FROM THE NUFFIELD ORTHOPAEDIC CENTRE, OXFORD

OSTEOCHONDRITIS IN CONGENITAL DISLOCATION OF THE HIP: A CLINICAL AND RADIOGRAPHIC STUDY

By

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Recent work on the changes of the vascular pattern in the human femoral head during growth (Trueta 1957) has shown that there are three distinct vascular arrangements corresponding to three successive periods of growth. The earliest system of circulation is characterized by the absence of penetration into the bone epiphysis of any vessel from the ligamentum teres while the lateral epiphyseal vessels carry its main blood supply assisted by the metaphyseal vessels for the epiphyseal growth cartilage is not yet an efficient barrier to these vessels, particulary at its periphery.

With individual variations this arrangement changes at about four years of age or shortly before, when the only metaphyseal vessels penetrating the epiphysis are a few thin branches reaching it through the perichondrium of the growth plate. From four until the age of seven or eight years, when the round ligament vessels usually penetrate the epiphysis, only the lateral epiphyseal vessels are responsible for the nutrition of the femoral head; this is the period of life when Legg-Perthes disease occurs. This peculiar vascular arrangement extending from before four to almost eight years of age has been considered to be basically responsible for the occurrence of osteochondritis of the hip (*Trueta & Lima* 1959).

The present paper summarizes a clinical and radiographic study of the bone changes not very dissimilar to those of Legg-Perthes type, accompanying many cases of treated congenital dislocation of the hip. These are known by several names, including epiphysitis, osteochondritis, aseptic necrosis and epiphyseal dysplasia. In the discussion an attempt is made to explain the osteochondritic changes of the femoral

head appearing in the course of treatment of C.D.H. in the light of recent advances on the understanding of the vascularity of the growing femoral head.

BIBLIOGRAPHICAL REVIEW

The incidence of this condition varies considerably in the reviews of results of treatment of C.D.H. by different authors; thus *Crego & Schwartzman* (1948) find 0 per cent, *Farrell & Howorth* (1935) 10.2 per cent, *Leveuf* (1948) 23.3 per cent, *Massie* (1957) 30 per cent and 45 per cent, *Ponseti (1949)* 46.2 per cent and *Bost et al.*(1948) 52 per cent. The discrepancy in these figures may be attributed to the variety of concepts sustained about the lesions appearing in C.D.H. Some authors include only those cases which develop changes similar to coxa plana (*Farrell & Howorth* 1935); other following *Putti* (1929), include all the changes present in the femoral head after reduction (*Ponseti* 1944; *Massie* 1951); finally, other do not state the type of lesion to which they refer. *Gill* (1948) considers those lesions as manifestations of a femoral dysplasia. There have been very few attempts to study the condition with the purpose of finding out the factor or factors responsible for its production, and therefore the measures that might result in the decrease of its incidence.

MATERIAL

During a revision of cases of congenital dislocation of the hip treated in this hospital (*Esteve* 1959) a preliminary study was made of the relative importance of some of the factors in the production of osteochondritis of the femoral head appearing during treatment of the dislocated hip. The effect of pressure over the upper femoral epiphysis and of the capsular pull and rotation was mentioned there.

In that analysis, out of a total of 184 hips available for study, 90 (48.9 per cent) showed pathological disturbances of the femoral head at different intervals after reduction. Sixteen patients with bilateral dislocation had osteochondritis in both femoral heads. These numbers did not include two patients who showed osteochondritic changes in the normal, non-dislocated side, besides those affecting the dislocated femoral head.

Of the 90 cases with changes in the femoral head 14 (15.5 per cent) occurred in males and 76 (84.5 per cent) in females. The sex incidence

does not apreciably diverge from that of congenital dislocation of the hip in the series of this hospital, there being 4.5 females to one male.

RADIOGRAPHIC STUDY

A detailed study of all the radiographs available of each patient has been made. A moderate degree of osteoporosis after reduction and immobilization of the dislocated hip has been seen in every case. This is considered an unavoidable consequence of the reduction and immobilization of the hip and not a pathological condition; it disappears without sequelae shortly after the joint has regained its activity.

Apart from this minor and transient osteoporosis there are three different types of radiographic changes, both in the early and late stages of osteochondritis as well as in their subsequent evolution.

Distribution of Cases.

In 83 instances it was possible to classify the cases into one of three radiological types.

The duration of the process was estimated from the earliest radiographs showing lesions, to those indicating the total healing of the process; it varied for each of the different types.

Type I, was the largest, comprising 54 cases (65.1 per cent). Average length of 2.48 years.
Type II, comprising 22 cases (26.5 per cent). Average of 4.06 years.
Type III, was the smallest one with only 7 cases (8.4 per cent). Average of 3.16 years.

Type I (54 cases). In the early stages osteoporosis of the proximal end of the femur appears. This starts in most cases in the epiphysis, spreads to the neck and involves the acetabulum, reaching a much more advanced stage than that which occurs in every case of treated C.D.H. When the osteoporosis is very severe, small cavities may appear in the epiphysis which on occasions has a honeycomb appearance. The osteoporosis is more marked in the periphery of the epiphysis where cyst-like images frequently occur. Bone rarefaction may be evident also in the neck and while less frequently than in the head, images of cavities may be seen at times surrounded by a sclerotic ring. Osteoporosis reaches its maximum in the proximity of the epiphyseal cartilage but the acetabulum may also show cyst-like cavities.

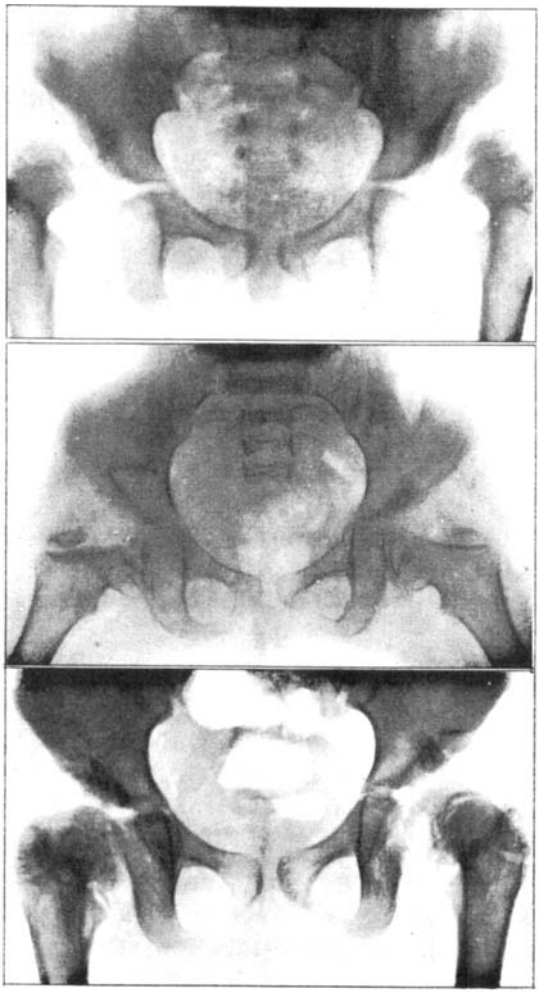


Fig. 1.
Case of Type I in the classification. Note the severe decalcification in *b* and the permanent deformity in *c*, due to anteversion and varus of the femoral neck.

The osteochondritis may follow one of two courses. Recalcification may occur in a short time or, contrariwise, flattening of the medial aspect of the epiphysis may take place. In these areas there is often an increase of the anteversion and a tendency to varus of the neck (Fig. 1) while only rarely has a valgus deformity been observed; this has always been found to accompany cases of failure of reduction or residual subluxation. The recalcification of the neck and head seem

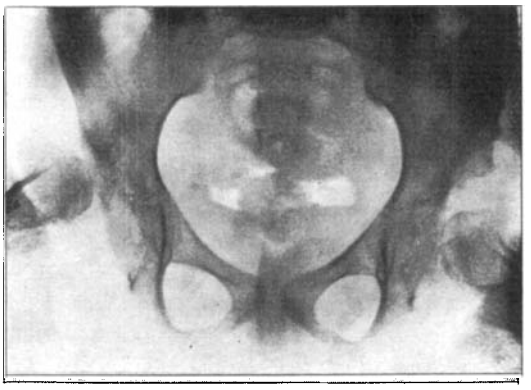


Fig. 2.
Case of Type II. Severe osteoporosis due to pressure over the outer border of the acetabulum.

to occur simultaneously and uniformly in some cases, while in others the neck proceeds to recalcify before the head.

Some cases showed enlargement of the neck, particularly in its upper border.

At the end, different degrees of flattening of the head remained. The neck showed very often a residual widening with or without alteration in the saggital and coronal angulations with the femoral shaft, alterations which were very marked in severe cases. In no case of this group was fragmentation of the head seen.

Type II (22 cases). In the cases of this group osteoporosis might be minimal at the start but there are from the beginning radiological images showing the effect of pressure over the femoral head, usually against the outer border of the acetabulum (Fig. 2); in a number of cases the changes in the head had appeared after a shelf operation (Fig. 3 and 4).

The femur may retain a fairly good calcification at times, but in other shows progressive and persistent osteoporosis (Fig. 5). This can be very severe in the epiphyseal nucleus and may progress, as in some cases of Type I, to involve the neck and acetabulum. The neck can undergo similar deformities as in the cases of the previous group. The recalcification starts in the head, neck and acetabulum, but the local deformity of the head will persist for a long time and may remain for ever (Fig. 6).

Thus, the main feature of this group are the signs of external pressure on the capital femoral epiphysis which frequently causes indenta-

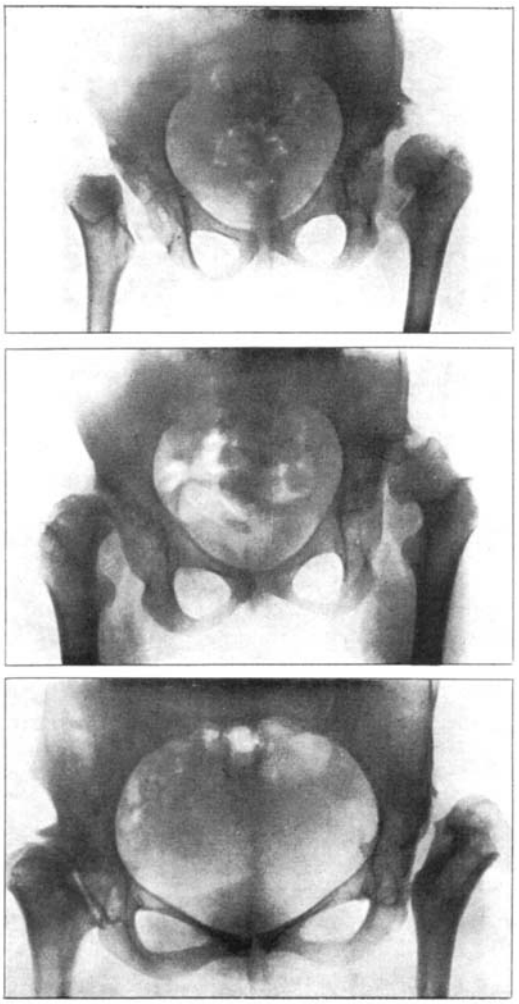


Fig. 3.
Case of Type II. Deformity of the femoral head caused by pressure after a shelf operation.

tions and tangential flattening of the femoral head. In many cases the imprint caused by the compressing structures—limbus, shelf and others—remains visible long after the osteochondritis has ended its course.

Type III (7 cases). This group consists of the cases with radiographic signs and evolution similar to those of Legg-Perthes disease. In two cases the first radiological sign was an increase in density of the head,

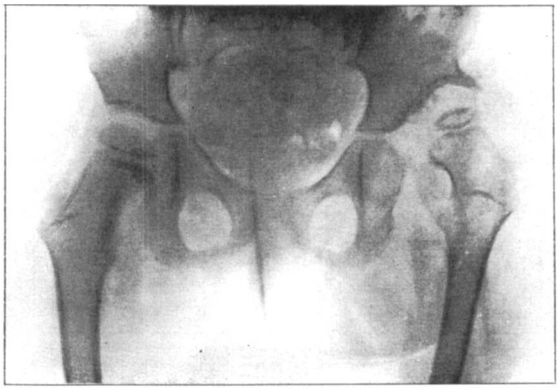
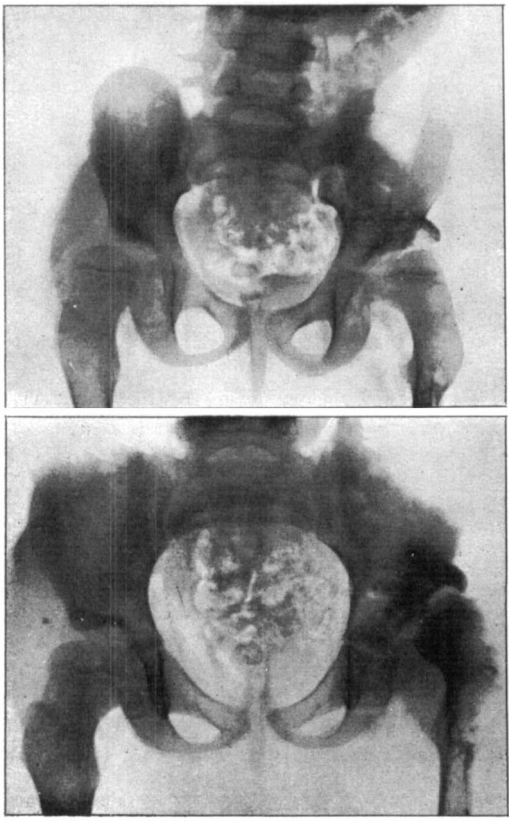


Fig. 4.
Case similar to that of Fig. 3. Note the severity of the osteoporosis.



a

b

Fig. 5.
Case of Type II. Severe osteoporosis. The radiograph in *a* was taken one year after the shelf operation. In *b* recalcification has just begun but still shows extremely rarefied femoral neck and trochanter six months later.

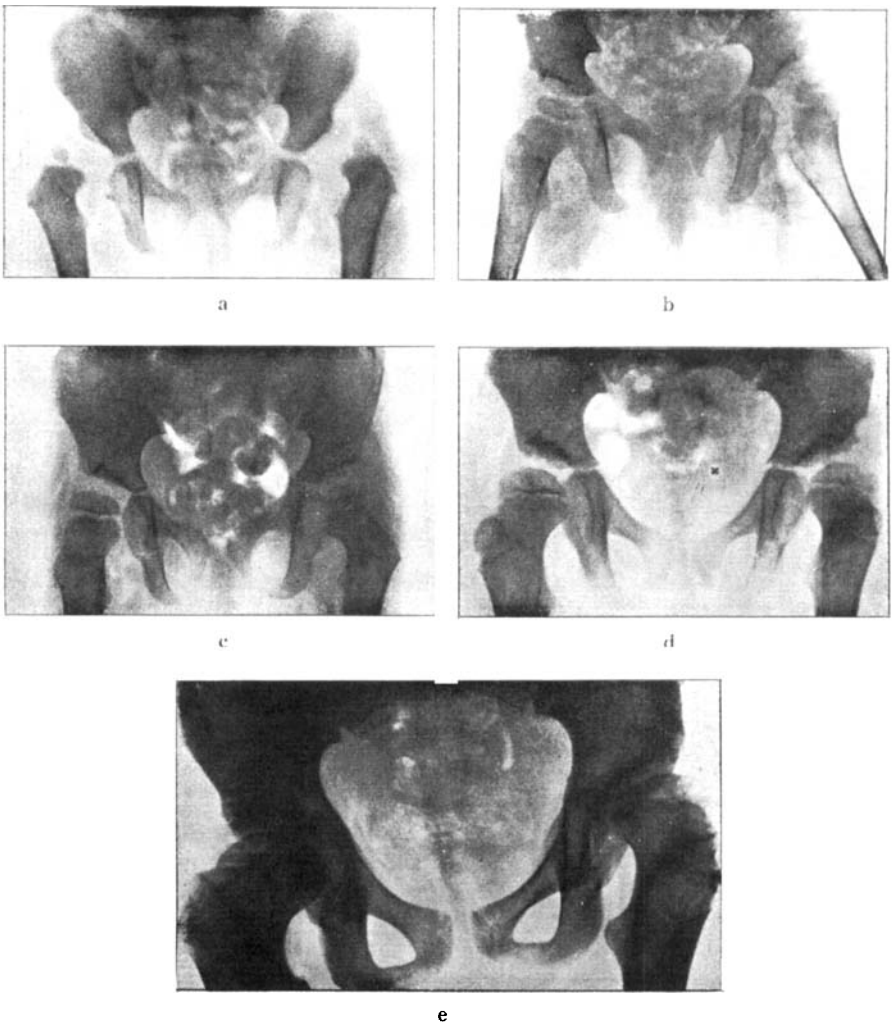


Fig. 6.
Case of Type II. These series of radiographs illustrate the persistance of deformity nearly ten years after reduction of the C. D. H.

which was followed by osteoporosis (Fig. 7). In the remaining cases the first radiological sign was bone reabsorption of the head and neck. The osteoporosis went on increasing in the femoral head and later fragmentation of the epiphysis, similar to that of the reabsorptive phase of Legg-Perthes disease, was seen (Fig. 8). This was never observed in any of the cases of Types I and II. Pseudocavitation of the

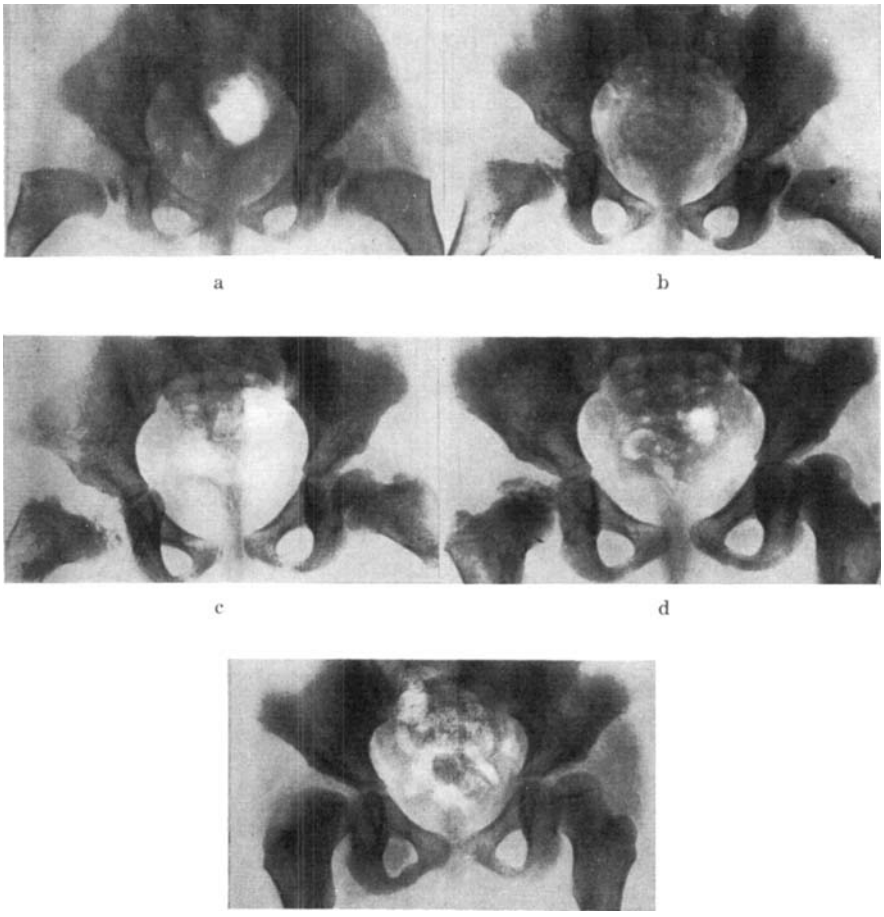


Fig. 7.
Case of Type III. Legg-Perthes-like disease showing increased calcification of the femoral head in *a* and fragmentation in *b*, *c* and *d*; healing with permanent flattening in seen in *e*.

neck and acetabulum occurred sometimes as is not uncommon in Legg-Perthes disease (Fig. 9). Recalcification started as a rule in the periphery of the capital epiphysis and advanced towards its centre, the last area to be fully recalcified.

As the recalcification of the head progressed its shape became more or less restored. Simultaneously the neck began to have a more regular density but remained with a variable amount of deformity. The final

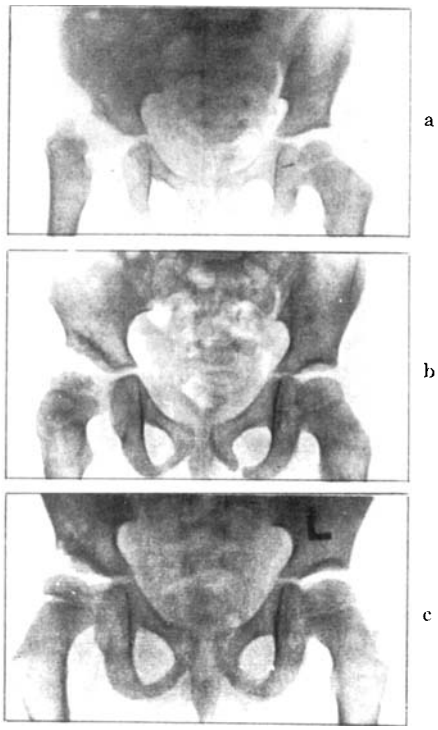


Fig. 8.
Case of Type III. Bone changes similar to those of Legg-Perthes disease, showing in *b* some pseudocavitations of the neck underneath the growth cartilage.

anatomical result varied with the severity and persistence of the deforming forces during that period in which the head undergoes the Legg-Perthes-like changes.

The Relationship of Osteochondritis to the Inital Method of Reduction.

The initial method of reduction had a definite bearing on the incidence of osteochondritis. As has been shown (*Esteve* 1959) the frequency of osteochondritis was much higher in the group of cases treated initially by manipulation (68.4 per cent) than in the cases which were initially reduced on a frame (37.5 per cent).

The distribution of cases in the three different types is:

Type I. Manipulation 25, Frame 28, Open reduction 1.
Type II. Manipulation 20, Frame 2.
Type III. Manipulation 3, Frame 3, Batchelor plaster 1.

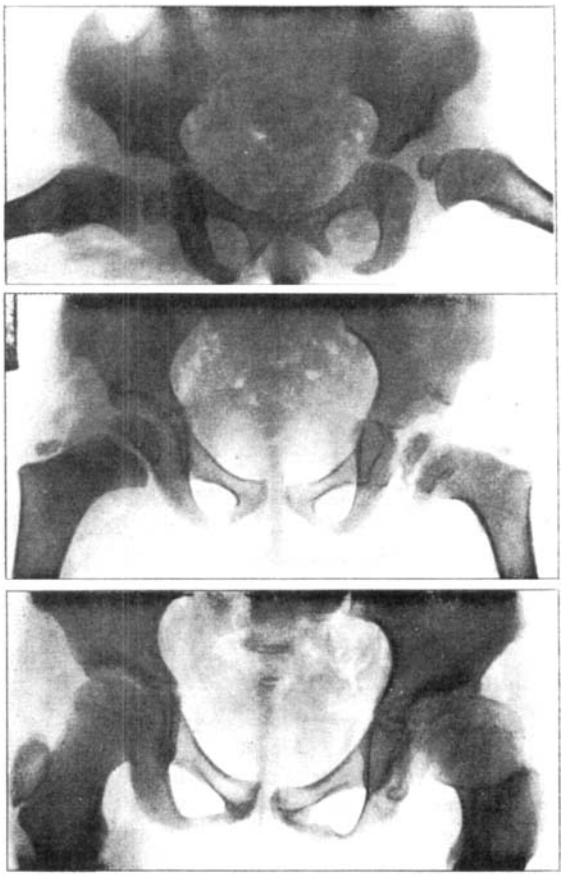


Fig. 9.
Case of Type III metaphyseal changes in b similar to those of Legg-Perthes disease.

The relationship between the severity of the process and the method of initial reduction[1] is shown in Table 1. This table demonstrates that the cases reduced gradually on a frame showed not only a smaller incidence of osteochondritis but also milder affections with a predominance of end results classified according to the severity of the final deformity of the femoral head and neck as mild (72.2 per cent of no. of osteochondritis) while final severe deformities were predominant in cases treated by manipulation (55.8 per cent of no. of osteochondritis).

[1] The cases have been grouped according to the initial method used for reduction. Some of them had other treatments later on.

TABLE I

Comparison of results of the osteochondritic process appearing after frame treatment and manipulation.

Treatment	Result								
	None or mild deformities					Severe deformities			
	None	Slight	Moderate	Total	%	Severe	Very severe	Total	%
Frame	4	13	9	26	89.7	1	2	3	10.3
Manipulation	0	6	9	15	34.1	10	19	29	65.9

Increase of severity of the process with the age of the patient at the beginning of reduction treatment was seen. It is also noted that the patients of 2 years of age showed a larger incidence of osteochondritis while the degree of its gravity was less than the process in older children.

The relationship between the end result of the osteochondritis and the anatomical result of the reduction (classification according to *Severin* 1941) shows a much higher incidence of osteochondritis of the more severe groups in the cases showing an incomplete defective reduction (Table 2).

TABLE II

Relationship between the anatomical result of reduction and the result of the osteochondritic process. Classification of results following the method of Severin.

Anatomical result of the reduction	Result of the osteochondrictic process								
	None or mild deformities					Severe deformities			
	0	1	2	Total	%	3	4	Total	%
I (a & b)	2	0	0	2	100.0	0	0	0	0.
II (a & b)	1	9	10	20	80.0	5	0	5	20.0
III	3	6	1	10	90.9	1	0	1	9.1
IV (a & b)	0	2	7	9	30.0	6	15	21	70.0
V	0	0	0	0	0.	0	5	5	100.0
VI	0	0	0	0	0.	1	2	3	100.0

Observations during open reduction.

In this hospital a method of open reduction aiming at the removal of the acetabular limbus has been used since 1950 (*Somerville* 1953). More than one hundred cases have been treated by this method but they

are not included in this analysis, having been the object of a separate study. The investigation of results as far as osteochondritis is concerned has been carried out in a group of 44 cases treated in this hospital by open reduction prior to the more widespread use of excision of the limbus.

Twenty-four cases (4 primary reduction and 20 after previous attempts at closed reduction) did not show osteochondritis at any time of their evolution. The other 20 showed signs of osteochondritis. Of these, in only two cases had open reduction been used as the primary treatment. The other 18 cases had had no successful attempts at reduction previously, and 14 of them showed radiological signs of osteochondritis already at the time of operation. Only a macroscopical examination of the different elements of the joint was made. Biopsy was not considered justifiable except of some fragments removed from the ligamentum teres at operation in a few of the cases.

The Femoral Head as seen at Operation.

Many of the femoral heads showed flattening medially, or in a few cases a mushroom shape. Some of the deformities corresponded clearly to what could be expected by looking at the radiographs. None of the cases which had had primary reduction had significant changes in the cartilage. The majority of cases that showed lesions in the cartilage has already radiological signs of osteochondritis at the time of operation; only exceptionally were very moderate lesions of the cartilage seen in cases which did not show signs of osteochondritis at any time. Six cases, which afterwards developed osteochondritis were submitted to operation before any radiological signs of the process had appeared. At the operation the cartilage had a normal appearance in all of them and in every instance satisfactory reductions were obtained.

The Ligamentum Teres as seen at Operation.

In 22 cases the ligamentum teres was identified at the time of operation. It was not noted in 18 instances. In 5 cases it was found to be torn; all of them had undergone previous attempts at reduction. In those cases in which the ligamentum teres was not seen, no increase in the frequency of osteochondritis was observed. *The excision of the ligamentum teres at operation did not seem to have any bearing on the production of osteochondritis in the 11 cases in which it was excised.*

The section of the ligamentum teres did not as a rule produce much bleeding but in one case it snapped at the fovea capitus and bled from there throughout the operation, indicating a fair blood supply to the epiphysis from other sources than the ligamentum teres. This is interesting, as it is known that in the normal child it is exceptional that vascular anastomosis occurs between the vessels of the epiphysis and those of the ligamentum teres before the age of at least six years.

DISCUSSION

This study draws attention to the great frequency of osteochondritic changes occurring in the capital epiphysis after reduction of congenital dislocation of the hip, especially following some forms of reduction.

In no case was any alteration of this type found before the commencement of treatment. This seems to indicate that the femur is adapted to the special nutritive conditions present in C.D.H. in relation with its pathological anatomy. The small size of the epiphyseal nucleus of the femoral head is a constant observation in the dislocated hip and is not confined to the cases that will develop further radiological changes after treatment.

The pathogenic importance of local pressure over the femoral head has to be taken into consideration. Some authors have attributed a primary role or even all the responsibility to it for the production of the disturbances in the femoral head after its reduction. *Leveuf & Bertrand* (1946) considered that the primary lesion is in the cartilage; this would determine later on the reaction from the ossified nucleus. From the present study it is evident that pressure over the femoral head plays an important part in the production of localized lesions in the epiphysis in a number of patients. In the cases classified in Type II, deformities of the head due to lack of congruency with the opposed surfaces (acetabular rim, shelf etc.) were evident. In spite of this, signs of local pressure over the head were not seen to be the cause of the process in most of the cases. Many in which the position obtained after reduction was found to be satisfactory subsequently presented osteochondritis. In several cases, the femoral heads exposed at operation when radiological signs of osteochondritis were already present, failed to show any damage to the cartilage.

Besides the cases in which local pressure over the femoral head seems to be a definite causative factor (cases of Type II) there is a large number of cases in which pressure seems to be only a local de-

forming factor, operating when the process of osteochondritis has started. The responsible factor in those later cases seems to be the damage to the vessels of the femoral head, either at reduction or during the period of immobilization. The blood supply to the femoral head at the age at which reduction is generally done is dependent mainly on the lateral epiphyseal vessels with the contribution of some arterioles from the metaphyseal system of vessels (*Trueta* 1957). Therefore, the stretching or extreme torsion of the posterior capsule, which contains those vessels can determine an impairment of the blood supply to the femoral head, either by sudden torsion of the vessels at manipulation or by continuous streching of them.

This alteration in the circulation of the femoral head causes a vicarious vascular reaction and thus decalcification of the head, neck, and acetabulum, all the elements of the hip being supplied by an anastomotic arterial net. Type I and Type II are radiologically different, but neither shows the presence of fragmentation as in the cases of Type III, similar to that present in Legg-Perthes disease.

An analysis of the present series shows a substantial reduction of the incidence of osteochondritis after progressive reduction on a frame. This, complemented with an immediate open reduction when the previous treatment has been unsuccessful, may deserve credit for the nearly total elimination of osteochondritis of Type II, the longest and most severe. The damage to the vessels of the femoral head is very lessened with the frame treatment and the severity of osteochondritic processes of Type I and II observed with this type of treatment was greatly decreased.

The immobilization of the hip in extreme rotation in cases of C.D.H. seems to be responsible for the production of osteochondritis. Two observations are of special interest here; in one case a typical osteochondritis appeared in both hips of a patient treated in a plaster which included both hips for a unilateral subluxation, which did not require reduction; in the other case a process similar to that in the dislocated—and reduced—hip appeared in the "normal" side encased in plaster also. The only likely causative factor in these cases seems to be the stretching of the capsule in forced internal rotation and abduction with consequent obstruction of the lateral epiphyseal vessels, passing through it into the capital epiphysis of the femur.

The interesting finding that typical osteochondritis of Legg-Perthes type is extremely rare may find an explanation in the peculiar vascular arrangement before the age of four years, during which some blood

flow from the metaphyseal vessels is still available to the head. This is at variance with what occurs during the age period of Legg-Perthes disease when only the lateral epiphyseal vessels are responsible for supplying the femoral head.

CONCLUSIONS

1. Osteochondritis after reduction of C.D.H. can be grouped into three radiological types which differ in their evolution, severity and duration. Only 8.4 per cent of the cases were similar to those of Legg-Perthes disease and showed *fragmentation* of the femoral head (Type III). The largest group, comprising 65.1 per cent of the cases, showed only *osteoporosis* of different degrees (Type I). The remaining 26.5 per cent is a group characterized by radiological evidence of *local pressure over the femoral head* (Type II).

2. Males and females were equally affected.

3. Osteochondritis was more frequent in the patients of two years of age but the severity increased with the age at initial treatment.

4. It was more frequent and much more severe after manipulation than after frame treatment.

5. Cases incompletely reduced showed the greatest incidence of osteochondritis. If closed reduction is not achieved it is desirable to do an open reduction as early as possible.

6. Weight bearing sould not be allowed during the evolution of the osteochondritis.

7. The peculiarity of the vascular pattern at the age of treatment of C.D.H. is considered responsible for the bone changes characteristic of osteochondritis of this type.

SUMMARY

This study is based on the review of 184 cases of congenital dislocation of the hip of which 90 showed signs of osteochondritis following the initiation of treatment. On the clinical and radiographic data collected the authors describe three different types of osteochondritis.

Type I, comprising 54 cases (65.1 per cent) show changes first of the femoral epiphysis which spread to the femoral neck and acetabulum. Severe osteoporosis with small cavities, particularly at the periphery of the femoral head appear. Some permanent deformity may follow, particularly flattening of the epiphysis and increase in ante-

version, and varus of the femoral neck. Recalcification of neck and head tend to occur simultaneously. The average duration of the condition is 2.48 years.

Type II comprised 22 cases (26.5 per cent). In this osteoporosis may be minimal but the effect of pressure on the femoral head is seen from the beginning. Local deformity of the head is frequent. The average duration is 4.06 years.

Type III. Only 7 cases were seen (8.4 per cent). They all show the radiographic changes typical or Legg-Perthes disease, particularly fragmentation of the femoral epiphysis. Average duration 3.16 years and the permanent changes found appear similar to those of the Legg-Perthes osteochondritis.

The authors believe that Types I and III are caused by interference with the blood flow of the femoral epiphysis through stretching or extreme torsion of the posterior capsule of the hip at the point where the lateral epiphyseal vessels penetrate the femoral head. Manipulative treatment causes damage to these vessels much more easily than reduction of the dislocated hip by progressive traction.

RESUME

Cette étude est basée sur l'examen de 184 cas de dislocation congénitale de la hanche chez lesquels 90 montrent des signes d'ostéochondrite après l'instauration du traitement. En se basant sur les données cliniques et radiographiques recueillies, les auteurs décrivent trois différents types d'ostéochondrites.

Type I comprenant 54 cas (65,1 %). Modifications de l'épiphyse fémorale qui s'étendent au col fémoral et à la cavité cotyloïde. Grave ostéoporose avec petites cavités, en particulier dans la périphérie de la tête fémorale. Une déformation permanente peut s'ensuivre en particulier un aplatissement de l'épiphyse, une antéversion accrue et l'inclinaison du col fémoral en coxa vara. Une recalcification du col et de la tête a tendance à apparaître simultanément. Durée moyenne de l'état, 2,48 ans.

Type II comprenant 22 cas (26,5 %). Chez ceux-ci l'ostéoporose peut être minime, mais on peut constater l'effet de la pression sur la tête fémorale, depuis le début. Une déformité locale de la tête est fréquente. Durée moyenne, 4,06 ans.

Type III. Seulement sept cas ont été observés (8,4 %). Ils montraient tous des altérations radiographiques typnques del a maladie de Legg-

Perthes, en particulier la fragmentation de l'épiphyse fémoral. Durée moyenne, 3,16 ans. Les modifications permanentes trouvées paraissaient être similaires à celles de l'ostéochondrite de Legg-Perthes.

Les auteurs croient que les Types I et III sont causés par une interférence avec l'épanchement de sang de l'épiphyse fémoral survenu à la suite de l'extension ou d'une torsion extrême de la capsule postérieure de la hanche et le point où les vaisseaux épiphysaires latéraux pénètrent dans la tête fémorale. Un traitement manipulateur peut plus facilement causer des dommages à ces vaisseaux que la réduction de la dislocation de la hanche par traction progressive.

ZUSAMENFASSUNG

Diese Studie hat zur Grundlage 184 Fälle von angeborener Hüftverrenkung, von denen 90 Zeichen von Osteochondritis nach dem Beginn der Behandlung aufwiesen. An Hand des erhaltenen klinischen und röntgenologischen Materiales beschreiben die Verfasser drei verschiedene Typen von Osteochondritis.

Type I umfasst 54 Fälle (65,1 %), die zuerst Veränderungen der Femurepiphyse mit Übergreifen auf den Femurhals und das Acetabulum zeigen. Schwere Osteoporose mit kleinen Hohlräumen besonders an der Peripherie des Femurkopfes treten auf. Gewisse dauernde Verbildungen, vor allem Abflachung der Epiphyse, Zunahme der Anteversion und Coxa vara können die Folge sein. Eine Neigung zur neuerlichen Kalkeinlagerung in Hals und Korpf besteht oft gleichzeitig. Die durchschnittliche Dauer dieses Zustandes ist 2,48 Jahre.

Type II umfasst 22 Fälle (26,5 %). In diesen kann die Osteoporose sehr gering sein, aber die Druckwirkung auf den Femurkopf ist vom Anfang an sichtbar. Örtliche Verbildung des Kopfes ist häufig. Die durchscnittliche Dauer beträgt 4,06 Jahre.

Type III. Nur sieben Fälle wurden beobachtet (8,4 %). Sie weisen alle die typischen röntgenologischen Veränderungen für Legg-Perthes Erkrankung, besonders Aufstückung der Femurepiphyse auf. Die Durchscnittliche Dauer des Prozesses beträgt 3,16 Jahre und die endgültigen Veränderungen gleichen der Legg-Perthes Osteochondritis.

Die Verfasser sind der Ansicht, dass Type I und III durch Verhinderung des Blutzuflusses zur Femurepiphyse infolge Überstreckung oder extremer Drehung der hinteren Hüftgelenkskapsel an der Stelle wo die lateralen Epiphysengefässe in den Femurkopf eindringen entstehen. Manipulative Behandlung ruft viel leichter Schädigung der

Gefässe hervor als Reposition der verrenkten Hüfte mittels zunehmender Exensionsbehandlung.

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