4 Imaging Examination and Measurement of the Hip Joints

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4.1 Imaging Examination of the Hip Joint

Ever since the German physicist W.C. Roentgen discovered the X-ray in November 8, 1895, and used it in the clinic, the diagnosis of bone the joint diseases has been greatly improved. An imaging examination of the hip joint plays an important role in the diagnosis and differential diagnosis of hip joint diseases. The most commonly used types of imaging examinations of the hip joint include X-ray, CT, and MRI.

4.1.1 X-Ray Examination of the Hip Joint

An X-ray imaging of the hip joint is simple and cheap, also it can indicate joint space, articular surface, and the whole image of the hip joint. The most common forms of X-ray imaging are anteroposterior films, lateral films, frog films, posteroanterior oblique films, oblique obturator films, and ilium oblique films.

X-ray radiography has succeeded in digital imaging technology; it is divided into two categories, one of them directly translates the X-ray signal into a digital radiography (DR) system, the other indirectly translates the X-ray signal into a digital signal computed radiography (CR) system. The advantages of DR and CR are: First, the resolution of images is improved. Second, multiple functions can be processed, and better storage management becomes convenient in the later stages, Third, images post-processing can be carried out according to the diagnostic needs, and can show bone tissue, articular soft tissue, and so on, so the disease detection rate is increased.

4.1.1.1 Anteroposterior Films of the Hip Joint

With the patient in the supine position, straighten the legs, 2 feet keep internal rotation 15 degrees and draw toes together, the tube center aims at the femoral head and is perpendicular to the inguinal plane. This position can indicate the frontal images of the hip joint, the femoral head, neck of the femur, greater trochanter and lesser trochanter, upper femur. In order to compare the diseased side with the healthy side, anteroposterior images of the hip joint are often replaced by anteroposterior images of the pelvis or anteroposterior images of the bilateral hip.

4.1.1.2 Lateral Films of the Hip Joint

With the patient in the supine position, raise the diseased hip up to the same height as the midline of the detection line, straighten the diseased leg, keep abduction and internal rotation, keep contralateral hip and knee flexion, the patient holds the legs with hands so that the thigh is perpendicular to the ground. The tube center horizontal line aims at the neck of femur and is perpendicular to the cassette. This position can indicate the lateral images of the femoral head, neck of the femur, greater trochanter, and lesser trochanter.

4.1.1.3 Frog Films of the Hip Joint

Do not take frog films for a suspected hip fracture or hip joint dislocation. When taking frog films, with the patient in the supine position, keep bilateral hip and knee flexion, draw feet together, and keep two thighs at maximum abduction. The tubing center aims at the midpoint of the femoral head on both sides. This position can indicate the frontal images of two acetabulum and the lateral images of the bilateral neck of the femur.

4.1.1.4 Posteroanterior Oblique Films of the Hip Joint

The posteroanterior oblique films of the hip joint are of great value in detecting the posterior dislocation of the femoral head. Patients with prone position, contralateral hip raise 35–40 degrees, knees and elbows are bent to support the body. The hip that is detected aims at the middle line of the cassette, and greater trochanter aims at the film center. The shoot is perpendicular to the cassette. This position can indicate the oblique images of the hip joint, ilium, and upper femur.

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C. Zhang (ed.), *Hip Surgery*, https://doi.org/10.1007/978-981-15-9331-4_4

4.1.1.5 Obturator Oblique Films of the Hip Joint

The patient is in the oblique supine position. Namely, the coronal plane of the patient's body keep 45 degrees with bed, the detected hip is above. The contralateral hip and knee are supported by cotton pads on the back. Horizontal shoot, namely, the tube centerline which is coming in from the midpoint of the connection between the superior ramus of the pubis and the inferior ramus of the ischium aims at the hip joint. Obturator oblique films of the hip joint are mainly used to indicate obturator, iliopectineal line, anterior hip column, and posterior acetabular margin.

4.1.1.6 Ilium Oblique Films of the Hip Joint

The patient is in oblique supine position, the detected hip is below, the coronal plane of patient body keeps 45 degrees with bed, place the cassette horizontally and directly face the hip joint, the tube centerline which is coming in from the anterior internal hip joint is perpendicular to cassette, aiming at the hip joint shooting. Ilium oblique films of the hip joint can indicate the whole ilium wing crista iliaca, posterior hip column, and anterior acetabular margin.

4.1.2 CT Examination of the Hip Joint

The CT plain scan and contrast enhancement are often used for hip joint CT. All CT examination is plain scan first. Some complex diseases need CT contrast enhancement, like a tumor or vascular disorders. Computed tomography (CT) shows the sectional anatomical image, no structural overlap, the density resolution is significantly higher than that of the X-ray plain. The multi-slice CT (MSCT) further improvers the temporal and spatial resolution, which greatly improves the detecting rate and diagnostic accuracy of osteoarthropathy [1], it can carry out post-processing techniques such as multi-plane reconstruction, surface overlay display and volume display at the same time, and we can know the location, border, and relationships with surrounding organizations from multi-sections. The structure of a hip joint is complex, the plain X-ray has limited ability to diagnose acetabular fractures or hip joint lesions due to overlapping. CT can significantly improve the diagnostic accuracy (Fig. 4.1).

Spiral three-dimensional CT reconstructs bone structure, which can display the three-dimensional structure of the hip joint and the lesions involved area. For example, three-dimensional CT reconstruction can observe the head of the femur and acetabula, respectively, which can display the relationship of the acetabula and head of the femur; otherwise, hip joint three-dimensional CT can provide data for three-dimensional printing implants [2]. It is of great significance to the diagnosis of disease and the design of preoperative surgery (Fig. 4.2).

During the CT examination, the patient should take the supine position and try to maintain the left and right symmetry.

Fig. 4.2 shows the boundary of the tumor on the medial side of the left acetabular, the damage to the bone cortex and the relationship with the surrounding tissue can be observed.

4.1.3 MRI Examination of the Hip Joint

Magnetic resonance imaging (MRI) is an examination technique that relies on the mission of hydrogen protons, with no radiation damage. Different tissues of bone and muses system have different hydrogen protons, and relaxation time, different signal intensities are generated, and images are formed by forming different gray scales after computer processing. The advantage of MRI is the high resolution of soft tissue, multi-parameter imaging, multi-directional imaging, such as cross

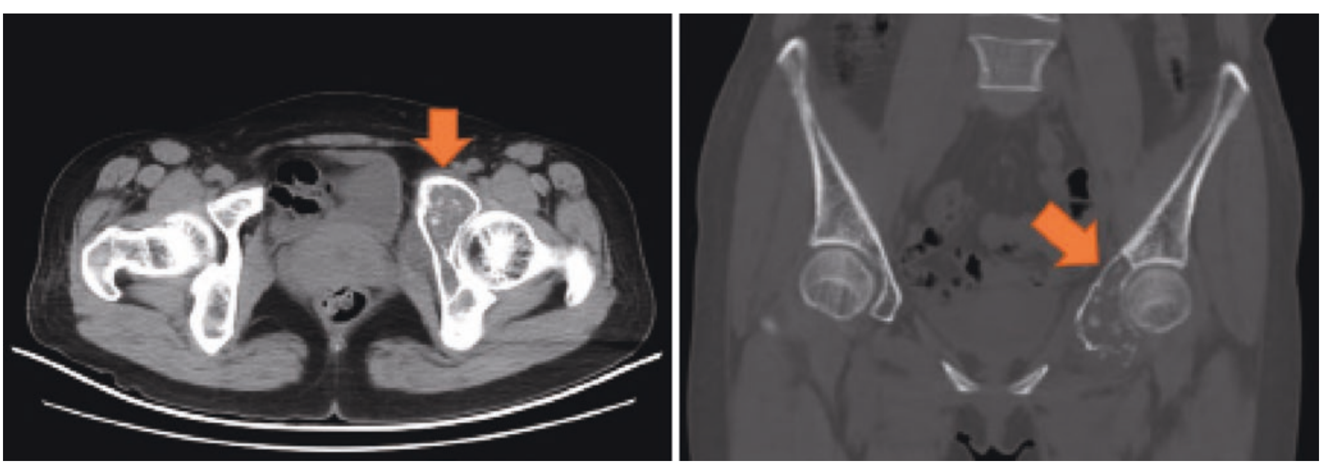

Fig. 4.1 Axial and coronal CT

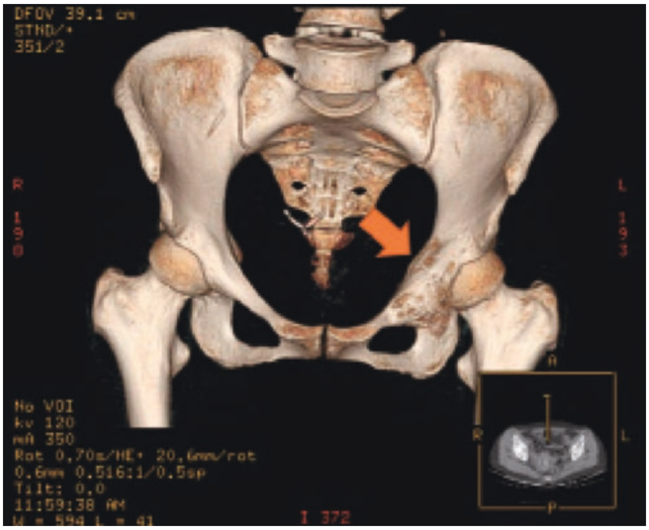

Fig. 4.2 Three-dimensional reconstructive CT

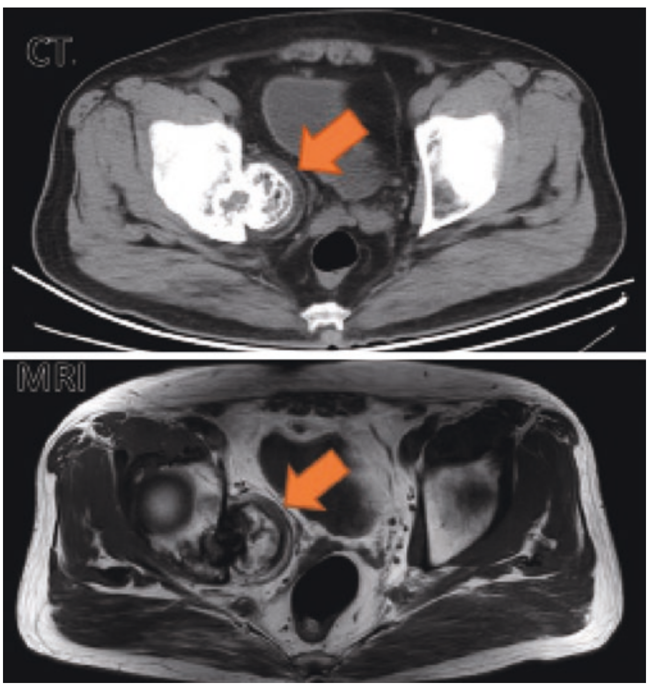

Fig. 4.3 CT and MRI of right acetabular tumor

section, coronal plane, sagittal plane, or any angle, MRI can sensitively detect changes in water content in tissue components and lesions earlier than X-ray and CT (Fig. 4.3).

Compared with CT, MRI can clearly show the condition of the surrounding tissue reaction zone of the tumor and the relationship between tumor and surrounding muscle, blood vessels, nerve, and other soft tissue structures.

During the hip joint MRI examination, the patient's position is the same as that of CT examination, supine position and toes contact are adopted to keep the body as symmetrical as possible.

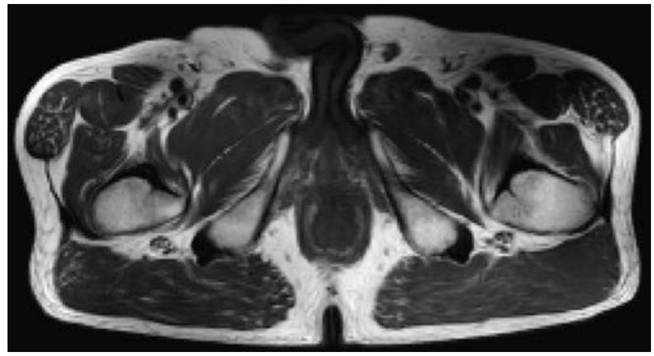

Fig. 4.4 Cross section of the femoral lesser trochanter

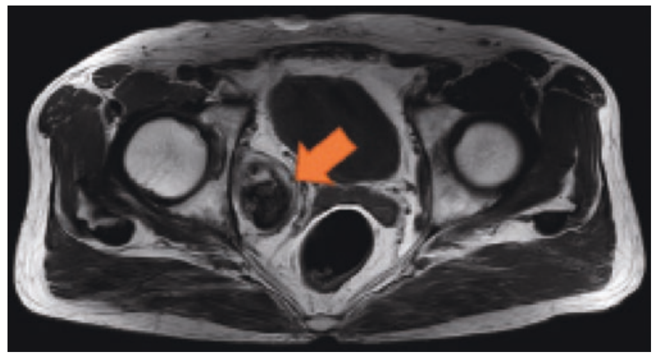

Fig. 4.5 Cross section of the femoral head

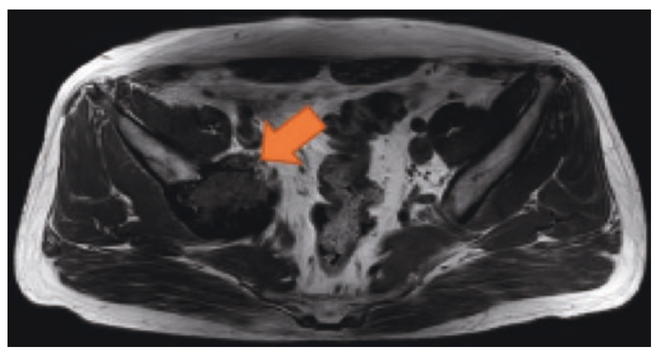

Fig. 4.6 Cross section of the upper acetabulum

MRI has good soft-tissue resolution and the advantage of multiple sequence imaging, it not only can display that the articular cartilage, ligaments inside and outside joints, intervertebral disc, and bone marrow, it can also reflect some of the pathological changes that CT cannot, such as edema of soft tissue and bone marrow cavity, bone contusion, muscle tear, the change of the bone marrow, and the injury and degenerations of tendons, ligaments and cartilage, and so on. MRI is the preferred examination method for joint lesions and an effective method for preoperative staging and efficacy observation of bone tumors (Figs. 4.4, 4.5 and 4.6).

Fig. 4.5 show that the right acetabular medial tumor can be seen, and the signal is uneven.

Fig. 4.6 shows that the tumor destroys the iliac bone and bulges into the pelvis.

4.2 II. X-Ray Measurement and Parameters of the Hip Joint

4.2.1 Hip Parameters

4.2.1.1 Shenton Line (Menard Line)

A continuous arc between the medial margin of the femur neck and the upper margin of the ipsilateral obturator foramen. The integrity of this line disappears with hip subluxation and dislocation. It can also be used to evaluate the position of the prosthesis (Fig. 4.7).

4.2.1.2 Calve Line (Iliac Neckline)

The arc of the outer margin of the ilium and the outer margin of the femur neck, it can reflect the relationship between the femoral head and the acetabulum, and the integrity of the upper margin of the acetabulum (Fig. 4.7).

4.2.1.3 Skinner Line

Anteroposterior films of the hip joint in adults, the line between the upper margin of the greater trochanter and the crypt which round ligament of the head of the femur attach, the angle with femoral stem central axis is 90 degrees in adults. The Dislocation fractures of the neck of femur or greater trochanter will lead to Skinner line exceed the round ligament fossa (Fig. 4.8).

Skinner line goes through the apex of the femoral greater trochanter and the acetabular round ligament fossa, and is perpendicular to the axis of the femoral shaft.

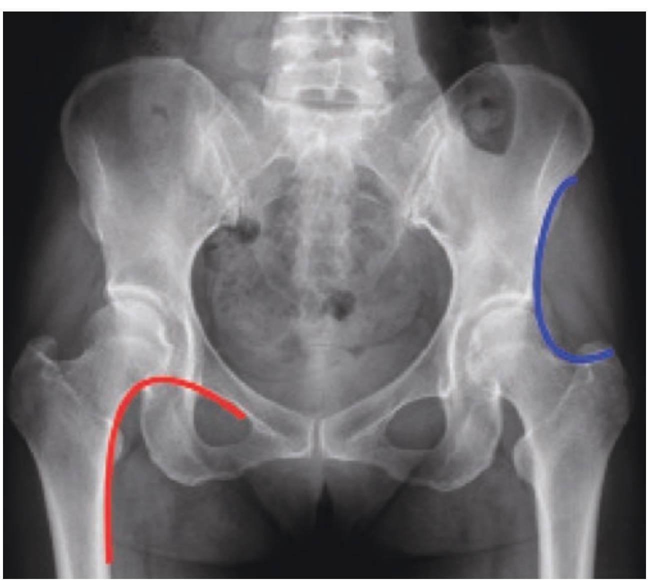

Fig. 4.7 Shenton line (red line) and Calve line (blue line)

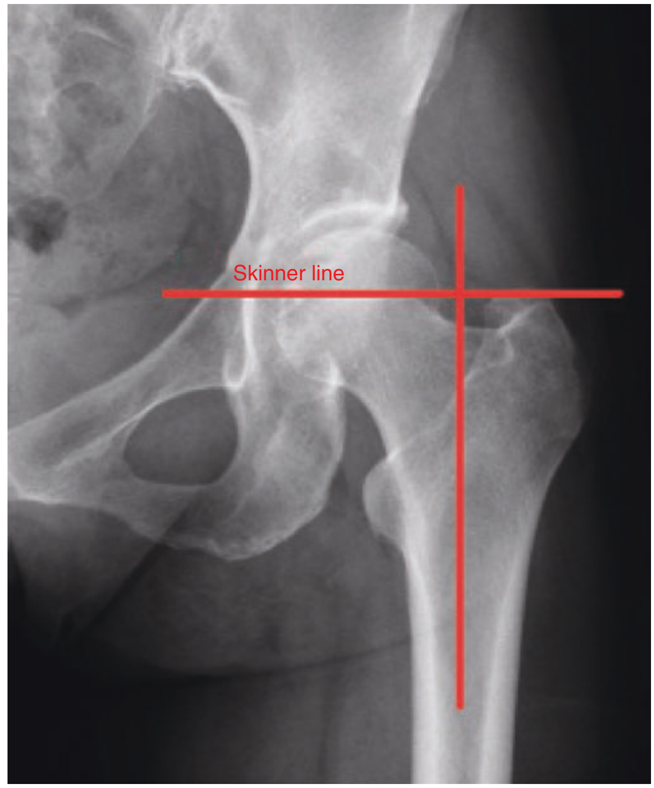

Fig. 4.8 Skinner line

4.2.2 Proximal Femur Parameters

4.2.2.1 Neck-Shaft Angle

On the AP films of the hip joint, draw the femoral shaft axis and the femoral neck axis, respectively, the Angle between the two lines intersecting on the medial side is the neck-shaft Angle (NSA). The normal range is 110–140 degrees (Fig. 4.9), more than 140 degrees is coxa valga, and less than 110 degrees is coxa vara.

4.2.2.2 Femoral Neck Anteversion

The angle between the neck of the femur axis and the human coronal plane. Femoral neck anteversion **(FNA)** is 12–15 degrees in adults (Fig. 4.10).

4.2.2.3 Femoral Offset

It is the vertical distance between the center of the femoral head and the axis of the femoral shaft, which is an important reference index for the reconstruction of hip joint biomechanics. The recovery of femoral offset by hip replacement is very important to balance the tension of the soft tissue of the hip joint (Fig. 4.11).

Normal value is 110 ° ~ 140 °.

Femoral neck anteversion is 12–15 degrees for adults.

Femoral offset is the vertical distance between the center of the femoral head and the axis of the femoral shaft.

Fig. 4.9 Neck-shaft angle

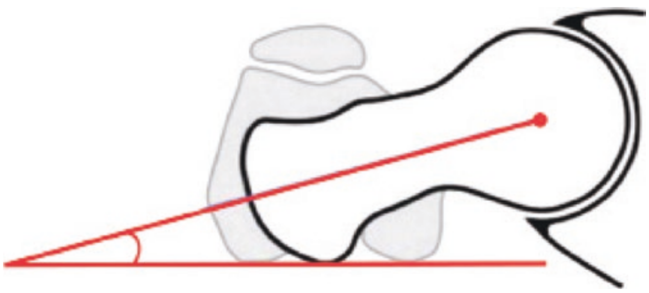

Fig. 4.10 Femoral neck anteversion

4.2.3 Acetabular Parameters

4.2.3.1 Center Edge Angle (CEA)

On the AP films of the pelvis, it is an angle formed by the line which is between the center of the femoral head and the external superior margin of the acetabulum with the vertical line at the center of the femoral head. The normal range is 22 degrees for 2 years old, 28 degrees for 4 years old, 30 degrees for 6 years old, and 35 degrees for 15 years old (Fig. 4.12). This angle reflects the relationship of the acetabulum and the femoral head; it is an important index to determine the stability of femoral head in acetabular fossa. When acetabular dysplasia, dislocation of the hip joint, shape change of femoral head, and external movement of the femoral head, this Angle decreases.

4.2.3.2 Acetabular Index

It is a method to determine the depth and inclination of the acetabulum, that is, the Angle formed between the central line of bilateral y-shaped cartilage and the line which is between the upper margin and the lower margin of the acetabulum. The normal range is 30 degrees for newborn, 20 degrees for 2 years old, 10 degrees for adults (Fig. 4.13). To some extent, the acetabular index reflects the inclination of the acetabular stress surface. The higher the index, the more likely the dislocation of the hip joint will occur. Acetabular index plays an important role in the treatment and prognosis of developmental dysplasia of the hip (DDH).

4.2.3.3 Sharp Angle

On the AP films of the pelvis, the angle between the line of the lower margin of the bilateral tear drops and the line from the lower margin of the tear drop to the upper margin of the acetabulum. Normal angle is 33–38 degrees. When the angle

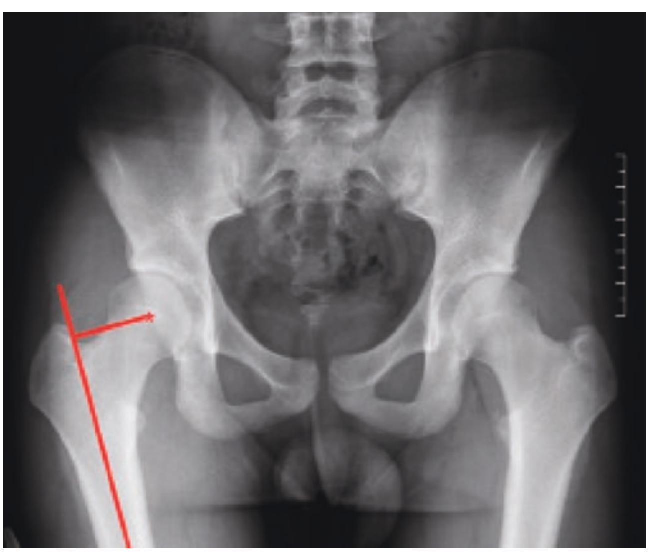

Fig. 4.11 Femoral offset

Fig. 4.12 Acetabular center edge angle

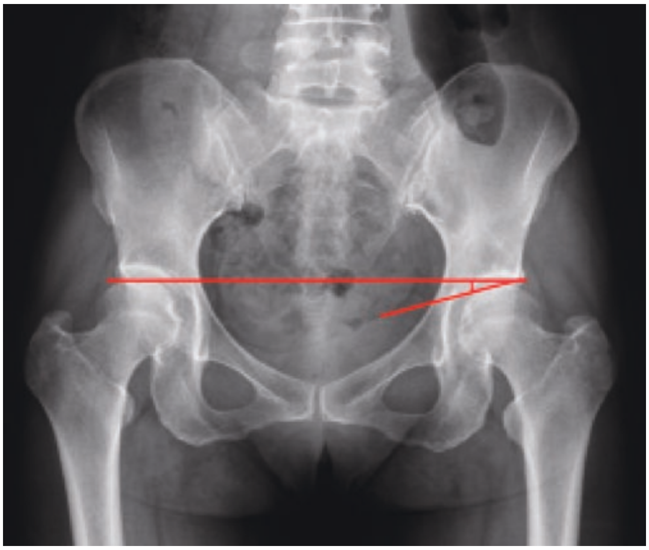

Fig. 4.13 Acetabular index

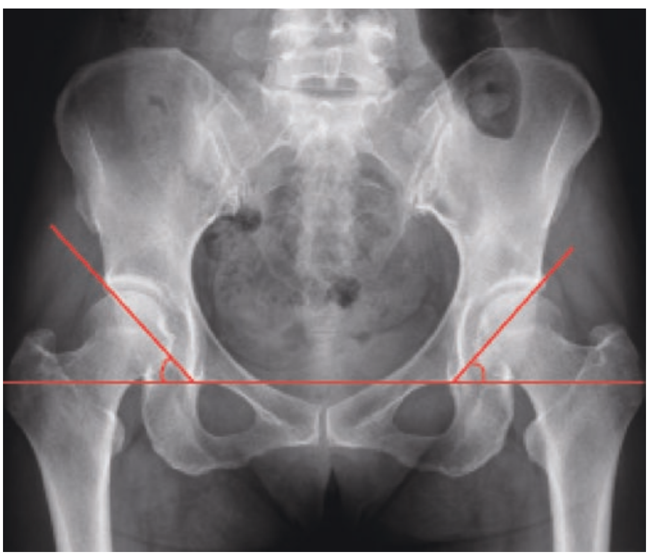

Fig. 4.14 Sharp angle

is greater than 40 degrees, it can be diagnosed with acetabulum dysplasia (Fig. 4.14).

4.2.3.4 Kohler Line (Nelaton)

The double tangential line between the inner margin of the ischium and the inner margin of the ilium, which represents the medial border of the acetabulum, Acetabular invagination or hip joint replacement when the bone mill file is too deep the acetabulum comes down to the medial side of the line, it is used for the evaluation of prosthesis depth in hip arthroplasty (Fig. 4.15).

Fig. 4.15 Kohler line

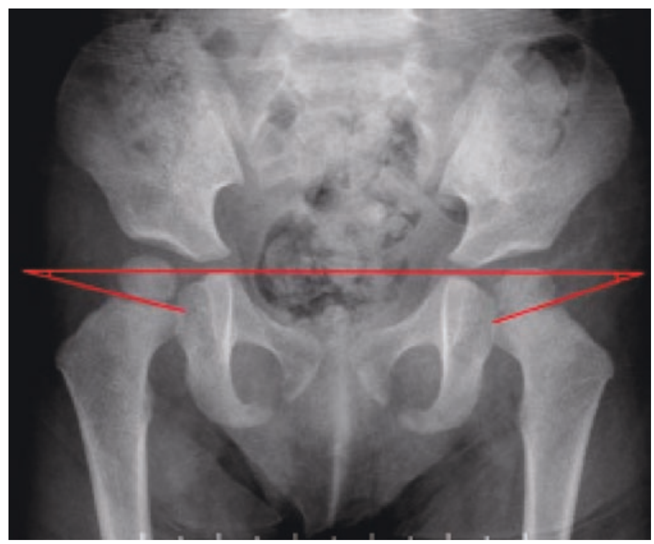

Fig. 4.16 HE angle

4.2.3.5 HE Angle

The angle between the line of the bilateral acetabulum and the extension line of the epiphyseal plate of the femoral head, normal range is about 25 degrees, HE angle is greater than 25 degrees when coxa vara. Continuous measurement of HE Angle can be used to understand the progression of coxa vara (Fig. 4.16).

4.2.3.6 Perkin Grid

The P-line is made from the outer upper margin of the acetabulum and is perpendicular to the Y-line which is the line

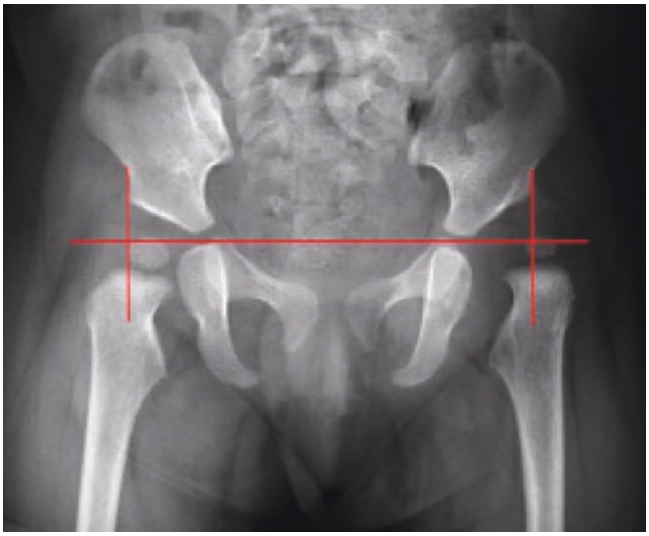

Fig. 4.17 Perkin grid

of the bilateral acetabulum. The P-line and Y-line divide the acetabular area into four quadrants. The normal epiphyseal center of the femoral head is located in the inner and lower quadrant, if the center of ossification moves out-and-downward or out-and-upward of the quadrant represents the dislocation of the hip joint (Fig. 4.17).

References

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