Cuneiform osteotomy of the femoral neck in the treatment of slipped capital femoral epiphysis

JB Fish


This information is current as of May 1, 2009

**Reprints and Permissions**

Click here to order reprints or request permission to use material from this article, or locate the article citation on jbjs.org and click on the [Reprints and Permissions] link.

**Publisher Information**

The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157

[www jbjs org]
Cuneiform Osteotomy of the Femoral Neck in the Treatment of Slipped Capital Femoral Epiphysis

BY JAMES B. FISH, M.D.*, WATERTOWN, NEW YORK

ABSTRACT: I reviewed the cases of eighty-two patients (106 hips) with slipped capital femoral epiphysis who were treated during a twenty-four-year period. Of these, forty-two hips had a sufficiently severe displacement to require surgical correction by means of a cuneiform osteotomy of the neck of the femur just distal to the physis. The purpose was to restore the normal anatomical relationship of the proximal capital femoral epiphysis to the neck of the femur. Follow-up of these patients ranged from two to twenty-two years, with an average of nine years and nine months. Aseptic necrosis developed in one femoral head and osteoarthritis developed in one hip. The remaining forty hips were graded as having an excellent result.

Controversy persists concerning the most satisfactory treatment of a severe slip of the capital femoral epiphysis. Many methods of treatment have been tried, but the final results have frequently been less than satisfactory. According to Howorth, "The lesion always heals spontaneously, and treatment is of no value unless it produces a better result than would have been accomplished by nature.''

Fixation in situ to prevent further slipping was advocated by O'Brien and Fahey, who reported remodeling of the femoral neck in patients in whom the triradiate cartilage was open. However, they thought that this treatment would not be satisfactory for a slip of more than 60 degrees. Epiphyseodesis and osteoplasty, as described by Herndon et al., does not improve the alignment of the head and neck but does improve function by removal of a bone block to motion. However, the bone that is removed is a portion of the normal proximal femoral metaphysis. Herndon et al. believed that anatomical reduction would be desirable, but that it was not worth the risk of aseptic necrosis and permanent severe disability. Osteoarthritis of the hip secondary to malposition of the femoral head does not develop until later. Although these procedures are less likely to result in the development of aseptic necrosis, many authors have predicted that without the restoration of normal alignment of the head and neck, osteoarthritis eventually will develop.

Even a first-degree epiphyseal slip may be responsible for late arthritic changes. Murray and Duncan described a medial angulation deformity of the femoral head in relation to the femoral neck that was seen in a high percentage of osteoarthritic hips. They thought that this deformity was the result of unrecognized first or second-degree slipping of the capital femoral epiphysis and believed this to be the precursor of the osteoarthritis. Jerre found evidence of minor epiphyseal slipping in the hip opposite the one treated for slipped capital femoral epiphysis. This slip had remained undetected during adolescence, and although the deformity was mild, eighteen hips in thirty patients had radiographic evidence of osteoarthritis at an average age of thirty-seven years.

Dunn and Angel stated that the articular cartilage of the femoral head is thicker at its zenith than at the periphery, and that if the head is not perfectly positioned, weight-bearing on the thinner peripheral cartilage will result in arthritis.

When a severe epiphyseal slip occurs, it is easier for osteoarthritis to develop because weight is borne partially on the periphery of the head and partially on the physis, which consists of cartilage that is intended for growth but not for weight-bearing.

Many types of trochanteric osteotomy have been performed in attempts to restore some degree of normal alignment while avoiding surgery in the region of the femoral head and physis, with its accompanying risk of aseptic necrosis. In 1967, Southwick described a two-plane osteotomy at the level of the lesser trochanter to compensate for the deformities caused by a severely slipped epiphysis. He subsequently reported on his experiences with this procedure, documenting the technical difficulties and the high incidence of chondrolysis. These were confirmed by Ogden et al. and Salvati et al.. This osteotomy, however, cannot correct a slip of more than 70 degrees. The derotation valgus osteotomy, designed to align the femoral head and shaft, creates an additional femoral deformity. As a result, the abductor musculature is displaced from its normal position, increasing the muscle force that is necessary to keep the pelvis level. Wedge osteotomy at the base of the femoral neck also does not correct the deformity at the site of the lesion, and a maximum correction of only 50 degrees is possible.

All of the methods of treatment just described either accept the deformity and the risk of future osteoarthritis or attempt to correct the malalignment between the femoral head and neck by an osteotomy at a location other than the site of the lesion. A cuneiform osteotomy at the level of the physis is the only method that anatomically restores the epiphysis on the neck of the femur and, in severe slips, the...
only method that achieves complete correction. Southwick stated that if anatomical reduction could be achieved without damage to the circulation to the epiphysis, a normally functioning hip could be expected. Whitman first described open reduction of the slipped epiphysis in 1909. In some patients this was done without removal of bone, the physis being parted apart and the epiphysis being forcefully realigned. The resulting capsular tension was considered to be sufficient to hold the femoral head in the reduced position on the neck. In four of the operative procedures that Whitman described it was necessary to remove a large wedge-shaped section of bone from the femoral neck before satisfactory position could be obtained. This probably was the first published record of a cuneiform osteotomy.

Gage et al. subsequently reported the collective incidence of aseptic necrosis after osteotomy of the femoral neck in 393 hips reported on by twenty authors. The percentage of aseptic necrosis ranged from zero to 100, with an average of 21 per cent. This is far too high a complication rate, as aseptic necrosis in a child's hip is a disaster. In this group, the authors who reported the best results (Bianco, Compere, Friberg, Lindström, and Martin) condemned manipulation of any type except in the acute slip and described meticulous dissection to preserve the blood supply to the head of the femur. Most of them also condemned the use of the Smith-Petersen nail for fixation and used wires, pins, or screws instead. Hall reported a 34.5 per cent incidence of aseptic necrosis and related the poor results to manipulation and the use of the Smith-Petersen nail for fixation. The reported complications from the use of the nail included aseptic necrosis, fracture of the neck and subtrochanteric area of the femur, and a gap between the neck and the epiphysis produced by driving the heavy nail into the dense bone of the femoral head.

Schnute reported on twenty-one hips with a slipped epiphysis treated by wedge osteotomy, with a 5 per cent incidence of aseptic necrosis. He emphasized the extreme care that is required to protect the posterior capsular blood supply, in addition to the necessity of removing enough bone to allow reduction without stretching the posterior part of the capsule. He also condemned manipulation and fixation with the Smith-Petersen nail.

In the present study I am reporting the results of wedge osteotomy for slipped capital femoral epiphysis in thirty-nine patients (forty-two hips).

**Materials and Methods**

From December 1960 to January 1981, thirty-nine patients (forty-two hips) had a cuneiform osteotomy for slipped capital femoral epiphysis. All of the femoral epiphyses had more than 30 degrees of displacement. The eighteen hips that I reported on in 1972 are included in this group. Five orthopaedic surgeons, in a private group practice, performed the surgery. All of the patients were white. There were thirty-four boys (87 per cent), whose average age at the onset of symptoms was thirteen years and eight months, and five girls (13 per cent), whose age at onset averaged eleven years and four months. Thirteen patients (33 per cent) had a bilateral slip. In three patients the slip was greater than 30 degrees in both hips, and a cuneiform osteotomy was done bilaterally. There was an equal incidence of involvement in the right and left hips of the thirty-nine patients. Six patients had a sibling who also had slipped capital femoral epiphysis. One patient (Case 15) was lost to long-term follow-up but had a viable femoral head two years and five months after surgery. Five patients were examined by orthopaedic surgeons in other cities. I personally examined the remaining patients and the radiographs of all of the patients, including those of the five patients who were examined elsewhere.

The follow-up period ranged from two to twenty-two years, with an average of nine years and nine months. Two years is generally considered to be the minimum length of time that a hip must be followed after operation before the surgeon can be sure that chondrolysis or aseptic necrosis has not developed.

Chronic slipped capital femoral epiphysis is most commonly classified according to the degree of displacement as seen on the frog-leg lateral radiograph of the femoral head and neck. In a first-degree or mild slip, the head is displaced as much as 30 degrees; in a second-degree or moderate slip, from 30 to 60 degrees; and in a third-degree or severe slip, more than 60 degrees (Fig. 1).

It is very important to have an accurate assessment of the degree of slip. An anteroposterior radiograph will determine the degree of downward (varus) slip of the head. A frog-leg lateral radiograph determines the degree of posterior displacement, although the presence of synovitis and irritability of the hip joint may prevent the achievement of 90 degrees of flexion. A lateral radiograph made in the operating room with the patient anesthetized enables the examiner to make the most accurate measurement of posterior displacement.

Seven patients had an acute slip superimposed on a pre-existing chronic slip. In an acute slip the femoral epiphysis is at increased risk of development of aseptic necrosis, and the lesion has been compared with an intracapsular fracture of the neck of the femur in this respect. In patients in this series, a slip of more than 30 degrees was considered unacceptable and a cuneiform osteotomy was done. Most authors have agreed that a slip of 30 degrees or more can be corrected only by a surgical procedure.

Cuneiform osteotomy is the only procedure that corrects the deformity at the site of the lesion. With an osteotomy at the base of the neck, the maximum head-shaft correction that is possible for a severe slip is 50 degrees, with a biplane trochanteric osteotomy, it is 70 degrees. Both procedures create an additional deformity to realign the head with the femoral shaft. Cuneiform osteotomy can correct any displacement and, since the correction is done at the site of the deformity, anatomical head-neck alignment can also be obtained.
The severity of displacement of the epiphysis on the neck is determined by a frog-leg lateral radiograph with the hip flexed 90 degrees. A first-degree, or mild, slip is one in which the epiphysis has slipped as much as 30 degrees from the center line of the neck. A second-degree, or moderate, slip is a displacement of the epiphysis of 30 to 60 degrees on the neck. A third-degree, or severe, slip is one in which the epiphysis has slipped beyond 60 degrees.

The hips were evaluated by the method of Hall. By his criteria, a hip is rated as excellent only if the patient has no pain, has unlimited function, and considers the hip to be normal. The range of motion of the involved hip must be essentially the same as that of the opposite hip, and in hips with bilateral involvement the combined range of motion must be 85 per cent of the normal range or more. A result cannot be considered excellent if there is any limitation in sports activity or in the ability to perform any type of work. For a rating of good, the patient has either no pain or slight pain and the hip has 75 to 85 per cent of normal motion. There can be radiographic changes of mild early arthritis, but the patient assesses the hip as good. For a fair rating, the patient makes concessions because of pain and the hip has between 50 and 75 per cent of the normal range of motion. The hip gives the patient some trouble in daily activities, and there are radiographic changes of increasing osteoarthritis. A poor rating means disabling or crippling involvement, with less than 50 per cent of the normal range of motion. The patient judges that the treatment of the hip was unsuccessful.

**Preoperative Management**

When the diagnosis has been made, the patient is admitted to the hospital on an emergency basis and is placed at bed rest. The involved limb is elevated on pillows and allowed to assume the position of mild flexion, abduction, and external rotation at the hip that results in maximum capsular relaxation and in which the patient is most comfortable. The synovitis that is present in a symptomatic hip increases intracapsular pressure and can, at least theoretically, embarrass the blood supply to the head. The hip joint should not be maintained in a position that causes tension of the joint capsule — especially extension, abduction, and internal rotation — as this "wrings out" the blood vessels running through it. For this reason traction should never be applied preoperatively. The patient is scheduled to have surgery in twenty-four to forty-eight hours.

**Surgical Procedure**

The procedure is done on a standard operating table with the patient supine, and a radiolucent roll is placed beneath the involved side of the pelvis to elevate it. The limb is draped free. This allows manipulation of the limb during osteotomy and the freedom to make radiographs to determine the position of the head of the femur and of the pins used for internal fixation. Gentle manipulation under general anesthesia is done only for patients with an acutely slipped epiphysis. Forceful manipulation can damage the periosteum on the posterior part of the femoral neck, with its contained blood vessels, and cause necrosis of the head of the femur. If the acute slip cannot be improved to a displacement of 30 degrees or less, a cuneiform osteotomy is done.

An anterolateral surgical approach to the hip is made, carrying the dissection between the tensor fasciae femoris and the gluteus medius to the anterior aspect of the capsule of the hip joint. A generous exposure of the capsule proximal to the rim of the acetabulum is essential for adequate visualization. The capsule is opened longitudinally first, and then proximal and distal transverse incisions are made at each end of the longitudinal incision to allow exposure of the neck of the femur. The capsule is carefully retracted with either Kocher clamps or a toothed Meyerding retractor (Fig. 2). A retractor should not be placed around the neck of the femur either medially or laterally. After opening of the capsule, the capital femoral epiphysis must be identified. It is usually barely visible at the rim of the acetabulum. The projecting metaphysis of the neck is very obvious, for as the epiphysis slips posteriorly and inferiorly, the anterior
Adequate exposure is necessary to perform this operation. The anterior part of the capsule is incised longitudinally, and proximal and distal transverse incisions are made at the acetabulum and base of the neck. The capsule is retracted with a toothed instrument. Note how little of the capital femoral epiphysis is visible.

A, This true lateral view is not seen at operation but is used to illustrate the position of the epiphysis relative to the femoral metaphysis. The location of the physis is determined by a hand-held small, sharp, curved osteotome.

B, The bone is removed in small pieces by a small, sharp osteotome and a mallet. As the fragments are removed they are wiped from the physis to allow continuous identification of the epiphysis.
A. This is a true lateral view demonstrating the removal of any remaining physeal cartilage before reduction of the epiphysis. Note that a sufficient amount of bone has been removed posteriorly to allow reduction of the epiphysis without tension on the posterior part of the periosteum.

B. After reduction there must be anatomical alignment of the epiphysis with the femoral neck. The diameter of the head is larger than that of the femoral neck after the wedge of bone has been removed, so the capital femoral epiphysis will overlap the neck.

and superior aspect of the metaphysis becomes more prominent anteriorly and can be mistaken for the capital femoral epiphysis.

It is very important that the correct anatomical relationship be recognized. In a very severe slip, it may be necessary to remove a portion of the anteriorly projecting metaphysis before the epiphysis can be seen. The location of the physeal is then identified and its spatial plane is determined by gentle probing with a Keith needle or hand-held small, sharp, curved osteotome (Fig. 3, A). The size of the wedge to be removed is determined by the degree of the slip and the position of the epiphysis. Enough bone must be removed to allow effortless anatomical reduction of the head on the neck. Therefore, a wider wedge is necessary in a more severe slip. At this time the surgeon must appreciate the direction of the slip, as the epiphysis will displace more posteriorly in some patients and more medially in others. The base of the curved wedge must be in the plane of anticipated correction of the epiphysis. The wedge of bone to be removed is shaped so that the curved contour of the physeal will match the corresponding curved cancellous surface of the neck of the femur. When the size of the wedge to be removed is determined, the bone is removed gently and in very small pieces with an osteotome and mallet. The fragments are wiped from the physeal cartilage as bone removal proceeds (Fig. 3, B). Extreme caution is essential as the posterior aspect of the neck is approached, since the posterior aspect of the periosteum must be protected to avoid vascular damage. A carelessly directed osteotome could damage the blood supply. Therefore, the bone on the posterior aspect is usually removed with a small curet or hand-held curved osteotome. A large curet is used to remove any remaining physeal cartilage (Fig. 4, A). If sufficient bone has been removed posteriorly, the epiphysis will reduce effortlessly with flexion, abduction, and internal rotation of the limb (Fig. 4, B). If insufficient bone has been removed posteriorly and force is required for reduction, an undue amount of tension will be placed on the posterior part of the periosteum and capsule. When an anatomical reduction of the epiphysis has been accomplished, fixation is obtained by means of three or four pins. The pins are six inches (15.2 centimeters)
<table>
<thead>
<tr>
<th>Case*</th>
<th>Age at Onset, Sex (Yrs.)</th>
<th>Side Operated on</th>
<th>Date of Surgery</th>
<th>Type of Slip</th>
<th>Range of Motion</th>
<th>Limb-Length Difference (cm)</th>
<th>Pain</th>
<th>Findings on Radiographs</th>
<th>Length of Follow-up (Trs. + Mos.)</th>
<th>Complications</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14, M</td>
<td>R</td>
<td>12/19/60</td>
<td>Acute chronic</td>
<td>Limited</td>
<td>1.2</td>
<td>Moderate</td>
<td>Moderately severe osteoarthritis</td>
<td>21 + 8</td>
<td>Osteoarthritis</td>
<td>Fair</td>
<td>Progressive arthritis for 12 yrs.</td>
</tr>
<tr>
<td>2</td>
<td>12, M</td>
<td>L</td>
<td>10/5/61</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>21 + 4</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>3*</td>
<td>15, M</td>
<td>L</td>
<td>3/8/65</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>17 + 5</td>
<td>None</td>
<td>Excellent</td>
<td>R. hip pinned in situ</td>
</tr>
<tr>
<td>4</td>
<td>15, M</td>
<td>R</td>
<td>2/22/66</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>18 + 2</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>13, M</td>
<td>L</td>
<td>6/8/67</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>15 + 2</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>6*</td>
<td>10, F</td>
<td>R</td>
<td>12/19/67</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>15 + 6</td>
<td>None</td>
<td>Excellent</td>
<td>Bilat. cuneiform osteots. 13 mos. apart</td>
</tr>
<tr>
<td>7</td>
<td>14, M</td>
<td>L</td>
<td>1/7/69</td>
<td>Acute chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>13 + 11</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>15, M</td>
<td>R</td>
<td>3/25/69</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>13 + 8</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>9*</td>
<td>15, M</td>
<td>L</td>
<td>1/26/70</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>13 + 5</td>
<td>None</td>
<td>Excellent</td>
<td>R. hip pinned in situ</td>
</tr>
<tr>
<td>10*</td>
<td>13, M</td>
<td>R</td>
<td>2/19/70</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>13 + 2</td>
<td>None</td>
<td>Excellent</td>
<td>L. hip pinned in situ</td>
</tr>
<tr>
<td>11</td>
<td>13, F</td>
<td>R</td>
<td>3/10/70</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>12 + 8</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>13, M</td>
<td>R</td>
<td>6/30/70</td>
<td>Acute chronic</td>
<td>Limited</td>
<td>5</td>
<td>Mild</td>
<td>Vitallium mold arthroplasty</td>
<td>12 + 6</td>
<td>Avascular necrosis</td>
<td>Poor</td>
<td>Patient does heavy labor, does not consider himself disabled</td>
</tr>
<tr>
<td>13*</td>
<td>11, F</td>
<td>R</td>
<td>10/6/70</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>11 + 10</td>
<td>None</td>
<td>Excellent</td>
<td>L. hip pinned in situ; brother is Case 14</td>
</tr>
<tr>
<td>14</td>
<td>14, M</td>
<td>R</td>
<td>10/6/70</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>11 + 10</td>
<td>None</td>
<td>Excellent</td>
<td>Sister is Case 13</td>
</tr>
<tr>
<td>15</td>
<td>15, M</td>
<td>L</td>
<td>12/22/70</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>2 + 5</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>13, M</td>
<td>L</td>
<td>12/25/70</td>
<td>Acute on chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>11 + 8</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>17*</td>
<td>13, M</td>
<td>L</td>
<td>4/9/71</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>11 + 3</td>
<td>None</td>
<td>Excellent</td>
<td>R. hip pinned in situ</td>
</tr>
<tr>
<td>18*</td>
<td>15, M</td>
<td>L</td>
<td>11/22/71</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>11 + 0</td>
<td>None</td>
<td>Excellent</td>
<td>Bilat. cuneiform osteots. 2 wks. apart</td>
</tr>
<tr>
<td>19</td>
<td>13, M</td>
<td>L</td>
<td>1/31/72</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>10 + 5</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>13, M</td>
<td>L</td>
<td>2/28/72</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>10 + 1</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>15, M</td>
<td>L</td>
<td>6/9/72</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>10 + 11</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>15, M</td>
<td>L</td>
<td>8/21/72</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>2</td>
<td>None</td>
<td>Normal joint</td>
<td>10 + 9</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>23*</td>
<td>14, M</td>
<td>R</td>
<td>8/24/73</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>9 + 0</td>
<td>None</td>
<td>Excellent</td>
<td>L. hip pinned in situ; brother is Case 37</td>
</tr>
<tr>
<td>24</td>
<td>12, M</td>
<td>L</td>
<td>12/11/73</td>
<td>Acute on chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>9 + 0</td>
<td>None</td>
<td>Excellent</td>
<td></td>
</tr>
<tr>
<td>25*</td>
<td>13, M</td>
<td>L</td>
<td>12/14/74</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>7 + 6</td>
<td>None</td>
<td>Excellent</td>
<td>R. hip pinned in situ</td>
</tr>
<tr>
<td>26*</td>
<td>14, M</td>
<td>R</td>
<td>4/28/75</td>
<td>2nd-degree chronic</td>
<td>Full R.</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>7 + 2</td>
<td>None</td>
<td>Excellent</td>
<td>L. hip, 2nd-degree chronic slip pinned in situ — abnormal range of motion</td>
</tr>
<tr>
<td>27*</td>
<td>10, M</td>
<td>R</td>
<td>5/9/75</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>7 + 1</td>
<td>None</td>
<td>Excellent</td>
<td>L. hip pinned in situ</td>
</tr>
</tbody>
</table>

THE JOURNAL OF BONE AND JOINT SURGERY
TABLE 1 (Continued)

CLINICAL DATA

<table>
<thead>
<tr>
<th>Case*</th>
<th>Age at Onset, Sex (Yrs.)</th>
<th>Side Operated on</th>
<th>Date of Surgery</th>
<th>Type of Slip</th>
<th>Range of Motion</th>
<th>Limb-Length Difference (cm)</th>
<th>Pain</th>
<th>Findings on Radiographs</th>
<th>Length of Follow-up (Yrs. + Mos.)</th>
<th>Complications</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>28*</td>
<td>12, M R</td>
<td>12/2/75</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>6 + 8</td>
<td>Excellent L. hip pinned in situ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>15, M R</td>
<td>7/25/77</td>
<td>Acute on chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>5 + 9</td>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>11, F L</td>
<td>8/17/77</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>1.2</td>
<td>None</td>
<td>Normal joint</td>
<td>5 + 1</td>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>12, M L</td>
<td>10/10/77</td>
<td>3rd-degree chronic</td>
<td>Full L.</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>4 + 10</td>
<td>Excellent Perthes disease causing limited abduction and rotation of R. hip</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>13, M L</td>
<td>6/8/78</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>4 + 6</td>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>13, M L</td>
<td>8/29/78</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>4 + 1</td>
<td>Excellent 1-mo. delay in treatment: 1st-degree slip progressed to 2nd-degree</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>12, M R</td>
<td>9/29/78</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>2</td>
<td>None</td>
<td>Normal joint</td>
<td>3 + 11</td>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>14, M R</td>
<td>9/18/79</td>
<td>3rd-degree chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>3 + 3</td>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36*</td>
<td>12, F L</td>
<td>10/9/79</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0</td>
<td>None</td>
<td>Normal joint</td>
<td>4 + 3</td>
<td>Excellent Bilat. cuneiform osteot. 2 wks. apart</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>13, M L</td>
<td>8/1/80</td>
<td>Acute on chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>2 + 0</td>
<td>Excellent Brother is Case 23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>14, M R</td>
<td>11/3/80</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>2 + 0</td>
<td>Excellent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>13, M R</td>
<td>1/12/81</td>
<td>2nd-degree chronic</td>
<td>Full</td>
<td>0.6</td>
<td>None</td>
<td>Normal joint</td>
<td>2 + 0</td>
<td>Excellent Brother is Case 32</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Bilateral involvement.

in length, of which three inches (7.6 centimeters) is smooth and three inches is threaded with a knurled nut on the threads (Fig. 5). The pins should be directed toward the center of the head, but should not be allowed to penetrate the articular cartilage of the epiphysis because this would cause damage to the acetabular cartilage. They should penetrate the epiphysis only deep enough to obtain firm fixation. The epiphysis cannot grow away from the pin and cause subluxation. Twenty-seven of the forty-two hips had shortening of the neck of the femur and a corresponding limb-length discrepancy. Except in the one patient with a poor result, the shortening ranged from 0.6 to two centimeters. The greatest shortening was seen in the patients with the greatest degree of displacement. In those patients a larger wedge of bone was removed to permit anatomical reduction of the head. However, none of the patients with shortening had a limp, wore a shoe-lift, or had abduction weakness.

Two patients had limitation of motion of the contralateral hip. One (Case 26) had a second-degree slipped epiphysis that was pinned in situ and had lost 20 degrees of internal rotation. The other (Case 31) had mild limitation of motion in the right hip because of Perthes disease.

The one patient with a fair result (Case 1) had progressive osteoarthritis in the right hip for twelve years to date. Early radiographic changes of osteoarthritis were evident in 1970. However, he had only mild discomfort after 1979. In spite of the advanced radiographic changes, he worked full time in a dairy at a job that required prolonged standing and heavy lifting (Figs. 6-A through 6-D).

Results

Of the forty-two hips that I studied, in forty the result was graded as excellent; in one, fair; and in one, poor. No patient had chondrolysis, a wound infection, or thrombophlebitis (Table I).

Twenty-seven of the forty-two hips had shortening of the neck of the femur and a corresponding limb-length discrepancy. Except in the one patient with a poor result, the shortening ranged from 0.6 to two centimeters. The greatest shortening was seen in the patients with the greatest degree of displacement. In those patients a larger wedge of bone was removed to permit anatomical reduction of the head. However, none of the patients with shortening had a limp, wore a shoe-lift, or had abduction weakness.

Two patients had limitation of motion of the contralateral hip. One (Case 26) had a second-degree slipped epiphysis that was pinned in situ and had lost 20 degrees of internal rotation. The other (Case 31) had mild limitation of motion in the right hip because of Perthes disease.

The one patient with a fair result (Case 1) had progressive osteoarthritis in the right hip for twelve years to date. Early radiographic changes of osteoarthritis were evident in 1970. However, he had only mild discomfort after 1979. In spite of the advanced radiographic changes, he worked full time in a dairy at a job that required prolonged standing and heavy lifting (Figs. 6-A through 6-D).
Figs. 6-A through 6-D: Case 1.
Fig. 6-A: I could not obtain the original radiograph showing the slip. This anteroposterior radiograph made ten years postoperatively shows early degenerative arthritic changes.
Fig. 6-B: Frog-leg lateral radiograph showing early degenerative arthritis. Note the normal alignment of the head and neck of the femur.

Fig. 6-C: Anteroposterior radiograph showing an increase in the osteoarthritis. Note the joint-space narrowing and the osteophyte formation on the superior margin of the femoral head.
Fig. 6-D: Frog-leg lateral radiograph showing progressive osteoarthritis with spurring of the acetabular margin and marked narrowing of the joint space.
The one poor result (Case 12) occurred in a boy with an acute slip superimposed on a chronic one. As gentle manipulation under anesthesia resulted in only a partial reduction, a cuneiform osteotomy was done. Aseptic necrosis was evident five months after surgery. A Vitallium mold arthroplasty was done, and at the time of writing the boy had a functional hip (Figs. 7-A through 7-E).

Five other patients had an acute slip superimposed on a chronic slip, but all of them had an excellent result. A thirteen-year-old boy (Case 16) had had a six-week history of aching in the left thigh and knee prior to a fall at home. We first saw him after the fall. Gentle manipulation of the acute slip did not produce a satisfactory reduction, and an osteotomy was done. The fixation pins were removed six months later (Figs. 8-A through 8-E).

The remaining thirty-five hips had a chronic slip with displacement of 30 to 90 degrees; all of them were treated by cuneiform osteotomy. The results in these hips were all graded as excellent. The following case reports are examples of this group.
Figs. 8-A through 8-E: Case 16.

Fig. 8-A: Anteroposterior radiograph of the left hip of a boy with an acute slipped epiphysis on a chronic slip.

Fig. 8-B: Anteroposterior radiograph made after a cuneiform osteotomy that was necessary to obtain anatomical reduction of the femoral epiphysis. Gentle manipulation had produced only a partial reduction.

Fig. 8-C: Frog-leg lateral radiograph showing anatomical reduction of the head on the neck and the pin fixation. Note that the diameter of the head is larger than that of the neck as a result of bone removal. After healing, this overlap should not be confused with the osteophyte formation seen in degenerative arthritis.

Fig. 8-D: Anteroposterior radiograph made eleven and one-half years after the injury, showing a normal hip joint. There is mild shortening of the neck due to the removal of bone at the time of the osteotomy.

Fig. 8-E: Frog-leg lateral radiograph demonstrating anatomical reduction of the femoral head and no evidence of osteoarthritis.

Case 11. A thirteen-year-old girl gave a typical history of intermittent discomfort in the thigh and knee for five months. The severe slipped epiphysis was corrected by a cuneiform osteotomy and the pins were removed six months later. At the time of examination, nearly thirteen years later, the patient was fully active, including participation in sports, and had not had any discomfort about the hip since the osteotomy. She had a normal range of motion of the hip and a normal radiograph (Figs. 9-A through 9-F).
Case 13. An eleven-year-old girl fell from a sled in February 1970. In spite of a limp and pain in the knee, radiographs of the hip were not made until September 1970, when the patient was first seen in the office. A diagnosis of a third-degree slipped capital femoral epiphysis was made and the girl was treated with cuneiform osteotomy. At follow-up nearly twelve years later, the patient weighed two hundred and twenty pounds (99.8 kilograms), had no restriction in activity, and had a normal physical examination of the hip. The radiograph showed a normal joint space but a shortened neck of the femur due to the amount of bone removal that was necessary to completely restore the head-neck relationship (Figs. 10-A through 10-F). The patient's brother (Case 14) also had a chronic third-degree slipped epiphysis.

Case 33. The case of this thirteen-year-old boy illustrates the urgency of treatment once the diagnosis has been made. The patient had had symptoms in the hip for four weeks when he was first seen in July 1978 and
Figs. 10-A through 10-F: Case 13.
Fig. 10-A: Anteroposterior radiograph of a chronic third-degree slip. There is varus displacement of the epiphysis.
Fig. 10-B: Frog-leg lateral radiograph showing a 70-degree posterior displacement. Note the extensive remodeling of the posterior aspect of the metaphysis.
Fig. 10-C: Anteroposterior radiograph showing reduction of the femoral head and healing of the osteotomy one year after surgery.

Fig. 10-D: Frog-leg lateral radiograph demonstrating anatomical reduction of the head. There is no evidence of osteoarthritis.
Fig. 10-E: Anteroposterior radiograph made twelve years after surgery, showing no evidence of osteoarthritis. The neck has undergone considerable shortening due to the amount of bone removal that was necessary for correction.
Fig. 10-F: Frog-leg lateral radiograph showing a normal hip joint. The sharp margin on the posterior aspect of the femoral head is not an osteophyte but is due to overlap at the time of osteotomy, as the diameter of the head is larger than that of the neck.

Discussion
This report demonstrates that it is possible to perform a cuneiform osteotomy of the femoral neck with only slight danger of causing aseptic necrosis of the head of the femur, provided the operation is meticulously done by an experienced surgeon. Trueta described a preadolescent period in

\[ \text{FIG. 10-A} \]
\[ \text{FIG. 10-B} \]
\[ \text{FIG. 10-C} \]

\[ \text{FIG. 10-D} \]
\[ \text{FIG. 10-E} \]
\[ \text{FIG. 10-F} \]
Fig. 11-A: Anteroposterior radiograph showing only slight irregularity of the physis.
Fig. 11-B: Frog-leg lateral radiograph showing mild posterior displacement of the capital femoral epiphysis.

Fig. 11-C: Anteroposterior radiograph made six weeks later, showing mild varus deformity of the capital femoral epiphysis.
Fig. 11-D: Frog-leg lateral radiograph showing posterior displacement of 40 degrees. The deformity developed in spite of protective walking with crutches.

the development of the hip that applies to patients in this age-group. The cartilaginous physis acts as a barrier to the vessels of the metaphysis, so the blood supply from the lateral epiphyseal vessels must pass through the posterolateral part of the periosteum of the neck to reach the epiphysis. A carelessly directed osteotome or manipulation producing tension on the posterior part of the periosteum can therefore damage these vessels.

As the patient passes from the preadolescent to the adolescent period, the physis begins to close, thus permitting anastomosis of the metaphyseal vessels with those of the epiphysis. DePalma et al.⁷ speculated that when an oste-
An osteotomy is done through the physis, followed by removal of the physeal cartilage and meticulous osteotomy of the metaphysis, the bone apposition obtained would permit some of the blood supply to the epiphysis to come from the metaphysis. For this reason, with the procedure described the physeal cartilage is thoroughly removed with a curet at the same time that the deformity is corrected. After skeletal maturation and closure of the physis, the metaphyseal vessels anastomose with the vessels of the epiphysis. When this has occurred, an osteotomy through the neck of the
femur will divide these vessels, with resultant damage to the circulation of the femoral head. For this reason, a patient whose physis has already closed is not a candidate for cuneiform osteotomy.

No patient in this series was treated by preoperative traction because of the risk of increasing intra-articular pressure by preventing flexion and external rotation of the hip, the position of capsular relaxation. Manipulation was used only in patients with an acute slipped capital femoral epiphysis and never in those with a chronic slip. Many authors have rightfully condemned manipulation in the presence of a chronic slip, as they believed that this produced a high incidence of aseptic necrosis.

Fixation of the osteotomy must be done with small smooth pins, and never with a device such as the Smith-Petersen nail, which can drive the head from the neck or cause a fracture of the head or neck of the femur.

Boyer et al. reported on a large series of patients with a slipped epiphysis who were treated between 1915 and 1925. The results were less favorable in patients who were treated by surgical correction than in those who were treated by fixation in the unreduced position. However, 93 per cent of the patients who were treated by a realignment procedure had a moderate or severe slipped epiphysis, while 61 per cent of those treated by in situ fixation had a mild slip. The hips with the worst results were those in which manipulation was the method of realignment of the epiphysis. Boyer et al. concluded that these results, however, should not be compared with results of current operative techniques for which long-term follow-up is not yet available. The Iowa hip-rating scale, which they used, is very liberal in its assessment of the hip: it stresses function in terms of activities of daily living but does not consider athletics or heavy labor. Boyer et al. found that patients with a severe slipped epiphysis that had been fixed without realignment all had limited motion, limited function, and reduced walking endurance, which are placed accurately into the center of the head of the femur.

For a successful cuneiform osteotomy, it is essential that treatment be administered immediately after the diagnosis has been made. Preoperatively the patient is placed at bed rest with the limb elevated on pillows in the position of comfort and is not placed in traction. Manipulation is done only for an acute slip, with the patient anesthetized, and is never forceful.

It is also essential that the operative approach provide enough exposure to allow full visualization of the head and neck of the femur. The surgeon must appreciate the pathological anatomy of the involved hip and must know precisely the locations of the physis and the femoral head. The surgery requires the meticulous dissection and removal of a wedge of bone in small pieces. Enough bone is removed posteriorly to allow easy and atraumatic reduction of the head on the neck of the femur. The wedge must be large enough to provide for anatomical reduction of the head of the femur on the neck without tension on the posterior aspect of the peristeme. Fixation is then done with smooth pins, which are placed accurately into the center of the head of the femur.

The patient is kept on partial weight-bearing with crutches until the osteotomy has healed. The operation should not be done in a patient whose physis has closed.

References