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Marcia A. Wehe
University of North Dakota

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A REVIEW OF TWO PELVIC OSTEOTOMIES USED IN THE
MANAGEMENT OF CONGENITAL HIP DISLOCATION

by

Marcia A. Wehe
Bachelor of Arts
Concordia College, 1987

Certificate of Physical Therapy
Mayo School of Health-Related Sciences, 1989

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
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for the degree of
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This Independent Study, submitted by Marcia Wehe in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Chairperson, Physical Therapy)
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ABSTRACT

This paper is a literature search of two common pelvic osteotomies used in the treatment/management of congenital hip dislocation. The Chiari and Salter procedures are reviewed along with their use in restoring normal hip joint, congruency, indication for use, and success rates. The Chiari procedure displaces the acetabulum medially and has the best results in children over four years of age or when the acetabulum is too small for the femoral head. A Salter procedure redirects the entire acetabulum and is optimal for subluxations one and one-half years to adult or dislocations one and one-half to six years.
CHAPTER I
INTRODUCTION

Congenital dislocations of the hip occur in approximately ten out of one thousand live births in the United States. \(^1\) Early detection and early treatment have met with success, with approximately ninety-six percent of affected children developing radiological and functionally normal hips. \(^1\) The longer the dislocation remains undetected and untreated, the greater the difficulty in satisfactorily returning the femoral head into the acetabulum. In addition, the condition of degenerative joint disease frequently develops early in untreated subluxations and dislocations due to the anatomical incongruencies at the hip joint. This further complicates the task of returning the femoral head into the acetabulum in later stages.

Methods for early detection of congenital hip dislocation have been reported in literature for at least seventy-five years. In Italy, Putti\(^1\) initiated a program for early screening and treatment in 1926. In the United States, Howorth,\(^1\) in 1932, developed the first screening program at Babies' Hospital in New York. However, it was not until after World War II that extensive work in congenital hip dislocation was done in the United States, Sweden, and Britain. As all statistics indicate, early recognition of congenital dislocation and
treatment results in improved congruency of the femoral head and acetabulum leading to improved normal function.

This paper is a thorough literature search of the history and two main pelvic osteotomies used today when acetabular dysplagia is the primary factor in congenital hip dislocation. The Chiari and Salter pelvic osteotomies are reviewed along with their use in restoring normal hip joint congruency, indications for use, success rates, and comparisons between them.
CHAPTER II
LITERATURE REVIEW

In the fetus, all structures of the hip joint are present at the eighth week, the end of the embryonic period. The formation of the hip joint itself is completed by the end of the first trimester. There are no reported cases of fetal dislocated hips prior to the third trimester in the literature. Studies have shown that no significant changes in the femoral head coverage or acetabular anteversion occur during the six- to twenty-week interval, so the hip joint remains congruent during this time period with no signs of dislocation or dysplagia evident.

At birth, the unduly lax hip joint capsule causes the hip to be dislocatable in three main ways. First, due to the ligament laxity, the acetabulum may become malaligned with the femoral head creating a subluxed or even dislocated joint. Second, with the repeated stretching of the joint capsule and ligaments, the capsule becomes permanently elongated and is no longer able to maintain the femoral head within the normal joint relationship. Third, muscle contractures about the hip, primarily the adductors and iliopsoas, limit the movement of the hip and contribute to instability within the hip joint by abnormal forces created by muscle tensions secondary to the contractures.
In the newborn, the bony components of the hip, principally the acetabulum and femur, are normal for that age. Thus, it is the dislocation that causes the dysplagia, and not the dysplagia which causes the dislocation. This is further supported by studies which have shown that the acetabular development of family members who do not have congenital hip dislocation is no different than control subjects, suggesting that the dysplagia of the hip results from the subluxation/dislocation and not inheritance. Furthermore, the secondary dysplagia of the acetabulum is greater than that of the femur, and the acetabular dysplagia is less reversible than the femoral dysplagia, including the need for early detection and treatment.

Historically, congenitally dislocated hips were treated very conservatively. Reduction of the hip was attempted by positioning the hip into flexion and abduction by a variety of methods, from splinting to casts. In addition, traction was used if the above methods were unsuccessful, especially in an older child or a larger child. Unfortunately, if reduction did not occur, these individuals had discomfort with sitting, standing, and walking or were unable to perform these tasks. However, in 1890, Alfonzo Poggi, performed the first documented surgical correction of congenital hip dysplagia including reconstruction of the acetabulum. In the 1960s, a variety of surgical methods and approaches were popularized. These methods ranged from fusion of the hip joint to resection of the femoral head, total hip arthroplasty, and pelvic osteotomies.
The potential for normal development after reduction is maximal at birth and gradually decreases thereafter. In most children eighteen to twenty-four months, the dysplasia before walking is mild and can be treated by closed methods (traction, adductor tenotomy, gentle reduction, and immobilization). Surgical measures may be needed to restore the mechanical relationship so the forces and pressures will create a physiological growth stimulation in the acetabulum and upper end of the femur. This will allow an increase in growth to make up for the delay in development. If this relationship is restored within the first year of life, there is an excellent prognosis for a normal hip joint.

After eighteen to twenty-four months, the dysplasia is severe and its reversibility by conservative methods limited. Surgical intervention of soft tissue structures will be needed to obtain complete reduction, and bony structures to maintain the reduction in the functional position needed for ambulation. After the age of twenty-four to thirty-six months, the growth potential is completed. Then the purpose of the pelvic osteotomy is to artificially restore the hip joint and biomechanics in the most optimal position to avoid further degeneration. Subsequently, early detection and early treatment are crucial in order to facilitate normal hip joint growth and development.

The goal of the pelvic osteotomy is to reconstruct the acetabulum and restore the normal biomechanical relationship of the hip joint. This may be done in a variety of ways, depending upon the individual's condition. An acetabuloplasty is an incomplete osteotomy of the pelvis through which only
the roof of the acetabulum is lowered down and maintained by a bone graft. The Pemberton technique is the most popular, extensive, and effective. Others are the Albee, Wiberg, Crego, and MacKenzie. An extra-capsular shelf procedure extends the acetabular shelf outside of the joint capsule by using a bone graft. Primarily the Wilson technique is used, and secondarily the Gill, Bosworth, Lowman, Dickson, or Ghormley.

The complete osteotomies will be the focus of this paper. First, the Chiari is a medial displacement osteotomy which provides a shelf for the femoral head. Second, the Salter is a redirectional osteotomy of the innominate bone and maintains the cartilage-to-cartilage contact in the joint. Thirdly, the triple innominate osteotomy or Steel is a modification of the Salter and realigns the acetabulum by dividing all three components of the innominate bone, the ilium, ischium, and pubis. The Steel will not be reviewed in this paper. These methods have distinct criteria which a patient must meet in order to be successful and will be discussed in detail.

Chiari Procedure

The Chiari procedure was developed in 1950 by Karl Chiari. It is the most technically precise pelvic osteotomy, as it is important to perform the osteotomy at the correct level in order to achieve success. It is best used in children over four years of age, or when the socket is too small for the femoral head. The goal is to construct a congruent shelf above the intact hip joint.
without bone grafting and to optimally correct the abnormal position of the femoral head.\textsuperscript{9}

The hip is placed in thirty degrees of external rotation and slight abduction. An eight to ten centimeter incision starts two centimeters behind the anterior superior iliac spine and curves distally with its convexity medially.\textsuperscript{10} The tensor fascia lata is exposed and retracted laterally to expose the posterior iliac crest. The gluteus medius is retracted laterally, and the femoral head is palpable. The gluteus medius is split in the direction of its fibers, and the gluteus minimus is retracted posteriorly to expose the sciatic notch. The dorsal margin of the rectus is reflected to mark the level of the osteotomy, just superior to the hip joint capsule. The osteotomy ascends in a semi-circular shape just above the intact joint line through the iliac isthmus close to the superior insertion of the capsule towards the opposite anterior superior iliac spine. It extends from under the anterior inferior iliac spine to the sciatic notch posteriorly.\textsuperscript{9}

Reduction of the hip joint is achieved by forceful abduction of the hip moving the femoral head and joint capsule medially and posteriorly to lie beneath a shelf of overhanging ilium. This also provides an extracapsular shelf for the femoral head, and the cut surface of the ilium forms a buttress.\textsuperscript{9}

The osteotomy along a curved line ending under the inferior iliac spine ensures adequate support for the femoral head anteriorly, which may be necessary in cases of anteversion of the femoral neck.\textsuperscript{9} The posterior
curvature descending to the sciatic notch is important for stability of the osteotomy. Otherwise, the hip joint could glide backwards and interfere with the sciatic nerve. The surgical method has also been designed to protect the sciatic nerve and gluteal vessels from damage during the osteotomy.\textsuperscript{11}

Longitudinal follow-up studies\textsuperscript{10,12,13} have shown improvements radiographically, particularly the percent coverage of the femoral head by the acetabulum, the center-edge angle (angle from the center of the pelvis to the center of the femoral head), and the distance from the center of the femoral head to the midline. The overall result of improved position shortens the body weight's lever arm, thus improving the efficiency of the pelvic/trochanteric muscles. Chiari has calculated that for each two centimeters of displacement medially, the load across the hip joint will be reduced by thirteen percent.\textsuperscript{14} Other studies have indicated that joint pressures may be reduced as much as thirty percent.\textsuperscript{15}

In rehabilitation, it is important to strengthen the gluteal muscles, as they have been retracted and are weaker after surgery. They are important in improving the efficiency of abduction and providing added muscular support to the joint posteriorly. Overall, abduction force is improved due to the reduction of the body's lever arm, unless the medialization is excessive or the joint is displaced superiorly on account of an excessive obliquity of the osteotomy.\textsuperscript{16}

The following criteria should be used in selecting individuals for the Chiari procedure.\textsuperscript{14} First, the symptoms should not be disabling. Second, the
deterioration has been gradual, and the joint is not irritable. Narrowing or absence of joint space is an unfavorable feature, especially if rapidly occurring. Localized narrowing, sclerosing, and cyst formation all indicate concentration of load and may signal impending or actual failure of cartilage and subchondral bone. Such joints are often irritable and may warrant a delay in surgery until the inflammation subsides to ensure success.

Thirdly, the break in Shenton’s line does not exceed one-point-five centimeters. Shenton’s line\textsuperscript{14} is an imaginary line which connects the inferior border of the neck of the femur to the inferior margin of the superior pubic ramus and is used in determining the severity of the subluxation or dislocation. The absolute limit for a Chiari procedure is two centimeters if no other adverse features are present.\textsuperscript{14}

The current degeneration should not be severe. Where articular cartilage is damaged or deficient, the joint is susceptible for further damage during the operation which can cause a stiffening of the joint. Also, the femoral head should be free of any lateral prominences. They make the correct upward slope of the osteotomy impossible and would create an abnormal concentration of load in the corrected position. Finally, there should be no evidence of generalized epiphyseal dysplasia.

Salter Procedure

The Salter procedure was developed by Robert Salter in 1959.\textsuperscript{4} It is a redirectional osteotomy of the innominate bone. Salter believes that the most
significant aspect of acetabular dysplagia is the abnormal direction in which the acetabulum lies. Instead of facing downward, the acetabulum faces more anterior and laterally than normal. This theory does explain why many hips are reduced and stable in flexion and abduction, and then re-sublux or dislocate in extension (i.e., walking position). Therefore, it is the purpose of the Salter procedure to divide the innominate bone and rotate the distal portion through the symphysis pubis to redirect the acetabulum for adequate coverage of the femoral head in the weight bearing position.

The surgical incision is made two centimeters distal to the center of the iliac crest and extends anteriorly to one centimeter distal of the anterior superior iliac spine ending just below the middle of the inguinal ligament. The interval between the tensor fascia lata medially and the sartorius laterally is exposed to the rectus femoris and anterior inferior iliac spine. All is reflected to expose the femoral capsule.

The osteotomy extends from the sciatic notch to the anterior inferior iliac spine, with caution to protect the superior gluteal vessels and sciatic nerve. The distal portion is rotated to the correct position and is maintained by a triangular bone graft.

By rotating the entire acetabulum in a forward and downward direction, including the preosseus cartilage of the acetabulum, the acetabulum is allowed to ossify forming a normal head covering, eliminating the risks of subluxation, progressive sliding of the femoral head, or late arthrosis. The procedure follows
an old orthopedic criteria: Any joint in which the contact surfaces articulate will develop arthrosis, but if support is restored to its normal axis, the risk of articular degeneration will be eliminated.\textsuperscript{17}

The Salter procedure does not affect the abductor lever arm, as the distance from the center of the femoral head to the center of the pelvis is not changed.\textsuperscript{18} It does, however, rotate the acetabulum laterally and anterior-laterally over the femoral head so that the vertical subluxing component of the femoral head is distributed over a larger area.\textsuperscript{18} This stabilizes the hip and provides a proper fulcrum around which the hip musculature can work. It also repositions the existing articular cartilage of the acetabulum to increase the load bearing area.\textsuperscript{16}

Studies\textsuperscript{15} have determined satisfactory results in eighty-nine percent of individuals younger than four years with a dysplastic or subluxed hip. This is compared to eighty-two percent when only a femoral osteotomy was used.

The Salter procedure permits early weight bearing, and the congruency of the articular cartilage in the hip joint remains uninterrupted since it is rotated as a whole. Post-operative weight bearing can begin after six weeks in the case of a corrected subluxation, or after ten weeks for dislocations.\textsuperscript{5}

The Salter procedure is the most successful when used in young children where dysplagia of the acetabulum is mild or moderate, since it only realigns the acetabulum and does not reshape or remold.\textsuperscript{8} It is not recommended for children over six years of age who present with a dislocation, as the
acetabulum is usually severely dysplastic, congruency of the hip poor, and muscle contraction may be severe. The recommended guidelines are:\textsuperscript{5}

Subluxations - one and one-half years to adult
Dislocation - one and one-half years to six years of age

These same guidelines should also be followed if performing the procedure on an individual where other measures have failed. Further specifics identify an acetabular angle not greater than thirty-five degrees in the eighteen to thirty months of age, and not greater than thirty degrees in those thirty to thirty-six months.\textsuperscript{5}

In addition, six prerequisites should be met.\textsuperscript{5} First, the ability to bring the head of the femur opposite the acetabulum. If this cannot be achieved, tight muscles which cross the hip joint can cause an increase in pressure between the femoral head and acetabulum resulting in articular cartilage necrosis. Second, any contractures of adductors and/or iliopsoas must be released as contractures diminish stability in weight bearing.

There must be complete and concentric reduction of the femoral head in the depth of the true acetabulum. Since the goal of the surgery is to stabilize a completely reduced hip, there will not be a full reduction if the femoral head is in a false acetabulum, a wandering acetabulum, or slightly dislocated laterally. Fourthly, there must be reasonable congruency of the hip joint surfaces, since the hip joint is rotated as a whole. Incongruence will only lead to degenerative arthritis of the hip after it is rotated into the new position. Also, good hip range
of motion is important, as redirection will only produce a hip joint with limited diverted movement and not coverage of the femoral head.

Finally, the correct age is important. Under the age of one and one-half years, conservative methods should be tried first. Over six years of age, the acetabulum will have undergone severe dysplasia, and reasonable congruency will not be present, especially in the case of a complete dislocation. The procedure may be performed in adults with subluxations of the hip, but only if the rest of the criteria is met. The best results are obtained when the individual is between the ages of one and one-half and six where the spherical congruency is present and the acetabulum is insufficient secondarily to maldirection and alignment.16
CHAPTER III
SUMMARY/CONCLUSIONS

Both the Chiari and Salter procedures have specific criteria individuals must meet in order to ensure a successful reduction. Careful physical and radiological examinations are key in determining which procedure is optimal for the individual with acetabular dysplagia.

The Chiari procedure is best suited for individuals over four years of age. The goal is to optimally correct the position of the femoral head by increasing the dimension of the acetabulum without using bone grafts. It is a technically precise procedure as the level of osteotomy greatly affects the success rate. An osteotomy too low will create a small joint space, where an osteotomy too high or oblique will displace the joint superiorly. In either case, the biomechanical relationship of the hip joint to the body is affected and creates increased abduction forces at the hip instead of decreasing these forces.\textsuperscript{16}

Longitudinal studies have found that osteoarthritis still occurs with Chiari hips.\textsuperscript{10} But it is unclear whether the osteoarthritis progresses at a slower rate due to the improved position of the acetabulum and femoral head versus what would occur by not treating the dislocation. Research is still continuing and needed in this area to make an absolute conclusion.
In contrast, the Salter procedure is best used in younger individuals, one to six years of age. The goal is to redirect and realign the intact hip joint. This provides adequate coverage of the femoral head and optimally places the joint in the best position to respond to biomechanical forces encountered at the hip joint. Also by rotating the joint in its entirety, the preosseus cartilage is allowed to ossify forming a normal head covering able to withstand the outside forces placed upon the hip joint and eliminate the risk of articular degeneration.

For both procedures, it is beneficial to strengthen the gluteal muscles pre-operatively as they are retracted during surgery and are weaker. It is an absolute that the gluteals are strengthened post-operatively, especially if the long term goal is ambulation. These muscles are an important component, improving the efficiency of abduction as well as providing added support to the joint posteriorly.

The Salter procedure permits early weight bearing and is best used with individuals who are ambulators or will be ambulators post-operatively. It does not reshape or remold the joint, only realigns and redirects the joint and its articular surfaces. If the acetabulum and femoral head are incongruent, then the Chiari procedure should be used to reshape these surfaces, even in ambulators.

The Chiari and Salter procedures are important tools in managing congenital hip dislocations where acetabular dysplagia is a factor. Each one has specific goals and individuals who are selected carefully according to the
established criteria will have excellent post-operative results. Again, careful pre-operative examination is the key in order to determine the correct procedure and ensure the individual's maximum functional outcome for his/her lifetime.
REFERENCES


