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Publisher Information
The Journal of Bone and Joint Surgery
20 Pickering Street, Needham, MA 02492-3157
www jbjs.org
Role of Innominate Osteotomy in the Treatment of Congenital Dislocation and Subluxation of the Hip in the Older Child

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An Instructional Course Lecture, The American Academy of Orthopaedic Surgeons

Early diagnosis is still the most important aspect of congenital dislocation of the hip. Despite the emphasis on early diagnosis, a disturbingly large number of congenital dislocations of the hip remain undiagnosed until after the child has started to walk. With these children, who are more than eighteen months old, innominate osteotomy has been helpful. This procedure has been useful also with the more difficult problem of residual or recurrent dislocation or subluxation after treatment by closed or open methods.

Clinical and Experimental Investigations

Before discussing innominate osteotomy, brief reference will be made to several experimental investigations carried out in the Research Institute of The Hospital for Sick Children, because the results have direct bearing on the concept and development of innominate osteotomy.

Dysplasia

Clinical investigation reveals that dysplasia of the acetabulum is minimum at

Fig. 1

Roentgenogram of the hips of a newborn baby (first day of life). The left hip is completely dislocated but there is no evidence of dysplasia of either acetabulum.

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The dysplasia of the left acetabulum and left femoral head is quite marked.

Furthermore, during at least the first year of life, the dysplasia is reversible to a large extent, provided the normal relationship between the head of the femur and the acetabulum has been restored (Figs. 4-A and 4-B). Therefore, it is believed that dysplasia is a secondary phenomenon, rather than a primary error of development.

The geographic and cultural incidence of congenital dislocation of the hip is very high among individuals who bind their newborn babies in such a way that the hips are extended and adducted (Fig. 5). An epidemiological study of northern Canadian Indians has shown that the incidence of congenital dislocation of the hip is higher than in the general population, but ten times higher in tribes that use the cradleboard than in tribes that do not.

By contrast, congenital dislocation of the hip is extremely rare in those parts of
R. B. Salter: Innominate Osteotomy

Fig. 4-A
Roentgenogram of the hips of a four-month-old child with bilateral congenital dislocation of the hip. There is a moderate degree of dysplasia of the acetabulum on each side.

Fig. 4-B
Roentgenogram of the hips of the same child one year after bilateral closed reduction. The hip joints have developed well on each side, indicating that the dysplasia is reversible in the very young child if the dislocations are well reduced and are kept well reduced.

The world where the baby is carried on the mother's back with its hips in flexion and abduction (Fig. 6). This led to development of the hypothesis that extension and adduction of the hip in the newborn infant might be responsible, in part, for dysplasia and dislocation. The initial instability and dislocatability of the congenitally abnormal newborn hip probably is related to genetic factors, but the effect of postnatal position on such a hip seems to be of significance.

An experimental investigation was conducted in newborn pigs to test the effect of maintained extension of the hip as compared to maintained flexion (Fig. 7).
Fig. 5: Northern Canadian Indian baby strapped to a cradleboard (Tikanogan). The hips are maintained in extension and adduction.

Fig. 6: A Nigerian baby being carried on her mother’s back with the hips in flexion and abduction.

Fig. 7

Newborn pig with left hip maintained in flexion and right hip in extension.

Growth changes are readily apparent because the pig grows very rapidly in the first few months of life. Maintained extension of the hip for periods of six weeks or longer resulted in dysplasia of the acetabulum, whereas maintained flexion was associated with normal acetabular development (Figs. 8 and 9).

In order to study the reversibility of this dysplasia, the restricting bandages were removed from one group of animals and they were allowed to run free. The dysplasia was reversible (Figs. 10 and 11), and the last component of the dysplasia that was reversed was the abnormal direction of the entire acetabulum. From these

THE JOURNAL OF BONE AND JOINT SURGERY
Fig. 8: Normal pelvis of a control pig six weeks old. Note the direction of the acetabulum on each side.

Fig. 9: Pelvis of an experimental pig six weeks old. The left hip had been maintained in flexion and the acetabulum on this side has developed normally. The right hip was maintained in extension during the six-week period. The right acetabulum is dysplastic; it is not only smaller and more shallow but it also faces in a completely abnormal direction.

Fig. 10: Roentgenogram of the pelvis of a pig six weeks old. The left hip had been maintained in flexion for six weeks and the acetabulum is normal. The right hip had been maintained in extension and there is roentgenographic evidence of dysplasia as well as subluxation.

Fig. 11: Pelvis of pig sixteen weeks old. The left hip had been maintained in extension for six weeks and was then released so that the animal could run about without difficulty. During the ensuing ten weeks the dysplasia was almost completely reversed. The hip on the right side had been maintained in flexion for six weeks and no dysplasia had developed.
experimental investigations, it was concluded that dysplasia of the hip was secondary to malposition, and not the cause of malposition.

**Femoral Antversion**

Clinical investigation revealed that in children whose hips had been maintained...
in internal rotation for long periods of time, anteversion was especially marked. One group of growing rabbits was placed with their hips in marked internal rotation (Fig. 12), and another group was placed with their hips in a position of external rotation (Fig. 13). Maintained internal rotation of the hip for six weeks or longer resulted in an increased femoral anteversion, whereas maintained external rotation resulted in retroversion (Fig. 14). It was concluded that at least part of the femoral anteversion was secondary to maintained immobilization of the hip in marked internal rotation and that this was a manifestation of what might be called biological plasticity of growing bone.

Pressure Necrosis of Articular Cartilage

The third relevant investigation concerned the reason for prolonged or permanent stiffness of hip joints after certain types of operation (Figs. 15-A, 15-B, and 15-C).

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**Fig. 15-A**

Roentgenogram of the hips of a ten-year-old girl with residual displacement of the right hip despite a long period of treatment. Note the relatively thin cartilage space.

**Fig. 15-B**

Eight weeks after an acetabuloplasty of the right hip. Note the marked decrease in the cartilage space of the hip joint.
One year after acetabuloplasty. The cartilage space has been completely obliterated and the hip has become ankylosed.

It was thought that the phenomenon of joint stiffness after acetabuloplasty, associated with loss of cartilage space, might be due to the pressure of prying the roof of the acetabulum down against the femoral head. The hypothesis was that the continuous pressure of living articular cartilage surfaces against one another interfered with the synovial-fluid nutrition of the cartilage and resulted in its death.

Experiments were carried out in rabbits by immobilizing their hips and knees in forced positions that were associated with excessive pressure of the femoral head against the acetabulum (Fig. 16-A). Continuous compression of two articular surfaces against one another resulted in a lesion that we have called pressure necrosis of articular cartilage (Figs. 16-B and 16-C). Pressure necrosis of articular cartilage is serious and irreparable. It is believed that this phenomenon is one explanation of...
Problem of Instability of Reduction

Initial reduction of congenital dislocation between the ages of eighteen months and six years usually can be obtained by a period of traction followed by closed or open reduction. In congenital subluxation, on the other hand, reduction occurs with simple abduction and flexion of the hip. The main problem is not the reduction but
Fig. 17-A: Dissected pelvis of a two-and-one-half-year-old girl. An innominate osteotomy has been performed on the left side. A graft has been taken from the left iliac crest and placed in the osteotomy site. The distal half of the innominate bone has been rotated on the symphysis pubis. (Note the appearance of the obturator foramen on the left side as compared to the right. Note also the redirection of the acetabulum.)

Fig. 17-B: Lateral view of the pelvis. Note that the osteotomy site is open anteriorly and closed posteriorly. The acetabulum has not been altered in shape or capacity.

Fig. 18-A: Acetabuloplasty of the left hip in the post mortem room; subject was two years old.

Fig. 18-B: Acetabuloplasty after prying the roof of the acetabulum down. Note that the acetabulum has been made smaller and that its shape has been altered considerably. It was not possible to put the femoral head back into the acetabulum on this side.
Fig. 18-C: Innominate osteotomy of the right hip on the same pelvis. Fig. 18-D: Innominate osteotomy after displacing the osteotomy site. Note that the acetabulum has not been altered in shape or capacity. The femoral head could be placed back into this acetabulum with ease.

THE PRINCIPLE OF INNOMINATE OSTEOTOMY

A. Congenitally dislocated hip
B. Normal hip
C. Hip dislocated in weight bearing position
D. Hip now stable in weight bearing position
the *instability of reduction*. The reduced hip is stable in the position of abduction, flexion, and varying degrees of rotation. However, the hip is unstable and either redislocates or resubluxates when the hip is brought back into the functional position of walking.

The potential for normal development after reduction is maximum at birth and remains relatively adequate during the first twelve months of life. However, the potential for normal development of the hip gradually decreases with age, whereas, at the same time, the severity of the secondary dysplasia of the hip gradually increases. Because of these two factors, the reversibility of the secondary dysplasia of the hip diminishes fairly rapidly. Indeed, when the child is about eighteen months old the reversibility of the dysplasia is so limited that normal development of the acetabulum and femoral head is no longer assured, even with prolonged retention of the reduced hip in a stable position.

**Basic Cause of Instability After Reduction**

Dissatisfaction with existing methods of treatment in the child more than eighteen months old stimulated a study of the basic cause of instability after reduction.
Only at the time of open operation can one obtain a three-dimensional concept of the abnormality of the acetabulum in congenital dislocation of the hip. It has been our repeated observation that there is much more than a defect of the roof of the acetabulum. Indeed, the entire acetabulum, instead of facing downwards, is directed anterolaterally more than normally. Therefore, the femoral head is inadequately covered anteriorly when the hip is extended and inadequately covered laterally when the hip is adducted. This observation explains why the reduced hip is stable in the position of abduction and flexion, why it redislocates or resubluxates laterally in the position of adduction, and why it redislocates or resubluxates anteriorly in the position of extension. This observation also explains why, in the presence of excessive femoral anteverision, the combination of external rotation and extension results in anterior redislocation or resubluxation. In my opinion, the basic abnormality responsible for instability of the reduced congenital dislocation in the child more than eighteen months old is the abnormal direction in which the entire acetabulum faces.

**Design and Principle of Innominate Osteotomy**

After reaching the aforementioned conclusion, the next problem was to con-
Case 1. A two-year-old boy with previously untreated congenital dislocation of the right hip.
At the time of open reduction and innominate osteotomy of the right hip.

Six and one-half years after open reduction and innominate osteotomy of the right hip.

sider how best to correct this abnormal direction of the acetabulum. It seemed reasonable that, if the entire acetabulum could be made to face in a normal direction, the reduced hip would become stable in the functional position of weight-bearing.

Studies in the Department of Anatomy and in the post mortem room revealed that if the innominate bone was divided completely just above the acetabulum, the distal half of the innominate bone containing the acetabulum could be redirected by rotating this portion on the symphysis pubis. The new position could be main-
Case 2. Two-and-one-half-year-old girl with previously untreated congenital dislocation of the right hip.

Further studies in the post mortem room demonstrated the essential difference between innominate osteotomy and acetabuloplasty (Figs. 18-A through 18-D). By means of innominate osteotomy, the entire acetabulum is redirected without changing either its capacity or its shape. Therefore, the principle of innominate osteotomy is redirection of the entire acetabulum in such a way that the reduced dislocation and subluxation, which were stable previously only in a position of abduction and flexion, are made stable in the position of function (Fig. 19). This procedure allows early weight-bearing, which in a stable hip is an excellent stimulus for further development of the various components of the joint.

THE JOURNAL OF BONE AND JOINT SURGERY
Six and one-half years after open reduction and innominate osteotomy of the right hip.

**Application of Principle of Innominate Osteotomy**

The principle of innominate osteotomy is applicable to both congenital dislocation and congenital subluxation in the age group under consideration (children more than eighteen months old). Complete reduction of the hip is an essential prerequisite for innominate osteotomy. In order to achieve absolutely concentric reduction of a complete dislocation in this age group, it is usually necessary to open the joint at the time of operation.

Preliminary traction is essential in a child over the age of eighteen months with a complete dislocation, and the traction should be maintained for a period of at least two to three weeks.

**Technique of Combined Open Reduction and Innominate Osteotomy**

The surgical approach is so designed that the combination of accurate open

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Fig. 23-C

Six and one-half years after open reduction and innominate osteotomy of the right hip.

Fig. 23-A

Case 3. Two-and-one-half-year-old girl with congenital dislocation of the right hip and congenital subluxation of the left hip.
After open reduction and innominate osteotomy of the right hip.

Eight weeks after the first operation and six weeks after innominate osteotomy of the left hip. It was not necessary to open the capsule, for the left hip was only subluxated.

reduction and stabilization of the reduction by innominate osteotomy can be performed through the same incision at a single operation. Blood transfusion is not always necessary, but continuous intravenous infusion is indicated as a precautionary measure if blood should be required. If the hip is subluxated only, it is not necessary to open the capsule at the time of operation, but if there is a complete dislocation, it is best to do the open reduction at the time of innominate osteotomy.

The hip is exposed through a modified Smith-Petersen anterior approach (Fig. 20-A, 5 and 6). The muscles are reflected from the inner and outer aspects of the
iliac crest and the hip joint is exposed (Fig. 20-A, 7). The labrum, or limbus, is not removed, for it is a normal part of the anatomy of the hip (Fig. 20-A, 8). If the hip joint is opened enough anteriorly and medially, the head of the femur can be reduced beyond the labrum which, in turn, adds both depth to the acetabulum and stability to the reduction.

A Gigli saw is drawn through the sciatic notch subperiosteally with a small right-angle forceps (Fig. 20-B, 9). The Gigli saw is the safest instrument for dividing the innominate bone. The osteotomy extends from the sciatic notch to the anterior-inferior spine (Fig. 20-B, 10), and then the osteotomy site is opened up anteriorly but kept closed posteriorly (Fig. 20-B, 11). The bone graft taken from the proximal fragment of the ilium is shaped and placed in the osteotomy site and held with a Kirschner wire (Fig. 20-B, 12).

The capsule of the joint is sutured after any excess has been resected (Fig. 20-C, 13).
Six weeks after open reduction of the right hip and immediately after external rotation-adduction osteotomy of the right femur. (Shortly after this boy’s right hip was operated on, the concept of innominate osteotomy was developed to a point at which the procedure could be done for a living patient.)

Three months after operations on right hip and immediately after open reduction and innominate osteotomy of left hip.

13), and the wound is closed (Fig. 20-C, 14, 15, and 16). It is suggested that the original operative technique, as reported initially 7, be studied carefully and in detail before the operation is undertaken for the first time.

It has been found that a subcutaneous adductor tenotomy and a lengthening of the tendinous portion of the iliopsoas muscle have been of primary importance in the operative technique.

Postoperative Management

Postoperatively, the child’s hip is immobilized in a single hip spica with the hip
Two years after operations. The right hip is still subluxated and there is a recurrence of valgus deformity of the femoral neck.

Four and one-half years after operations. The left hip, which was treated by open reduction and innominate osteotomy, is more satisfactory both clinically and roentgenographically than the right hip, which had been treated by two separate operations, open reduction and femoral osteotomy.

in the position of moderate flexion, slight abduction, and very slight internal rotation. If the capsule of the hip has been opened, it is best to leave on the hip spica for a period of six weeks. Then it is replaced by toe-to-groin plaster casts with an abduction bar to maintain the hips in abduction for four weeks more. After removal of the abduction plaster casts the child may be allowed to start walking, exactly ten weeks after operation.

If the hip is subluxated only and the capsule is not opened, the child can be placed in a hip spica for six weeks. However, if the child is very cooperative, traction can be used for a week or ten days, after which the child can lie in bed for the remain-
After three weeks of continuous traction the position has improved to some extent.

Indications for Innominate Osteotomy

The main indication for innominate osteotomy is the primary treatment of congenital dislocation of the hip in children between the ages of eighteen months and six years and of congenital subluxation of the hip between the ages of eighteen months and early adult life. The operation also is indicated as a secondary treatment for residual or recurrent dislocation or subluxation after failure of other methods of treatment.

Results of Innominate Osteotomy

A detailed follow-up study of the first five years of personal experience with innominate osteotomy will be published in the near future. The results published in
Six weeks after open reduction and innominate osteotomy of the left hip and eight weeks after open reduction and innominate osteotomy of the right hip.

Two years after open reduction and innominate osteotomy of each hip.

the original article (1961) have continued to be satisfactory. Examples of innominate osteotomy for seven patients are shown in Figures 21-A through 27-C.

Summary

The problem of instability of reduction of congenital dislocation and congenital subluxation of the hip has been studied. The basic cause of this instability is the abnormal direction in which the entire acetabulum faces. An operation, innominate osteotomy, has been designed to correct the abnormal direction of the entire ace-
Case 6. A five-year-old boy with congenital subluxation of the left hip. There had been no previous treatment. Note the cystic lesion in the left acetabulum. The boy complained of pain in the hip and he walked with a limp.

The advantages of innominate osteotomy are:

1. Correction of the abnormal direction in which the entire acetabulum faces
provides immediate stability of reduction in the functional position of weight-bearing without altering the congruity of the acetabulum or decreasing its capacity.

2. After innominate osteotomy, the area of articular cartilage of the femoral head and acetabulum in contact in the functional position of weight-bearing is increased considerably because the femoral head is covered better by the acetabulum. As a result, the pressure of weight-bearing is distributed over a larger area of articular cartilage. It is suggested that this may be an important factor in helping

Case 7. A ten-year-old girl who in early life had been treated for several years for congenital dislocation of the right hip. The patient had a marked limp and was beginning to experience pain at the end of the day. There is marked residual subluxation of the right hip.
At the time of innominate osteotomy of the right hip. The capsule of the joint was not opened.

One year after innominate osteotomy of the right hip.

to prevent the degenerative changes in articular cartilage with subsequent function of the joint.

3. Both reduction and stability are provided by a single operative procedure.

4. The stability of reduction permits early resumption of function of the hip, thereby avoiding the undesirable effects as well as the hardships of prolonged immobilization.

5. Early weight-bearing on a completely reduced and completely stable hip
R. B. SALTER: INNOMINATE OSTEOTOMY

seems to provide the best possible stimulus for subsequent normal development of both femoral head and acetabulum.

Since the development of innominate osteotomy in 1957, in our experience the results have been especially encouraging.

References