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Slipped upper femoral epiphyses : a study of twenty-eight cases

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(Appendix I)

SLIPPED UPPER FEMORAL EPIPHYSIS

A STUDY OF TWENTY-EIGHT CASES

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(Appendix II)

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INTRODUCTION

It was brought to my attention that the diagnosis of this disease is too frequently overlooked in the earlier stages. Why is this? What are the early signs and symptoms? What are the early X-ray changes and which views are most helpful? Many methods of treatment have been employed, but how successful have they been? What are the current trends in treatment? What are the complications and sequelae encountered? Is there a correlation between the degree of slipping and the result after treatment?

The purpose of this paper is to present an analysis of twenty-eight cases of slipped upper femoral epiphysis treated at the Nebraska Orthopedic Hospital between the years 1938 and 1956. Special emphasis is devoted to early diagnosis and the results of treatment in the various stages of the disease. A discussion of etiology, anatomy and blood supply, and pathology is presented as fundamental in understanding the disease.

HISTORY

Brousseau, 1867,[1] was the first to establish the possibility of the lesion. He reported a case of traumatic separation in a fifteen year old boy who died shortly after a wagon wheel had run over the left hip. Post-mortem examination revealed a complete separation of the upper femoral epiphysis.

In this paper, however, we are interested in slipped upper femoral epiphysis of nontraumatic origin. A description of this condition is even of more recent date. Monks, 1886,[2] reported the first case. He described a sixteen year old boy who had typical bilateral slipping of the upper femoral epiphyses. He misdiagnosed the case, however, and called it arthritis deformans affecting both hips with softening of the bone from weight bearing. Even though his interpretation was at fault, years of voluminous literature has added little to his accurate clinical description.

Müller, 1888,[3] is generally credited as being the discoverer of the condition, bending of the neck of the femur in adolescence. In one case, he performed a resection of the head and neck of the femur, the pre-operative diagnosis being tuberculosis of the hip. With the data he obtained from the excised specimen and from a study of the four cases, Müller introduced his new clinical entity into the surgical literature.

Following Muller's report, a number of leading German surgeons became interested in "the bending of the neck of the femur in early

life." In 1894, Hofmeister[4] and Kocher[5] independently and almost simultaneously introduced the term coxa vara for the condition. The term became very popular and was applied to various conditions in which an adduction deformity of the hip was present. At that time, the deformity was assumed to be due to a bending downward of the neck of the femur.

The subject, coxa vara, was prominent in the surgical literature up to about 1912. Then, very little was written until 1926 when Key[6] published an extensive review of the literature. He discussed the etiology and pathology as then known and reported the results of treatment in twenty-four cases. His article is an exhaustive review of the subject, carries an excellent bibliography, and has served as a guide in most of the articles published since that time.

INCIDENCE

Epiphyseal coxa vara is not a common lesion, yet Key found that it is probably the most frequent cause of disability of the hip which begins in adolescence. Approximately 1.5 cases per year were treated at the Nebraska Orthopedic Hospital during the past eighteen years.

The condition occurs more often in the male adolescent. Twenty-three of the twenty-eight cases studied were males and only five were females. This is approximately eighty-two per cent males to eighteen per cent females or nearly a four to one ratio.

The ages of these children at the time they presented at the crippled children's clinic varied considerably. The youngest was a girl, age seven; and the oldest were five boys, all aged sixteen.

It is remarkable that the disease begins earlier in the female. The average age at onset in the five girls studied was 10.8 years; whereas the average age at onset in the twenty-three boys was 14 years. In the girls, the age of onset varied from seven to thirteen; in the boys, it varied from eleven to sixteen.

It is of interest that the left hip is affected more than the right. In this series, the ratio is fifteen left to eight right. In fact, in one case in which both hips were affected simultaneously, the left hip was much more severely involved than the right.

The disease is frequently bilateral. Both hips were affected in four of the twenty-eight cases. This amounts to approximately fifteen percent bilateral involvement.

The majority of the patients were overweight. Approximately seventy-eight percent were in this category. A discussion of the four constitutional body types encountered follows under the heading of etiology.

ETIOLOGY

In considering the etiology of the disease, it is to be pointed out that this question has always been controversial.

Many theories have been put forth and still have their proponents even in contemporary papers. These individual hypotheses may be listed as follows:

1. Endocrine disturbance
2. Trauma or mechanical strain
3. Weakening of the periosteum
4. Infection
5. Localized osteomalacia
6. Circulatory disturbance
7. Familial
8. Renal rickets

Almost without exception the phenomenon of slipping occurs during adolescence. A most striking feature of the disease is its association in a number of cases with excessive weight.

A few of the overweight children were of the constitutional type described by Frölich (adiposogenital syndrome) with underdevelopment of the genitalia. One girl and one boy had marked underdeveloped genitalia and were obese.

On the other hand, many of these children had grown rapidly in height just before the onset of the disease. They were tall and slender for their age. Approximately twenty percent were of this body type.

Most of the overweight children, however, were of the constitutional type described by Mikulicz.[7] This is not the typical fat boy, but is the overgrown boy or girl with large bones and

large epiphyses; with rather flabby weak skeletal musculature, and with more subcutaneous fat tissue than is usual.

Only thirteen percent of the patients were of normal height, weight, and body build for their age. One of these was unusually thin.

Many authors have emphasized the association of epiphyseal coxa vara with these body types. This has often led to the belief that the skeletal lesion is due to some endocrine disturbance linked with puberty. In connection with this theory, Harris, 1950,[8] reported that he could affect the shearing strength of the epiphyseal plate in growing rats by the administration of hormones. In essence, he designed a machine to test the shearing strength of the femoral epiphyseal plate in rats. He studied rats nearing maturity and found the site at which the epiphyses sheared to be the layer of hypertrophied cartilage cells immediately on the epiphyseal side of the layer of provisional calcification. He administered female sex hormone to the rats and found that the shearing strength of the epiphysis was increased and the thickness of the layer of hypertrophied cartilage cells was decreased. On the other hand, when he administered anterior pituitary growth hormone to the rats, he found that the shearing strength of the epiphyses was decreased, but the thickness of the same layer of cartilage cells in the plate was increased. Therefore, Harris concluded that the shearing strength of an epiphyseal plate could be affected by the relative amounts of growth and sex hormones

in the circulation between the time when the gonads are activated and the time when growth ceases. It is to be appreciated then that a lack of hormonal balance causing a decrease in the shearing strength of the epiphyseal plate could be caused primarily by the gonads failing to make a normal amount of sex hormone at this time of life or by the anterior pituitary making excessive amounts of growth hormone. This experimental data correlates nicely with clinical observations since slipping of the upper femoral epiphyses (which by its location is particularly liable to shear or stress), has long been commonly associated with the growth abnormalities described above. It is suggested that a common basis for development of the disease is an imbalance of growth and sex hormones leading to a weakness of the epiphyseal plate. Thus, there is good evidence to believe that those examples of the condition occuring in the adolescent with the adipose genital syndrome can be explained primarily by a lack of gonadal function; and those that occur in the Mikulicz type and the thin, tall, rapidly growing individual can be due to a relative excess secretion of growth hormone.

Furthermore, the fact that the average age of onset in girls is approximately 3.8 years earlier than in boys correlates with an earlier onset of puberty in girls. Likewise, the frequent bilateral involvement suggests an endocrine disorder.

Nevertheless, endocrine therapy in general has been unsuccessful.

In the past, trauma was often accused of causing the condition and is still thought to be responsible by some authors. In fact, trauma was a frequent factor in the history of these patients. In spite of this, it is in quite general agreement today that trauma is not the main cause of the disease. The history of trauma given by these patients was more often of a trivial nature and rarely more than would occur in the normal activity of a child. The trauma was frequently an athletic injury, basketball being the worst offender. Other examples of injury were: slipped and fell to the floor; an evening of dancing; bicycle wreck; and fall from a horse. The early symptoms, however, were usually present before the history of the injury; but became more pronounced afterward.

Less than half of the patients gave a history of trauma. As pointed out by Key, 1926, if the degree of trauma encountered in the average case were sufficient to cause epiphyseal separation in the normal adolescent, then epiphyseal coxa vara would be almost universal, because the average adolescent suffers a number of such injuries yearly. In addition, the frequency of bilateral disease is further evidence against trauma as the main cause. To be sure, trauma may hasten the onset of symptoms and may initiate or aggravate a displacement. It is for these reasons that is is undoubtedly of some etiological significance.

Key, 1926, was the first to propose that weakening of the periosteum may be an important factor. He pointed out that in childhood and early adolescence the periosteum of the femoral neck is very

thick and strong, and in places it is thrown into folds or ridges (the retinaculae of Weitbrecht). This strong periosteum spans the epiphyseal line and apparently plays an important part in holding the femoral head in place. Harte, 1898, quoted by Key, 1926, found that with the periosteum severed, only one-fifth the amount of force was necessary to cause epiphyseal separation in cadavers as when it was intact. After puberty, the periosteum begins to atrophy and approach the adult type, and might conceivably produce a point of weakness at the epiphyseal line. Also, Key postulated that in those individuals who grew rapidly, "shot up like a weed," it might be possible that the periosteum spanning the epiphysis is stretched, thinned, and consequently weakened during this period of rapid growth, thus permitting the femoral head to be loosened. However, since this theory was first proposed, Badgley and others[9] have observed cases with very nearly complete separation in which the periosteum was intact. Although it was thinned to some extent, he believed it is more likely that the periosteal thinning was secondary to mechanical stretching rather than being the primarly causative factor in the slipping. Even though weakening of the periosteum is definitely not the main etiological factor, it may play a minor role.

Froelich, 1904,[10] first suggested the theory of a low grade infection. He cultured staphylococci from material obtained by boring into the trochanter in two cases of coxa vara, and concluded that the main cause of the disease was an epiphysitis. Ferguson

and Hosworth, 1931,[11] advanced an addition to this reasoning. They proposed that infection caused sclerotic changes in the soft tissue about the femoral neck causing secondary vascular stasis with osteomalacia and weakening at the epiphyseal disk. Numerous attempts have subsequently been made to culture microorganisms from affected hips at the time of operation. These have been unsuccessful and infection is no longer thought to be a factor.

Kirmisson, 1913,[12] reported four cases of epiphyseal coxa vara in one family and two cases in another family. He proposed that perhaps thiswas a familial disease, but it is generally now agreed that this is not the tendency.

Probably the most rare etiological factor of all was proposed by Brailsford as late as 1948.[13] He reported one case of renal rickets in which there was typical bilateral slipping of the upper femoral epiphyses. Even if there is a kinship, renal rickets is indeed uncommon.

SYMPTOMS

The symptoms occurred in the following order of frequency.

1. Pain in the affected hip
2. Limp
3. History of injury
4. Pain referred to the knee
5. Weakness of the affected hip (fatigue)
6. Stiffness and limitation of motion

7. Disability in athletics

8. Frequent falling

9. Shortening of the affected extremity

10. Coxa vara deformity

11. No symptoms, incidental finding on X-ray

The onset was gradual in every case. The duration of symptoms varied from two months to two and one half years. The average was eleven months.

The most common complaint was pain in the affected hip. Usually it was not severe in character nor constantly present. In fact, the pain may be of such a mild degree that it is overlooked or disregarded until an advanced stage of the disease is reached. It was typically relieved by rest or completely disappeared with rest, early in the disease. In a few cases, there was absolutely no history of pain.

The second most common symptom was a limp which usually accompanied the pain. This was commonly brought to the physician's attention by the parents. It is mild at first, being present only with increased activity, and often disappears with rest. In some cases as the condition progressed, the limp persisted even when the pain was not present. One patient with an early slipping had a limp and never did have pain.

From the standpoint of early diagnosis, I want to emphasize that the pain from a slipped upper femoral epiphysis need not be in the hip. In fact, in twenty percent of the cases, it was re-

ferred to the knee or anterior thigh. In several cases, pain in the knee was the only early symptom. One thirteen year old boy complained of pain in the left knee and a mild limp following basketball season. He was treated by a chiropractor as an injured knee for two years until finally a painful hip and severe limp developed. When first seen in the crippled children's clinic, this boy had a moderate degree of slip of the left upper femoral epiphysis. The left knee was perfectly normal. Another boy, age fourteen, complained only of knee pain and fatigue of the affected extremity early in the disease. This point is a general principal well worth remembering: pain in the knee is frequently a reflection of pathology in the hip.

Some patients complained that the affected extremity was becoming shorter than the other side. Some stated that the affected limb tended to turn outward. Others complained that the hip was becoming stiff or had limited motion. These, however, were usually not early symptoms of the disease.

Aside from pain and limp, a frequent early complaint was that the patient became tired easily or felt a weakness (fatigue) in the affected hip after more than usual activity.

A common history was that some months previously the patient began to tire easily after walking, dancing, or playing basketball more than usual and had some mild pain. The parents observed occasional limping. These early symptoms existed for a few days and then disappeared for a short time only to reappear and become more

pronounced. By the time the patients came to the clinic, there was usually a history of several such attacks. There was frequently a history of trauma or athletic injury from which time on the symptoms were more severe. In fact, several cases came in walking with crutches because of severe pain with weight bearing or marked coxa vara and external rotation deformity.

Because the disease is frequently bilateral, one should always ask the patient about symptoms in the other hip. Key, 1926, reported that in the bilateral cases he studied there was usually an interval of some months after the beginning of the trouble before the onset of symptoms in the second hip. In the bilateral cases in this study, the histories were inadequate on this point for evaluation.

I wish to further emphasize that early diagnosis is of extreme importance and the early symptoms must never be taken lightly. A youngster who limps or whose parents state that he occasionally limps, complains of pain, or tires easily should always be subjected to a thorough examination including X-rays.

PHYSICAL FINDINGS

The physical findings occurred in the following order of frequency.

1. Limitation of motion
2. Limp
3. Shortening

4. Pain on motion

5. Atrophy

6. Deformity

7. Adductor spasm

8. Positive Trendelenberg sign

9. Tenderness

10. Pelvic tilt

11. Swelling

In the stage of early slipping, one may find but little on physical examination. For example, one thirteen year old girl complained of pain in the left hip, yet there were absolutely no abnormal physical findings. X-rays revealed an early stage of slipping of the left upper femoral epiphysis. A seven year old girl fell from a slippery slide six months prior. She complained of pain in the left hip, and her parents noticed a limp on the left side. The only abnormal physical finding was a very slight limitation of internal rotation of the hips bilaterally. X-rays revealed early bilateral slipping. It should be stressed that the only abnormal physical finding early in the disease is often only a very slight limitation of internal rotation of the affected hip. To find this, one must be looking for it and always make a careful comparison with the sound side.

One may observe that the patient walks with a limp. If the slipping is recent and unilateral, the patient employs an antalgic gait. He leans toward the affected side to avoid painful weight

bearing. On the other hand if the coxa vara deformity is well developed the patient may employ the Trendelenburg gait in which the pelvis sags on the unaffected side when weight is borne on the affected extremity. Such a patient is said to have a positive Trendelenberg test. This was found to be much less common than the antalgic gait. Only ten percent of the patients had a positive Trendelenberg test.

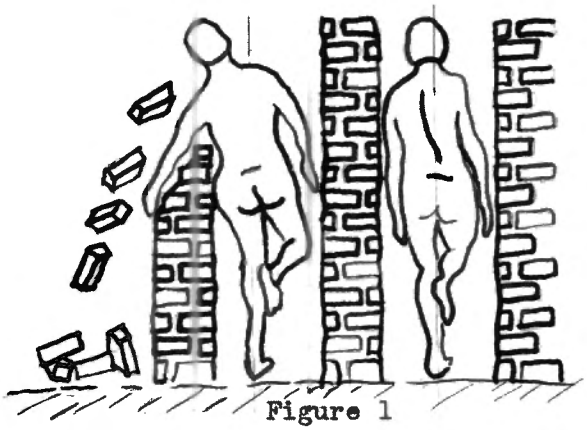


Figure 1

Comparison of the antalgic gait with the pure Trendelenburg gait. Patient with antalgic gait cannot walk down narrow corridor lined with blocks without striking them or knocking them over. Taken from Joplin, R. J.,[14] Slipped Capital Femoral Epiphysis, American Academy of Orthopedic Surgeons, Instructions Course Lectures, Vol. VII, 1950.

In moderate and severe slipping, the affected extremity was found to be from one-fourth to one-half inch shorter than the normal side. This was actual shortening based on measurement from the anterior superior spine to the medial malleolus. It was present in fifty percent of the cases. It is worth emphasizing, however, that most often the actual shortening was negligible when compared to the degree of shortening which the patient complained about.

There was an apparent shortening resulting from the adduction or varus deformity. Apparent length was measured from the umbilicus to the medial malleolus and in some cases revealed an apparent shortening of as much as one and one half inch greater than the actual shortening.

Quadriceps atrophy of the affected side was present in approximately one-third of the unilateral cases. The circumference on the affected side ranged from one-fourth inch to one and one-half inch less than that of the normal side. When there was more marked atrophy in the thigh, there was also slight atrophy of the calf.

On manipulation, it was common to find limitation of motion;, however, to reemphasize an important point, it was observed that the case with early slipping may have a complete range of motion. Internal rotation is the first to become affected. Limitation ranged from minimal in the early slip to nonexistent with a severe slip in which the patient stood with the leg in marked external rotation. Abduction was the second most commonly affected. Flexion was often limited, but to a lesser degree. Then external rotation and extension were limited in that order of frequency. In the severe cases all motions of the hip joint were markedly limited.

Lateral tilting of the pelvis when viewed from behind, adductor spasm, tenderness, and swelling occurred, but were uncommon.

The patellar and ankle reflexes were not affected.

Ferguson and Howorth, 1931, stated that if the femur is rotated, the femoral head may be palpable under the gluteal muscles. They believe that this sign, when present, is almost pathognomonic of a slipped epiphysis. It was not described in any of the twenty-eight cases studied.

In general, these patients were not sick and the remainder of the general physical examination was normal except for the frequent occurence of the constitutional body types described under etiology.

ANATOMY AND BLOOD SUPPLY

The upper femur consists of a head, a neck, a greater, and a lesser trochanter. It ossifies from three centers: one for the head and one for each trochanter. Of these, the upper femoral epiphyses does not close until after puberty.

"The head is round and constitutes approximately three quarters of a sphere. It is covered by a layer of articular cartilage about two millimeters thick, except for an ovoid depression, the fovea capitis femoris, which is situated a little below and behind the center of the head and gives attachment to the ligamentum teres."[15]

"The metaphysis is the zone of growth. It is the part of the neck nearest to the epiphyseal cartilage and is comprised of three parts during the adolescent period:

1. A zone of calcified cartilaginous cells adjacent to the epiphyseal cartilage which are ready to become transformed into bony tissue.

2. Newly formed bone tissue

3. A band of joint cartilage surrounding the metaphyses and comprising the lateral part of the joint surface of the head." Quoted from Waldenstrom, 1940.[16]

Waldenstrom, 1940, states that it is in the newly formed layer of bone of the metaphyses that displacement of the epiphyses takes place and not in the epiphyseal cartilage itself.

Waring, 1956,[17] stresses an anatomical point of practical importance. He states that the epiphyseal cartilage is thin, and is convex in relation to the head. Therefore, in pinning the hip, the pin must extend through the epiphyseal cartilage, but not be so long as to extend on through the articular cartilage of the head. In addition, Waldenstrom, 1940, states that the surface of the epiphyseal cartilage facing the metaphysis is not smooth, but is unevenly furrowed and pitted, particularly near the periphery, where it also curves down and covers the metaphysis.

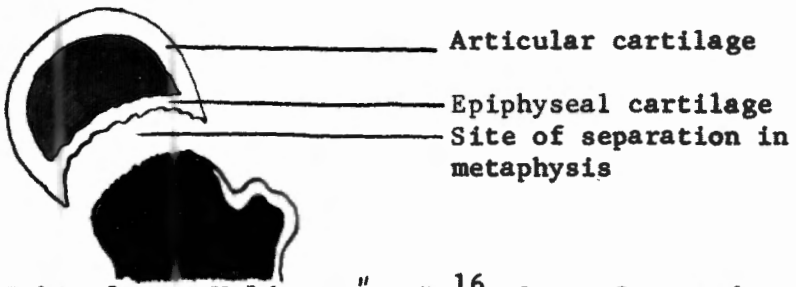


Figure 2. Taken from: Waldenstrom, H.[16] Surg. Gyn. and Ob., Vol. 71. p. 201, 1940.

Figure 2 illustrates the fact that when the epiphyses is displaced, the articular cartilage around the periphery totally

follows taking with it the outer circumference of the metaphysis. As a result, the slipping epiphysis forms a rounded excavation against the metaphysis which itself becomes a corresponding spherical surface. A simplified way is to think of this as a spherical articulation between the slipping surfaces.

Waldenström has thus anatomically located the weak bond to be between the epiphysis and the metaphysis; or, more specifically, to be at the newly formed layer of bone of the metaphysis adjacent to the epiphysis. The etiology of this weak bond, I feel, is best explained by the endocrine factors previously described.

The anatomical mechanism involved when slipping occurs is simple. The epiphysis and attached head rotate and become displaced usually posterior and inferior. It seems probable that this takes place by degrees. The reason that the displacement occurs in this direction is because the resultant of the lines of force from distribution of the body weight on the head of the femur is posterior and inferior to begin with. In fact, the further posterior the displacement becomes, the more it is exposed to the force of body weight, and less mechanical advantage is available. To further complicate this shearing resultant of force directed at the plane of separation, most of these patients are markedly overweight.

In my opinion, the above description explains the clinical fact that nearly all cases of adolescent epiphyseal slipping goes through stages of minor displacement before a major one occurs.

Since no special exertion is required to loosen the weak bone, it becomes very understandable why minor trauma is often a precipitating factor, or causes further displacement with worsening of symptoms.

Since the periosteum is thickened and strong at this time of life, one might think of it as acting in the capacity of a tubular splint around the femoral neck and epiphysis. Obviously, then, as the epiphysis and the attached head becom displaced, the tubular splint of periosteum with its rich nerve supply is put under tension. This, I feel, adequately explains why pain is such a frequent symptom of the disease. When the patient is bearing the weight of his obese body or attempting to play basketball, the accentuated resultant of the added force causes the resistant periosteum to be put under tension, even though further slipping does not occur at the time. As a result, the patient has pain and limps as an attempt to lessen the pain which becomes increased each time he takes a step and bears his full body weight on the affected extremity. When he rests, the tension on the periosteum is relieved, the pain disappears, and the limp also temporarily vanishes, provided there is no marked shortening of the extremity. Thus, the inevitable tendency is a worsening of the condition, if continued weight bearing is permitted.

Blood is supplied to the upper end of the femur by three groups of vessels. As described by Wolcott, 1943, and Tucker, 1949, these vessels are:

1. The nutrient artery of the shaft.

2. The retinacular or capsular arteries.

3. The foveolar artery or artery of the ligamentum teres.

The nutrient artery enters the mid-shaft of the femur and sends a superior branch upward in the medullary cavity which anastamoses primarily with branches of the retinacular arteries. The nutrient vessels are unimportant as far as the epiphyses of the child are concerned, but they do constitute a supplementary source of blood supply to the femoral head in some adults.

The retinacular arteries arise from the medial and lateral femoral circumflex arteries. They pierce the fibrous capsule near its lateral boundary and run medially along the neck of the femur lying deep to the reflected cuff of synovial membrane. It is in this position that these vessels are associated with the retinacular fibers. Along this course, they give branches which pierce the femoral neck and anastamose with branches of the nutrient artery previously described. Despite the branches piercing the neck, the mid-cervical parts of the retinacular vessels are quite mobile. These vessels then become quite fixed as they approach the epiphyseal plate.

Tucker, 1949,[18] describes three main groups of retinacular arteries. These are: the postero-superior, the postero-inferior, and the anterior. The anterior group is smallest and is made of inconsistent branches of the lateral femoral circumflex artery. The other two groups are moderately large, quite consistent, and

are principally located posterior to the neck. It is generally agreed that the retinacular vessels represent the chief arterial supply to the upper femoral epiphysis. Likewise, the femoral head is supplied almost entirely from these vessels. The epiphysis in the child is more dependent upon retinacular vessels than is the corresponding area of bone in the adult, thus explaining the greater frequency of avascular necrosis in children.

Wolcott, 1943,[19] showed that the retinacular vessels do not cross the epiphyseal plate, but by-pass it at the periphery to enter the head. Also, these vessels do not run in the substance of the external fibrous capsule, even though they are frequently called capsular vessels. Therefore, incision of the capsule does not necessarily impair circulation to the head. Excessive exposure about the base of the neck, disturbance of the retinaculum, or excessive subperiosteal exposure should, of course, be avoided.

The foveolar artery arises from either the obturator or the medial femoral circumflex or both, and follows the ligamentum teres to the femoral head. The evidence indicates that these vessels never constitute the chief vascular supply of the femoral head in children. They are, however, of some importance in a minority of cases; perhaps affording the additional protection to the ossification center. In the adult, the foveolar arteries become more important and take over an increasing share of blood supply to the femoral head.

From the preceding anatomical description, one might think that posterior displacement would be sure to damage the retinacular vessels with resulting avascular necrosis of the head. To be sure, irreparable damage to these vessels can occur, but Tucker suggests several anatomical facts to explain how these vessels escape severe injury when slipping occurs slowly by degrees. Also, he does not believe that gentle manipulation of the hip would cause damage to the retinacular vessels. He points out that displacement occurs between the epiphyseal cartilage and the metaphysis (Waldenstrom, 1930) at a level where the retinacular vessels are still quite mobile. Then, even if the epiphyseal plate does slip downward and backward, the vessels may escape traction injury if the slipping is gradual or slight so that they can elongate and accomodate themselves to the new position of the epiphysis. Obviously, if the slipping is rapid or extensive or if the manipulation is vigorous, the retinacular vessels are more likely to be damaged. Then the blood supply to the epiphysis at best may be meager. It is conceivable that these vessels might stand a greater chance of being injured by a sudden forcible manipulative reduction than by the gradual stretching from the progressive displacement of the epiphysis.

X-RAY DIAGNOSIS

The mistakes occasionally made in the past in X-ray diagnosis of slipped femoral epiphyses have been twofold. First, the

early changes on the anterior-posterior view were not recognized; and secondly, the lateral view was not taken.

Adequate roentenograms are not only important from the standpoint of early diagnosis, but also to determine the amount of displacement and in turn, to choose a type of treatment.

It is of greatest importance that both the anterior-posterior and lateral views be taken. Of these, the lateral view is the most informative. Since the epiphysis nearly always displaces backward and downward, the lateral view not only reveals the degree of displacement to the best advantage, but it may be the only view in which a mild displacement is at all detectible. Nevertheless, the anterior-posterior view should also be taken because occasionally mild slipping occurs in one plane only. It would be considered incorrect, however, not to take the lateral view, and to tell the patient that his hip is normal on the basis of the anterior-posterior view, particularly if symptoms are present.

Needless to say, X-rays of both hips should be taken for two reasons:

1. The disease is frequently bilateral
2. The affected hip should always be compared with the normal hip.

Joplin, 1950 described the following standardized method for taking roentenograms of slipped epiphyses. The anterior-posterior view of both hips is taken on one film with the knees extended and the great toe and heels touching, Figure 3, Part B.

The lateral view of both hips is taken on one film with the patient positioned so that the soles of the feet are touching each other, theknees are flexed, and the thighs are abducted and externally rotated as far as can be tolerated. This is the so called frog position first described by Lauenstein. See figure 3, part A.

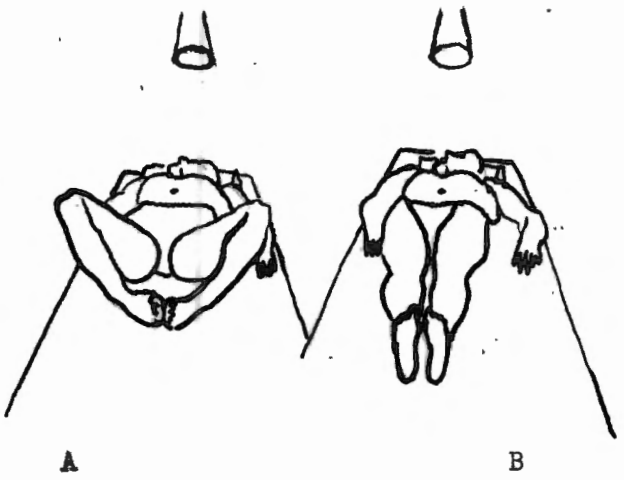


Figure 3. From Joplin, R. J., Slipped Capital Femoral Epiphysis, The American Academy of Orthopedic Surgeons Instructional Course Lectures, Vol. VII, p. 212, 1950.

Good exposures in these positions will enable one to detect slipping of the epiphysis in a very early stage with as little as one or two millimeters displacement.

What then are the early X-ray changes in the anterior-posterior view?

First, one often sees a broadening of the epiphyseal line com-

pared to the other side. This is due to the slight posterior and inferior rotation of the epiphysis in slipping. In addition to broadening, one may observe some slight irregularity and mottling along the distal border of the epiphyseal cartilage.

Mayer, 1937,[20] studied roentenograms of normal children and observed that the hemispherical head casts a bulging shadow at its junction with the upper margin of the neck. This shadow lies just proximal to the oblique lighter shadow caused by the epiphyseal plate and is normally present. He found that the first sign of slipping on the anterior-posterior view was the disappearance of this slight bulge and conversely the appearance of a slight prominence of the upper margin of the neck, which is just distal to the epiphyseal line. The other early change emphasized by Mayer is a shortening of the verticle diameter of the head as compared to the normal side. The reason for this, he states, is the combination of two motions which seem to occur synchronously, namely, a forward displacement of the neck; an anteversion, which Milch, 1937,[21] took pains to emphasize; and the slight inferior and posterior displacement of the head.

Another X-ray finding of interest that was observed in a few cases with moderate and severe slipping was a diffuse decalcification of the upper femur and innominate bone of the affected hip. Atrophy of disuse of this type was severe in one case in particular and gave a striking appearance to the X-ray.

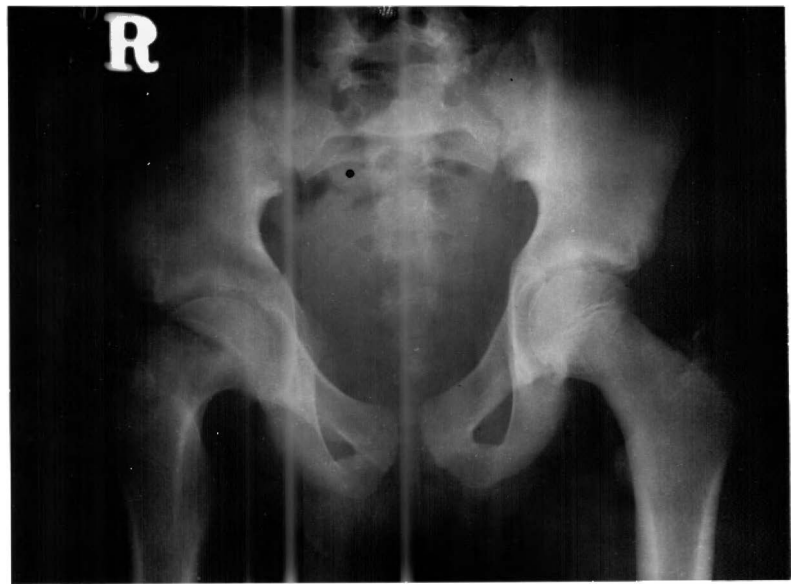
The degree of slip is ordinarily measured on the lateral

film according to the following scheme in figure 4.

Figure 4. Line AB is the superior border of the femoral neck, projected. Line BC is the distance from the femoral head to the projection of the superior border of the femoral neck, the distance that the head has slipped. From Joplin, R. J.,[14] Slipped Capital Femoral Epiphysis, The American Academy of Orthopedic Surgeons Instructional Course Lectures, Vol. VII, p. 212, 1950.

The following X-rays illustrate a mild, moderate and severe degree of slipping and comparison of the anterior posterior and lateral views.

Anterior-posterior and lateral views of a mild degree of slipping of the left upper femoral epiphysis in the same patient.



Moderate degree of slipping of the right upper femoral epiphysis.

Severe degree of slipping of the left upper femoral epiphysis.

PATHOLOGY

Gross and microscopic pathosis was not studied on the twenty-eight cases being reviewed; therefore, the following discussion is taken entirely from the current literature.

Howorth, 1949,[22] studied specimens taken from 169 hips operated at various stages of the disease at the New York Orthopedic Hospital. He considered four stages, The preslipping stage, the slipping stage, the healing stage, and the residual stage, and described the basic changes of each.

In the preslipping stage, the synovial membrane was found to be grossly swollen, edematous, and hyperemic with villous formation. Similar, but milder changes were observed in the periosteum and capsule. There were no gross changes of the head or acetabulum. Microscopic sections of the synovial membrane revealed edema, hypervascularity, often with perivascular lymphocytic infiltration, and villi formation. In addition, decalcification and hypervascularity were present at the junction of the neck and epiphyseal disk.

In the slipping stage, he observed that the epiphysis never became completely separated from the neck. Instead, it remained attached by periosteum and fibrous tissue which had grown over the exposed portion of the neck as the slipping gradually occurred. This new tissue was recognized by its bluish color, its softness and looseness, and the frequent presence of tiny islands of bare

bone. The cartilaginous epiphyseal disk also remained attached to the head, but was gradually absorbed and transformed into bone. It was observed that after slipping occurred, a callus rapidly formed in the angle between the head and the neck inferiorly and posteriorly. The callus was covered by a fold of hyperplastic and redundant synovial membrane. The articular cartilage and acetabulum were normal in appearance. He rarely found hemorrhage into the joint except after there had been violent manipulation. The sole tissue changes were similar to those seen in the preslipping stage. On the sections, the line of separation was found to be between the epiphyseal disk and the neck. Degenerative changes in the disk cartilage and evidence of repair at the junction with the neck were observed.

In the healing stage, the medial (superior-anterior) portion of the neck, which was exposed as a result of the slipping, had gradually become rounded. In addition, the callus had become incorporated with the neck. Gradually, the epiphyseal disk had become absorbed and bony union occurred between the epiphysis and the neck. The synovial membrane and periosteum became less vascular, and less edematous, more scarred, more sclerotic, and inelastic. The inflammatory reaction had usually subsided after several months, but spontaneous union of the epiphysis often required two or three years. If the head had separated from the neck in the course of treatment, degenerative changes in the head were the rule.

In the residual stage, the lesion was healed and the epiphysis was solidly united to the neck in the displaced position. The callus had become mature bone and was indistinguishable from the neck itself. Thus, the contour of the neck was smoother. The synovial membrane, the periosteum, and the capsule were sclerotic and inelastic. Osteoarthritic changes developed if there was deformity because of the faulty joint mechanics, especially if the joint was subjected to strenuous activity. Osteophytic production was often seen at the margin of the head and at the margin of the acetabulum.

Lacroix and Verbrugge, 1951,[23] studied the pathology of the disease from whole sections of completely excised heads of the femur. Their histological evidence showed that the basic pathological change associated with the deformity took place in the epiphyseal cartilage, which, instead of producing endochondral bone, was transformed into fibrous tissue. They observed that the epiphyseal cartilage cells proliferated and formed axial groups in a normal manner; but instead of becoming hypertrophied, dying, and initiating the formation of endochondral trabeculae, they retained their size, remained alive, and finally took part in the formation of dense fibrous tissue, which was invaded by capillaries. In sections of the neck, they found active remodeling of the trabeculae. This they believed was simply due to the gradual shifting of the stresses transmitted by the neck, for in bone a changing distribution of the stress is always followed

by an internal remodeling of the trabeculae. Signs of remodeling were also found in the head. These were also accounted for by its faulty position. These changes in the head and neck were believed to be secondary. The primary pathosis was believed to be a transformation of the epiphyseal cartilage into fibrous tissue. These findings strongly question the validity of the oftentimes repeated idea that the underlying pathological process in slipping of the epiphysis is a deficiency of circulation to the head. In fact, none of the specimens studied by Lacroix and Verbrugge showed avascularity or necrosis.

TREATMENT AND RESULTS

Method of Evaluation

For the purpose of evaluation, the degree of slip was divided into three categories. These are: mild, moderate, and severe. Mild is considered synchronous with early slipping and includes the socalled preslipping stage described by some authors. The degrees of slipping were defined as follows:

1. Mild--Those cases in which there was one-half centimeter displacement or less.
2. Moderate--Those cases in which there was between one-half centimeter and one and one-half centimeters displacement.
3. Severe--Those cases in which there was more than one and one-half centimeters displacement.

The distance that the head had slipped was measured on the lateral films by the method described under X-ray diagnosis.

The results were classified as good, fair, or poor. A good result was defined as the patient who had no symptoms and had full range of motion after treatment. Slight limitation of flexion and up to one-half inch actual shortening was permitted, but no deformity. These patients had good functioning hips.

A poor result was defined as the patient who had severe limitation of motion, severe pain and limp, or marked deformity. Every case that developed avascular necrosis of the femoral head or early osteoarthritis of the hip were considered a poor result.

The patients with moderate limitation of motion, slight deformity, occasional limp, mild pain, or fatigue were classified as fair.

PURPOSE OF TREATMENT

The primary goal is to secure bony union of the epiphysis as promptly as possible. This precludes the risk of further displacement and lessens the period of disability. It is desirable that the epiphysis fuse in the least deformed position obtainable. If no treatment were given, spontaneous fusion would eventually take place, but this might take several years in younger patients. During this long critical period, some effective means for protection of the hip for fixation of the epiphysis is required.

I want to emphasize the once the diagnosis is made, prompt treatment is the goal. If the disease is even suspected, the child

should be given two crutches and instructed not to bear weight on the affected extremity. I have pointed out that continued weight bearing and minor trauma may worsen the condition or even precipitate an acute severe slip. Anterior-posterior and lateral X-rays should be taken immediately to confirm the diagnosis. The number of centimeters of displacement is then measured on the lateral view. The disease may then be categorized as mild, moderate, or severe. The method of treatment then employed is based on the degree of slipping, the clinical evaluation of the hip, the X-ray appearance, and finally the physician's decision to adopt the means of treatment at his disposal in which he has been most proficient and obtained the best results.

METHODS OF TREATMENT

The conservative methods of treatment employed are listed as follows:

1. The hip was immobilized in a single hip spica cast in internal rotation and abduction, with subsequent use of an ischeal weight bearing brace and crutches.

2. Reduction by manipulation or an attempt of manipulation was first done. The hip was then immobilized in a double hip spica cast in internal rotation and abduction. An ischeal weight bearing brace or crutches or both were subsequently used.

3. Manipulation was first attempted. Then the hip was held by traction in abduction and internal rotation by a double hip

spica cast with a Steinman pin incorporated through the distal femur.

4. The hip was held in traction in abduction and internal rotation by a double hip spica cast with a Steinman pin placed through the tibia at the level of the tuberosity.

The operative methods of treatment employed are listed as follows:

1. The epiphysis was nailed in placd with one, two, three, or four Moore pins after a trial of gentle manipulation.

2. The epiphysis was nailed in place with a Smith-Peterson nail after a trial of gentle manipulation.

3. A wedge osteotomy of the neck was performed with fixation by either a Smith-Peterson nail or threaded pins. The hip was subsequently immobilized in a double hip spica cast except in one case in which a single hip spica was applied.

4. An intertrochenteric osteotomy was performed in the residual stage of the disease, after the epiphysis had closed to correct the deformity.

5. An arthroplasty was done and an intramedullary prosthesis was inserted in one case who developed avascular necrosis and an unstable hip after a wedge osteotomy.

6. An extra pelvic obturator neurectomy was performed in one patient who had severe pain in the hip. She presented with arthritis of both hip joints and was treated for bilateral mild slipped epiphysis. A review of her X-rays raised the question if

the diagnosis of slipped epiphysis was justified; therefore, in the analysis of results, this patient is excluded.

Another method of operative treatment which is currently being used by some orthopedic surgeons should be listed. This is epiphyseodesis by means of a bone peg graft across the epiphyseal plate to stimulate prompt union. None of the cases in this series were treated with bone grafts.

ANALYSIS OF RESULTS

A total of thirty hips are considered. A good result was obtained in only fifty-three percent or approximately half of the hips treated. In twenty percent, there was definitely a poor result. It is not correct to assume that every poor result is the fault of the treatment. Only those hips in which aseptic necrosis of the femoral head developed are considered as worse as a result of the treatment. Some cases were not improved from treatment, but the natural history of the disease is for the hip to become a poor one without treatment. Treatment attempts to prevent this, but may fail. In these cases, therapy is not considered to have worsened the condition.

The overall statistics change, however, when a comparison is made between the results obtained during the period of 1938 to 1948 to those obtained during the period of 1948 to 1956. Table I compares the results of treatment for these two periods of time.

Years	Results		
	good	fair	poor
1938-1948	29%	14%	57%
1948-1956	70%	20%	10%

Table I

It becomes evident that the results of treatment have markedly improved during the past eight years. A question then arises. Is such an improvement due primarily to earliest diagnosis or is it due to better methods of treatment. Table II compares the degree of slipping at the time treatment was begun for these two periods of time.

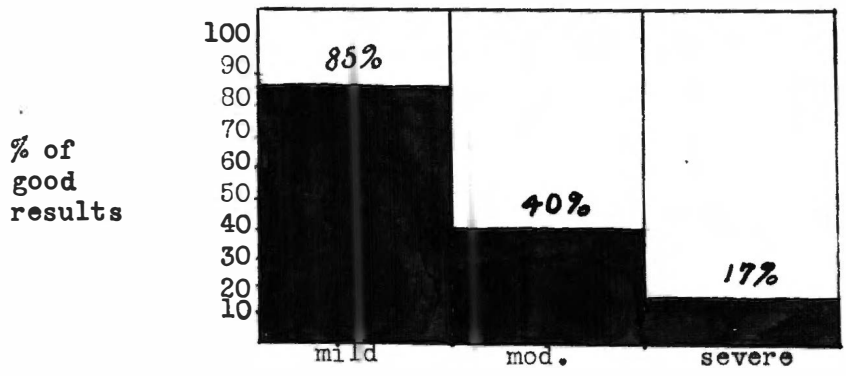
years	Degree of slipping		
	mild	moderate	severe
1938-1948	50%	17%	33%
1948-1956	44%	39%	17%

Table II

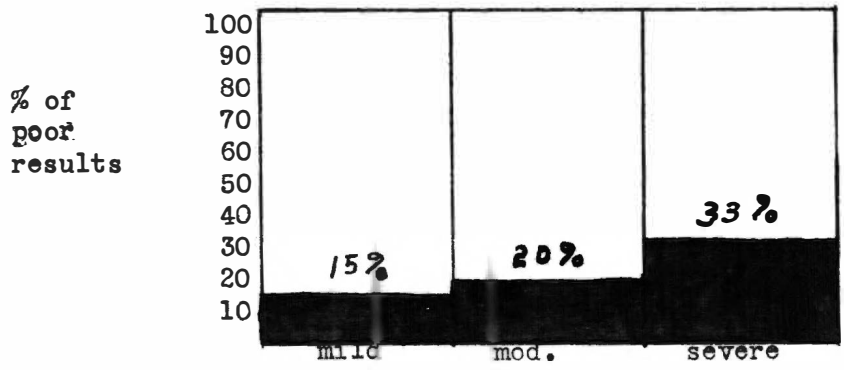
Table II illustrates that there has been no very significant improvement in earlier diagnosis during the past eight years. I presume, therefore, that most of the great improvement in results is due primarily to better methods of treatment. in spite of better treatment, it appears that we need to improve

our ability to diagnose the disease while in its early stages.

Is there a correlation between the degree of slipping and the result after treatment? If so, is this of significance to be of value in making a prognosis? The answers become obvious from inspecting graphs I and II below.



Graph I: A correlation between the percentage of good results obtained and the degree of slipping.



Graph II: A correlation between the percentage of poor results obtained and the degree of slipping.

There is a striking correlation between the degree of slipping and the result after treatment. This is of significance to be of definite value in making a prognosis. The prognosis of the patient with a mild degree of slipping is far better than that of the patient with a moderate or severe slip. The poorest results were obtained in patients with a severe degree (over one and one-half centimeters) of displacement of the epiphysis. It is during the mild stage that we have a real opportunity to obtain a good result, but with this opportunity we also have the responsibility for early diagnosis.

What then are the current trends in treatment that account for the better results? I realize that many equally competent orthopedic surgeons today have divergent opinions about treatment. Many of them report results equal to and even better than the recent trend of improvement in the treatment of these cases. It is not my purpose to review all of these different opinions from the literature, for there appears to be no settled answer to the treatment of slipped epiphysis at the present time. The general trend in this study, however, has been a shift from conservative management to operative treatment.

TREATMENT DURING THE STAGE OF MILD SLIPPING

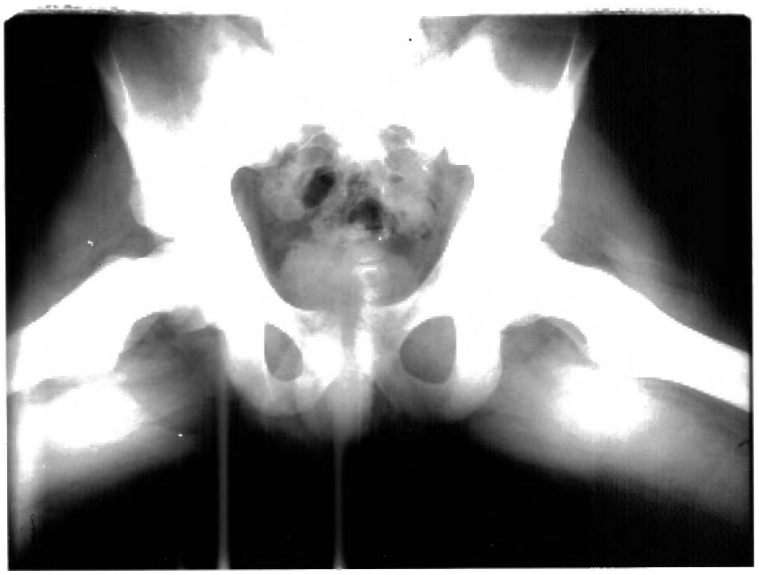
Table III summarizes the methods of treatment and the results obtained in the cases with mild slipping:

Method of Treatment	Result		
	good	fair	poor
1. Pinned in-situ with Moore pins	4		
2. Manip. Double hip spica cast.	4		
3. Nailed in-situ with S-P nail.	2		
4. Traction in D. H. S. cast with pin in lower femur.	1		
5. S. H. S. cast plus brace.	1		1
6. Wedge osteotomy			1

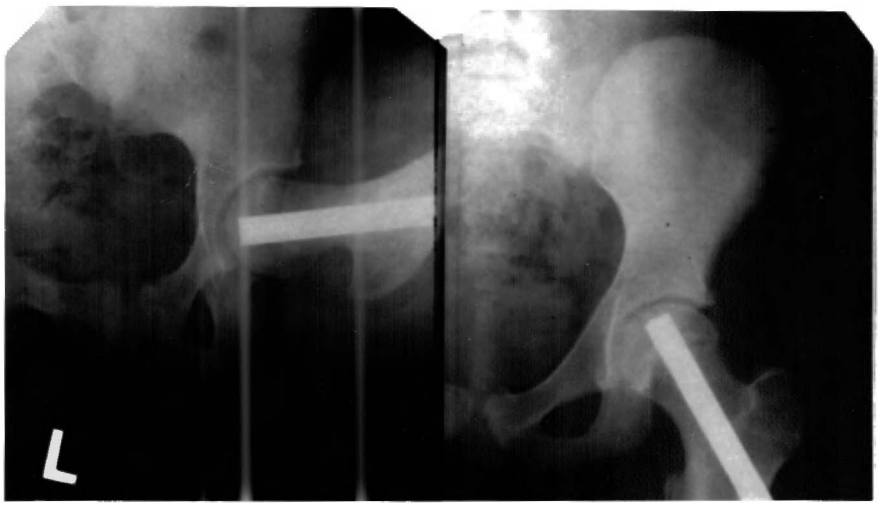
Table III

From table IV, it is apparent that good results were obtained in treating the stage of mild slipping by four different methods. All are satisfactory methods of treatment. The treatment of choice is considered to be pinning the epiphysis in-situ with two or more Moore pins, after a trial of reduction by gentle manipulation. Pinning or nailing has the advantage of secure fixation to prevent further displacement and stimulation of early fusion of the epiphyseal line. A spica cast does not have to be applied and these methods have the advantage of early ambulation. Moore pins are preferred over the Smith-Peterson nail for the following reasons: they are technically easier to insert with precision. The head of the femur in this condition may be very

hard and because of its larger size, the Smith-Peterson nail may drive the epiphysis further away from the neck. If conservative treatment is employed after the trial of gentle manipulation, a double hip spica cast should be used and not a single hip spica. The cast is applied with the thigh in abduction and internal rotation. A Steinman pin may be placed through the lower femur and incorporated in the cast for maintenance of internal rotation and abduction. The difficulty with conservative treatment is that the problem of how long to leave the patient in the cast will always arise. It may take many months before there is bony closure of the epiphysis, so these patients usually end up having the cast reapplied several times and are immobilized for long periods of time. The following X-rays illustrate a good result from pinning and nailing insitu.

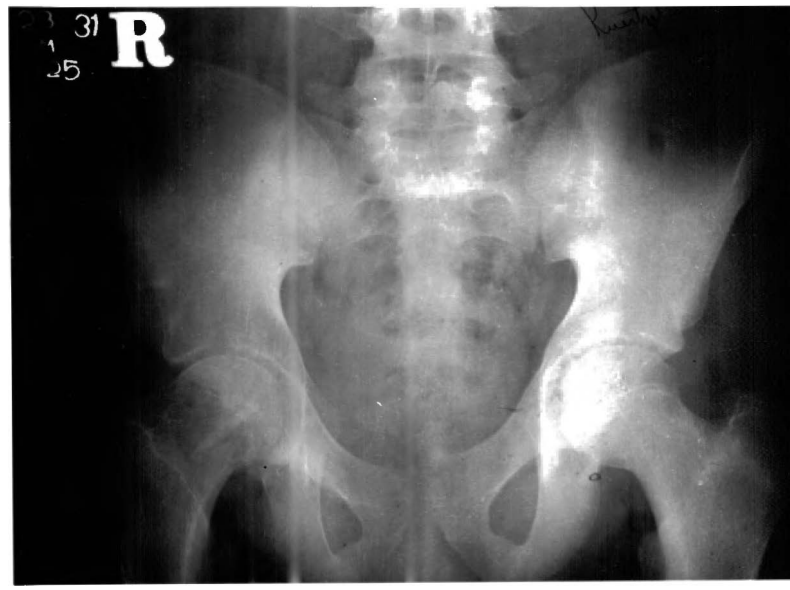


X-ray of good result after pinning with two Moore pins.



X-ray of good result after pinning with Smith-Petersen nail.

Howorth, 1951,[24] is opposed to nailing insitu. He advocates epiphyseodesis by means of bone grafts across the epiphyseal plate to stimulate prompt union. Both Heyman, 1954,[25] and Howorth, 1951,[24] found that fusion took place within three months after insertion of bone pegs. Heymen, 1956,[26] recommends epiphyseodesis by means of a centrally placed bone graft across the epiphyseal plate as the treatment of choice in the early stage of slipping. The following X-ray represents an example of successful treatment by a peg bone graft across the epiphysis (case of W. R. Hamsa, M.D.).



TREATMENT DURING THE STAGE OF MODERATE SLIPPING

Table IV summarizes the methods of treatment and the results obtained in the cases with moderate slipping.

Method of Treatment	Result		
	good	fair	poor
1. Pinned in-situ with Moore pins	3		
2. Wedge osteotomy with S-P nail	1	2	
3. Wedge osteotomy with 2 pins		1	
4. Wedge osteotomy failed. Arthroplasty with prostheses.			1
5. D. H. S. cast with pin in lower femur		1	1
6. S. H. S. Cast			1

Table IV

The treatment of choice in the stage of moderate slipping is pinning the epiphysis insitu after an attempt at reduction by gentle manipulation. Reduction with good alignment is frequently successful if callus formation has not occurred. If reduction is unsuccessful and objectionable deformity persists, this is best corrected by intertrocherteric or subtrochenteric osteotomy at a later date after the epiphysis has closed.

TREATMENT DURING THE STAGE OF SEVERE SLIPPING

Table V summarizes the methods of treatment and the results

obtained in the cases with severe slipping.

Method of Treatment	Result		
	good	fair	poor
1. Pinned in-situ with Moore pins	1		
2. Traction in D. H.S. cast with pin in lower femur		2	2
3. Manip. D.H.S. cast, pin in tibia. Inter-trochanteric osteotomy to correct deformity		1	

Table V

In treating the stage of severe slipping, one may attempt gentle manipulation, but it should definitely be gentle. If there is no improvement in alignment, it is probably best to accept the malposition and pin the epiphysis in-situ with Moore pins. A subtrochanteric osteotomy may be done at a later date to improve internal rotation and abduction. Howorth, 1951,[24] accepts the displacement in the severely slipped epiphysis and fuses it by means of bone grafts. He later does a subtrochanteric osteotomy to correct the deformity.

COMPLICATIONS FROM TREATMENT

The following complications were encountered:

1. Avascular necrosis of the head.
2. Stiff hip with severe limitation of motion.

3. Displacement of the head anterior and superior with development of an abduction deformity due to vigorous manipulation.

4. Early arthritic changes.

5. Flexion contracture after cast.

Table VI correlates the type of treatment with complication.

Type of treatment	Avascular necrosis	Stiff hip	Abduction deformity	Early Arthritis	Flexion Contracture
1. Wedge osteotomy of the neck.	2			1	
2. D.H.S. Cast, pin in lower femur.	2	1			
3. Single H.S.C. and brace.		1			
4. Vigorous manip. D.H.S. cast, pin in tibia.			1		
5. Manip. D.H.S. cast.					1

Table VI

Avascular necrosis occurred in two types of treatment. Table VII correlates the degree of slip with the type of treatment in the four cases that developed avascular necrosis of the head.

Type of Treatment	Degree of Slip		
	mild	moderate	severe
1. Wedge osteotomy of the neck.	1	1	
2. Traction in D.H.S. cast with pin in lower femur.		1	1

Table VII.

In general, poor results were obtained from wedge osteotomy of the neck, the main complication being avascular necrosis of the head. This operation carries a greater danger of injury to the retinacular vessels.

Traction in a double hip spica cast with a Steinmann pin in the lower femur gave some poor results in treating the moderate and severe degrees of slipping. A stiff hip and avascular necrosis were the main complications.

In general, vigorous manipulation is to be condemned. If callus formation has occurred, reduction from manipulation is near impossible. There is more chance of increasing the degree of displacement and causing injury to the retinacular vessels by such a procedure.

The following two cases are presented as examples of the complications that can occur in treatment.

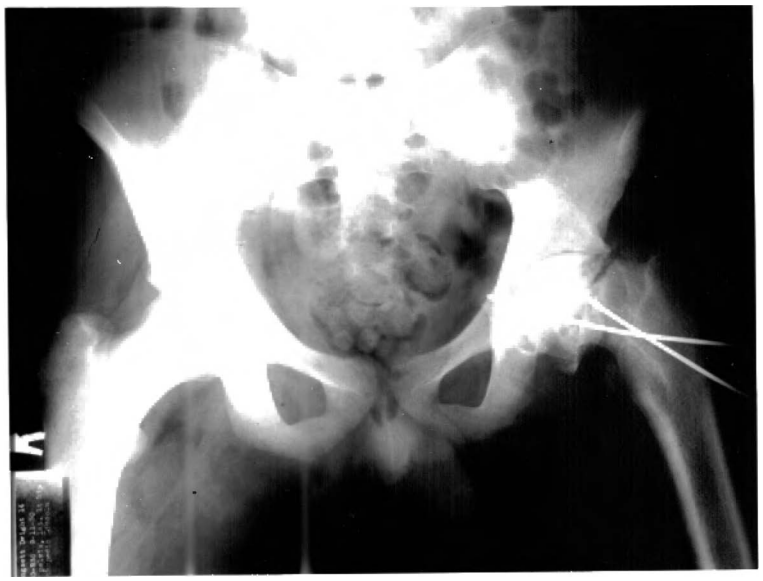
Case I

History: Pain in the left hip and limp for one year duration.

Physical Examination: This patient was a thirteen year old white male who was overweight. He stood with the left lower extremity held in adduction and external rotation. He walked with a limp, employing an antalgic gait. Flexion of the hip joint was possible to 90°. Abduction and internal rotation were impossible. There was one inch apparent shortening of the left lower extremity. There was one inch atrophy of the left thigh and one-half inch atrophy of the left calf.

X-ray: The following X-ray shows a moderate degree of slipping of the left upper femoral epiphysis.

Treatment: A wedge osteotomy of the neck was performed and the epiphysis was pinned in place. The result was bad for several reasons: the pins worked through the articular cartilage; avascular necrosis began; the hip was painful, stif, and unstable.



An arthoplasty was then done and a metalic head was put in place. The prosthesis became loose and the result was still poor.

Finally, by a third procedure, the metalic head replaced by a flange intramedullary prostheses.

For a year subsequently, the hip had good range of motion and the prostheses was well seated. There was about one inch shortening and the patient walked well with one crutch.

Shortly thereafter, however, a wobble developed at the junction of the body of the femur and the prostheses indicating more stress than the bone could withstand. See the following X-ray. The patient had been scooping grain for the past few months and was instructed to follow a less active occupation. The necessity for further surgery in the future is likely.

Case II

History: This patient is a fourteen year old white male. He first noticed the gradual onset of pain in the left hip approximately two and one-half years ago. The pain was not constantly present, and was sometimes accompanied by a mild limp. Approximately one month ago, after attending a dance, the pain in his hip became much worse and remained severe. The parents reported that a limp had become much more noticeable. He had never had any symptoms in the right hip.

Physical Examination: The patient was a slightly obese fourteen year old boy in good general health. He stood with both hips held in external rotation. Flexion was markedly limited on the left and to a lesser degree on the right. There was moderate limitation of internal rotation in both hips. There was one inch apparent shortening of the lower left extremity. There was approximately one inch atrophy of the left thigh.

X-ray: The following X-ray illustrates that the patient had bilateral slipping of the upper femoral epiphyses. Displacement was mild in both hips, but was slightly worse on the left.

Treatment: The right hip was pinned insitu with three Moore pins. A wedge osteotomy was done on the neck of the left femur and the epiphysis was secured with two Moore pins.

Result: The right hip had a good result. The left hip had a poor result. There was moderate restriction of flexion, abduction and internal rotation. The patient complained of fatigue and mild aching in the left hip with exercise. Early avascular necrosis of the left femoral head developed as seen in the following X-ray. Crutches and an ischeal weight bearing brace were prescribed to prevent further deformity of the femoral head during revascularization.

X-ray of bilateral slipping of the upper femoral epiphysis. Displacement is mild in both hips according to the criteria of one-half inch or less displacement, but it is more marked on the left.

The right hip was pinned insitu with three Moore pins with a good result. A wedge osteotomy was done on the neck of the left and the epiphysis was secured with two Moore pins. Early avascular necrosis developed with a poor result.

Table VIII, Summary of Cases

Initial	Sex	Age	Body Build	Side	Chief Complaint	Duration of Symptoms	Degree Slip	Treatment	Result	Comment
1. BB	M	11	Overwt.	L	pain, stiffening	?	Severe	4 Moore pins	good	
2. JS	M	14	Overwt.	L	pain, knee & hip, stiffening	1.5yrs	Severe	D.H.S. cast, pin in lower femur.	poor	Stiff hip
3. LR	F	12	Frolich type	R	pain, hip limp	6 mo.	mild	S.H.S. cast and brace	poor	Limited motion persistance of pain & disability.
4. PK	M	12	Overwt.	L	limp fatigue	4 mo.	mild	Manip., D.H.S. cast; brace.	good	
5. BC	F	12	Normal	B	Pain, limp	8 mo.	L-mild? R-mild?	Manip. D.H.S. cast, pin in tibia. Obturator neurectomy.	L-poor R-poor	Dx of slipped epiphysis Arthritis.
6. DJ	M	16	Normal	L	Pain, limp	2 yr.	mod.	S.S.C. cast, brace	poor	Deformity
7. ID	M	15	Tall, Slender	R	Pain, shortening	1 yr.	mod.	Wedge osteotomy, S-P nail	fair	Early arthritic changes
8. JE	M	16	Frolich type	R	Pain, Knee & hip	9 mo.	mod.	Wedge osteotomy S-P nail	good	
9. HR	M	16	Normal	R	Injury	1 yr.	mod.	Manip., D.H.S. cast. Wedge osteotomy, S-P nail	Fair	Flexion contracture after cast
10. RW	M	14	Overwt.	R	Pain, knee limp	?	mild	S-P nail	Good	
11. LC	F	7	Overwt.	B	Limp	6 mo.	R-mild L-mild	D. H.S. cast, Brace.	L-good R-good	
12. CA	F	10	Thin normal ht.	L	Pain, limp	2 mo.	mild	S.H.S. cast	good	
13. DH	M	13	overwt.	L	Pain, limp	1 yr.	mod.	Wedge osteotomy-pinned. Arthroplasty-metallic head. Replaced by Flange intramedullary prostheses.	poor	Osteotomy failed. Aseptic necrosis.

Table VIII, Summary of Cases, Continued

Initial	Sex	Age	Body Build	Side	Chief Complaint	Duration of Symptoms	Degree Slip	Treatment	Result	Comment
14. JR	M	13	Tall, Slender	L	Pain, Limp	1 yr.	Mild	D.H.S. cast-pin in lower femur	Good	
15. RP	M	15	Overwt.	L	Pain, knee	2 mo.	Mod.	Wedge Osteotomy, two pins	Fair	
16. EC	M	13	Overwt.	L.	Pain, injury	2 yr.	Sev.	Manip., D.H.S. cast, pin in lower femur	Fair	
17. LC	M	13	Overwt.	R.	Pain	?	Mild	Two pins	Good	
18. RD	M	15	Rapid growth, overwt.	L.	Pain, limp	4 mo.	Severe	Manip. D.H.S. cast, Pin in lower femur	Fair	
19. HB	M	14	Overwt.	B	Pain, Limp	2.5yrs.	R-mild L-mild	R-3 Moore pins L-wedge osteotomy-2 Moore pins	R-good L-poor	Avascular necrosis-L.
20. WS	M	14	Overwt.	L	Pain, knee, fatigue, limp	3 mo.	Severe	Manip., D.Y.S. cast, pin in tibia. Intertrochenteric osteotomy	Fair	Abduction deformity after manip.
21. EL	M	12	Tall	L	Incidental Finding	?	Mild	S-P nail	Good	
22. WS	M	14	Overwt.	B	Pain, limp	6 mo.	L-mod. R-mild	L-4 Moorepins R-3 Moorepins	L-good R-good	
23. AS	M	16	Overwt.	L	Pain, limp	8 mo.	Mod.	3 Moore pins	Good	
24. DJ	M	14	Tall	R.	Pain	3 mo.	Mod.	Manip., 3 Moore pins	Good	
25. HD	M	13	Overwt.	L	Pain, knee & hip, limp	2 yrs.	?	D.H.S. cast, pin in lower femur	Fair	
26. DC	M	13	Overwt.	L	Pain, limp	1 yr.	Mod.	D.H.S. cast, pin in lower femur	Poor	Avascular necrosis.
27. DJ	M	13	Overwt.	L	Pain	?	Mild	Manip. D.H.S. cast	Good	
28. LS	M	16	Overwt.	R	Pain, disability	7 mo.	Severe	D. H. S. cast Pin in lower Femur	Poor	Avascular Necrosis.

SUMMARY

Gradual slipping of the upper femoral epiphysis is a disease of adolscence. It is not a common lesion, but is probably the most frequent cause of disability of the hip that begins in adolescence. It is approximately four times more common in the male, but the onset is an average of three to four years earlier in the female. The left hip is affected more than the right and approximately fifteen percent of the cases are bilateral.

Approximately seventy-eight percent of the patients were overweight and four constitutional body types were observed. These are listed as follows:

1. Mikulicz type with large bone and flabby weak skeletal musculature and more subcutaneous fat than usual.

2. The tall slender individual who had just passed through a rapid phase of growth.

3. The Frölich type with under developed genitalia and obesity.

4. Normal height, weight, and body build.

The underlying cause is probably an endocrine imbalance causing a weakening of the epiphyseal bond. Trauma or continued weight bearing may hasten the onset of symptoms or aggravate a displacement.

The common symptoms early in the disease were pain in the hip, limp, pain in the knee, and fatigue with increased activity.

A general principle well worth remembering is that pain in

the knee is frequently a reflection of pathology in the hip. Shortening, deformity, stiffening, and limitation of motion were usually not early symptoms of the disease.

In the early stage, there may be no abnormal physical findings, but it is common to find only a very slight limitation of internal rotation of the affected hip. The patient often walks with an antalgic limp and may stand with the hip slightly externally rotated. In patients with a varus deformity, there is an apparent shortening greater than the actual shortening. When motion is limited, internal rotation is the first to be affected followed by limitation of abduction. Flexion is limited to a lesser degree and then external rotation and extension are affected in that order. Adduction is less affected. Quadriceps atrophy is common. Lateral tilting of the pelvis, adductor spasm, tenderness, and swelling occurred but were uncommon.

The displacement occurs at the newly formed layer of bone of the melaphysis and not in the epiphyseal cartilage. The major blood supply to the head of the femur is the retinocular arteries which arise from the medeal and lateral femoral circumflex arteries. They lie in close association with the periosteum of the posterior portion of the neck and do not cross the epiphyseal plate, but by-pass it at the periphery to enter the head.

Both lateral and anterior-posterior X-rays should be taken. Of these, the lateral view is most informative. It not only

reveals the degree of displacement to best advantage, but it may be the only view in which mild displacement is detectible.

The primary purpose of treatment is to secure bony union of the epiphysis as promptly as possible in the least deformed position that can be obtained. If no treatment is given, spontaneous fusion may take several months and increasing deformity is probable. Prompt treatment is the goal, once the diagnosis is made, and further weight bearing should be prohibited until definitive therapy.

The results of treatment were found to have markedly improved during the past eight years. This improvement was due to better methods of treatment and not to earlier diagnosis.

A striking correlation was found between the degree of slipping and the result after treatment. A good result was obtained in eighty-five percent of the patients with mild slipping, whereas forty percent of the patients with moderate slipping had a good result and only seventeen percent of the patients with severe slipping had a good result. It is, thus, during the mild stage that we have a real opportunity to obtain a good result, but with this opportunity, we do have the responsibility for early diagnosis.

The general trend in treatment has been a shift from conservative management to operative treatment.

In the stage of mild slipping, four satisfactory methods of treatment were found. These are listed as follows:

1. Gentle trial of manipulation. Pinning insitu with Moore pins.
2. Nailing insitu with S-P nail.
3. Manipulation. Double hip spica cast.
4. Traction in double hip spica cast with pin in lower femur.

Pinning insitu with Moore pins after a gentle trial of manipulation is considered the treatment of choice in mild slipping. It has the advantages of secure fixation to prevent further displacement, stimulation of epiphyseodesis, and early ambulation with crutches. Moore pins are technically easier to insert than the S-P nail. Howerth advocated epiphyseodesis by means of peg bone grafts across the epiphyseal line to stimulate prompt union.

The treatment found most satisfactory for the moderate and severe degree of slipping is to pin the epiphysis insitu after a trial at reduction by gentle manipulation. If a deformity persists, it is best corrected by a sub or inter-trochenteric osteotomy after the epiphysis closes.

In general, poor late results were obtained with wedge osteotomy of the neck. The main complication was avascular necrosis of the head.

Traction in a double hip spica cast, with a Steinman pin in the lower femur, gave some poor results in treating the moderate and severe degrees of slipping. A stiff hip and avascular necrosis were the main complications.

CONCLUSION

The results from analysis of twenty-eight cases of slipped upper femoral epiphysis have been presented. Special emphasis has been devoted to all phases of early diagnosis and to an analysis of the results of treatment in the different stages of the disease. In general, much improvement has been made in the results of treatment with the general shift from conservative management to the nailing operations, but little if any improvement has been made in early diagnosis. This paper has statistically illustrated that if the disease is diagnosed in its mild stage, the prognosis is greatly improved. In treating the disease, wedge osteotomy and traction in double hip spica cast with pin through the lower femur often failed to give improvement.

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