

The copyright of this thesis rests with the University of Cape Town. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

# **Single pin versus multiple pin fixation in the management of slipped upper femoral epiphysis**

By

Marc Boydell Nortje

Student no.: NRTMAR007

Submitted to the University of Cape Town in partial fulfilment of the requirements for the degree: Master of Medicine in Orthopaedic Surgery.

Faculty of Health Sciences

University of Cape Town

2009

**Supervisor**

Professor EB Hoffman

Associate Professor

Department of Orthopaedic Surgery

University of Cape Town

Groote Schuur, Red Cross and Maitland Cottage Hospitals

**Ethics**

This study has University of Cape Town Research Ethics Committee approval

REC REF 086/2007.

### **Declaration**

I, Marc Boydell Nortje, hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature: .....

Date: 14/08/2009

### **Acknowledgement**

To Professor EB Hoffman who supervised this thesis. Your tireless patience, endless knowledge and commitment are inspirational. Thank you for your mentorship.

## Table of Contents

Introduction .....	6
Definition .....	6
Aetiology .....	7
Clinical Features.....	8
Classification.....	8
Radiography .....	9
Complications .....	9
History of Treatment .....	10
Aim of the study.....	12
Patients and Methods .....	12
Results .....	18
Demographics.....	18
Duration.....	19
Severity.....	19
Complications .....	20
Discussion.....	24
Avascular Necrosis .....	24
Chondrolysis.....	27
Conclusion .....	30
References:.....	31

## Index of Tables

Table 1 .....	18
Table 2 .....	19
Table 3 .....	19
Table 4 .....	20
Table 5 .....	21
Table 6 .....	21
Table 7 .....	22
Table 8 .....	22
Table 9 .....	23

## Index of Figures

Figure 1: .....	14
Figure 2: .....	14
Figure 3: .....	16
Figure 4: .....	17

## Introduction

### Definition<sup>1,2</sup>

Slipped upper femoral epiphysis (SUFE), or slipped capital femoral epiphysis (SCFE) as the Americans call it, is instability of the femoral head epiphysis that can be likened to a Salter Harris type 1 fracture. The femoral head epiphysis 'slips' into a non-anatomical position and this may be progressive. SUFE may result in future hip complications including loss of motion, pain and arthropathy.

### Epidemiology

SUFE is one of the commonest hip disorders seen in adolescents. The incidence varies from 2 to 13 per 100 000 depending on which population is examined.<sup>1</sup> In a recent large analysis of paediatric discharges and census bureau data in the USA, the annual incidence was found to be 10.8 per 100 000.<sup>3</sup> The incidence in South Africa is not known but when comparing the number of patients we treated from 1999 to 2004 and the Western Cape census data from 2001<sup>4</sup> we have an estimated annual incidence of 2.3 - 4.1 per 100 000.

SUFE usually occurs between nine and eighteen years of age and patients presenting outside of this range should be scrutinised for underlying endocrine abnormalities.<sup>1,2,7</sup> In contrast to the wide chronological age range, the condition

occurs in a narrow bone age range; the means for both of which are getting younger.<sup>5</sup>

The literature reports a male predominance, with a male to female ratio of 1.43.<sup>3,6,7</sup> A previous study from our institution found a more even spread (ratio of 1.1)<sup>8</sup> and actually more girls than boys as reported in the current study.

## **Aetiology**

The cause of SUFE is unknown. Numerous authors have suggested various associations with SUFE, but none has proven to be present in all cases. Currently there appear to be two broad aetiological groups: mechanical and endocrine or biochemical.

Mechanical associations with SUFE are: increased femoral neck retroversion,<sup>9</sup> increased body mass index (BMI),<sup>6,7,9,10</sup> posterior slope of the physis<sup>11</sup> and a widened physis.<sup>12</sup> Abnormal forces (trauma) can cause the epiphysis to slip but more often it is a normal force acting on an abnormal physis that results in the abnormality.<sup>9,13</sup> Endocrine conditions that are associated with SUFE are hypothyroidism, hypopituitarism and renal abnormalities.

## **Clinical Features**

Hip pain and a limp are the most common presenting complaints. The limp may be a short leg limp or a Trendelenburg limp. Referred knee pain may be the only complaint. The femur is externally rotated and this is worsened with hip flexion. Approximately ten percent of cases are bilateral at the time of presentation and a further ten percent will develop SUFE in the opposite hip within eighteen months.<sup>3</sup> It is generally believed that SUFE is a progressive condition and that the epiphysis will continue to slip further if it is not stabilised.<sup>14</sup>

## **Classification**

SUFE has traditionally been classified clinically according to the duration of symptoms. The duration of symptoms is often difficult to elicit accurately from the history, but is divided into acute, acute-on-chronic and chronic duration. The definition of acute SUFE is if the symptoms began less than three weeks prior to presentation.<sup>15</sup> This classification has largely been replaced by Loder's classification of stable and unstable slips, where a slip is defined as unstable if the patient is unable to bear weight on the leg even with the use of crutches.<sup>16</sup> This classification has prognostic implications regarding the development of avascular necrosis. The differential diagnosis of SUFE is Perthes disease, particularly in the younger age group, and septic arthritis of the hip.

## **Radiography**

Antero-posterior x-ray of the pelvis is the standard film taken. A lateral of the hip is done as a 'frogleg' lateral or, if the slip is unstable or the patient is in too much pain, then a shoot through lateral is taken. A roll over lateral or Judet view may also be used. The severity of slip has been classified by various methods. The Wilson<sup>17</sup> percentage slip method classifies the slip as mild, moderate or severe, depending on the amount of maximum displacement of the epiphysis on the shaft. A slip is considered mild if the epiphysis is displaced less than a third of its length, moderate if one third to half is displaced and severe if more than half is displaced. The Southwick<sup>18</sup> head shaft angle method measures the angle subtended by a line perpendicular to the head and a line parallel to the shaft of the femur as seen on the lateral radiograph of the hip. A normal angle representing femoral neck anteversion would measure 10°-15°. A mild slip is less than 30°, a moderate slip 30°-60° and a severe slip greater than 60°. Some authors have used CT scans to classify the severity but this is not done routinely.

## **Complications**

SUFE is notorious for two complications: avascular necrosis (AVN) of the femoral head and chondrolysis.

Some authors believe that AVN does not occur in untreated SUFE,<sup>19</sup> others say that it is rare in untreated SUFE and mostly a complication of the treatment.<sup>14</sup> Recently it has been shown that the blood supply to the femoral epiphysis is occluded in certain cases suggesting that these would go on to develop AVN if left untreated.<sup>20</sup>

## **History of Treatment**

The goal of treatment of SUFE is a pain free stable hip with early physal fusion, normal anatomy and no future complications. The main complications associated with SUFE and its treatment are: avascular necrosis, chondrolysis and osteoarthritis secondary to the femoral head deformity. The primary goal is to stabilise the epiphysis and prevent further slipping. Before 1930 this was achieved with spica cast immobilisation. This form of immobilisation is problematic because the patients are often obese, the physis may take a year to fuse, there can be late slipping and chondrolysis is not eliminated. Surgical fixation of the epiphysis began around 1930.<sup>21</sup>

The first type of fixation used was a Smith-Petersen nail. This progressed to multiple Knowles pins fixation and finally has settled on single cannulated screw fixation.<sup>22</sup> There is still some controversy regarding the use of one or two screw fixation with some authors preferring two screw fixation for unstable slips.<sup>23</sup> In the past, some authors believed that pinning was not enough to hasten fusion and advocated bone peg epiphyseodesis.<sup>24</sup> This was popular in the 1950's.

Whilst the majority of contemporary authors agree that in-situ single cannulated screw fixation is the treatment of choice for mild stable slips, the treatment of severe slips is controversial. Previously it was thought that they should be pinned in-situ because the anatomical deformity remodels.<sup>25</sup> This remodelling has now been shown only to occur around the metaphyseal edges and does not influence the head-neck offset.<sup>26</sup> The best management would therefore be to restore the anatomy of the epiphysis. Some authors advocated surgical treatment with an open reduction or intracapsular osteotomy at the site of deformity. Although others had done intracapsular osteotomies or open reduction of the epiphysis around the turn of the 20<sup>th</sup> century, it was Dunn<sup>27</sup> and Fish<sup>28</sup> in the 1950's and 1960's that popularised this form of treatment. It was unfortunately associated with high complication rates, which led to the description of an intertrochanteric osteotomy by Southwick in 1967,<sup>18</sup> and a base of neck osteotomy by Kramer in 1976.<sup>29</sup> These extracapsular osteotomies did not interfere with the femoral head blood supply and had lower complication rates. However since Ganz described a safe method of dislocating the hip in 2001,<sup>30</sup> intracapsular osteotomies with meticulous attention to surgical technique are returning to popularity.<sup>31</sup>

## **Aim of the study**

The aim of our study was to compare the complication rates between two groups of patients that received different treatment and to compare our incidence of AVN in unstable slips with that of the literature. We also analysed the patients that developed chondrolysis, looking for any features that may be causal.

## **Patients and Methods**

We performed a retrospective review of patient notes and radiographs comparing two groups of patients. Group A consisted of 55 hips (44 patients) treated over a 27 year period from 1963 to 1989, all of which were treated with multiple pin fixation with or without an osteotomy. This group has been reported on previously.<sup>8</sup> Group B consisted of 106 hips (83 patients) treated over a seven year period from 1999 to 2005, all of which were treated with single screw fixation. Two patients were excluded as they had a definite aetiology. One patient, a seven year-old, had renal osteodystrophy and the other, a twenty year-old, had gigantism. The reason for the increased sample size in the second group was due to a consolidation of the paediatric orthopaedic services in the region in the early 1990's.

We compared the demographics of the two groups. The variables recorded were: age; sex; whether the slip was bilateral; and the weight of the patient. Patients were classified as obese if they were over the ninetieth centile of weight for age.

The duration of the slip was classified as acute if symptoms and signs were present for less than three weeks and chronic if present for longer than three weeks. If severe symptoms occurred on a background of low grade symptoms that were present for longer than three weeks then the patient was classified as acute-on-chronic. Stability was classified according to the Loder classification.<sup>16</sup> The slip was termed unstable if the patient had such severe pain that they could not walk even with crutches.

The severity of the slip was classified using a combination of the Wilson percentage slip method as shown in figure 1 (Mild <30%; Moderate 30-50%; Severe >50%) and the Southwick head shaft angle method as shown in figure 2 (Mild <30°; Moderate 30°-60°; Severe >60°). Both methods were used and the patient was classified according to the highest grade.

Figure 1:

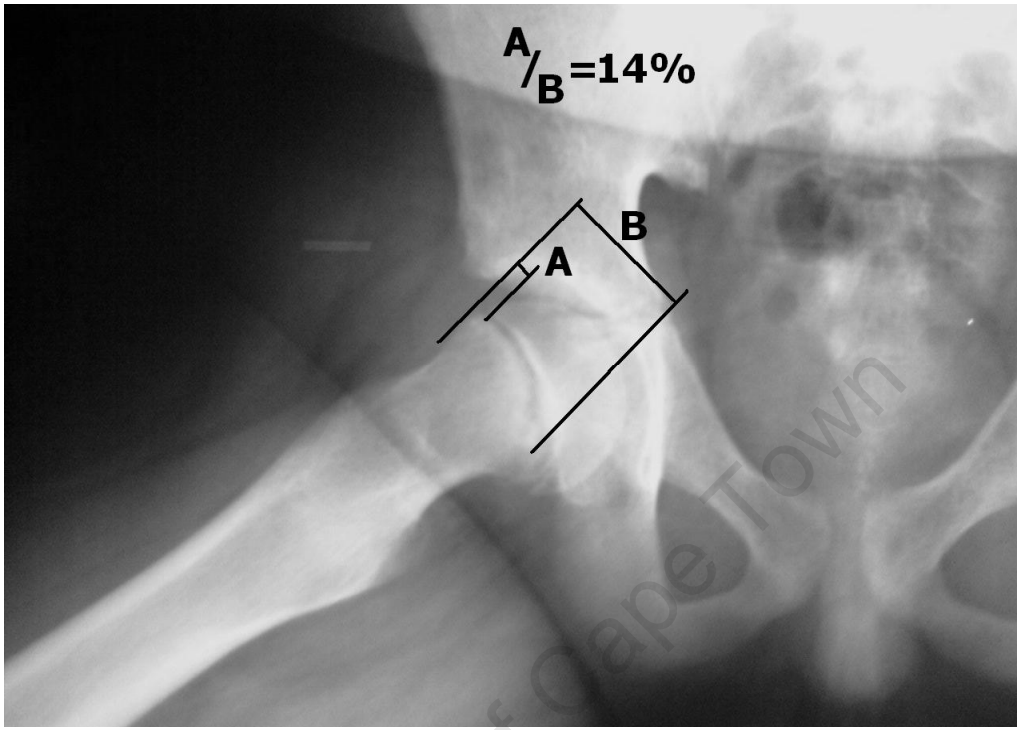
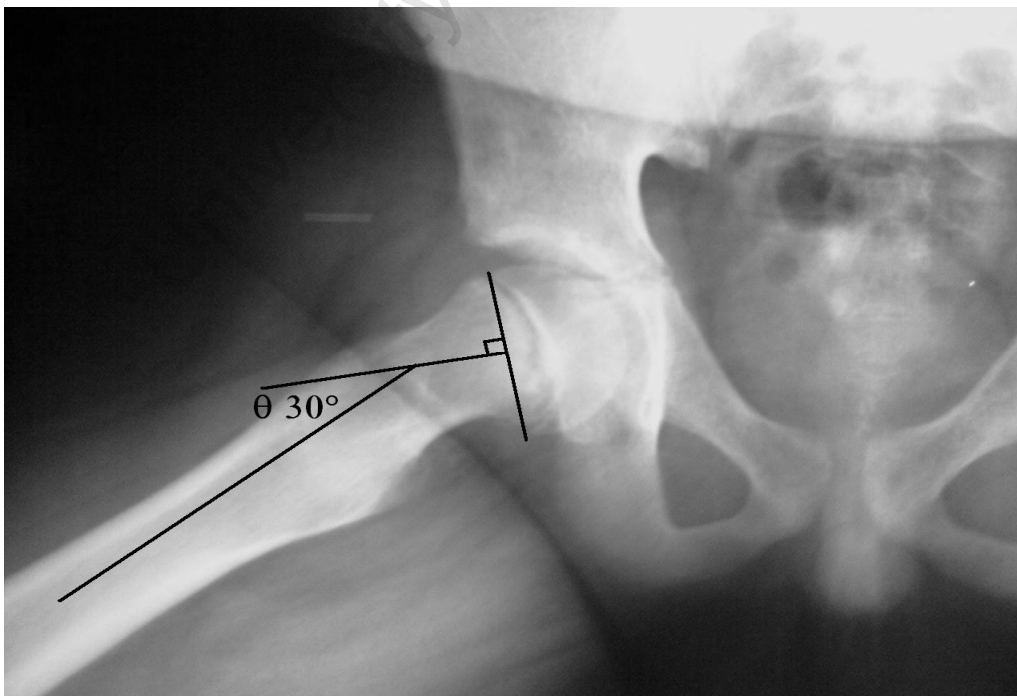
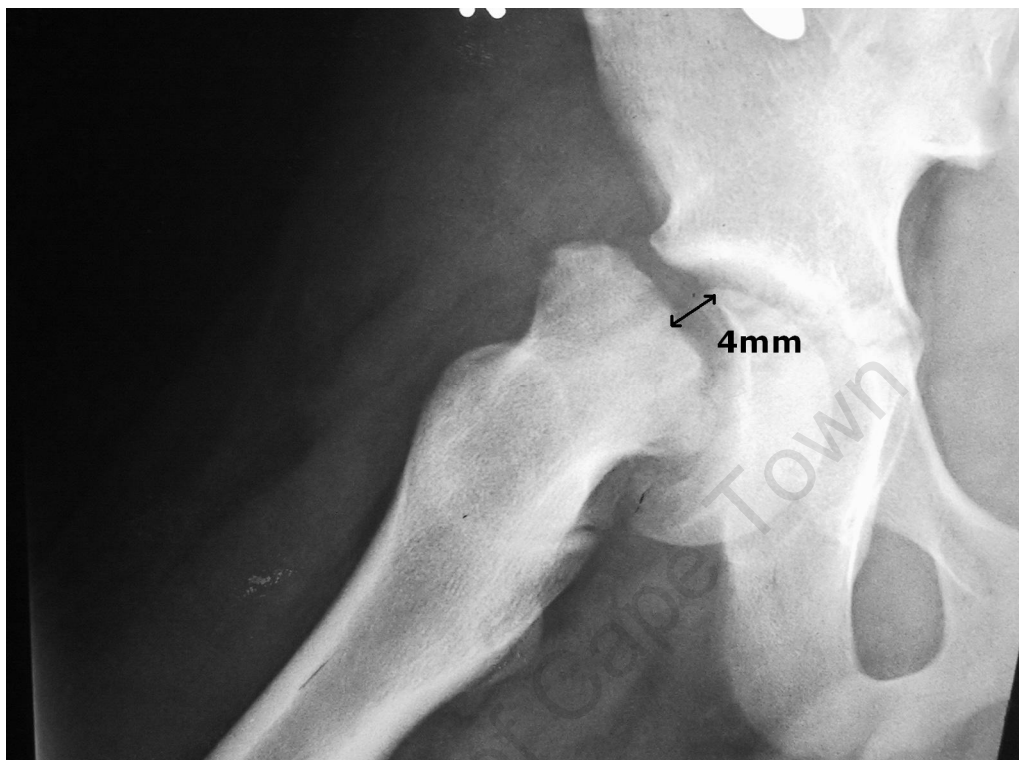


Figure 2:

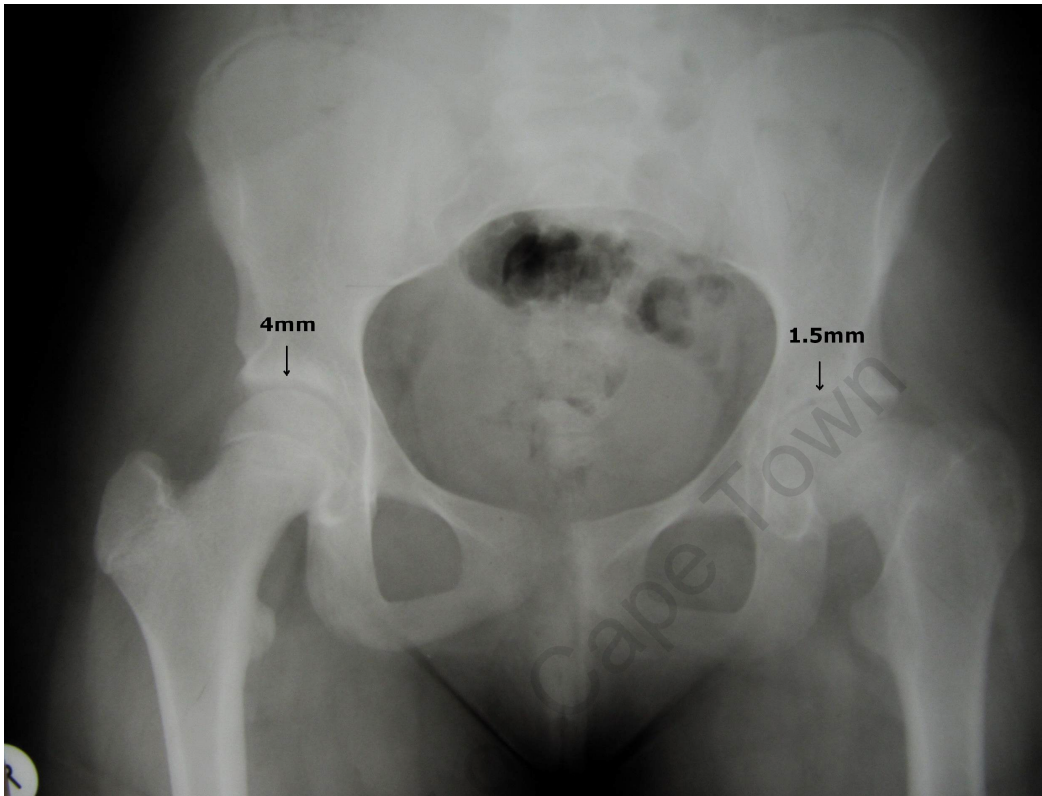


In group A, the hips had been pinned with multiple Knowles pins via open surgery. Eleven hips had osteotomies at presentation for severe slips: six were intracapsular (Dunn)<sup>27</sup>, and five extracapsular (Southwick)<sup>18</sup>. In group B, fixation had been done with a single 8 mm, partially threaded, cannulated screw with a hexagonal head for easy removal (Smith & Nephew Richards Medical, Memphis, Tennessee).<sup>32</sup> The technique used was the percutaneous method under image control, as described by Morrissy, with the screw perpendicular to the growth plate in the middle of the head. Hips were regarded as 'unpinnable' if anterior physeal separation on the lateral view i.e. the distance between the anterior lip of the epiphysis and the metaphysis, exceeded 3mm (Figure 3).

The concept of anterior physeal separation was described by Ballard et al<sup>19</sup> as a risk factor for AVN, but it was found to be useful in predicting those hips that would be difficult to pin in situ. These 'unpinnable' hips were reduced with traction in abduction and internal rotation, in a Thomas splint gradually over a few days as described by Casey et al.<sup>33</sup>

**Figure 3:**

The patients' notes and radiographs were reviewed for features of AVN or chondrolysis. All patients had been followed up for at least 2 years postoperatively. In terms of complications, chondrolysis occurs pre- or immediately postoperatively and AVN should be evident by one year.<sup>16</sup> Chondrolysis was defined as a painful, stiff hip with joint space narrowing on radiographs of  $\leq 3\text{mm}$ , or less than half the joint space of the normal side (Figure 4). Pin penetration into the joint was assessed on the anterior and lateral radiograph using the Pythagorean method described by Walters and Simon.<sup>34</sup>

**Figure 4:**

The patient data was subjected to statistical analysis. The Chi-squared test was used to assess whether or not there was a significant difference in the incidence of chondrolysis due to pin penetration in the two groups and to assess the significance of the severity of the slip in chondrolysis at presentation. The Binomial test was used to assess the significance of the sex of the patients and the duration of the slip in chondrolysis at presentation.

## Results

### Demographics

The demographics of the two groups were similar and are shown in table 1. Of the total patients, 27% had bilateral involvement (60% simultaneous and 40% sequentially within eighteen months). The average age found was twelve years for girls and fourteen years for boys and this correlates with the literature. All patients in the study were between nine and sixteen years of age. The male: female ratio of 3:2 reported in the literature, was reversed in our study.

**Table 1**

<b>Group A</b>	<b>Group B</b>	<b>Total</b>
55 hips (44 patients)	106 hips (83 patients)	161 hips (127 patients)
11 (25%) bilateral	23 (28%) bilateral	34 (27%) bilateral
M 23 (52%):F 21 (48%)	M 32 (39%):F 51 (61%)	M 55 (43%):F 72 (57%)
Ave. age 13y10m (8-16)	Ave. age 13y7m (9-16)	Ave. age 13y8m (8-16)
Obese 44%	Obese 57%	Obese 52%

## Duration

The duration of slip was similar for both groups and similar to that which is reported in the literature, with about two-thirds being chronic duration (symptoms for greater than three weeks) and the remaining third fairly evenly split between acute and acute-on-chronic duration slips (See table 2.)

**Table 2**

<b>Group A n=55</b>		<b>Group B n=106</b>		<b>Total 161 hips</b>	
Acute	15%	Acute	23%	Acute	20%
Acute-on-chronic	11%	Acute-on-chronic	14%	Acute-on-chronic	13%
Chronic	74%	Chronic	63%	Chronic	67%

## Severity

The severity of slip was similar for both groups and similar to that in the literature, with about half mild, 36% moderate and 13% severe.

**Table 3**

<b>Group A n=55</b>		<b>Group B n=106</b>		<b>Total 161 hips</b>	
Mild	47%	Mild	53%	Mild	51%
Moderate	44%	Moderate	31%	Moderate	36%
Severe	9%	Severe	16%	Severe	13%

## Complications

### Avascular necrosis

In group A, eight out of fifty five hips developed AVN (14.5%). Five were due to osteotomies, two due to manipulations and one due to pinning in the 'kill zone' (postero-superior region of the head). In group B, only two out of 106 hips (2%) developed AVN and both of these were unstable (shown in table 4).

**Table 4**

	<b>Total</b>	<b>Osteotomy</b>	<b>Manipulation</b>	<b>Pinning in kill zone</b>
Group A	8/55 (14.5%)	5/11	2	1
Group B	2/106 (2%)	N/A	N/A	N/A

### Instability and avascular necrosis

In group A the rate of instability was unknown because the sample period was before 1993 which is when Loder coined the term. In group B twenty of the 106 (19%) were unstable. None of the chronic slips was unstable. Eleven out of twenty two acute slips and nine out of fourteen acute-on-chronic slips were unstable. These figures are similar to the rates published by Loder.<sup>16</sup> There were no cases of AVN in stable slips and only two of the twenty unstable slips developed AVN (10%), compared with Loder's incidence of 47% (Table 5).

**Table 5**

<b>Loder's unstable slips</b>		<b>Unstable slips in Group B</b>	
Acute	17/38 (45%)	Acute	11/22 (50%)
A-on-C	13/17 (76%)	A-on-C	9/14 (64%)
AVN	47%	AVN	10%

Table 6 shows the relationship between AVN, instability and severity of slip. Avascular necrosis occurred only in severe, unstable, 'unpinnable' slips, all of which received pre operative traction as described in the methods.

**Table 6**

	<b>Unstable Hips</b>	<b>AVN</b>
<b>Total</b>	20	2
<b>Mild</b>	2	0
<b>Moderate</b>	8	0
<b>Severe</b>	10 (8 'unpinnable')	2

### **Chondrolysis**

There was a six fold decrease in chondrolysis due to persistent pin penetration in group B (Table 7). This is statistically significant ( $p < 0.05$ ). Chondrolysis at presentation, however, remains a significant problem (Figure 4).

Table 7

<b>Chondrolysis</b>	<b>Group A</b>	<b>Group B</b>	<b>Total Chondrolysis</b>
Pin penetration	6/55 (11%)	2/106 (2%)	8/161 (5%)
At presentation	8/55 (15%)	8/106 (8%)	16/161 (10%)

In table 8 the demographics, duration and severity of slip of all the hips (n=161) in the two groups are compared with the eight hips with chondrolysis due to persistent pin penetration. The distribution is similar.

Table 8

	<b>Chondrolysis - persistent pin penetration (n=8)</b>	<b>Total hips in study (n=161)</b>
<b>Male:Female ratio</b>	M 3:F 5	M 55 (43%):F 72 (57%)
<b>Average age</b>	14y (9-16)	13y8m (8-16)
<b>Obesity</b>	60%	52%
<b>Acute</b>	25%	20%
<b>Acute-on-chronic</b>	25%	13%
<b>Chronic</b>	50%	67%
<b>Mild</b>	50%	51%
<b>Moderate</b>	50%	36%
<b>Severe</b>	0%	13%

In table 9 a similar comparison shows that the 16 hips with chondrolysis at presentation occurred exclusively in females and was significantly more likely in chronic, moderate and severe slips ( $p < 0.05$ ).

**Table 9**

	<b>Chondrolysis – at presentation (n=16)</b>	<b>Total hips in study (n=161)</b>
<b>Male:Female ratio</b>	<b>M 0:F 16</b> ( $p < 0.05$ )	M 55(43%):F 72(57%)
<b>Average age</b>	13y (11-15)	13y8m (8-16)
<b>Obesity</b>	53%	52%
<b>Acute</b>	6%	20%
<b>Acute-on-chronic</b>	19%	13%
<b>Chronic</b>	75%	67%
	} $P < 0.05$	
<b>Mild</b>	0%	51%
<b>Moderate</b>	50%	36%
<b>Severe</b>	50%	13%
	} $P < 0.05$	

The patients with chondrolysis had been followed up for a minimum of three years. At final follow up the hips were assessed with the Iowa hip score.<sup>35</sup> Six of the eight hips (75%) with chondrolysis due to persistent pin penetration had a good or excellent outcome after removal of the penetrating pins. Of the sixteen hips with chondrolysis at presentation, only six (38%) had an acceptable outcome.

## **Discussion**

Avascular necrosis and chondrolysis are disastrous sequelae of SUFE. This comparative study shows a significant decrease in chondrolysis due to persistent pin penetration with single screw fixation compared to multiple pins (2% vs. 11%). Chondrolysis at presentation, however, remains an unsolved problem.

### **Avascular Necrosis**

Although avascular necrosis was also significantly lower (14.5% vs. 2%), the two groups are not entirely comparable. In group A, osteotomy was the main cause of avascular necrosis. The term 'unstable hip' was only coined by Loder in 1993, and is currently regarded as the main cause of AVN. The hips in group A that developed AVN could thus have been unstable but this could not have been recorded prior to 1993.

Our study showed a much lower rate of AVN (10%) in unstable slips than that reported by Loder (47%) in 1993.<sup>16</sup> Reports in the literature since then reveal rates of 3% to 84% of AVN in unstable slips.<sup>36,37,38,39</sup>

Current controversies in the management of unstable SUFE, <sup>23</sup> relating specifically to the development of AVN, impingement and osteoarthritis are:

1. Whether or not to manipulate the slip,
2. The timing of the manipulation,
3. Whether or not to do an immediate neck osteotomy with dislocation of the hip.

### **Manipulation and timing of manipulation**

Traditionally manipulation, especially forced manipulation, was thought to be unsafe with a higher rate of AVN.<sup>17,40,41</sup> Two of the hips in group A developed AVN as a result of overzealous manipulation.<sup>8</sup>

Clarke and co-workers 2001<sup>42</sup> and 2004<sup>43</sup> showed no AVN with 'gentle repositioning' of moderate and severe unstable slips within 24 hours, and a 2005 survey of the POSNA members showed that 88% felt that unstable slips should be treated within eight hours.<sup>22</sup> This approach has been supported with angiographic studies by Maeda which showed that the blood supply can actually be restored with careful manipulation of acute or acute-on-chronic SUFE.<sup>20</sup> He believes that the superior retinacular branches of the medial femoral circumflex artery are damaged at the time of the slip or by manipulation that over corrects the slip. Any manipulation therefore must not try to correct the slip to more than that which has occurred as the acute component.

Other authors, however, have shown a decreased rate of AVN with slow reduction in traction.<sup>16,33,44</sup> We have followed this approach in 'unpinnable' hips. The 2% incidence of AVN for all the hips (10% of unstable hips) in group B compares favourably with the literature. Although it seems logical that early gentle repositioning of the femoral head relieving pressure on the superior retinacular vessels should be the treatment of choice for unstable slips, the literature is controversial and our low incidence of AVN makes us loath to change our treatment approach. It should also be noted that serendipitous reduction, which was not assessed in this study, during placement of the patient on the traction table may not result in AVN.<sup>1</sup>

### **Neck Osteotomy**

In group A, three of the six hips that had a Dunn osteotomy of the femoral neck developed AVN. Dunn had a 4% incidence of AVN in chronic slips if the growth plate was open, but if the growth plate was closed a 42% incidence; in acute-on-chronic slips 38% developed AVN. Subsequently our unit stopped doing osteotomies and pinned all hips (except 'unpinnable' hips) in situ.

O'Brien and Fahey<sup>25</sup> felt that residual femoral neck deformity remodelled and Carney and Weinstein<sup>41</sup> showed a worse long term outcome in hips after osteotomy compared to hips pinned in situ. Long term studies from Sweden also

showed minimal osteoarthritis of mild and moderate slips pinned in situ and even in untreated slips.<sup>45</sup>

Siegel et al<sup>26</sup> showed with CT studies that the increased range of movement that occurred after the acute phase was due to decreased synovitis and not bony remodelling. Recently there has been a revival of femoral neck osteotomy. This has been driven by the Bernese school of Ganz.<sup>31</sup> By dislocating the hip and protecting the branches of the medial femoral circumflex artery, the femoral epiphysis can be reduced under vision and anterior interfering callus removed. They had no AVN and, by accurate repositioning of the femoral head, they believe cam impingement (blocking full flexion and internal rotation) and osteoarthritis will be prevented.

We however, agree with Kay<sup>1</sup> that the ratio of deformity correction vs. the risk of AVN with dislocation of the hip is not warranted. Our approach, compared to the current international trend is to pin in situ (unless 'unpinnable'). If symptoms persist after one year an intertrochanteric osteotomy (Southwick<sup>18</sup> or Imhäuser<sup>46</sup>) can be performed.

## **Chondrolysis**

Chondrolysis due to persistent pin penetration has almost been eradicated by the technique described by Morrissy using a single screw perpendicular to the

growth plate and in the centre of the femoral head. The 'approach withdraw' sign: removing traction from the leg and flexing, abducting and externally rotating the hip under image, should also confirm no penetration.<sup>47</sup> Even if joint penetration with chondrolysis does occur, there is a 75% chance of recovery if the screw is removed.

### **Chondrolysis at presentation**

Chondrolysis at presentation, however, remains a significant problem. The aetiology remains controversial. Mankin et al<sup>48</sup> proposed an auto-immune theory. They postulated that transient pin penetration caused an auto-immune response. The initial study from this unit on chondrolysis in 1993, however, showed radiographs (before image intensifiers) with transient pin penetration of the guide wire without subsequent chondrolysis. Also, only pins penetrating in the anterosuperior weight bearing quadrant of the femoral head and not pins penetrating in the posteroinferior quadrant developed chondrolysis.<sup>8</sup>

Our findings support the mechanical theory suggested by Waldenström<sup>49</sup> and Cruess.<sup>50</sup> The significant incidence of chondrolysis at presentation in chronic and moderate/severe slips could be due to the decreased range of movement with resultant reduction of synovial fluid production compromising cartilage nutrition.

The exclusive female incidence suggests a genetic predisposition. No male with a chronic, moderate/severe slip presented with chondrolysis. It is interesting to note that idiopathic chondrolysis which was first described from our unit by Jones in 1971 also occurred in adolescents and almost exclusively in females.<sup>51</sup>

The Bernese school believes that the uncovered anterior femoral neck articulating with the acetabulum is the cause of chondrolysis and another reason to accurately reduce the femoral head. However, this does not explain why chondrolysis does not occur in chronic, moderate/severe slips in male patients.

In our initial study we described a good outcome in two thirds of hips. However, we had combined the results of chondrolysis due to pin penetration with the results of chondrolysis at presentation. The results of chondrolysis at presentation are poor in two thirds of cases, which is disappointingly similar to that of idiopathic chondrolysis.

## **Conclusion**

Single cannulated screw fixation alone results in decreased complications. The risk of AVN is decreased because there is less chance of interfering with the femoral head blood supply. The risk of chondrolysis due to pin penetration is lower because there are fewer implants that may potentially enter the joint.

Compared to the literature the rates of AVN in this study are acceptably low.

The cause of chondrolysis at presentation was not proven but it seems to be associated with severity, suggesting mechanical factors, and gender, suggesting genetic factors.

University of Cape Town

## References:

- <sup>1</sup> **Kay RM.** Slipped Capital Femoral Epiphysis. In: Morrissy RT and Weinstein SL, editors. Lovell & Winter's Paediatric Orthopaedics, 6th Edition 2006. Vol 2 Chapter 26 pgs 1085-1124.
- <sup>2</sup> **Canale ST.** Fractures and dislocations in children. In: Canale ST editor. Campbells Operative Orthopaedics Tenth Edition 2003.
- <sup>3</sup> **Lehmann CL, Arons RR, Loder RT, Vitale MG.** The epidemiology of slipped capital femoral epiphysis: An update. *J Pediatr Orthop* 2006; 26:286-290.
- <sup>4</sup> Western Cape Census tables for 2001 as published on [www.statsa.gov.za](http://www.statsa.gov.za). Accessed 20 June 2009.
- <sup>5</sup> **Loder RT, Starnes T, Dikos G.** The narrow window of bone age in children with slipped capital femoral epiphysis: A reassessment one decade later. *J Pediatr Orthop* 2006; 26:300-306.
- <sup>6</sup> **Murray AW and Wilson NIL.** Changing incidence of slipped capital femoral epiphysis. *J Bone Joint Surg(Br)* 2008; 90:92-4.
- <sup>7</sup> **Loder RT, et al.** The demographics of slipped capital femoral epiphysis. *Clin Orthop* 1996; 322:9-27.
- <sup>8</sup> **Vrettos BC and Hoffman EB.** Chondrolysis in slipped upper femoral epiphysis: Long term study of the aetiology and natural history. *J Bone Joint Surg(Br)* 1993;75:956-61.
- <sup>9</sup> **Fishkin Z, Armstrong DG, Shah H, Patra A, Mihalko WM.** Proximal femoral physis shear in slipped capital femoral epiphysis- A finite element study. *J Pediatr Orthop* 2006; 26:291-294.
- <sup>10</sup> **Manoff EM, Banffy MB, Winell JJ.** Relationship between body mass index and slipped capital femoral epiphysis. *J Pediatr Orthop* 2005; 25:744-746.

- <sup>11</sup> **Barrios C, Blasco MA, Blasco MC, Gasco J.** Posterior sloping angle of the capital femoral physis - A predictor of bilaterality in slipped capital femoral epiphysis. *J Pediatr Orthop* 2005; 25:445-449.
- <sup>12</sup> **Adamczyk MJ, Weiner DS, Nugent A, McBurney D, Horton WE.** Increased chondrocyte apoptosis in growth plates from children with slipped capital femoral epiphysis. *J Pediatr Orthop* 2005; 25:440-444.
- <sup>13</sup> **Zupanc O, Krizancic M, Daniel M, Mavcic B, Antolic V, Igljic A, Kralj-Igljic V.** Shear stress in epiphyseal growth plate is a risk factor for slipped capital femoral epiphysis. *J Pediatr Orthop* 2008; 28:444-451.
- <sup>14</sup> **Carney BT, Weinstein SL, Noble J.** Long-term follow-up of slipped capital femoral epiphysis. *J Bone Joint Surg(Am)* 1991;63:667-674.
- <sup>15</sup> **Fahey JJ and O'Brien ET.** Acute slipped capital femoral epiphysis: Review of the literature and report of ten cases. *J Bone Joint Surg(Am)* 1965;47:1105-1127.
- <sup>16</sup> **Loder RT, Richards BS, Shapiro PS, Reznick LR, Aronson DD.** Acute slipped capital epiphysis: The importance of physeal stability. *J Bone Joint Surg(Am)* 1993;75:1134-1140.
- <sup>17</sup> **Wilson PD, Jacobs B, Schecter L.** Slipped capital femoral epiphysis: An end result study. *J Bone Joint Surg(Am)* 1965;47:1128-1145.
- <sup>18</sup> **Southwick WO.** Osteotomy through the lesser trochanter for slipped capital femoral epiphysis. *J Bone Joint Surg(Am)* 1967;49:807-35.
- <sup>19</sup> **Ballard J and Cosgrove AP.** Anterior physeal separation. A sign indicating a high risk for avascular necrosis after slipped capital femoral epiphysis. *J Bone Joint Surg(Br)* 2002;84:1176-9.
- <sup>20</sup> **Maeda S, Kita A, Funayama K, Kokubun S.** Vascular supply to acute slipped capital epiphysis. *J Pediatr Orthop* 2001;21:664-667

- <sup>21</sup> **Wilson PD.** The treatment of slipping of the upper femoral epiphysis with minimal displacement. *J Bone Joint Surg(Am)* 1938;20:379-399.
- <sup>22</sup> **Mooney JF, Sanders JO, Browne RH, Anderson DJ, Jofe M, Feldman D, Raney EM.** Management of unstable/acute slipped capital femoral epiphysis: Results of a survey of the POSNA membership. *J Pediatr Orthop* 2005; 25:162-166.
- <sup>23</sup> **Loder RT.** Controversies in slipped capital femoral epiphysis. *Orthop Clin N Am* 2006;37:211-221.
- <sup>24</sup> **Heyman CH and Herndon CH.** Epiphyseodesis for early slipping of the upper femoral epiphysis. *J Bone Joint Surg(Am)* 1954;36:539-654.
- <sup>25</sup> **O'Brien ET and Fahey JJ.** Remodeling of the neck after in situ pinning for slipped capital femoral epiphysis. *J Bone Joint Surg(Am)* 1977;59:62-68.
- <sup>26</sup> **DB Siegel, JR Kasser, P Sponseller and RH Gelberman.** Slipped capital femoral epiphysis. A quantitative analysis of motion, gait and femoral remodeling after in situ fixation. *J Bone Joint Surg(Am)* 1991;73:659-666.
- <sup>27</sup> **Dunn DM and Angel JC.** Replacement of the femoral head by open operation in severe adolescent slipping of the upper femoral epiphysis. *J Bone Joint Surg(Br)* 1978;60:394-403.
- <sup>28</sup> **Fish JB.** Cuneiform osteotomy of the femoral neck in the treatment of slipped capital femoral epiphysis. *J Bone Joint Surg(Am)* 1984;66:1153-1168.
- <sup>29</sup> **Kramer WG, Craig WA, Noel S.** Compensating osteotomy at the base of the neck for slipped capital femoral epiphysis. *J Bone Joint Surg(Am)* 1976;58:796-800.
- <sup>30</sup> **Ganz R, Gill TJ, Gautier E, Ganz K, Krügel N, Berlemann U.** Surgical dislocation of the adult hip. A technique with full access to the femoral head without the risk of avascular necrosis. *J Bone Joint Surg(Br)* 2001;83:1119-1124.

- <sup>31</sup> **Leunig M, Slongo T, Kleinschmidt M, Ganz R.** Subcapital correction osteotomy in slipped capital femoral epiphysis by means of surgical hip dislocation. *Oper Orthop Traumatol* 2007; 4:389-410.
- <sup>32</sup> **Gruber MA, Starkweather KD, Healy WA(III), Haralabatos S.** Percutaneous screw removal in slipped upper femoral epiphysis. *J Bone Joint Surg(Br)* 1996;78:137-139.
- <sup>33</sup> **Casey B, Hamilton H, Bobechko W.** Reduction of acutely slipped upper femoral epiphysis. *J Bone Joint Surg(Br)* 1972;54:607-614.
- <sup>34</sup> **Walters R and Simon SR.** Joint destruction: A sequel of unrecognised pin penetration in patients with slipped capital femoral epiphysis. *The Hip: Proceedings of the Eighth Open Scientific Meeting of the Hip Society. St Louis, MO, CV Mosby, 1980, pp145-164.*
- <sup>35</sup> **Larson CB.** Rating scale for hip disability. *Clin Orthop* 1963;31:85-93.
- <sup>36</sup> **Kallio PE, Mah ET, Foster BK, Paterson DC, LeQuesne GW.** Slipped capital femoral epiphysis. Incidence and assessment of physeal instability. *J Bone Joint Surg(Br)* 1995;77:752-5.
- <sup>37</sup> **Rathey T, Piehl F, Wright JG.** Acute slipped capital femoral epiphysis. Review of outcomes and rates of avascular necrosis *J Bone Joint Surg(Am)* 1996;78:398-402.
- <sup>38</sup> **Tokmakova KP, Stanton RP, Mason DE.** Factors influencing the development of osteonecrosis in patients treated for slipped capital femoral epiphysis. *J Bone Joint Surg(Am)* 2003;85:798-801.
- <sup>39</sup> **Peterson M, Weiner DS, Greene NG, Terry CL.** Acute slipped capital femoral epiphysis: The value and safety of urgent manipulative reduction. *J Pediatr Orthop* 1997;17:648-54.
- <sup>40</sup> **Boyer DW, Mickelson MR, Ponseti IV.** Slipped capital femoral epiphysis. Long-term follow-up study of one hundred and twenty-one patients. *J Bone Joint Surg(Am)* 1981;63:85-95.

- <sup>41</sup> **Carney BT, Weinstein SL, Noble J.** Long-term follow-up of slipped capital femoral epiphysis. *J Bone Joint Surg(Am)* 1991;73:667-74.
- <sup>42</sup> **Phillips SA, Griffiths WEG, Clarke NMP.** The timing of reduction and stabilisation of the acute, unstable, slipped upper femoral epiphysis. *J Bone Joint Surg(Br)* 2001;83:1046-9.
- <sup>43</sup> **Uglow MG and Clarke NMP.** The management of slipped capital femoral epiphysis. *J Bone Joint Surg(Br)* 2004;86:631-5.
- <sup>44</sup> **Dietz FR.** Traction reduction of acute and acute-on-chronic slipped capital femoral epiphysis. *Clin Orthop* 1994;302:101-10.
- <sup>45</sup> **Orderberg G, Hansson LI, Sandstrom S.** Slipped capital femoral epiphysis in southern Sweden. Long term result with no treatment or symptomatic primary treatment. *Clin Orthop* 1984;191:95-104.
- <sup>46</sup> **Kartenbender K, Cordier W, Katthagen BD.** Long-term follow-up study after corrective Imhauser osteotomy for severe slipped capital femoral epiphysis. *J Pediatr Orthop.* 2000;20:749-756.
- <sup>47</sup> **Moseley C.** The "approach-withdraw" phenomenon in the pinning of slipped capital femoral epiphysis. *Orthop Trans* 1985;9:497.
- <sup>48</sup> **Mankin HJ, Sledge CB, Rothschild S, Eisenstein A.** Chondrolysis of the hip. *The Hip: Proceedings of the third open scientific meeting of the Hip Society. St Louis, MO, CV Mosby.* 1975:127-35.
- <sup>49</sup> **Waldenstrom H.** On necrosis of the joint cartilage by epiphyseolysis capitis femoris. *Acta Chir Scand* 1930;67:936-46.

<sup>50</sup> **Cruess RL.** The pathology of acute necrosis of cartilage in slipping of the capital femoral epiphysis: a report of two cases with pathological sections. *J Bone Joint Surg(Am)* 1963;45:1013-24.

<sup>51</sup> **Jones BS.** Adolescent chondrolysis of the hip joint. *S Afr Med J* 1971;4:196-202.

University of Cape Town