LATERAL ROENTGENOGRAPHY IN THE DIAGNOSIS AND TREATMENT OF DYSPLASIA/DISLOCATION OF THE HIP

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ABSTRACT: The author emphasizes the importance of true lateral and multiple-position roentgenograms in providing a more comprehensive demonstration of the pathology, the attainment of reduction and the surgical alterations which are necessary to maintain a congruous reduction. A simple convenient technique for lateral roentgenography of the hip in children is presented. A series of cases with roentgenograms is also presented to demonstrate the value of the lateral roentgenograms. The horizontal lateral roentgenogram simulates the position of the upright human stance, and thus, depicts malocclusion, which may be seen when anteversion is present. Even though the anterior view depicts sphericity and apparent coverage, the lateral roentgenogram may show malocclusion which may lead to degenerative changes later in life. It is the author's belief that the treatment of children's hip conditions will show improved long-term results if predicated on the comprehensive x-ray examination outlined in this article.

Laage emphasized the advantages of the true lateral over the more frequently used frog-leg lateral view. The frog-leg view shows a lateral view only of the head and neck of the femur, but the acetabulum still presents an anterior view. The Laage technique shows a lateral view of the neck-head of the femur and the acetabulum, with the former at essentially a right angle to a vertical pelvis. Laage also suggested clinical applications of this view; particularly, anteversion could be demonstrated when present, and also, its disappearance with the same x-ray technique made with the hip inwardly rotated.

I quote from Laage's paper: "The combination of the anterior-posterior and horizontal lateral views is a more complete examination of the hip joint, since this combination is in accord with roentgenographic principle that bones and joints should be examined in at least two planes." To this I would add: Roentgenograms should be made in both anterior and lateral views with the femur in multiple combinations of positions of abduction, flexion and inward rotation in order to demonstrate adequately the components of deformity and the position of the femur which accomplishes reduction.

We are so accustomed to using only anterior roentgenograms of the pelvis in looking for subluxation and dislocation and in checking reduction, that it seems to be outside our comprehension that subluxation and dislocation can be demonstrated also in the true lateral view. These lateral roentgenograms, together with the anterior views in varying degrees of abduction and inward rotation, comprise a multiple-position x-ray technique which provides a much more comprehensive demonstration of the required position that accomplishes reduction, and the surgical correction that is necessary.

Laage and his co-authors described a technique which requires positioning of the patient in a suspended position; the lack of relaxation in this

History and Technique

Historical

Laage et al published their article on "Horizontal Lateral Roentgenography of the Hip Joint in Children" in the Journal of Bone and Joint Surgery in April 1953, in which they presented a technique for a true lateral view of the entire hip joint, which was similar to a lateral projection technique published in 1950 by C.F. Bridgeman of Eastman Kodak Company. These techniques demonstrate a lateral view of the hip joint very similar to that which is made with pinning fractures of the neck of the femur.

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position is evident in the photograph (Fig. 1) from their publication.

This author believes that it is preferable to have the patient flat with the hip extended (not hyper-extended) for the first lateral roentgenogram; this simulates the upright human stance. The pelvis should not be flexed on the head of the femur; if flexion is needed to give congruity, the femur should be flexed on the pelvis—this demonstrates the degree of flexion deformity to be corrected (Fig. 17C).

It is the purpose of this paper to present a variation of technique for lateral hip roentgenograms in children which is easier for the patient and the x-ray technician, and more serviceable for interpretation.

**Technique**

The patient is positioned flat in a supine position on a small platform placed on the x-ray table with both legs parallel and with knees straight forward, and the ankles about 3 inches apart. A cassette is placed lateral to the patient’s hip at a 45° angle, with the upper edge against the body at approximately the lowest rib. The leg not to be x-rayed is then abducted or flexed as far as necessary to permit the x-ray tube to be directed at a right angle to the cassette, so that the roentgen passes directly through the femoral head. Care is taken not to tip or angle the pelvis (Fig. 2-13, inclusive).

A grid cassette is recommended in order to obtain the maximum bone detail, although the increase in time necessary does occasionally cause a problem if a child is uncooperative. In these cases it has been found that the quickest, simplest method, and the one least likely to upset the child, is to have two adults, preferably the parents, hold the child: one standing at the head holding the torso flat, and one holding the legs. The sight and feel of a familiar person serves to reassure and calm the child.

**Technical Factors**

A 12:1 grid cassette, high speed screen (HSS) and R.P. Film are key technical factors.

**Clinical Advantages of Lateral Hip Roentgenograms in Children**

**Demonstration of Anteversion**

The normal hip of a child without anteversion, taken with the above technique, is shown in Fig. 14; a "few" (5-10) degrees of anteversion are normal and acceptable. Abnormal (excessive) anteversion is
Fig. 4: The base of the cassette holder.

Fig. 5: The upright portion of the cassette holder.

Fig. 6: The upright portion of the cassette holder is being set into the base of the holder.

Fig. 7: The x-ray cassette is being slipped into the upright portion of the cassette holder.

Fig. 8: The assemblage for the cassette holder and the cassette is shown placed under the platform.

Fig. 9: View of Fig. 8 as seen from above.
shown in Fig. 15A, with some lack of coverage of the anterior portion of the head; the antversion disappears with inward rotation (Fig. 15B).

Demonstration of Flexion Deformity

There is more than antversion and its position of correction that is demonstrable in the true lateral roentgenogram. Even when the hip is inwardly rotated to its maximum, the lateral roentgenogram occasionally will show apparent antversion still to be present, with perhaps some uncoveredness or the anterior portion of the head (Fig. 16). Force should not be used to accomplish more inward rotation; rather, the hip should be flexed in addition to the inward rotation until, with his combination of flexion and inward rotation, the neck and head are essentially at a right angle to the acetabulum and concentrically seated in it. The amount of flexion of the inwardly rotated hip which is necessary to produce a normal neck-head-acetabulum relationship is interpreted as a true osseous flexion component of the shaft-neck angle, and indicates the amount to be corrected by osteotomy.

Apparent Absence of the Femoral Capital Epiphysis

Lateral roentgenograms often will help to explain an apparent absent epiphysis (Fig. 17A) which is not visible in the regular anterior views. A lateral roentgenogram often will show that the epiphysis is present on an antverted neck, with incongruity and deformity (Fig. 17B). Additional lateral roentgenograms made with various combinations of flexion and inward rotation show which position gives the better joint apposition (Fig. 17C).

Comment: This importance of the lateral roentgenogram in various positions is emphasized by the above series of roentgenograms, and indicates the following: that the femoral capital epiphysis was not absent, but had developed in a deformed manner because of malocclusion and incongruity; that the neck and head should remain in the position demonstrated in the lower roentgenogram; and the direction and leverage of the shaft should be altered by an intertrochanteric osteotomy to produce outward rotation and extension of the distal fragment.

The “total avascular necrosis” cases presented by Westin may have shown some epiphyseal remnants, and Salter’s criteria for total avascular necrosis (which Westin quotes) may have been more fully demonstrated and explained if lateral roentgenography had been studied. Also, if the reduction and incongruity had been checked during the treatment stage by comprehensive x-ray studies, the “avascular necrosis” may have been prevented.

Lateral Roentgenograms

Although pelvic osteotomies may produce coverage in the anterior view, lateral roentgenograms occasionally show that it is inadequate in the lateral view (Fig. 18).

Migration of the Femoral Capital Epiphysis

I have previously described the phenomena of migration of the femoral capital epiphysis. This is
Fig. 12: Photograph from above showing the patient in place on the platform with the cassette resting against the lower ribs at 45°. The hip to be x-rayed is maintained in the position of neutral rotation and neutral abduction-adduction. The other hip can be adducted and/or flexed in order to get this extremity out of the way of the x-ray tube. Care must be taken not to rotate or tilt the pelvis with leverage of this extremity.

Fig. 13: This view is taken from the x-ray cassette toward the x-ray tube, showing the hip to be x-rayed with the extremity in the neutral position and the opposite extremity is out of the way by abduction.

Fig. 14: A normal roentgenogram of the hip joint is shown by the technique described in this article. The pelvis is always vertical or nearly vertical, with the iliac crest in the superior part of the picture. There is usually a few degrees of anteversion in all children’s hips. The head rests concentrically in the acetabulum, is well-covered anteriorly and the metaphyseal line is vertical and nearly straight.

Fig. 15A: Roentgenogram depicts excessive anteversion, with “uncoverage” of the anterior portion of the head.

Fig. 15B: The same lateral technique is repeated with the extremity inwardly rotated, which then presents the appearance of a normal shaft-neck-head relationship to a vertical pelvis.
Fig. 16: The superior roentgenogram shows apparent anteversion in this infant. Inward rotation (middle roentgenogram) attempts to correct this anteversion, but does not materially improve the appearance. However, if combined flexion and inward rotation (lower roentgenogram) are used together, the neck and head point at right angles to the acetabulum. This series of roentgenograms indicates more of a true osseous flexion deformity than excessive anteversion. These roentgenograms also emphasize the importance of maintaining the infant's hip in a flexed position. It is difficult and usually unnecessary to use this technique on an infant because the cartilaginous portions of the head and pelvis are difficult to outline.

Fig. 17A: This 5-year-old child had been watched for a period of time with anterior roentgenograms and with a diagnosis of congenital absence of the femoral capital epiphysis.

Fig. 17B: The appearance of the hip with the lateral roentgenogram technique shows marked anteversion and a vestige of a deformed femoral capital epiphysis.
Fig. 17C: The two roentgenograms demonstrate that the combination of flexion and inward rotation produces a right-angle relationship on the neck-head with the acetabulum. The importance of the lateral roentgenogram in various positions is emphasized by the above series of roentgenograms and indicates the following: that the femoral capital epiphysis was not absent, but developed in a deformed manner because of malocclusion or incongruity, that the neck and head should remain in the position demonstrated in the lower roentgenogram and the direction and leverage of the shaft should be altered by an intertrochanteric osteotomy to produce outward rotation and extension.

Fig. 18: A lateral roentgenogram made of a hip which had had an innominate osteotomy done in an effort to cover a deformed neck-head. A series of roentgenograms was made like those in Fig. 17, which showed that to place the head in better relationship with the acetabulum and provide better coverage, a derotation-extension osteotomy was necessary. The osteotomy was done at the time the K-wire was removed.

Fig. 19: Anterior view of the pelvis shows flattening and widening and shortening of the left neck and head in this case of Perthes' disease. The lateral roentgenograms of the right and left hip are shown in the lower portion. Note that the right hip shows a normal appearance in both the anterior and lateral views. The lateral view of the deformed left hip is very instructive, showing how—and probably why—this deformity occurred: the direction of the neck indicates that marked anteverision existed, but that the head remained concentric by migrating posteriorly to stay in the acetabulum. This author believes that when an early stage of migration is apparent in cases of Perthes' disease and CDH with anteverision, an osteotomy should be done early to prevent the deforming changes exhibited above.
demonstrated in Fig. 19, 20A and B and 21. Note that the migration is accomplished by the metaphyseal line becoming curved—it is no longer straight; except that the weight-bearing portion under the central portion of the acetabulum is relatively straight. Early migration in the dislocating/subluxing antverted femur may be considered an indication for correcting excessive anteverision. This migration is seen in congenital dislocation of the hip (CDH), Perthes' disease and slipped femoral capital epiphysis (Fig. 22).

**Demonstration of Congruity or Reduction in the Lateral View**

True lateral roentgenograms supplement anterior views in showing whether a surgical procedure has produced concentricity, congruity and coverage (Fig. 21).

It cannot always be relied upon that reduction is maintained after seating of the head with surgical observation; it may appear so in the anterior view, but
Fig. 22: Anterior and lateral views of a slipped femoral epiphysis. The true lateral views demonstrate that the main slippage of the epiphysis has been posteriorly with the metaphyseal line changed from a near-straight line to more of a curve. Because of the outward rotation of this extremity, the amount of anteversion seen in this lateral view is not indicative of the actual amount of anteversion that exists.

Fig. 23A: A lateral roentgenogram of the hip made in a cast (with windows cut) after an open reduction and Pemberton procedure shows that the head is posteriorly displaced from the acetabulum. The anterior view showed apparent normal positioning.

Fig. 23B: The position of the head in relation to the acetabulum after removal of the cast, manipulation and recasting.

Fig. 24A: This is an AP roentgenogram of the hip of a 20-year-old female who had been treated for a toeing-in-gait, without attention to the hip. Examination showed marked inward rotation of the hip with outward rotation limited to approximately 10°. Anterior roentgenograms of the hip made in positions of abduction and inward rotation showed congruity and coverage. Note that the cyst in the head of the femur is at the point of maximum and abnormal weight-bearing.

Fig. 24B: The area of flattening in the head is also at the point of maximum weight-bearing under the lateral margin of the acetabulum. This flattening and its relationship to the acetabulum with weight-bearing is not apparent except by this lateral technique (this view is distorted because of difficulty in placing the hip properly).
a lateral view may show that reduction has not been maintained (Fig. 23A and B).

**Demonstrations of Areas of Wear**

Lateral roentgenograms show that the area of wear in dysplastic hips usually occurs on the restricted area of weight-bearing on the anterior-superior portion of the femoral head (Fig. 24A and B and Fig. 25). This conforms with the findings of Craig et al.\(^5\)

**Summary**

There is a definite need for normal and abnormal criteria in the lateral roentgenographic views of the hip joint. On page 132 of Vernon Hart’s\(^8\) book on CDH is a diagram showing the various lines and angles which have been described to indicate and measure pathology in hip dysplasia—a total of 17; and more have been described since Hart’s publication.\(^7\) But essentially, there has been no study of the normal and abnormal landmarks in the true lateral roentgenograms of the hip. This author presents a possible method of measuring and expressing deformity of the femoral neck in the lateral view, in Fig. 26A and B; perhaps this may stimulate other authors to develop a better method. Can we arrive at a time when we

**Fig. 25:** This blow-up of a lateral view is of a painful hip of an 11-year-old girl who had had a frog-leg reduction at two years of age; it shows the pathology causing her pain: uncorrected anteversion with excessive wear and degenerative changes on the restricted area of weight-bearing at the point of contact of the head with the anterior-superior margin of the acetabulum. This osteochondritic body healed and the patient’s symptoms were relieved with a varus-derotation osteotomy.

**Fig. 26A:** The following landmarks are made on the lateral view of the hip joint: three points are located in the middle of the neck, using a rule for accurate measurement: (1) near the epiphysial line; (2) in the middle; (3) at the base. These three points are then connected with a line which extends proximally into the head; this line is designated as “A.” A second straight line is drawn across the neck of the femur connecting the margins of the epiphysial plate; this is designated as line “B.” A third line “C” is drawn at a right angle from line “B” where it crosses line “A” to the vertex of the head. The angle formed between line “A” and line “C” is called the neck-head angle. In many cases there will be no angle because line “C” superimposes on line “A”; if an angle is present in the normal cases, it is usually not over 2 or 3°.

**Fig. 26B:** This angle will serve to measure shifting of the epiphysis with widening of the head and neck. In applying this method to abnormal hips, line “B” is drawn along the epiphysis in its straightest portion, and so that it includes or superimposes on the maximum extent of the epiphysial plate. Line “C” is then drawn as described in Fig. 26A: at a right angle from line “B” where it crosses line “A.” The angle will be greater where there has been considerable posterior migration of the epiphysis, and most of the weight-bearing portion of the head will be posterior to line “C.” It is also to be noted that line “C” extends along the long axis of the shaft and into the highest point of the epiphysis and parallels the weight-bearing line. The setting of the migrated head on the weight-bearing line is better demonstrated by line “C,” drawn parallel to line “C.” (Note: It is recognized that there may be difficulty on some roentgenograms in establishing the points and lines in the above method, but not more so than in determining the acetabular index and C-E angle.)
accept that a certain angle in a migrating head indicates that we should use surgical intervention to produce a remodeling that nature is trying to accomplish?

This author doubts that any of the present methods of x-ray evaluation of the results of treatment of congenital dislocation/dysplasia of the hip provide the full explanation of the results, especially the bad results. I believe that the universal use of the lateral view and careful study and interpretation of what it can reveal offers opportunity and hope in this regard. It follows that true lateral roentgenography should be a part of the diagnosis and treatment of congenital hip dysplasia/dislocation, and any results analysis should be based on criteria which includes lateral roentgenography.

References