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Studies in slipped capital femoral epiphysis

Theodore Ronald Simon
Yale University

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Studies in Slipped Capital Femoral Epiphysis

by

Theodore Ronald Simon
B.A. Psych., Trinity College (Hartford, Conn.), 1970

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To my new wife, Marcia

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ANNOTATED TABLE OF CONTENTS

Slipped Capital Femoral Epiphysis--
Nature of the Disease, Its Classifications, and Diagnoses

by

Theodore Simon

Fourth Year Student

Yale University School of Medicine

> The epiphysis of the head of the femur sometimes becomes disjointed and separated in such a way that the surgeon is misled, thinking that it may be a luxation and not separation of the epiphysis of this bone.

These words of Paré, in 1572, introduced the problem of slipped capital femoral epiphysis (SCFE) to the world's medical literature. The keyword of this description is "misled," "<u>deçu</u>," for, despite four centuries of medical progress marked by numerous attempts to unravel the disease, its pathogenesis remains evasive and its etiology, spectral.

This section reviews the progress made in defining and characterizing the disease. Major theories explaining proposed etiologies for the disease will follow. The final section of this chapter outlines the various treatment modalities available in terms of their indications and complications.

The femoral head is attached to the femoral neck through the capital femoral epiphyseal plate. This plate has less shear resistance than solid bone. Forces that are sufficient to deform the epiphyseal plate, but are resisted by the bone, tend to displace the femoral head posteriorly. This deformation constitutes a slipped capital femoral epiphysis.

Several signs of this disease include: cephalad and external rotation of the femoral neck and shaft relative to the femoral head, manifesting both as an external rotation of the leg with restricted rotation and abduction most obviously displayed in flexion and as a laterally rotated leg often blocked from a neutral position even with passive internal rotation; slight adduction and a positive

Trendelenburg with the weight resting on the affected hip when standing; a one to two centimeter shortening of the affected lower extremity, often with noted elevation of the greater trochanter; some tenderness with pressure; irritation which may severely limit motion and hip contractures.

Symptoms associated with this disease include: hip pain, hip spasm, anterior thigh and knee pain and an antalgic gait disturbance. Sometimes they extend for months with intermittent pain-free episodes. Physicians most commonly pass over the knee pain as a local problem without ordering the x-rays to prove that the pain, in fact, does not stem from the hip. This failure to recognize SCFE in the referred pain constitutes a common SCFE diagnostic error.

The differential diagnosis at this point of inquiry includes: Legg-Calve-Perthes, congenital coxa vara, tuberculosis of the hip, fracture of the femoral neck, adolescent avascular necrosis and renal rickets. Let us look at each of these.

Legg-Calve-Perthes spawns less severe signs than does SCFE. Moreover, the patient is usually under ten years of age and the x-rays show a fragmentation of the femoral head without displacement. Such x-ray signs would not agree with the displacement of the femoral head so characteristic of SCFE.

Congenital coxa vara usually is diagnosed in the very young patient, a rare age for SCFE patients. Confirmation comes from x-ray studies depicting the femoral neck deformities uncharacteristic of SCFE.

Tuberculosis of the hip fosters very severe symptoms with

decreased ranges of motion in many directions and severe cartilage space narrowing. The fixed deformity in flexed adduction and internal rotation is usually most severe. X-rays picture an atrophic upper femur with varying degrees of head destruction, rather than the fixed deformity that would be expected from SCFE.

A fractured femoral neck results from greater trauma than a SCFE, causes more pain, involves more severe disability and should manifest a sharp femoral neck fracture line on x-ray examination.

Adolescent avascular necrosis can be readily detected as a deteriorated femoral head by x-ray, although the clinical situation often mimics that of SCFE.

Renal rickets cannot be ruled out even by x-ray. If there is concern about the kidneys, appropriate special tests should be initiated.

The diagnosis of SCFE depends upon x-ray studies, especially a frog-leg lateral view in order to delimit the diagnosis. Such studies can rule out all the potential diagnosis except renal rickets. Ferguson (10) reports that sixty-eight percent of patients show a medial slip visible in an A-P view but ninety-eight percent exhibit a posterior slip which a frog-leg lateral can detect. An A-P view can disclose an absence of normal prominences of the anterior lateral femoral epiphysis on the upper aspect of the head and neck, a sickle shaped epiphysis with the lower border projecting as a beak-like process below the lower cervical margin, a widened, occasionally irregular, epiphyseal line with demineralization in the adjacent bone and a displaced femoral neck that is short

and broad. A frog-leg lateral view can show a posteriorly slipped head overhanging an often thickened femoral neck. Avascular necrosis may also be found or necrosis of articular cartilage without bone necrosis. If the SCFE is associated with a supra-tentorial tumor in late childhood, x-ray studies may demonstrate an enlarged pituitary fossa, delayed epiphyseal fusion and a thickened growth cartilage.

At this point, an operative definition for SCFE has been presented and the differential diagnosis has been discussed. Before groping into its dim origins, let us further describe the syndrome in order to have the best possible chance of understanding its vaporous bowels.

The posterior inferior displacement leads to damage of the articular cartilage as explained in Section six. This ensuing cartilage damage increases the need for remodeling of solid bone, thus stimulating localized circulation posteriorly and giving rise to the frequently observed swollen synovial membranes with localized edematous villous formation, edema of the periosteum and joint capsule as well as the synovial hyperemia. It must be noted that some authorities, e.g. Strange (49), attribute the synovial changes to localized irritation. In any case, the villous formation is marked by an infiltration of perivascular lymphocytes and plasmacytes (10,24). At first, the epiphyseal line is smooth and glistening with the actual line somewhat hidden. Anteriorly and superiorly, bluish fibrous tissue with islands of bare bone appear among the normal articular cartilage structures. The epiphyseal disc remains attached to the

femoral head while slipping in the more distal areas. In the meantime, the angle between the femoral neck and epiphysis fills in with callus and the femoral neck stump becomes increasingly covered with calcified cartilage leading to fibrocartilage. Later, the synovia, after becoming hyperplastic, turns firm and sclerotic. The capsule becomes thickened with callus conversion at the inferior angle of the epiphyseal line to the bone. This unstable pelvis results in pathologic changes in the symphysis pubis in fifty percent of the cases (45).

Microscopically, a cleft develops in the growth plate through the hypertrophic cells. The cells proliferate and palisade but remain attached to the femoral head and the calcified femoral neck cartilage.

Throughout the centuries, much etiological speculation has generated little understanding of SCFE. Howorth (23) offers an excellent account of medical opinions regarding this syndrome, complete with a definitive bibliography through 1965. A rapid synopsis of the quest to understand SCFE follows.

Howorth quotes Paré as suggesting trauma and joint fluid stagnation cause SCFE. Later, he cites Petit in _Traite des Maladies des Os_ of 1837 as observing:

> ...slipping can occur only in young subjects where the cartilage which joins the epiphysis has not yet ossified; for, in those where ossification is complete, the neck and the epiphysis having become one, should the head become separated, this would be through fracture and not through simple slipping...

Thus the age of the group at risk for SCFE was limited, over a

century ago, to children and adolescents. Mueller (37), in the classic paper, provides a detailed description of the syndrome followed by speculation on the etiology. Howorth listed the front-running candidates for SCFE etiology by the turn of the century which included systemic diseases, "mysterious" femoral neck bending, and trauma. By 1926, hormonal influences were presciented by Key and Posetti (28) and McClintock (41). The former suggested that rapid growth contributes to SCFE. The latter reported on sixteen patients with SCFE, three of whom had hormonal dysfunction (two had hypophyseal tumors and one had euchnoidism), and observed that children with SCFE tended to be very large with small sellae turcicae. The list of impuned etiologies is comprised of mind-boggling numbers of seemingly unrelated suspects. In the face of this difficult situation, some had abandoned the single etiology theory, suggesting that the SCFE syndrome represents many disease entities each possibly with a separate etiology. This veritable graveyard of etiological phantoms must be examined systematically. The previously suggested etiologies may be grouped into three classes, the three "C's" of SCFE. The Core class contains possible congenital and idiopathic etiologies. Core etiologies are achondroplasia, idiopathic femoral neck bending, femoral periosteal weakening, osteochondrosis, dysplasia epiphysialis multiplex, spontaneous displacement of the capital epiphyses of the femur and humerus, heredity and habitus. The Contracted class comprises those possible etiologies linked to other disease states contracted during life. These include rickets, osteomalacia, osteitis deformans,

arthritus deformans, synovitis, rheumatic acetabular calcium deposits, infection, tumors and alteration in protein metabolism. The Control class comprises those possible etiologies over which the individual can exercise some control. These include the strain of lifting heavy weights, acute trauma, lack of fluorides, excess of aminonitriles, obesity, and seasonal distribution. This classification only simplifies consideration of the possible etiologies. Obviously various classes may work together: e.g. the Core class provides the patient's Froelich habitus while the Control class determines his obesity. Let us now consider the theories in terms of the Three C's.

The opening quotation from Paré linked SCFE to fusion of the epiphysis and noted that the syndrome could not occur after full femoral maturation had occurred. This is borne out by incidence reports of the disease occurring in boys ten to seventeen years and girls eight to fifteen years old. The high incidence of bilterality, twenty to forty percent, supports the notion that the condition of the patient is ripe for the displacement to occur. The Core class offers achondroplasia as a possible etiology. The absence of a cartilaginous cushion would magnify the forces acting through the hip joint on the femoral head. These increased forces are then transmitted to the fragile epiphyseal plate. Idiopathic femoral neck bending would alter the force vectors as they travel through the epiphyseal line. Femoral periosteal weaking is a mechanism rather than an etiology. If the periosteum cannot lend both nutritional and structural support to the femoral head

and neck, the increased burden must be borne by the bone and cartilage. This added stress could facilitate SCFE but provides little in the way of etiology. Osteochondrosis could so weaken the developing capital femoral epiphysis and lead to such a structural distortion that the structure might not completely regenerate and, therefore, never attain its maximum potential strength to bear the normal stresses on the joint. During the degenerative phase of osteochondrosis, the cartilage would be especially susceptible to the weakening processes, yet few case reports exist of SCFE occuring that phase. Dysplasia epiphysialis multiplex would alter the lines of forces through the flattened, hypoplastic epiphysis and thus subject the structure to unusually large stresses. Heredity comprises a panoply of possible etiologies. There is a significant familial aggregation of subjects afflicted with this disorder and of subjects whose close blood relatives have other similar orthopedic disorders. No good studies seem to have clearly delimited this association. Habitus or, more generally, hormonal status, proves to be worth a short discussion.

Epiphyseal closure depends upon hormonal control from the thyroid not, as often believed, from the hypophysis. Since SCFE can only occur before epiphyseal closure, hormones may well play a vital role in the disease. Strange (49) suggests that the disease is secondary to a mismatching of the physical adult and the physiological adult. In this regard he states that the commonly described Froelich habitus is only a resemblance to the Froelich syndrome since the adenohypophysis is neither squeezed nor hypertrophic.

Rather, the two most common patient habiti, i.e., the tall, obese, hypogonadal type and the tall, lean type, result from an excess of growth hormones relative to sex hormone. This imbalance favors height leading to widened hypertrophic cartilage cell layers in the epiphyseal line. This result increases the cellular size and the quantity of cells in the epiphyseal line at the expense of the supporting intercellular cartilaginous matrix. The widened, structurally poor plate then loses its ability to withstand stress. During adolescence, the normal horizontal orientation of the epiphyseal plate becomes more vertical while the periosteum and perichondrium become thinned. Harris' (16) studies demonstrated that epiphyseal slippage was facilitated by growth hormone and impeded with estrogen. Sharrod (45) reported that the growth plate, weakened by growth hormone, would alter the third epiphyseal plate layer and thus diminish the shearing strength of the epiphyseal plate. He also noted that sex hormones reversed this effect. The importance of this theory may be appreciated when one realizes that seventy percent of SCFE patients are classified as having a Frolich habitus.

The contracted class offers other interesting avenues of speculation. Rickets and osteomalacia are diseases weakening bone. A weakened bone cannot support its load as effectively as normal bone. The difference must be made up by the other structures, thus the epiphyseal plate is abnormally taxed, a tax it may not be able to bear. Osteitis deformans causes femoral bowing, resulting in altered lines of force which biomechanically stress the

epiphyseal plate as explained in Section four. Arthritis deformans contributes to SCFE in three ways: atrophy and rarefaction of the bones diminishes their strength with the consequences mentioned above, ankylosis leads to gait disturbances which by themselves increase the stress upon the epiphyseal plate as described in Chapter six, finally the accompanying synovitis undermines the strength of the epiphysis. Rheumatic acetabular calcium deposits restrict the motion of the joint and raise its resistance to motion. These effects require and increase in energy which, when absorbed, increase the stress on the epiphyseal plate. Infection can lead to the destruction of the capital epiphysis with or without dislocations of the hip or epiphyseal plate. Tumors of the adenhypophysis and lesions of the hypothalamus can induce the Froelich habitus and involke the mechanism described above. This etiology is associated with unextreme dwarfism, mental retardation, amenorrhea, undescended testes and lack of secondary male sex characteristics. Alterations in protein metabolism will affect the structural integrity of the supporting structures.

The control class of possible etiologies provides additional explanations for this syndrome. Thirty-three percent of SCFE patients have a history of hip injury. Since the epiphyseal plate transmits stress caused, in part, by the weight that the hip supports, increasing that weight by lifting heavy loads increases the stress upon the vulnerable epiphyseal plate and, in extreme cases, can induce a slip. A SCFE can be experimentally created if the semiflexed, abducted lower extremity is dealt a blow to the

outer side of the thigh just below the greater trochanter. Hyperextension, such as through trauma, of more than fifteen degrees so strains the epiphyseal plate that yielding and slipping can occur. Among patients under nine years old, the most common cause of sudden onset of SCFE is traumatic separation after injury or violence. Southwick and Kelsey (47) note that fluorides have no demonstrable effect on SCFE. Obesity is related to hormonal abnormalities and to increased epiphyseal plate stress due to increased loads. Both of these effects have been discussed above. Southwick and Kelsey (47) report that the incidence of SCFE during the spring and summer in Connecticut is higher than during autumn and winter. No explanation is offered for this effect. Finally, rat studies implicated aminonitriles in the disease process. A diet of fifty percent sweet pea (Lathyrus odoratus) seeds was associated with a host of diseases including SCFE. The proposed mechanism involved weakening of the transitional zone of the cartilage, presumably by affecting chondroitin sulfate in the ground substance, according to Ponsetti and Shepard (42).

After describing the phantom and speculating about how he may be conjured, it is important now to learn how to control him. Reasonable treatment goals are to favor healing, correct femoral head displacement, maintain the femoral head in a satisfactory position, correct the residual of any deformity and provide as normal a range of motion with function as possible. The earlier a treatment is implemented, the better the results seem to be. However, this fragile area penalizes increasingly radical therapy with decreasingly satisfactory results. Nevertheless, total neglect may

be greeted by a broadened, flat, and irregular femoral head with a thickened femoral neck bowed forward as well as possible disintegration of the cartilage over the lower portion of the head.

The treatment modalities fall into nine broad categories: bedrest, traction, plaster casts, endocrine therapy, reduction of the SCFE, internal fixation of the femoral head *in situ*, osteotomies, resection of femoral head and neck and excision of hump of femoral neck. These will be discussed in Section three. At this point, let us summarize how others suggest one treat SCFE.

Newman (39) considers SCFE as occurring in three groups. Group one defines those SCFE's with an acceptable epiphyseal position. This is broadly defined with a choice of either a displacement of less than one-third of the femoral neck diameter in the lateral view or less than one centimeter in each plane. He recommends *in situ* fixation without manipulation for this group. Group two comprises those SCFE's with an unacceptable but mobile epiphyseal position for whom he suggests either closed reduction or traction. The final group, three, has an unacceptable, immobile epiphyseal position. This group, he advises, should be treated by osteotomy.

Speed (48) divides SCFE into five types. Type I comprises those slips in an early gradual SCFE with the epiphysis migration on the femoral neck less than one-third of the diameter of the neck. These, he asserts, have an excellent prognosis with internal fixation that avoids opening the hip joint. Type II is identical to Type I except that the gradual slip extends to a greater degree. For this type, he advocates osteotomy through the femoral neck or

through the trochanteric area as a means of counteracting the deformity. Type III contains those that are not normally united. For these patients he offers several treatments. The young with a closed lesion whose displacement is more than one-half of the neck diameter should be treated with a trochanteric osteotomy. The young or early adolescent whose displacement is less than one-half of the femoral neck and who demonstrates minimal or moderate external rotation should receive a symmetrical cuneiform trochanteric osteotomy as primary treatment. Both types II and III carry a somewhat guarded prognosis (fifty percent excellent, twenty-five percent fair and twenty-five percent poor). Type IV, post-traumatic SCFE, carry a poor prognosis with the recommended treatment of logitudinally splitting the capsule and fixing the three Knowles pins. No specific treatment is offered for Type V slips, those old malunited SCFE with hypertrophic arthritic changes and possible coxa magnum. Ferguson (10) suggests internal _in situ_ fixation for SCFE of less than one centimeter but otherwise traction in abduction and internal rotation to increase the range of motion of the hip, followed by encasement in a spica cast. Bianco (5) agrees for a moderate SCFE. He stipulated that a non-extensive-moderate slip may be treated by osteoplasty and older patients may best be treated with a subtrochanteric osteotomy. He reserves arthrodesis for extensive slips in young active boys. He also suggested alternative treatments such as excision of the femoral neck protuberance and valgus subtrochanteric osteotomy.

Strange (49) agrees that acute SCFE should receive traction, about seven to fifteen pounds for seven to ten days without rotation.

For minor slips, less than one-third of the diameter of the femoral neck, he advocates non-weight bearing for at least three months or until the capital femoral epiphysis is fused. Severe slips should be treated with a curved or cuneiform subcapital osteotomy either at the displacement plane, or at a distance with a half wedge. Alternatively, he suggests accepting the deformity attempting only to prevent arthritis. Strange recommends that the contralateral hip be pinned and that Froelich patients receive FSH-LH therapy.

Sharrod (45) concurs with the notion of prophylactic pinning of the other hip but reserves this operation for those cases where there is some doubt about a possible SCFE in the contralateral hip. Sharrod's regiment is divided between acute and gradual SCFE. He believes that acute SCFE is best treated with gentle manipulation of the flexed hip in medial rotation causing abduction and extension providing the procedure is done less than two to three weeks after the episode. He reserves internal fixation for release of medial rotation. He maintains that gradual SCFE should not receive bedrest, traction or forced manipulative reduction. They should be internally fixed in the position of the deformity. A subtrochanteric osteotomy is also an acceptable treatment modality as is a femoral neck epiphyseal plate osteotomy with internal fixation if one accepts the thirty-eight percent rate of avascular necrosis. Sharrod notes that fusion of the epiphysis may be expected in nine months to one year after pinning. He recommends that pinning be aimed at the center of the capital epiphysis at the anterior lateral junction of bone. For alleviation of mechanical obstruction, he recommends the Herndon-

Heyman bumpectomy procedure.

The dangers of these forms of therapy are many. The most severe complication is avascular necrosis which occurs in five percent of gradual but fifteen to twenty percent of acute slips, especially those with an uncovered metaphysis. The disease tends to fix the acetabulum in abduction and medial rotation which, combined with the attendant epiphyseal avacularity leads to rapid osteoarthritis. Avascular necrosis was discussed in Frangenheim's (11) description of 1911. It can present as a limp, pain or spasm with activity, disability, ankylosis from diminished range of motion, a flexion adduction contracture, osteoporosis, destruction of the femoral head and acetabulum and as a narrowed joint space. Blacks are more commonly affected than whites. The immediate cause is poor femoral head circulation and consequent failure of nutrition to the articular cartilage via the synovial fluid. This compromised circulation may be brought about by osteotomy of the femoral neck which Wiberg (12) describes as a "difficult and dangerous" procedure. Other precipitating procedures include closed manipulation with or without reduction, open reduction, spica cast immobilization, cuneiform osteotomy without long leg casts, and internal fixation including bone pegging. Treatment may take the form of anti-inflammatory agents, and active motion within the limits of pain. This disease carries a bad prognosis for restoration of a good joint.

Osteoarthritic pain poses another treat to the SCFE patient. A joint deformity, compromised joint mechanics, joint abuse, poor

circulation and obesity can trigger inflammation leading to edema and effusions with increased cellular tension and an irritated synovial membrane. These events weaken an already mechanically disadvantaged joint. The process of supporting the same body weight, thus increases the work of the joint which in turn may cause painful muscular spasm.

These major complications are supplemented by a host of other problems with SCFE therapy. Elucidating these problems is the major task of this paper.

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Slipped Capital Femoral Epiphysis--
A Study of the Population Sample in Four Hospitals

by

Theodore Simon

Introduction

This study serves to define the population at risk for developing slipped capital femoral epiphysis (SCFE). Although epidemiological studies of this disease have been completed, this large sample helps to confirm the earlier work. Moreover, it characterizes the relationship of this sample with previous samples and hence evaluates the contention that the results of other studies on this sample are based on a typical group of SCFE victims.

Method

All patients receiving their initial SCFE therapy at Children's Hospital (Baltimore), before August 1, 1974, Johns Hopkins Hospital from July 1, 1967 to August 1, 1973, Newington Children's Hospital from July 1, 1953, to July 1, 1973, or Yale-New Haven Hospital before July 1, 1973, were included in this study. Patients were discovered by consulting the medical records departments of each of the four participating hospitals. Each chart was first screened to eliminate those patients who received their initial SCFE treatment at another hospital. The roentgenograms were then studied to confirm the SCFE diagnosis. The final list, with the accompanying x-ray chart data, served as the basis for this report. Some aspects of the disease can be affected by follow-up maintained by the institutions or the physicians. Attempts were made to follow up patients through the last known address or through private physicians' records.

In analyzing the population for this study, the following information was examined :patients' age when therapy was initiated,

sex, race, height, weight, size of slip and the incidence of disease in close relatives. The age at the initiation of therapy was selected because it was a precise and fairly accurate indication of the time of slipping. The physicians' estimate of the interval between the actual slipping and therapy for each individual is less than six months, usually much less, in the vast majority of cases. One case of undue long-term postponement was eliminated from the age data as noted. Also eliminated from the age, weight and height data were those cases of traumatic SCFE occurring before age three as noted. The weights and heights of the individuals at the time of SCFE were converted into percentiles using guidelines presented in Diem and Lentner (1). When this information was not available, it was either omitted from the study or, in those records supplying descriptions such as "obese" or "tall," the adjective was noted in the table reflecting the data from the individual hospital. The side of the SCFE was recorded as it appeared on x-ray except in those cases in which investigation revealed later development of a contralateral slip. These patients were listed as bilateral SCFE's with the appropriate explanation provided on the table reflecting the data from the individual's hospital.

Incidences, compiled in the manner described above, were supplemented with appraisals of the therapeutic outcomes. For this section, patients were evaluated on the basis of notations in the hospital chart. Four groups were differentiated, see Table 2-1. Patients rated as a "good" result had either no adverse comments or problems limited to the following: mild hypertrophy, device in joint space, mild cartilage space narrowing, difficult removal of device, osteoporosis,

Table 2-1

Criteria for Estimation of Results Based on Table 4

	Pain	Range of Motion	Roentgenogram	Function/Other
Good	None or rare Numbness	Nearly normal Nearly symmetrical	Normal Mild hypertrophy Device in cartilage Mild cartilage space narrowing Osteoporosis Minor femoral head flattening	Difficult device removal Thigh atrophy Wound infection
Fair	Bursitis with pain Pain on activity	Moderately decreased	Moderate to severe degenerative cartilage space changes Leg shortening of at least one inch	Moderate gait impairment Back knee
Poor	Severe disabling	Severely decreased	Aseptic necrosis Avascular necrosis Ankylosis	Severe gait disturbance
Indeterminate	THOSE SCFE RESULTS OBSCURED BY THE PRESENCE OF OTHER SEVERE CARTILAGE OR DEGENERATIVE DISEASES OF THE HIP.			

minor femoral head flattening, thigh atrophy, wound infection and numbness.

Patients rated as "fair" did not qualify as poor or indeterminate results but had one or more of the following comments: moderate to severe degenerative cartilage space changes, moderate decrease in range of motion, leg shortening of one inch or greater, moderate gait impairment, bursitis with pain, pain on activity and back knee.

Patients falling into the "poor" result category suffered aseptic or avascular necrosis, severe gait disturbances or ankylosis.

Patients falling into the "indeterminate" category suffered from diseases such as Legg-Calve-Perthes or Marfan's disease and, therefore, were not considered likely to be effectively evaluated.

Results

The population data is presented for each individual hospital in Tables 2-2 through 2-5 and is summarized in Table 2-6. Part A divides the group into the four combinations to compare their mean heights and weights with their sex and race. Part B groups them in order to compare the races and sexes with regard to these same criteria. It may be observed that the data are very similar for the two races represented. The only significant difference between the sexes is the expected two year separation in mean ages. It is noteworthy, however, that the heights and weights do reflect tall, heavy children, a fact in concert with the theory that the growth plate is both hypertrophied and subjected to substantial stress. The only very long term follow-up offered by this study appears in Section four. For this group with severe SCFE, the tendency to be obese was continued throughout the

Table 2-2

Slipped Capital Femoral Epiphyses Treated Primarily at the Children's Hospital to August, 1974

PATIENT POPULATION

Part A: Age and Weight Versus Combined Race and Sex

	Mean Age	Age Range in Years	Mean %ile of Weight	Range of Weight
Black females	12.60	(9.58-15.75)	72	(87#-189#)
Black males	14.42	(11.83-18.08)	76	(90#-324#)
White females	11.71	(9.50-14.25)	90	(90#-155#)
White males	13.90	(7.33-16.83)	92	(95#-234#)**

Part B: Age and Weight Versus Separated Race and Sex

	Mean Age	Age Range in Years	Mean %ile of Weight	Range of Weight
Blacks	13.54	(9.58-18.08)*	76	(87-324#)
Whites	13.39	(7.33-16.83)	91	(90-234#)**
Females	11.96	(9.50-15.75)	85	(87-189#)
Males	13.96	(7.33-18.08)*	92	(90-324#)**
Totals	13.41	(7.33-18.08)*	89	(87-324#)**

Part C: Side of Slip Versus Combined Race and Sex

	Left SCFE	Right SCFE	Bilateral SCFE	Total
Black females	6	3	5	14
Black males	10	2	4***	16
White females	16	13	7***	36
White males	47	47	24***	118

Part D: Side of Slip Versus Separated Race and Sex

	Left SCFE	Right SCFE	Bilateral SCFE	Total
Blacks	16	5	9***	30
Whites	63	60	31***	154
Females	22	16	11***	50
Males	57	49	28***	134
Totals	79	65	40***	184

* not including a traumatic SCFE black male patient aged eleven months

** plus thirty-two "obese" and two "thin"

*** nine patients with bilateral SCFE had only one hip treated at Children's Hospital including six white males, two white females, and one black male

Table 2-3

Patients Treated Primarily at Johns Hopkins Hospital from July 1, 1967 to August 1, 1973

PATIENT POPULATION

Part A: Age, Weight, Versus Combined Race and Sex

	Mean Age	Age Range in Years	Mean %ile of Weight	Range of Weight
Black females	12.04	9.67-14.17	95	103-220#
Black males	12.55*	11.67-16.67*	84**	114-265#**
White females	12.58	12.58		
White males	14.46	13.42-16	77	108-152#

Part B: Age, Weight, Versus Combined Race and Sex

	Mean Age	Age Range in Years	Mean %ile of Weight	Range of Weight
Blacks	12.37*	9.67-16.67*	89**	103-265**
Whites	14.08	12.58-16	77	108-152
Females	12.12*	9.67-14.17	95	103-220
Males	13.06*	11.67-16.67*	82**	108-265**
Totals	12.76	(9.67-16.67)*	87	103-265**

Part C: Side of Slip Versus Combined Race and Sex

	Left SCFE	Right SCFE	Bilateral SCFE	Total
Black females	3	0	3	6
Black males	6	0	5***	11
White females	0	1	0	1
White males	2	0	2	4

Part D: Side of Slip Versus Separated Race and Sex

	Left SCFE	Right SCFE	Bilateral SCFE	Total
Blacks	9	0	8***	17
Whites	2	1	2	5
Females	3	1	3	7
Males	8	0	7***	15
Totals	11	1	10***	22

* One twenty-eight year old black male was excluded from the age data because his SCFE was obviously chronic and atypically unnoticed for a very prolonged period.

** Two black males were listed as "obese."

*** One side was not treated at Johns Hopkins Hospital in the case of one patient.

Table 2-4

Slipped Capital Femoral Epiphyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1, 1973

PATIENT POPULATION

Part A: Age, Height and Weight Versus Combined Race and Sex

	Mean Age	Age Range in Years	Mean %ile of Height*	Range of Height*	Mean %ile of Weight	Range of Weight*
Black females	12.51	10.00-14.42	69	60 3/4-68 1/4	86	105 1/2-200#
Black males	13.98	13.33-15.17	67	61 -68 3/4	73	101 -240#
White females	11.39	7.67-14.08	69	51 -67 1/4	87	74 -191#
White males	13.82	7.08-17.00	70	52 1/2-72	86	83 -219#

Part B: Age, Height and Weight Versus Separated Race and Sex

	Mean Age	Age Range in Years	Mean %ile of Height*	Range of Height*	Mean %ile of Weight	Range of Weight*
Blacks	13.02	10.00-15.17	68	60 3/4-68 3/4	79	101-240#
Whites	12.84	7.08-17.00	70	51 -72	87	74-219#
Females	11.70	7.67-14.42	69	51 -67 1/4	87	74-219#
Males	13.84	7.08-17.00	69	52 1/2-72	83	83-240#
Totals	12.88	7.08-17.00	69	51 -72	85	74-240#

Part C: Side of Slip Versus Combined Race and Sex

	Left SCFE	Right SCFE	Bilateral SCFE	Total
Black females	1	0	7	8
Black males	3	5	0	8
White females	10	7	11	28
White males	21	5	16**	42**

Part D: Side of Slip Versus Separated Race and Sex

	Left SCFE	Right SCFE	Bilateral SCFE	Total
Blacks	4	5	7	16
Whites	31	12	27**	70**
Females	11	7	18	36
Males	24	10	16**	50**
Totals	35	17	34**	86**

* The following were unavailable for inclusion: black females, 1 height and 1 weight; black males, 2 heights; white females, 9 heights and 6 weights (4 marked "obese"); and white males, 12 heights and 7 weights (6 marked "obese").

** Three white males with bilateral SCFE's had their primary treated for the first slip at another hospital.

Table 2-5

Slipped Capital Femoral Epiphyses Treated Primarily at the Yale-New Haven Hospital

PATIENT POPULATION

Part A: Age and Weight Versus Combined Race and Sex

	Mean Age	Age Range in Years	Mean %ile of Weight*	Range of Weight*
Black females	12.05	11-15	96	74 - 219
Black males	12.47**	10-15**	86**	113 - 186**
White females	11.05	11-15	81	105 - 167
White males	13.97	12-19	86	89 1/2 - 220

Part B: Age and Weight Versus Separated Race and Sex

	Mean Age	Age Range in Years	Mean %ile of Weight*	Range of Weight*
Blacks	12.20**	10-15**	92**	74 -219**
Whites	12.64	11-19	84	89 1/2-220
Females	11.57	11-15	90	74 -219
Males	13.47**	10-19**	86**	89 1/2-220**
Totals	12.45**	10-19**	88**	74 -220**

Part C: Side of Slip Versus Combined Race and Sex

	Left SCFE	Right SCFE	Bilateral SCFE	Total
Black females	1	6	3	10
Black males	2	1	3	6
White females	2	4	5***	11***
White males	6	3	3	12

Part D: Side of Slip Versus Separated Race and Sex

	Left SCFE	Right SCFE	Bilateral SCFE	Total
Blacks	3	7	6	16
Whites	8	7	8***	23***
Females	3	10	8***	21***
Males	8	4	6	18
Totals	11	14	14	39

* The numbers of patients with no available weight record were: black females, 4; black males, 1; white females, 4; and white males, 1.

** One post-traumatic, right-sided SCFE occurring in a one month old black male weighing 6.7 kilograms was not included in these calculations in order to avoid skewing the means.

*** One white female with bilateral SCFE had her primary treatment for her first slip at another hospital.

Table 2-6

Disease Associated with SCFE for All Hospitals

PATIENT POPULATION

Part A: Age and Weight Versus Combined Race and Sex

	Mean Age ± SEM	Mean %ile of Heights ± SEM	Mean %ile of Weight ± SEM
Black female	12.25 ± 0.24	73 ± 5	87 ± 4
Black male	13.81 ± 0.41	63 ± 6	80 ± 4
White female	11.65 ± 0.16	75 ± 3	88 ± 2
White male	13.77 ± 0.13	68 ± 2	89 ± 2

Part B: Age and Weight Versus Separated Race and Sex

	Mean Age ± SEM	Mean %ile of Height ± SEM	Mean %ile of Weight ± SEM
Black	13.02± 0.25	69 ± 4	83 ± 3
White	13.13 ± 0.12	71 ± 2	89 ± 1
Female	11.86 ± 0.13	74 ± 2	87 ± 2
Male	13.77 ± 0.13	67 ± 2	87 ± 1
Total	13.11 ± 0.11	71 ± 2	87 ± 1

Part C: Side of Slip Versus Combined Race and Sex

	Left	(% total)	Right	(%total)	Bilateral	(%total)	Total	(% grand total)
Black female	11	(29)	9	(24)	18	(47)	38	(11)
Black male	21	(51)	8	(20)	12	(29)	41	(12)
White female	28	(37)	25	(33)	23	(30)	76	(23)
White male	76	(43)	55	(31)	45	(26)	176	(53)

Part D: Side of Slip Versus Separated Race and Sex

	Left	(%total)	Right	(%total)	Bilateral	(%total)	Total	(% grand total)
Black	32	(41)	17	(22)	30	(38)	79	(24)
White	104	(41)	80	(32)	68	(27)	252	(76)
Female	39	(34)	34	(30)	41	(36)	114	(34)
Male	97	(45)	63	(29)	57	(26)	217	(66)
Total	136	(41)	97	(29)	98	(30)	331	(100)

fifteen to twenty year follow-up. Part C examines the four combinations of race and sex with respect to the side of the slip. Part D goes on to group them by race and sex. Follow-up appraisals were grouped by race and sex. The results appear in Tables 2-7 through 2-11.

Overall, approximately three-fourths of the population received a "good"rating, fifteen percent a "fair", eight percent a "poor" and only about one percent an "indeterminate." The results were remarkably consistent throughout the hospitals. The slightly higher incidence of "poor" results at Johns Hopkins Hospital may be explained by the higher incidence of blacks in that population group.

The familial data appears as Table 2-12. It can be seen that slightly more than one percent of the families have multiple SCFE members. The incidence of diseases relating to cartilage and endocrine dysfunction in the close relatives of patients may also be slightly elevated.

Discussion

Bilaterality was most frequent in black females. Females in general showed the highest incidence of bilaterality with blacks slightly more frequent than whites. This finding will be considered later in the discussion of prophylactic pinning of unaffected hips. There was a preference for left SCFE as opposed to right SCFE. Section six cites a theory to explain this previously observed occurrence. Although whites outnumbered blacks more than three to one, Kelsey (2), in a study of a similar sample from some of the same hospitals, showed that this was an artifact of the predominately white population from which the hospitals drew their patients. That study showed the black race to predominate.

Table 2-7

Slipped Capital Femoral Epiphyses Treated Primarily at the Children's Hospital to August, 1974

PATIENT POPULATION

Part A: Condition of Patients by Combined Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	
Black female	7	(37)	6	(32)	6	(32)	0	(0)
Black male	17	(89)	1	(5)	1	(5)	0	(0)
White female	34	(83)	6	(15)	1	(2)	0	(0)
White male	106	(78)	19	(14)	1	(2)	0	(0)

Part B: Condition of Patients by Separated Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	
Blacks	24	(63)	7	(18)	7	(18)	0	(0)
Whites	104	(80)	25	(14)	9	(5)	3	(2)
Females	41	(68)	12	(20)	7	(12)	0	(2)
Males	123	(79)	20	(13)	9	(6)	3	(2)
Totals	164	(76)	32	(15)	16	(7)	3	(1)

Table 2-8

Slipped Capital Femoral Epiphyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1973

PATIENT POPULATION

Part A: Condition of Patients by Combined Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	(%)
Black female	7	(47)	5	(33)	3	(20)	0	(0)
Black male	2	(25)	4	(40)	2	(25)	0	(0)
White female	35	(90)	2	(5)	1	(3)	1	(3)
White male	44	(80)	7	(13)	3	(5)	1	(2)

Part B: Condition of Patients by Separated Race and Sex

	Good	(%)	Fair	(5)	Poor	(%)	Indeterminate	(%)
Blacks	9	(36)	9	(3)	5	(20)	0	(0)
Whites	79	(84)	9	(10)	4	(4)	2	(2)
Females	42	(78)	7	(13)	4	(7)	1	(2)
Males	46	(73)	11	(17)	5	(8)	1	(2)
Totals	88	(75)	18	(15)	9	(8)	2	(2)

Table 2-9

Patients Treated Primarily at Johns Hopkins Hospital
from July 1, 1967 to August 1, 1973

PATIENT POPULATION

Part A: Condition of Patients by Combined Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	(%)
Black female	6	(67)	3	(33)	0	(0)	0	(0)
Black male	10	(67)	1	(7)	4	(27)	0	(0)
White female	1	(100)	0	(0)	0	(0)	0	(0)
White male	6	(100)	0	(0)	0	(0)	0	(0)

Part B: Condition of Patients by Separated Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	(%)
Blacks	16	(80)	4	(20)	4	(20)	0	(0)
Whites	7	(100)	0	(0)	0	(0)	0	(0)
Females	7	(70)	3	(30)	0	(0)	0	(0)
Males	16	(76)	1	(5)	4	(13)	0	(0)
Totals	23	(74)	4	(13)	4	(13)	0	(0)

Table 2-10

Slipped Capital Femoral Epiphyses Treated Primarily at the Yale-New Haven Hospital

PATIENT POPULATION

Part A: Condition of Patients by Combined Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	(%)
Black female	10	(77)	2	(15)	1	(8)	0	(0)
Black male	6	(67)	2	(22)	1	(11)	0	(0)
White female	13	(87)	2	(13)	0	(0)	0	(0)
White male	12	(80)	2	(13)	1	(7)	0	(0)

Part B: Condition of Patients by Separated Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	(%)
Blacks	16	(71)	4	(18)	2	(9)	0	(0)
Whites	25	(83)	4	(18)	1	(5)	0	(0)
Females	23	(82)	4	(14)	1	(4)	0	(0)
Males	18	(75)	4	(17)	2	(8)	0	(0)
Totals	41	(79)	8	(15)	3	(6)	0	(0)

Table 2-11

Diseases Associated with SCFE for All Hospitals

PATIENT POPULATION

Part A: Condition of Patients by Combined Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	(%)
Black female	30	(54)	16	(29)	10	(18)	0	(0)
Black male	35	(69)	8	(16)	8	(16)	0	(0)
White female	83	(87)	10	(10)	2	(2)	1	(1)
White male	168	(79)	28	(13)	12	(6)	4	(2)

Part B: Condition of Patients by Separated Race and Sex

	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	(%)
Blacks	65	(61)	24	(22)	18	(17)	0	(0)
Whites	251	(81)	38	(12)	14	(5)	5	(2)
Females	113	(74)	26	(17)	12	(8)	1	(1)
Males	203	(77)	36	(14)	20	(8)	4	(2)
Totals	316	(76)	62	(15)	32	(8)	5	(1)

Table 2-12

Diseases Associated with SCFE for All Hospitals

Familial Incidence

- Brother, (two patients plus one set of three brothers)
- Sister
- First cousin, (one patient)

Other orthopedic diseases within the family of SCFE patients

- Brother with Osgood-Schlatter
- Grandmother with a "waddling gait"
- Father with arthritis
- Mother with a "hip operation"
- Grandfather with spinal carcinoma

Other orthopedic diseases in SCFE patients excluding fractures

- Congenital hip dislocation (two patients)
- Legg-Calve-Perthes, (three patients)
- Osteochondrodystrophy
- Osgood-Schlatter's
- Slipped distal epiphysis of tibia
- Recurrent subluxation and dislocation of bilateral patellae
- Osteochondroma, (two patients)
- Chondromalacia of knees
- Marfan's
- Marie Strumpel
- Myositis ossificans, (two patients)
- Osteitis condensans ilii
- Recurrent dislocation shoulder
- TB of femur, also of spine and tarsus
- Osteomyelitis
- Osteoma
- Myoma
- Schmorl's nodes, (two patients)
- Non-union of fractured tibia and fibula, (two patients)
- Scoliosis, (two patients)
- Knee pain-knee contralateral to SCFE, (two patients)
- Talo-navicular spining
- Clubbed foot
- Idiopathic synovitis of contralateral hip

Fractures

- Distal femoral epiphysis
- Distal tibial epiphysis
- Hip
- Pelvis
- Femur, (five patients)
- Also: wrist, forearm (five patients), humerus (three patients,) elbow, clavicle, concussion, tibia/fibula (two patients), foot (two patients, one of whom fractured his twice), and distal second metacarpal

Endocrine

- Hashimoto's thyroiditis
- Hyperthyroidism
- Thyroid medication, (two patients)
- S/P major weight and height spurt within six months
- Amenorrhea after first period

Number of Patients: Sixty-five

The population of patients for this study was in basic alignment with the typical groups of patients with SCFE previously reported. Males outnumbered females almost two to one, blacks were most frequently afflicted with respect to their incidence in the population served by the hospitals, though they were outnumbered by whites with respect to raw tallies. The girls were approximately two years younger than the boys and all groups demonstrated heights and weights well in excess of average.

It should be noted that some patients with bilateral SCFE who had just the first treated at one of the hospitals under study may be listed as unilateral if lost to follow-up before the second slip. Since black patients had shorter follow-ups than whites, the higher tendency of blacks to develop bilateral disease would probably be only accentuated if all the follow-ups were complete.

The hospitals taken together showed a somewhat poorer follow-up result for black patients as compared to whites. Sex, however, seemed to matter little with males achieving only approximately three percent better results than their female counterparts.

Again, the lack of adequate follow-up may have hidden some therapeutic problems from this study. However, since the black follow-up was grimmer than the white, the actual figures probably would make the racial difference larger.

No epidemiological analysis was performed upon the familial incidence of disease in the families of SCFE patients although SCFE and diseases involving cartilage and endocrine pathology were prominent enough to justify future efforts in this area.

Thus this study confirmed that SCFE patients tend to be tall, heavy, black and male. The highest incidence of bilateral clinical disease occurred in black females, the race and sex most prone to developing secondary difficulties. SCFE may be expected most often between the ages of twelve and fourteen in males with females afflicted about two years sooner. The expected inclination toward left SCFE was demonstrated with further discussion on the matter deferred until Section six.

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Slipped Capital Femoral Epiphysis--
Problems of Treatment

by

Theodore Simon

Introduction

The great advantage of a retrospective study is its ability to determine long-term results rapidly. This study considers the various treatment modalities employed and discusses the problems encountered with each of these treatments as applied to the patient sample analyzed in the preceding Section . Such information will both help physicians become aware of the treatment philosophies of others and the difficulties which must be overcome to assure success for their patients.

Methods

The methods for the selection of patients in this study and a breakdown of the population by race, sex, height, weight, side of slip and outcome of therapy appears in a previous article. Briefly, the subjects were treated for slipped capital femoral epiphysis (SCFE) at Children's Hospital, Johns Hopkins Hospital, Newington Children's Hospital or Yale-New Haven Hospital. The population is consistent with the characteristics predicted by the literature. The data were obtained by scrutinizing patients' charts and roentgenograms.

Results

The mode of treatment rendered these patients appears in Tables 3-1 through 3-4 for the individual hospitals and in Table 3-5 as a summary. The individual hospital data clearly demonstrate differences in therapy between the hospitals. These may be differences in patient population, in the availability of therapy or in therapeutic philosophy. The first possibility was significant only to the degree that patient population was associated with the severity of the slip and hence to the decision to treat radically or conservatively. It would not be a

Table 3-1

Patients Treated Primarily at the Children's Hospital before August, 1974

MODE OF TREATMENT

Type of Treatment	Treatment	# Hips	Subtotal
In *situ* pinning	Godoy-Moreira	1	
	Haines after Biplane	1	
	Knowles (16 with manipulation)	58	
	Peg	2	
	Smith-Petersen	1	
	Smith-Petersen after close reduction	1	
	Wood screw (25 with manipulation)	42	106
Osteotomies	Biplane (3 after manipulation)	38	
	Biplane after exploration of joint capsule	1	
	Biplane with Heyman	1	
	Biplane after peg	1	
	Biplane after woodscrew	1	
	Craig (2 after manipulation)	6	
	Craig with Knowles after Steineman and traction	1	
	Cuneiform of neck (1 with Knowles, 2 with Smith-Petersen, 1 with Steineman)	5	
	Cuneiform of shaft (total)	14	
	Cuneiform after Knowles	1	
	Cuneiform after manipulation and Jewett nail	1	
	Cuneiform after peg	1	
	Cuneiform, chiseled head and open reduction	1	
	Cuneiform with Godoy-Moreira	1	
	Cuneiform with Haynes	1	
	Cuneiform with Kirschner wire	1	
	Cuneiform with Knowles	1	
	Cuneiform with McMurray and Spline	1	
	Cuneiform with peg	1	
	Cuneiform with woodscrews	1	
	and Jewett nail	1	
	Dome	1	
	Rotary with Haynes	1	
	Rotary with Wood screw	1	71

Table 3-1

Type of Treatment	Treatment	# Hips	Subtotal
Other	Armin-Klein after wood screw after manipulation	1	
	Arthrodesis	1	
	Cup arthroplasty after cuneiform	1	
	Manipulation	21	
	Spica and hormones after manipulation	1	
	Splints for abduction and plaster boots	2	
	Traction	7	
	Untreated (including bedrest and spica)	4	38

Table 3-2

Patients Treated Primarily at Johns Hopkins Hospital
from July 1, 1967 to August 1, 1973

MODE OF TREATMENT

Treatment	# Hips	Subtotal
In situ pinning		23
Knowles	21	
Knowles with manipulation	2	
Osteotomy		5
Biplane	2	
Biplane after manipulation	1	
Cuneiform	2	
Other		
Untreated	3	
Total Hips Treated		31

Table 3-3

Slipped Capital Femoral Epiphyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1, 1973

MODE OF TREATMENT

Treatment	# Hips	Subtotal
In situ pinning		78
Moore (including 1 with manipulation)	12	
Moore after domed shaped osteotomy with pins and Kirschner wire)	1	
Haigie (including 3 with manipulation)	17	
Haigie after Smith-Petersen	2	
Haigie with hormones	2	
Knowles (including 4 with manipulation)	35	
Knowles and Austin-Moore	1	
Smith-Petersen	2	
Smith-Petersen after Haigie	1	
Smith-Petersen with Thornton plate after Smith-Petersen	1	
Steinman	1	
Turner	3	
Osteotomy		32
Biplane (including 1 with manipulation)	22	
Biplane after Knowles	1	
Cuneiform (including 1 with each of the following: Moore, Moore with Kirschner wire, Haigie, Knowles, Smith-Petersen, Steinman)	6	
Cuneiform after hormones	1	
Cuneiform with Haigie after Haigie pinning to distal femoral metaphysis and manipulation	1	
Derotational	1	
Other		7
Bedrest and Kirschner wire	1	
Heyman (including 1 Moore and Haynes)	4	
Manipulation	1	
Osteoplasty	1	
Total Hips Treated:		117

Table 3-4

Slipped Capital Femoral Epiphysis Treated
Primarily at the Yale-New Haven Hospital

MODE OF TREATMENT

Treatment	# Hips	Subtotal
In situ pinning		33
Moore	6	
Moore with Haegar	1	
Haines	2	
Knowles	3	
Smith-Petersen	10	
Smith-Petersen and Isinger pin after closed reduction	1	
Steineman	2	
Woodscrews	7	
Woodscrews after Steineman	1	
Osteotomy		19
Biplane	17	
Cuneiform after Steineman	1	
Cuneform with Haines	1	
Total Hips Treated:		52

factor in choosing the specific therapy within these broad categories. The two hospitals for which the data was available showed that each case of mild SCFE received conservative treatment and each case of severe SCFE received an osteotomy. Nevertheless, the choice of which conservative treatment and which osteotomy varied greatly, even though the proportion of severe SCFE's remained rather constant, sixty-three percent at Yale-New Haven Hospital and sixty-eight percent at Newington Children's Hospital.

Since each hospital is fully equipped with easy access to necessary materials and expertise, differences in therapeutic availability are unlikely to cause treatment differences.

Hospital policies, therefore, are a main determinant of the mode of therapy used. Interestingly, Table 3-5 shows that sixty-seven percent of patients were treated by those methods used for mild slips at Newington Children's Hospital and Yale-New Haven Hospital. Thus, while specific therapies differed between hospitals, treatments for mild slips were employed in roughly the same percentage of cases as mild slips would be expected to occur from Newington Children's Hospital and Yale-New Haven Hospital data. The most noticeable deviation from this proportion, the Johns Hopkins Hospital population, may stem artifactually from the small size of that group.

For the purposes of this study, therapies were divided into three groups: *in situ*, osteotomy and other. It was felt that fixation devices are often confused on the level of precise determination. Hence, a less precise but more reliable categorization was employed. *In situ* devices were divided into the following groups: nails, pegs,

Table 3-5

Therapy Associated with SCFE for All Hospitals

MODE OF TREATMENT

Type of Treatment	Treatment	# Hips	Subtotal
In situ pinning			240
	Large devices		73
	Nails	17	
	Smith-Peterson (including 1 after manipulation, 1 after Isinger pin and closed reduction, 1 after Haigie and 1 with a Thornton plate after Smith-Petersen)		
	Pegs	2	
	Pins	3	
	Haines (including 1 after biplane)		
	Screws		51
	Godoy-Moreira	1	
	Woodscrews (including 1 after Steinman, 25 with manipulation, and 1 with manipulation after woodscrew)	50	
	Small devices		168
	Threaded pins		162
	Haigie (including 3 with manipulation, 2 after Smith-Petersen and 2 with hormones)	21	
	Knowles (including 22 with manipulation, 2 after Knowles and 1 with Moore)	120	
	Moore (including 1 with manipulation, 1 after domed osteotomy, 1 with Haegar and 1 with Knowles)	21	
	Unthreaded		6
	Steinman	3	
	Turner	3	
Osteotomies			127
	Neck osteotomies of femur		12
	Craig (including 2 after manipulation, 1 after Steinman and traction)	7	
	Cuneiform (including 1 with Knowles, 2 with Smith-Petersen and 1 with Steinman)	5	
	Shaft osteotomies of femur		115
	Biplane (including 1 with manipulation, 1 after manipulation, 1 after exploration of joint capsule, 1 with Heyman, 1 after peg, 1 after woodscrew and 1 after Knowles	85	

Table 3-5

MODE OF TREATMENT

Type of Treatment	Treatment	# of Hips	Subtotal
Osteotomies	Cuneiform (including 1 after Knowles, 1 after manipulation and Jewett nail, 1 after peg, 1 with chiseled head and open reduction, 1 with Haigie after pinning to distal femoral metaphysis and manipulation), 1 after hormones after Steine-man, 1 with Godoy-Moreira, 2 with Haines, 1 with Kirschner wire, 1 with Knowles, 1 with McMurray and spline, 1 with peg, 1 with woodscrews, and Jewett nail	26	
	Derotational (including 1 with Haines and 1 with woodscrew)	3	
	Dome	1	
Other	Armin-Klein after woodscrew and manipulation	1	48
	Arthrodesis	1	
	Bedrest and Kirschner wire	1	
	Cup arthroplasty after cuneiform	1	
	Heyman (including 1 after Austin-Moore and Haines)	4	
	Manipulation	22	
	Osteoplasty	1	
	Spica and hormones after manipulation	1	
	Splints for abduction and plaster boots	2	
	Traction	7	
	Untreated	7	
Total Hips Treated			415

large pins, large screws and small pins, including threaded and unthreaded. Osteotomies were divided according to their location: neck osteotomies included Craig and cuneiform while shaft osteotomies included biplane, single plane cuneiform, derotational and dome. Other therapies were grouped together because of their low frequency, although they represented the ends of the treatment spectrum ranging from untreated to cup arthroplasties.

Follow-up with regard to patient race and sex was presented in Section two. The same data were rearranged to reflect differences between hospitals and modes of therapy. These results appear in Table 3-6. The criteria for assigning follow-up ratings were identical to those used in Section two as summarized in Table 2-1.

This grouping demonstrated that the treatment/severity of SCFE affected the long-term outcome. Mild slips, treated with *in situ* fixation, resulted in eight-four percent good and only three percent poor follow-ups. This can be compared to the severe, osteotomy treated, results of fifty-seven percent good and sixteen percent poor. Cervical osteotomies had both a larger percentage of good and a slightly smaller percentage of poor results than the shaft osteotomies. This may be caused by sampling error, but it indicates that a well performed cervical osteotomy can yield consistently good results. The sixty-seven percent good and twelve percent poor results realized from biplane therapy compares very favorably with the results of other osteotomies both shaft and neck.

The dismal fifty-seven percent good and twenty-nine percent poor results obtained in untreated cases may be caused by the small number

Table 3-6

Conditions of SCFE Patients by Treatment

Treatment Type	Hospital	Good	(%)	Fair	(%)	Poor	(%)	Indeterminate	(%)
In situ pinning	Children's	87	(83)	14	(13)	2	(2)	2	(2)
" " "	JHH	17	(74)	4	(17)	2	(9)	0	(0)
" " "	NCH	71	(92)	5	(6)	1	(1)	0	(0)
" " "	YNHH	26	(79)	5	(15)	1	(1)	1	(3)
" " "	ALL	201	(84)	28	(12)	6	(3)	3	(1)
Biplane	Children's	27	(69)	7	(18)	5	(13)	0	(0)
"	JHH	3	(100)	0	(0)	0	(0)	0	(0)
"	NCH	11	(50)	8	(36)	3	(14)	0	(0)
"	YNHH	13	(76)	3	(18)	1	(6)	0	(0)
"	ALL	54	(67)	17	(21)	10	(12)	0	(0)
Shaft Osteotomy (Non-Biplane)	Children's	5	(36)	6	(43)	3	(21)	0	(0)
" " "	JHH	2	(100)	0	(0)	0	(0)	0	(0)
" " "	NCH	1	(11)	4	(44)	3	(33)	1	(11)
" " "	YNHH	0	(0)	0	(0)	1	(100)	0	(0)
" " "	ALL	8	(30)	10	(38)	7	(27)	1	(4)
Neck Osteotomy	Children's	8	(72)	1	(9)	2	(18)	0	(0)
All Shaft Osteotomies	Children's	32	(60)	12	(23)	9	(17)	0	(0)
" " "	JHH	5	(100)	0	(0)	0	(0)	0	(0)
" " "	NCH	12	(38)	12	(38)	6	(19)	1	(3)
" " "	YNHH	13	(72)	3	(17)	2	(11)	0	(0)
" " "	ALL	59	(57)	27	(26)	17	(16)	1	(1)
All Osteotomies	Children's	31	(56)	14	(25)	10	(18)	0	(0)
" "	JHH	5	(100)	0	(0)	0	(0)	0	(0)
" "	NCH	12	(39)	12	(39)	6	(19)	1	(3)
" "	YNHH	13	(72)	3	(16)	2	(11)	0	(0)
" "	ALL	61	(56)	28	(26)	19	(17)	1	(1)
Other	Children's	27	(79)	5	(15)	2	(6)	0	(0)
"	NCH	5	(71)	0	(0)	2	(29)	0	(0)
	ALL	35	(90)	5	(13)	4	(10)	0	(0)
ALL	Children's	164	(76)	33	(15)	15	(7)	3	(1)
"	JHH	23	(74)	4	(13)	4	(13)	0	(0)
"	NCH	89	(76)	18	(15)	9	(8)	1	(1)
"	YNHH	40	(77)	8	(15)	3	(6)	1	(2)
"	ALL	3	(16)	63	(15)	31	(7)	5	(1)

of patients in this category or by the likelihood of the poor results needing and, therefore, attracting medical attention disproportionately often. Nonetheless, it underscores both the potential long-term disability SCFE and the need for either treatment or at least close follow-up.

The general results presented above can be effectively amplified by examining the particular problems encountered in the procedures. The mode of therapy along with the types and frequency of problems associated with each appears for each hospital in Tables 3-7 through 3-10. The data were then reversed to list the various problems along with the frequency for the various treatment modalities utilized. Such information appears for each hospital in Tables 3-11 through 3-14. Finally, the various problems were tallied and grouped etiologically. This summary appears as Table 3-15.

Discussion

Let us study Tables 3-7 through 3-10. Both Godoy-Moreira screws used in the patient group developed significant problems. Bone necrosis and bursitis around the device were most easily linked to the mode of therapy. The former was an x-ray diagnosis based on rarefaction of osseous areas around the device. The latter relates to clinical symptomatology confirmed by x-ray. Haines pins resulted in no problems in any of the three patients receiving the large devices. The seventeen Smith-Petersen treated patients demonstrated several problems, the least explicable in terms of therapeutic grouping was the high preponderance of difficulties with the brachial plexus secondary to crutch-walking. Not as difficult to understand was the dislodgement of the femoral head by this large nail piercing the hard cartilage. That complication was

Table 3-7

Patients Treated Primarily at the Children's Hospital Before August, 1974

TREATMENT PROBLEMS VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problem	# Hips	In O.R.
In situ pinning			
Godoy-Moreira	Bursitis around device	1	
	Joint space distorted	1	
	Necrosis of bone	1	
	Range of motion decreased	1	
Haines	None	1	
Jewett nail	Femoral head dislodged	1	
Knowles	Acetabular surface distorted	1	
	Avascular necrosis	1	
	Device broken	1	
	Device guide in joint space	1	
	Device in joint space	9	
	Device migrates	1	
	Device unremovable	1	
	Extra procedures	6	
	Femoral head distorted	1	
	Flexion contracture	1	
	Fractured femur	1	
	Gait disturbances	2	
	Genu valgum	1	
	Infection	1	
	Joint space distorted	1	
	None	20	
	Osteoporosis	1	
	Pain	1	
	Pain on activity	2	
	Range of motion decreased	9	
	Shortened leg	1	
	Shortened neck	1	
	Spasm of peroneal nerve	1	
	Thigh atrophy	1	
Peg	None	2	
Smith-Peterson	Ankylosis	1	
	Device in joint space	2	
	Extra procedure	1	
	Femoral head dislodged	1	
	Pain	1	
	Palsy of ulnar nerve	1	
	Pelvic tilt	1	
	Range of motion decreased	2	
	Shortened leg	1	

Table 3-7 Continued

Patients Treated Primarily at the Children's Hospital before August, 1974

TREATMENT PROBLEMS VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problem	# Hips	In O.R.
In situ pinning			
Woodscrew	Avascular necrosis	1	
	Device broken	2	
	Device guide in joint space	3	
	Device in joint space	5	
	Device unremovable	2	
	Extra procedures	2	
	Flecks of metal left	1	
	Gait disturbances	4	
	Genu valgum	3	
	Hepatitis	1	
	Joint space distorted	1	
	Keloid	1	
	None	10	
	Osteoporosis	3	
	Range of motion decreased	6	
	Shortened leg	7	
	Stiffness	1	
	Thigh atrophy	1	
Osteotomy			
Biplane	Acetabular surface distorted	3	
	Ankylosis	3	
	Avascular necrosis	1	
	Cartilage necrosis	1	
	Cysts in femur	1	
	Device migrates	1	
	DRill snapped in femur	1	
	Extra procedures	3	
	Femoral head cracked during device removal	1	
	Foot turned	3	
	Gait disturbance	2	
	Genu valgum	1	
	Infection	4	
	Joint space distorted	1	
	None	11	
	Osteophyte	3	
	Osteoporosis	8	
	Pain	3	
	Pelvic tilt	2	
	Range of motion decreased	12	
	Shortened leg	12	
	Skin pressure ulcer	1	
	Stiffness	1	
	Thrombophlebitis	1	

Table 3-7 Continued

Patients Treated Primarily at the Children's Hospital before August, 1974

TREATMENT PROBLEMS VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problem	# Hips	In O.R.
Osteotomy			
Neck osteotomy	Avascular necrosis	1	
	Device in joint space	1	
	Extra procedures	4	
	Femoral head distorted	4	
	Joint space distorted	1	
	Non-union	1	
	Range of motion decreased	1	
	Sclerosis	1	
	Shortened leg	2	
Non-Biplane Shaft Osteotomy	Acetabular lipping	2	
	Ankylosis	3	
	Avascular necrosis	2	
	Device guide in joint space	2	
	Device in joint space	4	
	Extra procedures	2	
	Femoral head distorted	5	
	Flexion contracture	1	
	Gait disturbance	2	
	Genu valgum	1	
	Joint space distorted	4	
	None	1	
	Osteophyte	2	
	Osteoporosis	2	
	Pain	2	
	Palsy of brachial plexus	2	
	Pelvic tilt	2	
	Range of motion decreased	6	
	Sclerosis	1	
	Shortened leg	9	
	Shortened neck	2	
	Stiffness	2	
Other			
Armin-Klein	Joint space distorted	1	
	Shortened neck	1	
Arthrodesis	None	1	
Arthroplasty	Osteophyte	1	

Table 3-7 Continued

Patients Treated Primarily at the Children's Hospital Before August, 1974

TREATMENT PROBLEMS VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problem	# Hips	In O.R.
Other			
Manipulation	Ankylosis	1	
	Avascular necrosis	1	
	Extra procedures	1	
	Femoral head distorted	2	
	Flexion contracture	1	
	Fractured femur	1	
	Joint space distorted	1	
	None	8	
	Osteophyte	1	
	Osteoporosis	3	
	Pain	1	
	Range of motion decreased	4	
	Sclerosis	1	
	Shortened leg	6	
Hormones	Shortened leg	1	
Plaster boots	Genu valgum	1	
	Osteoporosis	1	
Traction	Cysts in femur	1	
	Gait disturbance	2	
	Shortened leg	1	
	Shortened neck	1	
	Stiffness	1	
Untreated	Cysts in femur	1	
	Joint space distorted	1	
	None	2	
	Range of motion decreased	2	
	Sclerosis	1	
	Shortened leg	1	
	Shortened neck	1	

Table 3-8

Patients Treated Primarily at Johns Hopkins Hospital
from July 1, 1967 to August 1, 1973

TREATMENT PROBLEMS VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problems	# Hips	In O.R.
In situ pinning			
Knowles	Ankylosis	1	
	Avascular necrosis	1	
	Cartilage necrosis	1	
	Decreased range of motion	2	
	Device in joint space	3	3
	Extra procedure (pin withdrawn)	1	
	Gait disturbance	1	
	Infection	1	
	Irregular acetabular surface	2	
	Irregular femoral head	1	
	Joint space widened	2	
	Leg shortening	3	
	Migration of pin	1	
	None	9	
	Osteoporosis	2	
	Pain	1	
	Pain on activity	1	
	Sclerosis	1	
	Thigh atrophy	1	
Osteotomy			
Biplane	None	2	
	Pain	1	
Cuneiform	None	1	
Other			
Untreated	Avascular necrosis	2	
	Cystic changes	2	
	Degenerative arthritis	2	
	None	1	
	Sclerosis	2	

Table 3-9

Slipped Capital Femoral Epiphyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1, 1973

TREATMENT PROBLEMS VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problems	# Hips	In O.R.
In situ pinning			
Moore	Device in joint space	2	5
	Device unremovable	3	
	Femoral head distorted	1	
	Gait disturbances	1	
	None	1	
	Pain	1	
	Pain on activity	1	
Moore after domed osteotomy with pins and Kirschner wire	Back knee	1	
	Gait disturbance	1	
Haigie	Degnerative changes	1	
	Device in joint space	5	4
	Device bent	1	
	Device unremovable	5	
	Extra procedure (reinsertion)	1	
	Femoral head distorted	2	
	Fever of unknown origin	1	
	Foot drop	2	
	Fractured femur	1	
	Gait disturbance	1	
	None	2	
	Pain	1	
	Pain on activity	2	
	Range of motion decreased	2	
	Sciatic stretch	1	
	Sclerosis	1	
Haigie after Smith-Petersen	Device in joint space	1	1
	Device (Smith-Petersen) backed out	2	
	Gait disturbance	1	
Knowles	Bone chips	1	
	Cartilage necrosis	1	
	Chondrolysis or cartilage necrosis	1	
	Device in joint space	6	9
	Extra procedure (Hanging hip)	1	
	Femoral head hypertrophied	1	
	Joint distorted	3	

Table 3-9 Continued

Slipped Capital Femoral Epiphyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1, 1973

TREATMENT PROBLEMS VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problems	# Hips	In O.R.
In situ pinning			
Knowles	Knee pain	1	
	None	19	
	Pain	2	
	Range of motion decreased	2	
	Sclerosis	1	
	Wound infection	1	
Knowles and Moore	Device in joint space	1	
Smith-Petersen	Device in joint space	0	1
	Gait toed in and bowlegged	1	
Smith-Petersen after Haigie	Frozen hips	1	
	None	1	
Smith-Petersen with Thornton plate after Smith-Petersen	Device backed out	1	
	Extra procedure (reinsertion)	1	
	Range of motion decreased	1	
Steinman	None	1	
Turner	Device in joint space	0	
	None	2	
	Range of motion decreased	1	
	Shortened leg	1	
Osteotomy			
Biplane	Back knee	1	
	Cartilage necrosis	1	
	Degenerative changes	1	
	Device bent and broken	1	
	Device in joint space	2	
	Delayed union	1	
	Erosion	1	
	Extra procedures (Heyman)	1	
	Femoral head distorted	5	
	Frozen hips	1	
	Joint distorted	2	
	Neutropenia	1	
	None	9	

Table 3-9 Continued

Slipped Capital Femoral Epiphyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1, 1973

TREATMENT PROBLEMS VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problems	# Hips	In O.R.
Osteotomy			
Biplane	Pain on activity	2	
	Range of motion decreased	1	
	Shortened leg	9	
	Thigh atrophy	1	
	Wound infection	2	
Biplane after Knowles	Femoral head distorted	1	
	Pain on activity	1	
Cuneiform	Aseptic necrosis	1	
	Bone chips	1	
	Device in joint space	2	
	Femoral head distorted	1	
	Gait disturbance	1	
	Joint distorted	1	
	None	1	
	Osteophyte	2	
	Osteoporosis	1	
	Range of motion decreased	1	
	Sclerosis	1	
	Shortened leg	3	
Cuneiform after hormones	Femoral head distorted	1	
	Pain	1	
	Range of motion decreased	1	
	Shortened leg	1	
Cuneiform after manipulation	None	1	
Derotational	None	1	
Other			
Bedrest and Kirschner wire	Back knee	1	
	Gait toed in and bowlegged	1	
Heyman	None	2	
	Pain on activity	1	
	Shortened leg	2	
Osteoplasty	Femoral head hypertrophied	1	
Pure closed reduction	Cartilage necrosis	1	
	Chondrolysis	1	
	Extra procedures (Haigie <u>in situ</u>)	1	
	Femoral head distorted	1	
	None	1	

Slipped Capital
Newington Children's

TREATMENT PROBLEMS

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Table 3-10

Slipped Capital Femoral Epiphyses Treated Primarily at the Yale-New Haven Hospital

TREATMENT PROBLEM VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problem	# Hips	In O.R.
In situ pinning			
Moore	Condylar epiphyseal closure accelerated	1	
	Device bent	1	
	Device in joint space	2	
	Device unremovable	1	
	Femoral head distorted	1	
	Joint space distorted	1	
	No x-rays available	2	
	None	3	
	Osteophyte	2	
Moore and Haigie	Condylar epiphyseal closure accelerated	1	
	Device bent	1	
Haynes	None	2	
Knowles	Acetabular surface distorted	1	
	Device in joint space	1	
	Hypertrophied subcapital area	1	
	No x-rays available	1	
	None	2	
Smith-Petersen	Bursitis around nail	1	
	No x-rays available	8	
	Pain	1	
Smith-Petersen and Isinger pin after closed reduction	Device guide in joint space	1	
	Joint space distorted	1	
	Leg shortening	1	
	Osteophyte	1	
Steineman	No x-rays available	1	
	None	2	
Woodscrews	Device in joint space	2	
	Device guide in joint space	2	
	Distorted acetabular surface	1	
	Joint space distorted	1	
	None	2	
	Osteoporosis	1	

Table 3-10 Continued

Slipped Capital Femoral Epiphyses Treated Primarily at the Yale-New Haven Hospital

TREATMENT PROBLEM VERSUS TYPE OF TREATMENT

Type of Treatment	Treatment Problem	# Hips	In O.R.
In situ pinning (continued)			
Woodscrew after Steineman	Device in joint space	1	
	Epiphyseal line widened	1	
Osteotomy			
Biplane	Cartilage necrosis with hip ankylosis	1	
	Device in joint space	1	
	Device guide in joint space	1	
	Femoral head distorted	1	
	Femoral neck length decreased	1	
	Incomplete Moe fit	1	
	Joint space distorted	2	
	None	7	
	Range of motion decreased	1	
	Shortened leg	2	
Biplane with Haynes	Device in joint space	1	
Cuneiform after Steineman	Gait disturbance	1	
	Shortened leg	1	
	Aseptic necrosis	1	

Table 3-11

Patients Treated Primarily at the Children's Hospital to August, 1974

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Sub-total	In O.R.
Acetabular lipping	Cuneiform of shaft	1		
	Domed	1	2	
Acetabular surface distorted	Biplane	3		
	Knowles	1	4	
Ankylosis	Smith-Petersen	1		
	Biplane	3		
	Cuneiform of shaft	2		
	Cuneiform of shaft after Knowles	1		
	Manipulation	1	8	
Avascular necrosis	Knowles	1		
	Woodscrew	1		
	Biplane	2		
	Cuneiform of neck	1		
	Cuneiform of shaft	2		
	Manipulation	1	8	
Bursitis around device	Cuneiform of shaft with Godoy-Moreira apparatus	1	1	
Cartilage necrosis	Biplane	1	1	
Cysts in femur	Biplane	1		
	No treatment	1		
	Traction	1	3	
Device broken	Knowles	1		
	Wood screws	2	3	
Device guide in joint space	Knowles	1		
	Woodscrew	3		
	Cuneiform of shaft	2	6	
Device in joint space	Knowles	9		12
	Smith-Petersen	2		
	Woodscrew	5		6
	Biplane			1
	Craig			3
	Cuneiform of neck	1		1
	Cuneiform of shaft	4		
	Armin-Klein			1
Device migrates	Biplane	1		
	Knowles	1	2	
Device unremovable	Knowles	1		
	Woodscrews	2	3	
Drill snapped in femur	Biplane	1		

Table 3-11 Continued

Patients Treated Primarily at the Children's Hospital to August, 1974

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Sub-total	In O.R.
Extra procedures	Cuneiform of neck (draining sinus into joint excised)	1		
	Woodscrew (Heyman)	1		
	Biplane (Heyman)	3		
	Smith-Petersen (leg shortening)	1		
	Craig (McMurray)	2		
	Cuneiform of shaft with spline (McMurray)	1		
	Cuneiform of shaft (cup arthroplasty)	1		
	Manipulation (cup arthroplasty)	1		
	Knowles (proedure repeated)	3		
	Wood screws (procedure repeated)	1		
	Knowles (device withdrawn)	1		
	Craig (device withdrawn)	1	17	
Femoral head cracked during device removal	Biplane	1		
Femoral head dislodged	Cuneiform of neck with Smith-Petersen	1		
	Cuneiform of shaft with Jewett nail	1		
Femoral head distorted	Knowles	1		
	Craig	3		
	Cuneiform of neck	1		
	Cuneiform of shaft (1 with spline fixation)	4		
	Cuneiform of shaft after Knowles	1		
	Manipulation	2		
	Biplane	4	16	
Flecks of metal left	Woodscrew	1		
Flexion contracture	Knowles	1		
	Cuneiform of shaft after bone peg	1		
	Manipulation	1	3	
Foot turned	Biplane	3		
Fractured femur	Knowles	1		
	Manipulation	1	2	

Table 3-11 Continued

Patients Treated Primarily at the Children's Hospital to August, 1974

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Sub-total	In O.R.
Gait disturbances	Knowles	2		
	Woodscrew	4		
	Biplane	2		
	Cuneiform of shaft after bone peg	1		
	Domed osteotomy	1		
	Traction	2	12	
Genu valgum	Knowles	1		
	Woodscrew	3		
	Biplane	1		
	Domed osteotomy	1		
	Plaster boots	1	7	
Hepatitis	Wood screws	1		
Infection	Biplane	4		
	Knowles	1	5	
Joint space distorted	Godoy-Moreira	1		
	Knowles	1		
	Woodscrews	1		
	Biplane	1		
	Craig	1		
	Cuneiform of shaft	2		
	Cuneiform of shaft after bone pegging	1		
	Rotational osteotomy	1		
	Armin-Klein	1		
	Manipulation	1		
	None	1	12	
Keloid	Woodscrew (from pressure)	1		
Necrosis of bone	Cuneiform of shaft with Godoy-Moreira	1		
Non-union of osteotomy	Cuneiform of neck	1		
None	Bone peg	2		
	Knowles	20		
	Woodscrew	10		
	Biplane	11		
	Rotational osteotomy	1		
	Bedrest	1		
	Manipulation	8		
	Spica	1		
	Traction	3	57	

Table 3-11 Continued

Patients Treated Primarily at the Children's Hospital to August, 1974

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Sub-total	In O.R.
Osteophyte	Biplane	2		
	Biplane after peg	1		
	Cuneiform of shaft	1		
	Rotational osteotomy	1		
	Cup arthroplasty after cuneiform of neck	1		
	Manipulation	1	7	
Osteoporosis	Knowles	1		
	Woodscrews	3		
	Biplane	8		
	Cuneiform of shaft	1		
	Cuneiform of shaft after bone pegging	1		
	Manipulation	3		
	Plaster boot	1	18	
Pain	Knowles	1		
	Smith-Petersen	1		
	Biplane	3		
	Cuneiform of shaft	1		
	Rotational osteotomy	1		
	Manipulation	1	8	
Pain on activity	Knowles	2		
Palsy of brachial plexus	Cuneiform of shaft	1		
Palsy of ulnar nerve secondary to crutches	Smith-Petersen	1		
Pelvic tilt	Smith-Petersen	1		
	Biplane	2		
	Cuneiform of shaft	2	5	
Range of motion decreased	Godoy-Moreira	1		
	Knowles	9		
	Smith-Petersen	2		
	Woodscrews	6		
	Biplane	12		
	Craig	1		
	Cuneiform of shaft (1 with spline)	3		
	Cuneiform of shaft after bone peg	1		
	Cuneiform of shaft after Knowles	1		
	Domed osteotomy	1		
	Manipulation	4		
	None	1		
	Spica	1	43	

Table 3-11 Continued

Patients Treated Primarily at the Children's Hospital to August, 1974

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Sub-total	In O.R.
Sclerosis	Cuneiform of neck	1		
	Cuneiform of shaft	1		
	Manipulation	1		
	No treatment	1	4	
Shortened leg	Knowles	2		
	Smith-Petersen	1		
	Woodcrews	7		
	Biplane	12		
	Craig	1		
	Cuneiform of neck	1		
	Cuneiform of shaft	8		
	Domed osteotomy	1		
	Hormones	1		
	Manipulation	6		
	None	1		
	Traction	1	42	
Shortened neck	Knowles	1		
	Smith-Petersen	1		
	Cuneiform of shaft (1 with spline)	2		
	Armin-Klein	1		
	Spica	1		
	Traction	1	7	
Skin pressure ulcer	Biplane	1		
Spasm of peroneal nerve	Knowles	1		
Stiffness	Woodscrews	1		
	Biplane	1		
	Cuneiform of shaft	1		
	Cuneiform of shaft after bone pegging	1		
	Traction	1	5	
Thigh atrophy	Knowles	1		
	Woodscrews	1	2	
Thrombophlebitis	Biplane	1		

Table 3-12

Patients Treated Primarily at Johns Hopkins Hospital
from July 1, 1967 to August 1, 1973

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	In O.R.
Ankylosis	Knowles	1	
Avascular necrosis	Knowles	1	
	Untreated	1	
Cartilage necrosis	Knowles	1	
Cystic changes	Untreated	2	
Decreased range of motion	Knowles	2	
Degenerative arthritis	Untreated	2	
Device in joint space	Knowles	3	3
Extra procedures	Knowles (pin withdrawal)	1	
Gait disturbances	Knowles	1	
Infection	Knowles	1	
Irregular acetabular surface	Knowles	2	
Irregular femoral head	Knowles	1	
Joint space widened	Knowles	2	
Leg shortening	Knowles	3	
Migration of pin	Knowles	1	
None	Knowles	1	
	Biplane	2	
	Cuneiform	1	
	Untreated	1	
Osteoporosis	Knowles	2	
Pain	Knowles	1	
	Biplane	1	
Pain on activity	Knowles	1	
Sclerosis	Knowles	1	
	Untreated	1	
Thigh atrophy	Knowles	1	

Table 3-13

Slipped Capital Femoral Epophyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1, 1973

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Subtotal	In O.R.
Avascular necrosis	Cuneiform (with Smith-Petersen	1		
Back knee	Moore after domed osteotomy and Kirschner	1		
	Biplane	1		
	Bedrest and Kirschner	1	3	
Bone chips	Knowles	1		
	Cuneiform	1	2	
Cartilage necrosis	Knowles	2		
	Biplane with manipulation	1		
	Pure closed reduction	1	4	
Chondrolysis	Pure closed reduction	1		
Degenerative changes	Haigie with manipulation	1		
	Biplane	1	2	
Device backed out	Haigie after Smith-Petersen	2		
	Smith-Petersen with Thorton plate after Smith-Petersen	1	3	
Device bent and broken	Biplane	1		
	Haigie	1	2	
Device in joint space	Moore	2		5
	Haigie	5		3
	Haigie after Smith-Petersen	1		1
	Haigie with manipulation	0		1
	Knowles	5		9
	Knowles and Moore	1		
	Knowles with manipulation	1		
	Smith-Petersen	0		1
	Turner	0		1
	Biplane	2		1
	Cuneiform with Moore and Kirschner	1		
	Cuneiform with Knowles	1	20	
Device unremovable	Moore	3		
	Haigie	5	8	
Delayed union	Biplane	1		
Erosin	Biplane	1		
Extra procedures	Biplane(Heyman)	1		
	Haigie (reinsertion of pins)	1		
	Knowles (Hanging hip)	1		

Table 3-13 Continued

Slipped Capital Femoral Epiphyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1, 1973

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Subtotal	In O.R.
Extra procedures	Smith-Petersen with Thornton plate after Smith-Petersen (reinsertion)	1		
	Pure closed reduction (Haigie	1	6	
Femoral head dislodged	Cuneiform with Smith-Petersen)	1		
Femoral head distorted	Moore	1		
	Haigie	2		
	Biplane	4		
	Biplane after Knowles	1		
	Biplane after manipulation	1		
	Cuneiform	1		
	Cuneiform with hormones	1		
	Pure closed reduction	1	13	
Femoral head hypertrophied	Knowles	1		
	Osteoplasty	1	2	
Fever of unknown origin	Haigie	1		
Foot drop	Haigie	2		
Fractured femur	Haigie	1		
	Smith-Petersen after Haigie	1		
Frozen hips	Smith-Petersen after Haigie	1		
	Biplane	1	2	
Gait disturbances	Moore	1		
	Moore after osteotomy with Kirschner	1		
	Haigie	1		
	Haigie after Smith-Petersen	1		
	Cuneiform with Austin-Moore	1		
	Bedrest and Kirschner wire	1	6	
Gait toed in and bow-legged	Smith-Petersen	1		
	Heyman	1	2	
Joint distorted	Knowles	3		
	Biplane	2		
	Cuneiform with Smith-Petersen	1	6	
Knee Pain	Knowles	1		
Neutropenia	Biplane	1		

Table 3-13 Continued

SlippedCapital Femoral Epiphyses Treated Primarily at the Newington Children's Hospital from January 1, 1953 through July 1, 1973

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Subtotal	In O.R.
None	Moore	1		
	Haigie	2		
	Knowles	19		
	Smith-Petersen after Haigie	1		
	Steinman	1		
	Turner	2		
	Biplane	9		
	Cuneiform with Haigie after manipulation	1		
	Cuneiform with Moore	1		
	Derotational	1		
	Heyman	2		
	Pure closed reduction	1	41	
Osteophyte	Cuneiform with Moore and Kirschner	1		
	Cuneiform with Knowles	1	2	
Osteoporosis	Cuneiform with Steineman	1		
Pain	Moore	1		
	Haigie	1		
	Knowles	2		
	Cuneiform with hormone	1	5	
Pain on activity	Moore	1		
	Haigie	2		
	Biplane	2		
	Biplane after Knowles	1		
	Heyman	1	7	
Range of motion decreased	Haigie	1		
	Haigie with Leadbetter	1		
	Knowles	2		
	Smith-Petersen with Thornton plate after Smith-Petersen	1		
	Turner	1		
	Biplane	1		
	Cuneiform	1		
	Cuneiform with hormones	1	8	
Sciatic stretch	Haigie	1		
Sclerosis	Haigie	1		
	Knowles	1		
	Cuneiform with Haigie	1	3	

Table 3-13 Continued

SlippedCapital Femoral Epiphyses Treated Primarily at the
Newington Children's Hospital from January 1, 1953 through July 1, 1973

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Subtotal	In O.R.
Shortened leg	Turner	1		
	Biplane	8		
	Biplane with manipulation	1		
	Cuneiform with Haigie	1		
	Cuneiform	2		
	Cuneiform with hormones	1		
	Heyman	1		
	Heyman with Moore	1	16	
Thigh atrophy	Biplane	1		
Wound infection	Knowles	2		
	Biplane	2	4	

Table 3-14

Slipped Capital Femoral Epiphyses Treated Primarily at the Yale-New Haven Hospital

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Subtotal	In O.R.
Acetabular surface distorted	Knowles	1		
	Wood screws	1	2	
Bursitis around device	Smith-Petersen	1		
Cartilage necrosis with hip ankylosis	Biplane	1		
Condylar epiphyseal closure accelerated	Moore with Haigie	1	3	
Device bent	Moore	1		
	Moore and Haigie	1	2	
Device in joint space	Moore	2		
	Knowles	1		
	Woodscrew	1		
	Woodscrew after Steineman	1		
	Biplane	1		
	Biplane	1	7	
Device guide in joint space	Smith-Petersen and Isinger pin after closed reduction	1		
	Wood screw	3		
	Biplane	1	5	
Device unremovable	Moore	1		
Epiphyseal line widened	Woodscrew after Steineman	1		
Femoral head distorted	Moore	1		
	Haines	1		
	Biplane	1	3	
Gait disturbance	Cuneiform with Steineman	1		
Hypertrophied subcapital area	Knowles	1		
Incomplete Moe fit	Biplane	1		
Joint space distorted	Moore	1		
	Smith-Petersen and Isinger pin after closed reduction	1		
	Wood screws	1		
	Biplane	2	5	
Joint space widening	Haynes with wedge cup compression device	1		

Table 3-14Continued

lipped Capital Femoral Epiphyses Treated Primarily at the Yale-New Haven Hospital

TYPE OF TREATMENT VERSUS TREATMENT PROBLEM

Treatment Problem	Type of Treatment	# Hips	Subtotal	In O.R.
None	Haynes	2		
	Moore	3		
	Knowles	2		
	Smith-Petersen	8		
	Steineman	2		
	Wood screw	2		
	Wood screw or Wood screw after Steineman	1		
	Biplane	7	28	
Osteophyte	Moore	2		
	Smith-Petersen and Isinger pin after closed reduction	1	3	
Osteoporosis	Wood screw	1		
Pain	Knowles	1		
	Smith-Petersen	1	2	
Range of motion decreased	Biplane	1		
Shortened leg	Biplane	1		
	Smith Petersen and Isinger pin after closed reduction	1		
	Cuneiform with Steineman	1	4	

Table 3-15

Problems Associated with SCFE for All Hospitals

PROBLEMS ASSOCIATED WITH SCFE PATIENTS

Groups	Treatment	# Hips
Problems arising purely from disease process:		
Epiphyseal closure of condyle accelerated		1
Hypertrophy of subcapital area		1
Knee pain		1
Widened epiphyseal line of joint space		6
Problems arising purely from therapy:		
Bone chips	Small threaded pins	1
	Non-Biplane shaft osteotomy	1
Bone necrosis	Large screw	1
Bursitis around device	Large nail	1
	Large screw	1
Device difficulty	Large nail	1
	Large screw	2
	Small threaded pins	7
	Biplane	3
Device placed improperly	Large nail	2
	Large screw	2
	Small, threaded pins	30
	Biplane	5
	Neck osteotomy	1
	Other shaft osteotomy	6
Device difficulties with removal	Large screws	2
	Small threaded pins	9
	Biplane	1
Dislodged femoral head	Large nails	3
Extra procedures:		
Device withdrawal	Small threaded pins	2
	Craig	1
Excision of draining sinus	Neck cuneiform	1
Fever	Small threaded pins	1
Flecks of metal left after removal	Large screw	1
Foot drop	Small threaded pins	2
Foot turned	Biplane	3
Fractured femur	Small threaded pins	2
	Manipulation	1

Table 3-15 Continued

Problems Associated with SCFE for All Hospitals

PROBLEMS ASSOCIATED WITH SCFE PATIENTS

Groups	Treatment	# Hips
Problems arising purely from therapy:		
Hepatitis	Large screw	1
Infection	Small threaded pins	3
	Biplane	5
Keloid		1
Neutropenia	Biplane	1
Pain	Large nail	2
	Small threaded pins	12
	Biplane	7
	Other shaft osteotomies	3
	Heyman	1
	Manipulation	1
Palsy secondary to crutches		2
Pressure ulcer	Biplane	1
Sciatic stretch	Large threaded pins	1
Thrombophlebitis	Biplane	1
Problems arising from an indeterminate cause:		
Acetabular lipping	Shaft cuneiform	2
Ankylosis	Large nails	2
	Small threaded pins	2
	Biplane	5
	Neck osteotomy	1
	Other shaft osteotomy	
	Manipulation	2
	Untreated	2
Avascular necrosis	Large screw	1
	Small threaded pins	2
	Biplane	1
	Neck cuneiform	1
	Shaft non-biplane osteotomy	3
	Manipulation	1
	Untreated	1
Back knee	Small threaded pins	1
	Biplane	3
	Manipulation	1

Table 3-15 Continued

Problems Associated with SCFE for All Hospitals

PROBLEMS ASSOCIATED WITH SCFE PATIENTS

Groups	Treatment	# Hips
Problems arising from an indeterminate cause:		
Chondrolysis	Manipulation	1
Cysts	Biplane	1
	Traction	1
	Untreated	3
Degenerative changes	Small threaded pins	1
	Biplane	1
	Untreated	2
Distorted joint surface(s)	Large nails	1
	Large screws	5
	Small threaded pins	15
	Biplane	21
	Craig	2
	Other neck osteotomy	1
	Other shaft osteotomy	
	Armin-Klein	1
	Manipulation	4
	Osteoplasty	1
	Untreated	1
Extra procedures		
Additional first-line therapy	Large nail	2
	Large screw	3
	Peg	2
	Small threaded pin	7
	Small unthreaded pin	3
	Biplane	1
	Other shaft osteotomy	2
	Manipulation	5
	Other	1
Range of motion decreased	Large nail	3
	Large screw	7
	Small threaded pin	15
	Small unthreaded pin	1
	Biplane	14
	Craig	1
	Other shaft osteotomy	8
	Manipulation	4
	Other	1

Table 3-15 Continued

Problems Associated with SCFE for All Hospitals

PROBLEMS ASSOCIATED WITH SCFE PATIENTS

Groups	Treatment	# Hips
Problems arising from indeterminate cause:		
Shortened leg	Large nail	2
	Large screw	7
	Small threaded pin	5
	Biplane	23
	Craig	1
	Other neck osteotomy	1
	Other shaft osteotomy	14
	Manipulation	6
	Other	4
	Untreated	1
Stiffness	Large screw	1
	Biplane	1
	Other shaft osteotomy	2
	Other	5

unique to this patient group. Neither the two patients treated with bone pegs nor the three treated with Haines pins suffered recorded problems. Nevertheless, both bone pegging procedures were later supplemented by other procedures.

Woodscrews were used in fifty patients with only two serious problems. Two of these devices did break and two could not be removed. The high incidence of reported leg shortening is difficult to explain. Otherwise, the problems in this large group are probably a reflection of its size. The small devices had their own problems. The twenty-one patients with Haigie fixation suffered a twenty-four percent incidence of failure to successfully remove the device from the femur, a serious problem for this population so at risk for future hip problems that may require additional hardware for therapy. The other problems in this group were not distinctive of this therapy. Knowles pins were the most popular therapeutic regiment, 120 patients having received this therapy. No recorded problems were reported in forty-three of this group. This group also had the largest number of different problems. The frequency of the device in cartilage space stands out, but the problem is hardly the fault of the device. This diagnosis was made whenever the device protruded through at least half of the cartilage space. Patients in this group suffered a relatively high incidence of decreased range of motion, diagnosed when the slipped hip had less than fifty percent of the range of the contralateral side or a reduction of more than one hundred degrees compared to the normal range. Moore pins were used in twenty-one patients. As with Haigie pins, another small threaded device, the incidence of removal failure was quite high. Other problems in this group were of low frequency. Steinmen ique to this perfect [illegible]

ne pegs nor the [illegible]

oblems. [illegible]

plemented in [illegible]

[illegible]

and Turner unthreaded small devices did not raise any special problems.

The problems encountered in the severely slipped, osteotomized hips, were generally more severe. Cervical osteotomies were performed on twelve hips. The Craig-Kramer and cervical cuneiform problems were considered together because of the small number in each group. Femoral head distortion or avascular necrosis occurred in forty-two percent of these patients. The other major difficulty was the thirty-three percent incidence of additional procedures necessary in treating these patients. The extra procedures included excision of a draining sinus, withdrawal of fixation device, and two McMurray procedures. Biplanes were performed upon eighty-five hips. Leg shortening was a common problem in this group as would be expected since a wedge is removed in redirecting the shaft. This leg shortening should not be excessive if the wedge is less than thirty degrees. Osteoporosis was also somewhat of a problem but this tended to become corrected when the leg became weight bearing again, the sixteen percent incidence of decreased range of motion was large though probably not excessive in this group of severe SCFE's. Non-biplane shaft osteotomies proved to be ridden with problems in eighty-three percent of patients as opposed to sixty percent of biplane treated patients, presumably the group with the most similar SCFE. The problems most prevalent were: the fixation device penetrating into the cartilage space, distortion of the cartilage space and decreased range of motion.

The category of other therapies is difficult to evaluate because of the large range of treatments and their extremely low frequency. The major exception was manipulation or closed reduction. The

twenty-one hips treated in this manner showed a forty-three percent incidence of no problems. The other fifty-seven percent suffered a wide range of difficulties, including a twenty-nine percent incidence of leg shortening. This therapy was often administered concommitantly with other treatments. The extent to which it affects the results of other treatments has not been determined. It is noteworthy that an occasional persistent therapist subjected patients to repeated manipulations, as many as four.

Having considered the difficulties of each therapy, let us look at Tables 3-11 through 3-15. The first group of problems stems purely from the disease process. This includes accelerated closure of the condylar epiphysis, presumably a reflection of the general epiphyseal closure system. However, only one case in over 200 patients studied hardly argues for much significance. Hypertrophy of the subcapital area, also possibly involved with the osteogenic process, occurred too infrequently to be significant. Contralateral knee pain suggesting referred pain from the contralateral hip, perhaps indicative of bilateral disease, occurred but once. Widened epiphyses, based on hip roentgenograms, occurred in six patients, accounting for only one percent of the subjects. Even this frequency may be high due to nonstandard projection of the displaced head. Thus, this hardly merits a discussion of its role in epiphyseal malfunction. This etiological group, therefore, failed to demonstrate significant findings.

The second group consisted of those problems resulting purely from the therapy. Bone chips arising from procedures aimed at removing stubborn fixation devices were rare. The bone necrosis

secondary to the Godoy-Moreira screw was discussed above, as was the bursitis around the other Godoy-Moreira screw and a Smith-Petersen nail. Breakage and bending of devices occurred most commonly in small threaded pins, four percent sustained this problem. Some difficulties with the biplane apparatus, which totaled four percent, were due to incomplete fits commoner in earlier designs of the plate. Improper placement of the fixation device most commonly signified penetration through at least fifty percent of the cartilage space of the hip. This occurred throughout the range of devices, although it was most common with small threaded pins, nineteen percent. These same devices often went on to cause the most difficulty in removal as demonstrated in five percent of the hips. Only three percent of the large devices posed significant problems with removal. Large nails dislodged the femoral heads in eighteen percent of the so treated hips, accounting for every incidence of the problem in this study. This problem occurred during implacement when the nail was driven into the hard cartilage generating enough force to separate the femoral head and neck. Three devices were withdrawn post-operatively because roentgenograms showed placement into the cartilage space. A draining sinus, probably caused in one hip by reaction with the fixation device, had to be excised. A significant fever developed in one patient. This problem was one of a sub-group that originated as problems secondary to the type of procedures required for treatment and not specifically to a SCFE operation. Others in this sub-group include hepatitis--presumably from blood transfusion, infection, keloid, neutropenia, secondary to the [illegible]

the bursitis around [illegible]

Petersen nail. [illegible]

in small threaded pins, [illegible]

difficulties with the [illegible]

were due to incomplete [illegible]

improper placement of the [illegible]

penetrating [illegible]

the hip. This occurred [illegible]

[illegible]

crutch palsy, pressure ulcer and thrombophlebitis. Foot drop occurred during fixation with small threaded pins. The foot was turned during fixation in three instances, resulting in problem related most commonly to biplanes. Three instances of fractured femora occurred. This problem is discussed in the biomechanics section, Section six. Pain was recorded in six percent of the treated hips. The incidence was highest in biplanes, eight percent, and small threaded pins, seven percent. Sciatic stretch also occurred.

The largest groups of problems are those difficult to ascribe solely to the disease process, the mode of therapy, or another specific cause. Acetabular lipping was a roentgenographic problem without much practical importance. Ankylosis occurred in six percent of biplane procedures. It was diagnosed if joint sclerosis or chart notes demonstrating clinical ankylosis were discovered. Avascular necrosis, or the death of the femoral head due to an interrupted blood supply, occurred throughout a vast range of treatment modalities, even in the small untreated group. Back knee occurred most frequently among those treated with biplane; four percent sustained this problem. Chondrolysis occurred just once but, interestingly, that hip was treated by manipulation. Cysts of the femur occurred in three of the four untreated hips studied. This should not be taken as evidence that seventy-five percent of untreated SCFE's go on to cyst formation because of the biases reviewed above, but does constitute an interesting finding. Degenerative changes, especially arthritis, were separated from those degenerative changes clearly resulting from necrosis or chondrolysis. A related problem, distorted joint surface, includes those cases where

roentgenograph demonstrated perturbations in articulating bone contours. Cases demonstrating necrosis of the femoral head or chondrolysis, as noted above, were not included in this category. Thus, this group represents those cases of distortion not progressing to severe complications. Six percent of procedures, most commonly the small threaded pins, required an additional procedure to either refix or osteotomize the femur. Procedures requiring this repeated therapy may be considered to have failed to control the SCFE. Decreased range of motion occurred in thirteen percent of the hips studied. This difficulty was most pronounced in the non-biplane shaft osteotomies, as might be expected since these were severe slips with correction in only one plane. Shortened leg occurred in many treatment modalities. Femoral distortion due to the SCFE probably explains the leg shortening in non-osteotomized legs; osteotomized legs would be expected to have shortening due to the removal of the bone during the procedure. Stiffness, though a functionally significant problem, occurred most commonly with accompanying major problems in which case the subject would have been included in one of the groups considered above.

Thus, in situ fixation was the preferred method of treating mild slips while osteotomy was the most popular for severe slips. Success rates showed the former group to have the better prognosis but, even here, about one in five do run into problems. This statistic makes a case for abandoning prophylactic pinning in favor of a watch and wait management with, perhaps, hormonal therapy to speed epiphyseal plate closure and hence speed the end of the time during which the patient is susceptible to this disease. No evidence was available as

to the most effective drug, dose or schedule for such hormonal therapy.

Although cervical osteotomies realized a substantial number of good results, the high percentage of poor results argues against their use except by surgeons well experienced in this type of treatment. Biplane osteotomy was shown to yield better results than other shaft osteotomies and fewer poor results than the cervical counterparts. This may well be the treatment of choice in cases of severe slips where sufficient practice and expertise is not available to assure that the cervical procedure will not go awry.

In situ fixation was shown to be most successful with large screws. However, the Godoy-Moreira proved the least safe of these devices due to its tendency to cause bone necrosis and reaction around itself. Nails are discouraged because of the danger of dislodging the femoral head during insertion. Small devices carry the combined problems of difficult, often impossible removal, as well as a high incidence of failure through bending or frank breaks. No matter what therapy is selected, problems can occur. The normal surgical risks and the risk of transfusions combine with special problems relating to gait and range of motion. These must be expected so that they can be treated promptly. The hanging hip procedure proved quite effective for avascular necrosis.

While each individual patient presents a unique combination of clinical considerations, some guidelines seem in order. Any heavy, especially tall child with a gait disorder or hip pain, either direct or referred from the knee, should be x-rayed for possible SCFE. If the slip is mild, it should be conservatively treated with either to the most effective [illegible]

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good results, the [illegible]

use except by surgeons [illegible]

plane osteotomy was [illegible]

osteotomies and [illegible]

may well be the [illegible]

sufficient practice [illegible]

cervical procedure will [illegible]

In situ [illegible]

However, [illegible]

to its [illegible]

cells are [illegible]

bone during [illegible]

difficult, [illegible]

failure [illegible]

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of [illegible]

[illegible]

of [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

immobilization or, preferably, in situ fixation using a large screw. The amount of slipping should be recorded and the width of the cartilage space should be measured and recorded for each hip. Follow-up x-rays at six month intervals are important to predict the course of the cartilage space width, ascertain the extent of epiphyseal closure obtained, and keep abreast of possible developments in the contralateral hip. The index of suspicion for bilateral SCFE should be elevated for women and blacks but in few, if any, cases should prophylactic pinning be performed. The fixation device should be removed as soon as epiphyseal closure has been achieved in order to minimize bone overgrowth. Removal of the hardware should be undertaken with adequate provision for post-operative measures to minimize trauma to the femur, which is greatly weakened by the removal procedure, especially in the case of difficult removals. Severe slips should be treated either by cervical osteotomy or by biplane, depending upon the experience of the surgeon. The higher incidence of problems in this group argues for more frequent follow-up; otherwise, the management should be similar to that for mild SCFE. If avascular necrosis develops, a hanging hip procedure should be considered as a salvage procedure before a cup arthroplasty or total hip is undertaken.

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Slipped Capital Femoral Epiphysis--

Case Studies of Major Complications and Long Term Follow-Up

by

Theodore Simon

The method of choosing patients and discovering treatment problems has been described previously. In this article, individual patients were selected to illustrate some of the major complications encountered in slipped capital femoral epiphysis. These patients were selected as cases readily demonstrating the problem under consideration with a minimum of other difficulties to obscure the discussion. A second section deals with the long term follow-up of the original biplane osteotomy cases reported by Southwick (1). These patients were sought. Those located were examined after A-P and frogleg lateral views of the hips were obtained. They were then rated according to the criteria used in the preceding section.

Results

Case 1: Normal Surgical Risks

> This sixteen year old obese white boy (R.T. CH #11518) sustained a football injury eighteen months prior to admission. X-rays proved a left SCFE. He received a biplane osteotomy. One month after the procedure, the spica was removed. The patient exhibited a skin pressure ulcer from the cast, which took over a month to resolve. The patient enjoyed an excellent recovery from the SCFE.

This case serves as a reminder that any procedure requiring a cast carries a special set of complications such as pressure ulcers and thrombophlebitis. Of course, any osteotomy may result in non-union, any procedure requiring crutch walking jeopardizes the brachial plexus and any surgery carries the risk of infection andkeloid formation as well as hepatitis if blood transfusions are necessary. These complications all occurred in this sample of patients. They have been deemphasized in this paper because they are well studied phenomena, easily

available in standard surgical textbooks. Their importance to the patient as a source of pain, inconvenience, expenses and disfigurement make them important, nonetheless.

Case 2: Untreated Result, Asymptomatic SCFE, Poor Surgical Technique

This fourteen and one-fourth year old black girl (I.M. CH #30023) complained of left hip and knee pain for one year and demonstrated a limp of one year's duration which gradually worsened. X-rays revealed a bilateral SCFE. A left biplane was performed but the patient refused a similar procedure on the contralateral side. Four months after the operation, the right femur showed increased cervical osteoporosis with some dissolution of the inferior aspect of the femoral head. The patient complained of bilateral pain and decreased range of motion, most severe on the right. The operated side went on to develop disuse atrophy of the bone due to improper surgical technique. The right side developed cystic lesions in the femoral head.

This case serves as the best sample control for the effect of therapy on a patient. Although a poor result was obtained using grossly improper biplane therapy, the untreated side fared little better. Such a case suggests that certain patients are more likely to develop problems than others. The worse results in this study occurred in the race and sex of this patient. I.M. also reminds us that a SCFE may be asymptomatic as in the case of the severe slip in her right hip. This series contains numerous examples of bilateral slips detected on x-ray when only a unilateral slip was expected. Since early diagnosis permits much less radical treatment with a correspondingly improved prognosis over severe slips, bilateral SCFE's should be suspected especially in the case of black females.

Case 3: Stiffness, Osteoporosis, Herndon-Heyman Salvage

This twelve and one-third year old, massively obese black girl (J.B. CH# 28447) presented with a four month history of limping dating from a fall. X-rays confirmed a severe left SCFE. She was treated with a biplane. Four months after surgery, some femoral head deformity was noted

on x-ray. At this time, she suffered from stiffness and external rotation as well as moderate osteoporosis. She was noted to have a residual of thirty degrees of posterior tilting and about thirty degrees of external rotation. She underwent a Herndon-Heyman procedure three years after the biplane. Slight improvement was noted.

This case illustrates several important points. Stiffness was a fairly common problem throughout the sample. The osteoporosis was also very frequent. This osteoporosis on x-ray, however, may be ascribed to the prolonged bedrest accompanying many SCFE procedures. Surveying x-rays of comparatively aged patients suffering from unrelated diseases who were subjected to similar amounts of bedrest uncovered similar osteoporosis in the majority of roentgenograms. The Herndon-Heyman procedure was fairly commonly performed upon patients enduring decreased range of motion due to mechanical obstruction of the movement of the femoral head. In this situation, the procedure was usually useful in improving the range of motion.

Case 4: Biplane Plate Placement, Deformed Femoral Head and Acetabulum

This fifteen year old black boy (L.H. YNHH #43-73-04) presented with right hip pain following trauma. X-ray studies demonstrated bilateral severe SCFE with deformed femoral heads and acetabulae. No appreciable abduction could be achieved in either hip. Bilateral biplane osteotomies were performed. Two months after the operation, x-ray study revealed the Moe plates protruding into the soft tissue. The plates were removed bilaterally one year after surgery, without complications.

This case illustrates that the Moe plate need not hug the femur too closely in order to be both effective and acceptably non-irritating. Before the present design was established, the plate tailed off substantially into the soft tissue (see Figure 4-1). Over concern,

Figure 4-1

Ill-fitting Plate

demonstrated by numerous trials and plate bendings, unnecessarily increases operative time and weakens the plate.

The deformed femoral head and acetabulae prior to surgery prove that this problem can be a natural result of the disease process independent of the mode of therapy. Each case of deformity cannot, therefore, necessarily be ascribed to the treatment.

Case 5: Malpositioning of Distal Femoral Shaft

This sixteen and seven-twelfths year old white boy (C.B. CH #16291) with a history of limping for ten months and pain in the right hip that developed since the limping began was treated using a biplane with a benign postoperative course, although he could abduct only to neutral on the right side. Nine months later he complained of inability to bring his right leg back into extension and could abduct only to midline. His range of motion was: (R/L) flexion 80/80, extension lacked 20/full, abduction 50/50, adduction -15/+20, internal rotation 0/15 and external rotation 45/45. The lesser trochanter was found to impinge upon the right ischium. This obstruction was eliminated by lesser trochanteric osteotomy and transplantation of the same. The patient enjoyed increased range of motion.

This interesting complication stems from the relative realignment of the femur above and below the osteotomy site. More common problems such as a turned foot also resulted from malpositioning after osteotomy. These problems could be avoided if extra care is taken to foresee the ramifications of any positional changes made during surgery, if any are necessary at all.

Case 6: Decreased Range of Motion, Degenerative Arthritis, McMurray Salvage

This twelve and eleven twelfths year old black girl (A.N. CH #28249) complained of knee pain for eleven months. X-rays showed bilateral SCFE. The left hip was manipulated. The right and, subsequently, the left hip, received Craig-Kramer osteotomies. The patient suffered bilateral pain

and spasm with the following range of motion: (R/L) flexion 90/90, abduction 10/20, adduction 20/20, internal rotation 10/10, and external rotation, 20/20. Seven months post-operatively, degenerative arthritis was diagnosed bilaterally. Eight months after surgery, she underwent bilateral McMurray osteotomies for severe degenerative arthritis. At this time, her range of motion was: (R/L) flexion 60/10-15, internal rotation -/0, external rotation -/15. Fifteen months after the Craig-Kramer osteotomy, she had bilateral flexion contractures of 20-25 degrees.

The McMurray osteotomy as a salvage procedure for degenerative arthritis is outlined in Section six with regard to the biomechanics involved. Although this therapy was seldom used, the results did not seem as impressive as those gained with the hanging hip procedure.

Case 7: Acute Cartilage Necrosis, Hanging Hip Salvage

This fifteen and two-twelfths year old boy male (L.U. NCH #21082) presented with a two month history of left hip pain. X-rays showed a mild left SCFE. The patient was treated by closed reduction of the slip. Increasing hip pain and decreased range of motion led to a suspicion of chondrolysis. Two years after the procedure, an irregular femoral head was found on x-ray. Acute cartilage necrosis was diagnosed. A hanging hip procedure was of value in reducing the symptoms.

Closed reduction proved far from a benign procedure. One patient endured four such treatments before developing chondrolysis. The hanging hip procedure, discussed briefly in Section six, consistently proved very effective in relieving the symptoms of this serious complication.

Case 8: Device in Cartilage Space, Antalgic Gait, Decreased Range of Motion, Leg Shortening, Distortion of Femoral Head

This fourteen and three -fourths year old well proportioned white male (D.C. NCH #16253) presented with a one month history of right hip pain diagnosed by x- ray as a severe right SCFE and treated first by Buck's traction, then by cuneiform osteotomy. A Knowles pin was found by x-ray

and spasm with [illegible]
flexion 90/90 [illegible] 10/10
rotation 10/10, [illegible]
post-operatively [illegible]
bilaterally [illegible]
bilateral [illegible]
arthritis. At this [illegible]
flexion 60/10-15, [illegible]
-/15. [illegible]
she had bilateral [illegible]

The McMurray [illegible]

arthritis is [illegible]

involved. Although this [illegible]

seem as impressive as [illegible]

Case 7: Acute Arthritis [illegible]

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Case 8: [illegible]
[illegible]

[illegible]

to reside in the cartilage space but was not withdrawn for ten months. The patient developed an antalgic gait and decreased ranges of motion on the right. The lesser trochanter epiphysis was shown to close earlier on the right side. The patient suffered a one inch right leg shortening and gradual distortion of the right femoral head, plainly visible twenty months after surgery.

The only major indicator of trouble was the protrusion of the Knowles pin into the cartilage space. Thus, although no conclusions may be proved regarding the effects of a device in the cartilage space, such a condition may be quite dangerous. Presumably the mechanism of reaction is excoriation of the cartilaginous lining of the joint.

This patient also demonstrates some epiphyseal abnormalities on his right side. The moderate leg shortening may be ascribed to the wedge removed during surgery or to epiphyseal disturbance, but there is little explanation for the accelerated trochanteric epiphyseal closure. This phenomenon, although specifically sought, proved to be rare (see Section three), nevertheless. The presence of this disturbance in addition to the distorted femoral head, the leg shortening and the antalgic gait, as well as the SCFE itself, may point to a diathesis for growth area difficulties on the right side. Such a collection of problems was relatively common, see Table 2-12. There is no reason to assume that certain physicians were more apt to record the problems than others since the patients were not grouped by name of physicians, however, this was not tested. Rather, certain patients seemed more at risk to develop problems than others. This fact suggests a basic growth area defect in a specific subgroup of the SCFE patient population.

Case 9: Bone Necrosis Around Device, Drainage Requiring Surgery

This twelve and one-sixth year old white boy (J.S. CH #7011) complained of right hip pain and limped since a wrestling match one year prior to admission. At the time of the match, x-rays had been negative. On admission, they disclosed a right SCFE that was treated with a cuneiform femoral neck osteotomy performed with the insertion of a Godoy-Moreira screw. Follow-up x-rays demonstrated bone necrosis around the screw. Seven years after the procedure, drainage around the scar required surgical intervention to remove the bursa and a fistulous tract from the greater trochanter which was believed to be secondary to chemical or mechanical irritation from the screw.

In both instances in which the Godoy-Moreira screw was employed, bone necrosis occurred around the device. Perhaps the reaction was due to the pressure generated by the design or perhaps, though much less likely, a chemical incompatibility was present. In any case, this is enough evidence to discourage the use of the device under ordinary circumstances.

Case 10: Device Backed Out

This nine year old obese white girl (L.B. NCH #12731) presented with a five month history of left hip pain and a six month history of right hip pain. An x-ray diagnosis of bilateral mild SCFE was made and internal fixation was performed by nailing first the left then, eight days later, the right with Smith-Petersen nails. Four month follow-up x-rays showed that the nails had backed out. They were replaced with Haigie pins bilaterally in two separate operations. The right pin was post-operatively discovered to penetrate into the cartilage space. The pins were removed four (right) and five (left) months after implantation. The patient suffered only a temporary antalgic Trendelenburg limp.

This case demonstrates one of the two special problems associated with Smith-Petersen internal fixation. The nails lack threads which help to prevent backing out in other devices. Section three presents the incidence of this problem which can lead, as in this case, to an extra fixation procedure. The second special problem of these nails relates

to their insertion. The big devices must be hammered into place. When the nail courses through the neck into the epiphyseal plate, the relatively higher density of the cartilage increases resistance to the nail. A higher store of energy thus builds up, occasionally enough to dislodge the head. Figure 4-2 depicts the dislodgement of a femoral head by the Smith-Petersen device.

The temporary antalgic Trendelenburg limp occurred fairly frequently but was not considered a problem unless it persisted for eighteen months, a period of time that separated those patients who suffered limited therapeutic success from those that went on to resolve their gait difficulties.

Case 11: Unsuccessful Removal of Device, Fractured Femur, Abnormal Gait, Leg Shortening

This twelve and one-third year old white Foelich male (T.S. NCH #9805) presented with a one month history of left hip and knee pain. X-rays revealed a mild left SCFE which was fixed, in situ, by Haigie pins with a good result. Twenty-seven months later, the patient underwent a unsuccessful attempt to remove the pins. Soon after discharge, the patient sustained a fall, resulting in a left femoral fracture at the lateral angle of the trochanter. The fracture was reduced and fixed with temporary Haines pins. After six months of immobilization in a spica, the patient was discharged with only a mild gait disturbance and a three-quarter inch leg shortening.

This case illustrates the often overwhelming difficulties posed by removal of small, threaded pins. Successful removal often required gouging, which weakened the femur, thus creating a propensity for fracture, as occurred in three patients within this study. Nevertheless, the importance of removing the pins is two-fold. Firstly, their presence interrupts the normal lines of force acting within the bone, as outlined in Section six. This interruption serves to stress the femur in normally unanticipated directions, see section six. Secondly,

Figure 4-2

Head Dislodged During Nailing

they obstruct the upper femoral marrow, making later procedures such as femoral head replacement difficult. Since these patients are at risk for developing complications eventually requiring such a prothesis, this is a noteworthy consideration.

The problem of pin removal can be simplified by the use of larger devices, such as woodscrews, when possible. Even so, dangers exist such as femoral cracking which occurred during screw removal, and flecks of metal left in the wounds after difficult device removal. These problems, however, arose much less frequently than those associated with removal of the smaller, more easily broken, threaded devices.

The long-term follow-up section of this study resulted in locating seventeen of the original twenty-six patients (65 percent) making a total of nineteen slipped hips, treated with a biplane osteotomy. Of these SCFE procedures, Southwick's criteria (1) rate thirteen (72 percent) as excellent, three (17 percent) as good, two (11 percent) as fair and none (0 percent) as poor. For comparison to other results in this paper, the criteria listed in Table 2-1 would rate sixteen (89 percent) as good, two (11 percent) as fair and none (0 percent) as either poor or indeterminate.

Discussion

The above cases represent a relatively small number of the problems encountered in treating SCFE. After studying each of the patient's records, five comments seemed atypical of the others. Cartilage space narrowing was vaguely treated. This problem was, therefore, studied in depth and discussed in the following section. The other four were deleted from more than passing consideration in this work. "Device

they obstruct the [illegible]
femoral head [illegible]
developing [illegible]
a noteworthy [illegible]

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devices, such as [illegible]
such as femoral [illegible]
of metal left in the [illegible]
problems [illegible]
removal of [illegible]

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results of [illegible]
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[illegible]

guide in cartilage space" and "device in cartilage space during surgery" were eliminated because of the difficulty in assessing their significance and because those orthopaedic surgeons questioned regarded these occurrences as often unavoidable and insignificant. "Osteoporosis" was eliminated from consideration for the reasons discussed in the report on Case 3 above. "Thigh atrophy" was deleted both because it was seldom actually measured and because its significance is highly doubtful except as an indicator or disuse

The biplane follow-up study reveals the remarkably good long-term results that can be expected with this procedure. Indeed, many of the worse results encountered using the biplane procedure were obtained in cases which were ineptly executed, such as Case 2 that shows post-op films of the plate screws passing through the femoral head and anchored in the pelvis .

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[illegible]

Case #1 HBL (JHH #104796): not located

Case #2 WMHG (CH #7391, JHH #545903) evidenced cartilage space narrowing, acetabular lipping and several osteophytes by x-ray at twenty-four years post-op. She suffers chronic moderate pain with some gait disturbance. The Trendelenburg sign was negative. Her range of motion on the affected side after cup arthroplasty was flexion 60, IR 10, ERS, abd, 25, add 10. She is rated as fair. Her current age is 36.

Case #3 LJ (CH #7592): not located.

Case #4 JN (CH #7730) has an excellent cartilage space, head shape and texture at 23 years after surgery. He has a normal range of motion and complains of no pain or difficulties. He is rated as an excellent result. His current age is 36, height 68", and weight 234 pounds, down from a maximum of 330 pounds.

Case #5 SB (CH #7803): deceased. The last records on this patient indicate that her result did not improve over the fair result at age 28. She complained of pain and suffered chronic functional impairment at 14 years post-op.

Case #6 MNF (JHH #711315): has an excellent cartilage space, head shape and texture at 19 years post-op. She demonstrated a negative Trendelenburg with a range of motion (R/L) of flexion 110/120, extension 20/15, internal rotation 45/30, external rotation 30/45, abduction 40/40 and adduction 30/30. She retains only a one-quarter inch shortening and is rated as an excellent result. Her current age is 31, height 64 inches and weight 155 pounds.

Case #7 RF (JHH #381915): has some cartilage space narrowing on the unaffected side at seventeen years post-op. He complains of slight pain after activity on the unslipped side and demonstrates minor thigh atrophy. He demonstrates a negative Trendelenburg with a slightly decreased range of motion on the unoperated side. He has a one half inch leg shortening and is rated as an excellent result. His current age is 30, height 69 inches and weight 180 pounds.

Case #8 BM (CH #10529, JHH #796872): has no cartilage space narrowing, femoral head degeneration or pain at 16 years post-op. He is athletically active with a negative Trendelenburg. Only slightly decreased range of motion was evidenced. He is rated as excellent. His current age is 31.

Case #9 MH (JHH#310311) has an excellent cartilage space, head shape and texture at 16 years post-op. Her range of motion is excellent with a negative Trendelenburg. She has suffered only a one-half inch leg shortening and is rated as an excellent result. Her current age is 27, height 68 1/2 inches and weight 217 pounds.

Case #10 CN (JHH) not located

Case #11 KL (YNHH #48-95-47): she is rated as excellent at twenty-seven years old, sixteen years post-op.

Case #12] GS (CH #11901): He is deceased but was rated as excellent when examined bilaterally at twenty years of age, five years post-op.

Case #13 BS (NCH # 9594): She is rated as excellent at twenty-five years of age, thirteen and one-half years post-op.

Case #14 HD (CH #12838): complains of some stiffness and mild aching fifteen years post-op. X-rays revealed some osteoporosis with slight loss of head sphericity. His range of motion was moderately limited to rotation when the hip was flexed and slightly decreased to abduction when extended at fifteen years after the biplane. He demonstrated a negative Trendelenburg. He is rated as a good result at twenty-eight years of age.

Case #15 JM (JHH #863313): has a slight cartilage narrowing of the lateral edge of the joint and a negative Trendelenburg at fifteen years after the biplane procedure. He was treated for his bilateral SCFE with a biplane on the left and an in situ fixation on the right. His range of motion was (R/L) flexion 95/85, extension 10/10, internal rotation 5/15, external rotation 35/35, abduction 30/40, and adduction 20/15. He suffered a seven-eighths inch shortening and is rated as a good result bilaterally. His current age is thirty, height six feet and weight 265 pounds.

Case #16 WLB (U. of Va.): not located

Case #17 AO (YNHH #52-11-14): not located

Case #18 CH (JHH # 916339) has an excellent femoral head and texture with slight cartilage space narrowing at fourteen years post-op. She demonstrates a negative Trendelenburg with no shortening. Her range of motion (R/L) is flexion 110/110, extension 20/20, internal rotation in extension 45/45, internal rotation in flexion 20/0, external rotation 60/60, abduction 20/20 and adduction 20/20. She is rated as an excellent result. Her current age is twenty-eight, height 57 1/2 inches and weight 268 pounds.

Case #19 LD (YNHH #C9-47-00): not located

Case #20 PS (CH #14195) complains of occasional twinges in the groin and limited motion although he is able to walk long distances at fourteen years post-op. He demonstrates a negative Trendelenburg with the following ranges of motion (R/L) flexion 90/70, extension 20/30, internal rotation 0/0, external rotation 5/-30, abduction 30/30 and adduction 20/30. He has suffered no shortening or thigh atrophy. The left

side was slightly toed out. He is rated as good on the right and fair on the left. His current age is thirty-two, height 74 inches and weight 230 pounds.

Case #21 MH (JHH#940177): not located

Case #22 RDZ (CH #14349) complains of no difficulties or discomfort at fourteen years post-op. He has a negative Trendelenburg with a slight decreased range of motion. He is rated as excellent. His current age is twenty-eight.

Case #23 CS (NCH#10879): not located

Case #24 GM (BCH#277627): weight lifts without difficult or pain at fourteen years post-op. X-rays demonstrated an excellent cartilage space, femoral head and texture. He demonstrated a Trendelenburg with a normal range of motion except for a loss of 20 degrees of external rotation of the right side. He suffers a three-quarter inch leg shortening for which he wears a three -eighths inch lift. He has some genu valgum. He is rated as an excellent result. His current age is twenty-nine, height 73 inches, weight 308 pounds.

Case #25 TW (Vanderbilt): not located.

Case #26 JAW (YNHH #C4-24-56) has an excellent cartilage space, head shape and texture at twelve years post-op. She demonstrated a negative Trendelenburg with a normal range of motion and no thigh atrophy, although there was a one inch difference in leg length. She is considered an excellent result at age twenty-five.

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Slipped Capital Femoral Epiphysis--
Cartilage Space Narrowing

by

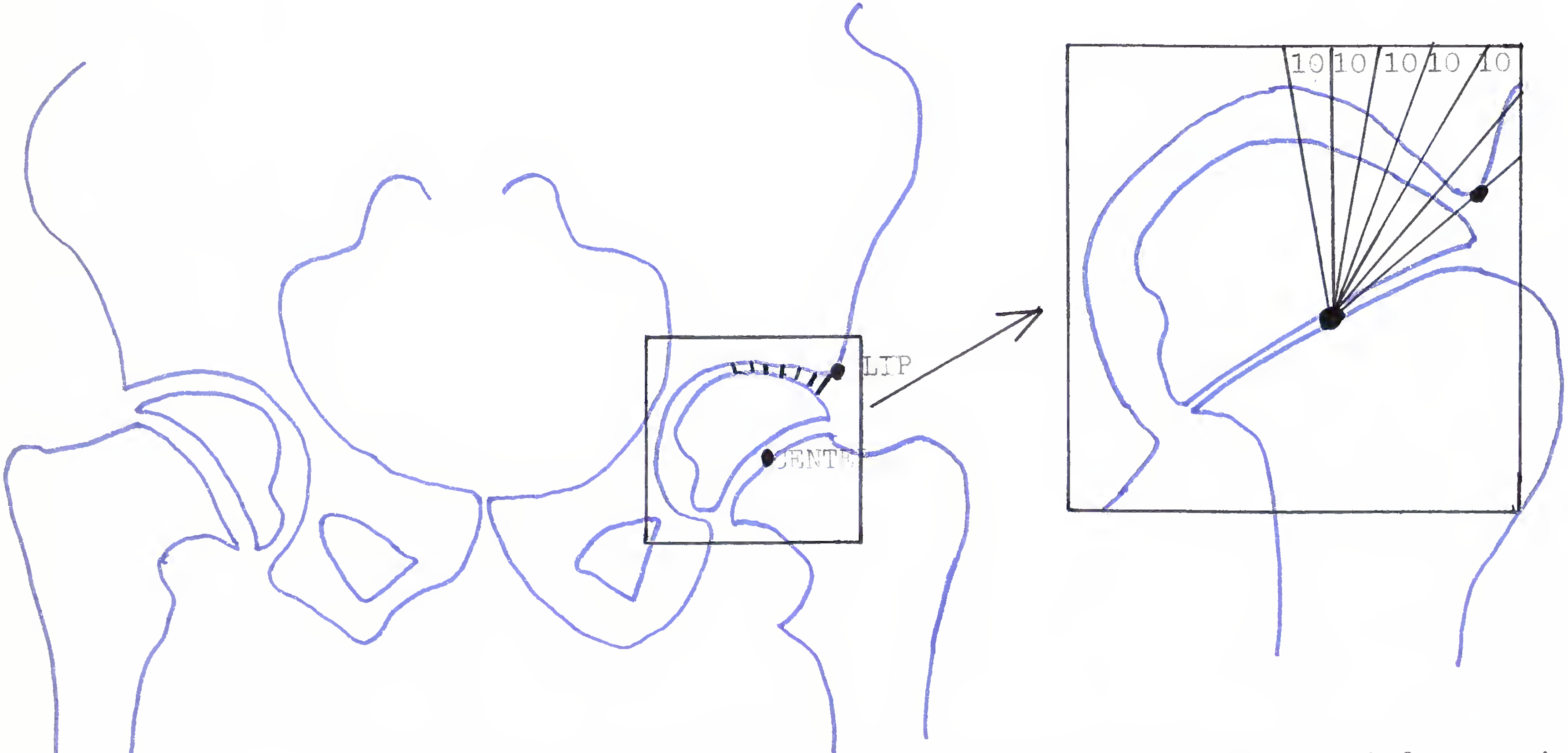
Theodore Simon

Introduction

While examining the results of various treatments for slipped capital femoral epiphysis (SCFE), it became apparent that a frequent concern was cartilage space narrowing in the involved hip. In this study we tried to learn more about the natural history of the disorder and discover any clues that might help avoid it or treat it. We, therefore, surveyed the SCFE population described earlier to determine (1) the population at risk for this problem, (2) the extent to which it occurred, (3) the effects of any treatments in general, as well as any measurable difference associated with the various treatments and (4) the natural course of the problem. For the purposes of this study, cartilage space narrowing is defined as any diminution in the space between the acetabulum and the articulating femoral head as measured on an A-P roentgenogram.

Method

All roentgenograms from all patients who received their initial SCFE treatment at either Newington Children's Hospital or Yale-New Haven Hospital were requisitioned. Patients were grouped by race, sex and the following treatment types: *in situ* fixation, biplane osteotomy or non-biplane osteotomy of the femoral shaft. Each studied roentgenogram of a hip was measured by noting the distance between the calcified acetabular margin and the calcified edge of the femoral head at the lateral extreme of the joint space as determined by two methods. Method I entailed drawing a line from the center of the femoral head to the acetabular lip (see Figure 5-1A). Six additional lines were then drawn at ten degree intervals through the center of the femoral head progressing medially along the acetabulum (see Figure 5-1B). The distance between the calcified limits of the joint was noted along each of the seven lines unless a line passed



Cartilege Space Width = Sum of lengths of each line from calcified acetabular margin to calcified femoral margin (black lines in figure 5-1a) /7.

Figure 5-1a

Figure 5-1b

through the femoral fovea, in which case the curve of the femoral head was extended and the distance between the acetabulum and the curve was used. The seven values for each hip were then averaged and the results, to the tenth of a millimeter, were recorded. This averaged value is defined as the cartilage space width (CSW). This method suffers from differential magnification of the cartilage space and the requirement that the technician intuitively locate the center of the head. The need for objectivity fostered Method II which was used for this part of the study. Method II entails the following steps: Step 1 - Construct a transverse baseline through the most superior portion of the obturator foramina on an A-P roentgenogram depicting both femoral heads. Step 2-Draw a line perpendicular to the base such that it forms a three centimeter cord with respect to the medial portion of the femoral head. Step 3 - Draw a second three centimeter cord through the superior portion of the femoral head perpendicular to the first cord. Step 4 - Extend the perpendicular bisectors of these cords until they intersect at the idealized center of the femoral head. Step 5- With the goniometer parallel to the base at the level of the newly determined center, construct a series of five rays through the cartilage space fifteen degrees apart beginning at forty-five degrees. Step 6 - Note the width of cartilage space at each of these points and average to the tenth of a millimeter. Step 7 - Draw a diameter through the head preferably 150 degrees to the first ray or 135 degrees, if the head could not be visualized entirely at 150 degrees. The length of this diameter standardizes magnification errors in cartilage space width (CSW). The procedure is then repeated on the contralateral hip. Serial x-rays can be compared for CSW by taking an average head diameter and proportionately altering the CSW

and individual diameters to provide a constant diameter (see Figure 5-2A and 5-2B). This method assumes no absolute growth in the femoral head during the series, but, we believe, the error incurred by that assumption is smaller than potential magnification errors in these often obese patients. This method is greatly facilitated by constructing a device that provides a right angle, metric ruler and holes drilled at the standard angles: 15, 30, 45, 60, 75, 135, and 150 degrees. The CSW values for the first eighty-five post-operative days were separated from the rest of the data. They were treated separately in order to concentrate upon the long term course. All patients who did not have at least two comparable roentgenograms taken more than eighty-five days after the SCFE surgery were excluded from the data. In the unilateral case, the cartilage space difference (CSD) was determined by subtracting the width of the affected hip from the width of the unaffected hip. In the case of bilateral SCFE, the right was subtracted from the left. At this point, linear regressions for all CSW were taken with respect to the day of surgery. The slope and intercept of the derived lines were examined with regard to race, sex and treatment type, using the unaffected hip as the control.

In addition, the first day that patients suffering unilateral SCFE's obtained a CSD of within one tenth millimeter of zero, i.e., when the width was equal bilaterally, was noted, as were the percentages of case in which the CSD resolved to this point. Those cases which did not resolve were noted and their smallest CSD recorded, along with the post-operative day during which this value occurred.

Maximum and minimum values for CSW were likewise recorded with respect to groups to determine the extent to which a joint may be expected to improve, the degree of cartilage space narrowing to be expected and the and individual [illegible]

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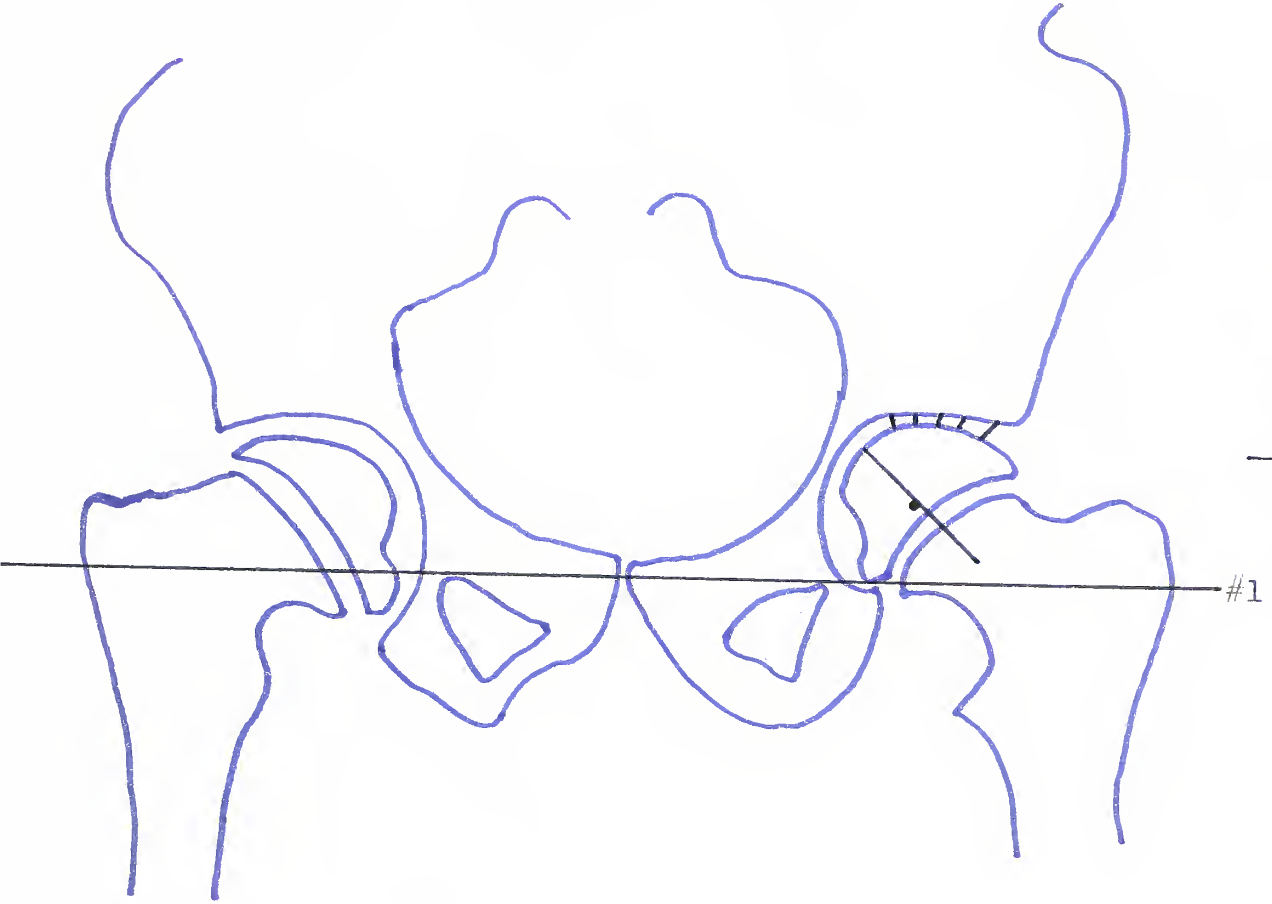

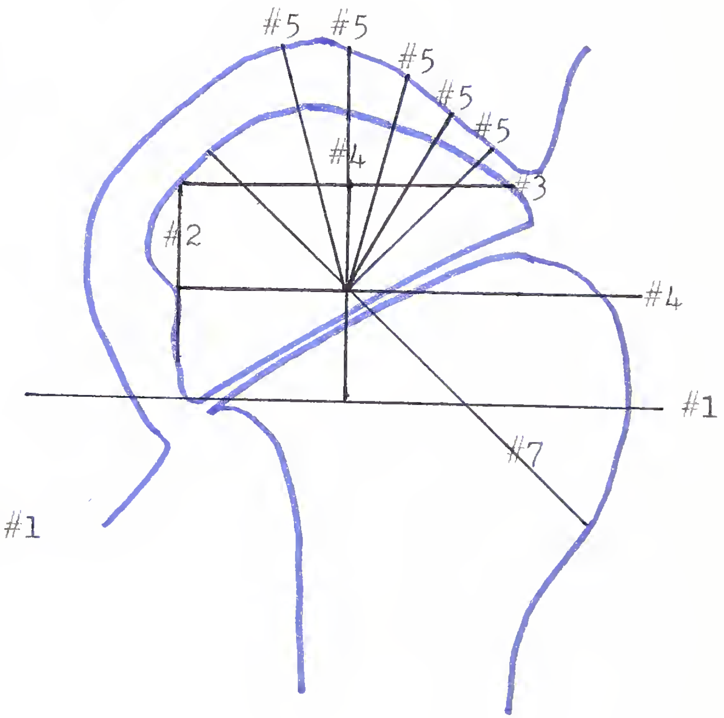

Numbers refer to the steps described in the text.

Figure 5-2a

Figure 5-2b

number of post-operative days required to reach these values. The second part of the study was performed upon the thirty Newington Children's Hospital and Yale-New Haven Hospital patients who endured a unilateral slip and who have the requisite number of x-rays available. Measurements were taken according to both Methods I and II. These results were related to the patients' race, sex, and mode of treatment.

Results

The breakdown of the population by treatment, race and sex appears in Table 5-1. Most of the population underwent an in situ fixation procedure. Males predominated. Although whites outnumbered blacks, this is a reflection of the higher relative white population from which the hospitals drew their patients. The first part of the study was performed using Method I.

The cartilage space narrowing qualitatively seemed to affect all patients with SCFE. The numerical analysis of this effect with respect to race and sex is summarized in Table 5-2 and 5-3. Briefly, females took longer to regain even their smaller average CSW than did males. Blacks took longer than whites but reached larger widths. Blacks and females showed the most cartilage space narrowing. This was also the group most commonly afflicted with severe SCFE's. Analysis with respect to treatment yields some interesting findings. The first of these was that all procedures involving biplane or cuneiform osteotomies were performed upon severe slips, i.e., slipping more than one-third the diameter of the neck or more than thirty degrees, whereas all in situ fixation procedures were performed upon lesser slips. Thus, we are unfortunately studying two separate populations, those with severe and those with mild slips. This number of post-oper [illegible]

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Table 5-1

Character of Patients in Cartilage Space Width Study Part I

nt	# Hips	(%total)	# Males	(%group)	# Females	(%group)	# Blacks	(%group)	#Whites(
	83	(100)	44	(53)	39	(47)	28	(34)	55
ipulative	78	(95)	43	(54)	36	(46)	27	(34)	52
tu fixation	40	(49)	22	(54)	19	(46)	11	(27)	30
tomies	38	(45)	21	(55)	17	(45)	16	(42)	22
lane	28	(34)	18	(64)	10	(36)	12	(43)	16
er sub- chanteric	10	(12)	3	(3)	7	(70)	4	(40)	6
ative	4	(5)	1	(25)	3	(75)	1	(25)	3
tu fixation	3	(4)	0	(0)	3	(100)	0	(0)	3
tomies (all ne)	1	(1)	1	(100)	0	(0)	1	(100)	0

Character of Selected 30 Patients in CSW Study in Part II

nt	# Hips	(%total)	# Males	(%group)	# Females	(%group)	# Blacks	(%group)	# Whites(%
	30	(100)	18	(60)	12	(40)	9	(30)	21
ipulative	28	(93)	17	(61)	11	(39)	8	(29)	20
u fixation	11	(37)	6	(55)	5	(45)	3	(27)	8
omies	17	(57)	11	(65)	6	(35)	5	(29)	12
ane	12	(40)	10	(83)	2	(17)	4	(33)	8
r sub- hanteric	5	(17)	1	(20)	4	(80)	1	(20)	4
ative	2	(7)	1	(50)	1	(50)	1	(50)	1
u fixation	1	(3)	0	(0)	1	(100)	0	(0)	1
omies (all e)	1	(3)	1	(100)	0	(0)	1	(100)	0

Table 5-2

Cartilage Space Width Maximized

Sex/Race	AP Maximum Cartilage Space Width (mm) ± SEM	Months ± SEM
Black female	4.8 ± 0.3	37 ± 10 (n=19)
Black male	5.9 ± 0.5	16 ± 7 (n=9)
White female	5.1 ± 0.2	19 ± 4 (n=20)
White male	5.8 ± 0.2	21 ± 5 (n=35)
Total female	5.0 ± 0.2	28 ± 5 (n=39)
Total male	5.9 ± 0.2	19 ± 4 (n=44)
Total Black	5.8 ± 0.2	30 ± 8 (n=28)
Total White	5.6 ± 0.2	20 ± 3 (n=55)
Grand Total	5.5 ± 0.1	23.5 ± 3.3 (n-83)

Table 5-3

Cartilage Space Width Minimized

Sex/Race	AP Narrowest Cartilage Space Width ± SEM	Months ± SEM	
Black female	2.8 ± 0.3	24 ± 9	(n=19)
Black male	3.8 ± 0.4	20 ± 5	(n=9)
White female	3.5 ± 0.2	19 ± 3	(n=20)
White male	4.0 ± 0.2	18 ± 4	(n=35)
Total Black	3.2 ± 0.2	22 ± 5	(n=39)
Total White	3.8 ± 0.1	18 ± 3	(n=44)
Total Female	3.2 ± 0.2	21 ± 5	(n=28)
Total Male	4.0 ± 0.1	18 ± 3	(n=55)
Grand Total	3.6 ± 0.3	19 ± 3	(n=83)

fact must be taken into consideration when evaluating the other results.

Linear regressions, as listed in Table 5-4 revealed slopes leading to progressively wider cartilage spaces in all treatment categories, including the untreated, unaffected hips. Since nearly all hips were shown to undergo slight cartilage space narrowing after the contralateral hip was operated upon, it can be seen that cartilage space widening commonly occurs in both hips after SCFE surgery upon a patient. There is no statistical difference in the rates of widening, although the biplane osteotomized hips tended to widen much more slowly than the other groups. The intercepts for these recovery rates also failed to statistically differ, although the non-biplane subtrochanteric osteotomized hips regressed to much lower widths than the other groups, implying an earlier response of the recovery process.

The maximum width of the cartilage space was remarkably similar throughout the groups, implying that no method resulted in consistently greater cartilage space narrowing than either another treatment or than the unaffected hips, see Table 5-5. The cuneiform osteotomies showed a propensity to take about two years longer to reach the maximum than the other groups, but the difference was not statistically significant.

The bilateral asymmetry of the CSW was kept to one tenth millimeter or less in 63 percent of the unilateral and 58 percent of the bilateral SCFE's. With the exception of a group of two patients whose original _in situ_ fixation failed, necessitating a biplane in one instance and a non-biplane subtrochanteric osteotomy in the other, the _in situ_ fixation of mild SCFE's, consistently showed the most frequent bilaterally symmetric recovery. Biplanes, in the case of unilateral slips, and non-biplane subtrochanteric osteotomies, in the bilateral case, produced the least frequent fact must be taken into con[illegible]

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Table 5-4

Linear Regression of Cartilage Space Width

Treatment	Intercept ± SEM (Days Post-Op)	Slope ± SEM	Number of Subjects
In situ	4.4 ± 0.5	5.6 ± 5.9	43
Biplane osteotomy	4.2 ± 0.3	6.2 ± 3.8	30
Non-biplane osteotomy	2.7 ± 1.0	2.3 ± 1.7	11
Subtotal Affected	4.1 ± 0.3	5.4 ± 0.3	84
Unaffected	4.2 ± 0.5	4.5 ± 0.5	34
Total	4.2 ± 0.2	5.1 ± 0.3	118

Table 5-5

Cartilage Space Width Maximized

Treatment	AP Maximum Joint Space Width $\pm$ SEM	Months $\pm$ SEM
In Situ	5.7 ± 0.2	19 ± 3 (n=43)
Biplane	5.2 ± 0.2	27 ± 5 (n=30)
Osteotomy	5.2 ± 0.5	58 ± 18(n=11)
Subtotal Affected	5.5 ± 0.1	27 ± 4 (n=84)
Unaffected	5.4 ± 0.2	19 ± 3 (n=34)
Total	5.5 ± 0.1	25 ± 3 (n=118)

bilaterally symmetrical recovery. Mean minimum differences among unilaterally asymmetric cartilage space widths ranged from three-tenths to five-tenths millimeters with a standard error of about two-tenths millimeters throughout the groups. If bilateral symmetry were to be obtained, a mean of nineteen months was required for the process. In situ fixation, usually recovered first and biplane osteotomy tended to take the longest time , see table 5-6.

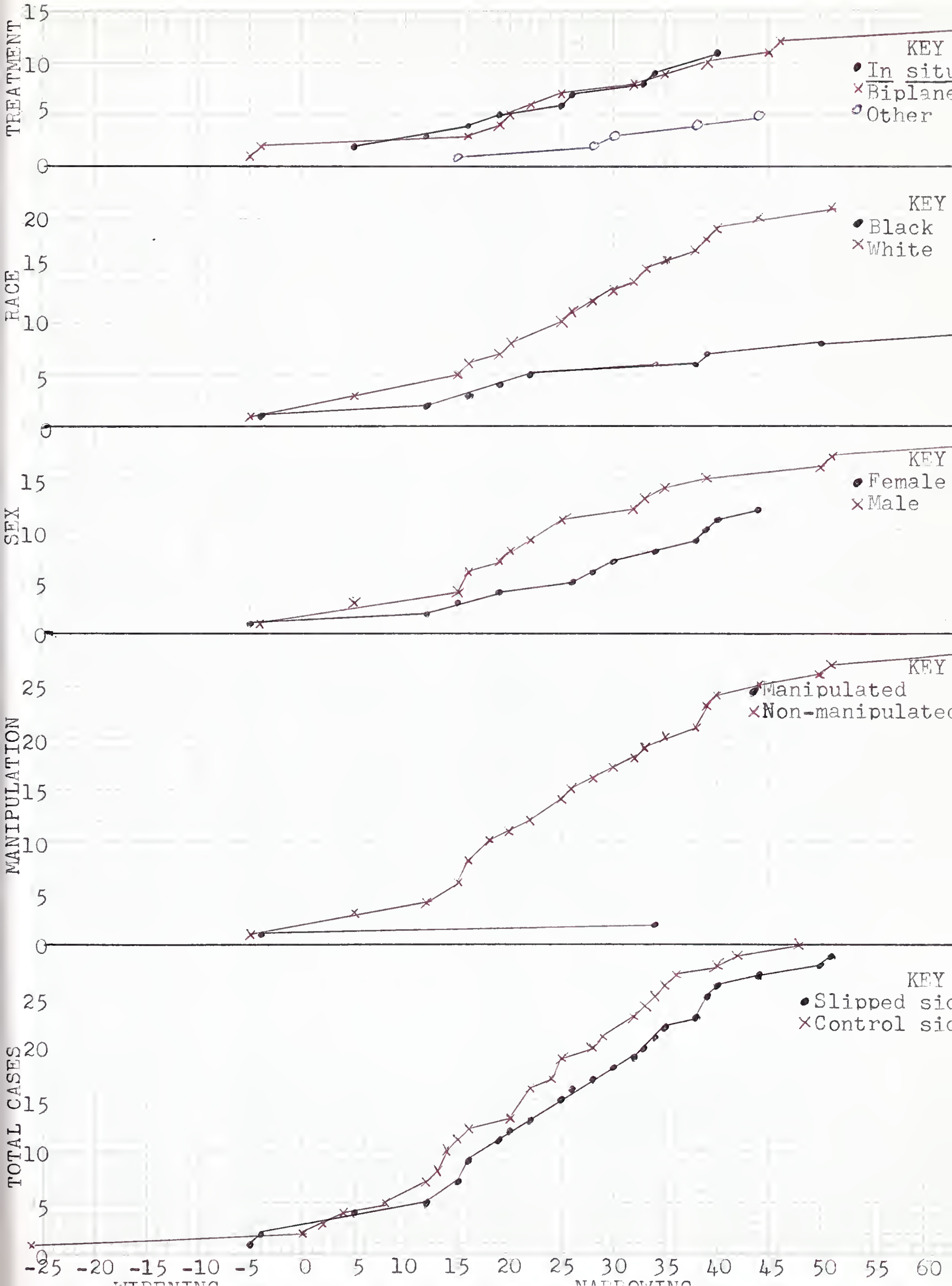
These results are based on follow-up ranging from forty-four months for in situ fixations to ninety-three months for non-biplane subtrochanteric osteotomies. The average follow-up for all groups was five years. This follow-up was far longer than the usual time required for the phenomena studied to occur. The differences in follow-up are probably insignificant when this fact is kept in mind.

Part II of the study yielded the results depicted in Figure 5-3. Again, the vast majority of patients underwent some degree of narrowing ($p < 10^{-4}$). Qualitatively, the bottom graph of affected versus unaffected hips suggests the former to demonstrate more severe narrowing. A cutoff around forty percent separatesthe two curves, implying that a narrowing of this degree is usually associated with a slipped hip. The small number of manipulated hips makes the distinction drawn in the next to bottom graph uninterpretable. The center graph demonstrates that males exhibited more extensive narrowing than females. This distinction is particularly interesting in light of studies presented earlier in this thesis that showed a higher complication rate in females than in males. Blacks suffered more severe narrowing than whites, as shown in the next to the top graph. The top graph illustrates more severe narrowing in biplane osteotomy than in the other treatment groups. This treatment

Cartilage Space Difference Minimized

	Follow-Up in Years ± SEM	# Symmetrical (%)	Cartilage Space Difference Eliminated in Months ± SEM	Unresolved Minimum Cartilage Space Difference ± SEM (in mm.)
Unilateral SCFE				
In situ	3.6 ± 0.7	11 (79%) (n=14)	11.4 ± 2.3	0.4 ± 0.05
Biplane	4.1 ± 0.6	6 (40%) (n=15)	30.8 ± 9.2	0.3 ± 0.05
Osteotomy	7.7 ± 1.2	3 (75%) (n=4)	17.5 ± 3.8	0.3
Combination	11.3 ± 8.4	2 (100%) (n=2)	25.3 ± 21.2	
Subtotal	4.9 ± 0.6	22 (63%) (n=35)	18.8 ± 3.6	0.3 ± 0.03
Bilateral				
In situ	5.8 ± 1.4	7 (58%) (n=12)	14.8 ± 3.9	0.5 ± 0.09
Biplane	4.4 ± 1.6	1 (25%) (n=4)	5.2	0.3 ± 0.05
Osteotomy	9.1 ± 7.5	0 (0%) (n=2)		0.3 ± 0.07
Combination	4.1 ± 0.6	4 (67%) (n=6)	15.1 ± 3.3	0.4 ± 0.05
Subtotal	5.8 ± 0.9	13 (52%) (n=25)	13.9 ± 2.3	0.4 ± 0.04
Totals	5.4 ± 0.5	48 (58%) (n=83)	17.0 ± 2.0	0.4 ± 0.02

Figure 5-3



TREATMENT
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Other
RACE
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SEX
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Female
Male
MANIPULATION
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Non-manipulated
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-25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60

relationship was significant only to a p of sixteen percent.

Since, by Method I, the widest width recorded in this part was a twenty-six percent widening, the average width was twenty percent narrowing and standard deviations of various groups approximated twenty percent, we believe our method to be accurate within twenty to thirty percent. Spot tests between experienced observers showed virtually no discrepancies.

Two unexplained peaks in CSW occurred in the frequency curve, at around twenty percent narrowing and forty percent narrowing, respectively.

The affected side usually narrowed more than the unaffected side ($p \leq 0.09$) but eventually rebounded to become the wider side ($p < 0.01$). Narrowing of thirty-three percent or more was most commonly associated with the affected side ($p < 0.07$).

Discussion

Thus, both hips in most patients showed narrowing regardless of whether the patient suffered measurable SCFE unilaterally or bilaterally. In most cases, this narrowing eventually underwent widening to reach fairly constant levels without regard to the treatment rendered, seemingly affected only by the sex and race of the subject. The ensuing widening followed three phases: an erratic early post-operative phase which lasted approximately three months, a nearly linear second phase which lasted two to five years during which symmetry of the cartilage spaces may be expected to be achieved within nineteen to forty months and a gradual phase marked by little widening leading to very slight changes in the cartilage space size and probably only reflecting the linear phase in those patients relatively slow to recover. It is in the linear phase relationships [illegible]

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that regular measurements of the cartilage are useful in predicting the course of an individual's widening providing some idea of the time and extent of recovery to be expected.

Thus, cartilage space narrowing is a fairly universal phenomenon in the population of patients suffering from SCFE but is usually temporary, tending to resolve on its own accord without specific treatment.

Bilateral asymmetry was most marked in the osteotomies of the femoral shaft but this asymmetry may be easily ascribed to the greater severity of the slip that initially dictated the choice of these radical procedures over the in situ fixation, always performed only on milder slips. If bilateral symmetry was not attained, the extent of asymmetry was remarkably constant throughout the groups.

The lack of a group of control subjects who underwent regular roentgenographic hip examinations over several years prevent comparison of the SCFE cartilage space width phenomena with comparable control groups of normal hips. The unaffected hips in the patients suffering unilateral SCFE displayed much the same phenomena as affected hips. The rebound of the cartilage space width may merely represent normal maturation of the cartilage space as the child grows, in which case it may be unrelated to SCFE.

The other drawback to the study was the lack of an untreated SCFE group. However, it seems reasonable that if untreated, unaffected hips follow the pattern of cartilage space narrowing then widening, untreated affected hips probably would do the same.

The linear regressions vary too much to depend upon. This may represent too many different populations of patients lumped into the same line or a bad hypothesis that the phase is, indeed, perfectly linear. The answer must await further analysis.

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Introduction

This section could easily be expanded into a thesis, itself, and could qualify as a full scale research project. Nevertheless, the disease under study cannot be understood or explained without a biomechanical look at the forces at work and the effects of these forces. Because of the vast scope of this topic, this section will necessarily be sketchy. Its purpose is to clarify points raised in other parts of the study rather than to provide definitive biomechanical analyses. The bibliography provides useful sources for those interested in pursuing some of the intriguing questions raised.

Methods

We will examine biomechanics related to SCFE by first reviewing the nature of the forces involved in the disease process. The occurrence of the disease will then be described. Some reasons for the major complications will comprise the final section.

Discussion

Basically, force is a vector concept with the attendant qualities of magnitude, direction and point of application. When standing, the femoral head must exert a reactive force against the pelvis of approximately two and three-quarters times the total body weight (3). Additional forces may be exerted externally, in which case they can lead to acceleration of the involved structures or internally, leading to variations in the strain endured by the components. The combination of acceleration and strain forces must be transmitted from the body to the ground via the femora. At the junction of the femoral head and the acetabulum, contact is

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habitually achieved only at the anterior and posterior areas of the acetabular cartilage with little, if any, contact occurring at the periphery, perifovea or the inframedial regions of the head (4). Thus, the relatively large force of 275 percent of the body weight must be transmitted through a relatively small area of the femoral head. A high amount of pressure generates strain upon the head. This erosive situation, long recognized as challenging for even the best prostheses, can be partially distributed to relieve some of the pressure, if not the summed forces upon the femur. Only a cone can regularly distribute a localized load over a large area (9), thus the femoral head must function conically in order to utilize this large bone for force transmission. The complexity of this task is reflected in the complex anatomy of the proximal femoral shaft and the neck.

Let us first examine the ramification of force applied to the shape. The neck is cylindrical at birth but gradually is altered to become increasingly elliptical. Eventually, the axial ratio reaches 1.65 at the shaft junction while remaining relatively more cylindrical at the middle with a ratio of only 1.15 (6). Simultaneously, the internal trabecular structure adapts to the forces described by forming a T-beam design against the directions of stress. The three trabecular systems: transverse, longitudinal and arcuate, serve this purpose of counteracting forces generated by vertical weight support. These adaptations, however, take place in a continually changing environment of force redirectioning.

At birth, the angle of the femoral neck to the shaft as depicted in Figure 6-1 is approximately 150 degrees (6). In this environment, the epiphyseal plate, itself perpendicular to both the medial trabecular habitually achieved only [illegible]

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Angle SON describes the relationship between the femoral neck (NO) and the shaft (SO).

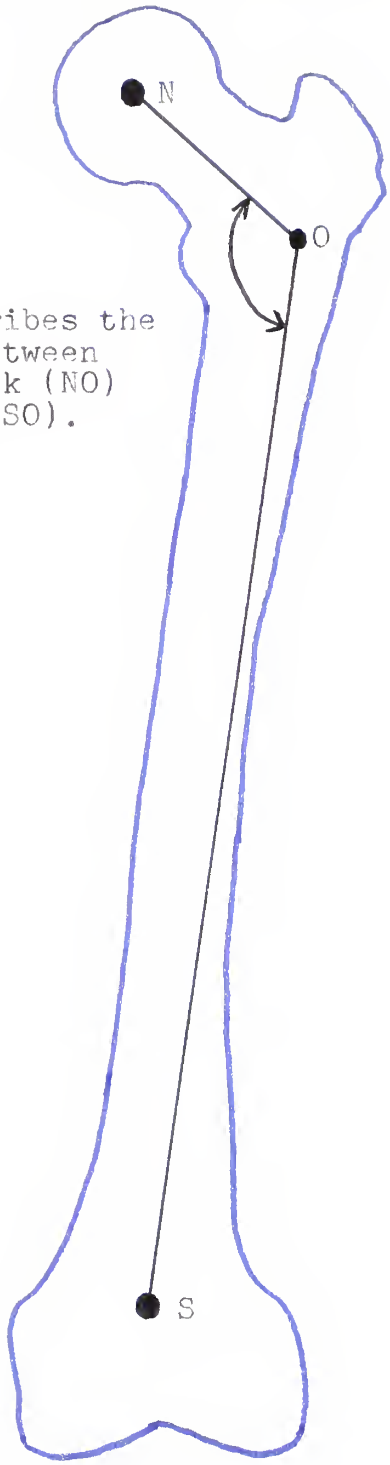

Figure 6-1

system and the maximum load direction, is oriented for least force transmission along its vulnerable shearing axis. This orientation is endangered, however, as that epiphyseal angle is diminished by weight bearing (5), to 130 degrees by maturity. The reorientation allows the pressures of erect posture to be transmitted with a higher shear component in addition to an augmented moment. It is the shear that dramatically increases the risk of developing SCFE. Heavy people have a larger force to transmit since the force is a direct function of body weight, and a more vulnerable angle, since it is an inverse function of the body weight. They are, therefore, doubly at greater SCFE risk than their lighter cohorts. Rydell (5) notes that hips not subjected to load during growth have larger angles than normally weighted hips. If this finding implies that load decreases the angle, one would expect obese patients to have smaller than normal angles. Such a situation would accentuate the shear effect described above.

The physical structure of the bones exists within the environment largely influenced by muscular structure. For example, abductor paralysis increases the vertical load while placing the femoral neck into valgus and placing a horizontal load component onto the femoral head. In addition, subtleties not yet described or truly understood seem to affect the environment; for example, it is postulated that the reported high incidence of left SCFE in right-handed individuals results from sitting stresses generated by the musculature (7). For the most part, these are not well enough understood to receive more than mere mention in a brief synopsis of this kind.

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Unfortunately, a large number of such obscure factors makes proper biomechanical analysis difficult, if not impossible. Although the forces at work cannot be adequately described, the pathogenesis of SCFE can be largely elucidated. The key lies in the difference between the characteristics of bone and cartilage. Bone is from two to three orders of magnitude stiffer than cartilage (4). Thus, it is significantly less able to absorb the large energy load discussed earlier. The burden is thus laid upon the cartilage to either absorb the forces not dissipated into the bone or permit deformation and possible fracture of the transmitting structure. Since the cartilage is inherently weak in those endocrine states allowing growth without accompanying supportive structures, an increased ratio of force to strength is visited upon this cartilage, carrying with it an attendant elevated risk of SCFE.

If the disease should occur, a number of structural changes ensue which lead to far-reaching biomechanical effects. A brief look at this process provides an idea of the complex ramifications or this, or any, disruption of the structural integrity of the femur.

SCFE involves a posterior inferior displacement of the femoral head, engendering a limp which reduces the strain on the gluteus medius and the hip load by reversing the lateral weight displacement of the deformed joint. This reduction amounts to twice the weight that the hip normally supports (9). The price of the reduction is a vertically directed load which tends to encourage vertical displacement of the femur. These factors lead to a vertically displaced epiphyseal line that suffers a shear factor of forty percent of the weight supported (9). The antalgic gait with its consequent vertical displacement of the load does serve to reduce the load

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[illegible] [illegible] [illegible] joint. [illegible] [illegible] which [illegible] lead to a [illegible] of [illegible] [illegible] by sixty-seven percent (9), but only at the cost of reducing the area of contact between the acetabulum and the femoral head by eighty percent (9). Thus, pressure upon the cartilage increases, potentiating superior cartilage damage. Coincidentally, the inferior cartilage undergoes diminished compression, thus reducing the pumping action so vital to cartilage nutrition. This paves the way for allowing inferior cartilage erosion to occur.

Every treatment of this disease used in this study was frought with danger. The biomechanical principles of even the most straightforward of these, in situ fixation, are complicated. Nevertheless, the basic theory is compellingly logical: align the fixation devices to counteract the most hazardous stresses while achieving the best possible bone tissue support.

Nevertheless, a slip properly fixed is still in a vulnerable situation. The difficulty stems from the extreme directionality of the devices' strength. Devices well suited for fixing a lesion will readily break if malaligned, allowing the forces to work along directions of weakness. Even after the devices are set, an involved analysis is required to ascertain the equivalent beam for the given spatial arrangement. Such an analysis is necessary to know the new dynamics of the bone but is rarely performed. The incidence of three femoral fractures in this study and at least one other occurring since the project was undertaken raises the specter of serious complications arising in SCFE patients, at least threepercent of whom have unremoved hardware already lodged in their femur, a situation serving tomake repair difficult at best. A quick mention of how these fractures come about illustrates the necessary considerations. Firstly, unlike iron, bone has its ultimate tensile by sixty-seven percent. ([illegible]) [illegible]

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strength perpendicular to its ultimate shear strength (3). Thus, the greatest likelihood of fracture occurs at an angle to the femoral shaft of between forty-five and ninety degrees. Normally, the direction of force is nicely compensated by structure. However, in the situation of disease, altered dynamics and structure remove this safety factor. These circumstances combine to threaten the shaft with dangerous orientations of forces. In addition, those femora still impregnated with hardware carry the risks of the devices functioning as a beam directing large torque forces to the stiffer, more brittle periphery and away from the energy absorbing center. The problem of torque is serious both in this group and in the group of those having experienced such femorally traumatic procedures as chiseling the cortex to remove stubbornly set devices. These two groups have been converted from the normally torque-resistant closed sections to the torque-vulnerable open sections, in which part of the perimeter of the cortical torus is incomplete. The resulting piling up of forces increases the risk of femoral fracture.

Before concluding this synopsis of SCFE biomechanics, a brief consideration of salvage procedures must be undertaken. The two used in this study were the hanging hip and the McMurray osteotomy.

The hanging hip, first described by Voss in 1956, reduces the muscularly generated compressive forces acting at the hip joint. It is indicated for osteoarthritis, geriatric hip disability and avascular necrosis but not for rheumatoid arthritis. Trout and Strong (8) assert that it is contraindicated in avascular necrosis. As performed on the patients in this study, however, it seems to be both useful and effective. The mechanism for pain relief is in doubt. Relieving muscular contractures strength perpendicular [illegible]

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may result in an even distribution of forces acting on the hip, thus dissipating localized excessive tensions. There is even a controversy over whether the pain stems from the joint capsule or from abnormal pain receptor stimulation in the calcinous bone of the femoral head and acetabulum. Nevertheless, it is clear that the strain on the necrosed hip is ameliorated, providing at least temporary pain relief and improvement in the range of motion of those suffering from this serious complication of SCFE.

The McMurray osteotomy involves the division of the femur with repositioning of the distal fragment directly beneath the head. The new relationship is usually fixed with Knowles pins. Thus, the force moment, normally greatly increased by the femoral neck, is minimized with a corresponding reduction in the forces exerted on the femur by weight bearing. This reduction in the forces hopefully places the stresses on the affected femur within the range in which the bone, compromised by disease, can fulfill its weight bearing function. Unfortunately, despite the simplicity of the theory, the procedure met with only limited success in the group studied.

No attempt was made to work out the exact biomechanical manifestations of this disease, although such an analysis could be both useful in designing optimal therapies and extremely intriguing.

Although brief, this section has outlined the biomechanical considerations inherent in SCFE. The discussion also clarified some of the clinical problems encountered in this disease and explained some of the rationale behind common treatments.

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