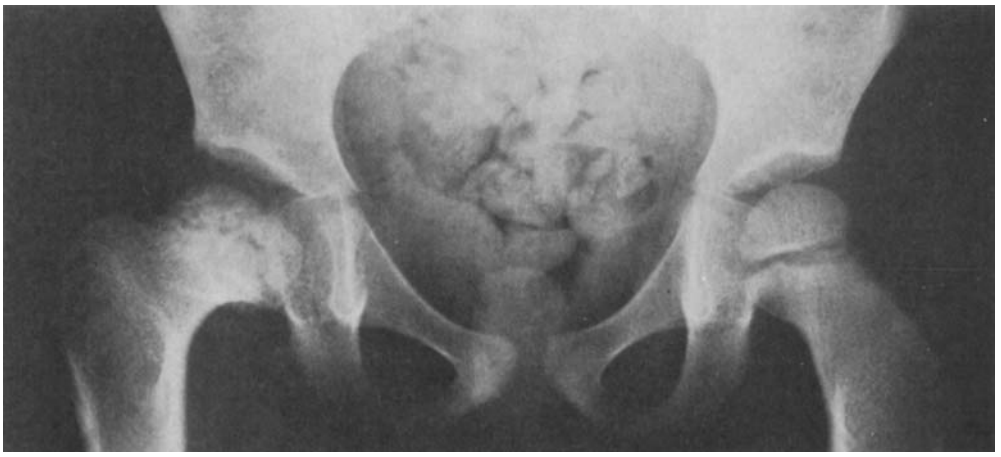


Fig. 13:III. 760814, M.L. No notes from the first examination at birth. Examination at 6 weeks at the Child Health Centre: instability of the right hip joint. No radiographic examination. Treatment: no traction therapy, no tenotomy; von Rosen splint for 9 weeks. Check-ups after 2 and 5 weeks and after termination of treatment were normal. Radiographic examination at 8 months: still somewhat smaller nucleus of the femoral head, no displacement. At 14 months: avascular necrosis of the femoral head and neck. Follow-up at 4 years and 9 months: severe sequelae of necrosis, coxa plana and coxa vara (Fig.).

Hip joint examination — present recommendations

Examination of newborns

The organization

At the end of the 1940's medical care in Sweden began to undergo considerable expansion. Obstetric, orthopaedic and paediatric departments were built at the central hospitals in all counties. In recent years most of the obstetric wards in small hospitals have been closed. In 1979 only nine children, i.e. 0.09 per thousand, were born at home (statistics from the National Board of Health and Welfare).

Most children are born in a hospital with not only an obstetric department but also departments of paediatrics and orthopaedics. We now have paediatric consultants at all maternity departments, and orthopaedic consultants at most of them.

This has created good conditions for the organization of hip joint examination of all newborns.

The National Board of Health and Welfare has distributed a booklet (proposed and written by me) with advice to the obstetric departments and the Child Health Centres concerning hip examinations (Palmén 1980 b). The Board stresses the importance of examining the hip joints when the newborn's health is being checked. The paediatric and orthopaedic consultants co-operate in this matter, the former carrying out the primary examinations at the same time as the general health examination of the child.

Most important is that *one* experienced paediatrician and *one* experienced orthopaedic surgeon share the responsibility of diagnosis and treatment. They should also assume the responsibility of instructing their colleagues in these procedures, thus enabling the latter to replace them during their absence.

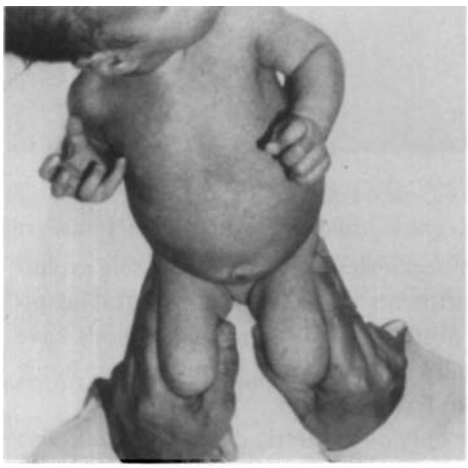
The newborns are examined twice by a paediatrician, the first time within 24 hours after birth and the second time when the mother is due to be discharged, normally on the 5th—7th day. The mother is present at the second examination. On both occasions the hip joints are examined.

The mother is asked about any family history of CDH, which is noted in the child's record.

Examination technique

The examination room should be comfortably heated and the examiner must have warm hands. The table should be high, about 90 cm, and its mattress rather hard.

The infant should be examined after a meal so that it is as calm as possible. If it is crying or tense a pacifier may be given. The child lies on its back, naked. The examiner stands at the foot-end of the table.



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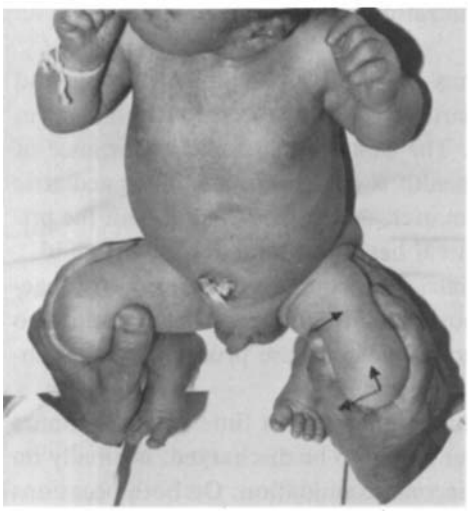

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Fig. 14 a. Hip joint examination of newborn infants. The abduction test. Initial position. 90° flexion at knee and hip joints, hips adducted.

Fig. 14 b. Slow abduction with slight pressure in the direction of the arrows.

Fig. 14 c. Subluxation-provocation. Examination of the left hip (left hand supports the pelvis). Slow adduction with the right hand and slight pressure in the direction of the arrows.

Stage 1: Inspection

Study the way in which the child actively moves its legs. If the hip joints are normal the child will move them symmetrically and will also now and then place its legs, flexed at the hip and knee joints, in symmetrical normal abduction.

A manifest dislocation may be suspected merely by the simple measure of observing the child.

Establish whether there are any deformities due to a fetal position which might imply an increased risk of dislocation, e.g. pes calcaneo-valgus, plagiocephaly, torticollis, oblique mandible.

Stage 2: Abduction test

(Le Damany 1912, Ortolani 1948).

Take hold of the legs, with your thumbs on the inside of the knees, and your fingers on the trochanter major region. Keep the legs together, completely adducted and stretched but without trying to force a possible restricted flexion of the hip and knee joints, which is apparent in some newborns, especially during the first days. Check that the legs are of equal length. N.B.: straight back and symmetrical pelvis. Then flex the hip and knee joints 90° (Fig. 14 a).

Abduct slowly and carefully, with your whole hand, giving simultaneous slight pressure both in the direction of the thigh towards the joint and upwards with your fingers on the trochanter major region (Fig. 14 b).

If the femoral head is subluxated in the initial position — or in a rare reducible dislocation — you can feel a slight resistance when you have abducted about 45—60°. Do not force the abduction if the child cannot relax. If you hold on with slight pressure the child will relax and you will gradually be able to continue abducting.

When you pass an abductional stage of 45—60° you will distinctly feel the femoral head gliding or jumping into the centre of the acetabulum. If you then adduct again, pressing in the reverse direction, the femoral head will subluxate or dislocate again.

If stage 2 is negative, go on with the next stage:

Stage 3: Provocation of subluxation

(Palmén 1961; Barlow 1962):

In slight cases the femoral head might, at the preceding stage, initially be in the centre of the joint, but it can be made to subluxate by provocation.

From an initial position of 90° of flexion and slight abduction, about 45°, with your thumbs a little further towards the upper parts of the thighs, press slightly backwards--upwards with simultaneous slight *adduction* and inward rotation, as if the femoral head were to be subluxated (Fig. 14 c). It is better to carry out this stage on one side at a time, while the other hand remains in the same position supporting the pelvis.

If instability is present, you will distinctly feel the femoral head being displaced backwards-upwards. Also, reversing this stage, it can easily be moved back into the centre of the joint. The feeling of reduction will be more or less distinct.

- Have a light touch — don't force any resistance!
- When examining you can sometimes hear and feel crepitations or creaks from the hips and knees, probably caused by tendons. They are unspecific.

Note in the child's record that a hip joint examination has been performed. Describe a positive finding correctly. Use the word "instability", not "click".

If a child has been moved to the neonatal ward or intensive care unit before the hip joint examination has been made, note this in its record in order that the examination is not overlooked later. The examination should be performed as soon as the child is able to undergo it. This is also true for prematurely born children.

If you make a positive finding, contact an orthopaedic consultant immediately. If there is one at your hospital he should preferably examine the child that very day, if possible together with the paediatrician.

The orthopaedic surgeon takes over the responsibility for the treatment. If an uncertain finding cannot be verified, a further examination is important.

- All mothers should be taught that their children should sleep in the prone position from the beginning, with the legs abducted, which is advantageous from several points of view, e.g. to avoid unspecific limited abduction of the hip joint.

Comments on the examination technique

The newborn infants should be examined during their first or second day of life. In many cases the tonus of the joint tissues and surrounding muscles is reduced by hormonal influence from the mother. When this influence has disappeared after some days it is more difficult to establish the presence of instability. In many cases this is probably one reason why, according to old observations, instability found during the first days may be absent after a few days (Palmén 1953).

During its first days, on the other hand, the child may show increased tonus, possibly due to its intrauterine position, and an instability may be found only at the second examination some days later. The second examination is therefore important.

If the child is very flaccid, with markedly reduced tonus of the hip joints and muscles, the femoral head may rotate in a subluxated/dislocated position at the abduction test, and no reduction or feeling of instability will be obtained. In such cases it is of great importance to press inwards, towards the joint, at the abduction manoeuvre, in the manner described above, as if attempting to reduce a displaced femoral head into the centre of the acetabulum.

Some cases show instability only when the examination is repeated. The muscular tonus has then decreased and the instability can be felt. Repeated examinations might result in the provocation of a so called "vacuum phenomenon" in the joint. Thus a change in pressure causes gas to be formed in the synovial fluid, possibly leading to minor instability. This could be one cause of over-diagnosis, but since it is of great importance not to miss a CDH-based instability, I still recommend that the examination be repeated two or three times.

However, if an instability has been found, it is not advisable to repeat the examin-

ation without due reason, as this might damage the joint tissues. Above all, do not try to force resistance to abduction when examining.

It is important to start the abduction test from a position with the legs extended and adducted. If the child is in the supine position, with its hip joints flexed 90—110° and abducted 80—90° — a normal resting position — a subluxation might now be reduced. I have observed the following in some cases with greatly increased laxity of the hip joints: If, with the child in the above-mentioned supine position, I have slowly extended its legs by pulling on its feet, meanwhile making its legs slide against the examination table, I have clearly noticed a subluxation sound and feeling when the legs are rotated inwards at the hips at about 45° flexion, before they are totally extended and adducted. Thus, extension — adduction, which also means inward rotation of the hip joint, is a "position of dislocation".

● This is certainly the explanation why CDH is much more common in regions where the mothers keep their infants with the legs stretched out and swaddled.

Other clinical symptoms

Since dislocation is rare in newborn infants, limited abduction, shortening of the leg and other asymmetries, e.g. of the medial thigh folds, all of which are signs of dislocation, only exceptionally are of importance in the examination of newborns.

If, however, there is a real dislocation, e.g. in malformation syndromes, the child will keep its leg adducted and often more or less extended, and will not move the leg at the hip joint spontaneously to any great extent. In unilateral cases considerable shortening of the leg, as well as asymmetries of the medial skin folds, will also be observed.

In the unusual cases of dislocation without any malformations, limited abduction may be the most obvious sign. If the child is calm and relaxed and repeated examinations meet with constant resistance to an abduction of less than 60°, especially in unilateral but also in bilateral cases, dislocation should be suspected. In a few rare cases we have seen restricted abduction caused by a haematoma in the adductor muscles.

As a dislocation in newborns is seldom reducible, instability is rarely found in these cases.

Except in cases of dislocations, asymmetries of the medial skin folds of the thighs are of no importance, since they are also encountered in healthy children. A previous study of healthy newborns (Palmén 1961) with respect to the medial skin folds of the thighs and to the abduction of the hip joint gave the results presented in Tables XI and XII.

Table XI. Medial skin folds of the thighs in 500 newborns.

	%
Symmetrical folds	40
Asymmetrical folds	32
No folds	28

Table XII. Abduction of the hip joints in 500 newborns.

Degrees	%
90—100°	70
80°	28
70°	2

Four of these newborns had hip instability; all of them had an abduction of 90°!

Conclusions:

- Limited abduction and asymmetry of the medial skin folds of the thigh are of no significance for a diagnosis of hip instability.
- Normal abduction of the hip joint does not exclude instability.

Examination after the neonatal period

It has been considered very urgent to organize hip examination at the Child Health Centres with the aim of discovering as early as possible any cases of CDH which for any reason have not been diagnosed before the newborn infant has left the obstetric hospital. This has been based on our opinion that early treatment gives better results. Therefore, when starting hip joint examinations of newborns in the 1950's, we recommended that the hips also be examined at the Child Health Centres.

This advice was intensified in the beginning of the 1970's, when we found that some late-diagnosed cases of CDH were being referred to the orthopaedic departments for treatment even at the age of more than one year.

The present organization of hip examination by the Child Health Service (Palmén 1980 b)

Examination of the hips is especially important at the child's first visit to the doctor, at the age of 6—8 weeks. It should be possible to detect most of our late-diagnosed CDH cases at this point in time.

During recent years the majority of the late-diagnosed cases have been discovered at the age of 1—6 months (77 % of such cases in 1976—1979). The infants also undergo general examinations at the age of 4, 6 and 10 months, and these should include an examination of the hips.

The examination at 10 months of age is important, since no further examinations are made under the Child Health Service until the age of 18 months.

Most of the 6—10 cases of dislocations and subluxations that we find every year after the age of one year should have been detectable earlier at a thorough hip examination.

Instead, the parents have usually noticed that the child is limping and have consulted a doctor.

In the instructions on hip joint examination issued by the National Board of Health and Welfare (1980b), I have added a special section dealing with the examination of children at the Child Health Centres. I recommend the following plan for the examination:

The hip joints are to be examined at every visit to the doctor, at least up to the check-up at 18 months.

At the first visit, at 6—8 weeks:

Ask the mother:

about potential heredity concerning dislocation;

whether the child moves and kicks both legs to an equal extent;

whether she has noticed any difference in the mobility of the baby's legs, when she is washing it or changing its nappies;

Look at the child's record from the obstetric department to see whether there has been anything giving rise to suspicion at the hip joint examination (a copy of the child's record is sent to the Health Centres as a matter of routine).

Hip joint examination (see also Fig. 14)

For the examination the child should be naked and placed in the supine position on a high table with a rather hard mattress.

Inspection:

Look for deformities due to an intrauterine position (see above).

Look at the way in which the child spontaneously moves its legs.

Look at the way the child is lying. Habitual unilateral supine position?

Ask the mother what position the child usually assumes when sleeping, after its first week — the prone or supine position? If supine, does it sleep on both sides? Does the child usually lie with one leg always stretched out? Ask the mother to show you the child's usual sleeping position.

Check the length of the legs. Try first with the legs extended and adducted, and then with the hip joints flexed 90° and the knees maximally flexed. It is important at these examinations that the pelvis is in a symmetrical position, (Fig. 15).

With the child in the same positions, look to see whether the following are symmetrical

- the lateral trochanter major region,
- the groins,
- the minor lateral folds on either side of the labia/scrotum down towards the gluteal region,
- the medial folds of the thighs.

In the event of pronounced one-sided subluxation and dislocation, you will see that the trochanter major region bulges, that the groin is somewhat "empty" and the minor skin folds are asymmetrical (see arrows on the figure). It is part of the picture that the medial folds are sometimes asymmetrical, but this may also occur in normal children.

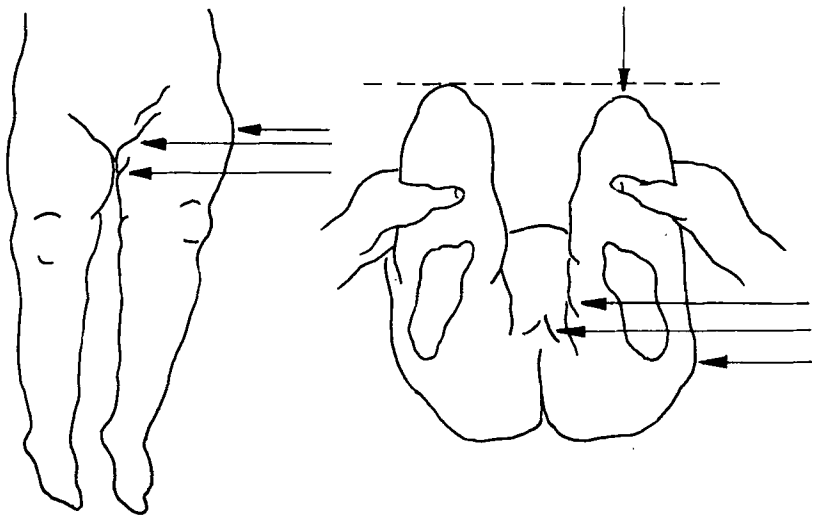


Fig. 15. Examining the length of the legs and other asymmetries. Left-sided subluxation/dislocation.

Abduction test and provocation of subluxation are then performed as at the examination of newborns.

- Crepitations and creaks are often heard at the hip examination, as at movements of other joints, but as mentioned concerning the examination of newborns, these are unspecific.

Signs of dislocation when the child has started to stand and walk:

- limited abduction, asymmetries and shortening of the leg, as described above. The child will often stand on tiptoes on the dislocated leg;
- the leg will sometimes be outwardly rotated, but such rotation of the legs and feet is not uncommon during the first year of life, not even unilaterally;
- limping, noticeable when the child walks; a waddling gait in bilateral cases;
- increased lordosis of the lumbar spine;
- Trendelenburg's sign is often positive in the presence of dislocation. If the child stands on the dislocated leg and lifts the other leg, the pelvis will sink on the unaffected side. The gluteal muscles of the dislocated hip are not sufficiently strong to support the pelvis.

As on examination of newborns, it is important to note in the child's record that the hip joints have been examined. This is also advisable in case a late diagnosis of dislocation is considered by the parents as grounds for legal action.

Instructions concerning the hip examination should be easily accessible in the examination room.

Comments

Hip joint instability:

In most cases of hip joint laxity the tonus of muscles and other tissues will soon increase and any instability of the femoral head will disappear after a few days up to a week or two. In the material of late-diagnosed cases of CDH, instability was found in only 8 %, and only among the youngest infants. However, it is important to diagnose instability, using the same technique as when examining newborns.

Difference in the length of the legs:

If the pelvis and the legs are held symmetrically at the examination, there is normally no difference in the length of the legs. On examination of 600 infants and children up to 6 years of age at the Child Health Centre, I found only two with a difference in leg length. In both children this was known before and was due to a condition other than CDH (one with coxa plana and the other with neurofibromatosis with a pelvic tumour).

An unmistakable shortening of the leg should always give rise to a suspicion of CDH. It might, however, be absent in cases of dysplasia of the acetabulum with or without a slight subluxation. With remarkable frequency examiners believe that they have found shortening of the leg even in the presence of unspecific limited abduction, when it can be difficult to keep the pelvis and the legs in a symmetrical position.

Limited abduction:

Most infants with dislocation and subluxation show contraction of the adductor muscles at an early stage, which will render reduction of the femoral head impossible at the examination. Out of 407 late-diagnosed cases of CDH, 80 %, according to the records, displayed limited abduction. As mentioned above, 8 % showed instability of the hip. For the remaining 12 % no information concerning abduction is given. Practically all the cases of late-diagnosed dislocation and subluxation that I have encountered have had limited abduction; in a few exceptions there has been persistent instability of the hip joint.

Unilaterally limited abduction is easy to diagnose and nowadays most late-diagnosed cases of CDH (94 %) are unilateral (Palmén 1980 a). Bilateral limited abduction can be more difficult to evaluate. It is difficult to state what degree of abduction is normal at different ages. To obtain maximum abduction at the examination the child must be totally calm and relaxed, a state which may be difficult to achieve with young children.

- As a rule the abduction can be expected to be at least 60° during the first 6 months.
- A bilateral abduction of less than 60° should, even as the only sign, arouse suspicion of a dislocation/subluxation, as should also all cases of unilateral limited abduction, irrespective of its degree.

In order to find the CDH cases as early as possible, we have recommended that all infants with restricted abduction be referred to an experienced orthopaedic surgeon. However, in many of these cases the abduction limitation has been unspecific. Since

this has caused new problems to orthopaedic surgeons and paediatricians, as well as radiologists, especially in infants at ages of 2—4 months, unspecific limited abduction of the hip joint will be dealt with in a separate chapter.

Unspecific unilaterally limited abduction

In 1973 the Child Health Service started to use a new structured examination schedule entered on a record form for visits during which the child is examined by a physician. Especially at the 2-month check-up an examination of the hip joint is recommended, with a view to discovering cases of CDH that may not have been found during the first week of life.

In the manual concerning this examination schedule it is pointed out that limited abduction is one of the main symptoms of CDH. This is clearly the reason why an increased number of infants were admitted to the orthopaedic departments during the subsequent years. It seemed as if the numbers of late-diagnosed cases of CDH were increasing in spite of renewed information to the obstetric departments concerning hip examination in all newborns. The diagnosis can, however, be uncertain even after radiography. But as a matter of precaution many of these cases were treated, often with tenotomy and plaster for some months.

On going through the late-diagnosed cases of CDH, I found that several had been unspecific. Under anaesthesia there had been no feeling of reduction. Radiography showed that the larger acetabular angle seemed to be due to a rotated position of the pelvis and there were no positive X-ray signs of subluxation/dislocation. At follow-up radiographic examinations the hip joint development was found to be normal.

In order to examine the question of limited abduction in infants more thoroughly I made an investigation at my Child Health Centres during the years 1974—1976 (Palmén 1977, preliminary report):

At the mother's first visit, when the baby was about 2 months old, I asked her in what position the baby usually slept — whether, from the start, it had slept on its back, on one side, on both sides alternately, or in the prone position. I then examined the child and noted the following deviations, if present: limited abduction of the hip joints, flattening of the skull, plagiocephaly, torticollis, haematoma of the sternocleidomastoid muscle, deformities of the thorax and pelvis and malposition of the feet. The child was later followed up on its regular visits at the ages of 4, 6, 10 and 18 months.

Material

The material finally comprised 794 infants, roughly 50 % of each sex, and the results are given in Tables XIII and XIV.

Table XIII. Sleeping position during the first 2 months of life of 794 infants.

Born in	Prone		Supine	
	n	%	n	%
1974	144	*58*	103	*42*
1975	180	*68*	83	*32*
1976	208	*73*	76	*27*
Total	532	*67*	262	*33*

Table XIV. Infants with unilaterally limited abduction of the hip joint, distributed with respect to sleeping position.

Born in	Prone		Supine	
	n	%	n	%
1974	7/144	*4.9*	15/103	*14*
1975	3/180	*1.7*	17/ 83	*21*
1976	3/208	*1.4*	18/ 76	*24*
Total	13/532	*2.4*	50/262	*19*

Among infants who had been lying in the prone position only few had unilaterally limited abduction, and by 1976 the proportion had diminished to 1.4 % (Table XIV). Among those who had been lying on their backs and on one side, however, the proportion with limited abduction had increased to 24 %.

Of the infants who had been lying in the prone position, 13 (2.4 %) had unilaterally limited abduction and in 11 of these it was very slight, about 10°. One child, a girl, was of special interest. At 2 months of age she had normal abduction, 80° bilaterally, but at 4 months the abduction on one side was moderately limited, to 60°, compared with 80° on the other side. This gave reason for a radiographic examination, which showed slight acetabular dysplasia and mild subluxation. The child was treated with plaster at the department of orthopaedics.

Of the 50 infants who had been lying on their backs and showed unilaterally limited abduction, 23 (8.8 %) had an abduction of only 45° on one side, compared with 60—80° on the other side. These comprised 2.9 % of the total 794 infants. It is of great interest that all of these 23 infants had been lying turned over half-way to one side, always in the same posture — the "*habitual unilateral supine position*" (Fig. 16).

Eighteen of the 23 infants showed hip abduction of only 45° already at the first examination, at 6—8 weeks, and all of them had flattening of the skull on the side on which they had been habitually lying (i.e. the side contralateral to the limited ab-

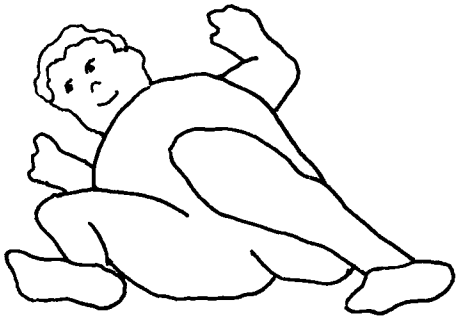
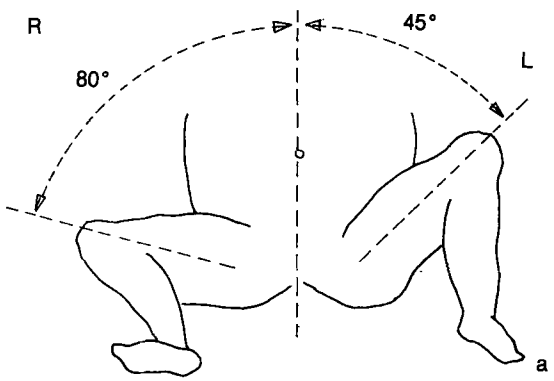


Fig. 16. Habitual unilateral supine position.



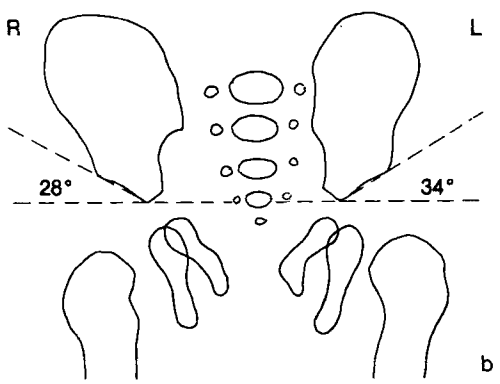


Fig. 17. a. Limited abduction of the left hip joint in an infant who had mostly been lying in a unilateral right-sided supine position during the first months.

b. Radiograph from the same infant. Note the false projection of the left os ilium, simulating an increased acetabular angle. The hip was normal at follow-up.

duction). Five infants in whom at 2 months the hip abduction was not markedly limited but at 4 months was restricted to 45°, showed no deformity of the skull. This deformity seemed to occur mainly in those who at an early stage had invariably been lying in an oblique position. A few (four) cases were more pronounced, with obliquity also of the thorax and pelvis. Most of the 23 infants displayed a more or less clear tendency to lie with their backs leaning towards the side on which they habitually lay, but none of them had a definite scoliosis.

Of these 23 infants, one was born with a breech presentation, one by Caesarean section, and two were born prematurely. The others were normally delivered without complications. It is interesting that none of these infants was found to have a haematoma in the sternocleidomastoid muscle. Whether there was any case of unilaterally flattened skull or of plagiocephaly at birth, as an intrauterine deformity, among these infants is not clear, but no notes concerning such conditions were found in their records and their parents had not observed anything abnormal initially.

Of the 50 infants who had been lying in the supine position and had unilaterally limited abduction, 27 showed a fairly slight limitation, with abduction of 60°, compared to 70—80° on the other side. In none of them were any other signs of CDH and a few were X-rayed with normal results. The abduction limitation disappeared within a few months when the infants started to lie on the other side also.

Radiographic examination

It is difficult to get the pelvis and legs in a symmetrical position at the examination. When the legs are kept extended and adducted, the pelvis will be rotated in the sagittal plane. The os ilium, which is more sagittally placed, will seem narrow and the acetabular angle increased. Asymmetries concerning the alignment of the thighs, together with a difference in rotation of the two legs due to the limited abduction, might lead to misinterpretations. Consequently, the radiographic diagnosis may sometimes be noted as acetabular dysplasia and suspected subluxation (Fig. 17 b). Of the 23 infants in my material mentioned above only seven were X-rayed at the age of 4—6 months. As these results were negative, the later cases were only followed up at the age of 1—3 years. The hip joints were normal at all examinations.

Treatment

When after a few months the infant starts to turn towards light and towards the direction from which it hears its parents' voices, the treatment consists of only one piece of advice to its mother — to place the baby in such a way that, when lying on its habitual side it will face the wall! This will have the desired effect provided the baby has an open cot with bars.

Results

At the age of 6—10 months all infants with unspecific limitation of hip abduction showed normal equilateral abduction.

Later follow-up

Towards the end of 1979 all the 23 infants with markedly limited abduction underwent a radiographic follow-up. Thus the follow-up time was 3 1/2 to 6 years.

- At all these X-ray examinations the development of the hip joint was found to be normal.

The spherical index of the femoral head was measured and was normal and equilateral. The acetabulum had also developed normally, and in no case was an actual pelvic obliquity observed. One prematurely born girl with a birth weight of 2,010 g had radiographically normal hips at 3 years, whereas at the age of 7 years she had a moderate coxa vara.

Discussion

Until recent years in Sweden newborn infants have traditionally been placed on their backs and often on both sides alternately, for instance after meals. At night they have been made to sleep in the supine position, because the parents have considered this to be safer, believing the risk of suffocation to be greater if the child lies face down on a pillow, which was frequently used in earlier times.

When, after some weeks, the infants are able to turn round a little, some of them, if they are lying in the supine position, always assume a semilateral position on the same side, the "habitual unilateral supine position" (Fig. 16). Some infants only turn their heads, but most of them also turn the rest of the body. The legs are usually flexed at the hip joints and the superposed leg is bent towards and over to the side on which the child habitually lies. This position will soon be so strongly fixed that it will be impossible to place the child on its other side, and it will immediately turn back. If placed in the prone position the child will become restless and start crying.

The reasons for such a habitual position are not clear. Among the explanations, an erroneous intrauterine position and immaturity of the primitive reflexes have been mentioned. As remarked above, the infants do not begin to sleep in this unilateral position until they are some weeks old. In my material there was no case of torticollis due to a tumour in the sternocleidomastoid muscle and no definite case of plagiocephaly at birth. Neither did these infants have a very strong or persistent tonic neck reflex. Moreover, the unilateral position was assumed earlier than the normal appearance of this reflex at the age of about 6—8 weeks.

Reisetbauer and Czermak (1972) proposed that a unilateral supine position may be due to the following. The head, which is elliptical at birth, assumes a unilateral position and this habitual position is later reinforced and fixed by the tonic neck reflex. The skull and chest will be distorted and the contralateral leg will be constantly adducted at the hip joint. They warn against an early supine position and also point out that in cases of dislocation it is always the adducted hip joint that will dislocate. I believe this is an erroneous conclusion as to cause and effect. It is correct that a position of adduction (limited abduction) is always found at dislocation, but in none of the 23 cases that I have seen with a habitual unilateral supine position and pronounced limitation of abduction has this affected the hip joint.

Other authors underline the importance of mechanical intrauterine effects as a cause of deformities, e.g. Dunn (1969, 1976) and Mau (1973). The latter also includes among such effects adduction contracture (limited abduction) with "slight dysplasia" in the hip joint.

In his text-book on paediatric orthopaedics, Tachdjian (1972) claims that a fetal malposition might give rise to a "congenital abduction contracture of the hip and pelvic obliquity", a state which he considers much more common than CDH. The other leg will then be adducted and a radiological examination may reveal dysplasia in the hip joint of that side. If a pronounced abduction contracture is not treated early by passive stretching exercises, a subluxation of the opposite hip may occur.

During my extensive work on examination of newborns and infants, I have never seen a case of pronounced abduction contracture. I have noticed that in a few infants with markedly limited abduction due to a unilateral supine position, the adduction on the opposite side has been somewhat restricted, an effect that I have attributed to the prolonged unilateral position of the legs. All such infants in my study have developed normal hip mobility without special treatment, and the radiographic follow-up has shown that the hip joints have developed normally.

The prone position as prophylaxis against limited abduction

Of the infants attending the Child Health Centres, more than 90 % sleep in the prone position, and for this reason cases of unspecific markedly limited abduction have been rare in recent years.

During the last three years I have carefully studied abduction of the hip joints in about 300 infants and have found six case of limited abduction and this has been slight, 10—15°. Two of these infants had mostly slept in the supine position and the others mainly in the prone position but sometimes in the supine position — and then often with their legs turned over to one side. None of them received treatment and all showed normal joints at a radiographic follow-up.

Does the prone position constitute a prophylactic measure against hip dysplasia or subluxation/dislocation in cases not diagnosed at birth?

At first this seemed an attractive thought. A position of flexed, abducted legs — achievable if the newborn is placed in the prone position — is ideal for congruency of the femoral head and the acetabulum and thus for normal development of the joints. But many infants do not flex their hip joints in this favourable way when in the prone posture. Most of them start stretching their legs, one or both, and a sleeping position in which the legs are completely adducted and flexed at the hips and knees is sometimes seen.

In spite of the active information given to the mothers to place the child's legs in flexion-abduction in the prone position from the beginning, the child will soon assume its own position.

In the questionnaire to the mothers of infants with late-diagnosed CDH I asked the mothers about the position in which their child slept during the first months of life. It

appeared that 87 % of 177 such infants slept in the prone position during 1977—1979. Thus the prone position does not seem to constitute prophylaxis against CDH.

Recommendations concerning the prone position

At the time of the above-mentioned study, in most parts of Sweden no recommendations were given consistently to mothers and nursing staff to place all infants in the prone position during their first months of life. The existing advisory pamphlets for new parents did not mention anything about how to place the child in bed, only that the prone position was favourable in the event of colic. As soon as I realised the connection between the supine position and the numerous limited abductions we were encountering at that time, and since the prone position is better for infants also from other points of view, I decided to recommend it. But first I wanted to make sure that this position did not harm the children's feet. Many parents were now worried by some newspaper articles warning against the prone position, for the reason that it might cause outwardly rotated feet and legs.

When studying the abduction of the hip joints I also noted the position of the feet, and again at the follow-up at the age of 18 months. After the follow-up of the whole material I compared the two groups — infants who had been lying in the prone position and those who had been lying supine.

I found that during the first year of life — also at 10 months of age — an increased outward rotation of the hip joints and feet was somewhat more usual than a valgus position of the feet in infants sleeping in the prone position. However, at the age of 18 months, when the children had walked for several months, these "erroneous positions" had in most cases corrected spontaneously. I found only about 3 % with moderate in-toeing and as many with out-toeing. There was no difference in the distribution of these children between groups sleeping in the prone position and supine position.

In January 1976 I sent some information to the chief physicians of the Child Health Service in all counties concerning these examinations, together with recommendations that the obstetric departments and the Child Health Centres be informed of the advantages in getting all infants to sleep in the prone position from birth. A preliminary report was published and sent out to all paediatricians (Palmén 1977).

Conclusions

- Unilateral, markedly limited abduction of 45° was found in 9 % of infants who had always slept in the supine position during their first months of life.
- Diagnosis of limited abduction due to the "habitual unilateral supine position" is easy. In most such infants the back of the head is flattened on the opposite side.
- Such limited abduction of 45° was not encountered in infants who had been sleeping in the prone position.
- At the radiographic examination it is vital to consider sources of errors such as a rotated pelvis and other asymmetries.

- In the 23 infants with unspecific unilaterally limited abduction the radiographic follow-up showed a normal development of the hip joint.
- There has been no need for special treatment.
- A prone position during the first months of life prevents this type of limited abduction of the hip.
- A prone position, however, is not a prophylactic measure against CDH.
- A prone position is the best sleeping position for newborns and infants for other reasons. It does not cause later in-toeing.

Treatment of hip instability in newborns

"... begin treatment the very moment the deformity is observed, even if that be on the first day of birth".

Putti 1929

Present programme of organization

The programme for the treatment and its organization has been worked out by the present author and Associate Professor Lars Danielsson, paediatric orthopaedic surgeon at the Department of Orthopaedics in Malmö. The programme has been made at the request of the Swedish Orthopaedic Society and has recently (1982) been recommended to all orthopaedic departments.

When an experienced paediatric consultant or an orthopaedic consultant discovers hip instability or a reducible dislocation, treatment with a von Rosen splint should be started immediately.

Even if in most cases of diagnosed instability, probably 80 % at least, this is slight and will disappear in a few days, all infants with hip instability, verified by the orthopaedic consultant, ought to be treated.

If the instability is uncertain or if an experienced orthopaedic consultant is unable to verify a positive finding, treatment may be deferred. Continuous checks, the first before the mother and child leave the obstetric department, will then be necessary.

While the mother remains in the obstetric ward the orthopaedic surgeon should explain the situation to her and tell her about the treatment. She will also receive written instructions (see below).

The following infants should be referred to a paediatric orthopaedic surgeon at a regional hospital:

Newborn infants with

a) dislocation which is not reducible;

b) high-grade hip instability, which often may be bilateral, where the retention of the femoral head in the acetabulum is deemed poor;

c) definite or suspected re-dislocation during the treatment;

d) definite or suspected instability or dislocation when the splint treatment is discontinued. In doubtful cases which possibly require further treatment, the X-rays may be sent for assessment if dysplasia of the acetabulum persists after treatment or if there is an uncertain subluxation.

A radiographic examination is not necessary in cases of instability when it is clearly felt that the femoral head has been reduced, either before or after the child has been placed in the splint. Neither should an X-ray examination be performed if at the subsequent checks during the treatment the child shows normal hip abduction, no asymmetries and no instability.

A routine radiographic examination is recommended on termination of the treatment at the age of 6 weeks to 3 months. If considered necessary by the orthopaedic surgeon, a further radiographic examination may be performed when the child is 6 months and/or one year old.

Treatment of late-diagnosed CDH

Concerning the treatment of late-diagnosed CDH, it is recommended that these cases be referred to the paediatric orthopaedic surgeon at the regional hospital. This treatment will not be dealt with in this book.

Information and instructions concerning treatment with a von Rosen splint

Lars Danielsson

Information to parents of children with hip dislocation

Your child's hip joints are not completely stable and you must therefore keep the child in a special splint for at least 6 weeks and possibly up to 3 months. If your child is not treated he or she may suffer from serious hip trouble in the future. If the treatment is followed, the hip joints will in all probability be completely normal.

As a rule the treatment involves no inconveniences to the child. Sometimes the skin may be irritated by the splint, especially if the skin is damp or unclean or if it is chafed by powder. Perspiration, fever or diarrhoea increases the risk of skin irritation.

Once a week the splint will be removed and the child will be given a bath by specially trained staff at the orthopaedic department.

Your child will be examined by an orthopaedic surgeon when discharged from the obstetric department, at the age of 1 month and after the treatment has been stopped, possibly again at 6 months and also at the age of one year. An X-ray check will be made after the treatment, possibly again at 6 months and also at the age of one year.

Advice:

Do not remove the splint yourself.

Do not pull or lift the child by its feet or legs. Keep your hand under its bottom when you lift it.

Let the child sleep in the prone position. Alternate between the prone and supine positions during the day.

Avoid dressing the child too warmly, so as to prevent sweating.

Use cotton clothing indoors and wool outdors only when it is cold.

Do not use too tight-fitting pants.

Rompers of terry cloth may be used over the napkin.

Wash your child in the splint with water and an unscented bar of soap. Dry the skin carefully. Powder lightly with unperfumed baby-powder. Avoid ointments and oils.

Change the napkins often.

If the skin should become sore or if any other problems arise in connection with the treatment, telephone the orthopaedic department, tel. no. .....

Instructions concerning treatment with a von Rosen splint

The original von Rosen splint exists in four standard sizes (small, small no. 2, medium, and large) and in three special sizes (mini, large no. 2, and extra large). Normally a standard size is used for three months. During this period it is mostly necessary to change the splints once or twice as the child grows. The special mini size is used on prematurely born children and the large no. 2 and extra large sizes are used for treatment after the age of 3 months.

The child is placed naked in the splint, with its hips fixed in at least 90° flexion and 70—80° abduction (Fig. 18).

The fixation is not completely locked, but permits slight movements.

When the child is being placed in the splint it is important to feel that the femoral head is positioned in the centre of the acetabulum, i.e. that the displacement is reduced.

The mother is given verbal instructions concerning the nursing of the child, and also written instructions.

Once a week the mother takes the child to the orthopaedic department, where specially trained staff remove the splint, bath the child, check that the displacement is reduced and put the child back into the splint.

The child is examined by the physician twice during its first week, and also after 1 month and at the end of the treatment. Later follow-ups are usually made at 6 months and at one year of age.

An X-ray check is made after the treatment and usually at the age of 6 months and/or at one year, according to the judgement of the orthopaedic surgeon.

One physician alone carries the responsibility for the treatment. A firm organization and strict principles of treatment are indispensable for optimum results.

Instructions to nurses concerning the bathing of children at the orthopaedic department

The child should not be bathed until the navel is completely healed; until then it should only be washed.

The child should be bathed once a week by a trained nurse or an assistant nurse.

Use a suitable tub. The temperature of the water should be 35—37°. Use baby soap and unscented powder. Do not use soap on children with very sensitive or irritated skin, but use unscented bath-oil in the water.

Remove the child from the splint, with one hand under its buttocks and the other

under its head (children with "dislocation" must never be lifted by the legs). Put the child in the prone position on a nursing table and soap its neck, back, arms and legs. Now place the child on its back, using the above-described lifting technique, and soap its neck, stomach, arms and legs.

Lower the child into the tub, with your left arm under the back of its neck, your left hand under its left upper arm and your right arm under its buttocks.

Having lowered the child into the tub, release your right-hand grip but keep your left arm around the child and let it "float" for about 5 minutes as you rinse the soap away with your right hand.

Take the child out of the tub and dry it meticulously, especially in the skin folds. Powder its back and front. Never stretch the child's legs!

Wash the splint with baby soap and water, rinse it, dry it well and powder it.

Put the child back into the splint, checking that it is the correct size. The bath will take about 15—20 minutes.

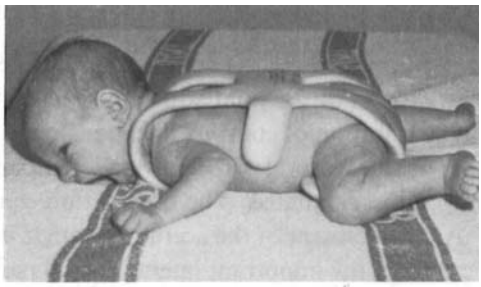


Fig. 18. The "Original von Rosen splint" (Available from Isaksson's Gummifabrik AB, Varan 5745, S-26090, Båstad Sweden). (Photograph by L. Danielsson)

Radiographic examination

Examination of newborns

Conventional radiography

In newborn infants the radiographs of the hip joints are difficult to evaluate, as the central parts of the joint still consist of cartilage, which is not visible on the film without an injection of contrast medium. In the main it is only necessary to decide the direction of the femoral shaft towards the part of the os ilium where the acetabulum is judged to be situated. The ossification centre in the femoral head is not yet visible.

A measurement of the acetabular angle is not reliable, owing to the insignificant ossification of the important lateral cranial part of the acetabulum, even though a more or less conspicuous lateral edge may be seen. The angle is affected by the position of the pelvis at the examination (see below).

For examination of newborns an anterior-posterior projection with the legs extended and adducted has been used for a long time. On the film the position of the femoral shaft is measured and the acetabular angle is constructed as described by Hilgenreiner (1925) (Fig. 19). Provided that the pelvis and the legs are in a symmetrical position the two distances *d* and *h* do not normally vary more than one millimetre between the two sides.

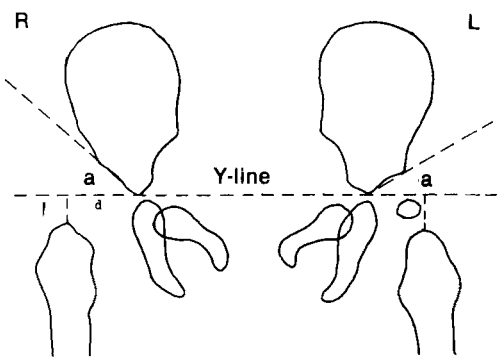


Fig. 19. Hilgenreiner's measurements. Right-sided subluxation. The acetabular angle *a* is larger, the distance *h* smaller and the distance *d* larger than on the left side.

In a case of unilateral instability of the hip joint, the femoral head may be more or less subluxated (when the legs are extended and adducted) and the femoral shaft will then be displaced laterally-proximally. The distance *d* will be larger and the distance *h* smaller (see Fig.). However, it is difficult to estimate the changes of the two distances in a case of slight subluxation. It may be even more difficult to diagnose a bilateral subluxation, when there will be no differences in the distances *d* and *h*. In a case of dislocation, on the contrary, the femoral shafts are obviously displaced.

When constructing the acetabular angle a correct pelvic position is important, otherwise the measurement will be misleading. A pelvic rotation towards one side causes the contralateral os ilium to be projected sagittally, which will give an apparently smaller angle (Fig. 20).

An increased tonus of the hip muscles may sometimes be found in newborns during their first days of life and may mean that the legs cannot be completely extended. An attempt to extend them may instead result in increased lordosis of the lumbar spine, which if pronounced will result in an incorrect projection of the acetabulum. The child should therefore be placed with its legs adducted at the hips with about 30° flexion at the hip and knee joints. In this position there will be no lordosis of the lumbar spine and the pelvis. The effect of increased lordosis on the pelvis will be a decreased acetabular angle (Fig. 21 b).

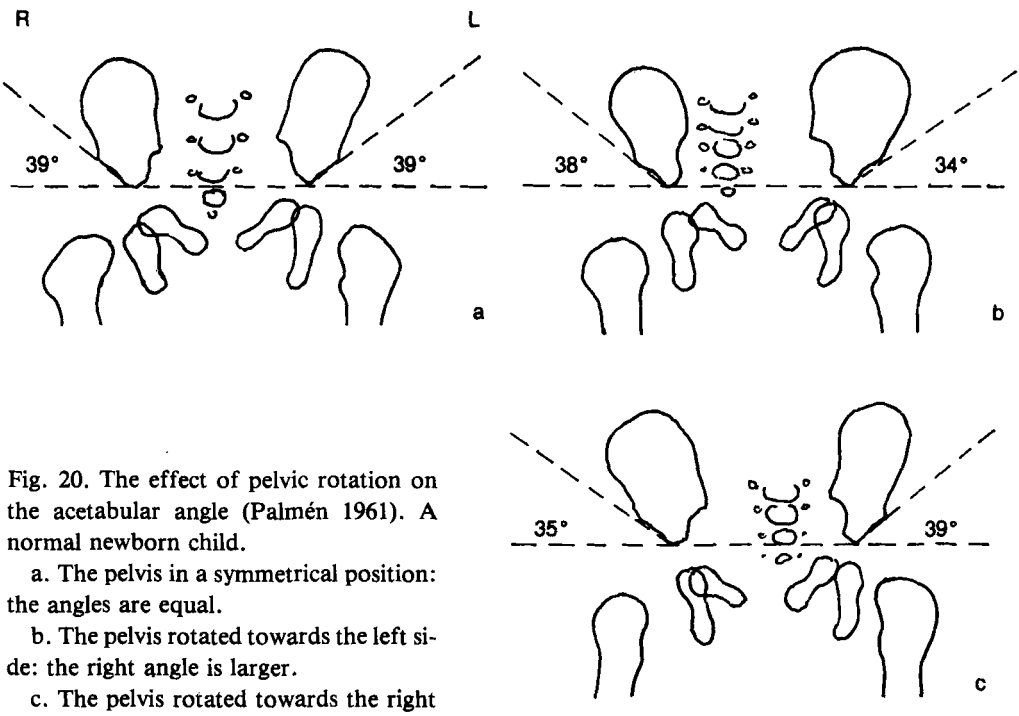


Fig. 20. The effect of pelvic rotation on the acetabular angle (Palmén 1961). A normal newborn child.

a. The pelvis in a symmetrical position: the angles are equal.

b. The pelvis rotated towards the left side: the right angle is larger.

c. The pelvis rotated towards the right side: the left angle is larger.

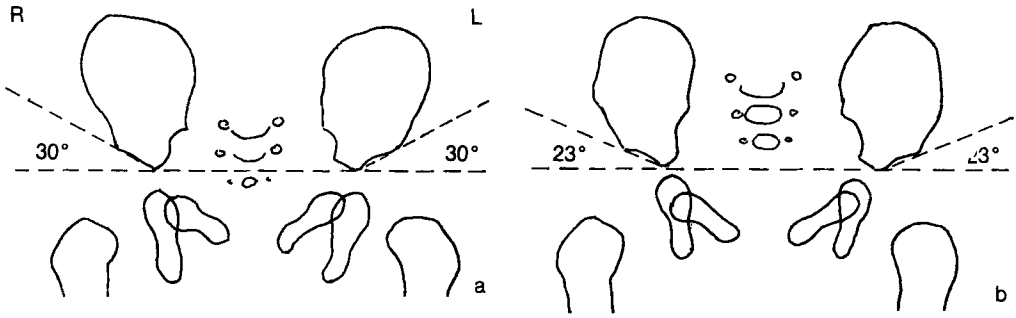


Fig. 21. The effect of pelvic tilting on the acetabular angle (Palmén 1961). A normal newborn child.

a. The pelvis in only slight lumbar lordosis: the angles are 30°.

b. The pelvis in increased lordosis: the angles are smaller, 23°.

In normal newborns, with no hip instability and with the pelvis symmetrically placed at the examination, the acetabular angle will be found to vary considerably (Table XV).

Table XV. The acetabular angle in normal newborns (Palmén 1961). Mean values and ranges.

	n	Acetabular angle (degrees)
Girls	40	36 (28—40)
Boys	40	31 (25—38)

The pelvis placed without lumbar lordosis.

In a material of 450 liveborn and 150 stillborn infants, Stanisavljevic (1964) found a mean acetabular angle of 28° and a range of 10—38°. All these clinically normal hip joints had a "normal acetabular edge" even if the angle was 38°. In four cases of subluxation the angle was greater than 28° and the acetabular bony edge was "absent", when the radiological examination was made without lordosis of the lumbar spine ("pelvic lordosis"). But when the pelvis was tilted 25° in these infants the angle was smaller than 25° and an acetabular edge was visible — a seemingly normal X-ray. This illustrates the difficulties in evaluating the acetabular angle and bony edge.

Another method of examining the hips in newborns was described by Andrén and von Rosen (1958) in Malmö. The legs are kept extended, abducted at least 45° and rotated inwardly. A line drawn through the axis of the femoral shaft will normally point to the bony edge of the acetabulum (Fig. 22, right hip), and in cases of dislocation often as high as towards the anterior-superior iliac spine (Fig. 22, left hip).

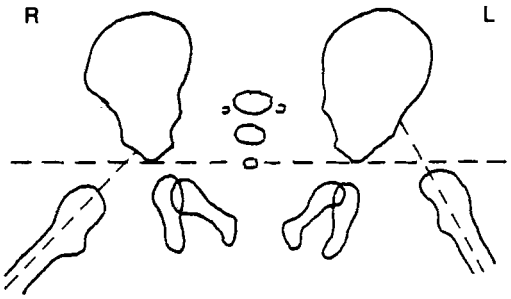


Fig. 22. The Andrén and von Rosen method of radiographic examination; see text.

If the capsule is very lax it is easy to demonstrate a subluxation in this way, but in mild cases it may be difficult. For a correct radiographic diagnosis it is necessary for the examiner to really maintain the child's leg in a position where he can *feel* that the femoral head is displaced.

The above findings illustrate the difficulties in performing a radiographic examination of the hips in newborns, and evaluating the results. A diagnosis of so called "acetabular dysplasia" can definitely not be made on the basis of an increased angle alone.

Is radiographic examination of newborns with instability of the hips necessary?

When the hip joint is unstable, it may be observed in different ways on the radiograph that the femoral shaft is displaced, on condition that the child's legs are maintained in a position in which the displacement has been felt. Thus,

- the radiographic examination only documents the findings of the clinical examination.
- Since radiography of newborns requires an experienced radiologist highly skilled in the technique and evaluation, it is in practice often uncertain.
- In cases where the femoral head has been subluxated/dislocated in utero, an acetabular dysplasia will certainly be found at birth, but if the instability is mainly due to a hormonal disorder radiographic changes may be lacking.

Among the late-diagnosed cases of CDH I found some with positive or suspected signs at birth at the hip examination, but with "no signs of displacement" at radiography. These children were not treated and some of them were not followed up either. After varying lengths of time subluxations/dislocations were discovered, some of them not until the children had started walking, when they were found to limp.

In Sweden we have chosen to treat cases of clinically established hip instability in newborns from the start, and in these cases radiography has not been considered necessary (Palmén 1961, Andrén 1962); see the section on the present programme of organization of treatment of hip instability in newborns.

On the other hand, if a non-reducible dislocation is suspected a radiographic examination should be performed. There will only be a few cases, as dislocation is mainly — but not always — encountered in rare cases of malformations. The dislocation will, as a

rule, give rise to typical signs, such as shortening of the leg and restricted abduction of the hip joint. In these cases arthrography is of value.

Risks at the radiographic examination

All manipulations aimed at increasing the displacement of the femoral head, e.g. "push and pull", especially at examinations of newborns, should be avoided because of the risk of damaging the joint. Furthermore, I know of two otherwise healthy and normal newborn infants who sustained fractures of the thigh bones at a radiographic examination!

Conclusions

- No radiographic examination should be performed in order to confirm an already diagnosed instability of the hip joint.
- A radiographic examination is recommeded in the rare cases where a non-reducible dislocation is suspected.

Arthrography

In 1960, in my early work on radiographic examination of newborns with hip instability, I was able to demonstrate by arthrography that in a newborn infant with a typical Ortolani phenomenon the femoral head was *subluxated* just before the "click" at the abduction manoeuvre. After the click the position of the femoral head in the acetabulum was normal (Palmén 1961).

Later, in a Swedish study, Felländer et al (1967) performed arthrography in nine newborns with a positive Ortolani sign. They observed that the femoral head was displaced cranially just over the ridge between the bony part of the acetabulum and the labrum, which had moved cranially. At the abduction manoeuvre the subluxated femoral head was reduced and the labrum assumed its normal position (Fig. 23). In none of these patients was a *dislocation,* with the labrum infolded in the acetabulum, demonstrated.

Arthrography, as well as computed tomography, can be of value in some cases for the diagnosis and treatment of CDH, both in newborns — in rare cases of dislocation — and after the neonatal period. A chapter is therefore devoted to these examinations.

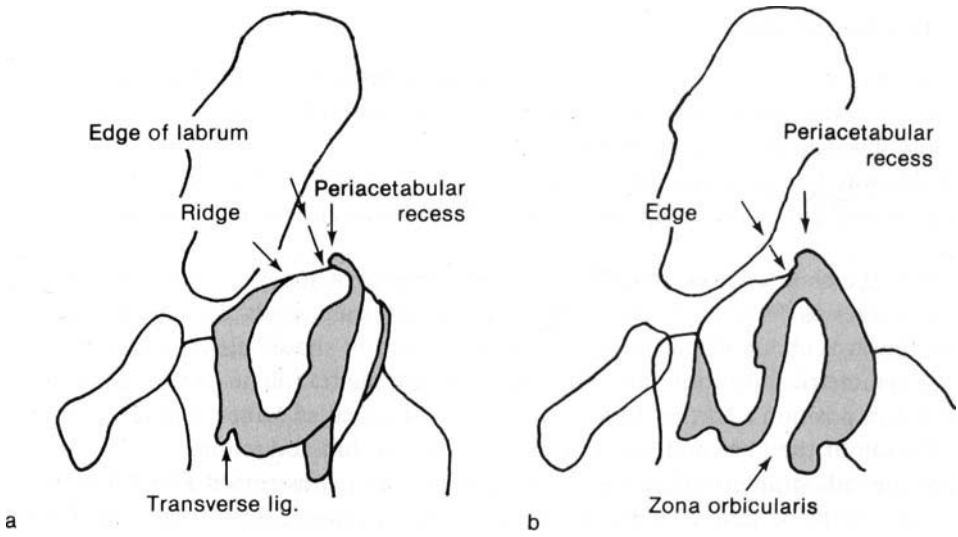


Fig. 23. Arthrogram in a newborn infant with hip instability. The ridge phenomenon.

a. The displaced head has no contact with the medial part of the acetabulum. Its pressure has moved the chondral part of the roof cranially and, as a result, the roof is divided into a medial and a lateral concavity. The intersection between the two concavities forms a ridge. The periacetabular recess indicates the edge of the labrum.

b. After reduction the acetabulum is one concavity up to the edge of the labrum. Its pressure is distributed over the entire acetabulum. The deformation of the acetabulum and the ridge are eliminated (from Felländer et al 1967).

Examination after the neonatal period

After some months it is easier to evaluate radiographs of the hips, especially when the ossification centre of the femoral head has become visible and indicates the position of the femoral head. The bony part of the acetabulum will also gradually increase and the ossification of the superior-lateral part will become more marked.

In a Swedish study on the normal time of appearance of the ossification centre of the femoral head, Pettersson and Theander (1979) found a mean time of 4.6 months in girls and 4.0 months in bovs. In none of their infants was the ossification centre visible before the age of 1 month, and at 1—2 months it had only appeared in 3 out of 52 infants.

In my own study (see below) 4 % showd no ossification centre at the age of 6 months.

Examination technique

In my opinion, to get the best view of the acetabulum and the femoral head the child should be in the supine position, with the legs together and the hip joints flexed about 30° and inwardly rotated about 30°.

In this way you get a standardized position; the varying lumbar lordosis is compensated, as well as the increased anteversion of the femoral neck normally occurring in infants.

Under the child's knees, which are held together by a strap, a firm small cushion, made in sizes to fit different ages, is placed. An assistant holds the legs, rotating the thighs inwards about 30° at the hip joints. The assistant should also see that the pelvis is in a symmetrical position, and not rotated in the sagittal plane. After the examination in this position a further film is exposed in the so called Lauenstein position, with 90° flexion of the knee and hip joints and maximum hip abduction.

For the radiographic follow-up of my treated cases I constructed a bench on which the child could be placed in the above-mentioned position, and it was found to be practical (Fig. 24).

Fig. 24. A bench constructed by the author for radiographic examination at later follow-ups (Palmén 1961).

The sources of error at the radiographic examination after the neonatal period are the same as at examination of newborns and make evaluation of the radiographs difficult, especially during the first months of life — before the ossification of the femoral head. In order to assess the effects of a rotated pelvis in the sagittal plane, it is of value to have a drawing from an X-ray film on which the lateral differences caused by the rotation are indicated (Fig. 25).

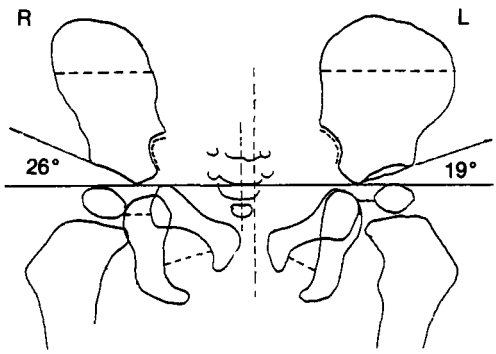


Fig. 25. Effects of pelvic rotation on the radiographic view. Here the pelvis is rotated to the left side at the examination. Drawing from an infant with normal hips.

Children who have been treated for hip instability are generally followed up at the ages of 6 and 12 months. Most often these examinations include radiography. Concerning the ossification of the femoral head and the acetabular angle at these ages, see below. As is evident from the study described there, the normal variations of ossification are very great.

Radiation risk at the examination

According to Andrén (personal communication) at the Department of Diagnostic Radiology in Malmö, the radiation dose to the gonads which a girl receives at three routine examinations during its first year is about 1.0 mGy. This is approximately the same dose to which people are submitted yearly by cosmic and environmental radiation.

Ossification of the normal hip joint

Normal standards at radiographic examination of 200 girls at 6 and 12 months.

When I planned to follow up infants treated for instability of the hip as well as late-diagnosed CDH cases, I became interested in having standard values for the development of the ossification of the hip joint — the femoral head and the acetabular angle. The knowledge of such values in normal infants had until then been based upon radiographs of the abdomen and at urography.

I considered that a prospective study with later radiographic examination of infants whom I myself had examined as newborns and later followed up clinically concerning the hip could be of value. I also considered that such a study might establish whether radiographically demonstrable dysplasia of the hip joint occurs in infants who have shown no abnormal signs at the clinical examination.

Material

In order to obtain as much information as possible concerning CDH without having to X-ray too many children, only girls were examined. The sex difference in the degree of ossification of the femoral head has been found in previous studies to be extremely small, especially during the first year of life. Furthermore, CDH in male infants is unusual in our country.

The material consisted of 238 girls, born during the period November 1970 — May 1972 at the Department of Obstetrics of Falköping Hospital, where I was a paediatric consultant at the time. Only those girls whom I myself was able to examine as newborns and at Child Health Centres were included. Infants with congenital malformations, prematurely born infants weighing less than 2,500 g, and immigrant infants were excluded.

Up to the age of one year 38 infants dropped out of the material because their parents moved or did not want the child to undergo radiographic examination. The results therefore refer to 200 completely examined girls.

During the neonatal period the hips were examined clinically twice, once within the first 48 hours and the second time on the 5th — 7th day. At the ages of 6 and 12 months a hip examination was performed in connection with the health check-up at the Child Health Centre. Having explained the purpose of the examination to the parents and obained their permission, radiography of the hip joints was performed. Only one X-ray exposure was made, an anterior-posterior projection, with the legs extended and adducted, flexed 30° and rotated 30° in the hip joints (Fig. 24). The film-tube distance was 90 cm and focus was on the symphysis pubis.

The general configuration of the hip joints was noted, and the acetabular angles and the breadth and height of the ossification centres of the femoral heads were measured (Fig. 26).

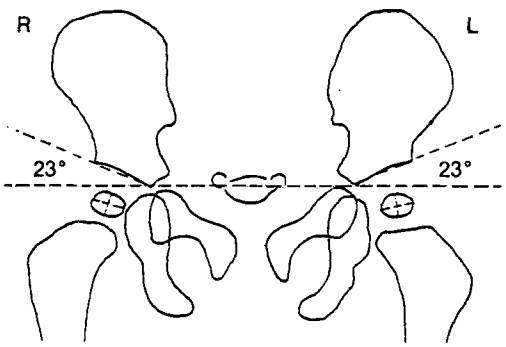


Fig. 26. Measurement of the acetabular angles and of the breadth and height of the ossification centres of the acetabular heads.

Results

CDH heredity was found in 16 (9.8 %) of the 164 girls for whom such information could be obtained. In four girls (2.4 %) CDH was found in the immediate family — in

the mother in two cases and in an older sister in the other two. All these 4 infants showed normal hip joints at the clinical and radiographic examination.

Clinical examination

A. Newborns
In all newborns the hip joints were normal, with no limitation of abduction or any abduction asymmetry.

B. Age 6 months
In three infants the hip abduction was limited unilaterally to 45°, compared with 60—80° on the other side. During their first months these children had been lying in the supine position, with the head and body exclusively turned to one side — the "habitual unilateral supine position". Without treatment the abduction became normal within 12 months. Radiography at both 6 and 12 months showed a normal development of the hip joints.

In addition, there were three further infants in whom the hip abduction was 10° less on one side. Two of them had been lying in the unilateral supine position. These three infants were also found to have normal hip joints at the radiographic examination.

All other girls had normal hips without any asymmetries.

C. Age 12 months.
All infants showed normal hip joints.

Radiographic examination

Even though efforts were made to get a symmetrical pelvic position at the examination, some infants showed some degree of rotation and/or tilting of the pelvis. However, only one exposure was made.
The results are presented in Figs 27—29 and in Tables XVI and XVII.

In the figures only the heights of the ossification centres are given, as representative of their sizes.

Table XVI. The sizes of the ossification centres of the femoral heads at 6 and 12 months. Mean values and ranges.

Age	A.	B.	C.
	Height (mm)		
6 months			
Right side	5.9 (2—10)		
Left side	5.9 (2—10.5)		
12 months			
Right side	8.9 (5.5—12.5)	5.9 (4—8.5)	8.7 (4—13)
Left side	8.9 (5.5—12)	5.4 (3—8)	8.7 (3—13)
	Breadth (mm)		
6 months			
Right side	7.5 (2—12.5)		
Left side	7.5 (3—12.5)		
12 months			
Right side	11.6 (8—18)	8.5 (7—12)	11.4 (7—18)
Left side	11.6 (9—18)	8.2 (4—12)	11.4 (4—18)

A. Girls with visible ossification centres on both sides at 6 months, 185/200.
B. Girls with no ossification centres or no such centre on one side and a very small one on the other at 6 months, 15.
C. All 200 cases.

Table XVII. Acetabular angles (degrees) at 6 and 12 months. Mean values and ranges.

Age	A.	B.
6 months		
Right side	22 (13—33)	23 (14—28)
Left side	23 (14—33)	24 (14—32)
12 months		
Right side	21 (14—30)	22 (15—29)
Left side	22 (13—31)	23 (16—29)

A. All 200 girls.
B. 15 girls with no ossification centres or no such centre on one side and a very small one on the other at 6 months.

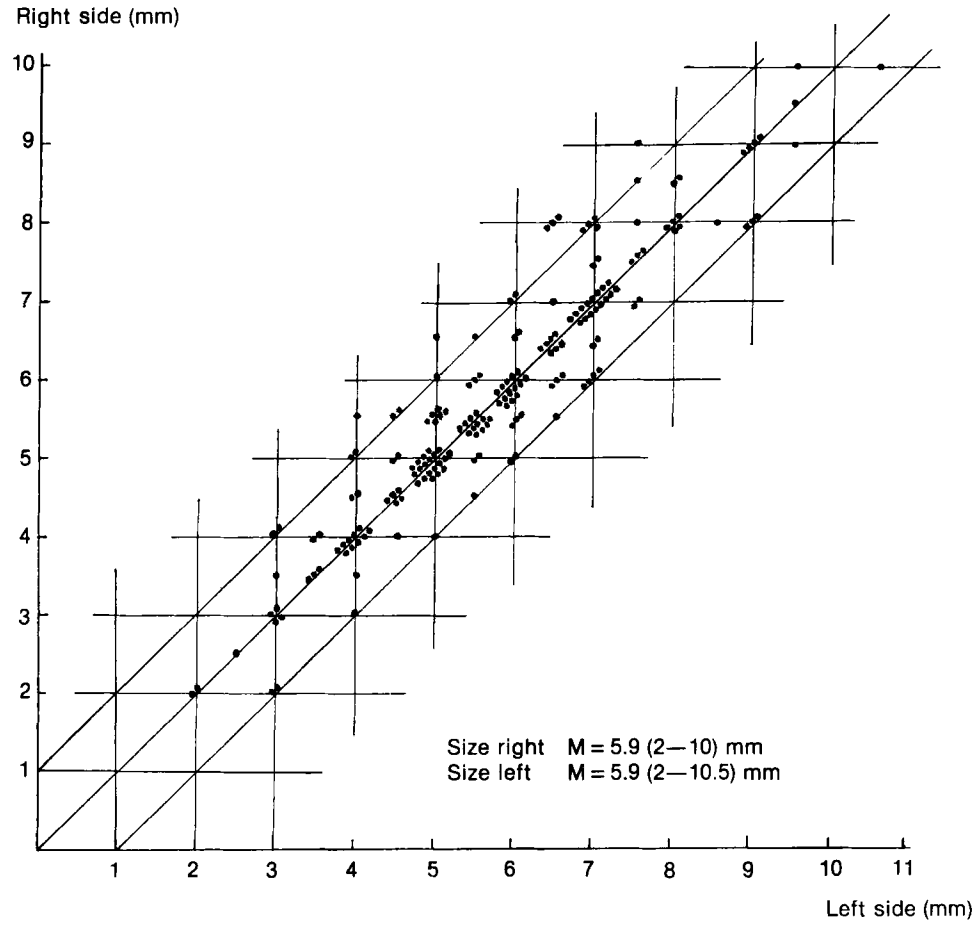


Fig. 27. The heights of the ossification centres of the femoral heads at 6 months. Each point indicates the size on the right and left side respectively. M = mean. 185 girls with visible centres.

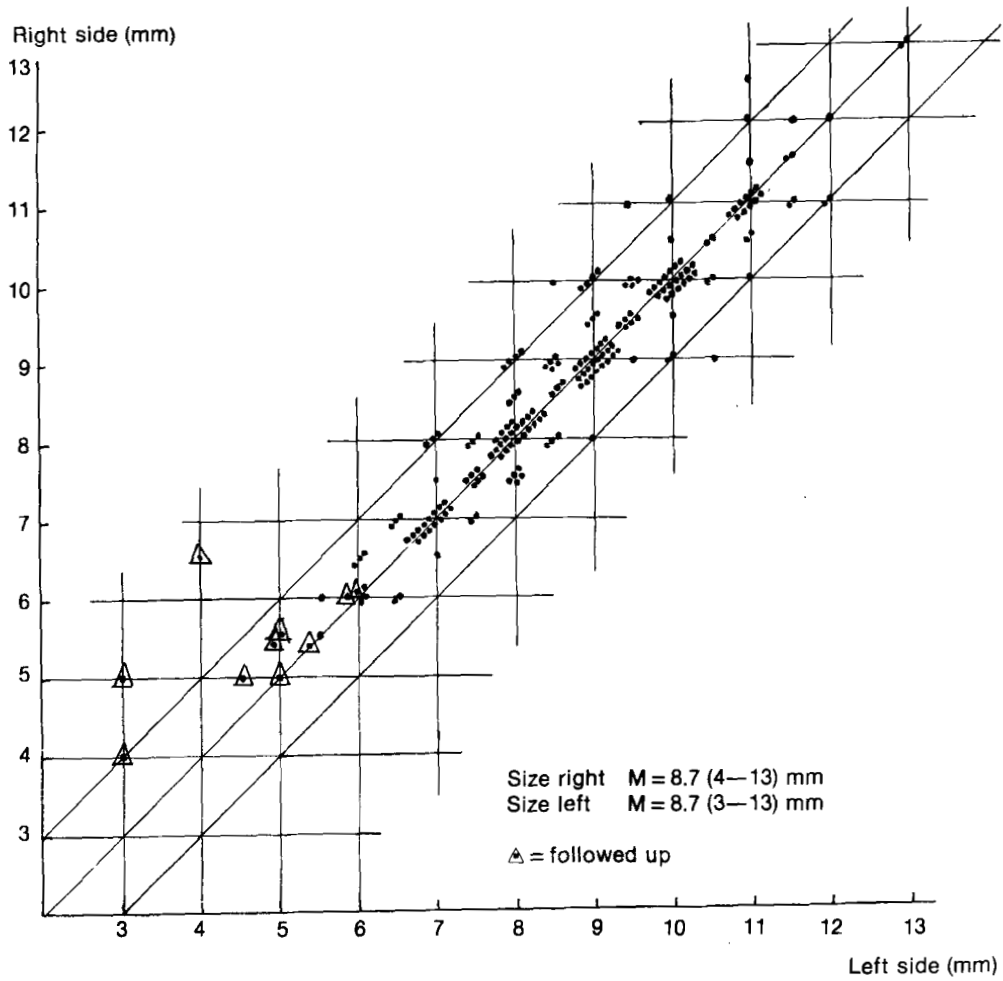


Fig. 28. The heights of the ossification centres of the femoral heads at 12 months. Each point indicates the size on the right and left side respectively. M = mean. 200 girls.

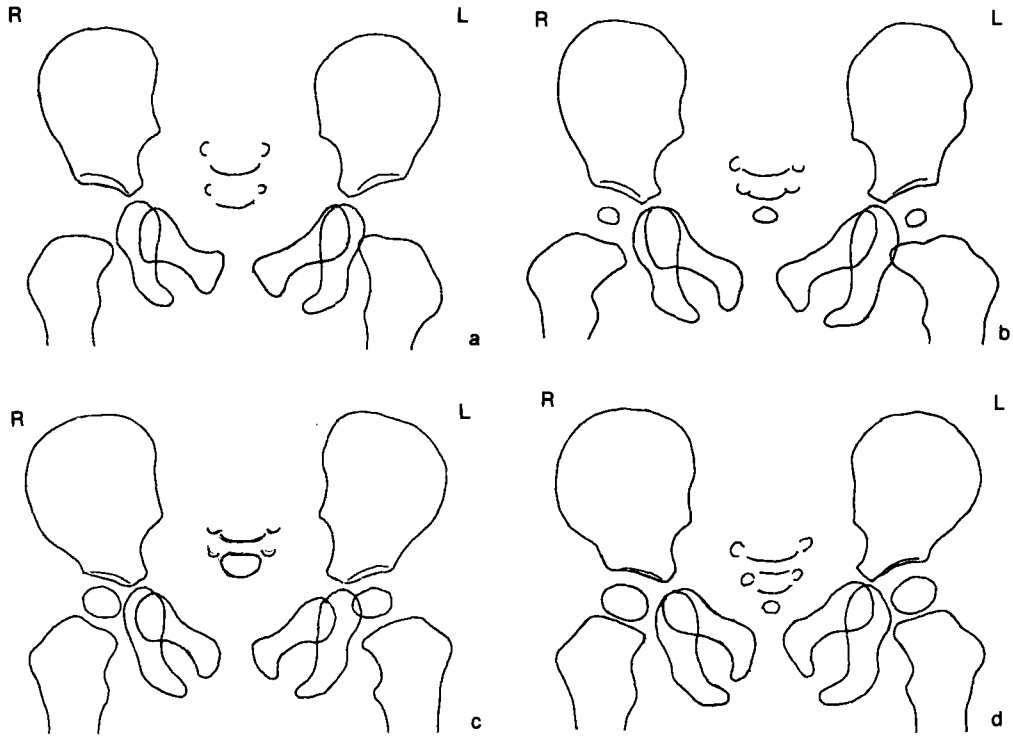


Fig. 29. Normal variations in the size of the ossification centre of the femoral head.
a. No visible ossification centres at 6 months.
b. Small centres at 12 months in the same girl.
c—d. Large centres at 6 and 12 months in another girl.

The mean acetabular angle was 1° greater on the left than on the right side both at 6 and at 12 months. This small difference may have been due to the fact that a rotation of the pelvis to the right is somewhat more common than to the left and gives a seemingly greater angle on the left side.

Other differences in the position of the pelvis, such as various degrees of lumbar lordosis, influence the size of the angle. Even with a symmetrical position the angles may differ considerably. Differences of up to 6° can be caused by rotation of the pelvis.

The lateral edge of the acetabulum was often not very pronounced at *6 months,* especially in the presence of increased lordosis at the examination.

No real case of acetabular dysplasia was found at the age of 6 months.

At the age of *12 months* there was very little decrease in the acetabular angle compared with the age of 6 months, averaging only 1°. The lateral edge was generally more marked, but at this age also the same errors could affect the examination.

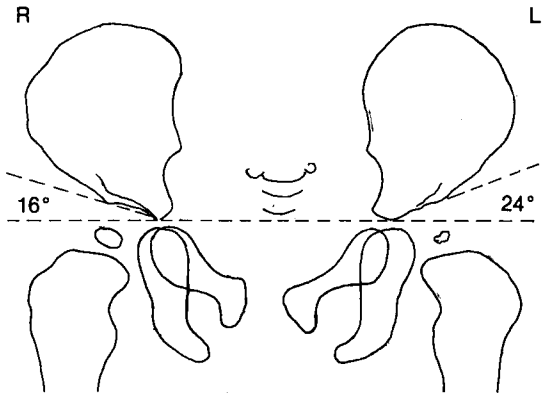


Fig. 30. Case report — dysplasia of the hip joint in a clinically normal girl. At 6 months: no ossified centres were visible in the femoral heads. At 12 months (Fig.): Left side — acetabular dysplasia and a very small ossification centre. Right side — normal. Follow-up at 8 years: normal hip joints.

Two cases of slight *dysplasia* were found. At 6 months these infants lacked ossified centres and at 12 months they showed small centres, measuring 4 and 3 mm respectively. At the later examination acetabular dysplasia was observed (Fig. 30).

Follow-up

In addition to the above-mentioned two girls with dysplasia, eight girls were examined at the age of 7—8 years because they had lacked ossification centres at 6 months and also had had the smallest centres at 12 months.

At the late follow-up, in all these 10 children the CF angles and the spherical indices (SI) were within the normal range reported by Fredensborg (Figs 9 and 10 respectively), and normal conditions were also found in other respects.

Some summarizing data

- The height of the ossification centre of the femoral head (a.p. view) can be used to determine its size.
- The size of the ossification centre varies considerably, by up to 10 mm, both at 6 and at 12 months.
- Differences in the size of the ossification centres of up to 1.5 mm between the two sides have also been found at these ages.
- At 6 months 7.5 % of the girls had no (4 %) or only slight (3.5 %) ossification centres. All except one of these infants had small ossification centres at 12 months.
- At follow-up eight girls of those who at 12 months had the smallest ossification centres were all found to have normally developed hip joints.
- The size of the acetabular angle varied considerably and to an equal extent at 6 and 12 months, often due to different degrees of rotation of the pelvis.

- Differences in the size of the acetabular angle between the two sides were mainly due to erroneous radiographic projections.
- Acetabular angles of up to 33° (only a few more than 30°) were observed in this normal material.

Contrary to earlier studies designed to obtain normal values, this was a prospective study in which clinically examined newborns were followed up at the age of 6 and 12 months and then also examined radiographically. Thus, the normal values at these ages are based on the same girls.

At the clinical hip examination no case of late-diagnosed CDH was encountered, but at the radiographic examination at 12 months dysplasia was observed in two girls, who at a subsequent follow-up showed a normally developed hip joint. It is of interest to know that such cases may occur.

At the age of 6 months, six cases of unilateral limited abduction were found, all of which proved to be unspecific. At the time of this study the mothers were not being asked especially to get their children to sleep in the prone position during the first months.

Arthrography

Torsten Lönnerholm, Uppsala

The Swedish orthopaedic surgeon Erik Severin is a pioneer in the field of hip arthrography in children. His book, entitled "Contribution to the Knowledge of Congenital Dislocation of the Hip Joint" (1941), contains arthrograms from investigations of children with congenital dislocation of the hip diagnosed after the age of one year. In the 1940's the most common reason for performing hip arthrograhpy was to evaluate the severity of CDH, and this is still a common indication for the examination (Lönnerholm 1980). However, arthrography is necessary only in a small number of all children with CDH, namely:

1. Cases diagnosed neonatally:
   a) if the primary reduction is difficult,
   b) if the reduced position is not easily maintained, or
   c) if the instability persists after 4 weeks of treatment. In these occasional cases interposed capsular tissue may impede closed reduction. It is important that such interposition be diagnosed early in order not to delay open reduction (Almby et al 1979).
2. Cases diagnosed after the neonatal period, before treatment is started. Arthrography is the best tool for finding the optimum leg position at closed reduction.

The arthrographic technique will be but briefly described below. More detailed information is given by Severin (1941), Grech (1971), Lönnerholm (1980) and Goldman (1981).

I have used the following technique. The children are examined under general anaesthesia. Children with signs of current infection should not undergo the examination and the demands for sterility are the same as at surgical operations.

An orthopædic surgeon should always be present at the arthrography. Before the hip joints are punctured his task is to perform a clinical examination, and he should also be prepared to initiate treatment, e.g. a hip spica and/or an adductor tenotomy, on the same occasion.

In infants bilateral arthrography is always performed. The joint is punctured with a short-bevel needle. The top of the needle is placed on the skin about 1 cm medial to the femoral artery and inserted into the joint where the capsule bulges outward just lateral to the distal part of the acetabular labrum (arrow in Fig. 31). The needle is connected to a 30 cm long connecting tube and an infusion set, suspended about 1 m above the table top and filled with an aqueous iodine contrast medium. When the needle is in the correct position in the joint cavity the contrast medium flows freely into the joint from the infusion set. The degree of contrast filling is assessed fluoroscopically. Too much contrast medium in the joint makes it difficult to evaluate its structures. Not more than about 1 ml should be introduced. The contrast medium is distributed in the joint by rotating the legs. The needle, connected to the connecting tube and equipped with a stop-cock, is left in situ during the examination, which will prevent extraarticular leakage from the joint cavity. Before the needle is removed, the stop-cock is opened and the contrast medium is allowed to run out.

The child is placed in a supine position with its legs symmetrically fixed. In general six anterior-posterior views of the pelvis with the legs in different well-defined positions give sufficient information about the joints. Additional films for stereoscopic analysis are exposed in difficult cases.

An X-ray tube with a small focal spot is used. The cassette containing the film is placed directly under the patient; there is no need for a metal grid. The cassette should be equipped with high-sensitive rare earth screens. By using this technique, the patient's radiation dose will be low (Lönnerholm 1980). The films should be immediately evaluated in collaboration with the orthopaedic surgeon so that decisions about treatment can be made without delay.

At arthrography the risk of side effects is very small, and only a few cases of septic arthritis have been reported since the 1930's (Laurent 1953, Grech 1977).

Faber (1938), Severin (1941) and Lönnerholm (1980) have established criteria for the normal arthrogram.

The anatomy of normal hips at arthrography is seen in Fig. 31, Fig. 32, b—d (right hip) and Fig. 33 (left hip). The femoral head is spherical except at the site of the fovea capitis femoris, where the ligamentum capitis femoris is attached. The edge of the acetabular labrum is well visible, since the capsule is attached to the outer part of the labrum and the contrast medium is collected on both sides of the edge. The proximal part of the edge of the labrum is pointed and directed distally. The distal part of the ligamentum capitis femoris is attached to the acetabulum at the site where the transverse

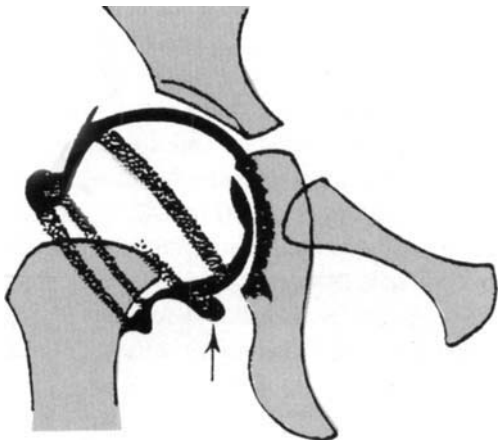


Fig. 31. Drawing from a normal arthrogram in a 3-month-old infant. Anterior-posterior view. Black areas indicate the distribution of the contrast medium in the joint cavity. There are layers of contrast medium in the ventral and dorsal parts of the femoral neck and head in the cavity (mottled areas). Only the ossified parts (dotted areas) are seen at conventional radiographs. Site of puncture (arrow).

ligament joins the acetabular labrum. The capsule bulges in the medial and lateral parts of the indentation, a few millimetres broad, caused by the transverse ligament. The cartilage of the femoral head and the acetabulum is smoothly bordered, but the outline of the acetabular fossa is slightly irregular.

The band of contrast medium has a breadth of 1—2 mm between the articular surfaces, except at the site of the acetabular fossa, where it can extend to 4 mm.

Since 1972 I have examined almost 100 children with CDH diagnosed after the neonatal period. Most of them were infants aged 3—6 months. In all cases (e.g. Fig. 32, left hip, Fig. 33, right hip) the joint capsule was widened and the femoral head displaced cranially and laterally. The proximal part of the acetabular labrum was deformed and the ossification in the iliac parts of the acetabulum retarded. Only one child, the oldest one, 21 months at diagnosis, had an actually dislocated femoral head. The others had subluxation. When an obvious subluxation or dislocation occurred it was clear from an examination of the stereofilms that the femoral head was displaced dorsally inside or out of the acetabulum, never anteriorly, and that the delayed ossification was always more marked in the dorsal than the ventral part of the acetabular roof. Closed reduction was easy in all cases at arthrography except in one girl, who had a residual limitation of abduction but no other impediment to reduction. Also in this case closed reduction was possible after adductor tenotomy and prolonged traction therapy.

The optimum leg position after closed reduction was either 90° flexion and 60—80° abduction or 45° abduction and 30° inward rotation. In infants with a slight or moderate subluxation the proximal part of the labrum was no longer deformed after reduction, as was obvious from the arthrogram. In cases with pronounced subluxation it took several months until the normal shape and position were regained, as was seen from the follow-up arthrograms (Almby and Lönnerholm 1978).

Even in infants with a slight subluxation the femoral head could be deformed; as a rule its proximal aspect was flattened (Fig. 32 c). After reduction the deformity decreased and the femoral head could even regain its normal spherical shape (Fig. 33 b).

The rate of ossification of the acetabular roof and the femoral head increased after reduction (Fig. 33 b), but it sometimes took about two years before ossification reached a normal stage.

In a small number of infants with hip instability at birth, arthrography after treatment with an abduction splint showed dislocation of the femoral head and narrowing of the capsule between the femoral head and acetabulum. Closed reduction at arthrography was impossible (Fig. 34). The subsequent operation revealed that the narrowing of the capsule was mainly due to compression by the iliopsoas tendon and the acetabular part of the rectus femoris tendon (Almby, Hjelmstedt and Lönnerholm 1979). The capsule displayed a prominent isthmus and reduction was not possible until the capsule was split between the femoral head and the acetabulum.

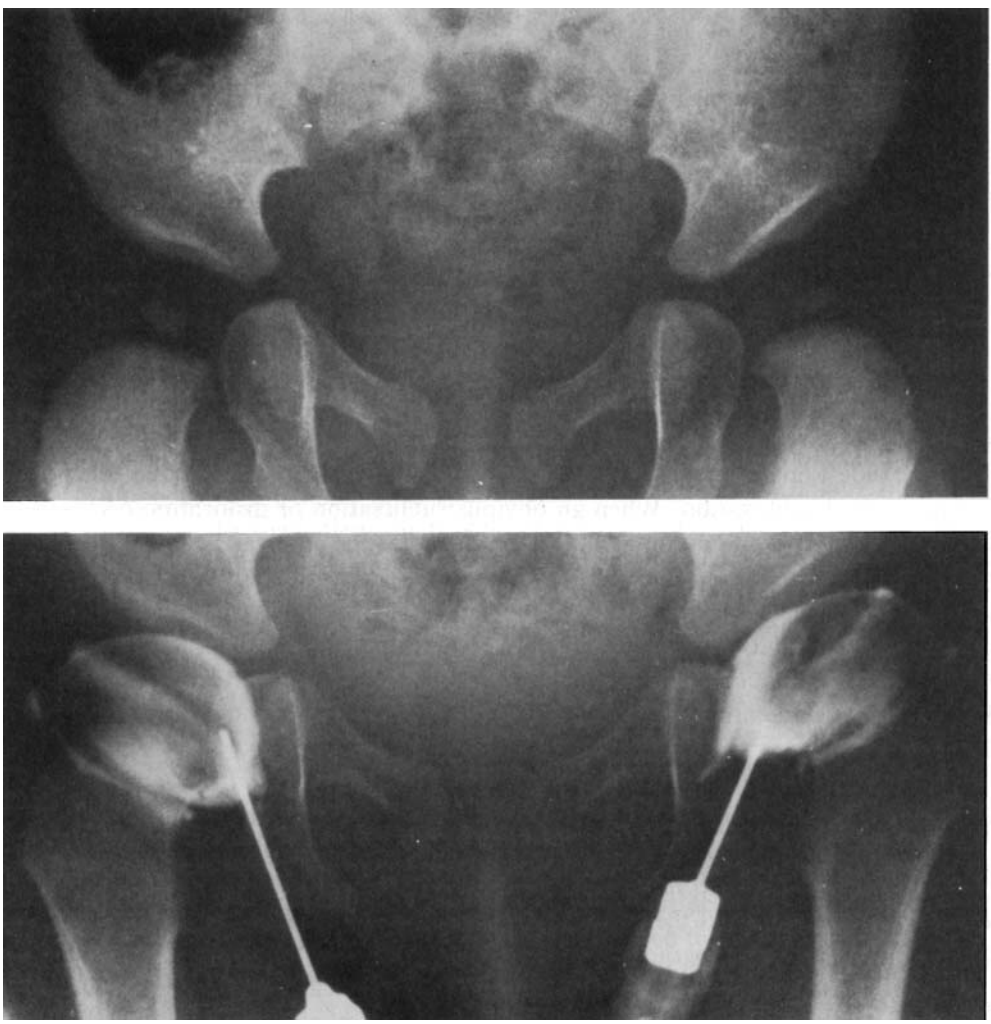


Fig. 32. a—b

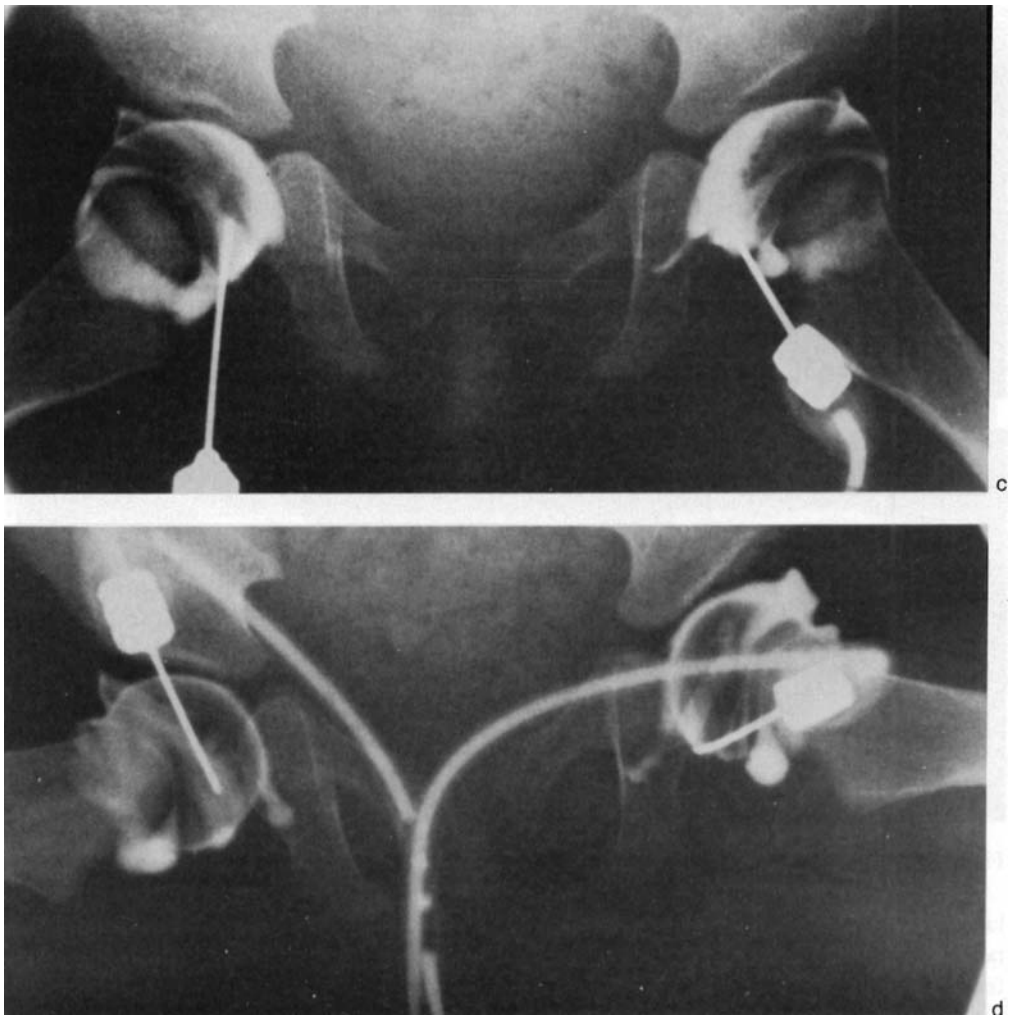


Fig. 32. Seven-month-old girl with hip joint subluxation. a Conventional radiograph at diagnosis. Anterior-posterior view. b—d Bilateral arthrography two weeks subsequent to a period of traction, a.p. view of the pelvis. Leg position: b. 10—20° flexion and 20° inward rotation. c. 45° abduction and maximal outward rotation. d. 90° flexion and 70—80° abduction. The needles and the connecting tube are best seen in d.
Right hip normal.
Left hip: subluxation of the femoral head. a—c.: The ossification of the femoral head and the roof of the acetabulum is deficient. The head is slightly deformed (b). The edge of the acetabular labrum is rounded in its proximal part (b and d), and is located 3—4 mm more proximally than that of the right side (b and d), which is best seen in d. The optimum leg position for treatment is that in d, since there is a broad layer of contrast medium between the femoral head and the proximal part of the acetabular labrum.

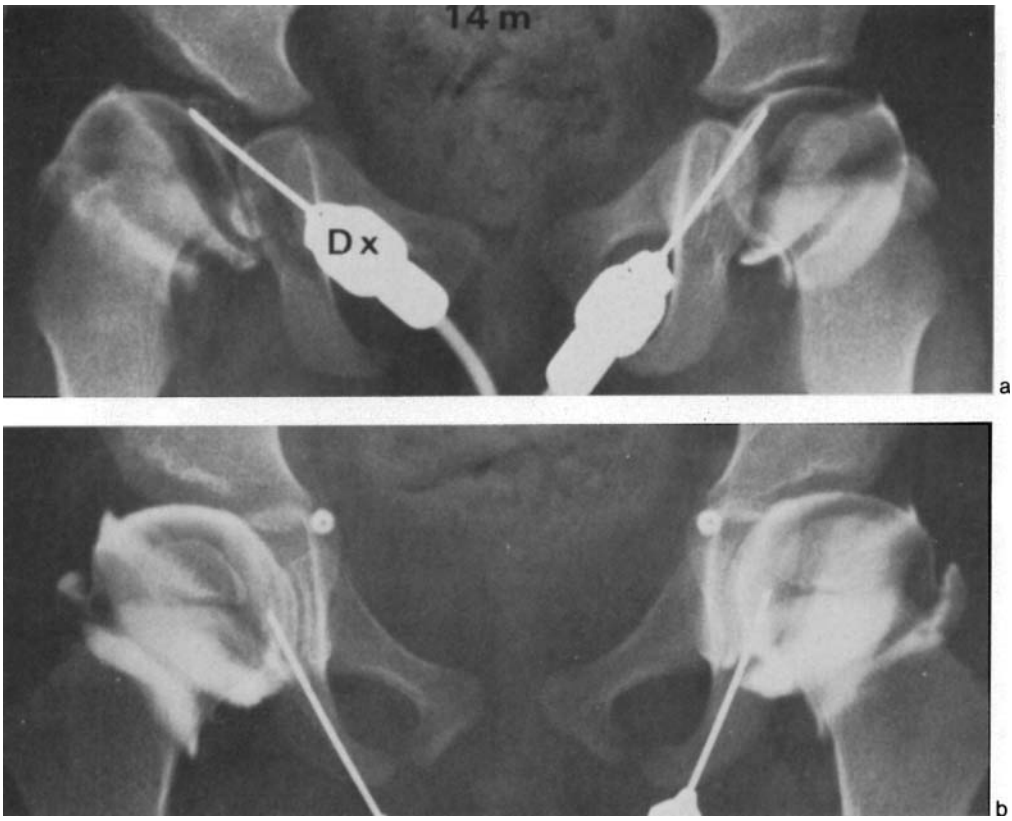


Fig. 33. Bilateral arthrography in a girl with hip joint subluxation treated with plaster of Paris.

a. Before treatment at the age of 14 months. b. Six months later. Right hip: The initially subluxated femoral head is markedly deformed. After treatment there is no deformity and the acetabular labrum is normal. The retarded ossification of the ilium in the acetabular roof and of the femoral head is less pronounced than before reduction. Left hip: normal.

Conventional hip radiographs at the age of 4 years are normal.

Fig. 34. Bilateral arthrography in a one-month-old girl. Caesarian section because of a breech presentation. At birth abduction was bilaterally restricted and conventional radiography showed dislocations. Closed reduction was found impossible, even after bilateral tenotomy of the hip adductors. The arthrogram shows bilateral dislocation. The femoral heads are deformed. The joint cavity is narrowed between the femoral head and the acetabulum (best seen on the right side). Closed reduction was not possible at arthrography (see text).

Computed tomography

Holger Pettersson, Lund

During the last decade, the introduction and widespread use of computed tomography (CT) has meant a revolution in diagnostic radiology. As in adults, CT in children has proven to be of great value in examination of the central nervous system and in neoplasms, trauma and certain infectious diseases, but during recent years the interest has also focused on several orthopaedic pædiatric conditions, among them congenital dislocation of the hip.

As has been stated in previous chapters, radiographic examination of newborns with CDH may be necessary if a non-reducible dislocation is suspected. Such failure to reduce and maintain reduction of a dislocated hip may be caused by interposition of capsular tissue, due to a tight iliopsoas tendon (Almby et al 1979, Scaglietti and Calandriello 1962). In this situation, plain film radiography offers great difficulties in the interpretation. Arthrography may give important additional information (Almby et al 1979), but CT, being a non invasive procedure, will also demonstrate the folding of the capsule and labrum, as reported by Hernandez et al (1982). The iliopsoas occupies a more medial position than normally, and this rearrangement of the anatomy produces a rectangular space between the capsule and the labrum posteriorly, the iliopsoas late-

rally, and the fascia that attaches the neurovascular bundle anteriorly, visible at CT (Hernandez et al 1982).

The pulvinar, which is a fibrofatty tissue in the centre of the acetabulum, may hypertrophy if there has been a longstanding subluxation. This hypertrophied pulvinar may prevent a total reduction, which is also easily detectable at the CT examination. If the reduction is achieved and maintained, the enlarged pulvinar will return to normal size.

After reduction and fixation in plaster of a dislocation that has been discovered after the newborn period, radiographic examination is important to assess whether the correct position is maintained. Plain film examination in these cases is difficult, especially if the femoral head is not yet ossified. Several projections may be needed, giving a high

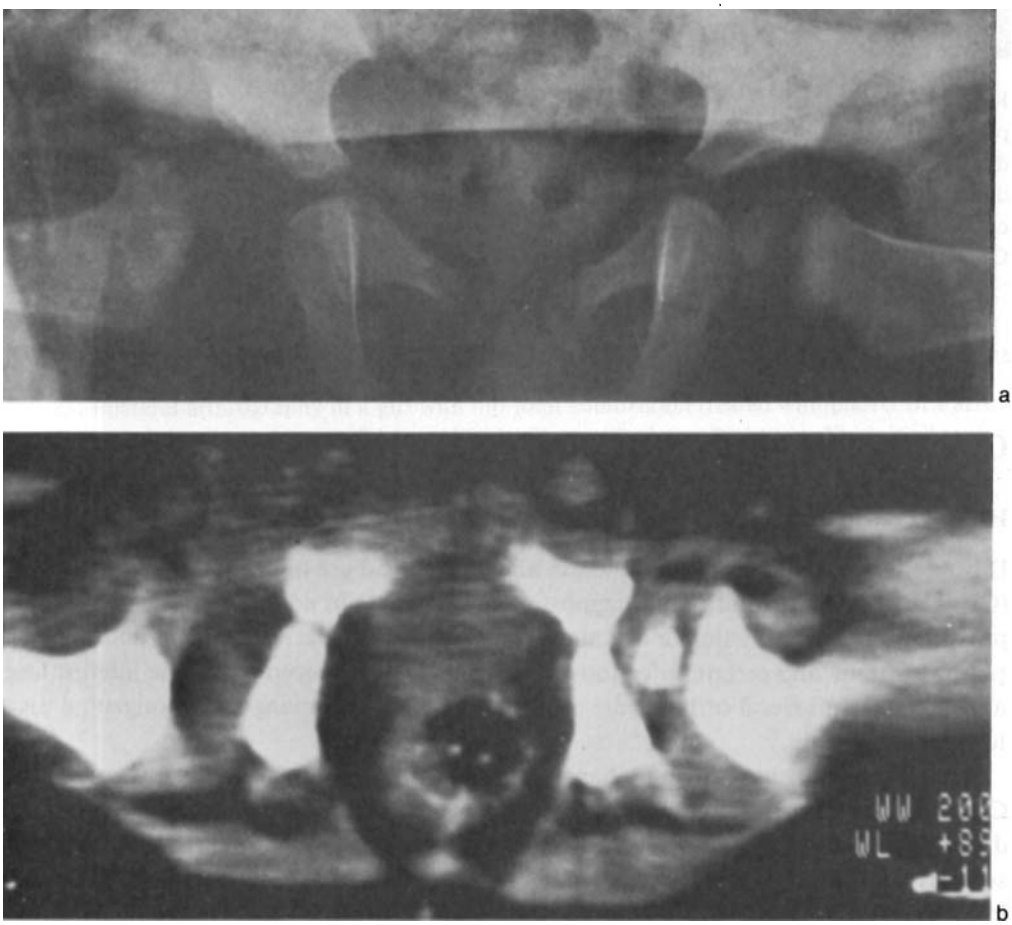


Fig. 35. Computed tomography. CHD, discovered at the age of five months, after reduction and fixation in plaster.

a. Conventional radiography. The distance between the proximal femur and the acetabulum is larger on the right side than on the left, but the degree of a possible subluxation is difficult to assess.

b. CT, same occasion. There is a dorsal dislocation of the right femur.

radiation dose, and still the assessment may be uncertain. In this situation, a few CT sections through the proximal femur and the hip joint will reveal if the position of the femoral head is correct or if there is still a dislocation (Fig. 35). Here CT is the best method, being accurate, noninvasive, and giving less radiation than repeated plain film exposures.

Present problems

> "The future calls for the universal application of neonatal examination of the hips by trained pediatricians, nurses, or orthopedists, and followed by competent preventive treatment. This is the credo of modern orthopedics".
>
> *Becket Howorth (1977)*

Finally I will discuss the problems that still remain in spite of the good results that have been obtained after many years of work on the diagnosis and treatment of hip joint instability in newborns and late-diagnosed cases of CDH.

Over-diagnosis of hip instability in newborns

It is very difficult to get a true idea of the frequency of hip joint instability, since our records are probably somewhat misleading and indicate over-diagnosis. In the mother's record it is noted whether the child has been given a diagnosis of "Dislocatio coxae congenita" or "Preluxatio coxae congenita, instability". A copy of the record is sent to the National Board of Health and Welfare for computer recording. A compilation of this material for the years 1977—1979 gave the figures presented in Table XVIII.

Table XVIII. Recorded cases of hip instability at all obstretic departments, children born in 1977—1979.[1]

Year	Hospitals	Total	Hip instability	Per thousand
1977	77	94,476	1,174	12.4
1978	84	91,179	1,142	12.5
1979	83	93,044	1,181	12.7

[1]Newborns who died during the first week are excluded.

An average of 12 per thousand newborns were diagnosed annually as having dislocation/preluxation and referred to an orthopaedic consultant. This frequency varied considerably at different departments, from about 2—46 per thousand, even at the large obstetric departments!

The most probable reason for this was that in some departments uncertain cases were also recorded. At the Department of Obstetrics in Malmö, where for a considerable time special interest has been taken in early diagnosis, 18—25 per thousand newborns have been referred to the orthopaedic consultant, who, as a rule, has examined the chil-

dren on that same day or next day and has confirmed about 50 % of the cases as distinctly unstable (Danielsson, personal communication). These have then been treated, giving a frequency of about 10 per thousand of all newborns.

Conceivable reasons for over-diagnosis

The hip examinations of newborn infants are performed by a number of doctors, approximately 300—400 in all obstetric hospitals annually. All of them are not sufficiently informed and experienced.

It is well known that late-diagnosed cases are recorded every year and the examiners are anxious not to overlook uncertain cases, which are therefore recorded.

In spite of the instructions that crepitations and creaks from the joints are unspecific, some examiners include these cases so as to be on the safe side.

At the examination a so called "vacuum phenomenon" may possibly occur in the joint, which might give slight instability.

At an examination on one of the first days of life, slight unspecific instability might be felt perhaps only as a result of laxity of the joint due to hormonal influence.

Is it possible to diagnose all cases of CDH at birth?

This has been a matter of debate for many years. Several physicians maintain that practically all cases can be found during the first week of life if the organization is good and the examiners are experienced. The late cases have therefore been called "missed cases".

On the other hand, some doctors with many years' experience of examining newborns have noted cases of late-diagnosed CDH in children who have been examined one or more times during their first week without any abnormal signs being discovered. The newborns may even have been examined with special care as there have been other CDH cases in the family. I have myself encountered two such infants, who at subsequent check-ups displayed noticeable instability of the hip joint at the age of 6—8 weeks!

The fact that the frequency of late-diagnosed cases of CDH varies greatly in different parts of Sweden underlines the importance of a good organization and experienced examiners.

From the beginning the number of late-diagnosed cases has been very small in the southern counties, where interest has long been focused on early diagnosis.

The numbers of late-diagnosed cases of CDH in children born in 1973—1979 in the three parts of Sweden are given in Table XIX.

Table XIX. Late-diagnosed cases of CDH, born in 1973—1976 in different parts of Sweden.

Part of Sweden	Counties	Total	Late CDH cases	Per thousand
Southern	12	204,180	75	0.37
Central	7	158,968	107	0.67
Northern	5	57,843	43	0.74
Total	24	420,991	225	0.53

The children were born in 1973—1976, and the diagnosis was made up to the end of 1979. There is a statistically significantly increased frequency from the south to the north.

The frequency of late-diagnosed CDH cases was especially high in the two northernmost counties, 1.06 and 1.51 per thousand respectively. These make up the province of Lapland, which is sparsely inhabited. Its area comprises 29 % of the whole of Sweden, but only 1.6 % of Swedish inhabitants live there. It has therefore been much more difficult to organize hip examinations in newborn infants by experienced paediatric consultants in these parts. It is conceivable that hereditary factors might cause differences in the frequencies of late cases of CDH in different parts of the country. The majority of the Swedish Lapps live in Lapland, and as mentioned earlier this ethnic group, with its past history as nomads, previously displayed a high frequency of dislocation of the hip joints, namely 4.7 % among girls (Mellbin 1962). This was certainly due to the practice of marriage between relatives — marriages between cousins were 20 times as common as in the rest of Sweden. Furthermore, there was a triggering factor — that their infants were kept in narrow cradles, with their legs stretched out and tightly wrapped. However, this latter practice had been abandoned by the time this material of CDH cases was recorded, and the number of infants with heredity for CDH has not been found to be higher in the northernmost counties.

Also in the central and southern parts of Sweden there are counties in which the frequency of late-diagnosed CDH is remarkably high, 0.73—0.78 per thousand, even in university hospitals, while in other counties it is 0.20—0.30 per thousand.

It seems most probable, therefore, that the varying frequencies of late-diagnosed CDH are due to organizational differences.

I have found an interesting correlation between the frequency of instability of the hips in newborn infants and the frequency of late-diagnosed cases of CDH born during the same period and at the same departments:

I have compared the frequency of reported cases of hip instability in newborns at the five obstetric departments (with at least 1,000 births annually) which, in 1978, had the lowest frequency, and the five departments (also with at least 1,000 births) with the highest frequency. These figures were compared with the number of late-diagnosed cases of CDH diagnosed in 1978—1979, born at the same obstetric departments (Table XX).

Table XX. Comparison of the frequencies of hip instability and late-diagnosed CDH in children born in 1978.

Total	Hip instability	Per thousand	Late CDH cases	Per thousand
A. 9,345	24	2.6	15	1.6
B. 10,478	322	31	1	0.1

A. Five departments with the lowest frequency of unstable hips, <5 per thousand.
B. Five departments with the highest frequency of unstable hips, >20 per thousand.

Even if there was considerable over-diagnosis at the obstetric departments which reported a high frequency of instability, it was clear that these detected practically all cases of preluxation.

- A high frequency of instability of the hip joints in newborns seems to be correlated to a low frequency of late-diagnosed CDH cases.
- It is realistic to find 1—2 late cases of CDH among 10,000 children.

Possible reasons for overlooking "preluxation" in newborns

Hip joint examination may have been omitted

For many years now practically all our children have been born in hospital. Out of 93,000 born in 1979, only nine were born at home! All of the 407 late-diagnosed cases of CDH in 1973—1979 were born in hospital. At least 85 % of this series were born in obstetric departments with paediatric consultants, and in recent years almost 100 %. Hip joint examination has certainly become a part of the routine examination of newborn infants at smaller hospitals also.

It is therefore safe to assume that virtually all newborns undergo a hip examination, possibly with the exception of those who are swiftly transferred from the obstetric ward to a neonatal unit for emergency measures. Some of these infants may not have their hip joints examined until after their first week of life. There were five such cases (1.2 %) in the present material.

Inexperienced examiner

This is probably one of the main reasons for a diagnosis not being made at birth. As I have mentioned, the deliveries have been centralized, but they still take place at 82 hos-

pitals (1981). In spite of our organization of experienced paediatric consultants, there are many locum tenentes and doctors completing their training who may, temporarily, examine newborns. Some interesting figures have been given to me by Dunn (personal communication): In 1969—1976, in Bristol, 300 newborns were treated for hip joint instability. Four late cases of CDH occurred during this time. Two of these cases were overlooked by the same doctor soon after he had joined the staff, while the other two were overlooked by locum doctors covering the holidays of the regular staff.

Special difficulties in examining newborns

As mentioned before it is very important that the child is calm and relaxed when examined. It can be difficult or impossible to feel a potential instability of the hip joint if the child is crying or tense, thereby increasing a flexion contracture in the hip joints which sometimes occurs after the intrauterine position.

Most often this contracture will disappear in a few days. Therefore, the prone position, with the legs abducted, is favourable from the first day of life. I have heard from paediatric consultants that sometimes they have found an instability only at the second examination just before the mother's departure!

- Thus, the second examination is important.

When discussing the reasons for late diagnosis I have mentioned that this may be due to the presence of a *dislocation* at birth. Reduction has been impossible and because of this the hip joint has not been unstable. However, this is very unusual, and I have described above the easily observed clinical signs. In our material of late-diagnosed CDH cases dislocation was infrequent during the first 6 months of life — 12 % of all cases; Table VI.

- Dislocation associated with impracticable reduction is therefore certainly an unusual reason for missing the diagnosis at birth.

Has the number of late-diagnosed cases of CDH increased during the last years?

As seen from my frequency figures for late-diagnosed cases of CDH, these have increased from about 30 annually during the 1960's to an average of 60 annually during the last six years, in spite of increased information on examining newborns.

It is conceivable that in earlier years reporting of the cases was less efficient, but the number of cases not included in the statistics for this reason should have been small. Practically all diagnosed CDH cases were referred to the orthopaedic departments and examined and treated as in-patients for some days and thus registered.

It is evident, however, that the interest in the annual compilation of cases from the orthopaedic departments has increased in the last years.

I consider that the main reason for the increase in late cases is the greater information issued to the Child Health Centres. This has resulted in a growing number of suspected cases, which have been referred to the orthopaedic departments. This applies particularly to infants 2—4 months old. Many of these cases have been slight ones. Most cases of mere "acetabular dysplasia" have certainly been wrongly diagnosed. The deviations observed radiographically have been due to errors of projection caused by a rotated pelvis due, in turn, to an unspecific limited abduction. I was convinced of this when I scrutinized the children's records and radiographs. I have therefore excluded about 10 such infants, all treated for probable CDH, from the annual statistics.

In the cases judged to be definitely pathological at this age, the ossification centre of the femoral head — in unilateral cases — was smaller, if visible at all, on the first radiographs, or at the later follow-ups. Moreover, most of these infants displayed an obvious subluxation, even if it was sometimes only slight.

Thus it seems obvious that we have been diagnosing an increasing number of cases of CDH at the early age of 2—4 months since the Child Health Centres have received increased information on hip examination.

It might be asked which these cases are. There has certainly been an important decrease in the number of cases diagnosed after the age of 6 months.

Some of the mild cases might be previously undiscovered and untreated ones in hips which nevertheless develop normally. We have long had the experience that even a slightly subluxated hip joint in infants may become normal. Others may be cases of residual dysplasia, perhaps combined with a slight subluxation, which has given rise to symptoms and thereby been diagnosed only at a later stage. Occasional such cases have been discovered at an age of 15—20 years. It may be instructive to mention one of my own cases:

> A 23-year-old mother of a girl with instability of the hip at birth denied that there were any cases of CDH in her family. Six months later she told me that her own hip joints had been painful since her family had changed apartments and now lived on the second floor without a lift. Radiographic examination revealed distinct acetabular dysplasia and slight subluxation on both sides!

It has been known for a long time that early arthrosis of the hip in adults is connected with subluxation in 25—50 % of the cases (Wiberg 1939).

It is encouraging to think that *early* treatment of the still great number of late-diagnosed cases of CDH might reduce the large number of patients with arthrosis.

What can be done to further reduce the number of late-diagnosed cases of CDH?

The main prerequisite is to have the best possible organization of hip joint examination of all newborns. I believe that our Swedish model is an efficient one, i.e. hip examination performed by paediatric consultants in connection with the health check of the

newborns. The consultants are attached to the paediatric departments and/or the Child Health Centres and are thus able to participate in continuous information and education.

As I mentioned above, the consultant work should be run by *one* paediatrician and *one* orthopaedic surgeon and they should carry the responsibility of informing and training the locum doctors.

The chief physician of the Child Health Service should, within his or her county, be responsible for giving information to all other doctors at the Centres.

Vital points for achievement of an efficient organization of early diagnosis

- Examination of the hips of all newborns should be performed on the first or second day of life, and again before the mother and child leave the hospital.
- The examination should be made by an experienced paediatric consultant.
- Diagnosed cases should be referred immediately to an experienced orthopaedic consultant.
- Both the consultants should carry the responsibility of giving information to and training locum doctors.
- Newborn infants running an increased risk of dislocation, such as those with CDH in the immediate family, should be paid special attention and re-examined at an early stage.
- The hip joint examination must not be neglected if the infant is transferred to a neonatal unit after birth.
- Newborn infants with suspicious symptoms that have not led to treatment should also be followed up.
- The hip joint should be examined at all check-ups at the Child Health Centre, at least during the first 18 months.
- Special attention should be paid to unilaterally limited abduction.
- The physicians at the Child Health Centres should be trained in hip joint examination by an experienced paediatrician.

General Summary

Treatment of hip joint instability in newborns prevents later dislocation.

Palmén (1961)

The extensive work on early diagnosis and treatment of CDH (in the broad sense of this term) in Sweden has formed the basis of our present organization of prevention of hip dislocation.

Practically all children are born in hospital, at present about 93,000 per year (1980). Routine examination of the hip joints has been included in the check-ups of newborns since the beginning of the 1950's.

The centralization of obstetrics, especially during the last decade, has facilitated the organization of these examinations by paediatric consultants in all obstretric departments.

All cases of hip joint instability are recorded, and during the last few years the frequency has been about 12 per thousand, probably with some over-diagnosis due to registration of uncertain cases.

All definite cases of hip instability have been treated immediately at the orthopaedic departments. A study of a series of untreated newborns with transient instability has shown that the majority, but not all, will develop normal hip joints without treatment. This has been one reason for the recommendation to treat all unequivocal cases of hip instability.

The present organization of examination and treatment is described. Detailed and practical instructions for the examination and treatment are given.

Follow-ups of children treated for hip instability in the neonatal period are reported. It has been found that in practically all these patients anatomically normal hip joints are achieved by means of correct and carefully followed up treatment.

The findings in 65 patients with neonatal hip instability in whom the treatment was unsuccessful or inadequate have underlined the importance of a strict treatment schedule, experienced doctors and detailed information to the parents.

The effect of diagnosis and treatment of hip instability neonatally on the frequency of late-diagnosed cases of CDH was studied by recording all late-diagnosed cases at all orthopaedic departments.

It was clear from the latter study that instability of the hip in newborns represents "preluxation" and that the treatment of this can prevent later dislocation.

Dislocation of the hip joint in newborn infants is very unusual. Nowadays it is rare even after the neonatal period — in recent years only 12 % of the late-diagnosed CDH cases between 1 and 6 months of age at diagnosis.

However, the total number of late-diagnosed cases in the whole country has not decreased by more than 50 % compared with the period prior to the introduction of hip examination of newborns. Now we find about 60 cases annually (0.6 per thousand), against 110—120 earlier. The reasons why cases are still discovered late are discussed.

Owing to the fact that virtually all children are now regularly examined at the Child Health Centres, where hip examination is included in the medical check-up, late CDH cases are diagnosed at increasingly early ages. In 1977—1979, 80 % were diagnosed at the age of 1—6 months.

Diagnosis of CDH after the age of 6 months is now rare, and in recent years there have only been about 10 such cases annually in the whole country.

From a study of limited abduction of the hip joint in infants followed up until the age of 18 months, it was clear that a very pronounced limitation of abduction caused by a "habitual unilateral supine position" during the first months could be avoided if the children were placed in the prone sleeping position from birth.

Radiographic examinations of newborn infants with instability is unnecessary, but is important in late-diagnosed cases of CDH. This examination, including arthrography, is therefore briefly described.

A study of the ossification of the hip joint in 200 normal girls who were clinically examined at birth and followed up at 6 and 12 months of age, at which times radiographic examinations were performed, provided normal standards for the size of the ossification centre of the femoral head and the acetabular angle. At 6 months 4 % of the girls had no visible ossification centres and 3.6 % had only slight ones. Among the clinically normal girls two showed hip joint dysplasia at X-ray at 12 months of age. Without treatment these had normal joints at later follow-up.

A follow-up of all the 52 late-diagnosed children with CDH born in 1976 and treated at the orthopaedic departments showed that early treatment gives the best results even in late cases. The hip joints become completely normal if treatment is started before the age of 6 months, with traction therapy and adductor tenotomy prior to reduction. If reduction is performed without preceding traction and tenotomy, there is a risk of avascular necrosis.

The examination and treatment of hip joint instability in newborns seem to be a simple method for prevention of subsequent dislocation. However, from our 30 years of experience in Sweden it is obvious that problems still exist, especially from a national point of view. Two things are of special importance — a firm organization of the screening at the obstetric departments and at the Child Health Centres, and continuing information to all doctors involved.

The decreasing frequency of late-diagnosed cases of CDH gives reason for centralization of the treatment to university hospitals or other regional orthopaedic departments.

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