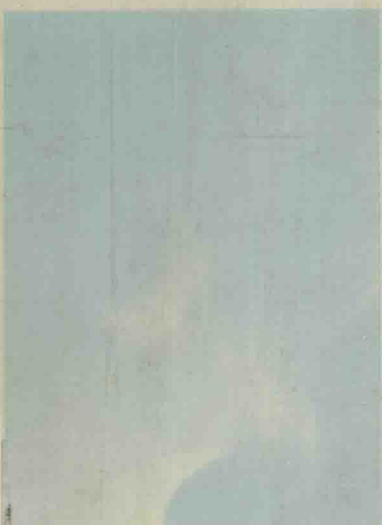
Diagnostic Radiology of the Sacroiliac Joints

Wolfgang Dihlmann

Translated by Lorenz S. Michaelis

With the Assistance of Margaret M. Clarkson

258 Illustrations



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Preface

The first edition of this monograph was so well received by the reader that both the publisher and myself decided to publish the second edition in the English language. In this way, information about diagnostic radiology of the sacroiliac joints can be made available to even more interested readers.

The first edition was completely revised, relevant new literature was added, a few illustrations were changed, and considerable new material was included.

Both the text and the illustrations point out the special position which the sacroiliac joints occupy among the joints of the human organism. This special position is based on at least three factors:

1. The sacroiliac joints occupy a key position for the diagnosis of some pathologic processes, e. g., ankylosing spondylitis.
2. In many respects, these joints react differently from other joints, e. g., pseudowidening of the joint space, multi-faceted sacroiliac x-ray picture.
3. Pathologic alterations are found in the sacroiliac joints which are unknown in other joints of this type, e. g., the various types of damage to the capsule-ligament system due to excessive strain, hyperostosis triangularis ilii.

By using illustrations of gross specimens and micromorphologic and pathologic findings, an attempt was made to clarify these sometimes little known alterations for the reader more thoroughly than would have been possible with the use of radiographs alone.

Hamburg, 1979 Wolfgang Dihlmann

Contents

Introduction

Morphologically, the sacroiliac articulations are true joints (**diarthroses**) containing articular cartilage, a joint space, a capsule with synovial and fibrous components (Fig. 1), as well as capsular ligaments for additional reinforcement. Physiologically, however, they normally permit only a **very slight** amount of movement. This can be demonstrated on the course of the sacrum which narrows distally. The individual levels of the auricular surfaces are displaced slightly against each other (Fig. 3). Movement is inhibited by the interconnections of the articular surfaces. These interconnections are further reinforced by surface irregularities which, in the adult, may rise several millimeters beyond the level

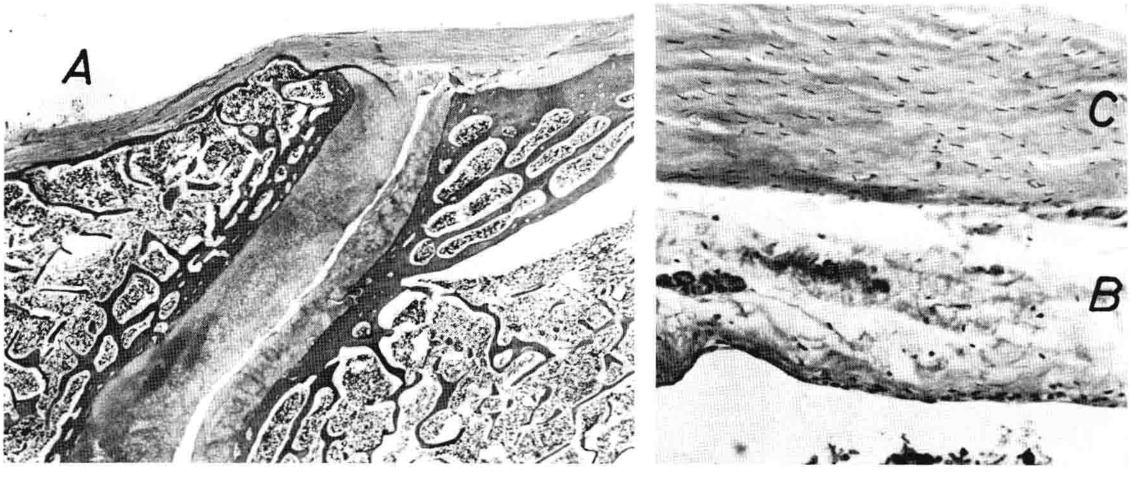

Fig. 1. Transverse section through right sacroiliac joint (*A*). *Hyaline cartilage* on both sides of the joint space. On the sacral aspect, almost 3 mm thick; on the iliac aspect, up to 1 mm wide.
Enlarged segment of *anterior joint capsule*: Loose *synovial membrane* with lining cells (*B*). Poorly vascularized, taut *fibrous membrane* (*C*), is the continuation of the periosteum of the pelvic bones.

the anatomical specimen and in the living subject (Weisl 1955, Colachis et al. 1963, Frigerio et al. 1974). These joints, therefore, are known as "tight joints" or **amphiarthroses**. The auricular surfaces of the ilium and the sacrum are covered with articular cartilage. This ear-shaped articular cartilage extends over the first and second segments of the sacrum and frequently also over the third segment. The layer of cartilage is usually somewhat thicker on the sacral side than at the ilium (Fig. 2) and may be several millimeters thick. Sacral cartilage is always composed of hyaline, while iliac cartilage sometimes consists of fibrocartilage.

The ear-shaped articular surfaces of the joints follow of the articular surfaces. Frequently, a pronounced iliac bulge (Fig. 4) is present in a corresponding depression of the sacrum.

In the direction of the pelvis, the synovial membrane, which contains very few villi, inserts into a tight fibrous capsule. This capsule is reinforced by the anterior sacroiliac ligaments and by bundles of fibers from the iliolumbar ligament in the superior segment of the joint. The fibrous anterior joint capsule is attached to the **paraglenoid (juxta-auricular) sulcus** of the ilium and sacrum (Löhr 1894, Fick 1904). This sulcus may vary in width, depth, or length (Figs. 5, 6, 7) and, therefore, is not always pronounced enough to be identified radiologically at

Fig. 2. The so-called *vacuum phenomenon* (→) shows that the articular cartilage of the sacrum is frequently some what thicker than that of the ilium (see also microscopic section, Fig. 1).

the arcuate line or at the **superior** margin of the joint. The **paraglenoid foramen** develops from ossification processes at the edges of this sulcus (Fig. 5).
At the posterior aspect of the joint, the synovial membrane follows the interosseous sacroiliac ligaments which are stretched in the retroarticular space. The interstices of these ligaments are filled with loose vascular, connective, and fatty tissue. These strong ligaments insert in the posterior sacroiliac ligaments and the distal sacrospinous and fan-shaped sacrotuberous ligaments.

The sacrospinous and sacrotuberous ligaments primarily provide cushioning resistance to the slight amount of physiologic movement in the sacroiliac joints.
The gluteus maximus also inhibits the movement of the sacroiliac joints. This muscle originates at the sacrum and at the ilium. When it contracts, it tends to press both bones together.
Blood is supplied to the sacroiliac joints by small branches of the iliolumbar artery, the lateral sacral arteries, and the superior and inferior gluteal arteries, i. e., the parietal branches of the internal iliac artery.
At the present time, lymph vessels of the sacroiliac joints have been established only on the pelvic side. One channel follows the obturator nerve and flows into the hypogastric lymph nodes; another channel into the lateral presacral lymph nodes. A third lymphatic vessel runs toward the lymph nodes of the "lumbosacral fossa" (Echeverri 1931).
Sensory nerve fibers reach the sacroiliac joints via direct branches of the lumbosacral trunk (L 4, L 5), the obturator nerve (L 2 to L 4), the superior gluteal nerve (L 4, L 5, S 1 [S 2]), and the posterior branches of spinal nerves S 1 and S 2.
The pelvic segment of the sympathetic nerve also dispatches small branches.
The sensory supply of the most important ligaments has also been established (Pitkin and Pheasant 1936). The anterior sacroiliac ligaments contain fibers from the anterior branches of L 2 and L 3; the interosseous sacroiliac ligaments, from the posterior branches of L 5, S 1, and S 2; the dorsal ligaments, from the anterior branches of L 5, S 1, S 2, as well as the posterior branches of L 1 to L 5 and S 1 to S 3.
Eight different segments of the spinal cord are involved in the sensory supply of the sacroiliac joints.

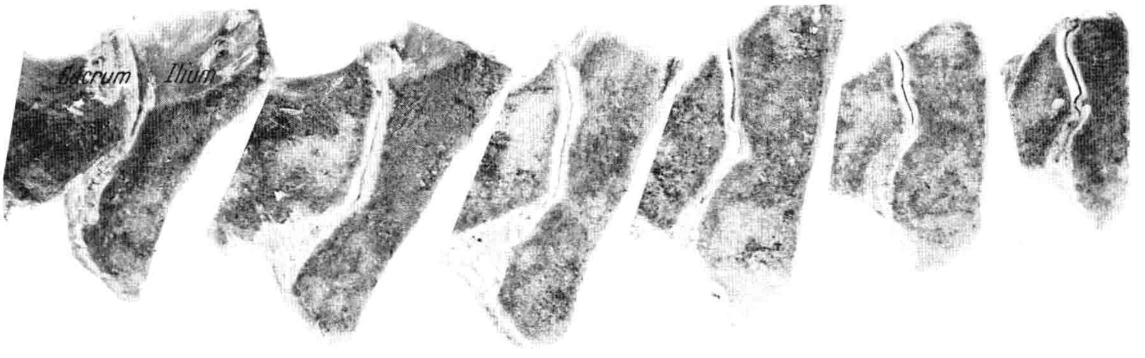

Fig. 3. Sections through right sacroilliac joint. *Left*: Superior joint margin. *Far right*: Section through inferior portion of joint. The alternating course of the joint space at each level is conspicuous.

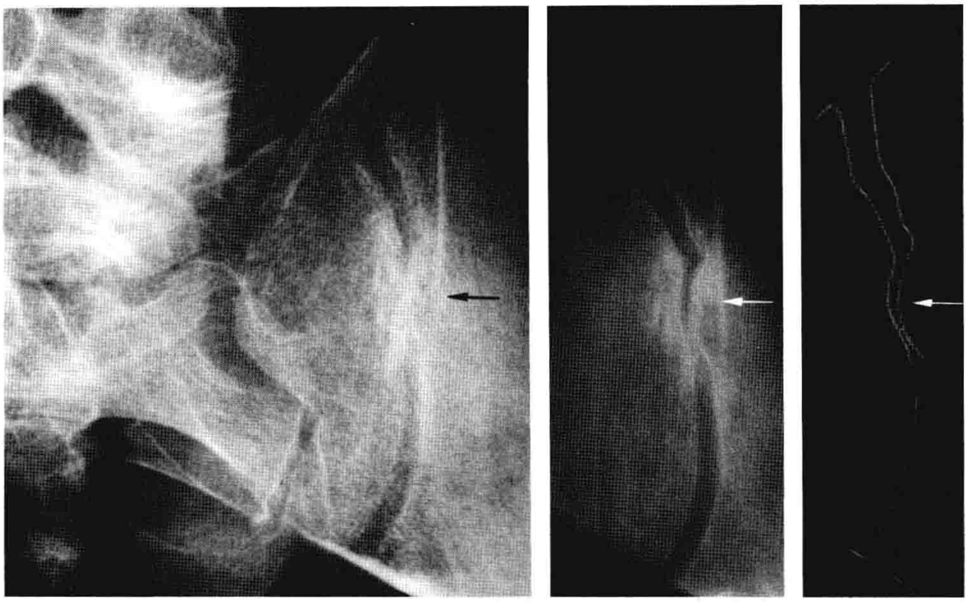

Fig. 4.
Iliac bulge (→).

Fig. 5. Forms of projection of *paraglenoid sulcus* on ilium or sacrum, including *paraglenoid foramen (far right)*.

As a result, the relationships between pain localization and sacroiliac disease is not clear. Pain evoked in these joints by sudden, firm pressure, e. g., with the **Mennell-Gaenslen-Gersuny** maneuver, can provide useful information for the differential diagnosis.

With the Mennell-Gaenslen-Gersuny maneuver, the examiner tests the tenderness of the sacroiliac joint by suddenly hyperextending the thigh of the ipsilateral leg while the patient is in the prone, supine, or lateral position.

Pain originating from the sacroiliac joints can also be evoked by manual compression of the pelvis while the patient is in the lateral position or by suddenly pushing the iliac crests apart while the patient is in the supine position.

These maneuvers, however, are not highly reliable; a

Fig. 6. →: Rare "superior" *paraglenoid sulcus* on iliac side.
≻→: *Paraglenoid sulcus* in usual location.

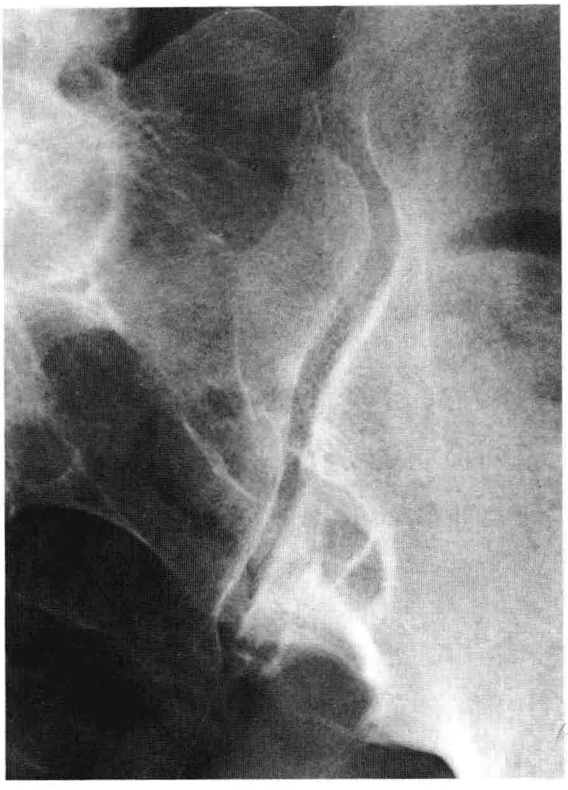

Fig. 7. "Double" *paraglenoid sulcus*.

negative result does not exclude the possibility of sacroiliac joint disease.

The "tripod sign" (Illouz and Coste 1965) sometimes successfully evokes pain in the diseased sacroiliac joint. The maneuver is carried out with the patient in the prone position. If the patient is not overly obese, the pelvis will rest like a tripod on the two anterior superior spines and the symphysis. When the examiner exerts firm, sudden pressure with his hand on the sacrococcygeal point, a lever effect is produced which mobilizes the sacroiliac joints.

The patient experiences so-called **referred pain** from the sacroiliac joints in the posterior dermatomic areas L 5, S 1, and S 2; in the sacrum; or in the buttocks. He may also describe pseudosciatic pain on the dorsal and lateral surface of the lower limbs. Pain produced by pathologic changes of the anterior sacroiliac ligaments radiates into anterior dermatomic areas L 2 and L 3, particularly into the region just below the groin.

There is one more way in which pain may be produced in sacroiliac joint disease. The lumbosacral trunk, obturator nerve, and anterior branch of the first sacral nerve run close to the joints. If the pathologic process in the sacroiliac joints spreads to these nerves, pain and motor deficits in the lower extremities may occur some distance away from the joint, in the areas supplied by the nerves.

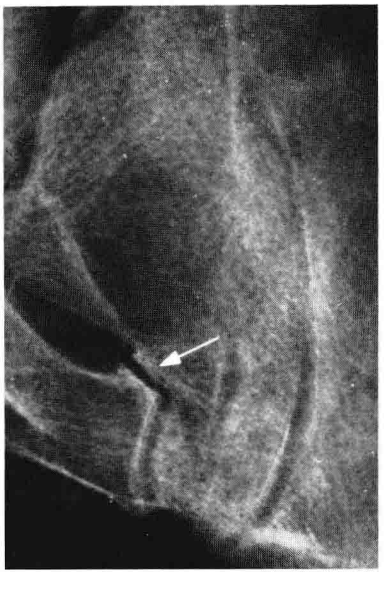

Fig. 8. *Accessory sacroiliac joint* (→).

Fig. 9. Degenerative altered *accessory sacroiliac joint*; joint space is abolished in lower part.

In man the weight of the body is transmitted onto the lower limbs by the pelvic girdle. The sacroiliac joints and the pubic symphysis are located within this bony girdle. They function as elastic buffers in order to cushion shock coming from above and below. In the latter stages of pregnancy, the pelvic girdle functions as the caudal floor of the uterus and, during labor, as part of the birth canal. This explains why, under the hormonal influences of pregnancy and also, to some extent, of the menstrual cycle, the sacroiliac joints and the pubic symphysis participate in reversible loosening processes. Over and above the buffer effect already mentioned, fibrous and synovial loosening as well as hypertrophy lend increased plasticity to the pelvic girdle during labor (see Fig. 128). Bone growth has been reported at the pelvic junctions during pregnancy (Loeschcke 1912, Tapfer and Haslhofer 1935) which permanently increases the size of the pelvis.

In addition to the sacroiliac joints, other junctions can sometimes be observed between the superior posterior iliac spine and the lateral sacral crest or between the iliac and sacral tuberosities. The junctions are similar to the joints between the ilium and the transverse processes of the sacral vertebrae foind in some mammals (Derry 1911). These **accessory sacroiliac joints** (Figs. 8, 9, 10) may be unilateral or bilateral; several such joints have been desdribed on one side. The articular surface of such joints is covered with hyaline cartilage, fibrocartilage, or fibrous connective tissue. Various data have been presented in the literature regarding the frequency with which accessory sacroiliac joints occur. Trotter (1940) observed them in approximately one out of every three persons. Other authors reported them in one out of every seven or ten individuals examined; they are dependent on race, sex, and age. Accessory joints occur more frequently in whites than in blacks, in men more frequently than in women, and in the elderly more frequently than in the young. This would tend to indicate that accessory junctions between the ilium and sacrum could be **acquired** (Keyl 1936) and may well be related to the changing position of the sacrum in the sacroiliac joint during the course of life. The superior segment of the sacrum drops anteroinferiorly; the inferior segments of the sacrum are displaced posterosuperiorly and may make contact with the superior posterior iliac spine. The pelvic entrance angle (von Schubert 1929) can be used to gauge this age-related sacral displacement. The angle is formed by the true conjugate diameter and the superior anterior surface of the sacrum. This angle measures 70° to 80° in children, 90° to 110° in mature women, and 130° to 140° in elderly individuals.

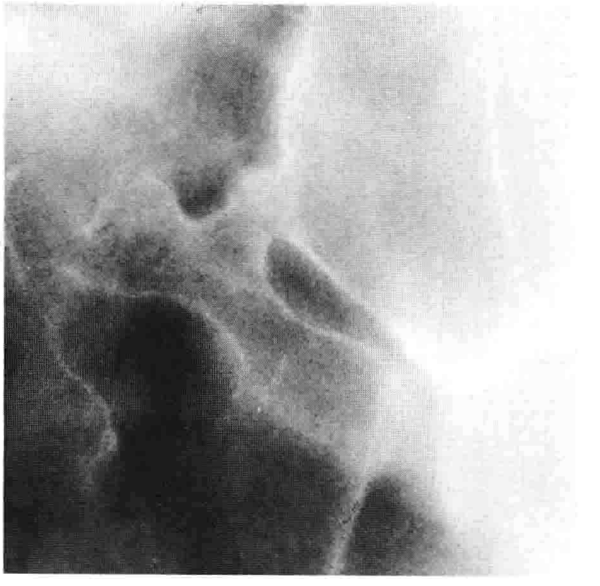

Fig. 10. Synostosis of an *accessory sacroiliac joint* (tomogram).

Degenerative changes in accessory sacroiliac joints lead to a narrowing of the joint space and marginal osteophytes. A synostosis sometimes develops between the opposing surfaces (Fig. 10).

Radiologic Technique and Projection of the Sacroiliac Joints

No standard technique is available to demonstrate the **joint spaces** of the sacroiliac joints in two planes intersecting at right angles. All radiologic techniques for visualizing sacroiliac joints are, therefore, compromise solutions which attempt to provide a (relative) maximum amount of information utilizing a (relative) minimum amount of time, material, and risk (e.g., adjustment of radiation field, radiation exposure).

There are four basic radiologic techniques for visualizing the sacroiliac joints:

- **Oblique views** with at least one film for each joint;
- Projections demonstrating **both joints** on one exposure;
- **Tomographic cuts** showing both joint spaces on the same film;
- **Functional films** to establish the pathologic increase in the mobility of the pelvic junctions.

Oblique views of the sacroiliac joints are made either with a Bucky diaphragm or under fluoroscopic control. The patient must, therefore, be positioned or turned in such a way that the beam strikes the joint space at a tangent.

Oblique views of the sacroiliac joints made in the supine position with unilateral inclination were first made by Dittmar (1929, 1930). The side of the joint to be visualized is elevated 30° to 35°.

Von Kovács (1935) and Logròscino (1936) described special projections for oblique views: the so-called **cavity projection** and the **posteroanterior oblique projection.**

Von Kovács' cavity projection (Fig. 11) demonstrates the joint space at the greatest ventrodorsal diameter. The desired side is elevated 15° to 22° from the supine position; the central beam is directed inferiorly 10° to 12°.

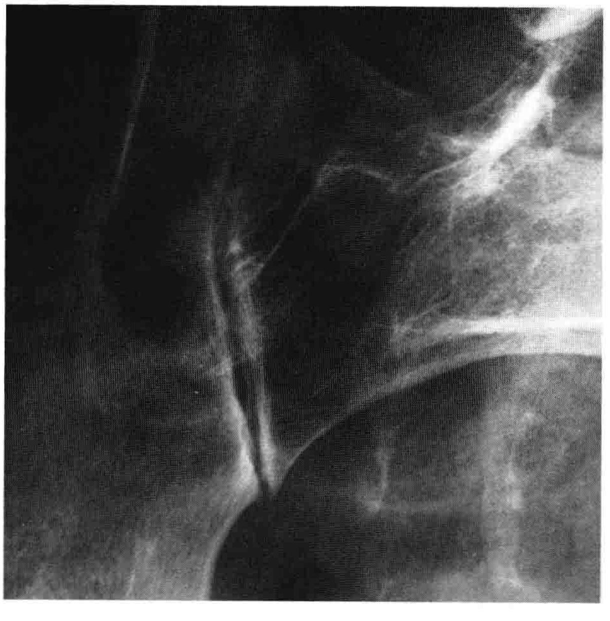

Fig. 11. Projection of sacroiliac joint space (von Kovács technique).

Fig. 12. Sacroiliac projection (Logròscino technique).

Logròscino (Fig. 12) recommended an adjustable frame so that the angle between the film plane and the sacrogluteal plane of the patient can be varied. With the patient inclined in the prone position, the central beam is directed at the joint nearest the film. Logròscino used an angle of inclination ranging from 15° to 30°. Today, with standard foam rubber wedges, it is possible to take oblique views in the supine position with unilateral inclination and in the inclined prone position, without using an adjustable frame.

For oblique projections under fluoroscopic control, whether anteroposterior (Resink 1952) or posteroanterior (Jaeger 1949), the sacroiliac space is aligned under vision.

Contrary to the opinion of some authors, it is usually impossible to visualize **all** of the joint space on an oblique view. Various angle sizes are suggested in the literature for the angle between the film plane and the sacrogluteal plane (from 10° to 45°).

Figure 13 shows an oblique view of the right sacroiliac joint (outlined with wire) of a cadaver. A cavity is also visible in the **inferior** part of the joint. It can, however, be assumed from the projection of the wire sling (→) that here the retroarticular space has been visualized instead of the joint space. Demonstration of a cavity between the sacrum and ilium on an oblique film does not mean that this cavity is the **joint** space.

Figures 14 and 15 also illustrate the possibilities for error with oblique films of the sacroiliac joints.

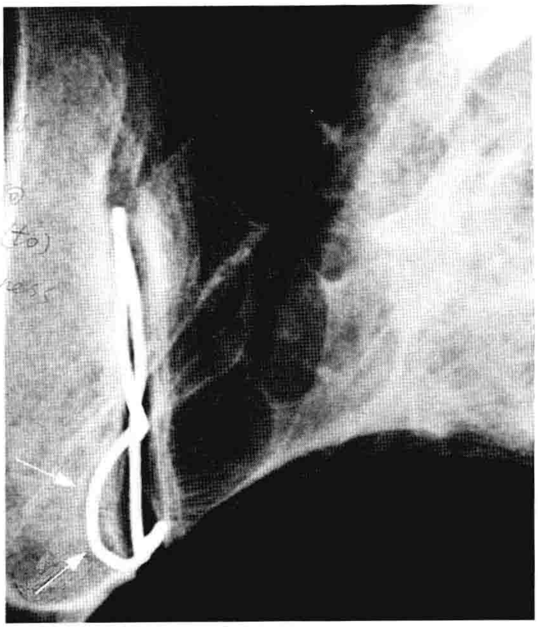

Fig. 13. *Oblique view* of right sacroiliac joint of a cadaver (outlined with wire). *This film shows that, in this case, orthograde visualization of the whole joint space is impossible*. If this were possible, the wire in the outlined "ear lobe" of the auricular surfaces would be superimposed of itself (→).

In Figure 14, both sacroiliac joints have been destroyed and partially ankylosed by ankylosing spondylitis. The interosseous sacroiliac ligaments do not usually ossify with

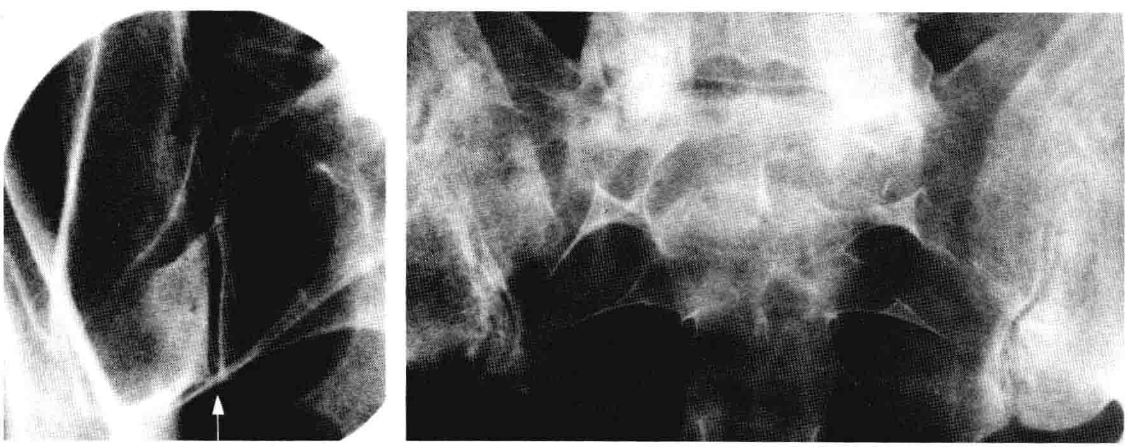

Fig. 14. Sacroiliac joints in *lithotomy position (right)*. Bilateral narrowing of the joint space, partial ankylosis, and irregular contours in ankylosing spondylitis.
→: The *spot film* of the right sacroiliac joint, taken under *fluoroscopic control*, indicates *no* pathologic changes. The extra-articular space between sacrum and ilium is visualized; the film, therefore, *simulates* a normal condition.

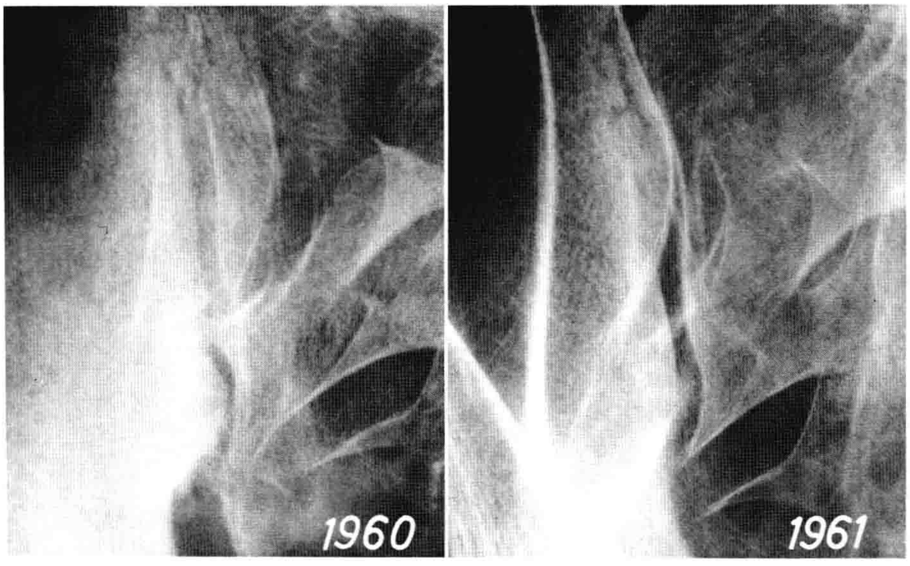

Fig. 15. Comparison of two *oblique views* of right sacroiliac joint (patient supine, right side elevated).
Even a slight change in the angle between the film plane and the sacrogluteal plane produces a different projection of the joint and can, therefore, be a possible source of error.
In *1960*, fine erosions could be seen on the iliac side (patient with ankylosing spondylitis).
In *1961*, normal radiologic findings were simulated.

this disease. During fluoroscopic control, the patient was intentionally turned in such a way that the retroarticular cavity together with the interosseous ligament was visualized; the severe pathologic changes in the sacroiliac joints were not observed.
The two oblique views in Figure 15 were made one year apart. In 1961, a slight change in the angle between the film plane and the sacrogluteal plane simulated normal findings. In 1960, however, distinct erosions had been detected on the iliac side of the right sacroiliac joint.

Both sacroiliac joints can be overlooked on **plain films of the pelvis** and films **of the lumbar spine** taken in the supine or prone position. The projection of these joints is determined by the shape and course of the auricular surfaces and by the inclination of the pelvis; the inclination of the pelvis, in turn, is dependent on the lumbosacral angle and the degree of lumbar lordosis. Kyphosis of the sacrum and the direction of the central beam influence the visualization of the joints. The individual and age-related aspects of each of these factors produce various forms of projection of the sacroiliac joints. The projections, however, have one principle in common: The posterior inferior part of the sacroiliac joint, the so-called ear lobe (Fig. 16, 2), frequently projects orthograde, medial to the other parts of the sacroiliac joints. The anterior articular margin (Fig. 16, 1) can be recognized lateral to the "ear lobe" by its lateral-convex course which continues cranially. The posterior middle (Fig. 16, 3) and posterior superior (Fig. 16, 4) margins of the auricular surfaces appear laterally, above the "ear lobe," but are still medial to the anterior joint contour. In contrast to the anterior margin, the posterior middle and superior margins of the joint, however, are not always visualized. The unmarked right sacroiliac joint in Figure 16 illustrates such a situation; only the anterior and posterior inferior joint contours can be seen.
In rare instances, the beam strikes all portions of the sacroiliac joint space, including the "ear lobe", orthoradially. The joint projection resembles the letter "S" (Fig. 17) or is visualized as a straight, even cavity.
The plain film of the pelvis as well as the anteroposterior (AP) and posteroanterior (PA) films of the lumbar spine show both sacroiliac joints on one exposure in such a way that the sacroiliac joints can usually be evaluated if the evaluator is aware of the projection relationships just mentioned. Both projections, however, have disadvantages which could complicate the interpretation:
The **sagittal projection of the lumbar spine** is centered on the third and fourth lumbar vertebral body.

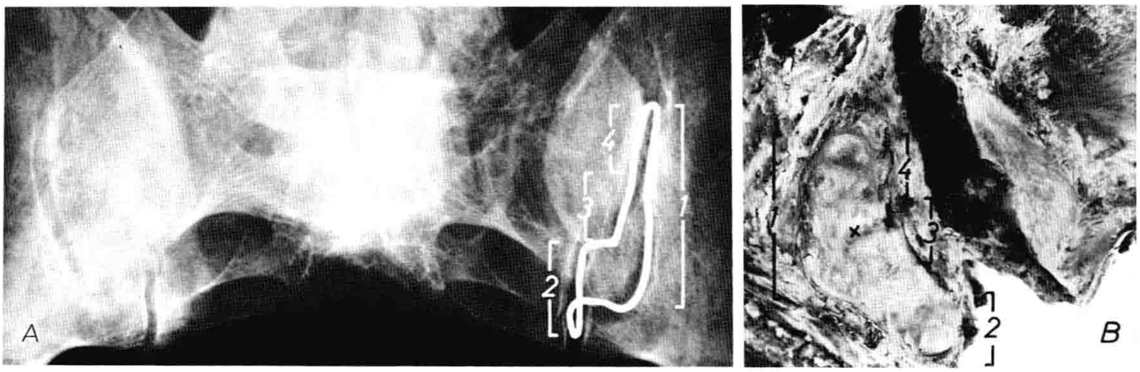

Fig. 16. Autopsy specimen of both sacroiliac joints (AP view). Edge of left auricular surface of sacrum is outlined with wire (*A*). Left sacroiliac joint has been opend (*B*).
X: Uneven articular surface of sacrum.
1: Anterior articular margin.
2: Posterior inferior part of joint, the so-called ear lobe of the auricular surface.
3: Posterior middle articular margin.
4: Posterior superior articular margin.
In the *right* sacroiliac joint (not outlined with wire), 3 and 4 are not demonstrated.

Since the longitudinal axis of the sacrum runs anterosuperior to posteroinferior rather than along the length of the body, the sacroiliac joints are not shown at their greatest longitudinal widening on films of the lumbar spine. The same is true, even if to a lesser degree, for plain films of the pelvis. Depending on the inclination of the pelvis, the joints appear "foreshortened" or seem to have been visualized axially.

Axial films show part of the joint space (generally the "ear lobe") at its ventrodorsal diameter, the retroarticular space, and the posterior superior iliac spine. If pathologic changes in these areas are present, this may even be desirable. The Perlès-Fishgold-Doassans radiologic technique (Figs. 18, 19) is then used. This technique always provides an axial projection of the sacroiliac joints, regardless of individual differences in the inclination of the pelvis.

The "foreshortening" in the sacroiliac projection mentioned above means that less information concerning the joint is available. Such information can

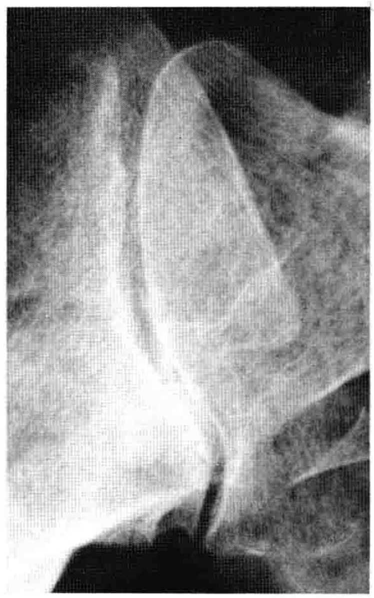

Fig. 17. AP view of a complete sacroiliac joint space.

Fig. 18. *Axial film* of sacroiliac joints such as found with sacrum arcuatum or sacrum acutum, hyperlordosis of lumbar spine, flexion contracture of hip joints, *or* when using the Perlès *technique*.
X: Retroarticular space with interosseous sacroiliac ligaments. ⊢⊣: Ventrodorsal diameter of joint at so-called ear lobe of the auricular surface. Usually the superior part of the joint would be lateral to it. In this case, however, the superior part of the joint is not demonstrated as a space.

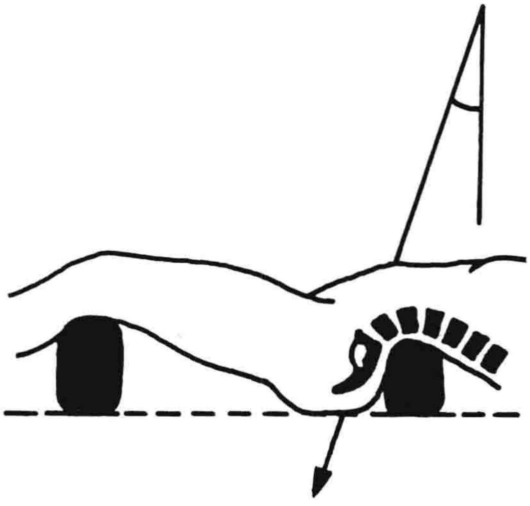

Fig. 19. Adjustment and positioning for the *axial projection of the sacroiliac joints* (Perlès – Fishgold – Doassans technique) (→: Direction of the central beam).

be obtained if the patient is positioned or the direction of the central beam is adjusted in such a way that the first three segments of the sacrum are parallel to the plane of the film. This is the principle behind the **sacroiliac projection in the so-called lithotomy position** (Samuel 1928, 1929; Teschendorf; Galland and de Las Casas 1929; Hartung 1931; Warner 1933) and the **Bársony sacroiliac projection** (1928).

Straightening the lumbar lordosis reduces the lumbosacral angle; the proximal segments of the sacrum are then parallel to the plane of the film. In order to achieve this, strong anteflexion and abduction of the thighs at the hip joints and flexion of the knee joint (Fig. 20A) are required. For this position, the patient grasps his thighs with his hands; the position can also be maintained with slings or supports behind the knee. Figure 21 B shows the sacroiliac joints at their greatest longitudinal widening. In addition, the contours of the joints are usually more distinct on films made with the patient in the lithotomy position than on plain films of the pelvis or lumbar spine. In films made in the lithotomy position, the central beam is directed perpendicular to the sacrum and strikes just above the pubic symphysis.

If the patient is unable to flex and abduct his thighs at the hip joints strongly, the same results as with the lithotomy projection can be obtained by adjusting the beam (Fig. 20B). The patient flexes and abducts his thighs at the hip joints; the knees are bent enough so that the feet can be placed flat on the Bucky table. The superiorly directed beam strikes the patient at less than a 5° angle (Fig. 22).

As mentioned above, the projection of the sacroiliac joints is age dependent. This will be discussed further on page 17 ff.

For the **Bársony projection of the sacroiliac joints**, hip and knee joints are flexed and abducted. The x-ray tube is moved caudally and then swung 30° to 35° cranially. The central beam strikes obliquely above the superior margin of the pubic symphysis, almost perpendicular to the superior half of the sacrum. In this projection, the anterior and posterior margins of the sacroiliac joints either overlap or lie very close together. For the Bársony projection, the angle of inclination of the x-ray tube must be determined individually for each patient so that the pubic bones are not projected on the inferior joint region. If such a projection should occur, the relationships are difficult to evaluate. A 30° to 35° angle of inclination for the beam usually does not produce a good projection (Fig. 23). In other words, Bársony projections made with various angles of incidence are frequently necessary if the sacroiliac joints are to be accurately evaluated. The radiation exposure for the patient increases correspondingly.

Tomography of the sacroiliac joints with one-dimensional, or better still, multidimensional exposure (patient supine) is an important supplement (Fig. 24) to the plain films already described.

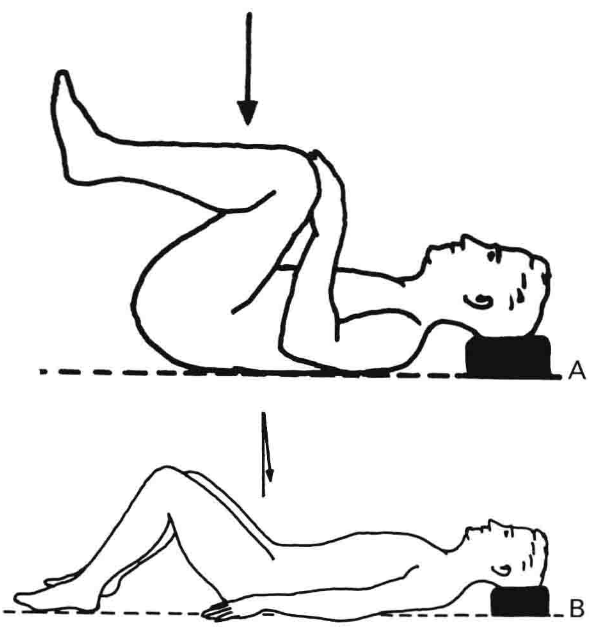

Fig. 20. A: Adjustment for *film of sacroiliac joints in lithotomy position*.
B: Adjustment for *film of sacroiliac joints in modified lithotomy position* (central beam directed cranially 5°).

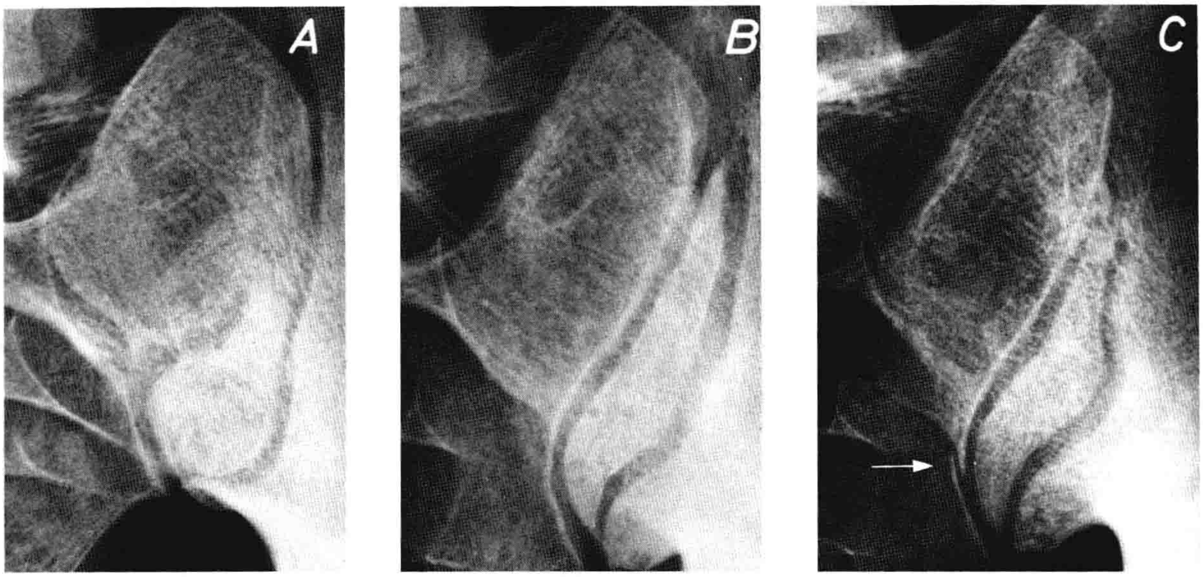

Fig. 21. *Comparison of AP films of sacroiliac joints* (A: Segment from plain film of pelvis) with *film taken in lithotomy position* (B) and *PA film of lumbar spine* (C).
For B, the first segments of the sacrum lie parallel to the plane of the film. The sacroiliac joints, therefore, are projected at their greatest longitudinal widening. The contours of the joint are usually more distinct.
→: Cutoff of contour caused by the projection ("encoche sacrée," Köhler-Zimmer 1956); it is not an infraction or a fissure.

Use of the **multisection cassette** for tomography has not proved to be advantageous; the details are not nearly as clear on multisection films as on single section films. **Zonography** (tomography where the blurring angles are small and the sections are thicker) is also not recommended for the sacroiliac joints. In cuts made 4, 5, 6, 7, 8, and 9 cm from the back of the supine patient, films with an 18 × 24 cm format will usually show all parts of the sacroiliac joints.
Transverse body-section procedures (Fig. 25) are also suitable for examining the sacroiliac joints. Since, however, transverse sectional radiography requires elaborate equipment, it has not been widely accepted.

The top cut is adjusted at the level of the posterior superior iliac spine (Frik and Hesse 1956) with a 360° rotation angle and a 20° angle of incidence of the beam in relation to the horizontal. A total of five superimposed cuts are laid through both joints at 1-cm intervals.

Diagnostic radiology of diseases of the sacroiliac joints and the regions surrounding them will undoubtedly be improved by the use of axial computerized tomography (CT) (see Fig. 79).
The practical significance of the radiologic techniques for sacroiliac joints described up to this point may be summarized as follows: Radiographs of the sacroiliac joints taken with the patient supine, particularly the lithotomy projection and its modification, AP and PA films of the lumbar spine, and AP plain films of the pelvis, are preferable to oblique projections.
If films taken with the patient supine do not provide the desired information about the joints, more elaborate oblique projections will, as a rule, not furnish the desired information either. In such cases, the single-film tomography made 4 to 9 cm from the patient's back (patient supine) is indicated. Multidimensional blurring is superior to blurring in one dimension.
Functional films of the pelvic junctions are required when the patient's symptoms suggest abnormal mobility of the sacroiliac joints or the pubic symphysis. Abnormal mobility may be suspected when the patient complains of sacrogluteal pain ("low back pain") which occurs during or is aggravated by walking, climbing stairs, carrying heavy objects, or altering the position of the body.
The pubic symphysis together with the sacroiliac joint form a functional unit. The symphysis, however, lacks the strong capsular and ligamentous reinforcement of the sacroiliac joints. The pubic symphysis is located on the long arm of the lever of the sacroiliac joints formed by the ilium, the ischium,