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THE ETIOLOGY OF CONGENITAL AND INFANTILE DISPLACEMENT OF THE HIP[1]

By

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Deformity of the acetabulum was described by *Dupuytren* in 1826 in reporting the late pathology of a case of congenital dislocation of the hip. Since this report primary dysplasia of the acetabulum has been widely believed to be the cause of congenital dislocation of the hip; a small minority have considered anteversion to be the primary factor. The author's studies and observations in the past thirty years indicate that the primary anatomic fault is in the ligaments or the capsule of the hip joint. *Chapple* in 1935, suggested that a hormonal factor might be responsible for the ligamentous relaxation. *Ortolani*, beginning in 1948, obtained a fine group of pathologic specimens of displacement of the hip, but apparently did not recognize the significance of the capsular elongation. *Massie* in 1951 confirmed the author's investigations and concept. A few other authors in the past few years have recognized the prime importance of the ligamentous relaxation, and experimental work has been done which is confirmatory.

PATHOLOGY AT OPEN OPERATION

The author, with *H. W. Smith* in 1932 and *B. P. Farrell* in 1935 reported the results of the open reduction of 121 hips. The ages at operation varied between 9 months and 12 years, averaging 4 years. Thirty nine of the hips were under 3 years of age. Nine hips were displaced posterosuperiorly, the others anterosuperiorly. Subluxation was present in 8 per cent of the hips, displacement opposite the superior lip of the acetabulum in 49 per cent and complete dislocation in 44 per cent. The acetabulum was too small for the head in four hips, indicating that the presence of the head is necessary for proper development of the

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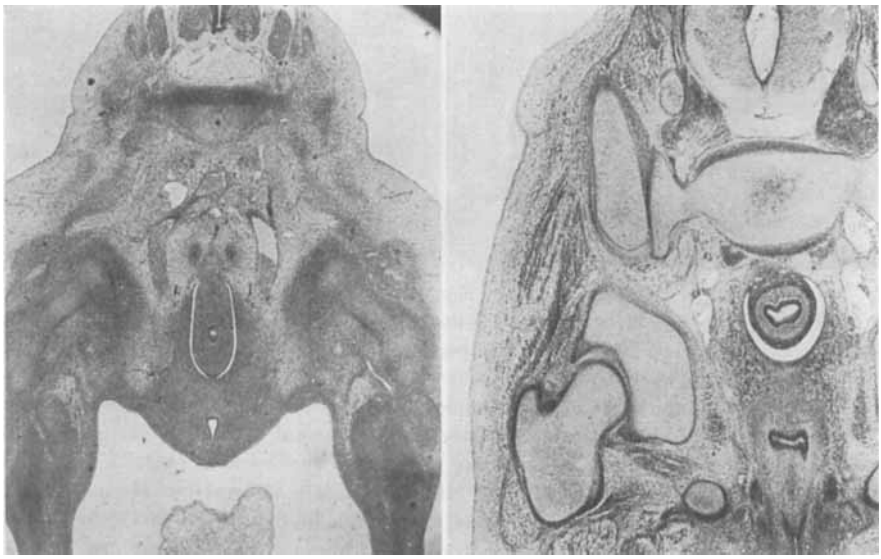

Fig. 1.

Development of hip joint in the embryo. All elements of the hip joint differentiate in situ from one mass of mesoderm (blastema). The head of the femur is globular at all times during its development. Dislocation of the hip cannot occur before the opening of the joint cavity. A: 15 mm embryo. The limb bud is well formed, the femur differentiated, the future femoral head and acetabulum indicated by cell condensations. As yet there is no joint cavity. The head is already rounded, the acetabulum concave. The femur is abducted and perpendicular to the acetabulum, the hips stable. Muscle masses are beginning to form. B: 30 mm embryo. The acetabulum, head, neck and greater trochanter are well developed, and the glenoid labrum overhangs the head. Cortical condensations are present on the head and the acetabulum, but the join cavity is not yet open. The gluteal muscles and the capsule are differentiating. The head is well supported and the hip stable. It is only after this stage that displacement might occur. (From *Strayer, L.:* Yale J. Biol. Med. *16*: 13, 1943).

acetabulum. The acetabular roof was well formed and the acetabulum of good depth and well rounded in 30 hips with complete dislocation, indicating that the acetabulum could not have been at fault in these hips.

Anteversion was more than 60° in only 20 per cent of the hips, it was 45° or more in 58 per cent, less than 45° in 42 per cent. Since anteversion was not always present, it could not have been the primary cause of all displacements.

The capsule was elongated in every hip, the only pathologic finding common to all of them, and evidently the primary anatomic etiologic factor, the other changes being secondary.

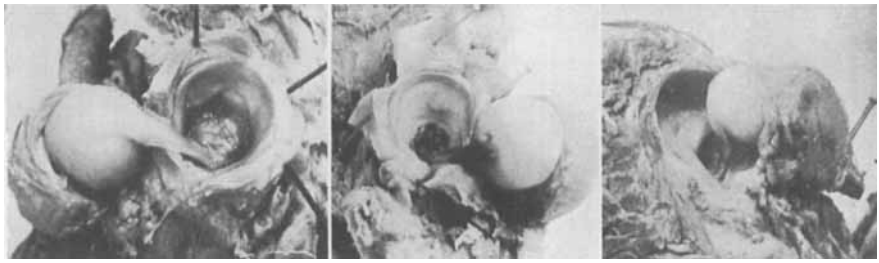

Fig. 2.

Pathology of hip displacement, specimens of *Ortolani*. A: Female, age 2 months. There was a positive jerk sign. The capsule was elongated, the hip moderately subluxated. There was no hour glass constriction. The acetabular roof and the glenoid labrum were flattened and widened from the pressure of the femoral head; these are secondary changes and would regress to normal at this age with complete reduction, well maintained. B: Male, age 3 months. There was a positive jerk sign. The capsule was elongated, permitting almost complete dislocation. The acetabular roof and the labrum are quite flattened due to the high position of the head and the prolonged pressure, but the head, stronger because of its structure and its spherical shape, is not yet deformed. Probably even this much deformity would regress to normal at this age with complete reduction, well maintained. C: Premature at 7 months, 1000 gms. There was no jerk sign. The capsule was much elongated, pulled up over the inferior portion of the acetabulum, pushed up and a pocket formed around the dislocated head. There was no side-to-side or "hour glass" constriction. The acetabulum was well shaped, not defective. The head presses downward and inward against the labrum, which thus intervenes between the head and the acetabulum. There is no acetabular "dysplasia" despite the complete dislocation. Anteversion was no factor in causing the dislocation. The capsule is adherent to the ilium above the labrum, the beginning of a false acetabulum. The head is not deformed and in this position is likely to be freely moveable and remain spherical. Complete well maintained reduction with obliteration of the superior pocket in the capsule at this age would result in a normal hip.

A simple open reduction was adequate in 54 per cent of the hips, all these reductions being stable, indicating little or no acetabular roof defect. The quality of the result did not depend on the extent of dislocation, but upon the age of the infant, the degree of acetabular roof deformity, the amount of uncorrected anteversion, and most important, correction of the capsular elongation and the maintenance of good reduction.

Massie & Howorth in 1951 reported 300 hips having open reduction, fifty eight of them followed to adult life. Twenty seven of the 58 hips had been well reduced and well maintained, and the adult results were normal hips. There was persistent subluxation in 34 hips, and in adult

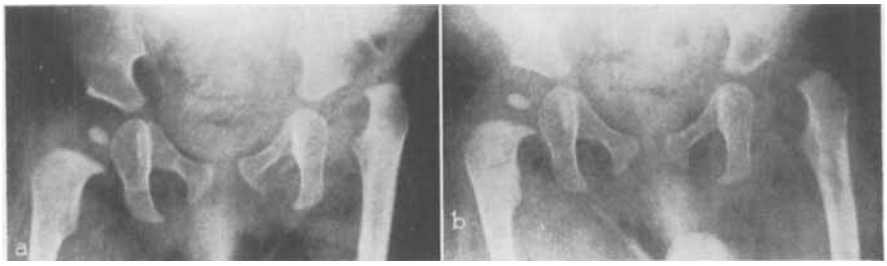

Fig. 3.

Dislocation of right hip, boy, age 14 months. A: With upward pressure the head is out of and completely above the acetabulum. The head must move laterally before it can move upward. The acetabular roof obliquity is little more than normal, despite the dislocation. B: Same, with manual traction. The head comes down nearly opposite the acetabular roof. In the normal hip there is no up and down movement, nor telescoping. Push-pull films not only confirm the diagnosis but also give a clue as to whether the head can be brought down to the level of the acetabulum for reduction. (From *Howorth*: Textbook of Orthopaedics, W. B. Saunders Co., 1952.)

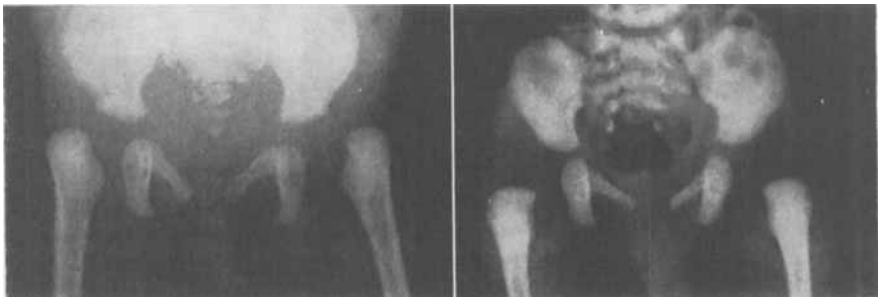

Fig. 4.

A: Stillbirth, at term. There is complete bilateral dislocation. There is no deformity of the acetabular roof, no "dysplasia", but the capsules are elongated, both findings confirmed at autopsy. The primary anatomic fault is in the capsule. B: Girl, age 5 days. There is moderate subluxation of each hip, more on the right, with slight increase in acetabular roof obliquity due to pressure of the head. Each hip became normal clinically and roentgenographically following prompt reduction, well maintained, and has remained so for 7 years.

life 85 per cent of these had an oblique acetabular roof. The opposite hip in some of the cases was subluxated but untreated, the subluxation persisted to adult life, always with a poor result. However, subluxations properly treated in infancy reached adulthood with normal hips. Subluxations which were not reduced gave worse results than dislocations well reduced. The acetabulum developed normally if there was early

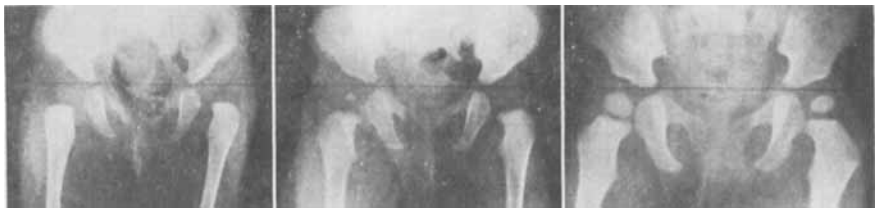

Fig. 5.

Girl, age 13 months. A: There is slight subluxation of the left hip, moderate on the right, with corresponding roof obliquity due to pressure of the head against the acetabular margin. An excellent result would be expected with complete reduction, well maintained. B: Same 3 months after closed reduction, incomplete or not well maintained on the right. There is improvement on the right, but subluxation with roof obliquity persists and the capital epiphysis is not yet ossified. The left is better, and ossification in the epiphysis has begun. C: Same, 11 months after first reduction. The right hip has been reduced again and well maintained. The epiphysis is ossifying well, but lags a bit. There is very little subluxation and the roof obliquity is almost normal on each side, not to be expected if there had been a primary acetabular "dysplasia".

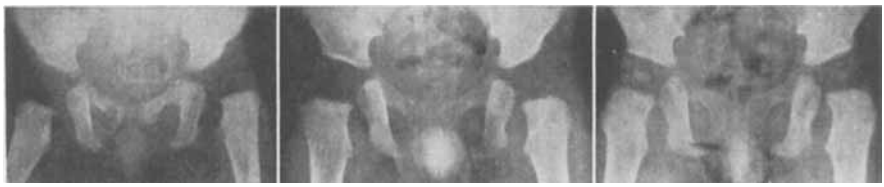

Fig. 6.

A: Boy, age 8 months. The right acetabular roof is moderately oblique, with moderate upward and slight outward subluxation of the hip, and pressure of the head against the acetabular margin. A Frejka pillow was applied. B: Same, age 15 months. There had been improvement in the interval with treatment, then treatment was stopped by the parents. C: Same at 23 months. The subluxation persists, and with pressure of the head against the outer acetabular roof the obliquity is unimproved. A double plaster spica was applied for five months, followed by an abduction brace, with complete reduction, and a normal acetabular roof.

adequate reduction, well maintained, but if subluxation persisted the pressure of the head against the margin of the acetabulum resulted in permanent obliquity. Thus, the result depended upon the simple mechanical forces involved. The location and degree of pressure determined the type and degree of deformity. Displacement of the hip is not due to a primary defect in the acetabulum, but to elongation or relaxation of the capsule.

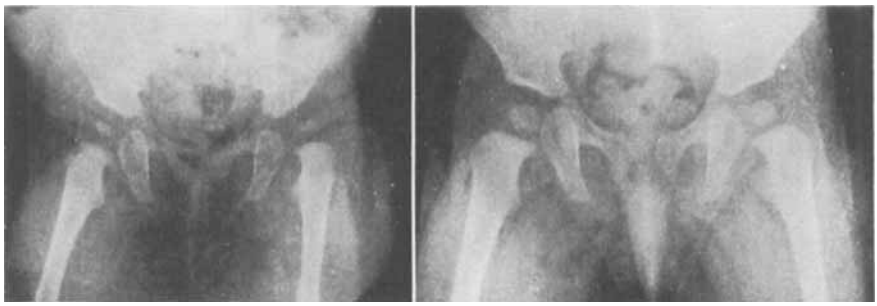

Fig. 7.

Girl, age 21 months. A: There is moderate subluxation of each hip, moderate acetabular roof obliquity due to pressure of the head. At this age complete restoration of the acetabular roof would be expected with complete reduction, well maintained. B: Same at age 24 months. Complete reduction, well maintained, has resulted in just 3 months in stable hips with the formation of a normal acetabular roof. This could not have occurred had there been a "primary dysplasia".

THE FETAL HIP

The author reported studies of normal fetal hips in 1933 and 1947 between the ages of ten weeks and full term. The acetabulum, femoral head and neck, and capsule were well formed even in the youngest specimens. The hips were all quite stable, lateral displacement being prevented by the capsule. If the capsule were divided the ligamentum teres would permit subluxation but not dislocation. Neither subluxation nor dislocation could occur with a normal capsule even in early fetal life. *Strayer*'s study indicates that displacement of the hip is impossible in the embryo.

HIP DISPLACEMENT IN DOGS

Twelve years ago the author found a highly bred miniature poodle with typical congenital subluxation of both hips. Hip displacement is common and often familial in this breed and in German shepherds, offering a fine experimental opportunity. The pathology is similar to that in humans.

PATHOLOGY OF SPECIMENS

Current knowledge of the pathology of hip displacement is derived from many clinical examinations and roentgenograms, open operations on selected cases at various ages, and a few autopsy examinations.

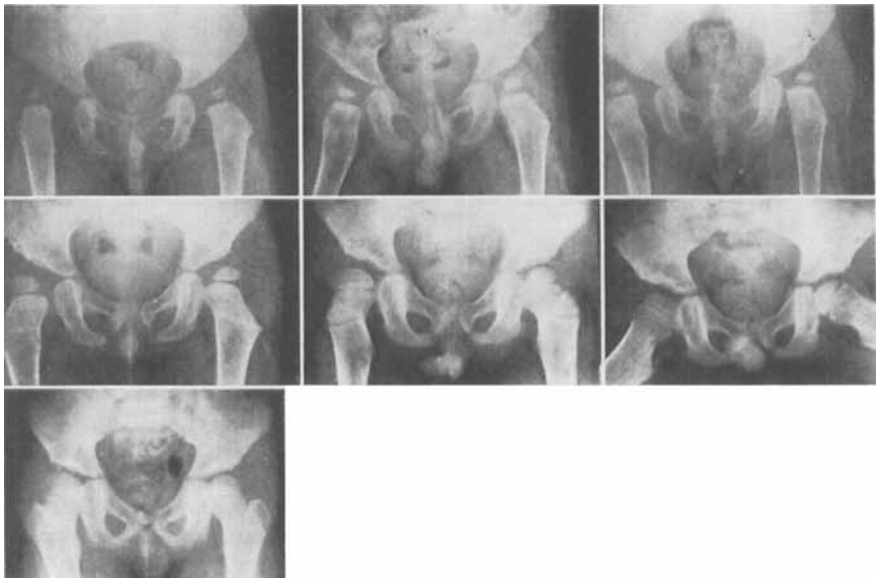

Fig. 8.

Boy. At one week of age this boy had marked general relaxation of the ligaments, with marked calcaneovalgus feet, but the hips were stable and in good position. At 7 months external rotation of the hips was 80°, internal 30°, but they were stable. He began to stand with support at the age of 18 months. A: at age 21 months the acetabular roofs were markedly oblique with bilabiation, and there was dislocation on the left, moderate subluxation on the right. Closed reductions were done; the left was unstable, the right stable. A double plaster spica was applied with hips in abduction, worn 5 months. B.: age 26 months. Both hips were subluxated, acetabular roofs oblique. A brace was applied with the hips in abduction, worn irregularly because of a poor situation at home. C: Age 31 months. The left hip was again dislocated, the right markedly subluxated, with bilateral marked anteversion and coxa valga. Open reductions were done at 33 months of age, the capsule inserted with the head on the left (Colonna operation), and a shelf turned down. Very good reductions were obtained. A double plaster spica was worn for three and a half months, followed by a brace worn irregularly. D: Age 43 months. The acetabular roof is moderately oblique, left hip markedly subluxated, right moderately, with marked anteversion and coxa valga. Walking was begun, with poor progress. At 4 years old walking was fair, and he had very relaxed arches and knock knees, as previously. The hips remained much the same, except the right roof improved. At 5 years old he really began to improve in his ligamentous and muscular development and his activites. E: Age 7½ years. The left roof was fair, with moderate subluxation, the right good, with slight subluxation, and coxa valga was less. There had been no vascular disturbance in the head. F: Same, lateral views. G: Age 12 years. There was further improvement in physical development and activity, and in the hips, which were quite stable, but he was under average in physical activity for his age. (From *Howorth:* Clin. orthop. *29*: 164, 1963).

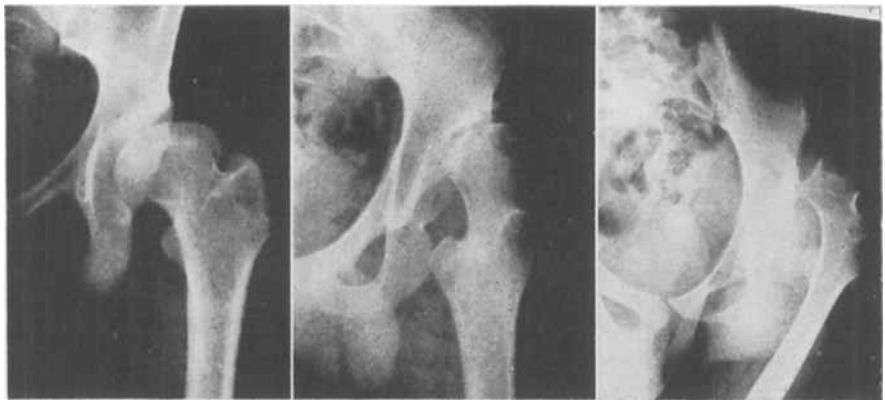

Fig. 9.

Differential diagnosis. The appearance of the hip subluxated from other causes is much the same in the older child or adult as subluxation of congenital or infantile origin. A: Subluxation with coxa plana. The head is broad and flattened superiorly, joint space wide inferiorly, and the roof slightly oblique, secondarily. The acetabulum has not migrated. B: Subluxation due to spastic paralysis, almost identical with congenital subluxation. C: Dislocation due to poliomyelitis at an early age, hip nearly flail. The acetabulum has filled in due to lack of pressure from the head. The head is flattened medially where it presses against the acetabular margin. There is coxa valga. (From *Howorth & Massie:* J. Bone Jt Surg. *33 A*: 171, 1951).

Thirty years ago the author obtained the roentgenogram of a complete bilateral dislocation of the hip in an eight month fetus. He has had two full term fetal specimens with multiple congenital deformities including bilateral dislocation of the hips. Each acetabulum was shallow and flattened and the posterior and superior margins narrow. The capsule was relaxed and elongated, permitting 3/8 inch displacement in various directions within the capsule. *Ortolani* in 1948 described 3 fetal specimens with multiple deformities and displaced hips. He stated that the pressure of the head against the posterior margin of the acetabulum had resulted in dislocation. He has since obtained 13 or more fetal specimens with complete dislocation, 18 with subluxation. Photographs of a number of the specimens clearly reveal the relaxed capsule and the molding of the cartilage at the acetabular margin due to pressure of the head. There is no evidence of "primary dysplasia" of the acetabulum, the entire pathology being related to the relaxed capsule and the pressure of the head.

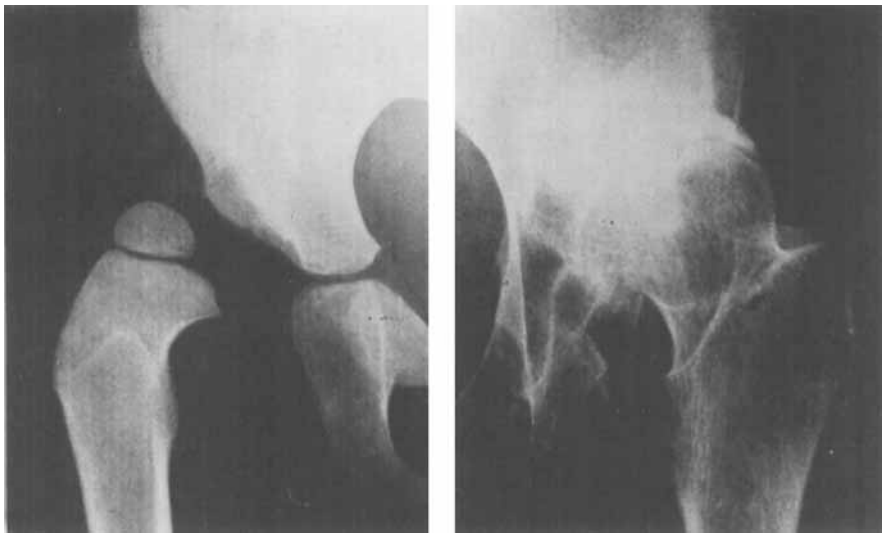

Fig. 10.

A: Boy, age 5 years. There is dislocation at and pressure against the superior margin of the acetabulum, with flattening and bilabiation. The base of the acetabulum has already filled in due to lack of pressure of the head. There is beaking inferiorly, and moderate anteversion. It is too late for reduction to result in restoration of a normal acetabulum. B: Woman, age 45 years. There is persistent moderate subluxation of the right hip since infancy. A new, somewhat shallow acetabulum has formed at the superior margin of the acetabulum at the level of subluxation, and bony overgrowth has produced a roof at this level. The inferior half of the acetabulum was left behind and has partly filled in with bone, probably also with cartilage and hypertrophied haversian gland. The changes all conform to the effects of pressure or lack of pressure. Osteoarthritis has supervened.

RELAXATION OF THE LIGAMENTS

More than 200 infants with hip displacement have been seen by the author in the past 25 years. In every case there has been relaxation of the ligaments of the fingers, wrists, elbows, and knees. When they began to stand all had moderately or severely relaxed arches which persisted; most of them developed knock knees, often with recurvatum. Relaxation of the hip joint is only part of general relaxation of the ligaments. One boy is of special interest (Fig. 8).

DISCUSSION

There is adequate evidence that not all hip displacements are present at birth. The word displacement includes dislocation and subluxation,

and the word congenital separates those which are truly present at birth from those which occur after birth and are properly called infantile.

Subluxation may persist, get worse, or improve, depending upon the balance of mechanical forces, such as muscle pull, weight bearing and the effects of treatment as well as the tendency of the capsule to shorten or lengthen. Dislocation rarely is reduced spontaneously and maintained, but tends to get worse unless properly treated. The reports of *Ortolani, Coleman, Caffey et al., von Rosen,* and others are helpful, but further studies and observations of hips in the first year of life, especially with reference to those which are or become displaced, are desirable.

Recent reports tend to confirm *Chapple*'s idea that ligamentous relaxation is hormonal in origin. Perhaps we shall soon have a safe and effective hormone which will be helpful in tightening relaxed ligaments.

CONCLUSIONS

The word displacement is accurate and convenient as a group term for both subluxations and dislocations. The word congenital is appropriate only when it is known that displacement was present at birth. The term infantile displacement is more suitable for displacements, especially subluxations, recognized some time after birth.

Increased anteversion is not a constant finding with displacement of the hip; occasionally there is retroversion. Anteversion or retroversion are due to torsional stresses against the displaced femur. Anteversion is not the primary cause of displacement; however, marked anteversion may interfere with complete reduction, or favor redislocation.

Acetabular deformity is not always present with hip displacement and when present is not proportional to the degree of displacement. Primary dysplasia of the acetabulum is a misnomer in reference to simple displacement of the hip and is not the anatomic cause.

The deformities of the acetabulum and the limbus are not primary but are due to pressure of the femoral head against the margin of the acetabulum. Medial flattening and "beaking" of the femoral head are likewise secondary to pressure of the head against the acetabular margin.

Muscle pull, weight bearing, or a hormonal effect may result in further stretching of the capsule. The application of favorable forces leads to improvement or correction. The deformities of hip displacement tend to regress if the hip is reduced early and completely, an outcome not to be expected if there were a "primary dysplasia". Complete correc-

tion of deformity may be expected if complete reduction of the hip is maintained in a young infant.

Displacement of the hip is not determined in the development of the embryo, but occurs during fetal development, or after birth.

All the facts of displacement of the fetal or infant hip are explained by the concept of the elongated capsule and the action of purely mechanical forces. No other theory is necessary to explain the facts, and no other theory is consistent with the facts.

RESUME

Le mot déplacement est approprié et commode comme terme s'appliquant au groupe des subluxations et des dislocations. Le mot congénital n'est approprié que si l'on sait que le déplacement existait à la naissance. Le terme déplacement infantile est plus approprié pour les déplacements, en particulier les subluxations, constatés quelque temps après la naissance.

L'antéversion accrue n'est pas une trouvaille constante dans le déplacement de la hanche; occasionellement il peut y avoir rétroversion. L'antéversion et la rétroversion sont dues à des forces de torsion contre le fémur déplacé. L'antéversion n'est pas la cause primaire du déplacement; quoi qu'il en soit, une antéversion marquée doit être redressée par réduction complète ou de préférence par redislocation.

Une déformité du cotyle n'existe pas toujours dans le déplacement de la hanche et si elle existe, elle n'est pas proportionnelle au degré du déplacement.

Une dysplasie primaire du cotyle est un nom erroné s'il est question d'un simple déplacement de la hanche et n'est pas une cause anatomique.

Les déformités du cotyle et des limbes ne sont pas primaires mais sont dues à la pression de la tête fémorale contre le bord du cotyle. L'aplatissement médial et le « prolongement en bec » de la tête femorale sont également secondaires à la pression de la tête contre le bord du cotyle.

La pression musculaire, le port du poids ou un effet hormonal peuvent provoquer une distension ultérieure de la cavité. L'application de forces favorables conduit à une amélioration ou à la correction. Les déformités du déplacement de la hanche tendent à diminuer si la hanche est réduite tôt et complèment, mais c'est un résultat auquel il ne faut pas s'attendre s'il y avait une « dysplasie primaire ». On peut s'attendre

à la correction compléte de la déformité si la réduction complète de la hanche a été obtenue chez un jeune enfant.

Le déplacement de la hanche n'est pas déterminé dans le développement de l'embryon, mais se produit durant le développement du foetus ou après la naissance.

Toutes les circonstances du déplacement de la hanche du foetus ou de l'enfant s'expliquent par la conception de l'élargissement de la capsul et l'action de forces purement mécaniques. Aucune autre théorie n'est nécessaire pour expliquer ces circonstances et aucune autre théorie n'est compatible avec les faits.

ZUSAMMENFASSUNG

Das Wort Verrenkung (displacement) ist genau und angemessen als eine Gruppenbezeichnung für sowohl Subluxationen als auch Luxationen. Das Wort angeboren ist nur anwendbar, wenn man weiss, dass die Verrenkung bie der Geburt vorhanden war. Der Ausdruck kindliche Verrenkung ist besser geeignet für Verrenkungen, besonders Subluxationen, die einige Zeit nach der Geburt erkannt werden.

Vermehrte Anteversion ist kein konstanter Befund bei der Hüftverrenkung, manchmal is eine Retroversion vorhanden. Anteversion und Retroversion werden durch Drehungsbeanspruchungen auf den verrenkten Femur hervorgerufen. Anteversion ist nicht die unmittelbare Ursache der Verrenkung, ausgesprochene Anteversion kann jedoch eine vollkommene Einrenkung verhindern oder eine Reluxation begünstigen.

Verbildung des Acetabulum ist nicht immer gleichzeitig mit einer Hüftverrenkung vorhanden und wenn vorhanden nicht proportional zum Grade der Verrenkung. Primäre Dysplasie des Acetabulum ist eine Fehlbezeichnung im Zusammenhang mit einer einfachen Verrenkung der Hüfte und ist nicht die anatomische Ursache derselben.

Die Verbildungen des Acetabulum und des Limbus sind nicht primär, sondern sind die Folge des Druckes des Femurkopfes gegen den Rand des Acetabulum. Mediale Abflachung und „Zuspitzung" des Femurkopfes sind gleichfalls als Sekundärerscheinungen wegen des Druckes des Kopfes gegen den Acetabularrand anzusehen.

Muskelzug, Belastung oder eine hormonale Einwirkung können eine weitere Streckung der Kapsel verursachen. Die Anwendung günstig wirkender Kräfte führt zur Besserung oder Korrektur. Die Verbildungen der Hüftverrenkung haben die Neigung zurückzugehen wenn die Hüfte frühzeitig und vollständig eingerenkt wird, ein Ausgang der nicht erwar-

tet werden kann, wenn es sich um eine „primäre Dysplasie" handeln würde. Man kan eine vollständige Korrektur der Deformitet erwarten, wenn die vollständige Einrenkung der Hüfte bei einem jungen Kinde aufrechterhalten wird.

Die Hüftverrenkung ist nicht in der Entwicklung des Embryo bestimmt, sondern entsteht während der fetalen Entwicklung oder nach der Geburt.

Alle die Tatsachen der Verrenkung der fetalen oder kindlichen Hüfte lassen sich mittels des Begriffes der verlängerten Kapsel und der Einwirkung von rein mechanischen Kräften erklären. Keine andere Theorie ist zur Erklärung der Tatsachen nötig und keine andere Theorie entspricht den Tatsachen.

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