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Bev Noble and my daughter, Michelle, who typed the thesis.

Nicola, my niece, who did the drawings.

My husband and children, for their patience and constant encouragement.

ACKNOWLEDGEMENTS

I wish to sincerely thank the following people:

Professor Einhard Erken, Head of the Department of Orthopaedic Surgery, who supervised my work. He provided guidance, positive support, and assistance in reading the X-rays.

Diane Baumgartner, Physiotherapy Co-ordinator, the physiotherapy assistants, and Char Vieira, the radiographer at Millsite Hospital, who willingly assisted in the study of the untreated patients.

Dr Becker and Antoinette Bellinghan of the Department of Biostatistics of the Medical Research Council, for the statistical analysis of the findings.

Michelle Sher and Karen Shnaier for their participation in the reliability study.

The Medical Research Council, who provided financial assistance towards the research.

DECLARATION

I declare that this thesis is my own, unaided work. It is being submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

5th day of December 1994.

ETHICS COMMITTEE CLEARANCE NUMBER 8/10/89

2. The difference in level of sitting ability, postural asymmetry and sitting tolerance between treated and untreated patients was not significant. The treated group, however, had a higher incidence of kyphosis.
3. Perineal care was significantly easier in the treated group, and facilitation of this aspect of management may be an indication for surgery.
4. There was little difference in the incidence of fractures in both groups. The incidence of decubitus ulcers did not decrease after surgery. It was concluded that prevention of these complications are not indications for surgery.

Recommendations are that unilateral hip surgery should be avoided, and that it is not advisable to reduce an established dislocation.

This study shows that generalised statements about the effect of hip instability on CP patients are inaccurate. Possible indications for surgery, in selected patients, could be simplification of perineal care and relief of persistent pain.

It is recommended that the patient be assessed according to the CPHA, and that the indication for surgery be established. Selection criteria should then be applied, before finally deciding on surgical intervention. The importance of comprehensive individual assessment is stressed.

was 5 years. Group B consisted of untreated patients resident at Millsite Hospital. An assessment protocol (the cerebral palsy hip assessment or CPHA) was specifically devised for this study. The CPHA is a comprehensive assessment tool which analyses the hip deformity, functional status and nursing care of the patient.

The outcome of surgery is presented in terms of hip status. Improvement in hip status in the operated group was highly significant. The complication rate was however high, especially in the older patient. Unilateral surgery was often associated with a deterioration in the stability of the unoperated hip. Iliopsoas transfer limited hip flexion, and postural asymmetry increased after this type of surgery, leading to the conclusion that this procedure should be avoided. It was found that the reflex patterns and predominant tone of the patients influenced the outcome of surgery.

Group A and Group B were compared and the major findings were:

1. The frequency of pain on brisk movement of the hip was significantly higher in untreated dislocated hips than in hips treated surgically for dislocation. However, in the majority of patients, this pain did not have a marked impact on the patient's lifestyle and management. Pain occurred intermittently during patient handling and seldom at rest.

ABSTRACT

Dislocation of the hip is a common deformity in cerebral palsied (CP) patients who are not walking. Surgery of the hip is performed to prevent or correct the deformity. This surgery is based on the assumption that a dislocated hip contributes towards patient management problems, in that it compromises nursing care, interferes with sitting, and may be painful.

Reports on the outcome of surgery vary, and there is a controversy as to whether an established hip dislocation should be reduced. This study was undertaken to investigate the above assumptions, and to assess the long term outcome of hip surgery, both in terms of stability, and patient management.

In the background to the study, abnormal development of the CP hip, causation theory, rationale of treatment (both conservative and surgical) and the evolution of hip surgery are described.

This comparative study involves two groups of patients. Surgically treated patients are compared to a random sample of untreated patients matched for age and non-ambulatory status. The treated patients (Group A) had undergone surgery at the Johannesburg Hospital between 1980 and 1987, and the minimum follow-up period

The Long-Term Results of Hip Surgery

in Non-Ambulant Cerebral Palsy Patients

Faith Bischof

A thesis submitted to the Faculty of Medicine, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Doctor of Philosophy.

Johannesburg, 1994.

The Long-Term Results of Hip Surgery in Non-Ambulant Cerebral Palsy Patients

F. Bischof

CHAPTER TWO

PATHOMECHANICS OF HIP INSTABILITY IN CEREBRAL PALSY

The development of the hip joint is influenced by muscular forces acting on the hip, and by weight bearing. Abnormal muscular forces and lack of weight bearing, as found in many CP patients, distort development of this joint.

2.1 NORMAL AND ABNORMAL DEVELOPMENT OF THE HIP

Tönnis (1987) states that all growing parts of the hip joint, namely the triradiate cartilage, the acetabulum and the proximal femur must be finely attuned to one another and must exist in an environment of physiological joint function and loading if they are to develop normally.

Centralised pressure from the femoral head is considered an essential prerequisite for normal acetabular growth. Likewise, the depth of the acetabulum and its spherical contour develop largely in response to the presence of a spherical femoral head. Acetabular dysplasia can be induced experimentally by dislocating the femoral head (Smith et al 1963).

Surgical treatment of the palsied patient is time consuming and costly. This is particularly true in surgery for established dislocation. The more extensive the surgery, the greater the postoperative disturbance in terms of depressed function and pain (Reynell 1965). Complications can occur (Samilson et al 1967; Samilson and Hoffer 1975). It is therefore essential to identify the benefits of operative intervention, and which patients are most likely to obtain these benefits.

observed that patients in my care, who had undergone the aforementioned surgery, presented with management problems which only became apparent in the longer term, particularly in respect of sitting function. In an earlier dissertation I stated that a study of hip deformity in both surgically treated and untreated patients would be worthwhile (Bischof 1983). For these reasons it was decided to conduct a study of all available non-walking CP patients who had undergone hip surgery at the Johannesburg Hospital between 1980 and 1987. The minimum follow-up was to be 5 years, so that long-term results could be assessed. The design of the study made it possible to assess the parameters of joint range, sitting function, hip pain and nursing care in a group of randomly selected, age matched non-treated CP patients, who were also non-ambulant.

The aims of the study were:

1. To evaluate the outcome of surgery in terms of function, as well as correction of deformity.
2. To evaluate the surgical procedures used.
3. To set guidelines for selection of patients for surgery.
4. To develop and validate an assessment protocol for the C.P patient with hip instability. This protocol would assess the patient *in toto*.
5. To determine whether management problems in these patients could be attributed to hip deformity, as stated in the literature.

been established that hip instability is most prevalent in this type of patient, the present study excluded all CP patients who could walk.

A prevailing theme in the literature, which forms the premise on which surgical intervention is based, is that hip dislocation:

(a) makes perineal care difficult

(b) may be associated with decubitus ulcers

(c) interferes with sitting ability and

(d) can become painful in adolescence and adulthood.

This was the view of, inter alia, Samilson et al (1972), Hoffer et al (1972), Sharrard et al (1975), Mackenzie (1975), McManus & Rang (1977), Bleck (1980), Cooperman et al (1987), Jones & Knapp (1987) and Gamble et al (1990).

These views were accepted by the surgeons operating on CP patients at the Johannesburg Hospital.

Erken et al (1984) reported on an early follow up of hip surgery at this hospital. They stated that these major operations were justified for the sitting rehabilitation of the children. This author (Bischof & Martin 1984) also conducted a short term follow up and commented that the patients could all sit comfortably. However, I

CHAPTER ONE

INTRODUCTION

Cerebral palsy (CP), a non-progressive disorder occurring in children, is a disease of the brain resulting in impairment of motor function ([illegible] [illegible]). The encephalopathy is static, but the effect of the brain damage on the motor system is progressive, leading to the development of muscle contractures and joint abnormalities.

A common joint deformity, particularly in the CP patient who is not walking, is subluxation or dislocation of the hip. Hip instability may be bilateral or unilateral. The frequency of this deformity was not apparent in the first studies of its prevalence, as both walking and non-walking patients were included. [illegible] and Pais (1950) reported a prevalence of 4.0%, Mathews et al ([illegible]) [illegible]% and Tachdijan & Minear (1956) 4.24%. Samilson et al (1977) studied institutionalized and predominantly severely involved CP patients and recorded a prevalence of hip deformity of 28%. Hoffer et al (1972) found that 75% of 20 bedridden patients had developed dislocated hips. Howard et al ([illegible]) found a strong correlation between hip stability and the patient's ability to walk. Bleck ([illegible]) stated that dislocation of the hip occurs almost exclusively in the non-ambulatory patient. [illegible]

LIST OF ABBREVIATIONS

Pt	=	Patient
DOS	=	Date of surgery
HS	=	Hip status
D	=	Dislocated
SS	=	Severely subluxated
S	=	Subluxated
B	=	Bilateral
L	=	Left
R	=	Right
AR	=	Adductor release
ON	=	Anterior branch obturator neurectomy
IR	=	Iliopsoas release
MIT	=	Mustard iliopsoas transfer
SIT	=	Sharrard iliopsoas transfer
FO	=	Femoral osteotomy
PO	=	Pelvic osteotomy
HR	=	Hamstring release
OR	=	Open reduction
SF	=	Spinal fusion
EAR	=	Extensor abductor release
HE	=	Hip excision arthroplasty
•	=	Present

5. Comparison of pain in surgically treated and untreated hips in cerebral palsy.

   40th Congress of the South African Orthopaedic Association. Pretoria, 1994.

6. Assessment and selection of cerebral palsy patients for hip surgery.

   40th Congress of the South African Orthopaedic Association. Pretoria, 1994.

LIST OF PRESENTATIONS BY F. BISCHOF RELATING TO THE THESIS

1. Long-term results of hip surgery in non-ambulant cerebral palsied patients.
   37th Congress of the South African Orthopaedic Association. Johannesburg, 1991.

2. Sitting function in non-ambulant cerebral palsied patients following hip surgery.
   19th Congress of the South African Society of Physiotherapy. Pretoria, 1991.

3. The hip in the untreated non-ambulant cerebral palsied patient.
   38th Congress of the South African Orthopaedic Association. Cape Town, 1992.

4. Spinal deformity in cerebral palsy.
   South African Paediatric Orthopaedic Society Meeting. Pretoria, 1993.

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for operation is independent of age, the severity of involvement or the neurological maturity of the child. It is hard to understand how a dislocated hip can cause an increase in spasticity, unless it is persistently painful at rest.
Their statement that hip surgery should be non-selective implies that hip instability causes problems in all CP patients.

Letts et al in 1984 described the windblown hip syndrome. They were of the opinion that this syndrome i.e hip dislocation, pelvic obliquity and scoliosis, occurred in sequence. If this were so, prevention or correction of dislocation should reduce the incidence of scoliosis. Gamble et al (1990) believed that established hip dislocation could adversely influence sitting balance, make perineal care difficult, and cause ischial or sacral pressure ulceration; they gave no data to support these assumptions. They regarded pain as a major issue.
The authors quoted above had observed these problems in the patients they encountered. They commonly regarded hip dislocation as the cause. The problems were not evaluated in terms of the patient's condition as a whole.

3.2 STUDIES OF UNTREATED HIPS

Subsequent to the publication of the paper by Sharrard et al in 1975 a few studies were undertaken, focusing on the untreated hip, to determine the extent of the so-for operation is independent of age, the severity of involvement or the neurological maturity of the child. It is hard to understand how a dislocated hip can cause an increase in spasticity, unless it is persistently painful at rest.

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CHAPTER THREE

STUDIES RELATED TO THE CONSEQUENCES OF HIP DISLOCATION

The justification of treatment of the unstable CP hip is based on the perceived consequences of hip dislocation. These concepts developed historically.

3.1 DEVELOPMENT OF A TREATMENT RATIONALE

The early literature focused on the cause of hip dislocation and the methods employed to correct the deformity. Little thought was given to the possible consequences of hip dislocation. Following Phelp's (1959) elaboration on the cause and treatment of acquired dislocation, Cooper in the discussion in the same article suggested that the real problem of dislocation was pain which, he stated, occurred frequently and was often severe.

There was a general presumption that dislocation of the hip in the less handicapped ambulant patient could lead to the impairment of walking ability. (Tachdijan and Minear 1956, Mollaferoze and Vora 1972, Sharrard et al 1975). In these patients the aim of surgery was to improve walking. Cooperman et al (1987), however, concluded that adults with CP who have dislocated hips as children are more likely

2.4 SUMMARY

The pathogenesis of hip dislocation in cerebral palsy is multifactorial. Muscle imbalance and femoral anteversion are always present in those patients at risk of developing hip deformity. True valgus of the femoral neck is not common, and should not be regarded as an important contributing factor. Functional valgus may however be present.

Recent studies indicate that acetabular dysplasia precedes dislocation and may occur quite early in the development of the deformity. The acetabulum is at its shallowest from the twentieth week of gestation to 18 months postnatally (Ralis and McKibbin 1973). It is probable that this shallowness persists in the CP child who is non-weight bearing. Persistent primitive reflexes also play a role. They result in abnormal muscle forces acting on the hip joint thereby distorting its development and leading to acetabular deficiency. CT scanning has established that the position of this deficiency is variable.

(19[illegible]) demonstrated elliptic deformation of the cartilaginous femoral head, and a deformation of the cartilaginous acetabulum. These increased with the increasing degree of subluxation. This deformation occurred more frequently in patients with total body involvement. Their data demonstrated that deformation of the cartilaginous acetabulum in spastic children occurs before, or as the hip subluxates.

Reports on the type of acetabular deficiency vary. Bleck (1987) stated that the posterior acetabulum is deficient, but the authors he quoted described congenital dislocation and dislocation in poliomyelitis. Computerised tomography (CT) scanning of the hips has facilitated a more comprehensive study of the acetabulum in recent years. Using this method Gugenheim et al (1982) demonstrated anterior deficiency of the acetabulum. Buckley et al (1991) found global deficiency (anterior, posterior and superior) in congenital hip dysplasia, CP and spina bifida. The acetabula of his CP patients had significant posterior deficiency and were the shallowest of the various groups evaluated. Zimmerman and Sturm (1992) found only anterior deficiency in their patients using CT scans.

dysplasia as secondary, i.e. occurring with progression of subluxation. He felt that it could be prevented by early soft tissue surgery. Vidal et al (1985) stated that acetabular obliquity commences at about the age of 30 months.

Cooke et al (1989), on the other hand, found that there is a high incidence of perinatal dislocation in CP and postulated that initial hypotonia in these patients may be important in the development of acetabular dysplasia. Their findings suggest that acetabular dysplasia occurs earlier than previously believed. This would imply that the dysplasia is part of the mechanism of dislocation. They advocate early measurement of the acetabular index, and use of this index to predict which CP patients are at risk of developing hip dislocation.

The femoral anteversion which exists in the neonate persists in the cerebral palsied child because of spasticity of the hip flexors. This prevents the derotation of the femur which occurs in normal development. Gamble et al (1990) reiterated that the cause of dislocation is multifactorial, being the result of muscular imbalance, persistent fetal femoral geometry and acetabular dysplasia. Scrutton (1989) believed there may be a genetic factor in hip instability. Matthias (1990) distinguished between early and late hip dislocation. He stated that the former is characterized by early acetabular dysplasia, and that the development of the hip joint is almost normal in the late type. An arthrographic analysis by Heinrich et al

X-ray depended less on true coxa valga and more on excessive anteversion. This correlated with Beals' study in 1969. Reimer's radiological study of hip instability in 1980 led to his conclusion that it is especially the balance between hip adductors and abductors which has significance for hip instability in the frontal plane.

Tönnis' (1976) investigation of normal values of the hip joint in children and adults showed that coxa valga and increased anteversion should not be regarded as pathological too quickly. Those features should not be considered an indication for osteotomy unless accompanied by acetabular dysplasia.

2.3 CURRENT THEORIES OF THE PATHOGENESIS OF THE DEFORMITY

Bleck (1980 & 1987) discussed the role of psoas major in hip dislocation and subluxation. In the non-walking, sedentary CP patient, the psoas flexes and externally rotates the hip. He stated that this action, combined with femoral anteversion, positions the head of the femur anteriorly in the acetabulum and results in acetabular dysplasia. The iliopsoas insertion becomes the new centre of rotation of the hip. The hip capsule stretches and the hip gradually levers out of the joint by the combined action of the hip flexors and adductors, dislocating laterally and eventually posteriorly. Bleck (1980) also regarded the acetabular the majority of cases. Samilson et al (op. cit.) found that the mean age of dislocation was seven years.

Sharrard (1975) analysed the biomechanics of hip dislocation. He postulated that muscle imbalance (mainly overactivity and resultant shortening of iliopsoas and hip adductors, in the presence of weak abductors and hip extensors) shifts the centre of movement of the hip. The fulcrum of movement is transferred from the head of the femur to the level of the lesser trochanter causing the head of the femur to slip out laterally. He regarded valgus and anteversion as aggravating factors. Scrutton (1989) disagreed with Sharrard's theory of the lesser trochanter being the fulcrum for dislocation.

Both Samilson et al (1972) and Sharrard et al (1975) felt that the shallowness of the acetabulum, which is a common feature of congenital dislocation of the hip, was not a constant feature of the cerebral palsy hip, unless the dislocation occurred in the neonatal period. Acetabular dysplasia was thought to follow on hip dislocation and not to precede it. In other words CP hips were regarded as normal at birth.

Fujiwara et al (1976) conducted a radiological study of hip abnormalities in CP. They stated that the apparent increased neck-shaft angle of the femur observed on

Batchelor (1966) felt dislocation was essentially due to the valgus position of the femoral neck. Beals'(1969) radiographic study of 40 cases led to his conclusion that the acetabular index (AI) is initially normal in spastic children. He attributed the failure of the AI to decrease with age to be partly dependent on the failure to ambulate. He said that the apparent abnormal valgus is due to anteversion. He disagreed with Baker et al's view that valgus is significantly increased. According to Beals effective valgus, flexion contracture and anteversion of the femur determine the site of contact of the femoral head with the acetabulum. Excessive pressure on the outer margin of the acetabulum may distort its development.

By the end of the sixties it was clear that the aetiology of dislocation was multi-factorial. Samilson et al (1972) studied a large group of patients (1,013) in a State hospital. They contended that the retention of neonatal reflexes may be significant in the pathogenesis of this deformity, a view also expressed by Fujiwara et al in the same year. This would explain the high incidence of hip dislocation in CP patients with total body involvement, who exhibit abnormal reflexes. These reflexes e.g asymmetrical tonic neck reflexes (ASTNR), crossed extensor reflex, tonic labyrinthine reflex (TLR), and the Galant reflex result in abnormal muscle action on the developing joints, leading to deformity. It is also known that in a patient with a predominantly one sided ASTNR, the hip is likely to dislocate on the flexed side (Bobath 1965). It was generally accepted that the deformity was acquired in treatment should address both the adductors and flexors, as he thought both were responsible. The theory of muscle imbalance around the hip as the causative factor of hip dislocation prevailed until the 1950's, when a spate of papers appeared on aetiology and treatment. Jones in 1954 concluded that the primary factor in the development of paralytic dislocation was coxa valga, or valgus deformity of the femoral neck. Tachdijan and Minear (1956) demonstrated the presence of dynamic muscle imbalance (weak abductors vs overactive adductors) to which they attributed the coxa valga observed radiologically.

Studies by Baker (1956), Phelps (1957), Pollock and Sharrard(1958), Somerville (1959) and Banks and Green (1960) all attempted to analyse the cause of spastic hip dislocation. They commonly regarded the development of coxa valga, in the presence of muscle imbalance around the hip, as a major contributing factor. Phelps (1957) mentions anteversion of the femur as an additional, but less important factor. He described two types of dislocation: one due to adductor muscle spasticity, the other due to gracilis spasticity.

In 1962 Baker et al and Lamb and Pollock mentioned anteversion of the femoral neck as a contributing factor in the development of dislocation. Baker et al stressed that the medial hamstrings are deforming forces. Brooks and Wardle (1962) considered the iliopsoas the prime deformer producing coxa valga.

2.2 HISTORICAL DEVELOPMENT OF CAUSATION THEORY

Early in the twentieth century, the occurrence of hip dislocation in spastic paresis was documented in articles by Ludloff (1902), Gaugele (1906), Wollenberg (1908), Weber (1911) and Künne (1914). They all observed that the hip adductors and flexors were overactive in hip dislocation, and speculated that this was the cause of the deformity.

Weber (1911) analysed in detail the hip radiographs of 18 children, 15 of whom had Little's Disease, as the diplegic form of cerebral palsy was then called. His observations led him to believe that CP hip dislocation was an acquired deformity found primarily in patients who could not walk. He described the shallowness and steepness of the acetabulum in cases of dislocation. He believed that the bony changes he observed in the acetabulum and pelvis were due to lack of normal contact of the head of femur with the bony socket. He elaborated on the effect of muscle imbalance on joint surfaces.

In 1921 Lange concluded that spastic adductors must be the cause of coxa valga in spastic palsy. The first report on spastic hip dislocation in the English literature was by Watson Jones in 1926. He described one case of "spontaneous dislocation" in a spastic paraplegic. He felt the deformity was preventable, and that surgical

Tönnis (op. cit.) explains how the growth and shape of the proximal femur are critically influenced by the static and muscular forces acting on the hip joint. Just as the shape and position of the femoral head influences the development of the acetabulum, so acetabular deformity influences the direction of growth of the femoral neck. An increase in the angle of the acetabular roof is associated with an increase in femoral anteversion.

During normal development the acetabular angle decreases and the acetabulum deepens. In the CP patient the acetabular index may remain high and the acetabulum remain shallow particularly if the patient is non-weight bearing.

The neck-shaft angle of the femur decreases during growth to the adult value of 126°/127°. Anteversion of the hip decreases from a mean of 38° at birth to 19° at adulthood (Shands and Steele 1958). Persistent anteversion occurs in CP, and Bleck (1987) has postulated that this is due to the lack of hip extension which decreases the torque strains on the proximal end of the femur preventing derotation.

Thus the mechanism of hip dislocation involves several factors. The relative importance of each factor contributing to the deformity has been a subject of debate in the literature.

W.T. Green (1975) said that the early enthusiasm for surgery was tempered by poor results, and that by 1930 many in the field were quite critical of surgical procedures.

Pollock and Sharrard (1958) stated that disillusionment was due to the treatment of the cerebral palsied being entrusted almost entirely to the orthopaedic surgeon.

Phelps, a professor of orthopaedic surgery at Yale, recognised the importance of an interdisciplinary approach to the problem. He became the first President of the American Academy of Cerebral Palsy which was formed in 1947, and which promoted interaction between various specialists in the field of cerebral palsy.

5.2 SURGICAL MANAGEMENT (1950 - 1970)

Interest in surgery in cerebral palsy revived in the 1950s. Mathews et al in 1953 advocated adductor tenotomy and anterior obturator neurectomy for hip instability in selected patients i.e. those who would possibly walk.

Jones (1954) regarded valgus deformity of the femoral neck as the primary factor in the development of dislocation and advocated femoral osteotomy as part of the surgical procedure.

CHAPTER FIVE

SURGICAL TREATMENT OF THE CP HIP

This chapter deals with the evolution of hip surgery in CP, and current concepts of surgical intervention.

5.1 EARLY ATTEMPTS AT SURGICAL INTERVENTION

At the same time as writers in the early 1900s were speculating on the cause of hip dislocation, attempts were being made to reduce the deformity. Ludloff (1902) was unsuccessful in his attempts to reduce a bilateral hip dislocation in a 6-year-old girl with CP.

Gaugele (1906) proposed transection of the hip adductors and flexors but could not reduce three cases of dislocation. Weber (1911) reduced three complete dislocations and one subluxation; in two cases the hips were reported to be in a good position 1½ and 3¾ years respectively, after reduction.

Watson Jones (1926) considered the hip deformity to be preventable. He said that the overactive flexors and adductors should be reduced by operative measures and the power of the antagonists increased by physiotherapeutic measures.

changes can be influenced by conservative means. The effectiveness of these measures has yet to be proven.

encourage acetabular development. However in many CP children an optimal position of the hip joints in standing is difficult, if not impossible, to achieve.

It is also difficult to control hip positioning in the other recommended positions e.g. prone lying and side lying, although these positions have other therapeutic advantages such as reduction of reflex activity.

The importance of conservative measures, including physiotherapy, after surgery to maintain correction of deformity and restore function has been emphasised by Mathias (1967), Craig (1973) and Bischof (1983).

4.3 SUMMARY

Conservative management of the CP child has been advocated for several reasons: the development of deformity could possibly be delayed and the degree of deformity lessened i.e severe contractures could be prevented. This is to be commended. One must, however, bear in mind that the factors which contribute to the development of hip dislocation are not only muscular in origin. The bony factors, mainly acetabular dysplasia and femoral anteversion, appear to occur quite early in the development of the deformity. It is debatable whether these bony

4.2 LIMITATIONS OF CONSERVATIVE MANAGEMENT

When considering conservative management as an option for prevention of hip deformity, the following points must be noted:

1. Splinting needs to be applied from an early age and for a considerable part of the day. Tardieu et al (1985) found that a spastic muscle has to be stretched for at least six hours a day to retain its length. The legs have to be held in extension and abduction. This may be uncomfortable for the patient. Unless the splints are well made, carefully applied and the position supervised, pressure sores may develop. Splinting imposes an additional burden on the parent or caregiver; it restricts mobility and exploration of the environment. Sitting becomes difficult.
2. Passive movements can be used to improve joint range but when incorrectly done may increase spasticity.
3. Strengthening of the hip extensors and abductors can only be undertaken with the active co-operation of the patient, which is often not possible.
4. Supported standing (e.g. in a standing frame) is good from the point of view of maintaining a straight position of the legs, prevention of bladder infections, and mental stimulation. Theoretically, early standing in a good position i.e. with legs slightly abducted and in neutral rotation, should

that it should be amenable to physiotherapeutic intervention and advocated prone lying with symmetrically abducted hips. Fettweis (1979) stressed the limitations of conservative and physiotherapeutic methods. Bleck (1987) was of the opinion that orthotics and physiotherapy have not demonstrated any effect on prevention of subluxation or dislocation of the hip.

Scrutton and Gilbertson (1975) elaborated on the physiotherapist's role in the treatment of cerebral palsy. They advocated early and correct weight bearing i.e. with extended and slightly abducted hips, from the age of one year, to avoid severe hip joint deformity.

Scrutton (1989) stated that CP children at risk of hip and spine problems need ea and persistent positioning. Matthias (1990) contended that physiotherapy plays the most important role in early treatment of impending dislocation and that all other measures are secondary to this. Heinrich et al (1991) stated that therapy recommendations for hip deformation are based on an incomplete understanding of the pathology of cartilage and bone in CP children. Thom (1991) believed that an abduction seating orthosis could prevent hip dislocation in the majority of cases.

Somerville (1959), on the other hand, stated that hip instability could not be controlled adequately by splinting. Hoffer et al (1972) emphasized that, in their view, a simple program of positioning and passive exercises could prevent the development of hip deformities. Samilson et al (1972) agreed that CP hip dislocation should theoretically be preventable, but that one is unable to prevent deformities by simple positioning, because of insufficient understanding of the action of the spastic hip muscles.

Sharrard et al (1975) compared a group of conservatively treated patients with a group of patients treated both conservatively and surgically. At review 39% of hips were subluxated or dislocated and only 15% normal in the former group as opposed to 13% subluxated, 35% dysplastic, and 52% normal in the group where surgery was added. Sharrard (1975) has highlighted the disadvantages of indefinite splinting: loss of the child's mobility and disuse atrophy of muscles. He felt abduction splintage should be used only at night and mainly in early childhood. He agreed that hip flexion and adduction contractures should be prevented by daily passive movements and reflex inhibiting postures.

Fulford and Brown (1976) elaborated on the windswept deformity, which was described by Künne as early as 1914. They said it was caused by the effect of gravity on an immobile growing child, rather than muscle imbalance. They felt

CHAPTER FOUR

CONSERVATIVE TREATMENT OF THE CP HIP

Prevention of hip dislocation by conservative methods is a theoretical alternative to surgical intervention. Such methods include splinting, exercises and positioning. Despite many references in the literature to these methods, there are no studies specific to the outcome of management by conservative means.

4.1 OPINIONS ON CONSERVATIVE MANAGEMENT

Watson Jones (1926) stated that hip dislocation can be prevented in both paralysis and infection by preventing the flexion adduction deformity and restoring muscle balance. Tachdijan and Minear (1956) emphasized the importance of conservative treatment, but reported that this produced poor results in three severe CPs and one of five patients with mild to moderate subluxation.

Phelps (1957) believed that very early weight bearing (before the age of one year), using splints, would reduce coxa valga, which he regarded as one of the causes of dislocation. He also said this method would prevent the development of anteversion.

3.3 SUMMARY

There is disagreement about the effect of a dislocated hip on the function and the management of the CP patient. It is generally agreed that a dislocated hip may become painful. Reports on the incidence and degree of pain vary. These differences are due to:

1) Endogenous and exogenous factors in the assessment of pain and

2) Differences in the populations of patients being studied.

Analysis of nursing care, sitting function and hip pain revealed that:

1. Perineal care was difficult in patients with bilateral fixed adduction deformities.
2. Pressure sores were related to the severity of the condition and difficulty in positioning, rather than to the hip dislocation.
3. Dislocation of the hip did not exclude prop-sitting. The level of sitting ability depended on the degree of neurological impairment.
4. One third of hip dislocations were painful. Only one patient had resting pain and associated poor sitting tolerance.

Investigation of the mental status of these patients led to the conclusion that the more profoundly retarded the patient, the less likely it was that hip pain would be experienced. This supported the findings of Moreau et al (1979).

Bagg et al (1993) scored hip pain from 0-3, with 3 denoting daily pain requiring medication and having a severe impact on the patients' lifestyles. Information about pain was obtained from a number of sources, introducing a large subjective element. There were only nine dislocated hips in their series and eight of them were reported to be mildly or severely painful. Only three of these hips had been not been treated; six had undergone soft tissue releases. The mental status of the patients was not documented.

Cooperman et al (1987) published a paper entitled "Hip dislocation in CP: long term consequences." However, 34 of the 38 patients evaluated had undergone hip surgery. They stated that pain was the primary indication for surgery in 18 of 43 procedures. Based on this pain documentation, they concluded that at least 50% of dislocated hips will become painful. Pritchett's follow-up study, in which he compared treated and untreated patients, was published in 1990 at the same time as this present work was being conducted. His results will be compared to the results of this study in the concluding chapters. His study of the untreated hip posed the question in an editorial of Lancet (1990) "Does hip dislocation matter in cerebral palsy?"

A study of the untreated unstable hip was conducted (Bischof and Erken 1993) prior to assessing the control group for this thesis. On examination 100 of 142 non-walking CP residents of an institution were found to have less than 30° hip abduction, and were radiographed. Their ages ranged from 7-33 years. Eighty-three of the 100 patients were spastic quadriplegics. Sixty-six of these patients had unstable hips (Thirty-five patients had frankly dislocated hips). In patients with unilateral dislocations the acetabular index (AI) on the dislocated side was on average more than double the value on the normal side, indicating long standing acetabular dysplasia.

[illegible] [illegible] of hip dislocation. [illegible] and [illegible] ([illegible]) conducted a retrospective study of [illegible] with dislocated hips. They felt that the effects of hip dislocation were exaggerated and that pain and [illegible] [illegible] were not major problems. They stated that no surgical attempts should be made to relocate the hips. They reported that scoliosis and poor sitting balance were related to the extent of the neurological involvement and not the dislocated hip. This study was presented at an American Academy of Cerebral Palsy meeting in 19[illegible] and published only as an abstract, exact figures on pain and perineal care problems are unavailable

Moreau et al (1979) reviewed 88 adult institutionalised patients, 21 of whom had dislocated hips. They concluded that the degree of pain was directly related to neurological maturity. Decubitus ulcers and perineal care problems were more associated with contractures than dislocation alone.

Pritchett (1983) studied a group of 80 profoundly retarded non ambulatory patients with untreated hips. He called pain which occurred on movement or examination minor. Minor pain occurred in 1/3 of his patients. He reported that a dislocated hip predisposed to lower extremity fractures, but did not present problems with regard to pain, decubitus ulcers or perineal hygiene. He correlated loss of function (e.g sitting balance) with severity of neurological involvement rather than a dislocated hip.

TABLE I

AGE AT SURGERY AND AT FOLLOW-UP

PATIENT	AGE (SURGERY)	AGE (FOLLOW-UP)	LENGTH (FOLLOW-UP)
1A	15	26	11
2A	5	12	7
3A	11	18	7
4A	11	19	8
5A	5	13	8
6A	4	12	8
7A	10	18	8
8A	3	13	10
9A	4	11	7
10A	5	12	7
11A	15	24	9
12A	5	14	9
13A	6	14	8
14A	5	12	7
15A	11	18	7
16A	8	18	10
17A	5	14	9
18A	9	19	10
19A	8	15	7
20A	10	17	7
21A	6	16	10
22A	16	24	8
23A	2	8	6
24A	11	18	7
25A	13	22	9
26A	18	25	7
27A	8	19	11
28A	12	23	11
29A	7	18	11
30A	11	18	7
31A	2	11	9
32A	6	17	11
33A	15	25	10
34A	8	15	7
35A	5	16	11
36A	11	16	5
37A	10	15	5
38A	3	13	10
39A	4	12	8
40A	10	21	11

Twenty-two of the 40 patients lived in an institution and 18 lived at home. The 22 institutionalised patients did not go out to a school or a training centre. They were either untrainable, or had been discharged because of age. Twelve of the 18 patients who lived at home attended a training centre. The other six spent all the time at home.

Thirty-nine patients were spastic quadriplegics, or CP with total body involvement. Six of these patients were dyskinetic. One patient was classified as diplegic because of her good upper limb function and fine motor co-ordination.

The hip status, age at surgery and type of surgery performed are detailed in Appendix I. The ages of the patient at surgery and at follow-up are shown in Table I. The ages, at surgery, ranged from 2 to 18 years with a mean of 8.35 years. Length of follow-up ranged from 5 to 11 years with a mean of 8.45 years.

CHAPTER SIX

PATIENTS

This chapter details the selection of patients for this study. Two groups of patients were compared. Group A consisted of patients who had hip surgery and Group B (the control group) had no surgical treatment.

6.1 TREATED GROUP (A)

Examination of records showed that 60 non-ambulant CPs underwent surgery for hip instability at the Johannesburg Hospital between 1980 and 1987. Eleven died before follow-up. It was established that the majority of the patients who died were severely scoliotic and bedridden. The major cause of death was respiratory failure. No child died at the time of surgery. Six patients could not be traced for follow-up assessment. Three patients were excluded because they had undergone a rhizotomy. This procedure might influence hip stability (Green et al 1991). Forty patients were assessed. It should be mentioned that two of these patients died within the same year they were re-assessed. Both were profoundly handicapped and had collapsed spines.

Trainer et al (1986) described the use of an obturator nerve block which provides temporary relief of hip pain in the CP adult.

5.5 SUMMARY

1. Early surgical intervention, consisting of adductor and iliopsoas release, combined with anterior obturator neurectomy, appears to produce the best results, in terms of obtaining hip stability.
2. An established hip dislocation requires extensive surgery to reduce it and results are variable. Controversy exists as to whether such surgery should be performed.
3. Other treatment options for established dislocations are:

   (a) Resection of the femoral head and neck.

   (b) Total hip arthroplasty.

   (c) Hip arthrodesis.

   (d) No treatment.

the other hand, Gamble et al (1990) treated 31 established dislocations and found that 84% remained reduced at follow-up evaluation. Good results were obtained with a combination of soft tissue release, open reduction and pelvic and femoral osteotomy. Herndon et al (1992) believed that every attempt should be made to prevent hip dislocation in total body involved CP patients. Once dislocation had occurred, however, they found the chance of a satisfactory outcome of surgery diminished.

Another treatment option for a painful dislocated hip in the older CP patient is a proximal femoral resection as advocated by various authors including Castle and Schneider (1978), Kalen and Gamble (1985), Baxter and d'Astous (1986), McCarthy et al (1988) and McHale et al (1990). During the period covered by this study (1980-1987) femoral resection was only used at the Johannesburg Hospital as a salvage procedure when hip relocation had failed. In this author's experience, patients undergoing this procedure experience considerable postoperative pain for about six months and a pain-free hip in the long-term is not guaranteed. This was also the experience of Perlmutter et al (1993).

Total hip arthroplasty or hip arthrodesis was advocated in certain cases by Root et al (1986). Bleck (1987) discussed the limitations of these two procedures. He did not recommend hip arthrodesis and was cautious about hip replacement.

skeletal age is eight years or less. Since the skeletal ages of CP children vary, and are generally less than the chronological age, the degree of femoral head uncovering rather than chronological age should be used as a criterion for the addition of a femoral osteotomy.

Pelvic osteotomy is performed to provide a better coverage for the femoral head when the acetabulum is deficient, particularly in the older child. Bleck (1987) used the Pemberton iliac osteotomy in the skeletally immature child and the Chiari osteotomy in the adolescent or mature child. The latter was the type of osteotomy used in this study. Mubarak et al (1992) reported good results (in terms of maintenance of reduction at follow-up) using a pericapsular acetabuloplasty to improve coverage of the femoral head.

There is currently still a debate as to whether an blished hip dislocation should be surgically treated or not. Once the hip is dislocated, surgery is more extensive and the deformity can possibly recur. Degenerative changes occur in the hip subsequent to dislocation, and it may not be advisable to relocate an abnormal femoral head. Cooperman et al (1987) do not advocate reduction of established dislocations where the pelvis is level. Jones and Knapp (1987) stated that a late chronic dislocation is best left unreduced. Bleck (1987) was also of the opinion that a painless dislocated hip in the skeletally mature patient should be left alone. On subluxations had not progressed on follow-up despite no treatment.

All authors concur that surgery should be done early, before five years of age, that is before definite skeletal changes are apparent. One must bear in mind, however, that bony changes e.g. acetabular dysplasia may already be present before the age of five.

The controversy surrounding the type of soft tissue surgery to be performed, and the disparate results reported in the literature are due to:

1. Differences in age at time of surgery.
2. Differences in ambulatory status.
3. Differences in the preoperative status of the hip.

Iliopsoas surgery should be added to the procedure if a hip flexion deformity is present (Fettweis 1979, Hiroshimo and Ono 1979, Sharrard and Burke 1982, Kalen and Bleck 1985, Hoffer 1986, Bleck 1987 and Bleck 1990).

The addition of a femoral osteotomy to the soft tissue surgery was advocated by Carpenter (1982) if the patient is over six and by Kalen and Bleck (1985) if the patient is over five years of age. This bony procedure was also advocated by Zimbler et al (1988) if there is 50% uncovering of the femoral head and the

Reimers' 1980 study of hip migration and surgical intervention led to his conclusion that hip adductor release could result in inward migration of the femoral head, and that the best results are obtained in children under four years of age. He regarded lengthening of hip flexors and hamstrings as being of minor importance.

5.4 CURRENT CONCEPTS OF HIP SURGERY

Kalen and Bleck (1985) disagreed with the contention of Sharrard et al (1975) and Reimers (1980) that only the adductors need to be released to produce good results. They stated that better results are obtained when iliopsoas surgery was added, particularly in non-ambulators. Silver et al (1985) obtained 80% good results with adductor tenotomy and obturator neurectomy alone in non-ambulant patients but stressed that there was a greater risk of subsequent dislocation of the hip if the migration percentage was more than 50% preoperatively. The rationale of Vidal et al (1985) for early surgery was prevention of acetabular dysplasia. Feldkamp and Denker (1989) found that release of the medial hamstrings was more important than release of the iliopsoas. Onimus et al (1991) stated that when soft tissue releases were performed before the age of four years, and when the migration percentage index was less than 33%, a 90% success rate could be expected. In this case one is operating on a hip which is close to normal and which may not necessarily progress to subluxation or dislocation. In a study by Bagg et al in 1993, 2/3 hip

In the 70s there were firm proponents of surgical intervention for the so called "hip at risk " and the already dislocated hip, but a note of caution was creeping in, suggesting that such surgery should be selective.

Pettit (1976) stressed careful assessment before surgery. She stated that results were unpredictable in the dyskinetic patient. She regarded lack of head control, balance and equilibrium reactions and the persistence of strong pathological reflexes as contraindications to surgery.

Moreau et al (1979) concluded that hip instability should be prevented by surgical means, but that treatment of the already dislocated hip should be reserved for the neurologically mature, and the athetoid patient. This was based on the observation that pain occurred more frequently in the more intelligent patient and in 4 of 14 patients with athetosis. Bleck (1980) advised routine radiographic examination in CP children to monitor hip status and surgery before the age of seven years to prevent dislocation. He advocated reducing a dislocated hip in the non-ambulatory patient with total body involvement because the hip could become painful in adolescence. He stated that this pain could prevent the patient from sitting, and result in his becoming bedridden.

obtained hip stability. The better results in Sharrard's patients could be attributed to the fact that as a group his patients were less severely involved, and surgery was performed early, in some cases before bony abnormalities could be seen radiologically. Sharrard and his colleagues regarded early subluxation as an indication for urgent surgical intervention, and suggested that limited abduction should form the basis for identification of "hips at risk". Poor results were obtained in their patients who were treated conservatively by splinting, passive movement and exercise.

Following on Smith's article describing surgery to reduce established dislocation, Ashley et al (1972) reported on two CP children, both aged nine years, in whom hip dislocation was successfully reduced by surgery. Hoffer et al (1972) described the results of what they called "salvage" hip surgery in severe CP children, to improve sitting posture. However, results were assessed in terms of improvement of sitting tolerance and perineal care, and sitting posture was not evaluated at all.

Sharrard (1975) stated that an attempt should be made to reduce established dislocation, provided it had not been present for more than two to three years. In the same chapter he describes his technique of transferring the insertion of the iliopsoas from the lesser trochanter to the greater trochanter in cases of progressive subluxation. This technique was first used in myelomeningocoele (Sharrard 1964).

Samilson et al (1967) reported the long term results of adductor tenotomy and obturator neurectomy. Results were graded according to achievement of pre-operative indication. The major indication was improvement in perineal care, which was subjectively judged to be improved in 46 of 69 cases. Overall satisfactory results were achieved in 60% of patients. Only three of nine pre-existing dislocations were reduced by soft tissue surgery.

Smith in 1969 described a single operation to reduce dislocation. He stated that this operation addressed all the factors contributing to dislocation. The stages of his operation involved adductor tenotomy, obturator neurectomy, psoas release and anterior transfer, open reduction of the hip and subtrochanteric osteotomy. However, he did not propose surgical treatment of the acetabular dysplasia.

5.3 SURGICAL MANAGEMENT (1970 - 1980)

Samilson et al (1972) reported a high percentage of failure of reduction of subluxation in their patients with the use of adductor tenotomy alone. This supported the findings of Phelps in 1959 and Baker et al in 1962.

In contrast Sharrard et al (1975) reported that in 75% of the hips operated on, a simple adductor release, sometimes combined with partial obturator neurectomy, Tachdijan and Minear (1956) emphasized early treatment to prevent hip deformity. Their patients were treated both conservatively and surgically. They reported that there were no poor results in patients treated operativel, , however, the grading of results was not explained. Phelps (1957) stated that early adductor tenotomy will prevent development of dislocation in the presence of a normal neck-shaft angle and acetabulum. He advocated release of a tight gracilis. This was also the view of Keats (1957). Phelps said that an osteotomy, if necessary, should correct both coxa valga and anteversion.

In 1957 Phelps expressed disappointment in the long-term results of surgery. Poor results were obtained with adductor tenotomy and obturator neurectomy. Better results were obtained where bony surgery was involved. Banks and Green (1960) advocated both adductor surgery and obturator neurectomy early in the development of hip deformity, and also in cases of established dislocation. They reported excellent results where surgery was done at age 10 years or less. In 1962 Baker et al and Lamb and Pollock emphasized early surgical intervention by a similar surgical method.

Jones (1962) reviewed patients to amplify his observations in his 1954 paper and stated that true valgus was demonstrated in all his patients, justifying his use of osteotomy.

factors.

The difficulty in assessing pain in the cerebral palsied patient is compounded by the fact that many of these patients are non-verbal. Because of the emotional component of pain (e.g. fear of the examiner) even a verbal response may not necessarily be accurate. Assessments of pain in the CP patient described in the literature include:

1. Caregivers' or parents' reports.
2. Information from patient's records.
3. A verbal report from the patient.

These all have subjective components. It was therefore felt that objective examination of the hip by the author would be most reliable. To ensure a more objective assessment, the patient's facial expression on movement of the hip was noted. The patient was positioned in supine with one leg stabilized by an assistant familiar to the patient. The leg to be tested was moved briskly into an outward direction and facial expression was observed. Grimacing, wincing or spontaneous crying was recorded as a positive pain response. To reduce the risk of a conditioned response the following procedures were adopted.

1. The patient was not given prior warning of the test for pain - it was performed during joint range assessment.

Knee flexion deformity was recorded by measuring the popliteal angle. In the supine position the hip of the patient is flexed to 90° and the knee extended to the point of resistance. The angle between the femur and the tibia is the popliteal angle.

Discussion

There is invariably a degree of error in goniometric measurements of joint range in CP patients (Harris et al 1985). It was therefore decided to present broad ranges of joint movement in the results, and not quote absolute figures. Limitation of hip abduction, hip flexion contracture and limited external rotation are clinical indications of hip subluxation. However, this can only be established with certainty by X-ray.

7.2.4 Pain

Pain may be defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage (Merskey 1979). Even in a normal individual accurate assessment of pain is difficult for the following reasons.

1. There is no way to measure pain itself since pain is a subjective experience.
2. There is much individual variation in the experience of pain since it has an emotional as well as a nocioceptive component (Craig 1990).
3. The patient's response to pain is conditioned by endogenous and exogenous

[illegible]

[illegible]

[illegible]

[illegible]

The presence of an asymmetrical tonic neck reflex (ATNR) is established by turning the head to one side. The ATNR is present if there is a relative increase in extensor tone on the side towards which the head is turned (face or jaw side) and a relative increase in flexor tone on the opposite side (skull side).

Both reflexes may be present with one dominant. If the TLR is dominant, the patient is more symmetrically extended. If the ATNR is dominant, the patient is asymmetrical.

Discussion

The type of muscle tone (e.g. rigid or spastic) may be difficult to differentiate in the older patient whose limbs have become fixed and relatively immobile. Similarly the continued presence of abnormal reflexes may be difficult to detect. In these patients the pattern of deformity and the posture in the supine position can be recorded. The persistence of abnormal reflexes, particularly the ATNR and the TLR, as well as the presence of persistent head turning should be established where possible, as these may influence the outcome of surgery (Sherk et al 1983).

7.2.2 Pelvic Obliquity

The anterior superior iliac spines (ASIS) were palpated with the patient supine; differences in the heights of the ASIS denoted pelvic obliquity. This was recorded as present or absent. If present, it was noted which side was higher.

7.2 PHYSICAL EXAMINATION

Physical examination included the assessment of the type of CP, joint range, nursing care, sitting function and transfer ability.

7.2.1 The Type of Cerebral Palsy

The type of cerebral palsy was assessed by movement of the limbs, testing of upper limb function, and observation of the patient. The patient was classified as a spastic quadriplegic if the upper and lower limbs were more or less equally affected, and the patient had poor upper limb function. The patient was classified as a diplegic if the legs were considerably more affected than the arms and if good upper limb function, particularly fine hand movement, was present. Observation of the patient at rest and during movement confirmed the presence of involuntary movements. T. .; was classified as dyskinesia whether the involuntary movement consisted of athetosis-like movements, or posturing. This classification was based on the assessment developed by the Oxford working group (Johnson et al 1989).

Reflexes were tested. Tone was tested with the patient's head in midline. A tonic labyrinthine reflex (TLR) is present if the arms are held in high guard and there is resistance to bringing them to the midline. The legs are predominantly extended.

CHAPTER SEVEN

ASSESSMENT

This chapter deals with the development of an assessment protocol for purposes of this study. No assessment, which looked at the total patient, could be found in the literature. To enable measurement of the relevant parameters the Cerebral Palsy Hip Assessment (CPHA), shown in Appendix II, was constructed. The tests used in the assessment and their derivation will be described and discussed.

7.1 HISTORY

On the first page of the assessment form the date and type of surgery performed were documented. These details were obtained from the operation notes (Appendix I). Postoperative complications were documented (Appendix IV). Management after surgery (Group A) and present management (Group A and B) were recorded (Appendix V).

The two groups were matched for age and ambulatory status. Group A had unstable hip/s before surgery and Group B all had unstable hip/s. Cerebral palsy differs in type and degree from one individual to another, and the type and number of associated handicaps vary. Thus it was impossible to match these factors. However the sex distribution, type of CP, level of retardation and number of associated handicaps in both groups were similar.

acetabulum.

Hip severe subluxation - more than 66.6% of the femoral head outside acetabulum.

Dislocated - femoral head entirely outside acetabulum.

A random sample of 40 patients matched age for age, was obtained from these 66 patients.

6.3 GROUP COMPARISON

Table II documents the characteristics of Group A and B.

TABLE II

GROUP CHARACTERISTICS

	GROUP A (N = 40)	GROUP B (N = 40)
AGES	8 - 26	8 - 26
LOCOMOTOR STATUS	Non-ambulant	Non-ambulant
HIP STATUS	Unstable (Preoperatively)	Unstable
TYPE OF CP	1 Diplegic 39 Quadriplegic (6 with dyskinesia)	2 Diplegic 38 Quadriplegic (4 with dyskinesia)
DOMICILE	22 Institution	40 Institution
MENTAL STATUS	15 Profound/Severe	18 Profound/Severe
SEX	19 F 21 M	17 F 23 M
ASSOCIATED HANDICAPS	46 (in total)	50 (in total)

6.2 UNTREATED GROUP (B)

The untreated patients were all residents of Millsite Hospital, a large institution catering for chronic disability on an inpatient basis. This hospital was chosen as the source for the control group as all patients could be assessed in one location. In addition, good records were kept at the hospital, and a radiographic department was situated on the premises. Unfortunately equipment was not available to take radiographs of the patients' spines, and spinal abnormalities had to be documented from clinical examination. Since the ages of Group A at follow-up ranged from 8 to 26 years, all non-walking CP patients from seven years upwards were identified. Hip abduction was measured and this formed the basis of selection of the patients for radiographic examination. In one hundred patients hip abduction measured less than 30°. Since it has been documented that limitation of abduction of this degree may be an indicator of hip instability (Sharrard 1975, Hiroshimo and Ono 1979 and Hoffer et al 1987), these patients had radiographs of their hips.

The sample of 100 patients formed the basis of a study of the untreated hip, which is discussed in Chapter 3. Hip instability was identified in 66 patients, using Reimers' migration percentage:

Hip located - less than 33.3% of the femoral head outside the acetabulum.

Hip subluxation - more than 33.3% to 66.6% of the femoral head outside the

The iliopsoas was transferred in 35 patients (48 hips). In 39 hips the iliopsoas was transferred posterolaterally (Sharrard procedure) and in nine hips anterolaterally (Mustard procedure). In three cases the Sharrard procedure was repeated. The complications of surgery, and results in terms of hip status and sitting function of the patients in whom the iliopsoas was transferred have been described by Erken and Bischof (1994).

Hamstring releases were performed at the same time as hip surgery in 21 patients, in most cases bilaterally. The hamstrings were considered a contributing factor in hip deformity.

Spinal surgery was performed on four patients (1A, 3A, 15A, 19A). In all cases spinal surgery was performed after the hip surgery. The patients underwent a two stage procedure consisting of an anterior fusion by the Dwyer method and Luque rodding.

Hip surgery was undertaken regardless of the type and severity of the patient's cerebral palsy or his mental status. Relocation of the hip was undertaken regardless of the age of the patient. Fifty percent of the patients with severe hip instability were 10 years or older at the time of hip surgery. Since the mean age of dislocation is seven years, it can be assumed that the dislocation or severe subluxation in these patients was well estabilshed.

Postoperative Immobilization

After soft tissue surgery the legs were immobilized in a Batchelor plaster. This plaster was kept on for six weeks when the iliopsoas was transferred, and three weeks when it was released. After bony surgery a hip spica was applied for six weeks.

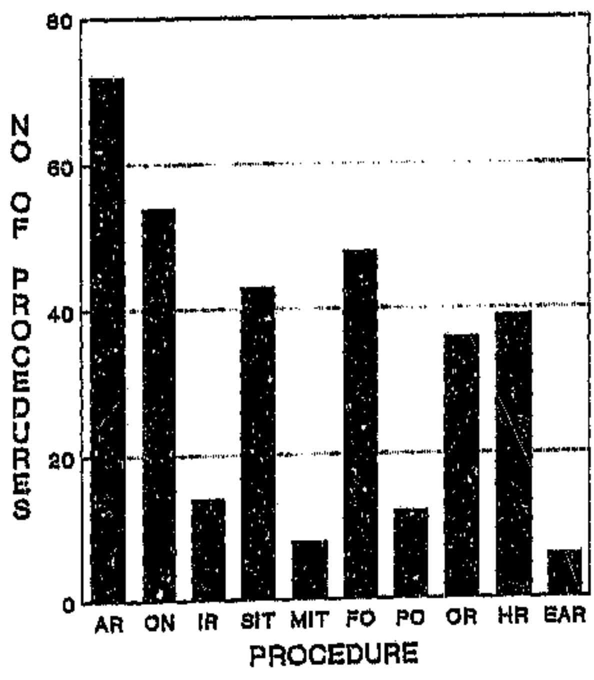
Discussion

Prior to the period covered by this study, six patients had undergone soft tissue releases which failed to prevent progression of the hip deformity. This is probably because the surgery did not alter the bony abnormalities which contribute to dislocation. Where marked subluxation was present, a femoral osteotomy was performed. This was generally a varus derotation subtrochanteric osteotomy. The main aim of this procedure is to correct the femoral anteversion. Since valgus of the femoral neck is not significantly increased the varus component of the procedure is of secondary importance. Only 13 pelvic osteotomies (all of the Chiari type) were done. In the Chiari procedure the acetabulum is augmented by a shelf of bone. In three cases the Chiari pelvic osteotomy was added when the hip instability progressed after surgery. At follow-up one of these hips was located, one was subluxated and one remained severely subluxated.

The surgical procedures which were undertaken are summarised below in Figure I. An explanation of the abbreviations used is given on page xviii.

FIGURE I

TYPE OF SURGICAL PROCEDURE



(1980), a subluxation is present when more than 1/3 of the femoral head lies outside the acetabulum i.e. a MP of more than 33%. A hip with less than 1/3 migration was regarded as located i.e. a stable hip, although dysplastic changes might be present on X-ray. We judged severe subluxation to be present when more than 2/3 of the femoral head lay outside the acetabulum. When subluxation is present, there is still some contact between the femoral head and the acetabulum. Dislocation is present when the femoral head lies entirely outside the acetabulum.

The migration percentage can vary according to the degree of abduction and adduction of the femur. Rotation of the femoral head does not affect the measurement (Reimers 1980). All radiographs of the hips were taken with the hips in as neutral a position as possible i.e. neither abducted or adducted. This presented some difficulty when severe contractures were present.

The acetabular index (Hensinger 1986), also referred to as the acetabular angle, is the angle between the Y line, and a line from the triradiate cartilage to the edge of the acetabulum.

The preoperative and postoperative acetabular indices were compared to determine whether acetabular remodelling had occurred. The migration percentage was measured in both groups:

2. Moderate - mild retardation.

   Responds to people and takes an interest in the environment. Attempts to communicate. May participate in a training or modified school programme.

3. Low - normal intelligence.

   Participates or participated in a normal school prog.am.

Inability to speak was recorded, as were blindness or severe visual problems. The occurrence of epilepsy was recorded. The presence of these associated handicaps gave an indication of the severity of the condition. Knowledge of these handicaps is essential in planning management of the condition.

7.4 RADIOGRAPHIC ASSESSMENT

The radiographic measurements used in this study were Reimers' migration percentage, and the acetabular index (Appendix VI).

Reimers' migration percentage (MP) indicates how large a part of the femoral head extends beyond Perkins' line, in proportion to the entire width of the femoral head. Perkins' line is a line passing through the acetabular edge. It is perpendicular to Hilgenreiner's line, a horizontal line drawn between the innermost parts of the ileum or the Y-shaped cartilage, also called the Y line. According to Reimers

1. Dependent: needs person or persons to lift patient out of his chair.
2. Assists : patient assists when lifted from his chair.
3. Independent: patient gets in and out of chair unaided.

7.3 ASSOCIATED HANDICAPS

Associated handicaps included mental retardation, aphasia, epilepsy or blindness. It was not possible to obtain uniform tests to classify the degree of mental retardation. Several patients in the control group, although admitted to an institution, were cared for there because of home circumstances, and not because of severe mental retardation. The patients in the treated group had attended various schools and institutions or lived at home and had not all undergone IQ tests. Even where tests are performed they are not necessarily a true reflection of the patient's intelligence, as his physical involvement may preclude an appropriate response to the test.

Because of all these factors it was decided broadly to categorise the mental status of the patients as follows.

1. Profound - severe retardation.

   Little or no response to people and minimal interest in surroundings. Functions on an extremely low level.

7.2.7 Upper Limb Function

This was included as it gave an indication of the severity of the physical involvement. If upper limb function is possible, a good sitting position is essential to facilitate and maximise the use of this function (Nwaobi 1987, Myhe et al 1990). The grading system developed by Johnson et al in 1989 was used, where upper limb function is graded from 1 to 4.

1. No apparent problem with bimanual tasks.
2. Some difficulty using both hands together, but dresses self.
3. Physically incapable of putting on vest or T-shirt without help, but able to feed self with one or the other hand.
4. Physically incapable of putting on vest or T-shirt, and unable to feed self with either hand.

The patient was tested in a sitting position, with support given where necessary.

7.2.8 Transfer Ability

Broadly speaking, this refers to the ability to transfer from one position to another. For purposes of this study, it was taken to refer to the ability of the patient to get out of a chair. Rang's classification (1981) was used.

3. Rotation about the vertical axis.

It was documented whether the position of the legs was symmetrical or not. Windsweeping is a term used to describe adduction and internal rotation of one leg and abduction and external rotation of the other leg (Fulford and Brown 1976). The direction of windsweeping was noted.

A diagrammatic representation of sitting posture is very useful (Appendix XIV).

7.2.6.3 <u>Sitting tolerance</u>

Sitting tolerance refers to the length of time the patient can sit in a chair without complaint. Tolerance was arbitrarily graded as follows:

Poor Tolerance - less than 2 hours.

Fair Tolerance - 2-4 hours.

Good Tolerance - more than 4 hours.

Sitting tolerance was only measured in those patients who were placed in sitting.

7.2.6.4 <u>Present Seating</u>

In cases where independent sitting is not possible, the patient may be propped i.e.: simply tied into a chair, or a special chair or chair insert might be used, depending on individual circumstances. The method of seating was documented (Appendix V).

independent sitting (levels 4-7) was not required.

The scoring system suggested by Staudt was both reliable (95% intrarater agreement) and simple to use, and was therefore chosen for assessment of patients in this study.

7.2.6.2 Sitting posture

Sitting posture refers to the alignment of the body in sitting. Analysis this posture must involve looking at the elements of the spine, pelvis, hips and lower limbs, and their relationship to each other. The uncorrected sitting posture was documented. The presence of a kyphosis was confirmed by observing the position of the spine from the lateral aspect. The presence of a scoliosis was confirmed by bending the patient forward in sitting. The spine was palpated to determine the direction and type of curve. Impingement of the ribs on the pelvis, denoting a decompensated spine, was recorded and where possible radiographs of the spine were taken.

The position of the pelvis in sitting was assessed. There are three axes of pelvic movement (Siff 1991):

1. Anterior-posterior pelvic tilt.
2. Lateral tilt (pelvic obliquity).

5. Independently maintains posture.

This is a modification of the scale used by Staudt (1989) to assess patients undergoing rhizotomy.

All three assessments were tested for inter- and intra-rater reliability, and suitability for use as a measuring instrument (Appendix III).

The assessments of all the patients in this study were undertaken by the author herself. Nevertheless it was considered worthwhile to also test the interrater reliability. This confirmed that the assessment could be used by other persons wishing to measure level of sitting ability (e.g. surgeons examining a patient prior to surgery).

Although all three assessments were reliable, it was felt that they were not all suitable for this study. The Rang assessment is a broad categorization of sitting, but does not provide a score for the patient who cannot be placed in a sitting position. This makes statistical analysis problematical. The Chailey Heritage assessment is the most complicated assessment. Some of the levels are not accurately defined, and are thus difficult to interpret. Since most non-ambulant children fall into the lower categories of sitting ability, a detailed analysis of

1. Unplaceable - wriggles and slides and cannot be placed in sitting.
2. Place, not maintain - can be sat, but needs holding to stay in position.
3. Maintain, not move - needs hands for support and loses balance when he moves.
4. Maintain, move within base - can sit independently and move forwards over sitting base.
5. Maintain, move outside base - sits independently, and can lean to either side and regain balance.
6. Move out of position - sits independently and can transfer weight across surface of seat but cannot regain correct sitting position.
7. Attain position - can attain or regain sitting position after moving out of it.

Stuart (1990) described a functional scale which was developed as part of a multicentre assessment protocol by therapists from five centres in the U.S.A. Children are scored on the ability to maintain sitting on a bench for ten seconds regardless of the quality of posture or movement pattern used.

The five levels are:

1. Cannot be placed in sitting.
2. Requires support by another person.
3. Requires use of own bilateral upper extremity support.
4. Requires use of own unilateral upper extremity support.

tolerance.

7.2.6.3 The level of ability

The level of ability refers to the amount of support the patient needs to sit. Many sitting assessments in the literature are based on the developmental sequence of sitting, and as a result contain many types and levels of sitting (Bobath and Bobath 1951, Ingram et al 1959, Scrutton and Gilbertson 1975, Banham 1978, Russell et al 1989).

Three assessments were found which specifically analysed chair sitting.

Kang et al (1981) described three groups of sitters according to level of ability:

1. Hand-free sitter (can sit without using hands);
2. Hand-dependent sitter (needs one or both hands for support);
3. Prop-sitter (needs external support for sitting).

Chailey Heritage Hospital and School developed an assessment of sitting ability (described by Mulcahy [illegible]) to be used as a tool in prescribing seating for the CP child. Seven levels of sitting ability are described. The assessment allows for scoring of the patient's ability to sit at each of the seven positions.

The seven levels are as follows:

hands are used for support. Gradually the trunk extends and balance improves. By about [illegible] months the normal baby can balance in sitting unaided. A child can adopt a variety of sitting positions: side sitting (legs bent to one side), long sitting (legs stretched out in front), tailor sitting (legs crossed) and W sitting (sitting with body between bent knees). Many of these positions are difficult and non-functional for the cerebral palsied child because of poor trunk rotation and balance.

Chair sitting (also referred to as bench sitting, short sitting or high sitting) describes the position of sitting on a bench or chair, with the knees bent and the feet on the floor. This is the position adopted by the CP patient in a wheelchair, and therefore the position used for the assessment of sitting function in this study.

In the normal individual, the head and trunk are well balanced over a level pelvis in chair sitting. The spine is fairly straight and the hips are located and mobile. In the upright sitting position, 60° of the hip flexion comes from the hip joints and 30° from flattening of the lumbar curve (Mandal 1981). Normal postural reflexes and equilibrium reactions enable one to maintain the sitting position and move in and out of the sitting base easily. In sitting the centre of gravity is just in front of the 12th thoracic vertebrae. In the CP patient, one or more of the elements of normal sitting is invariably impaired, therefore the evaluation of sitting function in cerebral palsy involves several parameters, mainly level of ability, posture and

7.2.5 Nursing Care

Many CP patients, particularly those with total body involvement, need assistance with toileting and washing. Many are totally dependent on their caregiver to perform these activities. If the patient is not mobile i.e. cannot move from one position to the other, the caregiver has to alter the position of the patient to prevent the development of decubitus ulcers. Perineal care is dependent on access to the perineum. It was objectively graded as follows:

1. Difficult - total abduction of legs less than the width of the perineum.
2. Fairly difficult - total abduction of legs equal to the width of the perineum.
3. Easy - total abduction of legs more than the width of the perineum.

Decubitus ulcers can occur more easily on bony prominences. The site of their development depends on the most frequently adopted position of the patient and on the distribution of pressure on these prominences.

Discolouration and scarring denoted the presence of healed (i.e. past) decubitus ulcers. The site of previous and existing ulcers was recorded. Records were also scrutinised. Skin breakdown (which might lead to a decubitus ulcer) was noted.

7.2.6 Sitting

By the age of four months, the normal child assists when pulled up into a sitting position, with no head lag. The trunk is at first very flexed in sitting, and the

2. It was only done once the patient was familiar with the handling of the examiner.

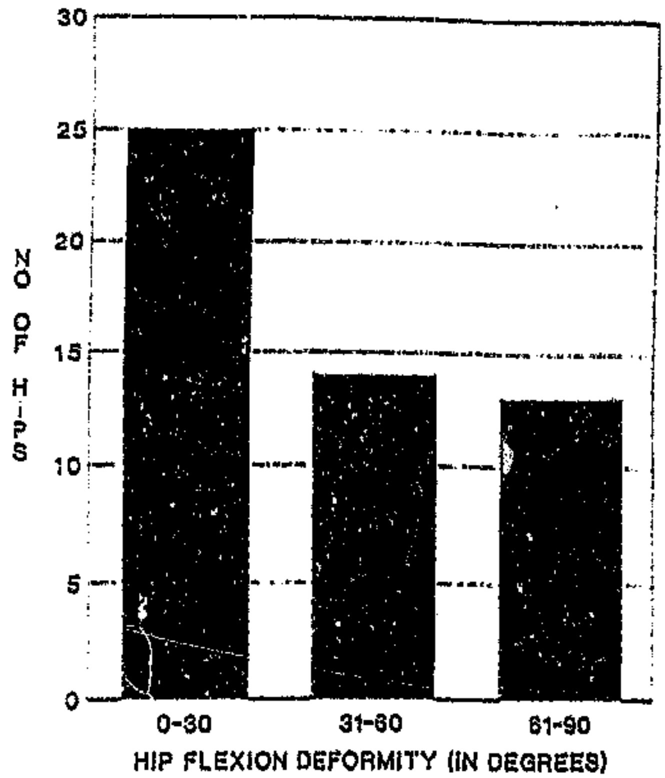
Because of the variability of the pain response the test for pain was repeated on two different occasions, so that three measurements were taken. Two out of three pain responses were accepted as being a positive response (Appendix IX).

A problem in assessing movement pain is encountered in CPs with severe visual problems. They are often tactile defensive i.e. averse to being touched, and may cry with any movement. Similarly, patients with severe contractures may be uncomfortable on being moved. In these types of patients other joints were moved as well e.g. elbow, and the response noted. If a pain response was obtained whenever a joint was moved, the patient was excluded from the analysis of hip pain.

Resting pain, or pain in the absence of movement was also documented. Accurate localization of this type of pain is often not possible, as it may be due to several factors, and subjective reports had to be relied upon. Resting pain is in effect chronic pain, which is a complex entity. The frequency of pain during washing, dressing and transfers was assessed daily for a period of one week in those patients who had a positive pain response.

FIGURE V

HIP FLEXION DEFORMITY IN GROUP B

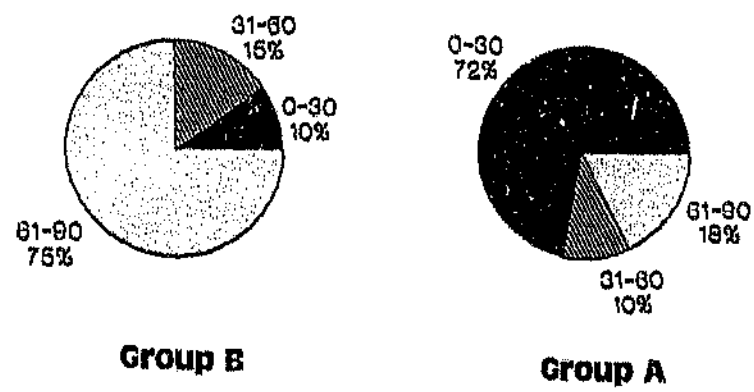


Fixed flexion deformity (FFD) was practically non-existent in operated hips. In unstable hips (Figure V) 25 (46%) had minimal (0-30°) FFD, and 54% had FFD of more than 30°-90°. Hip instability is commonly, but not invariably associated with fixed flexion deformity.

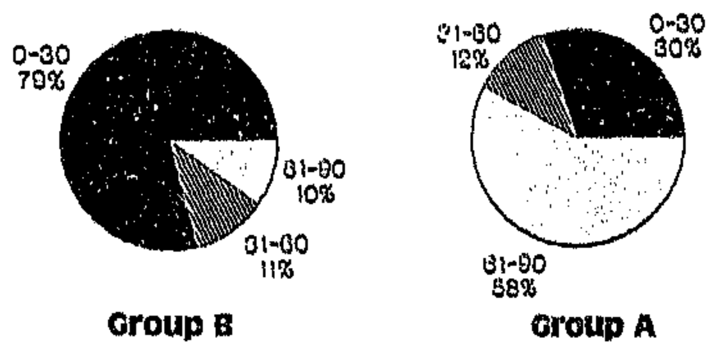
FIGURE IV

HIP ROTATION IN GROUP A AND GROUP B

INTERNAL ROTATION (in degrees)



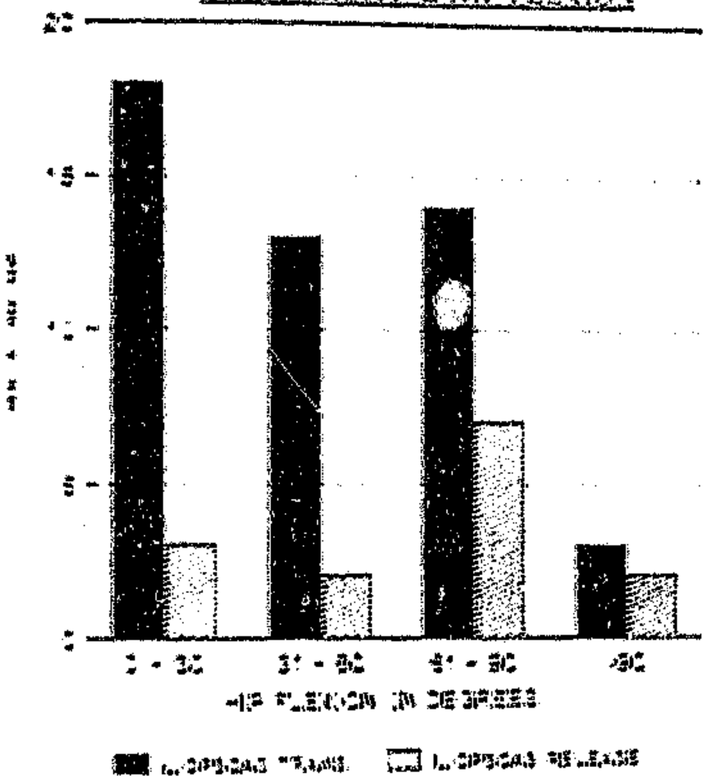
EXTERNAL ROTATION (in degrees)



Seventy-five percent of unstable hips in Group A were fixed in internal rotation, and 58% of the operated hips were fixed in external rotation (Figure IV). When the latter is combined with abduction, wheelchair seating becomes difficult.

FIGURE III

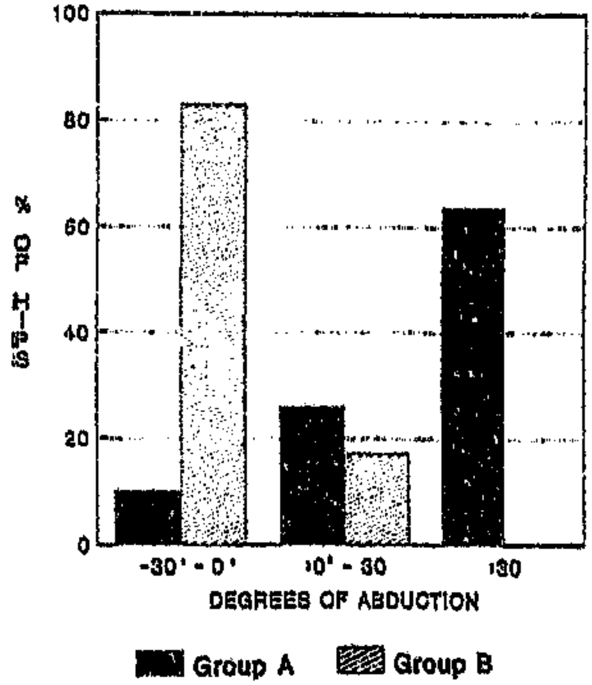
POSTOPERATIVE HIP FLEXION



[illegible] undergoing [illegible] Figure [illegible]

FIGURE II

HIP ABDUCTION IN GROUP A AND GROUP B



Adductor release resulted in abduction of more than 30° in the majority of operated hips (Figure II).

Unstable hips in Group B always had less than 30° of abduction, and the majority had no abduction. However, not all hips with this degree of limitation are unstable. (16 of 23 normal hips measured 30° or less). It can be concluded that tight adductors are a common feature in CP, but not always associated with instability. Dislocated hips are invariably associated with no abduction, or adduction contracture. In order to make a definitive diagnosis however, a radiograph is required.

It was more significant in the patient under 10 years of age, whereas in Reimers' (1992) study, significant changes occurred in both groups.

It is difficult to explain the wide variations in acetabular remodelling. It could be due to differences in hip status before surgery, and differences in the surgical procedures.

8.3 RANGE OF MOVEMENT OF HIP AND KNEE

The findings relating to ranges of movement in the hip and knee are represented in Figures II - VI.

TABLE V

PREOPERATIVE AND POSTOPERATIVE ACETABULAR INDEX

VARIABLE	HIPS (n)	PREOPERATIVE*	POSTOPERATIVE*
Chiari	13	31 (20-50)	28 (15-50)
No Chiari			
< 10 yrs	33	28 (15-40)	20 (10-40)
> 10yrs	16	32.5 (12-50)	30 (10-45)

* Median and Range in Degrees

Discussion

Chiari osteotomy produced varying results in terms of an improvement in the acetabular index (AI). The difference in the median value of the AI before and after surgery was small (3°). It was similar to the change in median values in the older patients where surgery did not include a pelvic osteotomy. The Chiari pelvic osteotomy increases lateral coverage of the femoral head.

Acetabular remodelling (without pelvic osteotomy) took place in both the younger and older patients, albeit with wide variations. This contrasts with the findings of Tylowski et al in 1980, and correlates with the findings of Wheeler and Weinstein (1984).

of the patients in this study who had shift of deformity were more than 9 years of age at the time of the unilateral surgery. This indicates that unilateral soft tissue surgery should probably be avoided at any age.

A further four patients who had undergone unilateral surgery (two: soft tissue only and two: soft tissue and bony surgery) did not demonstrate any effect on the unoperated hip. In these patients the unoperated leg was in an abducted externally rotated position, and the pelvis was level at follow up, thus the mechanical factors contributing to subluxation on the unoperated side (Samilson et al 1981B) were not present.

8.2 ACETABULAR INDEX

Change in the acetabular index was measured in two groups of treated patients: those who had undergone a Chiari osteotomy as part of the surgery, and those who had not. The results are presented in Table V.

In patient 29A, a profoundly handicapped CP, only an adductor release was performed on the right and the hip on this side remained dislocated. Patient 38A initially had surgery to the left hip only, and 5 years later the right hip was severely subluxated. It was relocated surgically, but redislocated, probably because the acetabular dysplasia was not corrected. At follow-up this hip was severely subluxated and the joint appeared ankylosed. Patient 40A had bilateral dislocations but surgery only consisted of a right adductor release and anterior obturator neurectomy. As a result of this minimal surgery, both hips were still dislocated at follow up.

In 12 patients, who initially had unilateral surgery, the stability of the opposite hip deteriorated (Figure [illegible]). Further surgery to the other hip was performed on 10 patients. Uncovering of the other, unoperated hip subsequent to unilateral surgery has been reported by Samilson et al (1967), Silver et al (1985) and Carr and Gage (1987). The majority of the patients in this study in whom a shift of deformity occurred, had a combination of unilateral soft tissue and bony surgery, but patients who had previous bilateral adductor releases did not show this phenomenon. It would appear that one-sided soft tissue surgery, rather than one-sided bony surgery, is responsible for the effect on the unoperated hip. This corroborates the findings of Carr and Gage (1987). These authors also state that unilateral soft tissue procedures should especially be avoided in patients under 9 years of age. One half

TABLE IV

PREOPERATIVE AND POSTOPERATIVE HIP STATUS

(BY HIP)

	POSTOPERATIVE +	POSTOPERATIVE -	N	p VALUE*
PREOPERATIVE +	9	48	57	<0.001
PREOPERATIVE -	4	19	23	
TOTAL	13	67	80	

* Mc Nemar Test

Discussion

The difference in preoperative and postoperative hip status was highly significant. The good long-term results in terms of stability of the hips contrasts with the unfavourable outcomes reported by Phelps (1959), Feldkamp (1982) and Zembo et al (1990). In the few cases where surgery failed to locate the hip, the type of surgery performed (in relation to the hip deformity) was analysed. Patient 18A had a subluxation of the right hip. The adductors were released bilaterally, and a Sharrard iliopsoas transfer done only on the right. At follow up the opposite hip was severely subluxated. The right hip of patient 20A remained subluxated, probably because the acetabular dysplasia persisted (despite innominate osteotomy).

TABLE III

PREOPERATIVE AND POSTOPERATIVE HIP STATUS

(BY PATIENT)

Pt	PRE		POST		Pt	PRE		POST	
	R	L	R	L		R	L	R	L
1A	L	D	L	L	21A	L	D	L	L
2A	D	D	L	L	22A	D	L	L	D
3A	S	L	L	L	23A	L	SS	L	L
4A	S	S	L	L	24A	L	S	L	L
5A	S	S	L	L	25A	D	L	L	L
6A	D	D	L	L	26A	D	L	S	L
7A	L	D	L	L	27A	S	S	S	L
8A	D	S	L	L	28A	L	SS	SS	L
9A	D	D	L	L	29A	D	D	D	L
10A	L	SS	L	L	30A	D	SS	L	L
11A	S	L	L	L	31A	L	S	L	L
12A	S	L	L	L	32A	SS	L	L	L
13A	D	L	L	L	33A	D	S	L	S
14A	L	S	L	L	34A	SS	SS	L	L
15A	S	D	L	L	35A	S	S	L	L
16A	L	S	L	L	36A	L	D	L	L
17A	S	D	L	L	37A	L	S	L	L
18A	S	L	S	SS	38A	L	S	SS	L
19A	S	S	L	S	39A	S	S	L	L
20A	D	L	S	L	40A	D	D	D	D

CHAPTER EIGHT

RESULTS OF SURGERY

The results of surgery will be presented and discussed in terms of radiographic changes, range of movement of hip and knee, postoperative complications, and the relationship of the type of patient to the outcome of surgery.

8.1 LOCATION OF THE HIP

The migration percentage of the hips was measured on the preoperative and follow-up radiographs. The hip status in each patient is shown in Table III. The letters L, S, SS and D denote a located, subluxated, severely subluxated and dislocated hip respectively. Comparison of hip status (by hip) is presented in Table IV. A positive sign represents a subluxated or dislocated hip, and a negative sign represents a located hip.

1. To establish the degree of hip instability and

2. To determine the effect of hip surgery on hip instability.

The X-rays were also searched for avascular necrosis of the femoral hea... ...
heterotopic ossification.

7.5 SUMMARY

This composite assessment included all aspects of the patient's disability, and enabled the hip instability to be evaluated in the context of the patient's type of cerebral palsy, the degree of handicap, his functional ability and problems of management.

FIGURE XI

Radiograph of patient 2A, a severe spastic quadriplegic with scoliosis, who underwent surgery for bilateral hip dislocation.

established hip dislocation, especially in the patient older than nine years, is not advocated.

Several authors have suggested that the severity of CP, and the neurological patterns of the patient be taken into account when considering surgery (Pettit 1976, Moreau et al 1979, Sherk et al 1983, Howard et al 1985 and Hoffer 1986). The reflex patterns, type of spasticity and predominant tone of the patients in Group A were assessed, and the dominant pattern established where possible (Appendix VII).

Two patients with rigid spasticity developed bilateral hip extension-abduction contractures. This was also found by Houkom et al (1986) in rigid and athetoid patients. Persistent head turning to one side (PHT) was found in six patients. Five out of six patients with PHT had a severe scoliosis (Figure XI) and three had bilaterally extended hips. The untoward effects of PHT have been described by Fulford and Brown (1976) and Robson (1987).

A dominant ATNR causes extension of the leg on the jaw side and flexion on the skull side, predisposing to dislocation of the hip on the skull side. If the hips become relatively fixed in a position after surgery, and this reflex is still active (or if tone is increased more on one side) it is highly possible that spasticity will be transferred to the trunk, accentuating scoliosis. This occurred in patients 2A, 3A, 10A, 14A, 15A, 25A, 26A, 28A, 32A, 36A, 38A.

8.5 THE INFLUENCE OF ENDOGENOUS FACTORS

The effects of the following parameters on the results of surgery were investigated:

1. Age of patient at surgery.
2. Hip status at surgery.
3. The type of patient i.e. severity of involvement, reflex patterns and type of spasticity.

As regards hip status and age of the patient at surgery, it has already been mentioned that half of the patients who had a severe subluxation or dislocation of the hip preoperatively were 10 years or older at time of surgery. This did not affect the result of the surgery in terms of locating the hip. Severe instability required more extensive procedures, and in cases where redislocation occurred or where the hip remained unstable at follow-up, it was not related to the age but rather to the procedure. Complications occurred more frequently in patients over nine years of age when the hip was already severely unstable, and in those patients where additional procedures had to be performed to locate the hip. The most common complications in the older patient were heterotopic ossification and avascular necrosis of the femoral head. Patients with extra-articular ossification had less mobile hips. In 60% of the older patients the functional outcome was complicated by severe scoliosis. (Appendix XIV). For the reasons cited above, surgery to an

FIGURE X

Radiograph of patient 20A who underwent surgery for a dislocated hip on the right. At follow-up the hip was subluxated, and there was avascular necrosis of the femoral head.

Avascular necrosis was found unilaterally in 10 patients (Figure X). Eight of these patients had dislocations prior to surgery, and two patients had subluxations. Avascular necrosis is due to impairment of the blood supply of the femoral head and is associated with, inter alia, reconstructive hip surgery and hip manipulation (Steinberg 1987). It can be accompanied by pain and decreased range of motion, particularly in a walking patient. In these patients it was associated with limitation of hip movement, but only two had pain (7A and 20A).

FIGURE IX

Radiograph of patient 28A showing ectopic ossification leading to bony ankylosis of left hip joint, and dislocation of right (unoperated) hip.

FIGURE VIII

Radiograph of patient 3A, showing heterotopic ossification along the transferred iliopsoas tendon.

Heterotopic ossification along the line of the transferred iliopsoas tendon was a common finding in early post-operative radiographs (Figure VIII). Ectopic ossification around the head of the femur occurred in 14 operated hips, an incidence of 21%.

An incidence of 8.6% following myotomy and tenotomy in CP was reported by Bouchard and d'Astous (1991). Patients in this study who developed ectopic ossification had undergone open reduction of the affected hip, and in the majority of cases combined with a pelvic osteotomy and/or a femoral osteotomy. In three hips this ossification led to virtual ankylosis of the joint (Figure IX). This complication has also been reported by Mc Hale (1991), Lee et al (1992) and Krum and Miller (1993).

Discussion

The complication rate was high. Seventy percent of patients developed complications; 35% had more than one complication. Redislocation of the hip occurred when the surgery was not sufficient to contain the hip, and further surgery had to be performed (Figure X). Sepsis occurred in 5 patients; it cleared up with treatment except in one case (7A) where septic arthritis of the hip joint developed. The affected head of femur was subsequently excised.

Eight patients sustained fractures of the femur; in two severely affected patients the same femur fractured twice (Appendix XIII). In two cases the fracture occurred shortly after removal of plaster. Directly after plaster removal all patients were placed in a sitting position, using wheelchair inserts or straps. In this early post-operative period they were all at least level 2 (prop) sitters. The most disabling complication found at follow-up (from the point of view of function) was bilateral extension contractures of the hips, which obviously prevented sitting. This complication was also documented by Szalay et al (1986). In three of the six patients in which this occurred a subsequent extensor abductor release was performed. This was only successful in one patient (12A). One patient (15A) had a unilateral extension contracture and a severe scoliosis, which prevented him from sitting.

8.4 COMPLICATIONS AFTER SURGERY

Details of complications after surgery were obtained from patients' notes and scrutiny of radiographs (Appendix IV).

Table VI gives a summary of the complications.

TABLE VI

POSTOPERATIVE COMPLICATIONS

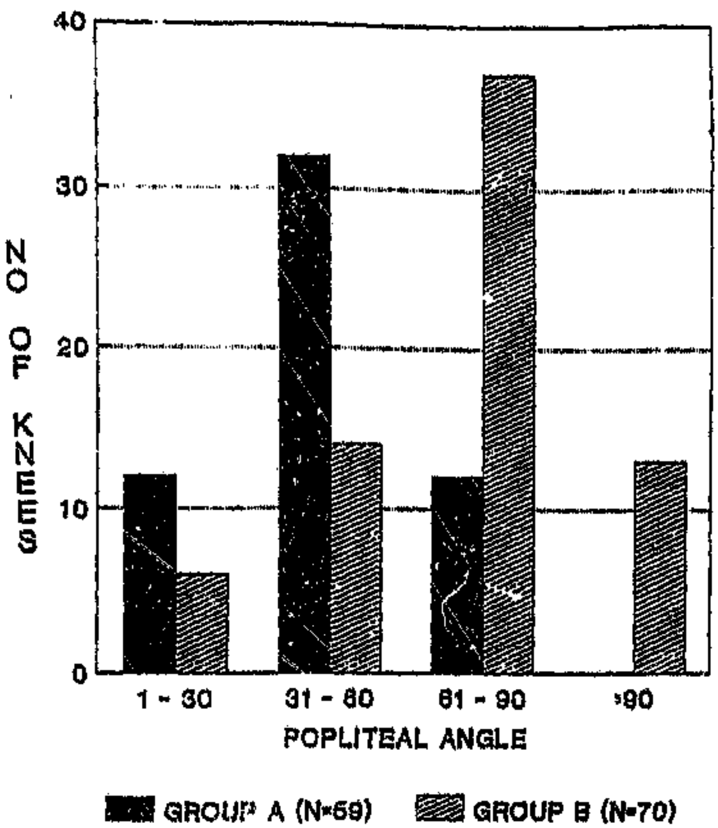
COMPLICATION	NUMBER OF PATIENTS
Redislocation	7
Sepsis	5
Heterotopic ossification	12
Fracture of femur	8
Bilateral extension abduction contracture	6
Avascular necrosis	10

FIGURE VII

Radiograph of patient 12A, a rigid spastic quadriplegic. Hips located following bilateral adductor and psoas releases for bilateral subluxation. Poor functional result: patient could not sit because of extension abduction contractures.

FIGURE VI

POPLITEAL ANGLE IN GROUP A AND GROUP B



Seventy-five percent of knees (N = 59) in Group A patients had a flexion deformity (Figure VI). This was despite bilateral hamstring surgery having been done in half of these patients. Fifteen percent of knees were hyperextended, which made wheelchair positioning difficult. Nearly 90% of knees in Group B had a flexion deformity.

TABLE X

COMPARISON OF POSTURE

VARIABLE	A (n = 40)	B (n = 40)	p VALUE*
Scoliosis	30	24	0.232
Kyphosis	20	8	0.03
Pelvic Obliquity	20	15	0.368
Windsweeping	20	28	0.110

* Fishers exact 2 tail test

There was no significant difference in the frequency of scoliosis, pelvic obliquity or windsweeping of the legs between Group A and Group B. However there was a significant difference in the frequency of kyphosis. In the treated group this can be attributed to the limitation of hip flexion caused by surgery which leads to backward tilting of the pelvis and rounding of the spine to maintain sitting position. It was also aggravated by poor trunk control. This compromised function in sitting and led to increased pressure on the thoracic and sacral areas. Lateral X-rays showed that these patients actually sat on their lumbar spines. Sharrard and Burke (1987) said that limitation of hip flexion in patients who had posterolateral iliopsoas transfers had not given rise to difficulty in sitting but the opposite was true in this study.

The greatest proportion of patients in each group could be propped into a sitting position (as in Pritchett's study in 1990), i.e. they sat with the use of external support. There were an equal number of independent (hand-free sitters) in each group. The results support the contention that the level of sitting ability is determined by the neurological involvement of the patient and not the hip status (Moreau et al 1979, Pritchett 1990). The less severe the neurological damage the better the sitting ability. Seven patients in Group A could not be placed in a sitting position. These patients were all supplied with a chair insert and/or propped up into sitting after surgery. They lost their ability to sit due to the development of hip extension and abduction contractures. In three cases this was combined with severe scoliosis which further compromised placed sitting. Three of the four patients in Group B who could not sit had severe contractures including scoliosis with rib impingement. One patient was very extended.

All self-propped sitters (levels 3-5) had a level pelvis. This was also the finding of Pritchett in 1990.

9.3.2 Sitting Posture

The elements of sitting posture were compared and the results are shown in Table X.

weighed up against this postoperative pain which will be experienced. When the hip is already dislocated, post surgical complications can occur, and a pain-free hip in the long term is not guaranteed.

9.3 SITTING

The parameters of sitting function were analysed separately.

9.3.1 Level of Sitting Ability

There was no significant difference in level of ability in the two groups (Table IX).

TABLE IX

COMPARISON OF LEVEL OF SITTING ABILITY

LEVEL	A (n = 40)	B (n = 40)	p VALUE*
1	7	4	0.465
2	23	28	
3	2	2	
4	3	1	
5	5	5	

* Chi square test

Only four out of 14 patients had daily pain on washing and 2 of these daily pain on dressing. Transfers caused the least discomfort. The two patients (23B and 33B) with the most frequent pain had bilateral dislocations and a level pelvis. One was athetoid. Patient 23B complained of pain, even in a resting position and did not want to sit. The majority of patients, therefore had occasional pain during handling. Moreau (1979) found that half the dislocated hips in his study were painful, which correlates with the findings of this study. Cooperman et al (1987) predicted that 50% of dislocated hips will become painful. A similar incidence is quoted by Gamble et al (1990) and Drummond et al (1979). In both his study and this study 45% of the patients were severely retarded, whereas in Pritchett's study (where a pain incidence of 38% was reported) all the patients were profoundly retarded.

Bleck (1980) stated that hip pain could prevent sitting and result in the patient becoming bedridden. In this study this only applied to patient 23B. The very low incidence of resting pain could possibly be attributed to the fact that half of the untreated patients were customarily in a lying position with no pressure on the dislocated hip. The seated patients in both groups tended to put more weight on the stable hip (in cases of unilateral dislocation) avoiding pressure on the dislocated hip (Appendix XIII). Resting pain might increase in patients where special adaptive seating is used, forcing more weight on the dislocated hip. If a patient only experiences occasional pain, the elimination of this pain by surgery should be

The mental status of the patients in the untreated group (App. X) was related to the pain response. Only one patient with a positive pain response was profoundly retarded. Four patients in the untreated group cried on all movements and were excluded from the analysis of hip pain. They were all profoundly retarded and cortically blind. The profoundly retarded cerebral palsied patient is unlikely to experience hip pain and the possible development of such pain should not be used as a rationale for treatment in such patients. This was also the finding of Moreau et al (1979). The intensity of pain on movement is almost impossible to assess in these patients and descriptions of the degree of pain in the literature are based on subjective judgements. Pain on movement of the hip is called minor by Pritchett (1983) and moderate by Moreau (1979).

It was decided that the best analysis of pain would be to investigate its effect on the management and lifestyle of the patient. Patients in Group B who had a positive pain response (pain on two out of three assessments) were evaluated daily, over a period of one week, during washing, dressing and toileting. Facial response during these activities (as in movement testing) was observed and grimacing, wincing, crying or verbalization of discomfort were taken as a positive indication of pain. Washing gave the most frequent pain response, followed by dressing and transfers (Appendix XI).

in a pain-free joint, except where hip instability recurred, as in the three patients described.

Pritchett (1990) found no difference in the frequency of pain between treated and untreated patients. However, 21 of his 50 patients treated surgically still had unstable hips at follow-up. He does state that there was no difference in the frequency of complications, whether the hips were unstable or stable, but there is no documentation to support this statement.

In Group B, movement pain occurred in 56% of the dislocated hips. The radiographs of the patients with a positive pain response were analysed and it was found that all had marked acetabular dysplasia related to the dislocated hips. Other features of the painful hips were deformity of the femoral head and impingement of head on the pelvis. Twelve of the 14 painful hips were laterally displaced. An interesting finding was that 75% of the patients with hip pain had a level pelvis. This contrasts with Cooperman's (1987) advice not to relocate the hip when the pelvis is level. Where pelvic obliquity was present, the pelvis was generally lower on the side of the painful dislocation. Nine out of the 13 patients with hip pain had unilateral dislocations and one had a unilateral severe subluxation.

She developed sepsis of the hip joint and pain in the hip persisted. She subsequently underwent surgery to excise that femoral head. On follow-up assessment, movement of the left leg was still intermittently painful. Patient 20A also had surgery for a dislocation of her right hip. Preoperatively her hip movement recorded as very painful. Relocation of the hip included a Chiari pelvic osteotomy. Hamstring releases were added in 1987. At follow-up the hip was subluxated and still occasionally painful. X-rays showed a very poor elongated acetabulum and a deformed femoral head (Figure X). The sixth patient (30A) had a painful located hip on follow-up. The acetabulum in this patient was poorly developed, and both the acetabulum and femoral head had irregular surfaces. This hip was also subjected to repeated surgery and developed sepsis. Infection of the hip joint may result in pain even though the hip may be located. Two treated patients were excluded from the analysis of pain as they cried on all movements. They both had severe contractures and were profoundly retarded.

Comparison of pain on movement in the treated and untreated groups showed that there was a tendency towards statistical significance ($p = 0.063$), i.e. less pain in the treated group. Fishers exact 2 tail test was used and a p value of < 0.05 was regarded as statistically significant. Follow-up pain in hips treated surgically for dislocation was compared to pain in untreated dislocated hips, and the difference was statistically significant. Surgery to reduce an established dislocation resulted

TABLE VIII

COMPARISON OF PAIN

VARIABLE	A	B	p VALUE*
Pain by Group	(N = 38) 6	(N = 36) 13	0.063
Pain by Dislocation	(N = 21) 3	(N = 25) 14	0.03

* Fishers exact 2 Tail Test

Discussion

Preoperative pain in the treated group was not always documented, so comparison of pain on follow-up with the preoperative status was not possible. It was documented as the rationale for surgery in eight patients in the study, but it is not certain how this was assessed.

Six patients from the treated group had definite hip pain on testing at follow-up. Two patients (22A and 28A) developed a painful contralateral hip, which in both cases had become dislocated. Both were dyskinetic patients. One patient (18A) developed a severely subluxed hip following an adductor release only, and this was painful, even at rest. Patient 7A had numerous surgical procedures to her left hip.

TABLE VII

GROUP COMPARISON OF HIP STATUS

HIP STATUS		A (N=40)	B (N=40)
L	L	29	0
S	L	5	8
S	S	0	1
SS	S	0	1
SS	L	3	5
D	S	0	4
D	L	2	16
D	D	1	5
PATIENTS WITH UNSTABLE HIPS*		11	40

* $p < 0.002$ (Fishers exact 2 tail test)

9.2 PAIN

The incidence of pain was analysed:

1. By comparison of whole group.
2. By comparison of patients who had surgery for hip dislocation with patients who had untreated dislocated hips.

CHAPTER NINE

RESULTS OF INTERGROUP COMPARISONS

The hip status, hip pain, sitting function and nursing care of Group A and Group B were compared and statistically analysed. The significance of the findings is discussed in terms of each parameter.

9.1 HIP STATUS

The difference between Group A and B, in terms of patients with hip instability, was highly significant, demonstrating the positive effect of surgical intervention. However, 29 patients in Group B had a unilaterally located hip, indicating that non-treatment does not always result in hip instability (Table VII).

the total body involved patient, superimposed themselves on the postoperative position of the limbs. These reflexes should therefore be taken into consideration when planning surgery.

A dominant TLR results in a symmetrical pattern in supine, with legs extended. This reflex can accentuate the extensor tone in the legs, which is already facilitated by surgery to the hip flexors, and make the attainment or maintenance of a sitting position difficult. Patients 4A, 5A, 6A, 9A, 12A, 17A, 19A, 23A, 27A, 31A, 34A, 38A exhibited predominant extensor spasticity which further compromised hip flexion. Dyskinesia facilitated the shift of deformity to the opposite side in patients 22A and 28A.

8.6 SUMMARY

Surgery was very successful in terms of producing a stable hip. Unilateral surgery frequently had an untoward effect on the unoperated hip, making it more unstable. Surgery markedly improved hip abduction. Iliopsoas transfer resulted in limitation of hip flexion which interfered with sitting. Limitation of flexion was also found after iliopsoas releases, but less frequently. Complications after surgery occurred frequently, particularly in the patient older than nine years, whose hip was already severely unstable. The incidence of complications correlated with the extensiveness of the surgery.

Neurological patterns had an adverse effect on the result of surgery, not in terms of obtaining a good surgical result radiologically, but in terms of obtaining a good sitting posture. Persistent abnormal reflexes, which were found predominantly in

Moreau et al (1979) stated that the frequency of decubitus ulcers depends on the severity of neurological involvement. It is a complication which can be prevented by good nursing care and emphasis on frequent change of position. If the patient is seated in an orthosis, the area of greatest pressure can be hollowed out and/or padded. The patient should be taken out of his seat at regular intervals, and should spend a period of the day in prone lying if possible. The key factor is frequent change of position.

9.9 SUMMARY

Comparison of the treated and untreated patients demonstrated that the surgically treated patients had more stable hips. Untreated patients had a significantly higher incidence of pain. Analysis of this pain, however, showed that it was not continuous, but in the majority of cases occurred intermittently, particularly during washing. Resting pain was rare. Sitting function was not significantly better in the treated patients. There was no significant difference in the incidence of fractures in both groups, and more decubitus ulcers were found in the treated group. In this group, however, perineal care was significantly easier.

In this study the site and frequency of pressure sores, both past and present in Groups A and B were recorded (Table IV). McNemar's test of symmetry was applied. In Group A, there was no significant difference between frequency of past and present pressure sores. However, more sacral pressure sores were found (in the treated group) at follow-up, showing that the surgery led to more pressure over the sacral area.

In Group B there was a highly significant decrease in the frequency of pressure sores at follow-up, compared to their incidence in the past. Many patients in Group B came to the institution from poor socioeconomic backgrounds, where care was inadequate. Within the institution a better method of patient management had evolved, with more attention being paid to skin care and change of position, although many spent a large portion of the day in a recumbent position. Pressure sores were more frequent and occurred in more areas of the body in the severely contracted, totally immobile patient, confirming the view of Moreau et al (1979). The total number of pressure sores in Group A on follow-up was almost 3 times the number in Group B. There were 9 sacral pressure sores in Group A as opposed to 1 in Group B (Appendix XII).

9.8 DECUBITUS ULCERS

Cerebral palsied patients who spend prolonged periods in fixed positions e.g. back lying or chair sitting, are prone to decubitus ulcers over bony prominences, especially where there is uneven distribution of pressure. The skin at the pressure point reddens and can break down and ultimately become ulcerated, as poor circulation in the immobile patient prevents healing of damaged skin. The area over the prominent dislocated hip and trochanter is purported to be prone to ulceration, if the patient's posture results in increased pressure on this area.

TABLE XIV

COMPARISON OF DECUBITUS ULCERS

A		PAST +	PAST -	N (40)	p VALUE*
Present	+	14	0	14	0.083
	-	3	23	26	
B		**PAST +**	**PAST -**	**N (40)**	
Present	+	4	17	21	<0.001
	-	2	17	19	

* McNemar Test

TABLE XIII

COMPARISON OF FRACTURES

VARIABLE	A (N = 40)	B (N = 40)	p VALUE*
# Femur	8	3	0.193

* Fishers exact 2 tail test.

There was no significant difference in the incidence of fractures in the treated and untreated groups.

The incidence of fractures (20%) in patients who underwent surgery is comparable to the postoperative incidence reported by Samilson et al (1967) - 20%, and by Pritchett (1987) - 18% . In Pritchett's comparative study (1990) more untreated patients sustained fractures, whereas in this study the incidence in this group was half that of the treated patients. It is possible that the legs of untreated patients in this study were not moved often. These results indicate that prevention of fractures should not be used as a rationale for surgery. The incidence of this complication can be reduced by careful handling of the patient.

TABLE XII

COMPARISON OF PERINEAL CARE

VARIABLE	A (N = 34)	B (N = 23)	p VALUE*
Easy	36	18	$p<0.001$
Fairly difficult/Difficult	4	22	

* Chi square test

9.7 FRACTURES

Hip dislocation has been observed to increase the risk of fracture of the femur (McIvor and Samilson 1966, Pritchett 1983). Gamble et al (1990) say this is probably due to lower extremity rigidity, joint contracture and osteopenia.

Table XIII gives a comparison of the number of patients in Group A and Group B who sustained fractures of the femur.

9.5 ASSOCIATED HANDICAPS

Appendix X shows that there was little difference in the numbers of profoundly handicapped in each group. Appendix VIII details the occurrence of epilepsy, aphasia and blindness. Both groups were similar.

9.6 PERINEAL CARE

Perineal care is difficult when both hips are adducted or when there is no passive abduction. Improvement of care is justified as a rationale for surgery in these patients. In the windswept patient, the abducted leg allows access to the perineum, and perineal care was relatively easy in most of these patients. Perineal care was difficult in one treated patient who resisted abduction because of pain.

There was a highly significant difference in ease of perineal care in the treated group as opposed to the untreated group, as shown in Table XII.

4. Transportation of the patient is easier when he can be seated in a wheelchair, even when he cannot propel himself.

One of the goals of hip surgery is to maintain or improve sitting function. This function was not significantly better in the group treated by hip surgery. Sitting can however be facilitated by the use of straps, special chairs, or individually designed orthoses which can be placed in a wheelchair. Various methods of seating have been discussed by Rang et al (1981), Pope et al (1985), Hundertmark (1985), Bleck (1987), and Atkinson (1990).

9.4 TRANSFER ABILITY

Only one patient in each group could transfer himself in and out of a wheelchair. Thirty-nine patients in Group B and 35 patients in Group A were totally dependent for transfers. Four patients in Group A assisted with transfers. Hip surgery did not improve transfer ability. Inability to transfer is due to inability to weight bear, hamstring contractures and a non-functional position of the legs.

present in 30% of the treated patients and 20% of the untreated patients. In general, patients with a good tolerance had less severe deformities. It was noted, however, that in several patients the desire to be sitting up was so great that they were prepared to put up with a great deal of discomfort to remain upright and did not complain, despite being in a poor sitting position.

9.3.4 The Importance of Sitting

The non-ambulant CP patient spends all of his time either in a lying or a sitting position. Sitting is a better position than lying for the following reasons:

1. In a recumbent position, the patient is more likely to develop pressure sores and respiratory problems. Bladder infections are more likely to occur. In this position he cannot observe the world around him and interact with it. There are of course those profoundly retarded patients who cannot interact, but even these patients can benefit from sitting.
2. Feeding, whether by the assistant, or performed by the patient himself, is better in the upright position (Hulme et al 1987). The patient is less likely to choke in this position.
3. Hand function (in those patients who have the capability) is facilitated in a good, well supported position.

TABLE XI

COMPARISON OF SITTING TOLERANCE

VARIABLE	A (N = 34)	B (N = 23)	p VALUE*
Poor	3	3	0.6767
Fair/Good	31	20	

* Fishers exact 2 tail test

There was no significant difference in the two groups indicating that relocating dislocated hips does not significantly improve sitting tolerance. Investigation of poor sitting tolerance in the treated group showed that it was due to hip pain in one patient, and severe contractures in two patients which caused discomfort in sitting. In the untreated group it was similarly due to hip pain in one patient, and severe contractures in two patients.

In the treated patients with fair tolerance, a common problem was the tendency to slide out of the sitting position due to a combination of limited hip flexion and extensor spasticity. The position of the patient had to be constantly re-adjusted. Scoliosis made sitting uncomfortable as it contributed to asymmetrical sitting. Rib impingement in severe scoliosis caused pain in sitting. This impingement was

The neurological patterns of the patient must be taken into account when planning hip surgery. As discussed earlier, these patterns superimpose themselves on the post-surgical posture of the patient, and can accentuate asymmetry of the hips and spine, or extension of the hips, depending on the dominant reflex.

It is important not to confuse the customary posture of the patient with his level of sitting ability. In a presentation by Erken et al (1984) 21 patients were judged to be bedridden, as this was the position in which they were managed. Only five were reported to be prop sitters. Seat inserts were supplied after surgery and all but two were prop sitters. The change in status could therefore not be ascribed to surgery but to change in management. The level of ability must be tested before surgery by putting the child up into a sitting position. In the untreated group, assessment of ability (as described in Chapter 7) showed that 28 patients out of the total group were prop-sitters. However, only 23 were actually placed in sitting during the day and therefore lying was their customary posture.

9.3.3 Sitting Tolerance

Sitting tolerance was only analysed in those patients who were placed in a sitting position, and the results are shown in the following table.

Lonstein and Beck (1986) stated that the hip dislocation, pelvic obliquity and scoliosis were all due to the same factors and developed at the same time and not in sequence. This seems to be a more logical explanation of the windswept triad.

Letts et al (1984) stated that the iliopsoas muscle is instrumental in the development of scoliosis because of its proximal attachment to the lumbar spine. When the psoas is transferred it has a tenodesis effect on the hip joint, fixing it in a relative extension and abduction. The muscle is still overactive and probably exerts more of an effect on the lumbar spine. This effect on the spine will be most pronounced in the patient with persistent head turning and/or a dominant ATNR (even if the iliopsoas transfer is bilateral). Iliopsoas release was not as dramatic in its effect on the rest of the body as iliopsoas transfer. It was the only method of surgery on the psoas in four patients. One of these patients, a rigid spastic quadriplegic (12A) with strong extension, still developed bilateral extension-abduction contractures which were subsequently released, enabling him to be propped in sitting. One of the four patients (37A), who was dyskinetic, maintained her windswept posture. One can theorise that even if the iliopsoas is released, instead of transferred, if other factors contributing to sitting asymmetry are still present, posture as a whole will not be improved.

Scoliosis compromised symmetrical sitting in both groups. The incidence of scoliosis in the untreated group was 60%, similar to the incidence in an institutionalized population reported by Madigan and Wallace (1981).

Transverse rotation of the pelvis was found in both groups compounding asymmetry in sitting. It could be due to suprapelvic factors (scoliosis), infrapelvic factors (windsweeping), and asymmetric postural patterns. The effects of iliopsoas transfer illustrate, albeit in an exaggerated way, how surgery to one joint affects adjacent joints adversely. Surgery to one hip can reverse the direction of windsweeping, as occurred in patients 3A, 11A, 14A, 16A, 18A, 22A, 26A, 28A. In general the hip surgery did not help to achieve a symmetrical sitting position.

Letts et al (1984) contended that hip dislocation, pelvic obliquity and scoliosis (which they called the windblown hip syndrome) occurred in sequence. This would imply that correction of hip dislocation would reduce the incidence of scoliosis. The converse appeared to be true in this study.

Scrutton (1989) said: "if one hip dislocates there is a much greater chance that the pelvis will become oblique (either way) and not infrequently this leads to scoliosis". Nineteen out of 40 untreated patients in this study had a level pelvis despite unilateral hip instability, which does not correlate with Scrutton's theory.

APPENDIX III (1)

RELIABILITY STUDY

(SITTING ABILITY)

METHOD

The patient was positioned on a bench with his feet on the floor, by an assistant. The subject had to hold the position for ten seconds. The position was given a score (for each of the assessments used) by two raters. The scoring was carried out in three sessions, with a week between each session. Three pre-existing assessments were used, namely Rang, Chailey Heritage and Staudt.

The Kappa Statistic was used to analyse interrater reliability. Intrarater reliability was expressed by percentage agreement, which was calculated as follows:

$$\% \text{ assessment} = \frac{100 \times \text{Agreements}}{\text{Agreements} + \text{Disagreements}}$$

The author was Rater I and Rater II was a final year physiotherapy student. Only the intrarater reliability of Rater I is shown. Rater II achieved an almost identical degree of intrarater reliability.

This study was presented by Michelle Sher and Karen Shnaier in a dissertation in fulfilment of the requirements for the degree of BSc Physiotherapy in the Faculty of Medicine, University of the Witwatersrand, Johannesburg in 1991.

APPENDIX II (4)

Associated Handicaps

Radiographs

Comments

APPENDIX II (3)

EXAMINATION

5. Knees — Right — Left

   Popliteal angle

6. Nursing Care

   Perineal care:

   Decubitus ulcers:

SITTING

1. Level of Ability
2. Sitting Posture (uncorrected)

   Spine

   Pelvis

   Legs

3. Sitting Tolerance
4. Present Seating
5. Upper Limb Function

STANDING

1. Transfer ability
2. Ambulation

APPENDIX II (2)

EXAMINATION

LYING

1. Type CP

2. Reflex Patterns

3. Pelvic obliquity

4. Hips

	Right	Left
Abduction, knees straight	____	____
Abduction, knees flexed	____	____
Flexion	____	____
Fixed flexion deformity	____	____
External rotation	____	____
Internal rotation	____	____
Leg length discrepancy	____	____

Pain: Frequency

Movement

Resting

APPENDIX II (1)

CEREBRAL PALSY HIP ASSESSMENT

NAME: ______________________________

DATE OF BIRTH: _________________________

ADDRESS: ______________________________________

____

DATE OF ASSESSMENT: _______________________

HISTORY:

APPENDIX I (2)

DETAILS OF SURGERY

Pt	DOS	HS	AGE	AR	ON	IR	MIT	SIT	FO	PO	HR	OR	OTHER
19A	1/84 12/85 10/87	R S L SS	8 10	R● L●	● ●		L●	R●	R● L●		R● L●	R● L●	SF
20A	8/83 9/87	R D R S	10 14	R●	●			R●	R●	R●	B●	R●	
21A	4/81 2/85 7/89	L S L D L D	6 10 14	B● L●	●	L●			L●	L●		L●	
22A	5/83	R D	16	R●	●			R●	R●	R●		R●	
23A	12/85	L SS	2	L●			L●				B●	●	
24A	5/84	L S	11	B●	●	R●		L●	L●		B●		
25A	12/81 2/83	R D L S	13 14	R● L●	● ●	L●		R●	R●		B●	R●	
26A	7/84 6/85	R D B S	18	B● L●	●		L●	R●	R● L●		B●	R●	
27A	10/80 1/82	B S R SS	8 9	L● R●	● ●			L● R●	R●		B●	R●	
28A	10/80	L SS	12	L●	●		L●		L●	L●		L●	
29A	4/81 6/81	B D L D	7	B● L●	● ●			L● L●	L●			L●	
30A	9/83 11/83 1/84	L SS R D	11	L● R●	● ●			L● R●	L● R● R●		B●	L● R●	
31A	9/82 4/84	L S L SS	2	B●	●	B●		L●	L●			L●	
32A	1/81 3/87	R SS L S	6 12	R● L●	●			R● L●	R● L●		L●	R● L●	
33A	3/81	R D	15	R●	●		R●		R●				
34A	2/84 3/84	B SS	8	R● L●	● ●			R● L●	R● L●		B●	R● L●	
35A	1/81	B S	5	B●	●	B●							
36A	7/87	L D	11	L●	●			L●	L●		L●	L●	
37A	5/87	L S	10	B●	●	B●							
38A	7/82 8/87 10/88	L S R SS R D	3 9 10	L● R●	● ●	L●		R● R●	R● R●		B●	●	
39A	10/84 7/87	B S R D	4 7	L● R●		L● R●			L● R●		B●	●	
40A	4/81	B D	10	R●	●								

APPENDIX I (1)

DETAILS OF SURGERY

Pt	DOS	HS	AGE	AR	ON	IR	MIT	SIT	FO	PO	HR	OR	OTHER
1A	1/82 5/82 3/87	L D L D	15	L•	•			L•	L• L•	L•		L•	SF
2A	11/82 12/82	B D	5	L• R•	• •			L• R•	L• R•	L• R•		L• R•	
3A	11/82 8/84 6/87	R S	11	R•	•			R•	R•	R•	B•	R•	SF
4A	8/82 8/82 8/90	B S	11	R• L•	• •			R• L•					B EAR
5A	10/82 10/82	B S	5	R• L•	• •			R• L•		R•	B•		
6A	11/82 11/88	B D	4	R• L•	• •			R• L•	R• L•	R• L•		R• L•	B EAR
7A	8/82 6/83 11/87	L D L D	10	L• L•	•			L• L•	L•		B•	L•	L HE
8A	3/81 11/81	R D L S	3 4	R• L•	• •		R• L•		R• L•			R• L•	
9A	2/83 4/83	B D	4	R• L•	• •			R• L•	R• L•			R• L•	
10A	6/84	L SS	5	B•	•			L•	L•		B•	L•	
11A	10/81 5/84 5/89	R S R D	15 18	B• R•	•			R•	R•	R•	B• B•	R•	
12A	8/81 11/88	R S	5 12	B•	•	B•					B•		B EAR
13A	1/82	R D	6	R•	•			R•	R•			R•	
14A	2/83	L S	5	L•				L•					
15A	5/83 6/83 2/92	L D R S	11	L• R•	•			L• R•	L• R•		B•	L•	SF
16A	8/82	L S	8	L•	•			L•	L•				
17A	4/82 8/82 11/82 7/85	L D L D R S	5	L• L• R•	• •		R•	L•	L• L• R•		L• B•	L• L•	
18A	3/80 9/90	R S L SS	9 19	B•	•			R•					L HE

7. *Scoliosis.*

8. Marked pelvic asymmetry (obliquity or rotation).

A decision must then be made whether the aim of surgery can be attained. It must also be considered whether the indication warrants the amount of surgery required to correct the hip deformity. Where surgical intervention is not indicated, conservative options should be recommended, including a program of positioning, gentle exercises, and most importantly, attention to seating. While conservative measures are unlikely to influence hip status, they will facilitate management of the patient. These management principles also apply after surgery.

This study has assessed the CP patient with hip deformity not only in terms of the hip pathology, but in the broader context of his disability. All components of sitting function have been analysed. The use of the CPHA requires comprehensive assessment of the patient, which will lead to a carefully considered decision regarding surgical intervention. This will benefit both cerebral palsied individuals and those entrusted with their care.

dislocation, not subluxation.

It is recommended that each patient being considered for hip surgery should be assessed according to the CPHA. To save the surgeon time, the CPHA could be partially or wholly completed by a therapist experienced in CP assessment, prior to the orthopaedic assessment. If pain is present, she should supply information about the frequency of the pain and its impact on the patient. The surgeon could then assess joint ranges, conduct a further pain test, and examine the radiographs.

Based on the CPHA, indications for surgery in each particular patient should be established. Following this, limiting factors must be considered. These are age, hip status, type of CP, degree of handicap, and general posture of the patient. A hypothetical "ideal" candidate for hip surgery would be the young CP child with bilateral subluxation, a level pelvis and straight spine, and a mild degree of spasticity. Based on the findings of this study, negative criteria for surgery are:

1. Age of more than nine years.
2. Established hip dislocation.
3. Dystonic or rigid CP.
4. Profound handicap.
5. Obligate postural reflexes.
6. Strong extensor tone.

symmetrically adducted. It is only truly problematical when there are bilateral adduction contractur..

Pain on movement of the hip is present in a substantial number of untreated patients. This pain is usually intermittent, occurring mostly when the patient is handled, although not invariably. Pain was rarely found in the profoundly handicapped patient. When present, it is recommended that the patient be handled gently and that brisk movement of the affected hip be avoided. The significance of pain should be established in each patient by observation over a period of time. If the patient with a dislocated hip has intractable pain, ie. frequent pain unresponsive to medication, a resection arthroplasty can be considered. The possible future development of pain as quoted by many authors, including Gamble et al (op. cit.) should not be used as an indication for surgery.

It must be remembered that abnormal postural reflexes continue to influence the posture of the patient after hip surgery. Reversal of a postural pattern was found to occur in a number of cases. Dystonia and rigidity influenced the results of surgery. Hence it is important to include diagnosis of the type of CP and testing of primitive reflexes prior to, or during orthopaedic assessment. In general, the more severely involved the patient, the less the indication for surgery. Pritchett (1990) expresses the same view, but confines his opinion to the treatment of hip is often quoted as a reason for surgery. Gamble et al (1990) said that one of the goals of treatment was to restore or improve upright posture.

It has been emphasized in this study that sitting function depends on several factors. Sitting balance, or level of sitting ability is dependent on the degree of neurological impairment. Patients could be placed in prop-sitting even if the hip was dislocated so this deformity does not preclude sitting. Posture in an upright position is determined by the position of hips, pelvis and spine as well as head and trunk control. Relocating the hip will not necessarily improve the overall posture. Hip surgery could however provide a broader base for sitting. Frischut et al (1992) also found that no functional changes occurred as a result of hip surgery.

Tolerance in sitting could be affected by spinal deformity as well as hip deformity. Poor tolerance as a result of hip dislocation alone was a rare finding in this study. Fraser et al (1990) concur that many persons with dislocated hips do not experience sitting difficulties.

Prevention of decubitus ulcers and fractures are not indications for surgery as their occurence is influenced by the management of the patient. Perineal care was simplified after successful surgery, but it is not difficult in all patients with hip deformity. It is relatively easier when the hips are windswept than when they are

CHAPTER TEN

CONCLUSION AND RECOMMENDATION

Surgery was highly successful in locating the hips of the patients in this study, but in many cases stability was gained at the expense of mobility. The complication rate was high, particularly where the hip was already dislocated, and extensive surgery was subsequently required. Reduction of : [illegible]shed dislocation is therefore not recommended. Pritchett (1990) and Herndon et al (1992) expressed this view in regard to severe CP. Bleck (1987) agreed with non-intervention in the skeletally mature CP with a painless dislocation.

This study confirms the view that unilateral surgery should be avoided because of a possible deterioration in stability of the opposite hip. The adverse effects of iliopsoas transfer have been demonstrated. This became apparent during the assessment of joint range and sitting function, leading to the conclusion that iliopsoas transfer should not be used in cerebral palsy.

The findings of this study indicate that generalised statements about the effect of hip instability on CP patients are inaccurate and should not be applied indiscriminately. The aim of improving the sitting balance, posture or tolerance

APPENDIX VIII

ASSOCIATED HANDICAPS

GROUP A	E	A	B	GROUP B	E	A	B
1A				1B	●	●	
2A	●	●	●	2B	●	●	
3A				3B	●	●	
4A	●	●		4B		●	
5A		●		5B			
6A	●	●	●	6B	●	●	
7A				7B			
8A	●	●		8B			
9A	●			9B	●	●	●
10A	●	●	●	10B		●	
11A				11B			
12A	●	●		12B		●	
13A	●	●		13B	●	●	
14A				14B		●	
15A				15B			
16A				16B		●	
17A				17B		●	
18A	●	●		18B	●		
19A	●	●		19B		●	
20A		●		20B	●	●	●
21A				21B		●	
22A	●			22B			
23A	●	●		23B			
24A	●	●		24B		●	
25A	●	●		25B	●	●	
26A				26B	●	●	
27A		●		27B	●	●	
28A		●		28B		●	●
29A	●	●	●	29B			●
30A	●	●		30B		●	
31A		●		31B		●	
32A	●	●		32B		●	
33A				33B			
34A	●	●		34B	●	●	
35A				35B	●	●	
36A		●		36B		●	
37A		●		37B	●	●	
38A				38B		●	●
39A				39B	●	●	
40A		●		40B		●	

E = Epilepsy

A = Aphasia

B = Blind or severely visually impaired

APPENDIX VII (2)

ABBREVIATIONS

Tr	=	Tremor
Rig	=	Rigid Spasticity
Sp	=	Spasticity (clasp knife type)
Dys	=	Dyskinetic
TLR	=	Tonic Labyrinthine Reflex
ATNR	=	Assymetrical Tonic Neck Reflex
↔	=	To both sides
→	=	Dominant side
PHT	=	Persistent Head Turning

Extensor Tone ++: Strong Extensor Tone

> R	=	Tone increased more on right

Dominant reflex underlined

APPENDIX VII (1)

TYPE OF MUSCLE TONE AND REFLEX PATTERNS

GROUP A

No:	Type	ATNR	TLR	PHT	REMARKS
1A	Sp	● → R	●		
2A	Sp			● → R	
3A	Sp	● → R	●		Tone > R
4A	Sp (Tr)		●		
5A	Dys		●		
6A	Rig	● ↔	●		
7A	Sp				
8A	Sp	● ↔	●		Extensor Tone ++
9A	Sp	● ↔	●		Extensor Tone ++
10A	Sp	●		● → R	
11A	Sp				Tone > R
12A	Rig		●		Extensor Tone ++
13A	Sp		●		
14A	SP	●	●		
15A	Dys	● → R	●	● → R	
16A	Sp				
17A	Sp				Extensor Tone ++
18A	Sp				
19A	Sp		●		
20A	Sp				
21A	Sp (Tr)				
22A	Dys				
23A	Dys	●	●		
24A	Sp		●		
25A	Rig	● → L			
26A	Sp				Tone > R
27A	Sp				Extensor tone ++
28A	Dys	● ↔			
29A	Sp	● → R		● → R	Tone > L
30A	Sp				Extensor Tone ++
31A	Sp	● ↔			
32A	Sp	● ↔		● → R	
33A	Sp				
34A	Sp		●		
35A	Sp				
36A	Sp	● → R	●		
37A	Dys	● ↔			Extensor tone ++
38A	Sp				
39A	Sp				
40A	Sp			● → L	

APPENDIX VI (4)

MIGRATION PERCENTAGE AND ACETABULAR INDEX

GROUP B

Pt	MIGRATION %		ACETABULAR INDEX	
	R	L	R	L
1B	48	>100	35	40
2B	15	>100	20	43
3B	>100	0	22	10
4B	>100	0	?	?
5B	>100	0	35	37
6B	>100	0	32	24
7B	>100	11	40	20
8B	>100	0	32	13
9B	>100	0	15	15
10B	>100	0	12	10
11B	>100	0	>60	20
12B	>100	10	>60	20
13B	0	>100	15	>60
14B	5	>100	20	>60
15B	>100	29	>60	35
16B	>100	50	40	25
17B	>100	0	>60	25
18B	>100	0	>60	20
19B	0	>100	20	>60
20B	38	44	20	20
21B	0	40	15	20
22B	>100	>100	>60	?
23B	>100	>100	>60	>60
24B	71	60	>60	40
25B	73	10	50	30
26B	30	35	22	20
27B	>10	55	20	37
28B	>100	>100	34	25
29B	28	41	25	33
30B	>100	>100	>50	>50
31B	100	0	35	12
32B	75	<10	45	40
33B	>100	>100	>60	>60
34B	>100	>100	>60	>60
35B	30	36	18	14
36B	80	0	>60	20
37B	0	58	20	45
38B	43	32	30	18
39B	78	<10	43	16
40B	26	48	30	30

APPENDIX VI (3)

ACETABULAR INDEX BEFORE SURGERY AND AT FOLLOW-UP

GROUP A

Pt	PREOPERATIVE		FOLLOWUP	
	R	L	R	L
1A	18	30	18	18
2A	20	31	30	15
3A	40	25	28	26
4A	24	30	30	30
5A	24	30	10	18
6A	30	25	15	20
7A	33	35	30	24
8A	36	28	31	20
9A	28	24	28	24
10A	26	35	25	15
11A	32	15	32	27
12A	19	19	20	20
13A	32	20	34	20
14A	20	20	20	10
15A	25	35	30	30
16A	20	25	21	15
17A	26	30	18	20
18A	31	15	31	29
19A	31	24	30	34
20A	45	22	35	21
21A	20	40	20	40
22A	50	18	50	35
23A	20	32	15	20
24A	12	22	10	10
25A	40	20	34	20
26A	20	30	20	30
27A	36	40	30	20
28A	15	45	42	18
29A	40	34	40	34
30A	38	40	22	20
31A	15	22	15	26
32A	30	18	20	20
33A	36	30	38	28
34A	31	30	32	22
35A	24	23	20	18
36A	10	50	10	38
37A	26	26	12	12
38A	20	22	30	16
39A	35	26	23	30
40A	45	40	45	40

APPENDIX VI (2)

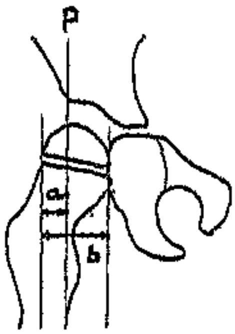
MIGRATION PERCENTAGE BEFORE SURGERY AND AT FOLLOW-UP

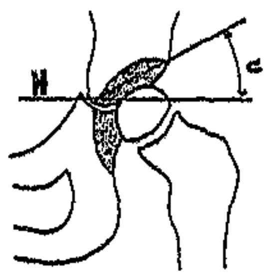
GROUP A

Pt	PREOPERATIVE		FOLLOWUP	
	R	L	R	L
1A	0	>100	0	<33
2A	>100	>100	<33	<33
3A	62	<33	<33	<33
4A	40	44	<10	17
5A	44	55	12	18
6A	100	100	0	0
7A	33	100	33	0 (exc)
8A	100	36	<30	<30
9A	100	100	0	0
10A	44	75	28	<10
11A	50	0	<10	25
12A	50	30	0	0
13A	100	14	19	0
14A	20	35	18	0
15A	34	100	0	0
16A	20	50	31	0
17A	55	100	0	0
18A	62	31	45	70
19A	50	36	18	38
20A	100	20	66	0
21A	<33	60	0	0
22A	>100	10	<10	>100
23A	0	75	50	22
24A	<10	50	0	0
25A	100	25	0	0
26A	100	0	34	0
27A	42	58	50	<10
28A	0	70	90	0
29A	>100	>100	>100	0
30A	100	83	0	0
31A	31	50	15	26
32A	90	16	0	0
33A	100	40	0	58
34A	91	82	28	0
35A	48	35	15	25
36A	0	100	<10	0
37A	28	34	0	0
38A	35	<10	76	<10
39A	40	60	32	<10
40A	100	100	100	100

APPENDIX VI (1)

RADIOGRAPHIC MEASUREMENTS





MIGRATION PERCENTAGE
(MP)

ACETABULAR INDEX
(AI)

MP = $\frac{a}{b} . 100\%$

C = AI
P = Perkins' Line
H = Hilgenreiner's Line

APPENDIX V (3)

SEATING AND MANAGEMENT

GROUP B

No:	PRESENT SEATING	MANAGEMENT
1B	— (lies)	P
2B	Special chair	M P S
3B	— (lies)	P
4B	Ordinary chair	P
5B	Special chair	P S
6B	Special chair	P S
7B	— (lies)	P
8B	— (lies)	-
9B	Special chair	P S
10B	— (lies)	P
11B	Special chiar	P S
12B	— (lies)	P
13B	— (lies)	P
14B	Special chair	P
15B	Ordinary chair	M P
16B	Ordinary chair	P
17B	— (lies)	-
18B	Ordinary chair	P
19B	Ordinary chair	P
20B	Special chair	P S
21B	Ordinary chair	M P
22B	— (lies)	-
23B	— (lies)	P
24B	— (lies)	-
25B	Ordinary chair	P
26B	Ordinary chair	P
27B	Ordinary chair	P
28B	Special chair	P
29B	Special chair	P
30B	— (lies)	-
31B	— (lies)	P
32B	— (lies)	-
33B	Special chair	M P S
34B	Special chair	P S
35B	Ordinary chair	M P
36B	— (lies)	P
37B	— (lies)	M P
38B	Ordinary chair	M P
39B	— (lies)	P
40B	Ordinary chair	P

APPENDIX V (2)

SEATING AND MANAGEMENT

GROUP A

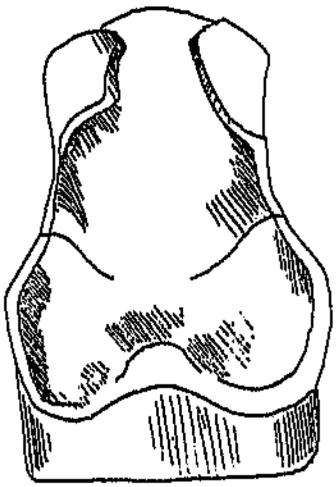
	PRESENT SEATING	POSTOPERATIVE MANAGEMENT	PRESENT MANAGEMENT
1A	Moulded insert	M P S	M P S
2A	Beanbag (lies)	M P S	M P
3A	Box insert	M P	-
4A	Cannot sit	M P S	M P S
5A	Box insert	M P S	M P S
6A	Beanbag (lies)	M P S	M P
7A	Moulded insert	M P S	M P S
8A	Box insert	M P S	M P S
9A	Box insert	M P S	M P S
10A	Wheelchair, straps	M P S	M P
11A	Wheelchair, no straps	M P	M P
12A	Moulded insert	M P S	M P S
13A	Moulded insert	M P S	M P S
14A	Moulded insert	M P S	M P S
15A	Beanbag (lies)	M P S	M P
16A	Moulded insert	M P S	M P S
17A	Wheelchair, no straps	M P	-
18A	Wheelchair, no straps	M P	-
19A	Moulded insert	M P S	M P S
20A	Box insert	M P	M P S
21A	Insert and Brace	M P S	S
22A	Box insert	M P	M P S
23A	Pushchair and straps	M P S	M P
24A	Wheelchair, no straps	S	-
25A	Cannot sit	S	-
26A	Wheelchair, no straps	-	-
27A	Wheelchair, no straps	M P	-
28A	Wheelchair, straps	M P	-
29A	Cannot sit	S	-
30A	Wheelchair, no straps	M P S	M P
31A	Box insert	M P S	M P S
32A	Moulded insert	M P S	S
33A	Wheelchair, no straps	M P	-
34A	Buggy with straps	M P	P
35A	Box insert	M P S	M P S
36A	Moulded insert	S	S
37A	Box insert	M P S	S
38A	Moulded insert	M P S	M P S
39A	Wheelchair, no straps	M P	M P
40A	Wheelchair, no straps	-	-

ABBREVIATIONS

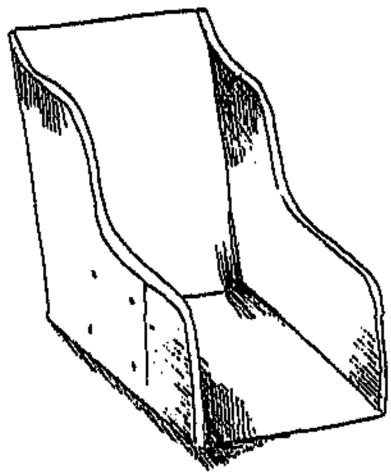
M	:	Movement - passive or assisted active
P	:	Positioning
S	:	Special Seating

APPENDIX V (1)

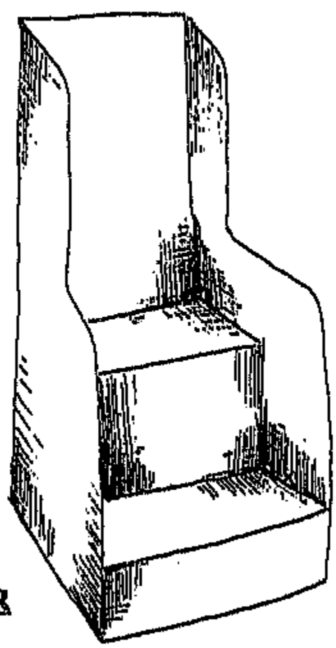
SEATING



MOULDED CHAIR INSERT



BOX TYPE CHAIR INSERT



SPECIAL CHAIR

(STRAPS NOT SHOWN)

APPENDIX IV (1)

POSTOPERATIVE COMPLICATIONS

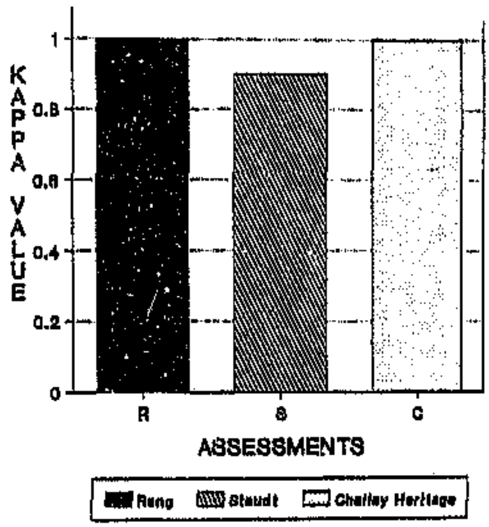
Pt	Age(S)	HO	SEPSIS	#	REDISL	AVN	EXT ABD
1A	15	L•			L•	L•	
2A	5	B•	L•				
3A	11	R•					
4A	11						B•
5A	5						
6A	4	B•		L••			B•
7A	11		L•		L•	L•	
8A	3						
9A	4						
10A	5						
11A	15	R•					
12A	5						B•
13A	6						
14A	5						
15A	11			R•			R•
16A	8			L•			
17A	5				L•		
18A	9						
19A	8					R•	
20A	10				R•	R•	
21A	6				L•	L•	
22A	16	R•	R•				
23A	2						
24A	11						
25A	13	R•				R•	
26A	18	L•				L•	
27A	8					R•	
28A	12	R•					
29A	7			L• R•			B•
30A	11	L•	R•	L•	R•		
31A	2						B•
32A	6	R•		L•			B•
33A	15						
34A	8						
35A	5						
36A	11					L•	
37A	10						
38A	3	R•		R•	R•	R•	
39A	4						
40A	10		R•				

ABBREVIATIONS

Pt	=	Patient
S	=	Surgery
HO	=	Heterotopic ossification
#	=	Fracture
REDISL	=	Redislocation
AVN	=	Avascular necrosis
EXT ABD	=	Extension abduction contracture
L	=	Left
R	=	Right
B	=	Bilateral

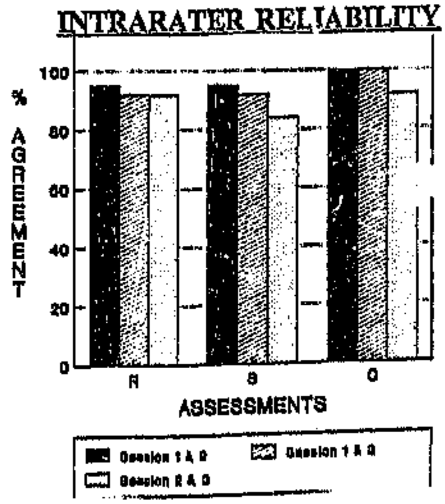
APPENDIX III (2)

INTERRATER RELIABILITY



Both Rang and Chailey Heritage scales proved to be 100% reliable. The Staudt assessment yielded a lower Kappa value of 0.935.

INTRARATER RELIABILITY



AVERAGE % AGREEMENT

Rang:	97
Chailey Heritage:	90
Staudt:	95

LIST OF REFERENCES

Ashley RK, Larsen LJ, James PM. (1972) Reduction of dislocation of the hip in older children: A preliminary report. *J Bone Joint Surg (Am)* 54: 545-550.

Atkinson G. (1990) Seating systems. In Fraser B, Hensinger RN, Phelps JA (Eds) Physical management of multiple handicaps. Baltimore: Paul H. Brooks. pgs 111-136.

Bagg MR, Farber J, Miller F. (1993) Long term follow-up of hip subluxation in cerebral palsy patients. *J Pediatr Orthop* 13: 32-36.

Baker LD. (1956) A rational approach to the surgical needs of the cerebral palsied patient. *J Bone Joint Surg (Am)* 38: 313-323.

Baker LD, Dodelin R, Basset FH. (1962) Pathological changes in the hip in cerebral palsy patients. Incidence, pathogenesis and treatment: A preliminary report. *J Bone Joint Surg (Am)* 44: 1331-1342.

Banham M. (1978) Measuring functional motor rehabilitation of cerebral palsied infants and young children. *Rehab Lit* 39: 111-115.

Banks HH, Green NT. (1960) Adductor myotomy and obturator neurectomy for correction of adduction contractures of the hip in cerebral palsy. *J Bone Joint Surg (Am)* 42: 111-126.

APPENDIX XIV (3)

SITTING POSTURE

GROUP B

PT	SCOLIOSIS	PELVIC OBL	KYPHOSIS	PELVIC ROTATION	WIND-SWEEPING
1B					● → R
2B	●	●			● → R
3B	● (RI)	●			● → L
4B				●	● → L
5B	● (RI)	●			● → L
6B	●				● → L
7B					● → L
8B	●	●			● → L
9B			●		● → L
10B	●			●	
11B	●			●	● → R
12B	●				● → L
13B	● (RI)	●			● → R
14B	●				● → R
15B	● (RI)				
16B			●		
17B	● (RI)	●			● → R
18B	●	●	●	●	● → L
19B					● → L
20B					● → L
21B					● → R
22B	●				
23B	●				● → R
24B	● (RI)	●			● → L
25B	●	●			
26B					● → R
27B			●	●	● → L
28B	●			●	
29B			●		
30B	● (RI)	●			● → L
31B	● (RI)	●		●	● → L
32B	●				
33B					● → L
34B	●	●			● → L
35B			●		
36B	●	●	●	●	● → R
37B	●	●			
38B			●		● → R
39B		●			
40B					

APPENDIX XIV (2)

SITTING POSTURE

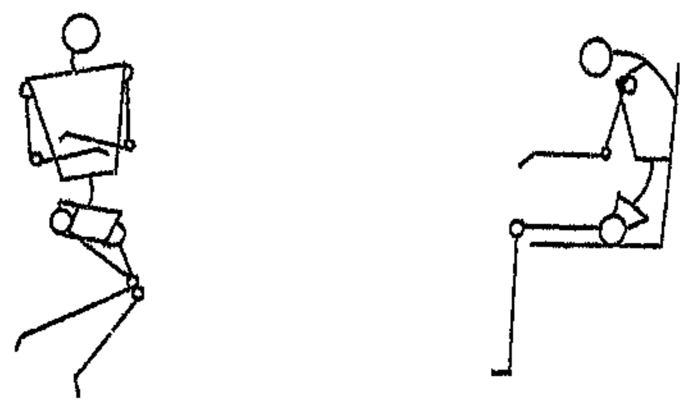
GROUP A

PT	SCOLIOSIS	PELVIC OBLIQUITY	KYPHOSIS	PELVIC ROTATION	WIND-SWEEPING
1A	•	•			
2A	• (RI)	•		•	• → R
3A					• → R
4A	•	•			
5A			•		
6A			•	•	
7A	•				• → R
8A					
9A	•		•		
10A	•		•		• → R
11A					• → R
12A			•		
13A	•	•	•		
14A	•	•		•	• → R
15A	• (RI)	•			• → L
16A	•	•	•	•	• → L
17A	•		•		
18A	•	•	•		• → R
19A	• (RI)	•	•	•	
20A	•	•		•	• → R
21A	• (RI)	•		•	• → R
22A	• (RI)	•	•		• → R
23A	•			•	• → R
24A	• (RI)		•		• → R
25A	• (RI)	•			
26A	• (RI)	•		•	• → R
27A	•	•	•		
28A	• (RI)		•		• → L
29A	• (RI)	•			• → R
30A	•	•	•		• → L
31A	•	•	•		
32A	• (RI)	•			
33A					
34A	•		•		
35A					
36A	•		•		
37A			•		• → R
38A	•		•	•	
39A				•	• → R
40A	• (RI)	•			

APPENDIX XIV (1)

SITTING POSTURE

DIAGRAMMATIC REPRESENTATION OF POSTURE



A B

A: ANTERIOR VIEW OF PATIENT SHOWING SCOLIOSIS, PELVIC OBLIQUITY AND WINDSWEEPING

B: LATERAL VIEW OF PATIENT SHOWING POSTERIOR PELVIC TILT AND KYPHOSIS

(After Pope et al 1988)

APPENDIX XIII

FRACTURES OF THE FEMUR

GROUP A

PT	TYPE OF FRACTURE	MONTHS AFTER SURGERY
6A	L Supracondylar	34
	L Supracondylar	46
15A	R Subtrochanteric	2
16A	L Supracondylar	10
29A	L Supracondylar	9
	R Shaft	11
30A	L Shaft	59
32A	L Subtrochanteric	2
34A	L Supracondylar	11
38A	R Supracondylar	14

APPENDIX XII (3)

ABBREVIATIONS

RI	=	Rib impingement
IT	=	Ischial tuberosity
TR	=	Greater trochanter
SAC	=	Sacrum

APPENDIX XII (2)

DECUBITUS ULCERS

PT	SITE	PAST	PRESENT	PT	SITE	PAST	PRESENT
21A	Sac, mid back	•	•	21B	R + L Tr	•	
22A	L IT		•	22B	Sac.	•	•
23A				23B	L hip, L ankle	•	
24A	L ankle	•		24B	R Tr	•	
25A	Sac. Sac.	•	•	25B	R Tr		•
26A	L Tr, R ankle L Tr, Sac	•	•	26B	R Tr	•	
27A				27B	R hip	•	
28A	Sac, IT	•	•	28B			
29A	R Ear, R Tr R knee, Back	• •	• •	29B			
30A	R hip, Mid back	•		30B	L hip	•	
31A				31B			
32A	RI, back	•	•	32B	R + L hip L Tr	•	•
33A				33B	R hip	•	
34A	Mid back		•	34B	R Tr	•	
35A				35B			
36A	Sac.		•	36B	L elbow	•	
37A				37B	Sac.	•	
38A				38B			
39A				39B	R Tr	•	
40A				40B	L Tr, L ankle L knee	•	•

APPENDIX XII (1)

DECUBITUS ULCERS

PT	SITE	PAST	PRESENT	PT	SITE	PAST	PRESENT
1A	Sac, L RI Sac	•	•	1B	L hip	•	
2A	R hip, R ear R elbow, R ankle	• •	• •	2B			
3A				3B			
4A	Sac		•	4B			
5A				5B	L hip	•	
6A	Sac, Knees Sac	•	•	6B	L hip, ankle L knee	•	•
7A	L inner thigh		•	7B			
8A				8B	L hip		•
9A				9B	R + L Tr	•	
10A	Mid spine	•	•	10B			
11A				11B			
12A	Knees, Sac Sac	•	•	12B	L Tr	•	
13A				13B	Tr, Feet R Tr	•	•
14A				14B	R hip R hip	•	•
15A	R RI	•		15B			
16A				16B	R hip	•	
17A				17B	L hip, L ankle	•	
18A	L hip		•	18B	R + L Tr	•	
19A				19B			
20A	L IT		•	20B	L Foot	•	

APPENDIX XI

ANALYSIS OF PAIN

GROUP B

PT	WASHING (N = 7)	DRESSING (N = 7)	TRANSFERS (N = 7)
2B	2	0	1
4B	4	1	1
8B	5	2	4
11B	6	3	3
12B	7	7	2
14B	7	2	2
15B	5	1	3
17B	6	3	0
18B	3	2	2
23B	7	7	1
33B	7	4	5
34B	3	3	2
36B	4	1	1

APPENDIX X

MENTAL STATUS

PT	STATUS	PT	STATUS
1A	MM	1B	PS
2A	PS	2B	PS
3A	PS	3B	PS
4A	MM	4B	MM
5A	MM	5B	MM
6A	PS	6B	PS
7A	MM	7B	MM
8A	MM	8B	MM
9A	MM	9B	PS
10A	PS	10B	PS
11A	MM	11B	MM
12A	PS	12B	MM
13A	PS	13B	MM
14A	MM	14B	MM
15A	MM	15B	MM
16A	MM	16B	MM
17A	MM	17B	MM
18A	MM	18B	MM
19A	PS	19B	MM
20A	MM	20B	PS
21A	MM	21B	PS
22A	MM	22B	MM
23A	PS	23B	MM
24A	MM	24B	PS
25A	PS	25B	PS
26A	MM	26B	LN
27A	MM	27B	PS
28A	MM	28B	PS
29A	PS	29B	PS
30A	PS	30B	PS
31A	MM	31B	PS
32A	PS	32B	PS
33A	LN	33B	MM
34A	PS	34B	MM
35A	MM	35B	MM
36A	PS	36B	MM
37A	MM	37B	PS
38A	MM	38B	MM
39A	LN	39B	PS
40A	PS	40B	MM

PS = Profound - severe retardation

MM = Moderate - mild retardation

LN = Low - normal intelligence

APPENDIX IX (2)

PAIN ASSESSMENT

GROUP B

Pt	HIP STATUS	R1	R2	R3	L1	L2	L3	PAIN RESPONSE
1B	LD							Negative
2B	LD					•	•	Positive (L hip)
3B	RD							Cries all movements - excluded
4B	RD	•		•				Positive (R hip)
5B	RD							Negative
6B	RD							Cries all movements - excluded
7B	RD							Negative
8B	RD	•	•	•	•			Positive (R hip)
9B	RD							Cries all movements - excluded
10B	RD							Negative
11B	RD	•	•					Positive (R hip)
12B	RD	•	•					Positive (R hip)
13B	LD							Negative
14B	LD				•	•	•	Positive (L hip)
15B	RD		•	•			•	Positive (R hip)
16B	RD	•						Negative
17B	RD	•	•					Positive (R hip)
18B	RD	•	•	•				Positive (R hip)
19B	LD				•			Negative
20B	BS							Negative
21B	LS							Negative
22B	BD		•			•		Negative
23B	BD	•	•		•	•		Positive (R + L hip)
24B	RSS							Negative
25B	RSS							Negative
26B	LS							Negative
27B	LS							Negative
28B	BD							Negative
29B	LS							Negative
30B	BD							Cries all movements - excluded
31B	RD							Negative
32B	RSS							Negative
33B	BD		•	•	•	•	•	Positive (R + L hip)
34B	BD					•	•	Positive (L hip)
35B	LS							Negative
36B	RSS	•		•				Positive (R hip)
37B	LS							Negative
38B	RS						•	Negative
39B	RSS			•				Negative
40B	LS	•			•			Negative

R1 = Right hip, 1st Assessment
R2 = Right hip, 2nd Assessment
R3 = Right hip, 3rd Assessment
L1 = Left hip, 1st Assessment
L2 = Left hip, 2nd Assessment
L3 = Left hip, 3rd Assessment

APPENDIX IX (1)

PAIN ASSESSMENT

GROUP A

Pt	HIP STATUS	R1	R2	R3	L1	L2	L3	PAIN RESPONSE
1A	BL							Negative
2A	BL							Cries all movements - excluded
3A	BL							Negative
4A	BL							Negative
5A	BL							Negative
6A	BL							Cries all movements - excluded
7A	L (exo)				•		•	Positive (L Hip)
8A	BL							Negative
9A	BL							Negative
10A	BL							Negative
11A	BL							Negative
12A	BL							Negative
13A	BL							Negative
14A	BL							Negative
15A	BL							Negative
16A	BL							Negative
17A	BL							Negative
18A	LSS				•	•	•	Positive (L hip)
19A	LS							Negative
20A	RS	•	•	•				Positive (R hip)
21A	BL							Negative
22A	LD				•	•	•	Positive (L hip)
23A	BL							Negative
24A	BL							Negative
25A	BL							Negative
26A	RS							Negative
27A	RS							Negative
28A	RSS	•	•	•				Positive (R hip)
29A	RD							Negative
30A	BL	•	•					Positive (R hip)
31A	BL							Negative
32A	BL							Negative
33A	LS							Negative
34A	BL							Negative
35A	BL							Negative
36A	BL							Negative
37A	BL							Negative
38A	RSS							Negative
39A	BL							Negative
40A	BD							Negative

BL = Bilaterally located
(exo) = Excised
S = Subluxated
SS = Severely subluxated
D = Dislocated

Pettit B. (1976) Surgery of the lower extremity in cerebral palsy - considerations and approaches. *Arch Phys Med Rehab* 57: 443-447.

Phelps WM. (1957) Long term results of orthopaedic surgery in cerebral palsy. *J Bone Joint Surg (Am)* 39: 53-59.

Phelps WM. (1959) Prevention of acquired dislocation of the hip in cerebral palsy. *J Bone Joint Surg (Am)* 41: 440-447.

Phelps WM. (1967) Complications of orthopaedic surgery in the treatment of cerebral palsy. *Clin Orthop* 53: 39-46.

Pollock GA, Sharrard WJW. (1958) Orthopaedic surgery in cerebral palsy. In Illingworth RS (Ed) *Recent Advances in Cerebral Palsy*. Boston: Little, 286-329.

Pope PM, Booth E, Gosling G. (1988) The development of alternate seating and mobility systems. *Physio Prac* 4: 78-93.

Pritchett JW. (1983) The untreated unstable hip in cerebral palsy. *Clin Orthop* 173: 169-172.

Pritchett JW. (1990) Treated and untreated unstable hips in severe cerebral palsy. *Dev Med Child Neurol* 31: 3-6.

Ralis Z, McKibbin B. (1973) Changes in shape of the human hip joint during its development and their relation to its stability. *J Bone Joint Surg (Br)* 55: 780-785.

Mubarak SJ, Valencia FG, Wenger DR. (1992) One stage correction of the spastic dislocated hip. Use of pericapsular acetabuloplasty to improve coverage. *J Bone Joint Surg (Am)* 74: 1347-1357.

Mulcahy CM. (1986) An approach to the assessment of sitting ability for the prescription of seating. *Occ Ther* 367-368.

Mullaferoze P, Vora PH. (1972) Surgery in lower limbs in cerebral palsy. *Dev Med Child Neurol* 14: 45-50.

Myhe U, von Wendt L. (1991) Improvement of the functional sitting position for children with cerebral palsy. *Dev Med Child Neurol* 33: 246-256.

Nwaobi OM. (1987) Seating orientations and upper extremity function in children with cerebral palsy. *Phys Ther* 67: 1209-1212.

O'Brien JJ, Sirkin RB. (1978) The natural history of the dislocated hip in cerebral palsy. Paper presented at the Annual Meeting of the American Academy for Cerebral Palsy and Developmental Medicine, Atlanta. *Dev Med Child Neurol* 20: 241 (Abstr).

Onimus M, Allamel G, Manzone P, Laurain JM. (1991) Prevention of hip dislocation in cerebral palsy by early psoas and adductor tenotomies. *J Pediatr Orthop* 11: 432-447.

Perlmutter MN, Synder M, Miller F, Bisbal R. (1993) Proximal femoral resection for older children with spastic hip disease. *Dev Med Child Neurol* 35: 525-531.

Matthias HH. (1990) Hüftgelenksveränderungen bei infantiler Zerebralparese. *Zeit für Orthop* 128: 373-376.

McCarthy RE, Simon S, Douglas B, Zawacki, Reese M. (1988) Proximal femoral resection to allow adults who have severe cerebral palsy to sit. *J Bone Joint Surg (Am)* 70: 1011-1016.

McHale KA, Bagg M, Nason SS. (1990) Treatment of the chronically dislocated hip in adolescents with cerebral palsy with femoral head resection and subtrochanteric valgus osteotomy. *J Pediatr Orthop* 10: 504-509.

McHale KA. (1991) Bilateral spontaneous arthrodesis of the hip after combined shelf acetabular and femoral varus osteotomies. *J Pediatr Orthop* 11: 108-111.

McIvor WC, Samilson RL. (1966) Fractures in patients with cerebral palsy. *J Bone Joint Surg (Am)* 57: 404-408.

McManus F, Rang M. (1977) Preventive Orthopedics. *Clin Orthop* 125: 243-248.

Merskey H. (1979) Pain Terms: A list of definitions and notes on usage. Recommended by the IASP Subcommittee on Toxonomy. *Pain* 6: 249-252.

Moreau M, Drummond DS, Rogala E. Ashworth A, Porter T. (1979) Natural history of the dislocated hip in spastic cerebral palsy. *Dev Med Child Neurol* 21: 749-753.

Lee M, Alexander MA, Miller F, Steg NL, McHugh BA. (1992) Postoperative heterotopic ossification in the child with cerebral palsy: Three case reports. *Arch Phys Med Rehabil* 73: 289-292.

Ludloff K. (1902) Zur Pathogenese und Therapie der angeborenen Hüftgelenksluxation. *Klinisches Jahrbuch 10.* Jena: Gustav Fischer.

Letts M, Shapiro L, Mulder K, Klassen O. (1984) The windblown hip syndrome in total body cerebral palsy. *J Pediatr Orthop* 4: 55-62.

Lonstein JE, Beck K. (1986) Hip dislocation and subluxation in cerebral palsy. *J Pediatr Orthop* 6: 521-526.

Mackenzie IG. (1975) Abnormalities of the hip in cerebral palsy. *Dev Med Child Neurol* 17: 797-799.

Mandal AC. (1981) The seated man. (Homo Sedens) The seated work position. Theory and practice. *Appl Ergonomics* 12: 19-26.

Madigan RK, Wallace SL (1981) Scoliosis in the institutionalised cerebral palsy population. *Spine* 583-590.

Mathews SS, Jones MH, Sperling SC. (1953) Hip derangement seen in cerebral palsied children. *Am J Phys Med* 32: 213-221.

Mathias A. (1967) Management of cerebral palsy. Physical therapy in relation to orthopaedic surgery. *Phys Ther* 47: 473-482.

Kalen V, Bleck EE. (1985) Prevention of spastic paralytic dislocation of the hip. *Dev Med Child Neurol* **27**: 17-24.

Kalen V, Gamble JG. (1984) Resection arthroplasty of hip in paralytic disorders. *Dev Med Child Neurol* **26**: 341-346.

Keats S. (1957) Combined adductor-gracilis tenotomy and selective obturator nerve resection for the correction of adduction deformity of the hip in children with cerebral palsy. *J Bone Joint Surg (Am)* **39**: 1087-1090.

Koffman M. (1981) Proximal femoral resection or total hip replacement in severely disabled cerebral spastic patients. *Orthop Clin North Am* **12**: 91-100.

Krum SD, Miller F. (1993) Heterotopic ossification after hip and spine surgery in children witn cerebral palsy. *J Pediatr Orthop* 13: 739-743.

Künne B. (1914) Paralytische und spastische Hüftluxationen. *Arch für Orthop* **13**: 111-139.

Lamb DW, Pollock GA. (1962) Hip deformities in cerebral palsy and their treatment. *Dev Med Child Neurol* 4: 488-498.

Lancet (1990) Does hip dislocation matter in cerebral palsy? **335**: 823-824 (Editorial).

Lange F. (1921) Die Entstehung der coxa valga durch Muskelzug (Adduktoren - coxa valga) *Zeit für Orthop Chir* 4: 147.

Hulme JB, Shaver J, Acher S, Mullette L, Eggert C. 1987. Effects of adaptive seating devices on the eating and drinking of children with multiple handicaps. Am J Occup Ther 41: 81-89

Hundertmark LH. 1985. Evaluating the adult with cerebral palsy for specialized adaptive seating. Phys Ther 65: 209-212

Ingram TTS. 1955. A study of cerebral palsy in the childhood population of Edinburgh. Arch Dis Child 30: 85-98.

Ingram AJ, Withers E, Speltz E. 1959. The role of intensive physical and occupational therapy in the treatment of cerebral palsy. Arch Phys Med 40: 429-438

Johnson A, Evans P, Mutch L, Alberman E. 1989. A standard form for recording clinical findings in children with a motor deficit of central origin. Dev Med Child Neurol 31: 119-127

Jones ET. 1954. Paralytic dislocation of the hip. J Bone Joint Surg Br 36: 375-376

Jones ET. 1962. Paralytic dislocation of the hip. J Bone Joint Surg Br 44: 573

Jones ET, Knapp DR. 1987. Assessment and management of the lower extremity in cerebral palsy. Orthop Clin North Am 18: 725-738

Hensinger RN. (1986) Hip and pelvis. In Hensinger RN (Ed). *Standards in Paediatric Orthopaedics*. New York: Raven Press, 46-81.

Herndon WA, Bolano L, Sullivan JA. (1992) Hip stabilization in severely involved cerebral palsy patients. *J Pediatr Orthop* 12: 68-73.

Hiroshimo K, Ono K. (1979) Correlation between muscle shortening and derangement of the hip joint in children with spastic cerebral palsy. *Clin Orthop* 144: 186-193.

Hoffer MM, Abraham E, Nickel VL. (1972) Salvage surgery at the hips to improve the sitting posture of mentally retarded, severely disabled children with cerebral palsy. *Dev Med Child Neurol* 14: 51-55.

Hoffer MM. (1986) Management of hip in cerebral palsy. *J Bone Joint Surg (Am)* 68: 629-631.

Hoffer MM, Knoebel RT, & Roberts R. (1987) Contractures in cerebral palsy. *Clin Orthop* 219: 70-77.

Houkom JA, Roach JW, Wenger DR, Speck G, Herring JA, Norris EN. (1986) Treatment of acquired hip subluxation in cerebral palsy. *J Pediatr Orthop* 6: 285-290.

Howard CE, McKibbin B, Williams LA, Packle I. (1985) Factors affecting the incidence of hip dislocation in cerebral palsy. *J Bone Joint Surg (Br)* 67: 530-532.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Feldkamp M. (1982) Late results of hip and knee surgery in severely handicapped cerebral palsy patients. *Arch Orthop Trauma Surg* 100: 217-224.

Feldkamp M, Denker P. (1989) The importance of the iliopsoas muscle in soft tissue surgery of hip deformities in cerebral palsy children. *Arch Orthop Trauma Surg* 108: 225-230.

Fettweis E. (1979) Adduktorenspasmus, Präluxationen und Luxationen von den Hüftgelenken bei spastisch gelähmten Kindern und Jugendlichen, Klinische Beobachtungen zur Ätiologie, Pathogenese, Therapie. *Zeit für Orthop* 117: 39-49.

Fraser BD, Hensinger RN, & Phelps JA. (1990) Orthopaedic treatment of lower extremity deformities. Eds in: *Physical Management of Multiple Handicaps.* Baltimore: Brooks, 81-10.

Frischhut B, Krismer H, Sterzinger W. (1992) Die Hüfte bei der infantilen Zerebralparese, naturlicher Entwicklungsverlauf und Behandlungskonzepte. *Orthopade* 21: 312-322.

Fulford GE, Brown JK. (1976) Position as a cause of deformity in children with cerebral palsy. *Dev Med Child Neurol* 18: 305-314.

Fujiwara M, Basmajian JV, Strom CH. (1972) EMG study of hip dislocation in cerebral palsy. *Am J Phys Med* 53: 171-196.

Fujiwara M, Basmajian JV, Iwamoto M. (1976) Hip abnormalities in cerebral palsy: A radiological study. *Arch Phys Med Rehabil* 57: 278-281.

Castle ME, Schneider C. (1978) Proximal femoral resection - interpostiton arthroplasty. *J Bone Joint Surg (Am)* **60**: 1051-1054.

Cooke PH, Cole WG, Carey RPL. (1989) Dislocation of the hip in cerebral palsy, natural history and predictability. *J Bone Joint Surg* **71**: 441-446.

Cooperman DR, Bartucci E, Dietrick E, Miller EA. (1987) Hip dislocation in cerebral palsy: Long term consequences. *J Pediatr Orthop* 7: 268-276.

Craig JJG. (1973) The orthopaedic approach to the treatment of cerebral palsy. *S Afr Med J* 47: 1904-1908.

Craig KD. (1990) Emotional aspects of pain. In Wall PD and Melzack R. (Eds) *Textbook of Pain*. Edinburgh: Churchill Livingstone. 220-230.

Erken EHW, Craig JJG, von Bormann PFB, Katz K. (1984) Dislocation of the hip in cerebral palsy. Management in children with total body involvement. Paper presented at the 30th Congress of the South African Orthopaedic Association, Bloemfontein. *J Bone Joint Surg (Br)* **66**: 451 (Abstr).

Erken EHW, Bischof FM. (1992) Long-term results of hip surgery in non-ambulant cerebral palsy patients. Paper presented at the 37th Congress of South African Orthopaedic Association, Johannesburg. *J Bone Joint Surg (Br)* 74: (Suppl 2): 199-200 (Abstr).

Erken EHW, Bischof FM. (1994) Iliopsoas transfer in cerebral palsy. The long-term outcome. *J Pediatr Orthop* 14: 295-298.

Bleck EE. (1990) Management of the lower extremity in children who have cerebral palsy. *J Bone Joint Surg (Am)* 72: 140-144.

Bobath K, Bobath B. (1958) An assessment of the motor handicap of children with cerebral palsy and of their response to treatment. *Occ Ther J* 21: 19-34.

Bobath B. (1965) Tonic neck reflexes. In Bobath B. (Ed) *Abnormal Postural Reflex Activity Caused by Brain Lesions*. William Heinemann, London. 22-37.

Bouchard J, d'Astous J. (1991) Postoperative heterotopic ossification in children: a comparison of children with spina bifida and with cerebral palsy. *Can J Surg* 34: 454-456.

Brooks M, Wardle EN. (1962) Muscle action and shape of the femur. *J Bone Joint Surg (Br)* 44: 398-411.

Buckley SL, Sponseller PD, Magid D. (1991) The acetabulum in congenital and neuromuscular hip instability. *J Pediatr Orthop* 11: 498-501.

Carpenter EP. (1982) The unstable hip in cerebral palsy - recognition, prevention and treatment. Paper presented at the Annual Meeting of the American Academy of Cerebral Palsy and Developmental Medicine, Detroit. *Dev Med Child Neurol* 24: 255 (Abstr).

Carr C, Gage JR. (1987) The fate of the non-operated hip in cerebral palsy. *J Pediatr Orthop* 17: 262-267.

Batchelor JS. (1966) The surgical treatment of dislocation of the hip in cerebral palsy. *Dev Med Child Neurol* 8: 568-570.

Baxter MP, D'Astous JL. (1986) Proximal femoral resection-interposition arthroplasty: Salvage hip surgery for the severely disabled child with cerebral palsy. *J Pediatr Orthop* 6: 681-685.

Beals RK. (1969) Developmental changes in the femur and acetabulum in spastic paraplegia and diplegia. *Dev Med Child Neurol* 11: 303-313.

Bischof FM. (1983) A survey of the results of physiotherapy combined with surgery on ineducable cerebral palsied children. Thesis for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg.

Bischof FM, Erken EHW. (1993) The hip in the untreated non-ambulant cerebral palsied patient. Paper presented at the 36th Congress of The South African Orthopaedic Association, Cape Town. *J Bone Joint Surg (Br)* 75 (suppl 1): 79 (Abstr).

Bischof FM, Martin S. (1984) Physiotherapy relating to subluxation and dislocation of the hip in cerebral palsy. *S Afr J Physio* 40: 11-14.

Bleck EE. (1980) The hip in cerebral palsy. *Orthop Clin North Am* 11: 79-104.

Bleck EE. (1987) *Orthopaedic Management in Cerebral Palsy*. Oxford: Blackwell Scientific Publications.

Zembo MM, Jameson D, Roberts J, Burke SW. (1988) Operative treatment of hip subluxation or dislocation in children with cerebral palsy : a nine year retrospective study. Paper presented at the Annual Meeting of the American Academy of Cerebral Palsy and Developmental Medicine, Toronto. *Dev Med Child Neurol* (Suppl 57) **30:** 2-3 (Abstr).

Zimbler S. (1988) Management of the hip in patients with cerebral palsy. Poster paper presented at Annual Meeting of the American Academy of Cerebral Palsy and Developmental Medicine, Toronto. *Dev Med Child Neur* (Suppl 57) **30:** 37-38 (Abstr).

Zimmerman SE, Sturm PF. (1992) Computed tomographic assessment of shelf acetabuloplasty. *J Pediatr Orthop* **12:** 581-585.

Tönnis D. (1976) Normal values of the hip joint for the evaluation of X-rays in children and adults. *Clin Orthop* **119**: 39-47.

Tönnis D. (1987) Development of the hip joint. In: Tönnis D (Ed). *Congenital Dysplasia and Dislocation of the Hip in Children and Adults.* Berlin, Heidelberg: Springer Verlag. 13-22.

Trainer N, Bowser BL, Dahm L. (1986) Obturator nerve block for the painful hip in adult cerebral palsy. *Arch Phys Med Rehabil* **67**: 829-830.

Tylowski CM, Rosenthal RK, Simon SR. (1980) Proximal femoral osteotomy in cerebral palsy. *Clin Orthop* 151: 183-192.

Vidal J, Deguillaume P, Vidal M. (1985) The anatomy of the dysplastic hip in cerebral palsy related to prognosis and treatment. *Int Orthop* **9**: 105-110.

Watson Jones R. (1926) Spontaneous dislocation of the hip. *Br J Surg* **14**: 36-57.

Weber H. (1911) Uber die spastische Hüftluxation und die Veränderungen des Hüftgelenkes bei spastischen Zuständen der unteren Extremitaten. *Münchener Medizinsche Wochenschrift* **58**: 794-798.

Wheeler ME, Weinstein SL. (1984) Adductor tenotomy - obturator neurectomy. *J Pediatr Orthop* 4: 48-51.

Wollenberg GA. (1908) Little'sche Krankheit und Hüftluxation. *Berliner Klinische Wochenschrift* 45: 1174.

Somerville EW. (1959) Paralytic dislocation of the hip. *J Bone Joint Surg (Br)* 41: 279-288.

Staheli LT. (1977) The prone hip extension test. *Clin Orthop* 123: 12-15.

Staudt L. (1989) Rhizotomy Symposium. Annual Meeting of the American Academy of Cerebral Palsy and Developmental Medicine, San Francisco.

Staudt L. (1990) Personal Communication (Letter).

Steinberg ME. (1987) Avascular necrosis of the femoral head. In: Tronzo RG (Ed). *Surgery of the Hip Joint*. New York: Springer Verlag. Vol II: 1-29.

Szalay EA, Roach JW, Houkom JA, Wenger DR, Herring JA. (1986) Extension abduction contracture of the spastic hip. *J Pediatr Orthop* 6: 1-6.

Tachdijian MO, Minear WL. (1956) Hip dislocation in cerebral palsy. *J Bone Joint Surg (Am)* 38: 1358-1364.

Tardieu C, Lespargot A, Tabary C, Bret MD. (1988) For how long must the soleus muscle be stretched each day to prevent contracture? *Dev Med Child Neurol* 30: 3-10.

Thom H. (1991) Prophylaxe der Huftluxation bei spastisch gelahmten Kindern durch therapiegerechte Rollstuhlversorgung. *Rehabilitation* 30: 109-115.

Sharrard WJW. 1964. Posterior iliopsoas transplantation in the treatment of paralytic dislocation of the hip. *J Bone Joint Surg Br* 46: 426-444.

Sharrard WJW. 1975. The hip in cerebral palsy. In: Samilson RL. Ed. *Orthopaedic Aspects of Cerebral Palsy*. London: William Heinemann. 145-17[illegible].

Sharrard WJW, Allen JMH, Heaney SH, Prendiville GRG. 1975. Surgical prophylaxis of subluxation and dislocation of the hip in cerebral palsy. *J Bone Joint Surg Br* 57: 160-166.

Sharrard WJW, Burke J. 1982. Iliopsoas transfer in the management of established dislocation and refractory progressive subluxation of the hip in cerebral palsy. *Int Orthop* 6: 149-154.

Sherk HH, Pasquariello PD, Doherty J. 1983. Hip dislocation in cerebral palsy: selection for treatment. *Dev Med Child Neur* 25: 738-746.

Siff M. 1991. The biomechanics of pelvic tilt. *S Afr J Physio* 4[illegible]: 5[illegible]-5[illegible].

Silver RL, Rang M, Chan J, de la Garza J. 1985. Adductor release in non-ambulant children with cerebral palsy. *J Pediatr Orthop* 5: 672-677.

Smith WS, Coleman CR, Olix ML, Slager RF. 1963. Etiology of congenital dislocation of the hip. *J Bone Joint Surg Am* 45: 491.

Smith ET. 1969. Hip dislocation in cerebral palsy. *Dev Med Child Neurol* 11: 251-256.

Samilson RL, Tsou P, Aamoth G. Green NM. (1972) Dislocation and subluxation of the hip in cerebral palsy: Pathogenesis, natural history and management. *J Bone Joint Surg (Am)* 54: 863-873.

Samilson RL, Hoffer MM. (1975) Problems and complications in orthopaedic management of cerebral palsy. In: Samilson RL (Ed). *Orthopaedic Aspects of Cerebral Palsy*. London: William Heinemann, 258-274.

Samilson RL. (1981A) Orthopaedic surgery of hips and spine in retarded cerebral palsy patients. *Orthop Clin North Am* 12: 83-90.

Samilson RL. (1981B) Current concepts of surgical management of deformities of the lower extremities in cerebral palsy. *Clin Orthop* 158: 99-107.

Scrutton D, Gilbertson M. (1975) The physiotherapists role in the treatment of cerebral palsy. In: Samilison RL (Ed). *Orthopaedic Aspects of Cerebral Palsy*. London: William Heinemann, 98-111.

Scrutton D. (1989) The early management of hips in cerebral palsy. *Dev Med Child Neurol* 31: 108-116.

Scrutton D. (1990) Does hip dislocation matter in cerebral palsy? *Lancet* 335: 1285 (Letter).

Shands AR, Steele MR. (1958) Torsion of the femur. *J Bone Joint Surg (Am)* 40: 803-816.

Rang M, Douglas G, Bennet GC, Korsetka J. (1981) Seating for children with cerebral palsy. *J Pediatr Orthop* 1: 279-287.

Reimers J. (1980) The stability of the hip in children. A radiological study of the results of muscle surgery in cerebral palsy. *Acta Orthop Scand* 184: 1-100.

Reimers J. (1992) Acetabular development after femoral osteotomy in cerebral palsy after age four years. *J Pediatr Orthop (Br)* 1: 35-37.

Reynell JK. (1965) Post operative disturbances observed in cerebral palsied children. *J Dev Med Child Neur* 7: 360-376.

Robson P. (1987) Lower limb deformity and prevention of scoliosis in cerebral palsy. *Arch Disease Child* 62: 547-548.

Root L, Goss JR, Mendes J. (1986) The treatment of the painful hip in cerebral palsy by total hip replacement or hip arthrodesis. *J Bone Joint Surg (Am)* 68: 590-598.

Russel DJ, Rosenbaum PL, Cadman DT, Gowland C, Hardy S, Jarvis S. (1989) The gross motor function measure: A means to evaluate the effects of physical therapy. *Dev Med Child Neur* 31: 341-352.

Samilson RL, Carson JG, James P, Raney FL. (1967) Results and complications of adductor tenotomy and obturator neurectomy in cerebral palsy. *Clin Orthop* 54: 61-73.