

From Sophies Minde Ortopedisk Hospital, Oslo (Head: Ivar Alvik) and
The Department of Orthopaedic Surgery, The University of Washington.

CAPITAL FEMORAL EPIPHYSIOLYSIS TREATED BY PLUGGING WITH CORTICAL BEEF BONE

By

STEWART M. SCHAM

Received 8.ii.67

Treatment of capital Femoral epiphysiolysis by plugging, or epiphysiodesis, is well established, though not widespread, and has been used in several hundred cases. In the reported cases, autogenous cancellous bone of local and iliac origin has been used. At Sophies Minde, cortical beef bone, processed in the hospital, is used. The purpose of this report is to evaluate this technique, and also to emphasize again a valuable early radiological sign in epiphysiolysis which has previously been described.

Two results are sought from the plugging operation; the prevention of further slip, and accelerated closure of the cartilaginous growth plate. An advantage is that no second operation is required to remove metallic fixation material, such as a Smith-Petersen nail or threaded pins. Possible disadvantages are that in the plugging operation, which is intracapsular, infection, if it occurs, will be very serious, and that the incidence of ischemic necrosis of the femoral head might be increased.

DIAGNOSIS

The usual diagnostic signs and symptoms, sought upon hip or knee complaints in an adolescent, are well known. A less well-known, early radiological sign, has been described by *Capener* (1956), *Durbin* (1960) and *Jacobs* (1962). This is the extrusion of the diaphyseal component of the caput femorale from the acetabular contour, and is seen on the frontal film. This means that the dense triangle normally seen below the caput's main epiphyseal portion, and resulting from overlapping of the lower part of the acetabulum with the diaphysis of the neck, is not present. Of course, the usual other radiological findings are found, particularly those on the lateral view. But this sign is occasionally the only finding in an early case, as in

4 of 24 hips *Jacobs* reviewed. It was the only sign in 1, and possibly 2, of the hips in this paper. As *Jacobs* points out, it is of special value when the clinical diagnosis is unsuspected, so that a lateral film is not taken. For example, in the usual follow-up of a patient with known unilateral disease, without complaints on the opposite side, lateral films on that side may not perhaps be made. In these cases it is a particular advantage to be able to utilise a sign visible early on a routine film, and offering a very high degree of reliability.

In case 5959 of this report, it is seen in the clinically normal right hip, which went on to undiagnosed slip and progression. See Figure 7 a-e. The final appearance in the hips of this case is that frequently seen in hips which some surgeons feel are "particularly susceptible to osteoarthritis". This suggests that undiagnosed epiphyseolysis may be a more common cause of "Primary" osteoarthritis than is generally realized.

M A T E R I A L

Thirty-six patients, whose clinical records and x-ray folders were studied are reported. For the purposes of this report, final clinical examination of the patients by the author was not necessary. Nineteen were boys, and seventeen were girls, giving the anticipated slight male preponderance. Four boys and four girls had bilateral disease, an incidence of bilaterality of 22 per cent. Because thirteen uninvolved epiphyseal plates were open at the last follow-up, a slightly higher bilaterality rate could occur. Thirty-two cases had slipped less than 30 per cent. 7 between 30 and 50 per cent and 4 over 50 per cent. One case could not be evaluated for degree of slip. Two of the minor slips were discovered only on reviewing the x-rays, and, being clinically unrecognized, were untreated.

The average age at operation was 13 years, 1½ month. The oldest was a boy, 15 years and 7 months old, and the youngest a girl 9 years and 10 months old, without a history of trauma. The average boy at operation was 13 years 11 months old, the average girl 12 years and 2 months. The coincides with the usual age difference of 2 years between boys and girls, presumably related to difference in bone age.

T R E A T M E N T (See Table 1)

The two S-P-nailings were performed elsewhere, before admission to Sophies Minde. Of the 10 osteotomies, 8 were intertrochanteric, one was sub-capital, and one was through the lower third of the neck. They were all fixed with staples, except for the sub-capital one, which was held with the bone plugs. Five of the intertrochanteric osteotomies had bone plugs introduced through the osteotomy site.

Table 1. Treatment of 44 hips.

Total number with plugging alone	29
Total number with osteotomy alone	2
Total number osteotomy plus plugging	8
Total number with S-P nail	2
Total number untreated	3
Total number of hips involved	44

On admission the cases were placed in slightly abducted, otherwise straight, bilateral skin traction of 2-3 kilograms. A few had tibial skeletal traction. Surgery was not done as an emergency. The incision approach was between the tensor fascia lata and gluteus medius. The capsule is longitudinally incised, and the neck and site of slip seen. Drill-holes of about 1/4 inch are made into the head through the neck, starting antero-laterally. Cortical beef bone plugs are then shaped to fit, and driven in according to length, determined by placing a thin K-wire into the drill hole, and rotating the femur to see when the wire no longer moves with the femoral neck. The capsule is loosely closed. Traction continues for 10 weeks after surgery. Active and passive exercise begins one to two weeks after surgery. Traction is discontinued at 10 weeks, but bed rest continues 6 weeks longer. Then gradual weight-bearing with crutches begins.

Roentgen films are made at 10 and 16 weeks, and thereafter at intervals of several months.

RESULTS

1. Obliteration of the Growth Plate

Seventeen male hips were evaluated in this respect, and twelve female hips, both groups being treated with plugging. Fourteen normal hips, five male and nine female, were also evaluated. The results are in Table 2. These times seem rather long. It should be stated that what is referred to here is complete disappearance of the cartilaginous growth plate, including the small portion laterally which was generally seen to disappear last. Bone trabeculae crossed the plate in every case earlier, usually by several months. However, it is difficult to evaluate when bone trabeculae first cross a plate, or when there are enough crossing to assure stability. Therefore, the endpoint of 100 per cent closure was chosen. If the plate were almost closed at one date, and completely closed on the next study several months later, the latter time was chosen. See Figures 1, 2a, b, 3 and 4a, b, c, to see when closure is accepted in comparison to when closure for clinical purposes is apparent.

Table 2. Obliteration of growth plate, time after plugging, and age in normal and plugged hips.

	Male	Female
Average age following plugging operation	15 years 2 months	13 years 4 months
Average time following plugging operation	12.9 months	14 months
Average age in normal hips	16 years 7 months	13 years 11 months



Figure 1. Closure is not roentgenologically complete, but clinically adequate.

Figure 2. a) both not considered completely closed, b) was taken 9 months after operation.



Figure 3. Almost, 2 years after surgery, clearly clinically closed, but not 100 per cent roentgenologically.

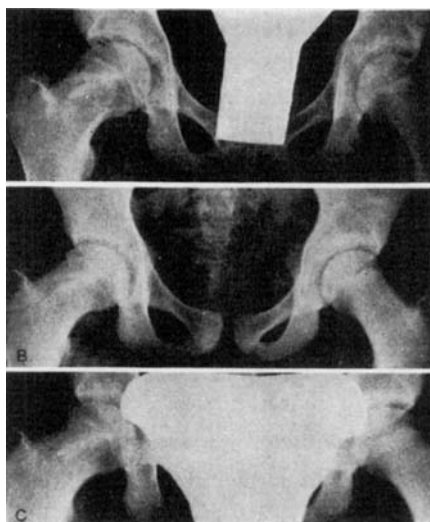


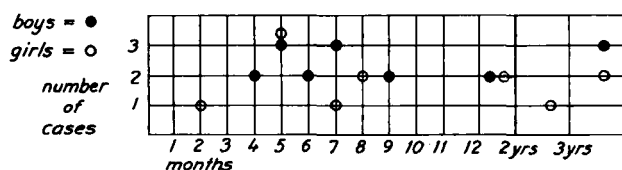
Figure 4 a, b, c. a) Is clinically closed, as is 4 b. Full roentgenological closure was accepted with 4 c, 15 months after surgery.

Howorth, reporting on results with autogenous iliac plugs in 1965 reported obliteration of the epiphyseal plate within a year. *Heyman & Herndon*, in 1954, reported that cancellous bone plugs produced "roentgenographic evidence of fusion within three months after operation". In the present series though average obliteration took a little over a year, these were average values. Several cases took well over one year, suggesting that beef cortical plugs are not as efficient in this regard as are autogenous cancellous plugs. See Table 3.

No cases in this series slipped after plugging, so that clinically adequate "healing" actually occurred within four months, when ambulation began.

Table 3. Breakdown of closure times.

Three boys and 3 girls required over 2 years for full plate obliteration.



2. Evaluation of Matters of Technique: Bone Plugs

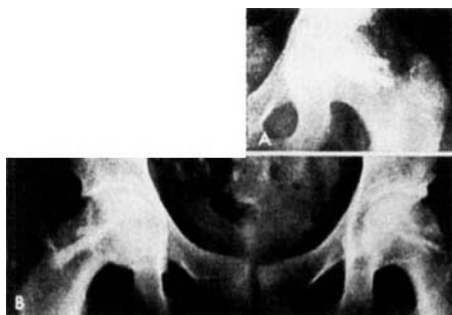
79 plugs were used. As evaluated on routine 2-view study, and disregarding the concavity of the growth plate, 13 or 16 per cent of the plugs did not cross the plate. In three of the 37 cases plugged, or 8 per cent, no plugs crossed. None of these cases slipped further.

In 6 cases a plug protruded through the head into the joint space, and in one the plug clearly entered the acetabular cartilage. No harm was noted except in the latter case, to be discussed later. Bone in the joint space either backed into the head or broke off, the loose fragment usually becoming invisible within one year.

In many cases plugs at the site of entry into the neck were allowed to protrude to a varying degree above the neck surface. This protrusion either resorbed or rounded out and only one case, to be discussed, became a problem.

In distinction to autogenous cancellous bone, beef cortical plugs are visible clearly on x-ray study for a long period. Initial host invasion, as determined by distinct, rather uniform serrations on their edges, was seen an average of 4 months after operation. The time required for complete plug disappearance varied greatly, a few becoming invisible in 1 year, and some clearly visible after six to eight years.

Figure 5 a, b: Shows plug fragments unchanged in 7 years.



Figures 5 a and b show bone plugs protruding on the neck unchanged 7 years after surgery.

Osteotomies

Of the 7 intertrochanteric osteotomies and one just above the greater trochanter, all fixed with staples, which were treated similarly to plugged cases afterwards, all healed in 3 to 4 months. Five of these had plugs through the osteotomy site, which in no apparent way interfered with healing.

A sub-capital osteotomy, held with the bone plugs through the neck, fell apart. It was then reduced and fixed with an S. P.-nail. Interestingly, this case, a 50 per cent slip at the start, did not develop necrosis, with a follow-up of 3 years and 4 months. The 10th osteotomy was through the lower third of the neck, held with 2 staples. It dislocated and required re-operation with new fixation applied on the neck. Necrosis and deformity followed.

Antibiotics and Infection

No infections occurred.

Over one half of the cases received Penicillin from the day of surgery to a variable post-operative period. See Table 4. There is no significant difference in the post-operative temperature curve for the two groups.

Table 4. Comparison of average temperature curves 10 days post-op in cases with plugging only, with and without antibiotics.

Post-on day	1	2	3	4	5	6	7	8	9	10
Penicillin	38.4	38.0	37.8	37.8	37.8	37.6	37.6	37.6	37.4	37.4
No antibiotics	38.5	38.1	38.1	37.7	37.6	37.6	37.5	37.4	37.5	37.4

Complications

See Table 5. The bone graft effect occurred in a hip which also sustained necrosis, so that seven patients had complications. Five of eleven hips with a degree of slip over 30 per cent developed necrosis, an incidence of 45 per cent.

This includes one hip treated elsewhere with S.-P.-nailing. There was one hip out of 32 with slip under 30 per cent that developed necrosis. It was treated with plugging alone.

Table 5. Complications.

Caput necrosis	6 cases
Mechanical damage from plugs	1 case
Bone graft effect on neck, restricting motion	1 case

ANALYSIS OF COMPLICATIONS

A. Necrosis

1. *Case 11224.* Over 80 per cent slip, with only slight callus, slightly reduced with pre-operative traction. At surgery some manipulative reduction was attempted with the capsule open. One plug entered the joint space, broke off in 2 months, and the fragment could no longer be seen after 10 months. Necrosis which was clear 10 months after surgery, seems due to an extensive acute slip.

2. *Case 8392.* Over 50 per cent slip with callus. Treated with 2 well-placed plugs and osteotomy through the lower third of the neck, held with staples. Osteotomy was displaced, and required re-operation, with new staples. Necrosis and deformity in 18 months. Inadequate fixation and 2 operations on the neck may well have contributed.

3. *Case 5959.* 10 per cent slip, with callus, capsule opened, one plug into the joint broke and backed into the head without causing difficulties. The patient was a diabetic. Necrosis and deformity in 5 months. Cause not clear. This was the only hip of less than 30 per cent slip to develop necrosis.

4. *Case 8566.* 30 per cent slip, with callus. No manipulation, and capsule not opened. Treated with intertrochanteric osteotomy and 1 plug through osteotomy site. Necrosis and deformity in 7 months. Cause not clear.

5. *Case 8389.* 30 per cent slip with callus. No manipulation, and cap-

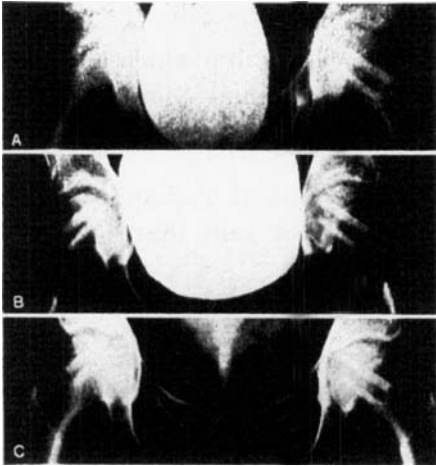


Figure 6 a, b, c. Damage to left head from bone pegs, advanced 4 months after operation.

sule not opened. Treated same as case 8566. Necrosis and deformity in 17 months. Cause not clear.

6. *Case 10325 L.* 50 per cent slip without callus, treated elsewhere with manipulation and S.P.-nail. Necrosis and deformity in 1 year. Possibly attributed to extensive acute slip and manipulation.

Only one case of necrosis, no. 3, occurred in a case treated by the plugging operation alone, in a slip of a mild degree. In the 6 cases with necrosis, the average time for obliteration of the growth plate was 8.8 months, less than the average for the series.

B. Direct Mechanical Damage from Plug

In case 8850 L, a 15 per cent slip with callus, two bone pegs entered the acetabular cartilage. Free movement in the joint immediately after operation was recorded. Damage to the dome of the head was suggested 2 months later, and advanced in 4 months. See Figure 6. This was a complication from a technical error. With the plug fixed at both ends, motion damaged the surface of the head.

C. Bone Graft Effect, Causing Mechanical Obstruction to Joint Motion

Case 5959, which also developed necrosis, developed a large mass of bone over the protruding ends of the plugs on the femoral neck. This grew to a size where it impinged on the edge of the acetabulum. See Figure 7 a-e.

Figure 7 a e. Progression of slipping in unsuspected right hip, and bone graft effect in plugged left hip. The photos are reversed.



DISCUSSION

Bone plugging with cortical beef bone in epiphysiolysis is a clinically successful method. The time required for obliteration of the cartilaginous growth plate is diminished, though probably not so well as with autogenous cancellous bone. Further slipping has not occurred, either in pre-operative traction, or at any time in the post-operative period. One may speculate that drilling across the cartilaginous growth plate alone, associated with over 6 weeks of traction, might be a successful form of treatment, but it seems unworthy of clinical trial.

One patient in this series who underwent simple plugging associated with opening of the capsule developed necrosis. Five other cases that developed necrosis could either be explained by the degree of acute slip, could not be explained, though *not* treated with the simple plugging operation, or, in one case the necrosis was probably related to inadequate fixation of a cervical osteotomy.

Two complications were related to positioning of bone plugs and could have been avoided with more careful surgical technique.

SUMMARY

A series of 44 hips with capital femoral epiphysiolysis is reviewed, most of which were treated by plugging with cortical beef bone plugs.

Complications due to the method are described, and found, for the most part, to be avoidable.

The method is found to be successful, though probably not as fast in causing obliteration of the cartilaginous growth plate as that using autogenous cancellous bone.

A valuable roentgenologic diagnostic sign, previously described in the literature, is emphasized.

RESUME

Une série de 44 hanches avec épiphysiolyse de la tête fémorale est réexaminée, la plupart ayant été traitées par enchevillement avec chevilles d'os cortical de boeuf.

Les complications découlant de la méthode sont décrites, en démontrant que la plupart peuvent cependant être évitées.

On considère que la méthode a été un succès, probablement pas tellement parce qu'elle produit une oblitération de la croissance de la croissance de la plaque cartilagineuse que parce qu'elle utilise de l'os spongieux autogène.

Il est souligné, comme cela a été préalablement décrit dans la littérature qu'il est précieux d'avoir un bon diagnostic radiologique.

ZUSAMMENFASSUNG

Eine Gruppe von 44 Hüften mit Epiphyseolyse des Femurkopfes wird besprochen. Die Merzahl der Hüften wurde mittels Einschlagen von kortikalen Ochsenknochenpflöcken behandelt.

Komplikationen, die im Zusammenhang mit der Methode stehen, werden beschrieben und man findet, dass sie gröstenteils vermeidbar sind.

Die Methode ist erfolgreich, obwohl sie wahrscheinlich nicht so rasch zur Obliteration der Epiphysenplatte führt, als die, welche autogenen Spongiosaknochen verwendet.

Ein wertvolles, röntgenologische, diagnostisches Zeichen, das früher in der Literatur beschrieben wurde, wird hervorgehoben.

ACKNOWLEDGEMENT

I would like to thank Professor, dr. med *Ivar Alvik* for allowing me access to all necessary material at Sophies Minde. To dr. *Victor Segalstad* I am grateful for help in evaluating roentgenograms wherever needed, and particularly for calling my attention to the roentgenological sign described here.

REFERENCES

1. Capener, N. (1956) Modern trends in orthopedics (Second Series), Ed. H. Platt. Butterworth & Co. Ltd., London.
2. Durbin, F. C. (1960) Treatment of slipped upper femoral epiphysis. *J. Bone Jt Surg.* 42B, 289.
3. Heyman, C. H. & Herndon, C. H. (1954) Epiphyseodesis for early slipping of the upper femoral epiphysis. *J. Bone Jt Surg.* 36A, 539.
4. Howorth, B. (1957) Slipping of the upper femoral epiphysis. *Clin. Orthop.* No. 10, 148.
5. Howorth, B. (1965) Slipping of the capital femoral epiphysis. *Amer. J. Orthop.* 7, 10.
6. Jacobs, P. (1962) A note on the diagnosis of early adolescent coxa vara (slipped epiphysis). *Brit. J. Radiol.* 35, 619.