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THE SACROILIAC JOINT IN THE LIGHT
OF ANATOMICAL, ROENTGENOLOGICAL
AND CLINICAL STUDIES

BY

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PREFACE

The subject of this investigation was suggested to me by my greatly respected teacher and chief, Professor K. E. Kallio, head of the Orthopaedic Clinic of the University of Helsinki, after I was appointed a resident at the Clinic in 1952. I have been greatly encouraged by his untiring interest towards the investigation, and his readiness to impart pertinent advice and constructive criticism have been an invaluable aid in my work. It is a pleasure to express my sincere, appreciative thanks to Professor Kallio.

The anatomical section of this study as well as a part of the roentgenological examinations were carried out in the Department of Anatomy of the University of Helsinki, where Professor N. Pesonen, then head of the Department and now General Director of the State Medical Department, placed at my disposal the facilities and working premises of the Department of Anatomy and willingly assisted me in the early stages of the work with his friendly advice, for all of which I am deeply grateful.

Further I tender my appreciative thanks to all persons who in various ways have given me willing assistance in connection with the work now presented. I also thank Miss Elvi Kaukokallio for translating the manuscript into English.

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Helsinki, May 1957

Kauko A. Solonen

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INTRODUCTION

Diseases of the back constitute today an important social as well as a medical problem. Among cases treated in surgical and orthopaedic hospitals and outpatient departments, patients suffering from trouble in the back comprise a very large group and numerous working days are lost because of diseases of the back.

The human back is a highly complicated structure. The vertebrae, intervertebral discs, apophyseal joints, sacroiliac joints, the bones of the pelvis, the ribs, the spinal cord and its membranes, spinal nerves with their branches, the muscles and their aponeuroses and tendons, fascias, blood vessels, connective tissue, subcutaneous tissue, ligaments, and the skin are the principal components of this part of the human body, which possesses numerous functions and is subjected to great stress. Pathological changes — congenital or acquired — may be present in any of these organs and tissues. Since, furthermore, pathological conditions in the lower extremities, endocrine diseases (HUTTON 1944) and numerous visceral diseases (RIVERS and ROODENBURG 1944) produce sensations reflected in the back, and since, conversely, diseases of the back may be reflected in other parts of the body, the diagnosis of these diseases frequently is difficult and subject to possibilities of error. It is well known that the mental distress of the human being is also experienced as physical pain, and the back is probably the most common »mirror of the soul« in these cases (LINDSTEDT 1931, ECHOLS 1944, BARTON 1949).

In present day society, insurance and other social benefits have made it possible, in view of the low cost to the individual, for a large proportion of the population to consult physicians and outpatient departments to an increasing extent and to have the

security of an income also during the time of invalidity. Frequent cases are therefore seen where persons consider themselves incapable of working under circumstances in which, in the absence of the above mentioned social benefits, they presumably would continue to work (PRINCE 1937, ECHOLS 1944, GHORMLEY 1944, BARTON 1949, DEJONG 1950). This observation is made from time to time by physicians who examine patients complaining of pain in the back in whom frequently there can be found no somatic disease but only, at the most, normal wear and tear processes and their conscious or unconscious aggravation. It therefore is open to question whether the number of cases of diseases of the back has in fact increased to the same extent as the number of patients claiming to have these diseases. It is, of course, possible that modern methods of work, for example in many fields of industry, and possibly also other phenomena of every day life which differ from those earlier prevailing are proving a stress on the back.

Subluxation and strain of the sacroiliac joint occupied a very central position in the great number of reports of diseases of the back published during earlier decades, in contrast to the publications during the past two decades. In France, active interest still appears to be felt towards diseases and research methods relating to the sacroiliac joint; in other countries, rupture of intervertebral discs is the predominant subject in the literature dealing with diseases of the back. This neglect of the sacroiliac joint has possibly gone to the extreme (PLATT 1948, GHORMLEY 1951). Sciatica, which now is known to be caused by a ruptured disc, was fifty years ago ascribed to affections of the sacroiliac joint (GOLDTHWAIT and OSGOOD 1905, PLATT 1949, KALLIO 1955). As late as in 1928, YEOMAN considered sacroiliac arthritis responsible for 36 per cent of his cases of sciatica, and in 1939 ABEL considered strain of the sacroiliac joint the most common cause of low back pain. In HOWORTH'S »A Textbook of Orthopedics» published in 1952 there is no mention of subluxation or strain of the sacroiliac joint. CYRIAX writes in his »Textbook of Orthopaedic Medicine», published in 1954, as follows: »Lesions of the sacroiliac joint are as rare as pain felt at the inner aspect of the buttock is com-

mon.» In his opinion, the only non-specific affection of the sacroiliac joint in men is »the sacro-iliac arthritis that ushers in spondylitis deformans (ankylopoetica)». He admits that the same disease also occurs in women, in whom there also may occur, in his opinion, strain of the sacroiliac joint, although the incidence is but one case among 500 patients with low back pain. WATSON-JONES, in Volume II of his recent textbook »Fractures and Joint Injuries», published in 1955, mentions subluxation of the sacroiliac joint and states that it is demonstrable by roentgen but can also be seen directly on the patient. He further states that even a minor subluxation may cause constant pain and invalidity.

For several decades the accepted opinion was the theory advanced by GOLDTHWAIT and OSGOOD (1905), ALBEE (1909) and other pioneers that sciatica develops on the base of increased pressure or irritation of the lumbosacral plexus lying across the joint, caused by subluxation, relaxation or other disease of the sacroiliac joint. As late as in 1934 — in the same year that MIXTER and BARR definitely made sciatica due to herniation of a disc generally known and brought it within the scope of surgical treatment — it was suggested that, in cases of sciatica, changes in the sacroiliac joint are always visible on the same side in the roentgenogram, and that there always are roentgenologically demonstrable changes in both sacroiliac joints if the sciatica is bilateral (FREIBERG and VINKE 1934). COMPERE wrote in 1937 as follows: »Most low back lesions can be localized to one or to both sacroiliac joints or to the lumbosacral region by careful physical examination.»

Especially the older papers on low back pain or sciatica frequently have historical value only, in describing in various ways the symptoms due obviously to rupture of a disc, and in drawing even far-reaching conclusions from the erroneous interpretation of symptoms. We cannot but wonder that the results of treatment nevertheless were frequently described as very satisfactory whether the therapeutic measures were conservative, physiatric or manipulative procedures of various kinds or one of the numerous intra- or extra-articular arthrodeses or spondylodeses.

It seems probable that during the past few years, and especially in the beginning of modern treatment for rupture of a disc, the latter condition has too often been held to be responsible for low back pain. However, as CYRIAX said, even this may be considered an improvement over the earlier situation, for the rupture of a disc is in any case much more common than a sacroiliac lesion. There probably are no definitely certain diagnostic means to localise the etiological factor to the sacroiliac joint and there exist nearly as many opinions on this point as there are writers.

In addition to interpretation of the symptoms, also the nomenclature of low back pain is greatly varied, and this inexactness has tended to augment the perplexity and confusion in the mind of the reader of this field of medical literature. It is apparent, however, that lesions of the sacroiliac joint are rare, due basically to the anatomic structure of the joint, concerning which there have been expressed surprisingly greatly diverging opinions.

THE PROBLEMS

It was the purpose of the present investigation to obtain replies to the following questions relating to the sacroiliac joints:

What is the osteological structure of the sacroiliac joint?

What is the origin of its innervation?

What is the statico-mechanical function of the joint?

How can this joint be studied by roentgenological methods?

What is the incidence of non-infectious lesions of the sacroiliac joint?

What results may be attained by surgical treatment of non-infectious lesions of this joint?

What is the reaction of the sacroiliac joint in cases in which pathological response may be expected, especially in association with disturbed statics and mechanics of the lower extremities?

This investigation is not concerned with lesions of infectious origin in the sacroiliac joints.

ANATOMY OF THE SACROILIAC JOINT

REVIEW OF THE LITERATURE

The sacroiliac joints, like most joints of the human body, are developed about the tenth week of intrauterine life (CLARK 1952) but are distinctly outlined only after the sixth or seventh month (FEHLING 1876, SCHUNKE 1938). During the seventh foetal week the ilia take their position beside the first sacral vertebrae (WILLIS 1933, 1944, INGELRANS 1950) and articulate with the transverse processes of the vertebrae by means of the gradually developing sacroiliac joints. At the same time the sacral vertebrae increase in size and fuse to form the sacrum (WILLIS 1937, INGELRANS 1950). The synovial membrane of the joint is present shortly before birth (SCHUNKE 1938). The pelvis and sacroiliac joint of the human foetus closely resemble in structure the corresponding parts of the body of quadrupeds. At this stage the joint is narrow and straight and runs parallel to the spinal column. It undergoes change as the child grows, curving in the caudo-dorsal direction and increasing relatively in width (MARTIN 1928, BROFELDT 1929, GELLER 1931, PETER, WETZEL and HEIDERICH 1938, DELMAS 1950). The change is brought about by torsion between the ilia and the sacrum and by curvature of the sacrum, which mainly are caused by mechanical factors during growth, i.e., erect posture, weight of the body, pressure of the femurs, and tension of the symphysis (MARTIN 1928), all of which are intensified or reduced by individual habits and characteristics during the growth period, such as the amounts of movement, sitting and carrying, nutrition, different loads on the various muscle groups, and so on. Rachitis

is perhaps the most significant of the pathological factors which influence the shape of the pelvis and the sacroiliac joints. Sexual characteristics of the pelvis are seen as early as the fourth month of intrauterine life (THOMSON 1899) but the slight characteristic differences in the sacroiliac joints in the male and female do not become evident before the age of about 12—14 years (BROOKE 1924). The male sacroiliac ligaments then begin definitely to increase in strength and the female sacroiliac joints become more mobile. As adaptation to the erect posture has greatly reduced the size of the pelvic outlet, the mobility of the sacroiliac joints and the laxity of the ligaments in the female are important with a view to facilitating parturition (DERRY 1911, MASSART 1952).

As far as is known, BERNHARD SIEGFRIED ALBINUS (1697—1770) and WILLIAM HUNTER (1718—1783) were the first to demonstrate that the connections between the sacrum and the ilia are true joints having synovial membranes (LYNCH 1920). Their observation was confirmed by MECKEL (1816). BARKOW (1841) described the structure of the joint in greater detail, KOLLIKER (1850) found in the joint a fluid similar to the synovia, and VON LUSCHKA (1864) was the first to describe the sacroiliac joint as a true diarthrodial joint, which opinion is still supported by many writers (FICK 1904—1911, MORRIS' Anatomy 1942—1944, ROUVIÈRE 1948, *et al.*). On the other hand, it is considered by BRAUS (1921) and GRAY's Anatomy (1944) an amphiarthrodial joint, by RAUBER-KOPSCH (1940) an intermediary form between synarthrosis and diarthrosis, and by TESTUT-LATARJET (1949) a diarthro-amphiarthrodial joint.

According to the statistics of PATERSON (1893), the various vertebrae participate in the formation of the sacroiliac joint as follows: S I in about 97.7 per cent of cases, S II always, S III in about 91.4 per cent, S IV in about 2.1 per cent, L V in 1.8 per cent, and L VI in 1.1 per cent. The most common combination is S I—S II—S III, which is seen in about 86.4 per cent. According to DERRY (1912), only S I and S II form the auricular surface of the female sacrum, with additionally SIII if six vertebrae are incorporated in the sacrum. MARTIN (1928) reported that the vertebrae

in question are S I, S II and S III in 60 per cent, but mentioned racial differences, such as the absence of S III from the auricular surface in 19.2 per cent of Europeans; this is a higher incidence than in other races. According to RAUBER-KOPSCH (1940), the auricular surface of the sacrum consists of two and one-half sacral vertebrae in about 60 per cent of the individuals.

The articular cartilage is according to SCHUNKE (1938) hyaline or fibrous during intrauterine life and always fibrous after birth. BROOKE (1924), SASHIN (1930) and FRANCIS (1952) state that it is hyaline cartilage, but according to the last mentioned it may also be fibrocartilage in later life. RAUBER-KOPSCH reported that on the iliac side there is almost only fibrocartilage but on the sacral side only a thin superficial layer of fibrocartilage and a deeper layer of hyaline cartilage. The articular surfaces differ from those of other joints of the body in being always clearly, and frequently very markedly, uneven, the irregularities fitting into one another and thus increasing the stability of the joint. In the opinion of some anatomists, the auricular surface of the ilium often shows a ridge or eminence, which fits into a corresponding depression in the slightly larger auricular surface of the sacrum. They consider that these formations determine the mobility of the sacroiliac joint (STRASSER 1908, FICK 1911). The roughness, size and shape of the articular surfaces vary greatly according to the individual; the same is true of the course of the articular slits (PATERSON 1893, WALDEYER 1899, FICK 1911, BROOKE 1924, MARTIN 1928, CUNNINGHAM's Anatomy 1931, RAUBER-KOPSCH 1940, DELMAS 1950, FRANCIS 1952, *et al.*). According to various investigators there are, especially in men after the fiftieth year, fibrous intra-articular adhesions across the joint as well as partial or complete ankylosis (BROOKE 1924, CUNNINGHAM's Anatomy 1931, SCHUNKE 1938, FRANCIS 1952). Congenital adhesions also are claimed to have been found, but according to BROOKE (1924) they are extremely rare and indicate that mobility of the joint is slight or entirely absent. The articular capsule is strong and stiff. It is attached to the more or less distinct juxta-auricular sulcus which is situated on both sides of the joint and is according

to MARTIN more distinct in women than in men. Dorsally the capsule cannot be distinguished from the interosseal sacroiliac ligaments. Small but distinct folds of the synovial membrane enter the joint slit from the capsule (e.g., BROOKE 1924, CUNNINGHAM'S Anatomy 1931, RAUBER-KOPSCH 1940).

Dorsally, cranially and caudally the ligaments of the sacroiliac joint are the strongest ligaments of the human body, but ventrally they seem to be a thickening of the periosteum (e.g., SMITH-PETERSEN in CHRISTOPHER'S »A Textbook of Surgery« 1947). The sacroiliac ligaments are sites of origin or insertion of several strong muscles and derive their innervation from the nerves of these muscles (HILTON 1879, BRYCE 1923, PITKIN and PHEASANT 1936). Thus the sacrotuberous ligament frequently is like a continuation of the ligamentous origins of the m. semitendinosus and the long head of the biceps femoris (LESSHAFT 1893, FICK 1911, FREIBERG and VINKE 1934, v. LANZ and WACHSMUTH 1938). It also serves as attachment to a portion of the m. gluteus maximus, m. semimembranaceus and m. piriformis (FREIBERG and VINKE 1934, v. LANZ and WACHSMUTH 1938, RAUBER-KOPSCH 1940). The long posterior sacroiliac ligament may give partial origin to m. sacrospinalis (STEINDLER and LUCK 1938, RAUBER-KOPSCH 1940). The iliolumbar ligament may also give origin to some fibres of m. sacrospinalis and m. multifidus (PITKIN and PHEASANT 1936). The sacrospinous ligament may give partial origin to m. coccygeus (LESSHAFT 1893, FICK 1911). The anterior sacroiliac ligaments may be regarded as direct continuations of fibres of m. iliopsoas (MORRIS' Anatomy 1942—1944). It is to be noted, however, that none of the muscles mentioned above are intended to move the sacroiliac joint.

The lumbosacral plexus crosses ventral to the joint and is separated from it only by the articular capsule and the weak ventral ligaments (SASHIN 1930, HERSHEY 1943, LEWIN 1943). According to BRAUS (1921) the m. piriformis often has in part its origin also in the capsule of the sacroiliac joint. The adjacency to the sacroiliac joint of the psoas muscle, the autonomic nervous plexus and the rectum is of importance clinically.

The frequently cited »Hilton's law« states as follows concerning the innervation of joints in general: »Joints are supplied by branches which reach them either directly or indirectly from the nerves supplying the overlying skin and the muscles which move the joints« (HILTON 1879).

It seems from the literature that the innervation of the sacroiliac joint is a field of anatomy that has been fairly little studied. Several anatomical textbooks and handbooks of merit pass cursorily over the subject, and from some extensive works I have in vain sought a description of this nerve supply.

A number of authors state that RÜDINGER (1857) was the first to study the innervation of the sacroiliac joint. According to PITKIN and PHEASANT (1936) he described only the nerve supply to the dorsal portion of the sacroiliac joint, which arises from the posterior rami of the first and second sacral nerves. In VON BARDELEBEN'S »Handbuch der Anatomie« (1896—1909) FICK stated that the sacroiliac joint receives branches from all the neighbouring nerve trunks, i. e., the lumbosacral plexus, superior gluteal nerve, posterior rami of the first and second sacral nerves, and sometimes the obturator nerve. QUAIN'S Anatomy (1897), SMITH-PETERSEN (1924), CUNNINGHAM'S Anatomy (1931), PITKIN and PHEASANT (1936), TESTUT-LATARJET'S »Traité d'anatomie humaine« (1949), INGELRANS (1950), FRANCIS (1952), and others, expressed the same opinion. RAUBER-KOPSCH (1940) cursorily stated that the sacroiliac joint receives its innervation »von allen benachbarten Stämmen«. The participation of the obturator nerve has been a subject of great divergence of opinion. HILTON (1879) was the first to observe that this nerve gives off branches to the sacroiliac joint, and all the authors cited above support his opinion. In MORRIS' Anatomy (1942—1944) the participation of the obturator nerve is disclaimed, and numerous later authors are of the same opinion.

PRESENT INVESTIGATION

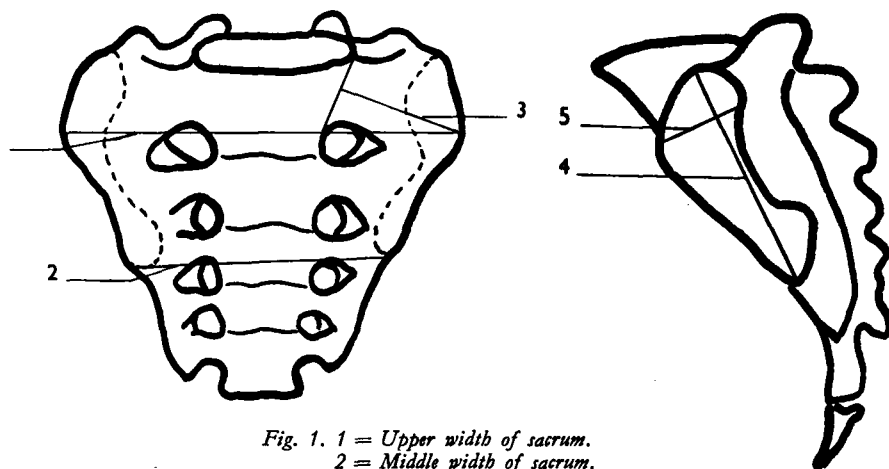
OSTEOLOGY OF THE SACROILIAC JOINT

It was the object of this part of the present investigation to study the macroscopic osteological structure of the sacroiliac

joint, chiefly for the purpose of understanding the mechanics and statics of the joint.

Thirty pelvis skeletons in the collections of the Department of Anatomy in the University of Helsinki were used as material for study. No attempt was made to determine the sex of the individual, and it was not known what the age had been at death and whether or not there had during life been any diseases or accidents which possibly had had an effect upon the bones. Unless otherwise stated, all the measurements were made according to the method of MARTIN (1928).

The following measurements and determinations were carried out on the sacrum (fig. 1):



*Fig. 1. 1 = Upper width of sacrum.
2 = Middle width of sacrum.
3 = Width of lateral mass.
4 = Length of auricular surface.
5 = Width of auricular surface.*

1. The upper width of the sacrum, i.e., the greatest distance measured as a straight line between the foremost point in the anterior projecting edge of the two auricular surfaces;

2. The middle width of the sacrum, i.e., a straight line between the antero-caudal terminal points of the two auricular surfaces;

TABLE 1. *Measurements of Skeletal Sacra*

1 = Upper width of sacrum.
 2 = Middle width of sacrum.
 3 = Width of lateral mass.
 4 = Length of auricular surface.
 5 = Width of auricular surface.

Measurement No.	Pelvis No.																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	106	97	99	118	110	110	139	112	95	117	118	102	112	103	98	116	113	118	113	104	116	117	108	110	115	102	119	103	109	112
2	91	83	90	94	87	90	100	93	92	94	98	87	97	89	88	96	101	101	92	92	93	93	92	87	96	88	90	90	93	85
3 dx	34	29	30	41	38	35	51	46	32	37	39	34	34	32	36	40	38	39	40	47	33	38	40	36	42	34	37	28	32	42
sin	36	36	30	41	38	37	39	40	30	42	42	36	38	34	35	40	37	42	40	46	38	40	43	42	45	37	38	38	40	45
4 dx	60	57	57	65	53	60	78	58	65	74	65	63	68	58	51	61	58	58	53	51	53	58	58	58	59	57	57	59	59	46
sin	57	58	57	66	51	53	80	58	64	70	62	61	63	61	48	60	63	57	49	50	55	60	55	62	62	55	55	58	62	51
5 dx	25	22	30	28	22	24	*)	29	25	*)	25	25	*)	27	28	24	29	21	25	33	*)	20	*)	25	27	31	25	31	29	24
sin	28	25	28	25	21	16	33	27	28	*)	21	20	*)	26	28	27	31	22	21	33	*)	23	*)	23	21	22	25	33	27	22

*) Measurement not possible because of ankylosed joint.

3. Width of each lateral mass of the sacrum, i.e., the shortest distance between the centre of a line drawn from the lateral margin of the cranial terminal surface of the sacrum to the median margin of the first anterior sacral foramen, and the outermost lateral point in the anterior margin of the auricular surface;

4. Length of the auricular surface, i.e., the distance from the most cranial point in the margin of the auricular surface to the most caudal point in the margin;

5. Width of the auricular surface, i.e., the greatest distance at right angles to the longitudinal line measured as described in point 4;

6. Angles formed by the two auricular surfaces of the sacrum. For anthropological purposes MARTIN measured only »der Winkel, den die beiden Facies auriculares miteinander bilden. An jede Gelenkfläche wird eine Stahlnadel in horizontaler Richtung angelegt und der Winkel, den diese Nadeln an der Dorsalfläche des Kreuzbeines bilden mittels eines Transporteurs abgelesen.« — In the present work, however, it was considered necessary to carry out several angle measurements, for the auricular surface is not part of a single plane but has irregularities of the most varied shapes and therefore has a number of different planes which, if extended, would converge sometimes in one direction sometimes in another. I therefore measured the angles formed by each auricular surface and the median sagittal plane and by the two auricular surfaces in three frontal planes as shown in fig. 2, i.e., at the levels of the first, second and third sacral vertebrae. The angle formed by the auricular surfaces was measured in three horizontal planes, i.e., at the levels of the first, second and third sacral vertebrae, as shown in fig. 3. For these measurements it was necessary to make the pelvis stationary in the erect posture, which is considered to be the position where the two anterior iliac spines are in the same horizontal plane, and also are in the same vertical plane with the anterocranial margin of the pubic symphysis (VON BARDELEBEN 1896, FICK 1911, CUNNINGHAM's Anatomy 1931, FRANCIS 1952, WALDEYER 1953);

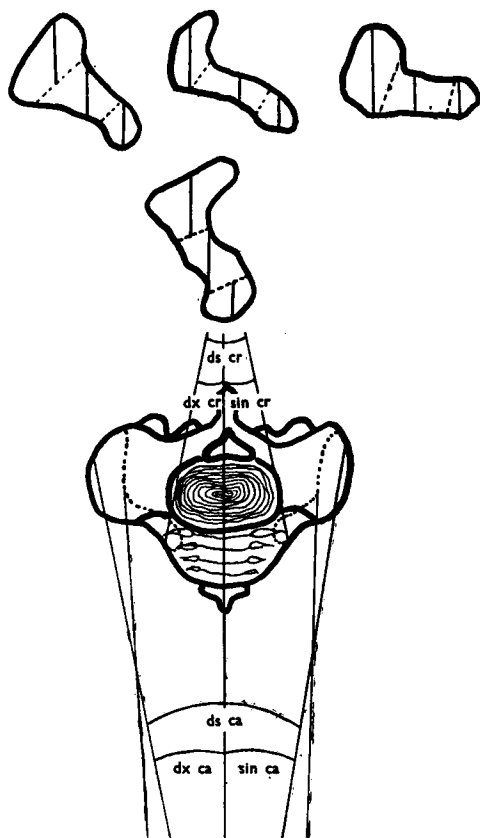


Fig. 2. Angle between the auricular surface and the median sagittal plane, and angle between the auricular surfaces in the frontal plane at the levels of vertebrae S I, S II and S III.

$dx\ cr$ = Angle between the right auricular surface and the median sagittal plane; apex of the angle is cranial to the sacrum.

$dx\ ca$ = Angle between the right auricular surface and the median sagittal plane, with apex of the angle caudal to the sacrum.

$\sin\ cr$ and $\sin\ ca$ = Corresponding angles on the left side.

$ds\ cr$ = Angle formed by the two auricular surfaces, with apex of the angle cranial to the sacrum.

$ds\ ca$ = Angle formed by the two auricular surfaces, with apex caudal to the sacrum.

----- = Margin of vertebra.

————— = Levels at which the angle measurements were made.

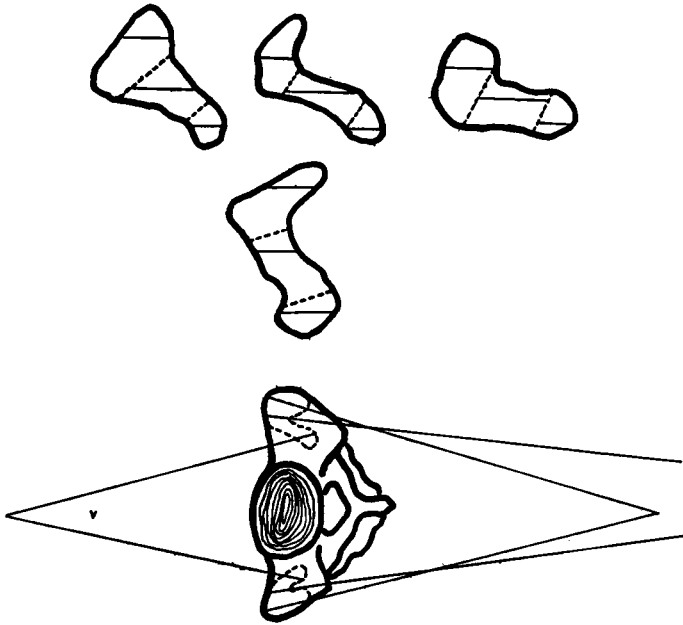


Fig. 3. Angle between the auricular surfaces in the horizontal plane at the levels of vertebrae S I, S II and S III.

v = Apex of angle is ventral to the sacrum.

- - - - - = Margin of vertebra.

————— = Levels at which the angle measurements were made.

7. Angle of inclination of the sacroiliac joint, i.e., the angle formed by the longitudinal axis of the auricular surface and the horizontal plane (fig. 4);

8. The hypo-, homo- or hyperbasal shape of the sacrum. RADLAUER termed a sacrum hypobasal when the cranial margins of the auricular surfaces lie below the level of the cranial terminal surface; homobasal when the said margins and the cranial terminal surface of the sacrum are in the same horizontal plane; and hyperbasal when the cranial margins of the auricular surfaces rise higher than the cranial terminal surface of the sacrum. It seems probable that by this description he means the sacrum as such, and not the sacrum of a person standing erect. In the present investigation, however, the hypo-, homo- or hyperbasal

TABLE 2. *Angle between the Auricular Surface and the Median Sagittal Plane and Angle Between the Auricular Surfaces in the Frontal Plane*

Pelvis No.	At Level of Vertebra																	
	S I						S II						S III					
	dx		sin		ds		dx		sin		ds		dx		sin		ds	
	ca	cr	ca	cr	ca	cr	ca	cr	ca	cr	ca	cr	ca	cr	ca	cr	ca	cr
1		4			2		6	5		0	0	5		13		10		23
2	13			11		24		18		20		38		3		0	0	3
3	*)			4		4			4		2		6		13		12	25
4	5			10		15			10	0	0		10		10		3	13
5	15			13		28		8		18		26			5		2	7
6	4			6		10		4		3		7		16		10		26
7	**))			11		11				2		2				2		2
8	17			18		35		22		15		37		4		6		10
9	10			11		21		2		23		25		12		9		21
10	***)																	
11	11			3		14		4		2		6		2		12		14
12	16			20		36		21		13		34		4		7		11
13	***)																	
14	4			7		11		0	0	0	0	0	0	12		11		23
15	10				10	0	0	10		11		21		7		10		3
16	8			6		14		3		2		5			8		7	15
17	6			6		12			5	15		10		18		5		23
18	7			12		19			12		10		22		25		15	40
19	19			18		37		19		18		37		11		16		27
20	10			23		33		40		40		80		3		1		4
21	***)																	
22		3			5		8	30		5		35		10		18		28
23	***)																	
24	9			13		22		6		12		18		12		17		29
25	31			0	0	31		16		6		22		0	0	0	0	0
26	8			8		16		6		5		11		14		13		27
27	1			2		3		11		10		21		11		20		31
28	5			10		15		10			2	8		5		20		25
29	13			9		22		18		12		30		11		11		22
30	15			11		26		30		25		55		5		5		10

dx = Angle between the right auricular surface and the median sagittal plane.

sin = Angle between the left auricular surface and the median sagittal plane.

ds = Angle formed by the two auricular surfaces.

ca = Apex of the angle is caudad to the sacrum.

cr = Apex of the angle is cranial to the sacrum.

*) Owing to a longitudinal ridge in the antero-cranial part of the right auricular surface the line of intersection of the auricular surface in the frontal plane passing through S I forms an angle of about 135°.

**) Right sacroiliac joint was ankylotic.

***) Bilateral ankylosis of the sacroiliac joint.

TABLE 3. *Angle between the Auricular Surfaces in the Horizontal Plane*

Pelvis No.	At Level of Vertebra		
	S I	S II	S III
1	45	20	20
2	3	10	9 ▽
3	46	32	5
4	51	15	13 ▽
5	46	50	25 ▽
6	43	22	3 ▽
7	*) 43	23	15 ▽
8	12	3	10 ▽
9	30	40	32 ▽
10	**)		
11	62	23	0
12	19	8	3 ▽
13	**)		
14	64	35	37
15	0	18	0
16	38	35	2
17	45	10	12 ▽
18	51	25	15
19	64	22	22 ▽
20	48	6 ▽	28 ▽
21	**)		
22	75	30	25 ▽
23	**)		
24	45	62	20 ▽
25	38	6 ▽	40 ▽
26	55	22	15 ▽
27	47	28	2 ▽
28	62	40	26 ▽
29	37	13	13 ▽
30	48	55	45 ▽

▽ = Apex of the angle is ventral to the sacrum. In other cases the apex of the angle is dorsal to the sacrum.

*) Right sacroiliac joint is ankylotic and the degrees are therefore approximate only.

**) Bilateral ankylosis of the sacroiliac joint.

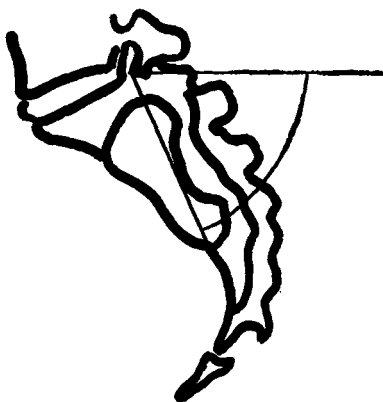


Fig. 4. Angle of inclination of the sacroiliac joint.

shape of the sacrum was determined from the sacrum fixed in the erect posture;

9. Possible presence of accessory sacroiliac joints. PETERSEN (1905) found them to be present in 16 per cent, DERRY (1910—1911) in 10.4 per cent, JAZUTA (1929) in 27 per cent, KAIBÔ (1934) in 50 per cent, TROTTER (1940) in 36 per cent, and HADLEY (1952) in 16—18 per cent of pelves. SELIGMAN (1935) and TROTTER (1937, 1940) suggested that the incidence depends on age, sex and race, and STEWART (1938) found accessory sacroiliac joints in other higher primates still more frequently than in man.

10. Number of sacral vertebrae which constitute the auricular surfaces;

11. Comparison of the size of the articulating surfaces of the ilium and the sacrum;

The results of the measurements made according to points 1—5 are shown in table 1. In table 2 are listed the angles formed by the auricular surfaces and the median sagittal plane, and the angles between the two auricular surfaces, measured in the frontal plane at the levels of vertebrae S I, S II and S III, or at corresponding relative intervals in those cases in which the auricular surface was in the area of S I and S II or of S I, S II, S III and

TABLE 4. *Angle of Inclination of the Sacroiliac Joints*

Pelvis No.	Right Joint (Degrees)	Left Joint (Degrees)
1	40	46
2	43	43
3	35	30
4	40	40
5	42	49
6	42	42
7	52*)	53
8	39	37
9	40	40
10	30*)	32*)
11	46	43
12	48	58
13	32*)	32*)
14	47	53
15	52	42
16	46	48
17	49	44
18	43	45
19	48	49
20	44	47
21	40*)	44*)
22	30	34
23	47*)	46*)
24	50	50
25	44	50
26	46	46
27	31	32
28	53	49
29	43	43
30	40	32

*) Approximate values were measured from ankylotic sacroiliac joints.

S IV (fig. 2). The angles formed by the auricular surfaces measured in three horizontal planes intersecting vertebrae S I, S II and S III or at corresponding intervals (fig. 3) will be seen in table 3. In some cases the auricular surface was curved. In measuring the angles, such surfaces were taken as a part of the plane which most closely corresponded to their general direction.

The angles of inclination of the sacroiliac joints are shown in table 4.

Of the examined sacra 22 were hypobasal, 4 hyperbasal and 3 homobasal. In 1 case there was unilateral sacralisation.

In 2 pelves only was there a unilateral accessory sacroiliac joint, which was formed by a rudiment of the transverse process of S II and part of the ilium dorsal to the auricular surface, as was stated by DERRY (1910—1911) to be generally the case. In the small number of specimens studied in the present investigation, which was further reduced by inability to examine possible accessory joints in 5 pelves because of ankylosis, the incidence of accessory sacroiliac joints was thus only 8 per cent.

The auricular surfaces of the sacrum were composed of vertebrae S I, S II and S III in 23 cases, vertebrae S I and S II in 3 cases, and S I, S II, S III and S IV in 2 cases. In 2 cases the auricular surface was in the area of S I, S II and S III on one side of the sacrum and of S I, S II, S III and S IV on the other side.

In all the cases examined the auricular surface of the ilium extended $\frac{1}{2}$ —1 mm beyond the margins of the corresponding articular surface of the sacrum, as if forming a »lid» over the latter.

The juxta-auricular sulcus was always visible with varying degrees of clarity.

In addition to considerable variation in the size of the sacrum and the sacroiliac joints, as seen from table 1, the measurements also brought out marked variations in their shape and direction (tables 2—4). Like the entire sacrum, the auricular surfaces of the sacrum were more or less asymmetrical. With the body erect, the frontal section through the auricular surfaces at the level of S I showed that the sacrum narrowed caudally like a wedge

in 23 cases, or in 88.5 per cent of pelves. In 1 case (pelvis No. 15; 3.8 per cent) one of the auricular surfaces formed the side of a wedge and the other auricular surface the side of an inverted wedge, but also in this case the former shape was more marked. In 2 cases (Nos. 1 and 22), equivalent to 7.7 per cent of cases, the sacrum at this level in the frontal section had the shape of an inverted wedge. At the S II level these incidences were as follows: Wedge in 22 cases (84.6 per cent); uniform width in 1 case (No. 14; 3.9 per cent); and an inverted wedge in 3 cases (Nos. 4, 15 and 22; 11.5 per cent). In cases 17 and 20 one auricular surface in this section formed the side of a wedge and the other auricular surface that of an inverted wedge, but also in these two cases the wedge shape was more definite. At the level of S III the figures were as follows: Wedge in 4 cases (Nos. 1, 2, 7 and 22; 15.4 per cent), uniform width in 1 case (No. 25; 3.8 per cent), and inverted wedge in 21 cases (80.8 per cent). At this level only 1 sacrum (No. 15) was of a form combining the wedge and inverted wedge, with the latter shape more marked.

It is common that the lateral parts of the sacrum vary in width. The left lateral part was wider in 19 cases, the right in 6 cases, and the two sides similar in width in 5 cases. Expressed in percentages, these were 63.3 per cent, 20.0 per cent and 16.7 per cent, respectively. MARTIN (1928) stated that RADLAUER found the same variations with the frequencies of 77.4 per cent, 6.5 per cent and 16.1 per cent, respectively. The material examined in the present study was too small to permit the drawing of general conclusions.

The angle of inclination of the sacroiliac joint ranged from 30° to 58° and was on an average 43.3° on the left and 42.7° on the right. The greatest difference found in the angles of inclination of the two auricular surfaces of the same sacrum was 10° (pelves No. 12 and 15) but generally these angles were of nearly the same degree. The differences were apparently due to difference in the shape of the auricular surfaces, which, however, probably does not always signify a difference in the mechanics of the joints. Because of the great variability in the shape of the auricular

surfaces, the angle of inclination was found to bear no definite relationship to the horizontal or vertical position of the sacrum.

It will be observed that the horizontal section of the cranial vertebra (S I) of the auricular surface indicated that at this level the two auricular surfaces had a parallel direction in one case (pelvis No. 15) but in all the other cases converged dorsally. In sections made at the level of S II the articular surfaces converged ventrally in 2 cases (20, 25) but dorsally in all the other cases. In the horizontal section at S III, or other part of the sacrum selected as the most caudal point of measurement, there was, on the other hand, convergence in the ventral direction in 19 cases, the same direction in 2 cases (11, 15) and dorsal convergence in 5 cases only (1, 3, 14, 16, 18).

The stereometric drawings in fig. 5 illustrate the variations in the direction of the articular slit as revealed by the angle measurements. The drawing was made on basis of the measurements of pelves No. 4 and 18.

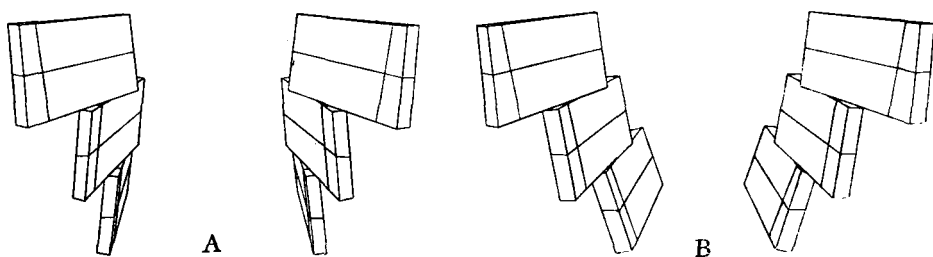


Fig. 5. Stereometric drawings of three different planes in the sacroiliac joints of pelves No. 4 (A) and No. 18 (B), simplified by depicting the joints as symmetrical. The sheetlike pieces illustrate three different planes, on which are also drawn their horizontal and vertical sections. The graphs depict the joints as seen in anteroposterior projection.

In addition to variations in the direction of each auricular surface, numerous depressions, elevations and other irregularities influence the shape of the auricular surfaces and of the articular slit. In no case was there a distinct ridge-furrow or eminence-depression formation, which FICK considers to be common and to determine the movements of the joint. On the contrary, the

impression was gained that great irregularity prevails in respect to the surface formations, as a result of which the sacrum and ilia probably are capable of moving only slightly and irregularly in relation to each other. The development of a dislocation must in most cases be nearly impossible except in the case of simultaneous fracture of the pelvic girdle.

INNERVATION OF THE SACROILIAC JOINT

Since a knowledge of the innervation of the sacroiliac joint is of great importance for the correct interpretation of symptoms from this joint, I have endeavoured to obtain further information on this deficiently known point. The innervation of 9 cadavers, making a series of 18 sacroiliac joints, was studied in the Department of Anatomy. The examination was macroscopic only, since it was not possible to obtain sufficiently fresh samples to ensure a reliable histological study.

The examination of the specimens was carried out as minutely as possible, using a binocular loupe. All the nerve branches observed were very delicate, and it was laborious to follow their course, which often could not be observed beyond the ligaments. It is therefore possible that even important branches were not seen. This difficulty was pointed out by, e.g., GARDNER (1950), who furthermore noticed that the intra-articular innervation is more abundant than a macroscopic examination indicates. The results obtained are best shown in the drawings in figs. 6—14. The drawings are not topographic (the lumbosacral plexus is depicted in a slightly more median situation than it actually occupies) and the sympathetic lumbosacral nerve is not shown, since no noteworthy deviations were observed from its usual relation to the spinal nerves. The findings are listed in table 5, which thus includes the ventral, cranial and caudal nerve supply observed in the sacroiliac joints.

On examination of these findings it will be observed that the innervation is not always symmetrical on the two sides of the pelvis as far as the origin of the articular nerves is concerned.

Figs. 6—14. Origin of the cranial, ventral and caudal innervation of the sacroiliac joints in 9 pelves.

1 = Third lumbar nerve.

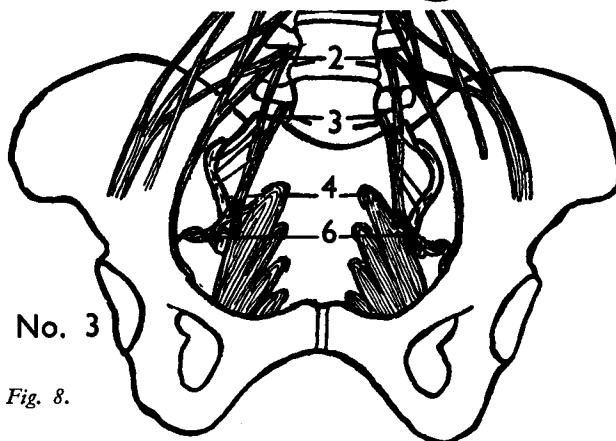
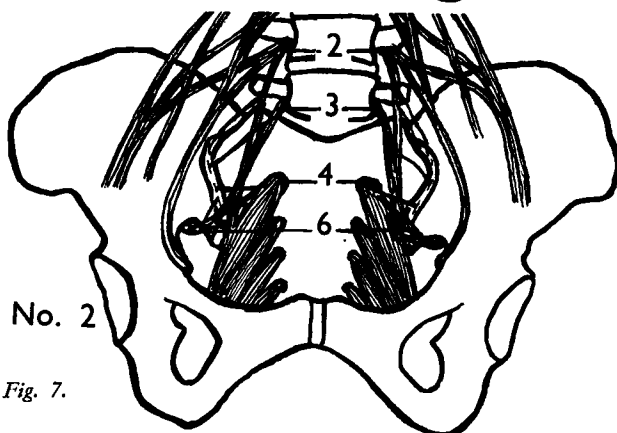
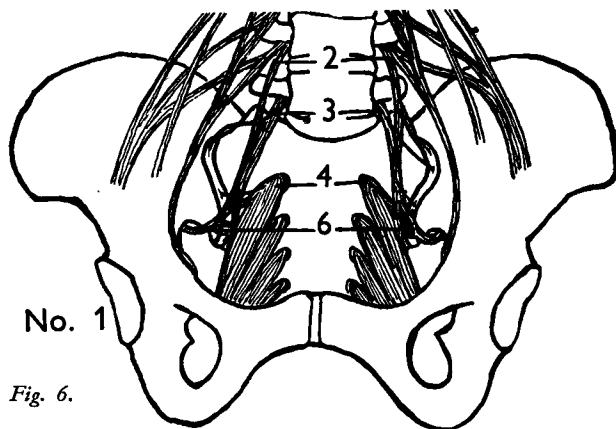
3 = Fifth lumbar nerve.

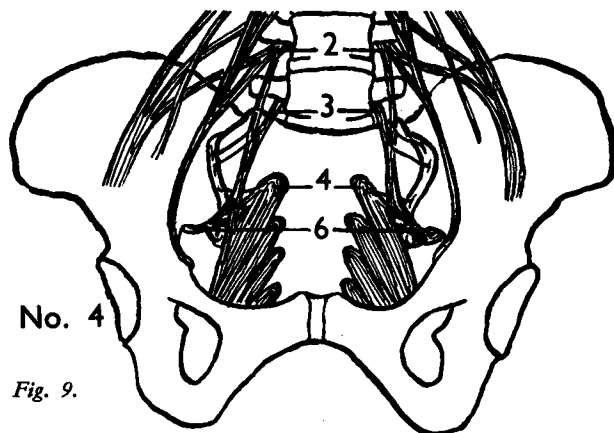
5 = Second sacral nerve.

2 = Fourth lumbar nerve.

4 = First sacral nerve.

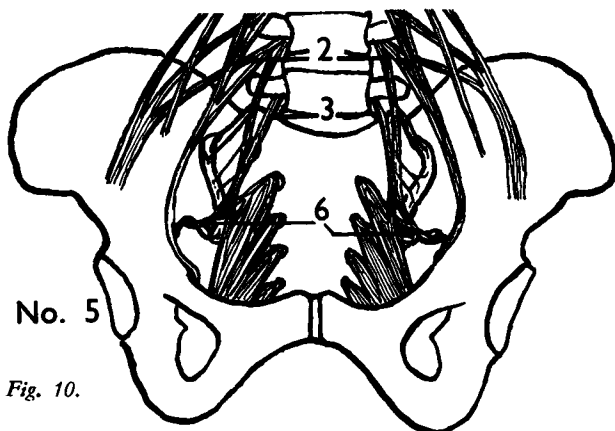
6 = Nervus gluteus cranialis.





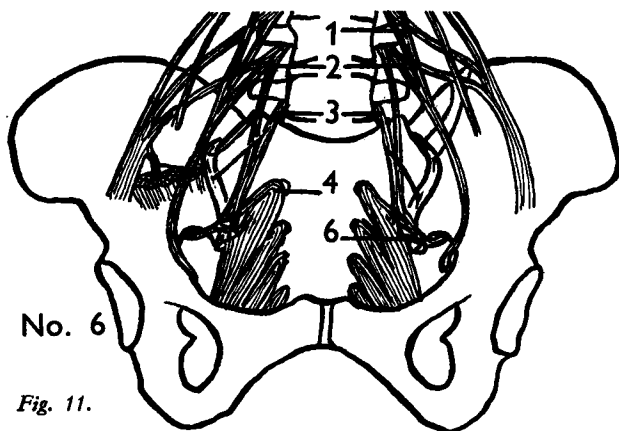
No. 4

Fig. 9.



No. 5

Fig. 10.



No. 6

Fig. 11.

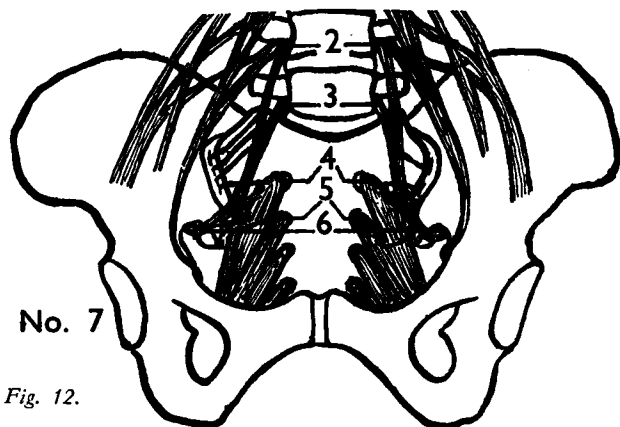
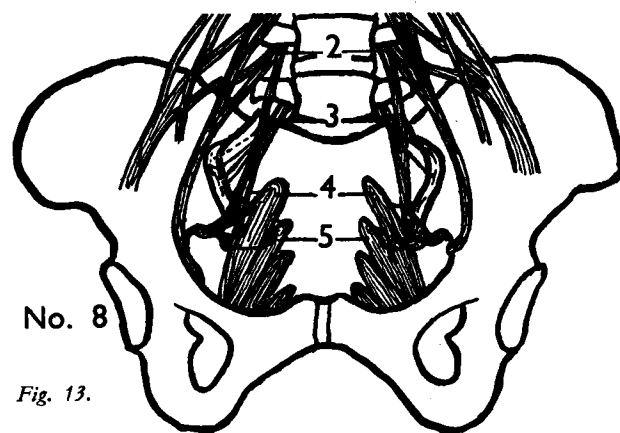
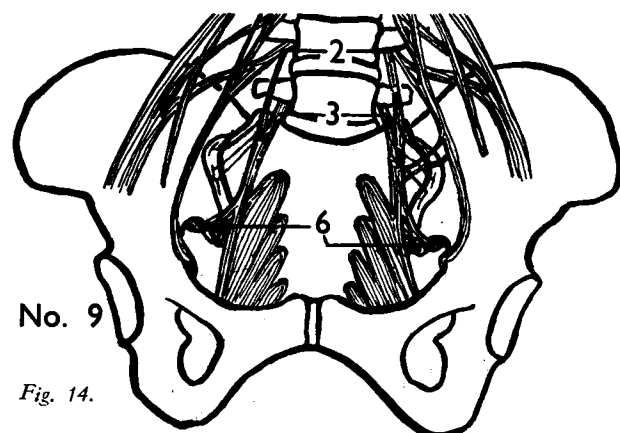
*Fig. 12.**Fig. 13.**Fig. 14.*

TABLE 5. *Origin of the Cranial, Ventral and Caudal Innervation of the Sacroiliac Joint*

Specimen No.	Spinal Nerve					N. glu- teus cra- nialis
	L 3	L 4	L 5	S 1	S 2	
dx 1			x	x		x
sin		x	x			x
dx 2		x	x	x		x
sin		x	x	x		x
dx 3		x	x	x		x
sin		x	x			x
dx 4		x	x	x		x
sin		x	x	x		x
dx 5		x	x			x
sin		x	x			x
dx 6		x	x	x		
sin	x	x	x			x
dx 7		x	x	x	x	x
sin		x	x	x	x	x
dx 8		x	x	x	x	
sin		x	x	x	x	
dx 9		x	x			x
sin		x	x			x
Total	1	17	18	11	4	15

The obturator nerve did not in any of the cases participate in the innervation, which on the ventral side of the joint is supplied variably by nerves from L 3 to S 2, and by the superior gluteal nerve. The latter, in turn, has its origin in the ventral branches of L 5—S 2 (RAUBER-KOPSCH 1943). In specimen No. 9 the obturator nerve, which has its origin in L 2, L 3 and L 4 (RAUBER-KOPSCH 1943), was found to be connected with the lumbosacral trunk by means of two communicating rami. The interesting additional finding was made in the same pelvis, and indeed on the same side, that a part of the sciatic nerve passed through the piriformis muscle and joined the other portion of the nerve to form a main trunk at the caudal margin of the muscle. According to BEATON and ANSON (1938), this anomaly is present in about 7.1 per cent of individuals and according to FREIBERG and VINKE (1934) in about 10 per cent. In the earlier years this anomaly and the relationship between the piriformis muscle and the sciatic nerve was generally considered to play an important part in the etiology of low back and sciatic pain.

The innervation on the dorsal side of the sacroiliac joint had its origin in all the 18 cases in the first and second sacral nerves (fig. 15). This was in conformity with the opinion held by anatomists since the publication of the studies of RÜDINGER (1857).

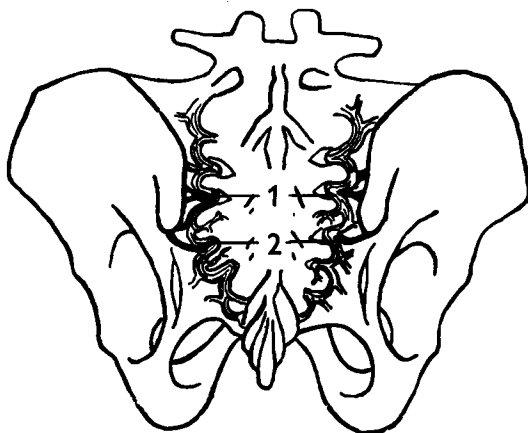


Fig. 15. Origin of the dorsal innervation of the sacroiliac joint.

1 = First sacral nerve.

2 = Second sacral nerve.

MECHANICS AND STATICS OF THE SACROILIAC JOINT

REVIEW OF THE LITERATURE

The pelvic girdle may be said to be an arched structure which rests upon the heads of the femurs. The horizontal thrust which arises when the arch is subjected to a load by way of its »keystone«, the sacrum, is opposed by the symphysis pubis and, outside the arch, by the femurs. Surprisingly, greatly conflicting concepts have been presented concerning the shape and mechanical action of this »keystone«. According to one opinion (MEYER 1853, ALBEE 1909, MAGNUSSON 1937, WILLIS 1937, RAUBER-KOPSCH 1940, FRAZER 1948, GRANT 1948, SHIPP and HAGGART 1950) the sacrum, during the erect posture of the body, widens downwards when seen in frontal section made through its cranial part and seems to hang down from its dorsal ligaments. As the load is increased, the ligaments become taut and draw the dorsal parts of the two ilia towards each other, thus pressing the sacrum the more firmly between them the greater the load upon it. On the other hand it has been suggested (LESSHAFT 1893, WALDYER 1899, STRASSER 1908, FICK 1911, BRAUS 1921, ROUVIÈRE 1924, BROFELDT 1929, CUNNINGHAM's Anatomy 1931, WALTER 1934, WILENSKY 1938, MORRIS' Anatomy 1944) that the sacrum when seen in the said section is shaped like the usual keystone of an arch or like a wedge that tapers downwards. A similar finding was made in most of the specimens examined in the osteological part, in which the measurements also demonstrated that a horizontal sacrum more or less tapers upwards in this section (cf. fig. 30) and a vertical sacrum, again, is a typical wedge-shaped »keystone« (BROWN 1937). As is well known, the female sacrum is usually

slightly horizontal, while the male sacrum rather is slightly vertical.

In contrast to other joints of the body, the sacroiliac joint has a stable equilibrium (FICK 1911), and considerable force is required before this equilibrium is disturbed. The strongest muscles of the human body surround the sacroiliac joint but none of these muscles have the function of moving the joint. Neither can we speak of voluntary movements of this joint, for its movements are produced by other movements of the body and especially by the weight and changes in the posture of the body. Since the lumbar spine and the sacroiliac joints have the same muscular support, they are in a stable position simultaneously (SMITH-PETERSEN 1947). The posture and shape of the lumbar spine is greatly dependent upon the position and shape of the sacrum, which thus may indirectly be predisposing factors in fatigue and pain of the back and especially of the lumbosacral joint (ABERLE, ERLACHER and HARTWICH 1955).

The relationship between the sacroiliac joints and the centre of gravity of the body, which varies with the individual, determines the stability of the sacroiliac joints and the strain upon the muscles and ligaments which control the stability. Today the most generally accepted opinion is that of BRAUNE and FISCHER (1892), according to which the centre of gravity of the body in the »normal posture» (i.e., when the centre points of the shoulder, hip, knee and talocrural joints and the centres of gravity of the parts between these points are situated in the same frontal plane) lies below the promontory at the level of the posterior inferior iliac spine and the third sacral vertebra. Thus it is evident that the weight of the body, when the subject is standing, causes the upper portion of the sacrum to tend to tilt forwards and downwards. The greater the distance between the sacroiliac joint and the weight line passing through the said centre of gravity, the stronger the rotatory force and the more instable the sacroiliac joints.

The first to observe movement in the sacroiliac joint were BARKOW (1841), LUSCHKA (1855), DUNCAN (1867), MEYER (1878)

and BALANDIN (1873). It is held that not only the distinct articular slit but also the synovia and synovial membrane as well as the difference in the sizes of the articular surfaces of the sacrum and the ilium are proof of the presence of movement (STRASSER 1908, FICK 1911). Concerning joints in general, GARDNER (1950) stated that movement is important for the maintenance and development of the shape of a joint. From this may be drawn the inverse inference that only slight movement can take place in the sacroiliac joints, in which ankylosis is very common with advancing age. The onset of ankylosis in the sacroiliac joints in men has been seen already after the 35th year (WILLIS 1944), and in men over 50 years of age ankylosis has been found in about 76 per cent (BROOKE 1924). In a series of 105 female pelvises examined by him, the latter worker was unable to find ankylosis of the sacroiliac joints, although the mobility of also the female sacroiliac joints has been found to decrease already after the 25th year.

Various opinions have been advanced concerning the type of movement in the sacroiliac joint. MEYER (1878) described two kinds of motion, one of which occurs in his opinion around an axis passing through the most concave point of both articular surfaces of the sacrum, and the other around a transverse axis passing through the sacral canal about 1 cm dorsal to the second sacral vertebra. The latter movement is considered by, e.g., KLEIN (1891) and FICK (1911) to be the more important; FICK, however, regarded both movements as slight and merely of a rocking type. FICK also presented the theory of a screw movement of the sacrum between the ilia. PITKIN and PHEASANT (1936) observed movement of two kinds, one of which, as already demonstrated earlier by GOLDTHWAIT and OSGOOD (1905) and supported by, among others, GRAY's Anatomy (1944) and GRANT (1948), occurs around the transverse axis passing through the body of the second sacral vertebra and lying »at the approximate centre of the circle that would be formed by continuing the rough arc of the upper two-thirds of the auriculate articular cartilage. Movements of the sacrum about this transverse axis are analogous to flexion and

extension of the spine.» According to PITKIN and PHEASANT the other movement takes place as a unilateral antagonistic movement of the ilium around a transverse axis passing through the middle point of the symphysis pubis. This axis »lies at the approximate centre of the circle that would be formed by continuing the rough arc of the lower two-thirds of the auriculate cartilage«. The amplitude of the first mentioned movement is, on an average, 4° and that of the latter 11° (3° — 19°). The authors describe the observation of this movement both by X-ray and inclinometre.

During pregnancy there is, from hormonal causes, a softening and relaxation of the sacroiliac ligaments and the symphysis pubis (LOESCHKE 1912, HISAW 1925, 1929, BROUHA and SIMONNET 1928, HEYMAN and LUNDQVIST 1932, TAPPER and HALSHOFER 1935, ABRAMSON, HURVITT and LESNICK 1937, THORP and FRAY 1938, YOUNG 1939, 1940). The same phenomenon is seen in a milder form during menstruation (PITKIN 1937). As a result, the mobility of the sacroiliac joints increases and the pelvic diameters may become longer as the symphysis rotates downwards (BALANDIN 1871, WALCHER 1889, KLEIN 1891). Occasionally this relaxation of the sacroiliac joints and the symphysis pubis may result in »pelvic insufficiency« (GENELL 1948), which was observed by YOUNG (1939, 1940) in 3.7 per cent of pregnant women, or in rupture of the sacroiliac joints or the symphysis during delivery (ENGSTRÖM 1904, TURTOLO 1939, INGMAN 1950, REIS, BAER, ARENS and STEWART 1932). The reduction of the sacroiliac joints following delivery is believed to be more or less incomplete (BROOKE, ROBERTS and BRISTOW 1934).

Consequent upon ankylosis of adjacent joints, compensatory relaxation and greatly increased mobility of the sacroiliac joints has been observed (PITKIN 1937).

INFERENCES ON STATICS AND MECHANICS ON BASIS OF CERTAIN OSTEOLOGICAL OBSERVATIONS

It is natural that the width of the sacrum does not influence the components of the load transmitted to the ilia through the sacroiliac joints. On the other hand, the extent to which the

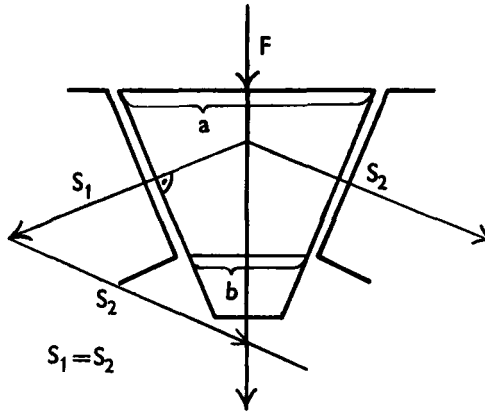


Fig. 16 a. Distribution of the load on the sacroiliac joints.

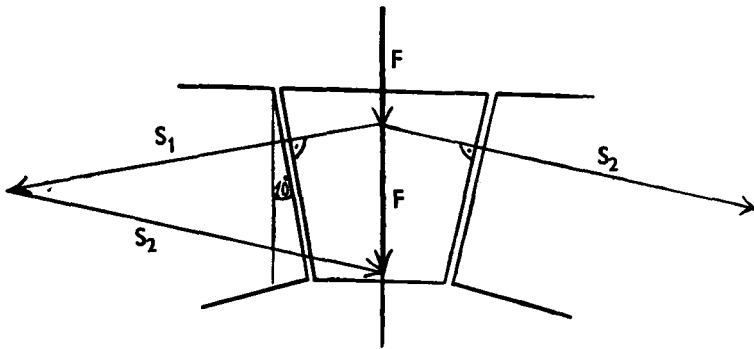


Fig. 16 b. When the articular slit has an inclination of 10° , then $S_1 = S_2 \sim 3F$.

sacrum decreases in width as seen in the frontal section of its ventral part has a definite effect. Examination of fig. 16a shows that the ratio $b:a$ influences the components, so that the smaller the ratio $b:a$ is, the smaller will also S_1 (and S_2) be. Since at the level of the auricular surfaces the sacrum usually is narrower dorsally than ventrally, b may be greater than a in a horizontal sacrum (as for instance in fig. 30). Thus the load on the ligaments obviously is greater than usually.

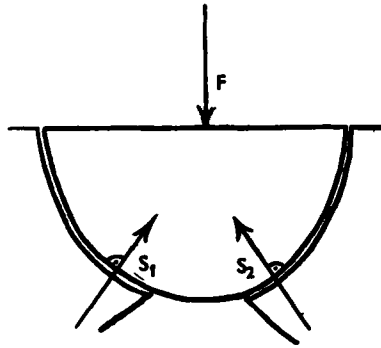


Fig. 17. Owing to convexity of the articular surfaces the load is greatest on the lower portion of the joint.

It is difficult to determine the effect of a difference in the width of the lateral masses of the sacrum on the distribution of S_1 and S_2 , since the structure is, in fact, statically indeterminate. Broadly expressed, the effect of asymmetry probably is small but it seems evident that the load on the ligaments is greater on the side with the narrower lateral mass.

If the articular surfaces of the sacrum are convex in frontal section (fig. 17) the direction of the components is more vertical, in other words they decrease. The load then is frequently transmitted from the sacrum to the ilia at the lower part of the joint (as seen in the frontal section), in other words, the compression on the auricular surfaces of both the sacrum and the ilia is here greatest. Frequently the articular slit of the sacroiliac joint in frontal section is indeed somewhat convex laterally.

The ligaments and the pubic symphysis must compensate the forces S_1 and S_2 (fig. 16 a). When the articular slit has an inclination averaging about 10° in the area where the load chiefly is transmitted from sacrum to ilia, then

$$S_1 = S_2 \sim 3 F \text{ (fig. 16 b).}$$

At a body weight of about 80 kg., F is approximately 50 kg. (according to BRAUNE and FISCHER the weight of the head, upper limbs and trunk is 0.6272 of the total body weight). Then $S_1 =$

$S_2 \sim 150$ kg. without dynamic effect (or impact). When the impact force is F_{dyn} , then

$$F_{dyn} \times t = mv \text{ and } F_{dyn} = \frac{mv}{t} \text{ and } v = \sqrt{2gH},$$

where v = velocity, H = height of fall, t = duration of the impact. When, e.g., $t = 0.1$ sec., $H = 0.05$ m., $g = 9.81$ m. sec.² ~ 10 m. sec.², then

$$v = \sqrt{2 \times 10 \times 0.05} \text{ m./sec.} = 1 \text{ m./sec.}$$

$$m = \frac{F}{g} = \frac{50 \text{ kg.*}}{10 \text{ m./sec.}^2} = 5 \frac{\text{kg.* sec.}^2}{\text{m.}}$$

$$F_{dyn} = \frac{5 \times 1}{0.1} = 50 \text{ kg.*}$$

From this it may be concluded that rapid walking causes a person weighing 80 kg. an about 50 kg.* greater force than walking at a very slow pace. Accordingly, S_1 and S_2 will be increased by three times this amount (if the angle of inclination of the articular slit is about 10° , as mentioned above). This would indeed be the case had not the lower extremities a capacity to take the impact springily.

The concavity and curvature of the sacrum as well as its horizontal or vertical position may have an influence on the distance of the sacroiliac joints from the weight line of the body (fig. 18).

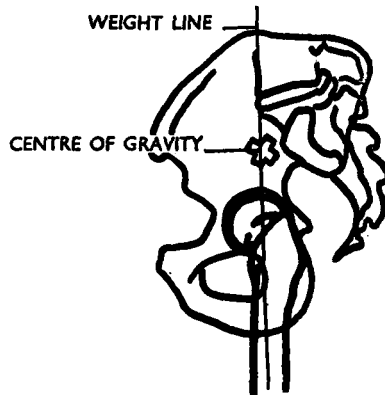


Fig. 18. Relation of the sacroiliac joint to the weight line and the centre of gravity.

The nearer the bearing surface of the sacroiliac joint is to the weight line, the greater will the stability be. On the other hand, a suitable distance between the weight line and the sacroiliac joints produces a force which must be overcome by the muscles (cf. BASLER's so-called *Statische Haltearbeit*, 1940).

The weight of the upper part of the body tends to press the anterocranial portion of the sacrum downwards and forwards, but since the sacrum is wedge-shaped the weight causes it to be pressed all the more firmly between the iliac bones. As the cranial part of the sacrum is pressed forwards, the caudal part tends to rise upwards and backwards, and because of its inverted wedge shape the sacrum is lodged still more firmly between the iliac bones. This movement also causes tension of the sacroiliac ligaments, which adds to the pressing together of the ilia and the sacrum.

The hypo-, homo- or hyperbasality of the sacrum can have no great static significance, but it appears probable that the stability is the greater the closer the lumbosacral joint is to the sacroiliac joints.

The significance of the angle of inclination of the sacroiliac joint lies in the fact that the greater the area of auricular surface participating in the weight-bearing wedge, the smaller the weight per unit of area which is directed upon this portion of the articular surface. A large proportion of the articular surface generally participates in the wedge-shaped weight-bearing part when the longitudinal axis of the articular surface is vertical, i.e., when the angle of inclination of the auricular surface is great.

The effect of an asymmetric tilt of the sacroiliac joints in the frontal section may be examined with the aid of fig. 19 as follows (without regard to the action of the ligaments):

If angle α' is greater than angle α , the component S_2 moves downwards; in other words, it exerts the greatest stress on the lower portion of the joint (the support of the ligaments is not taken into consideration). The relation $S_2 : S_1$ increases with the increasing relation $\alpha' : \alpha$.

All the above estimations have been made on the presumption

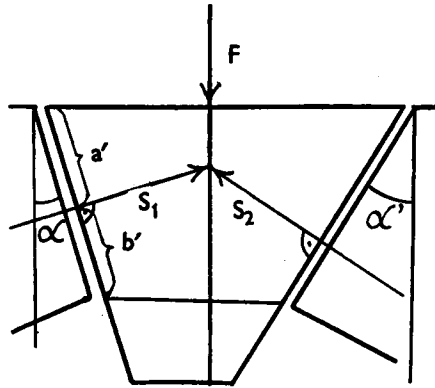


Fig. 19. Effect of an asymmetric tilt of the sacroiliac joints on the distribution of the load on the joints.

of simplified conditions. The circumstances in actual life, i.e., the ligaments, muscles, curvatures of the articulating surfaces and other factors, influence the result greatly, but in any case the above mentioned features play an essential part. Structural or postural asymmetry may thus, according to these evaluations, cause asymmetric load of the sacroiliac joint, which naturally is all the more significant the greater the number of stress-increasing factors which simultaneously affect one and the same sacroiliac joint. This increased load is borne chiefly by the sacroiliac ligaments.

When we hold in mind the irregular shape, direction and structure of the sacroiliac joints, the presence of tight ligaments and capsule, as well as the narrow articular cavity between the nodular and pitted auricular surfaces, it is evident that there can be no marked movement of the two joints at the same time and in the same direction around a common axis. The more probable unilateral movement of the sacroiliac joints evidently consists only in a slight rocking motion.

Accessory sacroiliac joints probably have no functional significance, but undoubtedly they are evidence of the slight mobility of the sacroiliac joints since, although they may be complete diarthrodial joints, they may deviate as much as 60° from the principal direction of the sacroiliac joint on the same side (HADLEY 1952).

ROENTGENOLOGICAL EXAMINATION OF THE SACROILIAC JOINTS

REVIEW OF THE LITERATURE

Roentgenological examination is not only an indispensable aid in the diagnosis of diseases of the back but it also may be a source of error, since pathological findings may frequently be made in roentgenograms of subjects who have never suffered from back pain (BRECK, HILLSMAN and BASOM 1944, BISTRÖM 1954). Even more difficult than the interpretation of roentgenograms of the spinal column in general is the evaluation of X-ray findings in the sacroiliac joints, which may even be associated with considerable technical difficulty.

Various methods of roentgenography are employed, viz.: Ordinary roentgenography (a) in anteroposterior projection (e.g., CLARK 1938, SHIPP and HAGGART 1950, RICHARD 1951, SCHINZ, BAENSCH, FRIEDL and UEHLINGER 1952), (b) in posteroanterior projection (CLARK 1938, RICHARD 1951, SCHINZ *et al.* 1952), (c) in anteroposterior oblique projection from individually variable angles ranging from 30° to 45° (CLARK 1938, MERRILL 1949, RICHARD 1951, RESINK 1952, SCHINZ *et al.* 1952), (d) in posteroanterior oblique projection (MERRILL 1949), (e) in lateral projection (RICHARD 1951), (f) in oblique projection following fluoroscopy made to determine the direction of the joint slit (JAEGER 1949, RICHARD 1951, RESINK 1952), and (g) in posteroanterior projection with the patient seated (MERRILL 1949); (h) stereoscopic roentgenograms (SHIPP and HAGGART 1950, JANES 1951); (i) tomograms, which are regarded as indispensable by, e.g., INGELRANS (1950) when a tuberculous process is suspected.

In this connection may also be mentioned CHAMBERLAIN'S roentgenological method for demonstration of laxity of the sacroiliac joint (CHAMBERLAIN 1930, ANDERSON and PETERSON 1944, WILLIS 1944), which is based on the elevation, when the subject stands alternately on each foot, of the os pubis at the pubic symphysis on the side of the body where the loose sacroiliac joint is situated. This is the phenomenon known for a long time to gynaecologists, i.e., the movement which is palpable at the pubic symphysis when a pushing or pulling force is exerted on one of the pubic bones by means of the lower extremity, and which is due to softening of the pelvic articulations during pregnancy (BUDIN 1875, v. FERNWALD 1894, ENGSTRÖM 1904, SKAJAÄ 1929, ABRAMSON, ROBERTS and WILSON 1934, *et al.*).

PRESENT INVESTIGATION

COMPARISON OF ANTEROPOSTERIOR AND OBLIQUE PROJECTIONS AND OF CAST MODELS

Using skeletal pelves, ordinary roentgenograms were made in the anteroposterior projection and in the oblique anteroposterior projection of the sacroiliac joints of pelves tilted at an angle of 35°—40° to the side opposite to the joint being visualised. For comparison, similar roentgenograms were made of the same joints after the articular slit was outlined with a thin strip of lead, thus accurately visualising the margins of the slit in the roentgenogram. A somewhat similar method was previously employed by, at least, BARSONY and SCHULHOF (1931) and UNTEREINER (1951).

Cast models were also made of the joint cavities of the same sacroiliac joints which were roentgenographed, using the mixture employed in STORCH'S casting medium (Voss 1939) and in some cases an acrylic sheet, which was heated and pressed between the articulating surfaces to give an impression of the cavity. These models, of course, do not give a fully correct picture of the sacroiliac joint slit since it is wider in a skeletal pelvis than

during life because of shrinkage of the cartilage and the bone. The casts obtained were photographed in the anteroposterior projection in the position which the corresponding sacroiliac joints would have had in the erect posture of the body. To indicate the shape of the auricular surfaces the casts were also photographed in the lateral projection.

Examination and comparison of the roentgenograms and photographs make the following observations possible:

The cranial margin of the joint cannot be seen with certainty in the ordinary anteroposterior or oblique projection, since the space between the iliac tuberosity and the lateral mass of the sacrum may misleadingly simulate the joint cavity (fig. 20 a and b, 21 a and b, 23 a and b, 24 a and b, 26 a and b, and 27 a' and b). This possible source of error is also referred to by BARSONY and SCHULHOF (1931).

It is frequently difficult to differentiate in the roentgenograms the ventral and the dorsal aspects of the joint slit, although in the anteroposterior projection the ventral portion usually is visualised lateral to the dorsal portion. The differentiation is

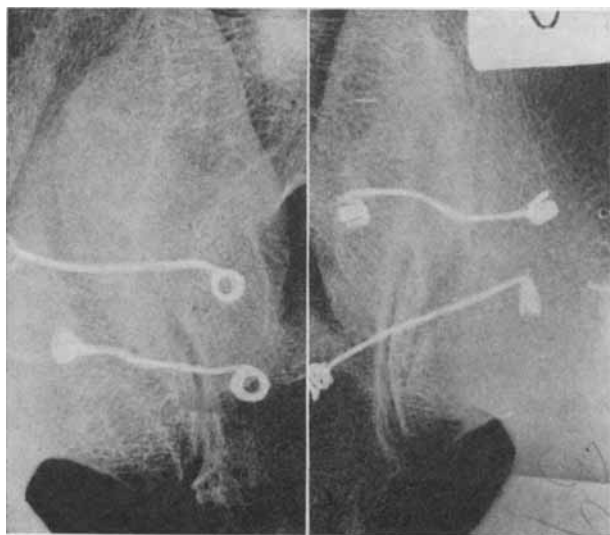


Fig. 20 a. Pelvis No. 11. Ordinary roentgenograms in AP projection.

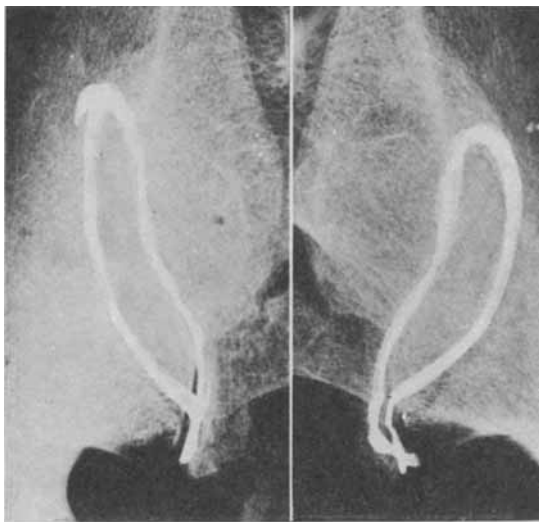


Fig. 20 b. Pelvis No. 11. Roentgenograms in AP projection with articular slit outlined by a lead strip.



Fig. 20 c. Pelvis No. 11. Casts of the articular slits photographed in AP projection.

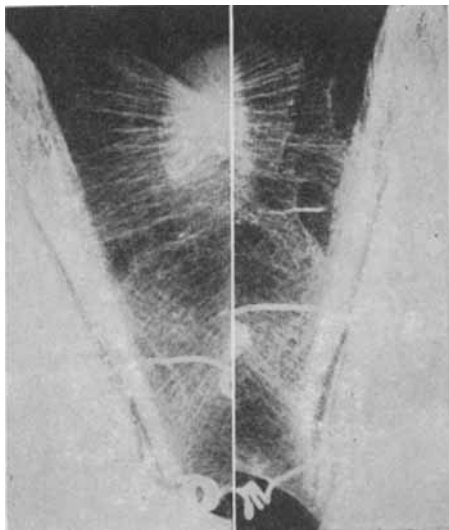


Fig. 21 a. Pelvis No. 11. Ordinary roentgenograms in oblique AP projection.

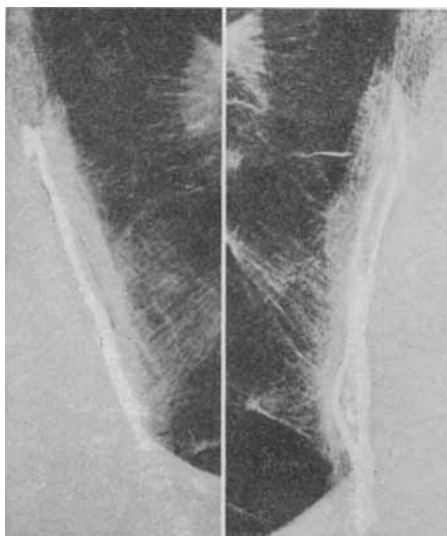


Fig. 21 b. Pelvis No. 11. Roentgenograms in oblique AP projection with articular slit outlined by a lead strip.

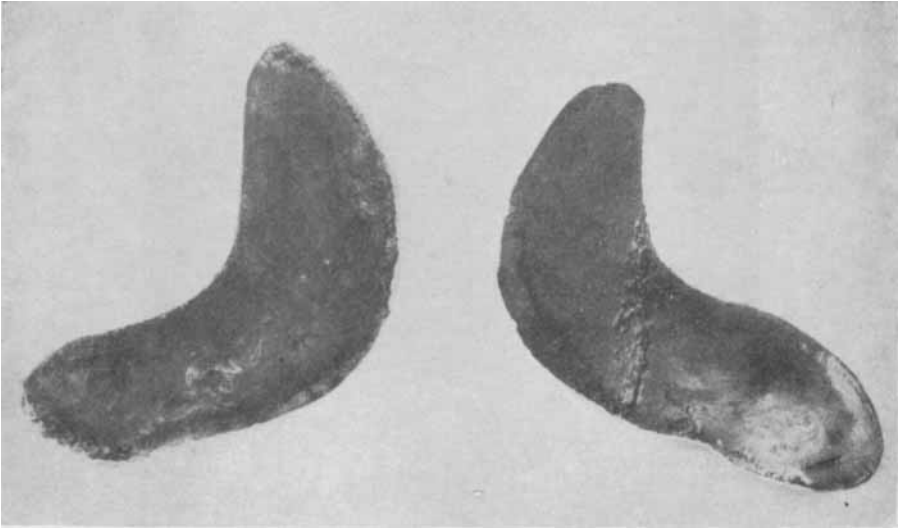


Fig. 22. Pelvis No. 11. Lateral view of articular slit casts shows the shape of the auricular surfaces.

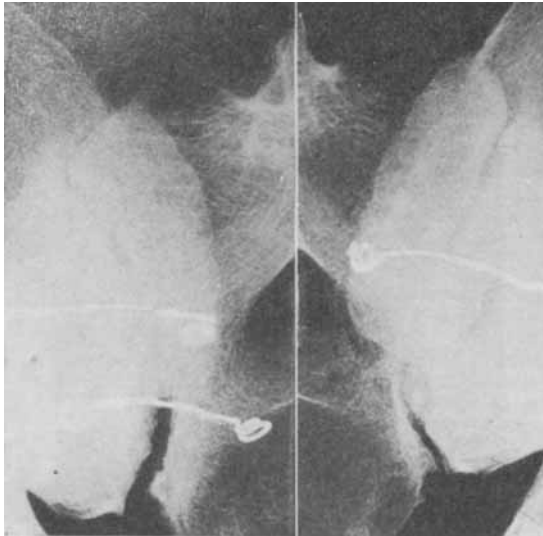


Fig. 23 a. Pelvis No. 17. Ordinary roentgenograms in AP projection.

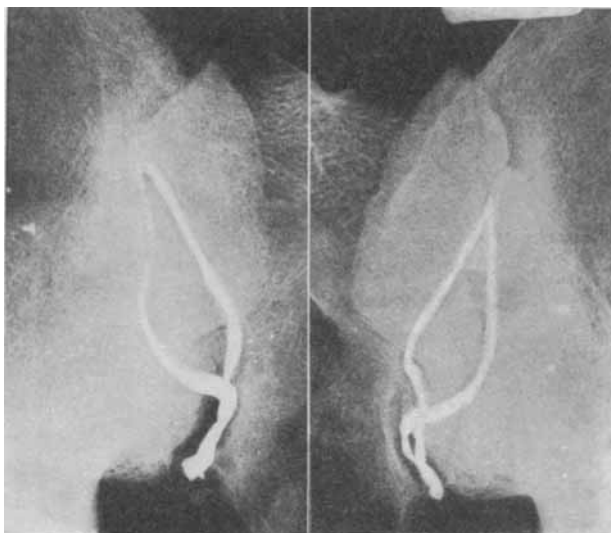


Fig. 23 b. Pelvis No. 17. Roentgenograms in AP projection with articular slit outlined by a lead strip.

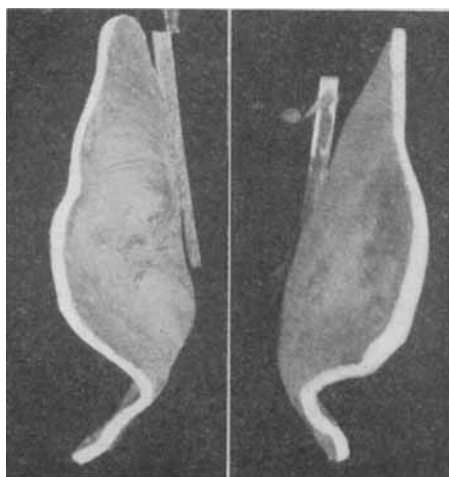


Fig. 23 c. Pelvis No. 17. Casts of the articular slits photographed in AP projection.

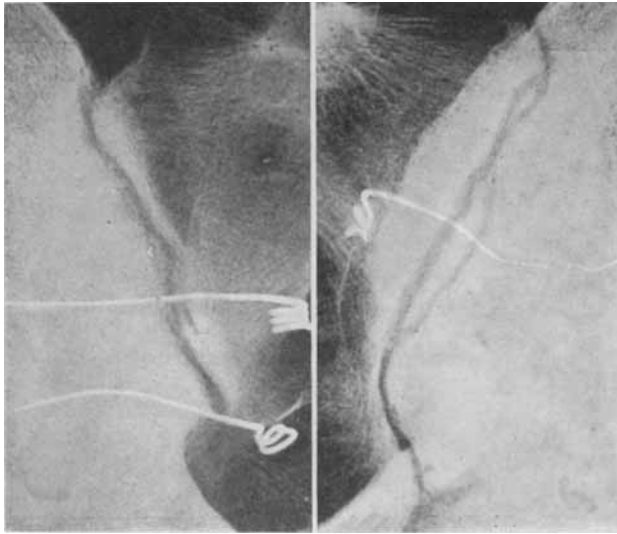


Fig. 24 a. Pelvis No. 17. Ordinary roentgenograms in oblique AP projection.

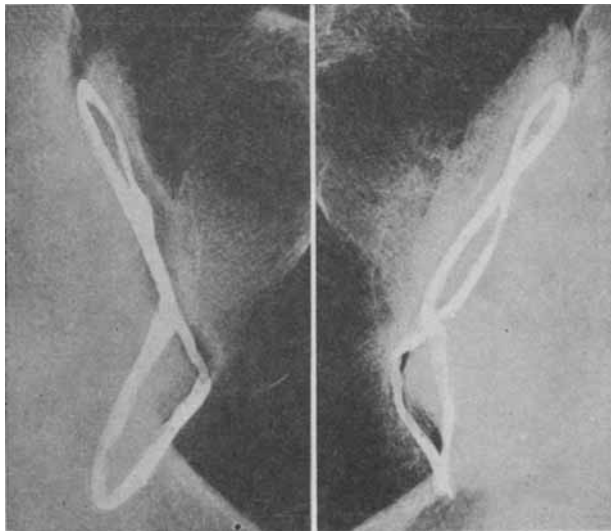


Fig. 24 b. Pelvis No. 17. Roentgenograms in oblique AP projection with articular slit outlined by a lead strip.

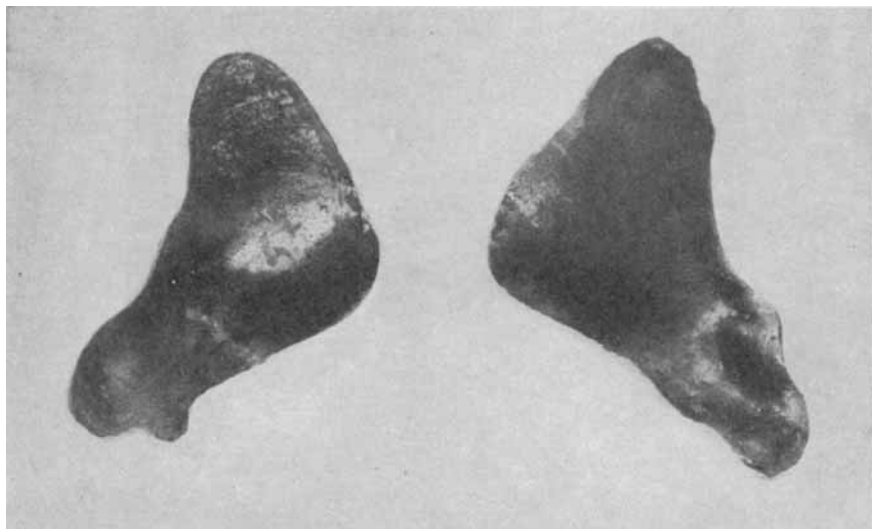


Fig. 25. Pelvis No. 17. Lateral view of articular slit casts shows the shape of the auricular surfaces.

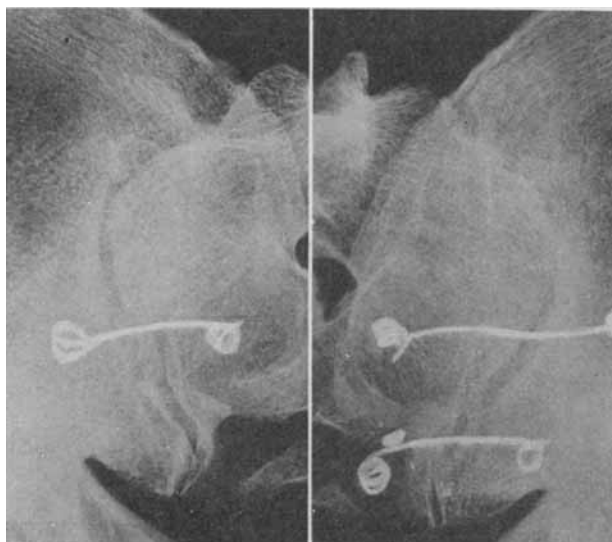


Fig. 26 a. Pelvis No. 22. Ordinary roentgenograms in AP projection.

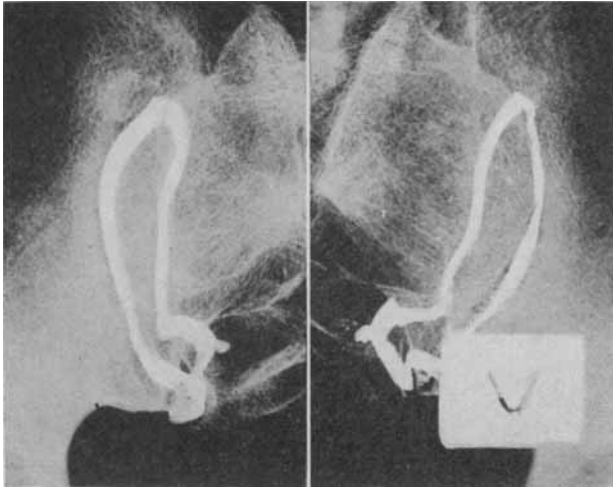


Fig. 26 b. Pelvis No. 22. Roentgenograms in AP projection with articular slit outlined by a lead strip.

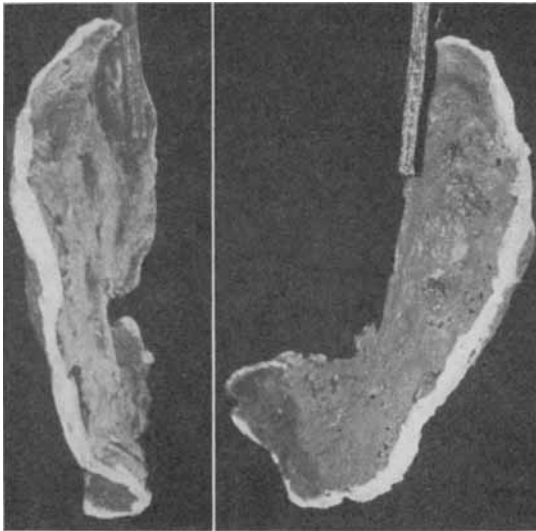


Fig. 26 c. Pelvis No. 22. Casts of the articular slits photographed in AP projection.

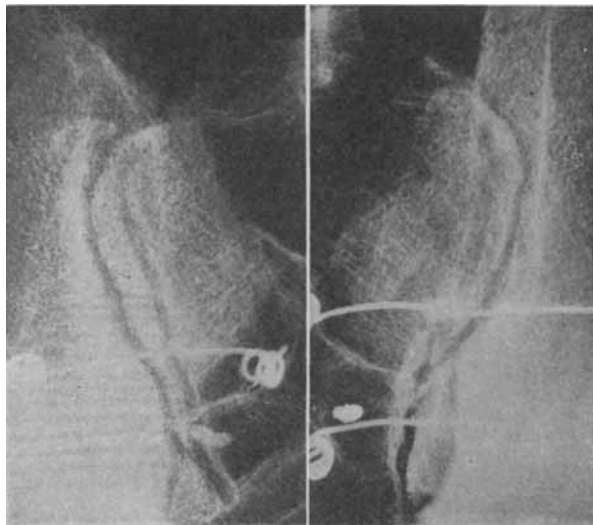


Fig. 27 a. Pelvis No. 22. Ordinary roentgenograms in oblique AP projection.

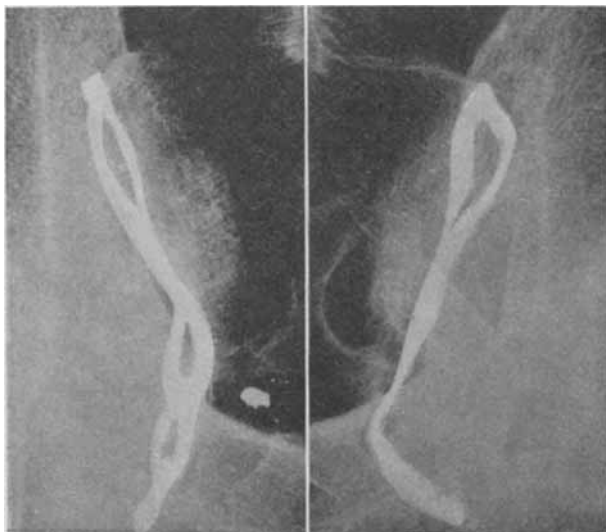


Fig. 27 b. Pelvis No. 22. Roentgenograms in oblique AP projection with articular slit outlined by a lead strip.

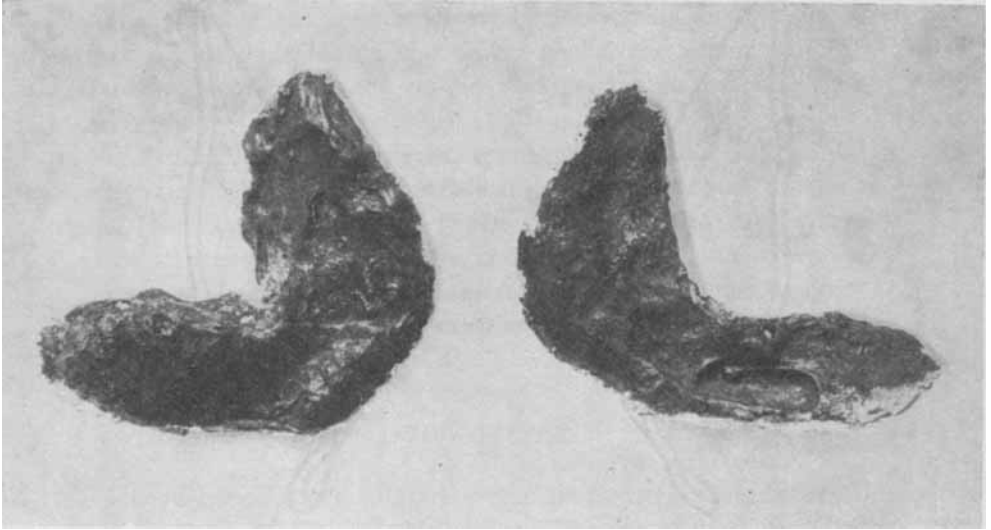


Fig. 28. Pelvis No. 22. Lateral view of articular slit casts shows the shape of the auricular surfaces.

especially difficult when the dorsal and ventral projections of the slit have a winding course and in the oblique projection traverse each other (specimens 17 and 22, fig. 23 a-c, 24 a and b, 26 a-c and 27 a and b).

Of the joint cavity itself only the portions adjacent to the dorsal and ventral aspects could be seen, as is evident on comparison of the photographs of the cast models and the roentgenograms. Thus the slit may extend far more medially than the projections of the dorsal and ventral portions visualised in the roentgenograms (fig. 29).

Also in the oblique projection the joint slit is usually seen only to a very low depth because of the pronounced torsion of the slit and the almost non-existent joint cavity. Specimen No. 11 is an exception, since the auricular surfaces were unusually smooth and their torsion was slight, enabling the roentgen rays to pass through a large part of the joint slit (fig. 20 a-c and 21 a and b). In a case like this, preceding fluoroscopy is useful, but this

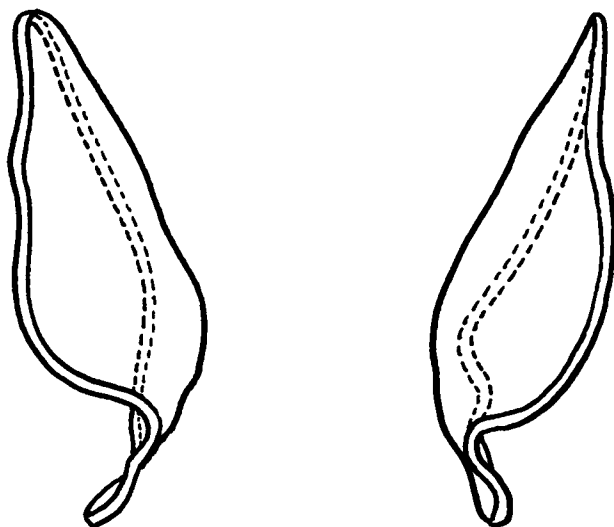


Fig. 29. Cast models of the articular slits of pelvis No. 17 in AP projection show that the slit may extend far more medially than the ventral and dorsal peripheries of the slit as seen in the roentgenogram.

is not the case with the more common winding auricular slits, in which roentgenography in the oblique projection is in general of minor value.

It also is not possible to obtain a clear view of the direction of the different planes of the joint slits. Thus, for instance, the sacrum in specimen No. 22 is in its ventral portion an inverted keystone which narrows cranially, but this cannot be seen in the roentgenogram (fig. 26 a and b and 27 a and b). Nevertheless the determination of this condition would probably be significant, for a sacrum of this shape is a cause of greater than normal stress of the ligaments, as was observed above.

A reliable picture of the shape of the auricular surfaces was not obtained with the methods employed. Roentgenograms in the lateral projection are successful only in the case of very lean subjects. Roentgenograms in the oblique projection may show the localisation and nature of various para-articular processes but even then several roentgenograms should be taken from various

angles. These roentgenograms may be serviceable for instance in cases of osteomyelitis of the pelvic girdle, the vicinity of the sacroiliac joint being one of the sites of predilection of pelvic osteomyelitis (WILENSKY (1938).

In numerous cases, however, tomography is the only method which may give reliable information on various parts of the joint slit. Horizontal tomography (FRIK and HESSE 1956) may prove to be an improvement over the roentgenographic methods used heretofore. In the present investigation, tomography was not considered necessary in the examination of the sacroiliac joints in the skeletal specimens.

ARTHROGRAPHY

I have been unable to find in the literature any reference to arthrography of the sacroiliac joint. The observation made by FUIKS and GRAYSON (1950) of the spontaneous presence of gas in the sacroiliac joint and the »vacuum pneumarthrographies» obtained by them point to a possibility to perform arthrography of this joint. Theoretically regarded, arthrography of the sacroiliac joint may be a useful diagnostic tool, for instance when dislocation, rupture of the joint capsule or other laxity of the joint is suspected, and possibly also in the diagnosis of partial ankylosis.

Anaesthetisation of the sacroiliac joint is often spoken of, and many clinicians indeed believe that they are injecting the anaesthetic into the joint.

These experiences prompted me to attempt the injection of contrast medium into the sacroiliac joint by the anaesthetic injection technique of HALDEMAN (1936). Some injections were performed with the patient lying prone; in other cases the patient was standing upright and fluoroscopy was used to direct the injection needle. Contrast material was not seen in the sacroiliac joint in the roentgenograms in any of the cases, being present only in the soft parts dorsal to the joint or along the lumbosacral plexus. In one case arthrography was attempted in connection with the sacroiliac arthrodesis operation (LEFORT) but no trace

whatsoever of the contrast medium (35 per cent Umbradil »Astra«) was seen in the arthrogram, probably because of the thickness of the bones and soft parts.

In view of the difficulties thus experienced with live subjects, an attempt was made to study the possibilities of performing puncture of the joint and arthrography in anatomic specimens. For this purpose I used skeletal pelvises from which the muscles, nerve trunks and blood vessels had been removed but in which the ligaments were intact. In nearly all cases it proved impossible to puncture the sacroiliac joint by dorsal approach, which in the live subject is topographically the only approach possible. The posterior iliac spine projects so far dorsal to the sacroiliac joint that introduction of the puncture needle beneath the spina ilica dorsalis into the joint slit is not possible. Moreover, there is very little space within the joint slit and its direction generally deviates from the direction possible for punctures (fig. 30). The long, fine puncture needle is also readily displaced by the hard and tough ligaments from its intended direction, a correct determination of which is, furthermore, entirely open to chance. An almost impassable hindrance to puncture consists already in the fact that the auricular surface of the ilium, being slightly broader than the articulating surface of the sacrum, forms a »lid» over the latter, and its narrow borders frequently overlap the joint slit. Some indistinct arthrograms were obtained after injections

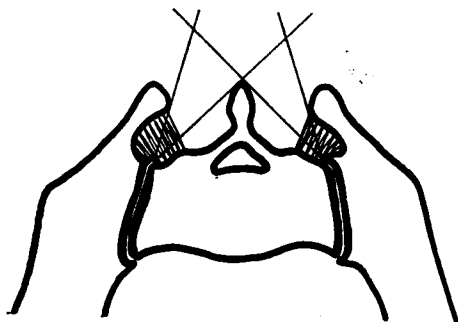


Fig. 30. Puncture of the sacroiliac joint from the dorsal aspect is usually impossible because of the direction of the articular slit.

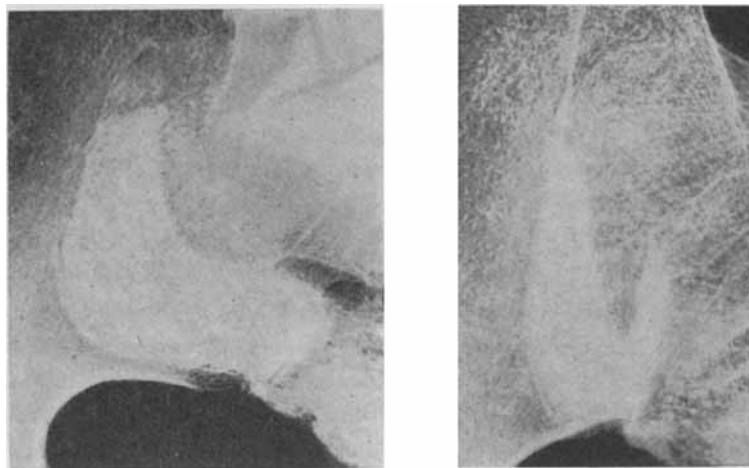


Fig. 31. Roentgenograms in lateral and AP projections of a sacroiliac arthrography performed on an anatomical specimen.

made by ventral approach. It will be seen from the example in fig. 31 that the amount of contrast medium in the joint is so small that reliable information on the condition of the joint cannot be obtained from the arthrogram, despite the fact that soft parts were not a hindrance in the examination of the skeletal specimens.

The attainment frequently of analgesia of the sacroiliac joint by means of anaesthetisation of the articular ligaments, which in other words is periarticular anaesthetisation of the sacroiliac joint, is not an unexpected finding, for observations indicating this have been made concerning joints in general by, e.g., SAPPEY 1889, LERICHE 1930, BRUNSCHWIG and JUNG 1932 and KELLGREN and SAMUEL 1950.

In most cases arthrography of the sacroiliac joint is technically impossible to perform already because of the difficulty of puncture and the topography of the joint. It is apparent that, even were puncture possible, the present methods of arthrography would not be able to give us much information concerning this joint, which is but little more than a fine line enveloped by thick bones and strong soft parts.

CLINICAL STUDIES

REVIEW OF THE LITERATURE

The etiology of the rather diffuse and overlapping clinical picture of strain, subluxation and »insufficiency» of the sacroiliac joint, the differentiation of which generally is not possible by clinical methods, have been studied by numerous investigators from different aspects and at more or less great extent and thoroughness (e.g., GOLDTHWAIT and OSGOOD 1905, ALBEE 1909, BAER 1917, DANFORTH and WILSON 1925, CARNETT 1927, GAENSLER 1927, SOMMER 1928, YEOMAN 1928, BOLAND 1933, BRAGARD 1933, FREIBERG and VINKE 1934, JACKSON 1934, ROGERS and CLEAVES 1935, SHORDANIA 1936, GOLDTHWAIT 1937, THIELE 1937, HAGGART 1938, MITCHELL 1938, TROSTLER 1938, MONTANT 1942, HERSHEY 1943, LEWIN 1943, MENGERT 1943, HANDFIELD-JONES and PORRITT 1945, SMITH-PETERSEN 1947, SAIDMAN 1948, DE LUCCHI 1949, INGELRANS and OBERTHUR 1949, INGELRANS 1950, LIPSCOMB 1951, OBER 1952, SICARD-MOULONGUET 1953, CYRIAX 1941, 1954). In addition to these workers, the symptomatology of these conditions have been discussed by many others (e.g., BRADFORD and LOVETT 1915, SMITH-PETERSEN 1924, VERRAL 1926, WALKER 1928, CAMPBELL 1930, LANGENSKIÖLD 1930, MAS-SART 1933, 1952, HEYMAN 1934, MENNELL 1935, MERCER 1936, NACHLAS 1936, PITKIN and PHEASANT 1936, FREIBERG 1937, BARR, HAMPTON and MIXTER 1937, ABEL 1939, BRAENDLI-WYSS 1939, GRAFF 1940, VERAGUTH and BRAENDLI-WYSS 1940, WILLIS 1944, MCBRIDE 1946, BURUS and YOUNG 1947, FORESTIER, ROTÈS-QUÉROL and JACQUELINE 1950, SCHAPIRO 1950, JANES 1951, NIELSEN 1951, BONICA 1954, ABERLE, ERLACHER, HARTWICH,

KÖNIGSWIESER and STRACKER 1955, WATSON-JONES 1955). Various points in connection with differential diagnosis have been referred to by numerous writers (e.g., AYERS 1926, LUX 1927, YEOMAN 1928, HASS 1929, OBER 1935, 1936, 1940, WILLIAMS 1937, BURREWS 1938, HADLEY 1938, STEINDLER and LUCK 1938, WILENSKY 1938, JOSTES 1940, STEINDLER 1940, MAGNUSSON 1943, LIVINGSTON 1944, HARBIN 1947, PLATT 1948, BARTON 1949, LANCE 1949, PHALEN 1949, WIBERG 1949, ZUELZER 1949, ARMSTRONG *et al.* 1950, BELLÓN 1950, DAL LAGO and VERA 1950, DEJONG 1950, KATZ and BERK 1950, KURTZ and DU VIGNAUD 1950, LASSERRE 1950, MARCHE 1950, RAVAUULT, VIGNON and BERTHIER 1950, TAVERNIER 1950, BARR 1951, IVINS 1951, MASSERA 1951, H. H. YOUNG 1951, J. H. YOUNG 1951, WEIL 1952, EDSTRÖM 1953). The principal features of the clinical picture of this sacroiliac syndrome fit into the picture given by SMITH-PETERSEN in CHRISTOPHER'S »A Textbook of Surgery» (1947). In the case history, which is very important in the differentiation of low back pain, attention is especially to be paid to the mechanism of a possibly preceding accident, to pregnancies and deliveries and coincident back pain, as well as to the patient's occupation and working habits. It is held that a risk of strain of the sacroiliac joint is present chiefly in association with a lesion arising from lifting a burden when the object to be lifted is situated at a lower level than the person, when the hamstring muscles are taut and tend to turn the ischium downwards and the ilium backwards away from the sacrum. The same traumatic mechanism is effective also when the trunk is held immobile and movement of a lower extremity tends to make the relation between the body and the extremity similar to that in the mechanism of trauma cited above. It is doubtful, however, whether an action of a lower extremity such as putting on the brake in a motorcar will be able, even when performed repeatedly, to produce a sufficiently great force and movement to produce a sprain of the sacroiliac joint, as was stated by SMITH-PETERSEN (1947). Probably the most common mechanism of traumatism of the sacroiliac joint is when the patient falls on his feet or buttocks. Congenital weakness, for

example an unreasonably great load on the ligaments due to the form of the joint or the position of the sacrum, is evidently an important etiological factor.

The nature and site of the pain rarely offers a clue to the condition. Local pain may originate in any of the elements of the joint capable of the sensation of pain, i.e., from all parts of the joint other than articular cartilage and compact bone (LENNANDER 1906, FOERSTER 1927, KELLGREN 1939, RAUBER-KOPSCH 1940, DAVIES 1945, LEWIS 1946, KELLGREN and SAMUEL 1950, BONICA 1954, LLOYD-ROBERTS 1955, and others). Having a more abundant innervation, ligaments are probably the most common site of pain (SAPPEY 1889, KELLGREN and SAMUEL 1950). According to the origin of the innervation of the sacroiliac joint (cf. table 5), which arises in the range L 3—S 2 (most commonly L 4—S 2) and from the superior gluteal nerve, referred pain (HEAD 1893, BADGLEY 1937, HAGGART 1938, KELLGREN 1939, FAY 1939, BONICA 1954, CYRIAX 1954, JUDOVICH and BATES 1954, and others) is felt in the buttocks and in the dorsal and lateral aspects of the thigh and the lower leg. Pain provoked by a lesion deep below the skin as in the case of sacroiliac disorders, tends to be more or less diffusely referred and is felt in the areas of the deep segments somewhat different from the areas of the corresponding cutaneous segments (v. LANZ and WACHSMUTH 1938, KELLGREN 1939, FEINSTEIN, LANGTON, JAMESON and SCHILLER 1954). This referred pain is associated also with tenderness of the deep tissues in the area of the pain, and by muscular rigidity, hyperalgesia, hyperaesthesia and hyperactivity of the autonomic nervous system (LEWIS and KELLGREN 1939, BONICA 1954, FEINSTEIN, LANGTON, JAMESON and SCHILLER 1954). It is therefore obvious that the differentiation of referred pain from pain produced by actual irritation of the nerve trunk or nerve root is difficult (KIMBERLEY 1937, LEWIS and KELLGREN 1939, ADKINS 1955). Owing to the location of the sacroiliac joints, even the subjective localisation of joint pain is difficult, and since palpation of the joints is possible only deficiently and with considerable difficulty and several other possible sources of pain and tenderness are situated adjacently,

also the objective localisation of tenderness is difficult. As in lumbosacral lesions, secondary pain due to protective muscle spasm is present in the area of m. erector spinae and the gluteal muscles.

Important points to observe in the examination are structural and static disturbances, posture, scoliosis, faulty function of the lower extremities, muscle spasm, and so on, which may give important indications for a differential diagnosis. A patient with a sacroiliac lesion is able to bend forward more readily when seated than when standing, since in the seated position the hamstring muscles relax because of flexion of the knees and thus do not tend to move the tender joint. Hyperextension of the spine is usually possible if there is a lesion of the dorsal ligaments, since in such a case they relax. The patient frequently stands bent laterally to the healthy side, walks with difficulty and limps, sometimes finds it difficult to turn when lying down, and when seated he tries to prevent the weight of the body from falling on the buttock of the affected side. There may be tenderness to palpation over the dorsal sacroiliac ligaments. The LASÈGUE (GOLDTHWAIT) test is positive, possibly because of the movement of the sacroiliac joints owing to tension of the hamstring muscles. The establishment of a diagnosis may be aided by a number of tests for disorders of the sacroiliac joint. The BAER test demonstrates the tenderness to pressure of the ventral ligaments and the capsule of the sacroiliac joint, and the tests of BONNET, FREIBERG, GAENSLEN, MCBRIDE, MENNELL, NACHLAS and YEOMAN are based on the rotation of the ilium in the sacroiliac joint resulting in tenderness in that part of the joint in which the lesion is situated. The FABERE-PATRICK and LAGUERRE tests, again, seek to produce a movement which provokes tenderness by widening the ventral portion of the joint slit. As a more specific and reliable test may be regarded the compression and separation test of the pelvis involving pressing on the iliac crests (VERRALL 1926, YEOMAN 1928, BROFELDT 1929, CAMPBELL 1930, MERCER 1936, CYRIAX 1954). Tenderness of the sacroiliac ligaments, especially of the sacrospinous and sacrotuberous ligaments, may very

frequently be observed by rectal examination. Often the anaesthesia of the posterior sacroiliac ligaments may be of assistance in the differential diagnosis (LERICHE 1930, LERICHE and ARNULF 1936, STEINDLER and LUCK 1938, HALDEMAN 1936, HALDEMAN and SOTO-HALL 1938).

The various methods of roentgen examination were already discussed above.

The series of cases which will be described was examined by the test methods mentioned above as well as by roentgenography using the ordinary anteroposterior and anteroposterior oblique projection, CHAMBERLAIN'S roentgenological method, and sometimes tomography.

PRESENT INVESTIGATION

NON-INFECTIOUS DISORDERS OF THE SACROILIAC JOINT

A total of 77,410 new patients called at the surgical outpatient department of the Helsinki General Hospital during the period January 1, 1950—April 30, 1955. Various affections of the back were the reason for the visit in 6,895 cases, or in about 8.9 per cent. In 1,726 (about 25 per cent) of these cases the disorder was considered to be a result of a lesion of an intervertebral disc of the lumbar spine, and in 241 cases, or in about 3.5 per cent, to have its origin in the sacroiliac joint. The latter included 10 cases of acute trauma, consisting of acute strain and of luxation of the sacroiliac joint in connection with fracture of the pelvis. So-called »insufficiency» of the sacroiliac joint and the sacroiliac syndrome were present in 133 cases. These were cases in which there had been no clear etiological trauma but in which the symptoms were pain and/or tenderness in the region of the sacroiliac joint with attending secondary features and without signs of infection.

In 23 cases the cause of the pain was held to be degenerative lesions of the sacroiliac joint (arthrosis and ankylosis, which often have been considered — probably erroneously — the cause of the pain). There were 8 cases of osteitis condensans ilei; these

cases were excluded from the present investigation since this condition is of unknown etiology. Diseases of the sacroiliac joint of infectious origin (tuberculous, ankylopoietic, etc.) were present in 67 cases. Excluding the cases of osteitis condensans ilei and those of infectious origin, the patients with sacroiliac disorders totalled 166. This figure may best be evaluated by comparing it with the number of cases of lesions of lumbar intervertebral discs. It will be seen that the ratio of 166:1726 is approximately equivalent to 1.0:10.4.

It seems probable that degenerative lesions of the sacroiliac joint are not always an indication that this joint is an etiological factor in low back pain. Indeed CYRIAX (1954) expressed the opinion that »taken as a disease, osteo-arthritis of the sacro-iliac joints is an imaginary disorder» and that osteophytes are a sign of ossification of the sacroiliac ligaments or of a complete and definite stabilisation of the joints. Thus the ratio of true affections of the sacroiliac joint and of affections of the intervertebral discs of the lumbar spine would be still greater in favour of the latter.

In the presence of symptoms such as strongly positive sacroiliac tests and of the positive result of the frequently employed novocain test, a diagnosis of the sacroiliac syndrome or of sacroiliac »insufficiency» made in the present cases at the first visit to the hospital was considered adequate by the examining physician, but after the essential symptoms became predominant and evidently were known in greater detail both to the physician and the patient the diagnosis sometimes was corrected at later visits of the patient. The new diagnoses then made were the sciatic syndrome in 7 cases, strain of the back muscles in 3 cases, lesion of the lumbosacral joint in 3 cases, coccygodynia in 1 case, spondylolisthesis in 1 case, haemorrhage of the gluteal muscles in 1 case, and arthrosis deformans of the hip joint in 1 case. In a number of other cases it seemed advisable to add to the diagnosis of the sacroiliac disorder a subdiagnosis of other conditions possibly influencing the symptoms, such as spondylolisthesis, osteochondrosis, spondylarthrosis, degeneration of a disc, or lumbago.

However, there were some definite cases of strain of the sacroiliac joint, of which the following case may be cited as an example.

Case Report. — A charwoman, aged 61, was examined on September 17, 1953, after falling on the previous day on a slippery floor from an upright position obliquely onto her right buttock. Simultaneously there had been a sensation of great pain in the abdomen to the left of the umbilicus. On examination the patient complained of great pain and tenderness in the back in the region of the left sacroiliac joint. Walking and sitting were difficult and she was better able to stand still. Turning when recumbent was painful. Over the dorsal ligaments of the left sacroiliac joint there was slight tenderness to pressure, but marked tenderness on the ventral aspect of the joint was observed on performance of the BAER test. The BONNET, FREIBERG, GAENSLEN, MCBRIDE, YEOMAN and the pelvis compression and separation tests were positive on the left. In testing the joints by alternately pushing one extended lower extremity cranially and pulling the other distally the patient felt a severe pain in the region of the left sacroiliac joint. No pathological findings were made in the roentgen examinations, including CHAMBERLAIN's method. The treatment was bedrest and a tight compressing bandage around the pelvis. Already 10 days later the patient was subjectively and objectively asymptomatic and during an observation period of 1 year did not complain of any signs pointing to a sacroiliac or lumbosacral lesion. It appears probable that this was a case of »slipping» of the sacroiliac joint, evidently attended with lesion of the ventral ligaments of the joint. There was no definite visible dislocation, and the rapid healing may probably be ascribed to the immediate immobilisation of this joint which already by nature is very stable. It deserves to be noted that there was no referred pain in this case.

During the period mentioned above, 19 patients with non-infectious lesions of the sacroiliac joint received treatment at the then Orthopaedic Clinic of the University of Helsinki¹⁾. Of these cases, 13 were treated surgically and 6 conservatively. In the same period there were 379 patients with lesions of the intervertebral disc, of whom 275 were treated surgically and 104 conservatively. The ratio between the cases with sacroiliac joint lesion and those with lumbar intervertebral lesion is thus 1.0: 20.0.

¹⁾ A list of the patients described here and to be described later in this report will be available for perusal at the First Surgical Clinic of the University of Helsinki.

The surgical patients included 11 women aged 28—53 years and 2 men aged 28 and 46 years. The etiology in the surgical cases was trauma in 5 cases, in 2 of which there was a fall backwards, strain due to lifting of a heavy load in 1 case, subluxation in association with fracture of the pelvis in 1 case, and a lesion due to a trauma of unknown mechanism causing fracture of the right femur in 1 case. The onset of symptoms in the other cases was gradual and without known cause. No clear relationship was seen between pregnancies or deliveries and sacroiliac lesions, although 8 of the 11 women had had at least two deliveries.

The treatment in the 13 surgical cases was SMITH-PETERSEN arthrodesis (SMITH-PETERSEN 1921, 1926, SMITH-PETERSEN and ROGERS 1926) in 11 cases and LEFORT arthrodesis (OBERLIN and BERGERON 1942) in 2 cases. As the primary result of the operation the patient's condition was good in 11 cases, improved in 1 case, and unimproved in 1 case. It was not aggravated either subjectively or objectively in any of the cases. Two to four years later the condition was still good in 8 cases, better than preoperatively in 3 cases, and poor in 1 case. This data is based on written information from all but one patient, since a sufficient number of them did not submit to a follow-up examination. The basis of evaluation of the result of operation was the degree of success in the treatment of the disorder for which the patient had sought relief. The evaluation of the primary result in this series of patients was carried out by several physicians and therefore probably was more objective (although perhaps made on slightly varying grounds) than if made by only one interested person. The result was regarded as good if the pain was entirely absent and the patient himself or the examining physician no longer could observe symptoms. The condition was held to be improved if the patient reported definite abatement of the pain and functional disorder and if the objective symptoms were milder or absent. The unimproved case was one in which the subjective and objective symptoms persisted unchanged. There were no deaths during or after operation. One of the patients with a good primary result was hospitalised later because of the sciatic syndrome and

TABLE 6. *Surgically Treated Cases of Non-Infectious Disorders of the Sacroiliac Joint*

Age, Yrs.		Trauma	Length of History, Yrs.	Deliveries before Operation	X-Ray Finding before Operation	Surgical Operation	Primary Result of Operation	Present Status	Follow-Up, Yrs.
Female	Male								
39		Fall	4	4	Negative	S-P	Good	Good	2
37		—	1	3	Sacrum horizontale	—»—	—»—	—»—	4
40		—	½	2	Negative	—»—	—»—	Improved	4
28		—	1	3	—»—	—»—	—»—	Good	4
38		—	15	2	Subchondral sclerosis	—»—	—»—	—»—	4
36		—	1	—	Bilateral arthrosis	—»—	—»—	—»—	4
41		Crushing injury	2	2	Positive Chamberlain test	—»—	—»—	—»—	4
52		—	3	—	Arthrosis	—»—	Improved	Improved	4
41		—	1½	5	Negative	—»—	Good	Good	2½
53		Lifting	6	3	—»—	—»—	—»—	—»—	3
30		—	1	—	Arthrosis	Lefort	—»—	Unknown	3
46		Fracture of pelvis	1	—	Positive Chamberlain test	—»—	—»—	Improved	3
28		Fall	1	—	Negative	S-P	Poor	Poor	2

S-P = Arthrodesis by method of Smith-Petersen.

Lefort = Arthrodesis by method of Lefort.

an exploratory operation on an intervertebral disc was performed. In this connection the spinal nerve was freed from adhesions which evidently were incidental to an old case of rupture of the disc. Following this operation the patient reported great satisfaction with the result.

The patient whose primary condition was unimproved was a 28-year-old man with an originally somewhat doubtful diagnosis. Following the operation he was examined a number of times in the outpatient department of the clinic, where the diagnoses of lumbago, strain of the muscles of the back, and neurasthenia were given to this case. It appears probable that the original diagnosis was not accurate. In a man aged 46, who had unilateral fixation performed because of subluxation of the sacroiliac joint following fracture of the pelvis, the primary result was good and also the follow-up condition was better than preoperatively. However, also the other sacroiliac joint of this patient is unstable.

An interesting case is that of a woman aged 28 years, married, whose primary and long-term recovery was good. As a school-girl she had observed a peculiar snapping sound in the pelvis on walking, coinciding with the step. There was no pain or other symptoms for several years, but the sound was sufficiently loud to be heard also by other persons. There was an onset of pain, which gradually became aggravated and formed the indication for an operation. The sound has been absent postoperatively and roentgen examination has revealed no special findings.

Conservative treatment was given to 3 male and 3 female patients. The etiology in one of the male cases was a fall from some height on to his buttocks, and the onset of pain in another case followed a sudden jerk of the body backwards on lifting of a heavy load. In the other cases the onset had been gradual. Only one of the women had been pregnant. The pain in her case started during the second pregnancy (twin pregnancy) and became aggravated during the third pregnancy which began shortly after the second delivery. Her case history attested to definite »insufficiencia pelvis» (GENELL 1948), with goose gait and pain. Examination

TABLE 7. *Conservatively Treated Cases of Non-Infectious Disorders of the Sacroiliac Joint*

Age, Yrs.		Trauma	Length of History, Yrs.	Deliveries before Treatment	X-Ray Finding before Treatment	Treatment	Primary Result of Treatment	Present Status	Follow-Up, Yrs.
Female	Male								
29	45	Fall	2	3 (1 twin pregnancy)	Negative Osteitis condensans iliei	Corset —»—	Good —»—	Improved Good	1 2
	31	—	3						
25	36	—	4	—	Negative	—	Poor	Good*)	4
	36	—	3	—	—»—	Corset	—»—	Poor	3
	38	Lifting	1½	—	—»—	—»—	Good	Unknown	
			14		—»—	—»—	—»—	—»—	

*) Removal of herniated disc one year later.

revealed a bilateral insufficiency of the sacroiliac joint and roentgenologically there was the typical bilateral osteitis condensans ilei. Surgery was not indicated since the pain was greatly relieved by a corset. A female patient with rather indefinite symptoms reported recovery as a result of an operation made later on a ruptured intervertebral disc. The third woman reported the persistence of unabated pain regardless of the use of a corset for 3 years. All the 3 male cases had been prescribed a corset and the primary result was good. Only one of them replied to the follow-up inquiry made about one year later and reported that his condition had regularly been better than before hospitalisation.

An examination of case histories of the surgically treated patients with rupture of a disk revealed that, in addition to the symptoms of ruptured disk, the sacroiliac tests were positive in many of the cases. This group also included 2 cases earlier diagnosed as »insufficiency of the sacroiliac joint» and therefore treated conservatively until the correct diagnosis was made and surgical treatment led to recovery.

The observations made in this small clinical series will evidently permit cautious drawing of the following conclusions:

It seems evident that strain, subluxation and insufficiency of the sacroiliac joints exist;

These conditions appear to be more common with women than with men;

In cases which have the indications for sacroiliac arthrodesis, this operation will give good results. Such cases are a lengthy history of pain or instability in the sacroiliac joint or a luxation of the joint.

In the differential diagnosis, consideration should be given to rupture of an intervertebral disc, which is a considerably more common disease of the back than lesions of the sacroiliac joint. The so-called sacroiliac tests are non-specific and most of them are, at least at the first glance, positive also in cases of a ruptured disc. The most reliable test is probably the pressure and separation test of the pelvis. The disturbances in the reflexes and sensitivity produced by a ruptured disc are not present in insufficiency or

strain of the sacroiliac joint. However, the sensation of pain may in both cases be present in approximately the same area, in the former case as pain due to nerve root compression and in the latter as referred pain. — Differentiation can generally be made most readily on the basis of disturbed posture and motion. Occasionally roentgenograms will be of considerable aid in differential diagnosis, and in some rare cases it may be well to employ myelography. However, the best means of reaching a correct diagnosis is undoubtedly an accurate case history and a thorough clinical examination based on a good knowledge of the anatomy, mechanics and statics of the sacroiliac joints.

EFFECT OF DISTURBED STATICS AND MECHANICS OF THE LOWER EXTREMITIES ON THE SACROILIAC JOINTS

A study was made of 50 patients with a lengthy history of a disease or congenital or acquired deformity or defect of one or both of the lower extremities. There were 29 female and 21 male patients. Some but not all of the patients had had back pain. In the great majority of patients the pathological condition of the lower extremities was unilateral, but in a few cases it was bilateral and more or less symmetrical. The object of this section of the investigation was to study the reaction of the sacroiliac joint in these cases, since symptoms from the joint could be expected because of the changed statics and mechanics of the lower extremities.

In all the cases the usual examinations on »back patients» were made, with attention to the posture and manner of standing and walking, flexion and extension of the back, findings on inspection and palpation of the muscles and the spine, results of the sacroiliac tests mentioned earlier in this chapter and of the LASÈGUE test, reflexes and sensitivity of the skin in the lower extremities, condition and motion of the joints, symmetry of muscles and bones, quality of a possible amputation stump, and fitness of the prosthesis. A rectal examination was made on all the patients and

a simple gynaecological examination on the female patients. In all cases a roentgenographic examination was performed of the lumbar spine and the sacroiliac joints. In some cases the latter consisted of roentgenograms made in the usual anteroposterior projection only, since the information so obtained was evidently adequate in these cases and roentgenograms made in the oblique projection are not, according to the results obtained in the preceding chapter, of decisive value. The laboratory tests always included the erythrocyte sedimentation rate. In many cases the blood picture was analysed and a simple urinalysis and WaR were made. For the sake of brevity, only the positive results of the examinations will be mentioned in the case descriptions given below, only those negative findings being referred to which have a direct bearing on the case.

The series of 50 cases was divided into 20 groups according to the diagnosis made, as follows:

Group No.	Diagnosis	Number of Patients
1	Tuberculosis coxae	14
2	Arthrosis deformans coxae	5
3	Coxa vara et arthrosis deformans secundaria	3
4	Luxatio congenita coxae unilateralis	5
5	Luxatio congenita coxae bilateralis	1
6	Anchylosis coxae	2
7	Osteochondritis dissecans et subluxatio coxae	1
8	Pseudarthrosis colli femoris	1
9	Morbus Legg-Perthes-Calvé	1
10	Arthrosis deformans coxae et genus	1
11	Arthrosis deformans coxae et stylus cruris post amputationem	1
12	Stylus femoris post amputationem	1
13	Osteomyelitis chronica femoris	1
14	Sequela poliomyelitis (Paresis extremitatis pelvinae)	2
15	Aplasia extremitatis pelvinae	1
16	Arthrosis deformans genus	2
17	Anchylosis genus	1
18	Stylus cruris post amputationem	4
19	Pes equinovarus congenitus	2
20	Pes equinus traumaticus	1
		Total 50

A brief description of the patients in each group is given below.

Group 1: Tuberculosis coxae

Patient No. 1—1. A farmer's daughter aged 14 years had a history of tuberculosis of the left hip of 7 years' duration. After receiving conservative treatment for 4 years, she was mostly confined to her bed. Now on admission the left hip joint was ankylosed in 90 degrees flexion, 15 degrees adduction and 70 degrees external rotation. The apparent shortness of the limb was about 3.5 cm. In the lumbar spine there was a 90 degrees lordosis and a left scoliosis and the sacrum was horizontal. No back pain was present. The tuberculous process was not active; the sedimentation rate was 6 mm/1 hr. The sacroiliac joints were clinically and roentgenologically asymptomatic.

Patient No. 1—2. A 16-year-old farmer's daughter had had an onset of tuberculosis of the left hip 13—14 years previously. During conservative treatment the hip joint became ankylosed in 20 degrees flexion, 20 degrees adduction and slight internal rotation. The apparent shortness of the limb was 8 cm. The patient walked with the right knee in flexion and only the toes touching ground. The lumbar spine showed slight left scoliosis. There was no back pain. The sacroiliac joints were clinically and roentgenologically asymptomatic.

Patient No. 1—3. A female patient aged 24 years, attending a vocational school for the disabled, had 21 years previously had osteomyelitis of the left hip, which presumably was tuberculosis. She had received practically no treatment. There was pain in the lower back and the left hip on walking. On admission the head of the left femur was 5 cm cranial to the Roser-Nelaton line and the apparent shortness of the limb was 7 cm. Active and passive flexion and abduction of the hip were greatly restricted and the hip had an about 15 degrees flexion and 15 degrees adduction contracture. In the lumbar spine there was increased lordosis and a left scoliosis. Clinically the sacroiliac joints were asymptomatic but roentgenographically the area around the right sacroiliac joint was definitely denser than on the left side, especially in the ilium. The entire left pelvis was hypoplastic, the head and neck of the delicate left femur were absent, and the proximal end of the bone rested on the ilium cranial to the original site of the acetabulum. In the region of this neo-arthritis and in the proximal end of the femur there were clear areas evidently due to an old tuberculous process. The sedimentation rate was 8 mm/1 hr.

Patient No. 1—4. A 29-year-old female pupil in a vocational school for the disabled had had an onset of tuberculosis of the right hip about 10 years previously. Treatment had been plaster cast immobilisation and antibiotics. She had been ambulant for the past 8 years. There had been no back pain but movements of the hip were greatly restricted

and painful. On admission extension-flexion of the hip joint was 170—140 degrees, abduction and adduction about 20 degrees and rotations minimal. Clinically the back and the sacroiliac joints were asymptomatic. In roentgenograms the area around the left sacroiliac joint was increased in density (fig. 32). The articular slit appeared to be normal. The sedimentation rate was 24 mm/1 hr.

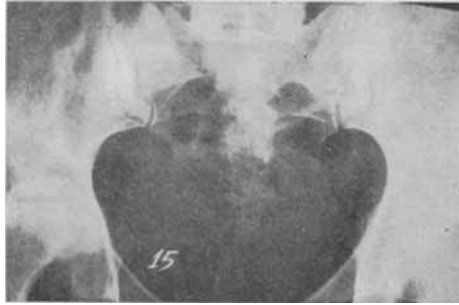


Fig. 32. Case No. 1—4, female, 29 yrs. History of tuberculosis of right hip of 10 years' duration. Increased density of bone around left sacroiliac joint.

Patient No. 1—5. A dressmaker aged 30 years had 25 years previously had an onset of tuberculosis of the left hip. Conservative treatment was given for several years. Subsequently there had been difficulty in walking and tenderness and pain in the hip and lower back, radiating along the posterolateral aspect of the limb to the lower leg. On admission the left lower extremity was found to be 8 cm short, and there were no active movements of the hip joint. Passive extension flexion was 180—120 degrees and abduction and adduction were unrestricted. Rotations were greater than normal. There was a positive Trendelenburg's sign on the left and tenderness to palpation over the left hip joint and sacroiliac joint. Otherwise the sacroiliac joints were clinically asymptomatic. There was right lumbar scoliosis. According to the roentgenogram the left femoral head was absent and the acetabulum was destroyed; the entire left half of the pelvis was hypoplastic. In the region of the right sacroiliac joint, especially on the iliac side, the osseous tissue appeared to be denser than on the left.

Patient No. 1—6. A female patient aged 30 years, daughter of a labourer, had a history of tuberculosis of the right hip of 7 years' duration and had received conservative treatment for 6 years, with no weight-bearing by the affected limb during this period. There was mild low back pain on exertion. The right hip joint was now ankylosed

in 5 degrees flexion, 20 degrees adduction and 30 degrees internal rotation. The right lower extremity had an apparent shortness of 4 cm. Extension of the right knee was complete but only 10 degrees flexion was possible (contracted due to lack of exercise therapy). Trendelenburg's sign was positive on the right side. In the lower thoracic spine there was scoliosis with the convexity to the right. Clinical sacroiliac tests gave no symptoms with the exception of Baer's test, which was positive on the right side. Roentgenography revealed an asymmetric pelvis, destruction of the femoral head and part of neck on the right, with the neck stump resting on the ilium cranial to the acetabulum. The bone in the iliac portion of the left sacroiliac joint was markedly increased in density (fig. 33).

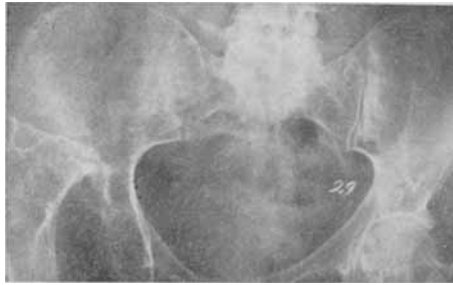


Fig. 33. Case No. 1—6, female, 30 yrs. Onset of tuberculosis of right hip 7 yrs. previously. Increased density of bone around left sacroiliac joint, especially on the iliac side.

Patient No. 1—7. A 48-year-old woman in sedative factory work had 8 years previously had tuberculosis of the right hip. In the absence of proper treatment the joint had gradually become ankylosed. Walking was difficult and attended with pain in the right knee and lower back. The limb now had an apparent shortness of 14 cm, and the hip joint was ankylosed in 30 degrees adduction, 45 degrees flexion and slight internal rotation. Extension was limited by 30 degrees in the right knee. The right foot showed a transversoplanus deformity, hallux valgus and a mild equinus contracture. In the lumbar spine there was right scoliosis but the sacroiliac joints were asymptomatic clinically. Roentgenography revealed a hypoplastic right half of the pelvis. The right femoral head had moved cranially in an enlarged acetabulum and the entire joint showed a pronounced deformity. In the vicinity of the left sacroiliac joint the bone appeared sclerotic.

Patient 1—8. A labourer's wife aged 56 years had a history of untreated tuberculosis of the right hip since the age of 10. There had

been no back pain. On admission the shortness of the limb was 2 cm. In the right hip joint the extension was limited to 160 degrees, flexion was 160—120 degrees, and abduction and adduction as well as rotations were only of a few degrees. The hip joint had an external rotation contracture of about 30 degrees. The spine and sacroiliac joints were asymptomatic clinically. Roentgenograms showed on the right a hip joint deformity due to an old tuberculous process and the left sacroiliac joint was surrounded by a narrow sclerotic layer on both the sacral and the iliac sides of the joint.

Patient No. 1—9. A male patient aged 19, son of a mechanic, had 14 years previously had an onset of tuberculosis of the left hip, which had been conservatively treated in a sanatorium for 9 years. There had been no back pain. On admission there was a slight right scoliosis at the margin of the thoracic and lumbar spines. The left hip joint was ankylosed in 35 degrees flexion, 20 degrees adduction and 10 degrees internal rotation. There was an apparent shortness of 8 cm in the left lower extremity. The sacroiliac joints were asymptomatic clinically. Roentgenography revealed dislocation of the femoral head from the acetabulum and bony ankylosis of the femur and ilium. On the iliac border of the right sacroiliac joint there was a definite sclerotic zone.

Patient No. 1—10. A male patient aged 25 years, attending a vocational school for the disabled, had had an onset of symptoms of tuberculosis of the right hip 8 years previously. Conservative treatment was immediately instituted, followed 5 years later by extra-articular arthrodesis. Through his illness he had chiefly been a bed patient, with the exception of the past 2 years, when he had been walking a little with crutches. He had had no back pain. Examination on admission showed right thoracic and left lumbar scoliosis, but otherwise the spine as well as the sacroiliac joints were asymptomatic clinically. The right hip joint was ankylosed in a good position and a definite shortening of the limb was not observed. In the roentgenograms there was seen the condition following a tuberculous process and extra-articular arthrodesis of the right hip. No abnormal findings were made in the sacroiliac joints.

Patient No. 1—11. A 34-year-old mason had a history of tuberculosis of the left hip of 28 years' duration. In the absence of adequate treatment the hip had been ankylosed in a position of deformity for 16 years. There had never been noteworthy back pain. On admission the left hip was ankylosed in 20 degrees flexion, 30 degrees adduction and 15 degrees external rotation. The left knee had a 30 degrees valgus deformity and the range of motion was 170—155 degrees. There was an apparent shortness of 10 cm in the left lower limb. There was a

marked left lumbar scoliosis. Clinically the sacroiliac joints were asymptomatic. In the roentgenogram the left hip joint was seen to be ankylosed in a deformed position and there was sclerosis around the right sacroiliac joint (fig. 34).



Fig. 34. Case No. 1—11, male, 34 yrs. Tuberculosis of left hip of 28 years' duration. Increased density of bone around right sacroiliac joint.

Patient No. 1—12. An automobile mechanic aged 37 had 35 years previously had tuberculosis of the right hip. For brief periods he had received conservative treatment. During only the past month there had been pain in the right hip but no back pain. The right hip joint was now ankylosed in 50 degrees flexion and 5 degrees abduction. Extension of the right knee was limited to 170 degrees and flexion was complete. No tenderness was observed in the hip or the knee. There was an apparent shortness of about 6 cm in the limb. The lumbar spine had a hyperlordosis and a right scoliosis; otherwise the spine and the sacroiliac joints were asymptomatic clinically. Roentgen examination revealed destruction of the right femoral head and bony ankylosis of the right hip joint. The borders of the left sacroiliac joint were more sclerotic than those of the right (fig. 35).

Patient No. 1—13. This was a labourer aged 41, who about 35 years previously had had tuberculosis of the right hip and had been treated conservatively in childhood. During the past few years there had been low back pain on exertion. On examination the range of extension-flexion of the right hip was 180—130 degrees, abduction 5 degrees, adduction 15 degrees and the external and internal rotation about 5 degrees. The lower right extremity had an apparent shortening of about 8 cm. The right knee was capable of full flexion and of hyper-extension *ad* 195 degrees. The lumbar spine showed left scoliosis but otherwise the spine and the sacroiliac joints were asymptomatic clini-



Fig. 35. Case No. 1—12, male, 37 yrs. Tuberculosis of right hip of 35 years' duration. Increased density of bone at the margins of left sacroiliac joint.

cally. The roentgenograms revealed conditions following tuberculosis of the right hip joint, consisting of destruction of the femoral head and the acetabulum and luxation of the femur, as well as hypoplasia of the right half of the pelvis. The vicinity of the left sacroiliac joint appeared somewhat more sclerotic than that of the right.

Patient No. 1—14. A 75-year-old man, a former nightwatchman, had had an onset of tuberculosis of the right hip 55—60 years previously. Treatment had apparently been inadequate. He complained of low back pain during the past 10 years, especially in the morning and on exertion. On admission all the movements of the right hip were greater than normal and there was a marked luxation of the femur and the right lower extremity had an apparent shortness of about 12 cm. There was a right lumbar scoliosis. The Lasègue test was positive on the left side at 45 degrees and negative on the right side. The left sacroiliac joint was tender to percussion. The reflexes and sensitivity were normal. Ability to bend forward on sitting and standing was greatly limited because of the low back pain. The roentgenograms revealed that the head and neck of the right femur were completely destroyed, the trochanter major of this femur was situated about 12 cm higher than that of the left femur and the acetabulum could not be visualised; otherwise there was no notable pelvic asymmetry. Marked spondylosis and right scoliosis were seen in the lumbar spine. The right sacroiliac joint appeared to be normal but the area around the left joint seemed markedly sclerotic, especially on the iliac side.

Group 2: Arthrosis deformans coxae

Patient No. 2—1. A charwoman, aged 36, had 19 years previously suffered a traumatic fracture of the left femoral neck, which was repaired by nail fixation. About 5 years before admission to our clinic there had developed stiffness in the hip, limp and considerable hip pain on movement. No back pain had been present. In the left hip there was now a contracture of 45 degrees flexion, 10 degrees adduction and 40 degrees external rotation and the limb had an apparent shortness of about 4 cm. The Trendelenburg sign was positive on the left. The sacroiliac joints were asymptomatic clinically. The roentgenogram revealed considerable arthrosis of the left hip joint and marked sclerosis in the vicinity of the right sacroiliac joint, especially in the ilium (fig. 36: roentgenogram made after performance of vitallium cup arthroplasty for arthrosis of the hip joint).



Fig. 36. Case No. 2—1, female, 36 yrs. Traumatic fracture of neck of left femur, followed by arthrosis of left hip joint. Markedly increased density of bone in vicinity of right sacroiliac joint.

Patient No. 2—2. A 46-year-old woman, married, had a history of symptoms of arthrosis of the right hip joint of 5 years' duration and of similar pain in the left hip of 2 years' duration. The left hip was more painful. Since onset of the hip pain there also had been low back pain, even on resting. On admission the movements of both hips were approximately similar, with extension-flexion of 170—80 degrees, abduction of 30 degrees, adduction of 10 degrees, and rotations 0 degree. Trendelenburg's sign was positive on both sides. There was a deep lumbar lordosis. The spine and the sacroiliac joints were asymptomatic clinically. Roentgenograms revealed subluxation of both hips, with marked arthrosis. Sclerosis was present in the right sacroiliac joint.

Patient No. 2—3. A labourer aged 37 years had 25 years previously had an onset of osteomyelitis in the femoral diaphyses of both lower extremities and in the left femoral head and neck. With the exception of the past 6 years, he had been incapable of work. There had been no back pain. On admission the joints of the right lower extremity were free but in the left extremity the hip joint was capable of 160—140 degrees extension-flexion, with the other movements practically normal, the knee had an extension-flexion of 175—160 degrees, and there was a deficit of 10 degrees in the plantar flexion of the left ankle. The spine and sacroiliac joints were asymptomatic clinically. In the roentgenograms there was a marked protrusion of the left acetabulum and a pronounced arthrosis of this hip joint, presumably consequent upon the osteomyelitis. The right sacroiliac joint was definitely more sclerotic than the left.

Patient No. 2—4. A 64-year-old business manager had a history of symptoms of arthrosis of the right knee and ankle of 31 years' duration, and of tenderness, stiffness and pain in the right hip of 11 years' duration. There had been no back pain. On admission the right hip was ankylosed in a position of 30 degrees flexion and 15 degrees adduction. The right lower extremity had an apparent shortness of about 3 cm. There was a right lumbar scoliosis, but in other respects the spine and the sacroiliac joints were asymptomatic clinically. Roentgenograms revealed considerable arthrosis of the right hip joint and slight arthrotic changes in the left hip joint. On both sides of the left sacroiliac joint the bone was definitely sclerotic (fig. 37).



Fig. 37. Case No. 2—4, male, 64 yrs. Symptoms of arthrosis of right knee and ankle for 31 yrs. and of right hip for 11 yrs. Increased density of bone around left sacroiliac joint.

Patient No. 2—5. A forester aged 64 years had had symptoms of arthrosis of the left hip for about 20 years and of the right hip for the past 2 years, with greater tenderness and pain in the latter. There had

been no back pain. On admission there was a contracture of 15 degrees flexion, 15 degrees adduction and 15 degrees external rotation in the left hip joint and of 20 degrees flexion, 15 degrees adduction and 15 degrees external rotation in the right hip joint. All movements in both hips were greatly limited. The sacroiliac joints were asymptomatic clinically. Roentgenologically there was, in addition to considerable subluxation arthrosis of both hips, definitely greater arthrosis and sclerosis of the left than of the right sacroiliac joint.

Group 3: Coxa vara et arthrosis deformans secundaria

Patient No. 3—1. A farmer's wife aged 44 had had progressively increasing tenderness and pain in the left hip of 2 years' duration. Recently there had also been low back pain on the right side, especially on exertion. On admission the left lower extremity was found to have an apparent shortness of 3 cm, the hip had a 35 degrees deficiency in extension and a contracture of about 10 degrees adduction, with extension-flexion 145—90 degrees and abduction, adduction and rotation nearly 0 degree. The right hip was asymptomatic. There was a left lumbar scoliosis. In other respects the spine and the sacroiliac joints were asymptomatic clinically. Roentgenograms revealed a left coxa vara, evidently due to epiphyseolysis, and considerable arthrotic changes in the joint. The right hip appeared normal. In the right sacroiliac joint there was sclerosis and signs of arthrosis (fig. 38).



Fig. 38. Case No. 3—1, female, 44 yrs. Symptoms of arthrosis of left hip joint during 2 yrs. Increased density of bone around right sacroiliac joint.

Patient No. 3—2. An automobile driver aged 33 years had during 17 years had an ache in the left hip and pain on exertion, and during 14 years also frequent low back pain. On admission the left lower

extremity was found to have an apparent shortness of 3 cm, extension-flexion of the left hip was 160—80 degrees, and the Trendelenburg sign was positive on the left. Roentgenograms revealed a marked varus deformity of the left hip, with arthrotic changes. The spine and sacroiliac joints were asymptomatic both clinically and roentgenologically.

Patient No. 3—3. A mechanic aged 37 had 12 years previously suffered a fracture of the left femoral neck, which had been treated conservatively. During several years there had been low back pain on exertion. On admission there was an apparent shortness of 3 cm in the left lower extremity; the spine and sacroiliac joints were asymptomatic clinically. Roentgenograms revealed a left coxa vara and secondary arthrosis deformans. The borders of the right sacroiliac joint slit were sclerotic.

Group 4: Luxatio congenita coxae unilateralis

Patient No. 4—1. A woman aged 43 had an untreated congenital luxation of the left hip. There had been no back pain of notable degree. Findings on admission were, in addition to the luxation, a resulting apparent shortness of about 5 cm in the left lower extremity and a left lumbar scoliosis. Otherwise the spine and the sacroiliac joints were asymptomatic clinically. Roentgenograms revealed a high-degree luxation of the hip and hypoplasia of the left pelvis. In the region of the right sacroiliac joint there was marked sclerosis and arthrotic osteophytes (fig. 39).



Fig. 39. Case No. 4—1, female, 43 yrs. Congenital luxation of left hip. Markedly increased density of bone in the region of the right sacroiliac joint.

Patient No. 4—2. This patient, a 46-year-old office clerk, female, suffered from an untreated congenital luxation of the right hip, with pain and tenderness during the past 7 years. In the left hip there had been arthrotic pain and stiffness for about 9 years. During the past 4 years she complained of low back pain on exertion, situated more on

the left and radiating along the dorsal aspect of the left thigh and the lateral aspect of the left leg to the dorsum of the foot. On admission the typical symptoms of right hip luxation were seen, there was an apparent shortness of 5 cm in the limb, and the hip had an extension-flexion of 180-70 degrees and an adduction contracture of 15 degrees. In the left hip, abduction and adduction were 0 degree, extension-flexion 170—100 degrees, and internal and external rotations 5 degrees. The Achilles reflex was absent on the left. The sacroiliac joints were asymptomatic clinically. In the lumbar spine there was a pronounced lordosis and tenderness to percussion at the lumbosacral joint. Roentgenograms showed considerable luxation of the right hip. In the left hip there was subluxation and marked arthrosis deformans, evidently following epiphyseolysis. The region of the left sacroiliac joint was definitely more sclerotic than that of the right joint.

Patient No. 4—3. A farm woman aged 48 had an untreated congenital luxation of the right hip attended with hip pain but no noteworthy back pain. On admission the right lower extremity was found to have an apparent shortness of 10 cm and there was a contracture of 35 degrees flexion and 20 degrees adduction in the hip and a genu valgum of 20 degrees in the right knee and of 5 degrees in the left knee. The lumbar lordosis was deepened and there was a right lumbar scoliosis. Clinically no other findings were made in the spine or the sacroiliac joints. Roentgenologically there was seen a luxation of the right hip joint. The neck of the femur was in a pronounced varus position. The area surrounding the left sacroiliac joint gave a denser shadow than that on the right and appeared to be sclerotic.

Patient No. 4—4. A woman aged 50, married, had an untreated congenital luxation of the left hip. For the past 3 years there had also been symptoms of arthrosis of the right hip. There had been no back pain. On admission the left lower extremity was found to have an apparent shortness of 5 cm; the movements of the left hip joint were unrestricted. The right hip joint had an extension deficiency of about 40 degrees and complete flexion, but abduction, adduction and rotations were 0 degree. The patient was only able to walk with the aid of two walking sticks. The spine and the sacroiliac joints were clinically asymptomatic. The roentgenograms visualised the left hip luxation, with a deformed femoral head situated cranial to the acetabulum. In the right hip there was marked arthrosis deformans. The region of the right sacroiliac joint was markedly sclerotic but a lesser degree of sclerosis was also seen in the caudal portion of the left sacroiliac joint.

Patient No. 4—5. A mechanic aged 47 who had an untreated congenital luxation of the right hip had had low back pain on exertion during the past 3 years. On admission the right lower extremity was found

to have an apparent shortness of 5 cm. Extension-flexion of the hip joint was 180—110 degrees and there was a contracture of 20 degrees adduction and 20 degrees external rotation. There was a right lumbar scoliosis. Tenderness to percussion was observed over the left sacroiliac joint in the back. The Lasègue test was positive on the left side at 60 degrees, the Bonnet, Ely, Freiberg and Gaenslen tests were positive bilaterally, and the Baer test was positive on the right. The compression and separation test of the pelvis was negative. Rectal palpation revealed tenderness bilaterally in the region of the sacrospinal ligament. The roentgenograms showed luxation of a deformed femoral head and very marked arthrotic changes as well as a valgus deformity. Sclerosis was more marked along the borders of the left sacroiliac joint than of the right.

Group 5: Luxatio congenita coxae bilateralis

Patient No. 5—1. A 34-year-old woman who was attending a vocational course for the disabled had a bilateral congenital luxation of the hip, for which McMurray's osteotomy had been performed on the right and Schanz's osteotomy on the left 8 years previously. She complained of fatigue and pain on exertion during the past few years. On admission she walked with a duck-like gait because of a bilaterally positive Trendelenburg sign. The range of movement of both hips was practically normal. No special clinical features were seen in the back or in the sacroiliac joints. The roentgenograms showed that the heads of both femurs rested on the ilium cranial to the acetabulum and the post-osteotomy conditions were clearly visible. The lumbar spine had a slight right scoliosis and abundant osteophytes. The sacroiliac joints appeared to be symmetrical.

Group 6: Anchylosis coxae

Patient No. 6—1. A 23-year-old woman, a hospital attendant, gave a history of post-traumatic ankylosis of the right hip following an accident 15 years previously. A corrective osteotomy had been performed 6 years ago with poor results, resulting in osteomyelitis of the femur. On admission the right hip was ankylosed in 45 degrees flexion and 10 degrees abduction. The apparent shortening of the extremity was 3 cm. There was a left lumbar scoliosis. The sacroiliac joints were clinically asymptomatic. The roentgenograms showed the right hip ankylosed in the position of abduction-flexion deformity. The vicinity of the right sacroiliac joint was definitely more sclerotic than that of the left joint (fig. 40).

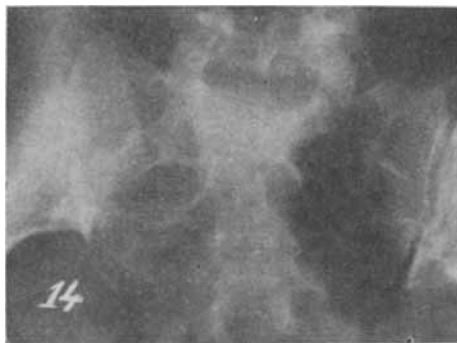


Fig. 40. Case No. 6—1, female, 23 yrs. Right hip ankylotic for 15 yrs. Increased density of bone in vicinity of right sacroiliac joint.

Patient No. 6—2. A farmer's wife, aged 50, related that her right hip had become ankylosed for no known reason 25 years previously. The poor posture and the shortness of the extremity had handicapped her but there had been no back pain. On admission the right hip was ankylosed in 45 degrees flexion and 20 degrees abduction and the apparent shortening of the limb was about 3 cm. There was a left lumbar scoliosis but otherwise the spine as well as the sacroiliac joints were clinically asymptomatic. Roentgenologically there was seen, evidently as a result of epiphyseolysis, a deformity of the femoral head and the acetabulum and a severe arthrosis; definite osseous ankylosis could not be observed. In the region of the left sacroiliac joint the bone was sclerotic and osteophytes were present on the caudal margins of the joint.

Group 7: Osteochondritis dissecans et subluxatio coxae

Patient No. 7—1. A 25-year-old factory worker, male, had 22 years previously (at the age of 3) fractured the right femur, which had been treated conservatively. As far back as he could recollect the right hip had always been sensitive to exertion. About 6 months before admission an operation had been performed for osteochondritis dissecans of the right femoral head. Following the operation there had developed a subluxation of the hip with pain and restriction of movement. There had been no back pain. On admission the extension-flexion of the right hip was 180—150 degrees, the abduction, adduction and rotations were 0 degree, and the Trendelenburg sign was positive. The

apparent shortening of the extremity was 3 cm. The spine and sacroiliac joints were clinically asymptomatic. The roentgenogram showed in addition to subluxation of the arthrotic right femoral head, also sclerosis of the left sacroiliac joint (fig. 41).



Fig. 41. Case No. 7—1, male, 25 yrs. Pain in the right hip of 22 years' duration. Subluxation of right hip. Increased density of bone around left sacroiliac joint.

Group 8: Pseudarthrosis colli femoris

Patient No. 8—1. A farmer's widow, aged 57, had 16 months previously fractured the head of the left femur. Conservative treatment had been followed by pseudarthrosis, after which she had been entirely unable to put any body weight on this limb. Arthroplastic resection of the hip was made 8 ½ months after the accident. Since the accident she had ambulated only if indispensable, using crutches. On admission there was an apparent shortness of 4 cm in the left lower extremity. The limb was held in a slight external rotation and because of the tenderness on motion the movements of the hip were very greatly restricted. She was totally unable to step on this extremity. The spine and sacroiliac joints showed no symptoms clinically or roentgenologically.

Group 9: Morbus Legg-Perthes-Calvé

Patient No. 9—1. A domestic servant, aged 20 years, had a history of pain on exertion in the right hip of about 10 years' duration due to Legg-Perthes-Calvé disease. There had been no definite pain in the back. Clinical examination on admission revealed no special findings in the hips, spine or sacroiliac joints. In the roentgenograms was seen the deformity following the Legg-Perthes-Calvé disease but no definitely unusual findings were made in the sacroiliac joints.

Group 10: Arthrosis deformans coxae et genus

Patient No. 10—1. A painter's wife, aged 49, had had osteomyelitis in the region of the right knee 39 years previously. Since then she had walked with a limp and had suffered from arthrotic pain in the right hip and from low back pain on the right side on exertion. On admission the right hip was in a contracture of 20 degrees flexion, 15 degrees adduction and 30 degrees external rotation. Extension-flexion of the hip was 160—140 degrees and other movements 0 degree. There was a valgus deformity of the right knee, which had an extension deficiency of 10 degrees. The right lower extremity was 4 cm short. The lumbar lordosis was increased and there was a left lumbar scoliosis. The sacroiliac joints were asymptomatic clinically. Roentgenographically there was arthrosis of the right hip and knee joints and sclerosis in the region of the left sacroiliac joint (fig. 42).



Fig. 42. Case No. 10—1, female, 49 yrs. Osteomyelitis of right knee 39 yrs. previously, followed by arthrosis. Density of bone increased in region of left sacroiliac joint.

Group 11: Arthrosis deformans coxae et stylus cruris post amputationem

Patient No. 11—1. A 47-year-old leather worker, male, had been wounded 11 years previously and the right lower leg had been amputated. During shock treatment for schizophrenia in a mental hospital 1 year later the neck of the right femur had fractured and had been repaired by nail fixation. A tender neuroma had been excised from the stump 6 years before admission. Due to tenderness of the hip he had been unable to use the prosthesis during the past 3 years. There had been indefinite low back pain on exertion during recent years. Examination on admission showed a right below-knee stump about 25 cm in length and thighs of equal length. Extension-flexion of the right hip was 180—110 degrees, abduction and adduction about 30 degrees,

and rotations about 10 degrees. The prosthesis was good but tenderness in the hip prevented the use of a prosthesis of this type. No special findings were made in the spine or the sacroiliac joints. The roentgenograms revealed severe arthrotic changes in the right hip and the right femoral neck was short. In the region of the left sacroiliac joint there was increased sclerosis, especially on the iliac side of the joint.

Group 12: Stylus femoris post amputationem

Patient No. 12—1. A war-disabled man, aged 52 years, had had no occupation during the past several years because of his injury and psychological condition. Immediately after being wounded 11 years previously the right leg had been amputated below the knee, followed later by an above-knee amputation. Four operations had subsequently been performed on the stump, among other reasons due to neuromas. There had been no noteworthy back pain. On admission the above-knee stump was found to be in a satisfactory condition and the spine and sacroiliac joints showed no clinical symptoms. The prosthesis was serviceable. Roentgenographic examination revealed a slightly increased lumbar lordosis, bone atrophy in the lumbar spine, and sclerosis in the region adjacent to the left sacroiliac joint.

Group 13: Osteomyelitis chronica femoris

Patient No. 13—1. An automobile mechanic's wife aged 24 had a history of chronic osteomyelitis in the distal portion of the left thigh of 10 years' duration, resulting in ankylosis of the left knee. There had been no back pain. On admission the lower extremities were of equal length. Extension-flexion of the left hip was 180—90 degrees and of the left knee 180—100 degrees. The spine and sacroiliac joints were clinically asymptomatic. Roentgenograms revealed changes produced by chronic osteomyelitis of the left femur, no special features in the hip or knee, but slight sclerosis in the region of the right sacroiliac joint, especially in the ilium.

Group 14: Sequelae poliomyelitis (Paresis extremitatis pelvinae)

Patient No. 14—1. A trainee nurse, aged 20, had had poliomyelitis at the age of 18 months, resulting in a shorter right lower extremity. There had been an onset of back pain only about 1 week before admission. Examination revealed a right pes equinovarus paralyticus. The right lower extremity was about 6 cm shorter than the left. There was a right lumbar scoliosis but in other respects the spine as well as the sacroiliac joints were clinically asymptomatic. Also roentgenologically the sacroiliac joints were normal and symmetrical.

Patient No. 14—2. A former outdoor labourer, female, aged 57 years, had had poliomyelitis at the age of 5. Total arthrodesis of the right ankle had been made 21 years before admission to our clinic and she had continuously used a stiff shoe-type ankle support. She had never learned to walk correctly. During the past 2 years there had been low back pain on exertion. The findings on admission were a rigid equinus deformity of the right foot, greatly increased passive movement of the right hip, and a positive Trendelenburg's sign on the right. The right lower extremity was 5 cm shorter than the left. The lumbar lordosis was increased and there was a postural left lumbar scoliosis. The region over the left sacroiliac joint in the back was sensitive to palpation. The Baer, Freiberg, Gaenslen, Yeoman and the pelvis compression tests were positive bilaterally. The roentgenogram revealed hypoplasia of the right half of the pelvis and bilateral arthrosis of the hip joint. The right femur was considerably more delicate than the left, and definite sclerosis was seen in the borders of the left sacroiliac joint (fig. 43).



Fig. 43. Case No. 14—2, female, 57 yrs. Poliomyelitis at age of 5 yrs. Total arthrodesis of right ankle performed 21 yrs. ago. Increased density of bone around left sacroiliac joint.

Group 15: Aplasia extremitatis pelvinae

Patient No. 15—1. In a female labourer, aged 52, the left lower extremity was congenitally smaller and weaker than the right and habitually cold. During the past few years there had been low back pain. Examination on admission showed that the left lower extremity was more delicate and the foot smaller than the right. The left foot had a planovalgus deformity. Of the sacroiliac tests only those of Patrick and Yeoman were positive, both of them bilaterally. In the roentgenogram the right sacroiliac region was clearly more sclerotic than the left.

Group 16: Arthrosis deformans genus

Patient No. 16—1. A goldsmith's apprentice, aged 39, had 34 years previously (at the age of 5) had osteomyelitis of the left femur, as sequelae of which there were an extension deficiency and severe arthrotic symptoms in the knee, and low back pain on exertion. On admission the left knee had an extension deficiency of 20 degrees and a normal flexion. There was a mild right lumbar scoliosis. The sacroiliac joints were clinically asymptomatic. Roentgenologically there was severe arthrosis of the left knee and a pronounced sclerosis on the iliac border of the right sacroiliac joint (fig. 44).



Fig. 44. Case No. 16—1, male, 39 yrs. Osteomyelitis of left femur 34 yrs. previously, followed by arthrosis and contracture of the knee. Increased density of bone on iliac border of right sacroiliac joint.

Patient No. 16—2. A male labourer, aged 65, had 6 years previously had an operation for excision of a corpus liberum from the right knee. This had caused an extension deficiency of 30 degrees, ache, tenderness and a crushing sound. There had been no back pain. On admission the right knee was found to have a mild varus deformity with an extension deficiency of 30 degrees, flexion 150—70 degrees, and tenderness to palpation at the articular slit medially. He limped with the right leg. No special clinical findings were made in the spine or the sacroiliac joints. Roentgenograms revealed severe arthrosis deformans in the right knee. In the lumbar spine there was pronounced osteochondrosis and degeneration of intervertebral discs, and spondylolisthesis of the fifth lumbar vertebra. On both borders of the left sacroiliac joint there was marked sclerosis.

Group 17: Anchylosis genus

Patient No. 17—1. A woman aged 30, married, had an ankylosed left knee following gonitis 22 years previously. During the past 8 years she had had low back pain. On admission there was severe muscular atrophy of the left lower extremity, the left knee was ankylosed in an angle of 125 degrees, and the apparent shortness of the extremity was about 9 cm. There was a left lumbar scoliosis. The sacroiliac joints showed no clinical symptoms. Roentgenograms revealed a bony ankylosis in the left knee and marked sclerosis on both borders of the left sacroiliac joint (fig. 45).



Fig. 45. Case No. 17—1, female, 30 yrs. Left knee ankylosed during 22 yrs. Increased density of bone around left sacroiliac joint.

Group 18: Stylus cruris post amputationem

Patient No. 18—1. A 25-year-old woman, pupil at a school for the disabled, had had the right leg amputated below the knee following a trauma 5 years previously. The stump and prosthesis had been satisfactory but during the past few months she had had low back pain on the left after sitting for some time. On admission there was found a good below-knee stump on the right and a satisfactory prosthesis, a slight left lumbar scoliosis, and tenderness to pressure over the left sacroiliac joint, which also was painful during, for instance, the Lasègue test. The Gaenslen and Patrick tests were positive on the left. She walked satisfactorily with the prosthesis. Roentgen examination revealed that the left transverse process of the fifth lumbar vertebra was larger than usually and articulated with the sacrum; the right sacroiliac joint was clearly more sclerotic than the left (fig. 46).



Fig. 46. Case No. 18—1, female, 25 yrs. Below-knee amputation of right leg 5 yrs. previously used a prosthesis. Increased density of bone in region of right sacroiliac joint.

Patient No. 18—2. This was a married woman aged 62, whose right leg had been amputated 56 years previously, when she was 6 years old. She had since then used a prosthesis, where the short below-knee stump was fitted by kneeling. The stump and the prosthesis had caused no special distress, but during the past 2 years there had been low back pain on the left side and pain on exertion in the left hip. Examination on admission showed a below-knee stump about 10 cm long in the left lower extremity; the knee had a contracture of 90 degrees flexion. She was able to walk well, with the stump in a kneeling position in the satisfactory prosthesis. The spine showed no symptoms clinically. There was tenderness to pressure over the left sacroiliac joint and Patrick's test was positive on the left side. Roentgenograms revealed sclerosis of the left sacroiliac joint, especially in the ilium.

Patient No. 18—3. A 43-year-old ironplate worker, had 10 years previously been wounded in the left heel and foot. After several operations, the left leg was amputated below the knee 6 years ago, followed by a further amputation of the stump 1 year later because of a lesion. During the past 3 years there had been symptoms of sciatic syndrome on the left and during the present year an operation had been performed for rupture of an intervertebral disc, after which the symptoms disappeared. On admission now there was seen a good below-knee stump and a satisfactory prosthesis. The spine and the sacroiliac joints were asymptomatic clinically. Roentgen examination revealed increased sclerosis in the ilium in the caudal portion of the right sacroiliac joint.

Patient No. 18—4. A 54-year-old tailor had a below-knee stump after amputation of the right leg because of a bullet wound 34 years previously. The knee had immediately assumed a flexion contracture.

The prosthesis had caused no noteworthy inconvenience and it had been satisfactory in use. Clinically the spine and the sacroiliac joints showed nothing of note. In the roentgenograms the sacroiliac joints appeared normal and symmetrical, but the left apophyseal joint between the fifth lumbar and first sacral vertebra was clearly more sclerotic than the right.

Group 19: Pes equinovarus congenitus

Patient No. 19—1. A 23-year-old woman, attending a school for the disabled, complained of pain on walking of 4 years' duration in a congenital right pes equinovarus. She had had no back pain. Examination on admission showed a typical marked equinovarus deformity of the right foot, and extension of 170 degrees in the right knee and the right hip. Otherwise the movements of the lower extremities were free and the limbs were equal in length. The sacroiliac joints showed no symptoms clinically. There was a slight left lumbar scoliosis. Roentgenograms revealed very marked sclerosis in the ilium bordering on the left sacroiliac joint (fig. 47).

Patient No. 19—2. A man, aged 37, who attended a course for the disabled, had a congenital bilateral pes equinovarus, for which a corrective operation had been performed on the right foot 3 years previously and on the left foot 2 years previously. Owing to subsequent necrosis, digits 4 and 5 of the right foot were later amputated. A persistent osteitis in this foot had made walking difficult. There had been no back pain. On admission the spine and the sacroiliac joints were asymptomatic clinically. There was a bilateral, almost symmetrical deformity of the feet. No pathological findings were made in roentgenograms of the lumbar spine and the sacroiliac joints.

Group 20: Pes equinus traumaticus

Patient No. 20—1. A farmer aged 45 had 11 years previously had an open fracture of the right lower leg, followed by osteomyelitis and equinus deformity of the foot. During the past few years there had been progressively increasing pain in the right foot and ankle and indefinite low back pain on exertion. On admission the right foot was found to be in an equinus position of about 130 degrees, which was completely rigid and compelled the patient to walk with the knee flexed. Clinically the spine and the sacroiliac joints were asymptomatic. Roentgenograms showed that the borders of the left sacroiliac joint, especially the iliac border, was sclerotic throughout its full length.

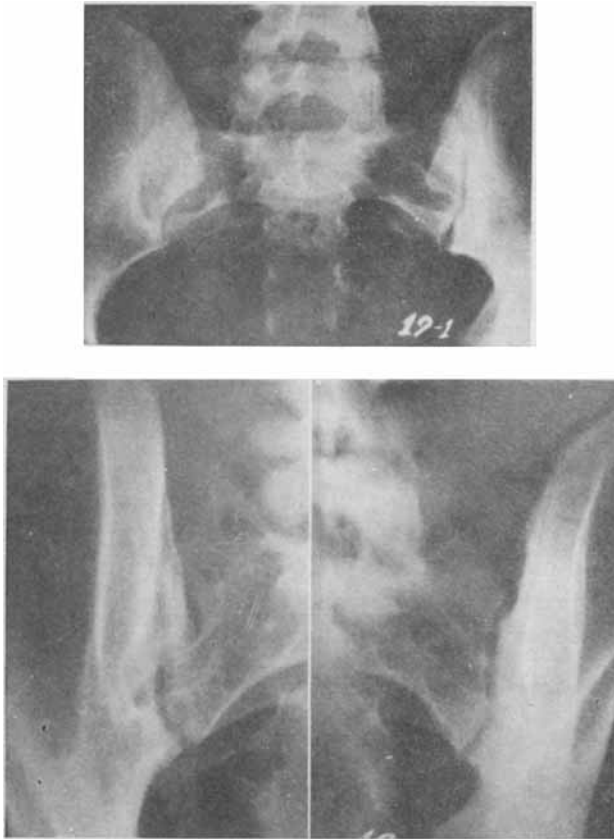


Fig. 47. Case 19—1. female, 23 yrs. Congenital right pes equinovarus. Very marked sclerosis on iliac side of left sacroiliac joint.

In 24 patients there thus was a history of low back pain but this was not in a single case of the typical kind pointing to the sacroiliac joint. Clinical symptoms from the sacroiliac region were found in 5 cases, in all of which there also were roentgenological changes in the joint. However, in only 2 cases (Nos. 1—14 and 18—2) the clinical symptoms and roentgenographic findings were on the same side. In the other cases the clinical symptoms were approximately equally clear on both sides. Of the 24 patients

with a history of low back pain, 22 showed changes in the sacroiliac joint in the roentgenograms.

A unilateral disease or other disorder of a lower extremity was present in 46 patients, in 35 of whom the roentgenograms showed sclerosis of the bone in the parasacroiliac region on the opposite side. This sclerosis usually was more marked on the iliac side of the joint, probably because of the greater protection afforded by the thicker cartilage on the auricular surface of the sacrum. Attention was drawn to this finding by KALLIO already in 1952. — Three patients in this series had sclerosis in the parasacroiliac region on the same side as the disorder of the extremity. In 8 cases both joints were roentgenographically asymptomatic.

Of the 4 cases with a bilateral disease or other disorder of the lower extremities, 2 patients (Nos. 2—2 and 2—5) revealed in the roentgenogram sclerosis of the sacroiliac joint on the side opposite to the more painful and tender arthrotic hip joint. In both cases a unilateral arthroplasty of the hip joint was indicated and performed on the more painful side. Both patients reported that the arthrotic symptoms in the other hip, i.e., on the side of the sacroiliac joint showing roentgenological changes, were of longer duration than the symptoms in the hip which, according to their information, had caused them greater distress. In the other 2 patients in this group no pathological features were seen in the sacroiliac joints.

The group of 35 patients with a unilateral disease or other disorder of the lower extremity and with parasacroiliac sclerosis on the side opposite to the primary affection comprised 19 women and 16 men. The mean age of each sex and of the entire group was 44 years, the age limits ranging from 19 to 75 years. Eight women had had 1 to 10 deliveries.

The group with no parasacroiliac sclerosis comprised 5 female patients and 3 male patients. One of the former had had one delivery. The mean age of the female patients was 25 years, of the male patients 37 years, and of the group 30 years, the ages ranging from 14 to 57 years.

The 3 patients (Nos. 6—1, 17—1 and 18—1) with parasac-

roiliac sclerosis on the same side as the primary affection were women aged 23, 25 and 30 years, averaging 26 years. One woman had had two deliveries.

In the light of this small series of cases it is probable that sex and deliveries have no bearing on the etiology of increased density of the parasacroiliac bone.

It would be interesting to know the correlation of the duration of the disease or other disorder of a lower extremity and of the age of the patient to the onset of increased density of the parasacroiliac bone, but unfortunately the present series of cases does not provide data necessary for a study of these correlations.

The increased density of bone may have been due to proliferation of the bony tissue or to its increased mineral content. This feature simulates most closely the pathological condition known as osteitis condensans ilei (SICARD, GALLY and HAGUENAU 1926, BÁRSONY and POLGAR 1928). This disease has generally been regarded as bilateral (HARE and HAGGART 1945), but unilateral condensation of the lateral aspect of the caudal portion of the sacroiliac joint has also been included in this picture (RENDICH and SCHAPIRO 1936). Osteitis condensans ilei is regarded as sex-linked and present only in women (BERENT 1933, 1934, HARE and HAGGART 1945, SHIPP and HAGGART 1950). The causes suggested are traumatism during pregnancy or delivery (BERENT 1933, 1934, RENDICH and SCHAPIRO 1936), local ischaemia on a traumatic or inflammatory base (PAIS 1951), local infection due to bacterial embolism in the area of the nutrient artery entering the bone at this site (RENDICH and SCHAPIRO 1936) or an increased compression between the sacrum and the ilium due to relaxation of ligaments during pregnancy (SHIPP and HAGGART 1950). Osteitis condensans ilei is believed to give almost no symptoms (ARMSTRONG 1950), and with the exception of roentgenographic changes an objective finding is open to question. It is held that the roentgenographic changes are restricted to the iliac side of the joint slit. Also in the cases in the present series with a positive roentgenographic finding in this respect the changes frequently bordered on the joint slit or at least were more clearly seen on the

iliac side, and especially on the lateral aspect of the caudal portion of the joint slit.

In the examined cases of asymmetrical statics of the lower extremities the most common cause of static disturbance was inequality in the length of the limbs, with or without associated deformity, ankylosis or restricted motion of the hip joint. In some cases the limb was not short, but the disorder consisted of ankylosis, deformity, restriction of motion or tenderness of the hip, knee or ankle joints or of the foot and in a few cases of an above-knee or below-knee stump. Common for all the cases was the effort of the patient to spare the affected limb at the expense of the healthy one. The non-compensated shortness of one of the lower extremities, either true or due to deformity of a joint, results in a pelvic drop causing skoliosis. Shortness of a lower extremity is sometimes compensated by wearing a built-up shoe, but even if this in some cases compensates for the deficient length it is not physiological compensation and gives rise to other disadvantages, for instance the heavier shoe, in addition to which the deformity or restricted motion remains unchanged in many cases. In a pelvis with a lateral tilt the articular slit in the elevated sacroiliac joint has assumed a more vertical direction. As was observed in the section on mechanics and statics, the load on the sacroiliac ligaments is the greater the more vertical the direction of the articular slit. The lateral convexity of the articular slit in frontal section is, as was found, the reason for the greater load on the caudal portion of the joint in comparison to other parts of the joint.

It has been observed that an amputee usually takes a longer step with the prosthesis than with his healthy limb (Prosthetic Devices Study, 1951), in other words, the load during walking rests on the healthy limb for a longer time and is greater than that on the prosthesis limb; also on standing the centre of gravity is always situated more on the side of the healthy limb (CONTINI 1954, KLOPSTEG and WILSON 1954, RADCLIFFE 1955).

Stiffness of the joints of the foot and ankle can be compensated by modification of knee and hip motions so that the location of

the centre of gravity and its course during walking will remain normal (SAUNDERS, INMAN and EBERHART 1953), but the tenderness of these parts of the limb naturally results in an uncompensated sparing of the limb and an above-normal load on the other limb.

The increased density of the parasacroiliac bone may be a result of the above described greater load on the corresponding lower limb, of the altered direction of the sacroiliac joint slit due to pelvic tilt, or possibly of exceptional muscular work caused by the altered posture and abnormal stress of the back and the limb. This muscular work may cause increased traction of the ligaments and joint capsule, which in part are the points of origin and insertion of the involved muscles, on the bone to which the ligaments are inserted. This bone may react by increasing in density, as seen in the roentgenograms.

ALBEE (1909) has mentioned that the functional disorder syndrome of the sacroiliac joint includes, among others, increased density of bone along the margins of the joint. MONTANT (1942) found that a short limb caused low back pain, a greatly shortened limb causing greater pain than a less short one, but he did not speak of roentgenological symptoms although he mentioned that the sacroiliac joints are particularly interested. The same conclusion was reached by OBER (1952). Changes of the observed type in the sacroiliac joints have frequently been regarded as a sequela of sacroilitis. Indeed, it is to be held in mind that spondylarthritis anchylopoetica, for instance, may be painless even during an active stage of sacroilitis and therefore escape diagnosis, and that this disease may also cease at various stages (FORESTIER 1939, SCOTT 1942, FORESTIER, ROTÉS-QUERÓL and JACQUELINE 1950, KNUTSSON 1950). The paraosteoarthropathy of paraplegic patients, which simultaneously may be present in different situations in the bone and even in soft tissues, occasionally simulates in the roentgenogram spondylarthritis ankylopoietica when present in the sacroiliac region (DEJERINE, CEILLIER and DEJERINE 1919, ABEL 1950). However, it does not appear probable that the phenomenon here observed and the bone reaction in paraplegic patients

resulting in a somewhat similar roentgenographic picture in the sacroiliac region would have a common etiology. ROGERS and CLEAVES (1935) report similar condensation of the bone in the »adolescent sacroiliac joint syndrome» described by them; however, the histories in their cases included a more or less definite strain of the sacroiliac joint, i.e., an acute trauma. BRAILSFORD (1948) stated that several months after occurrence of the trauma dense, reactive bone may be seen on the iliac side of the joint. KAJAVA (1923) observed that when one of the hip joints has not been subjected to a load for some length of time complete ankylosis of the sacroiliac joint may develop on the healthy side, especially during adolescence. The phenomenon observed in the sacroiliac joints in the present series of cases may also be, at least in a part of them, the manifestation of a given arthrotic stage preceding such ankylosis. In many cases the roentgenograms revealed, in addition to eburnation of the articular surfaces, narrowing of the articular slit and formation of osteophytes, all of which are symptoms of arthrosis.

A number of other possible etiologies may be suggested for these roentgenographic findings. For this reason an effort was made to learn from the case histories and objective observations the possible etiological contribution of tuberculosis, osteomyelitis and syphilis in the region of the sacroiliac joint as well as PAGET's disease, lymphogranulomatosis, marble bones, malignant metastases, etc. Further, in interpreting the roentgenograms there were held in mind hypoplasia or bone atrophy and porosis which are known to occur in the pelvis on the side of the unloaded, less loaded, or amputated lower extremity (INMAN and EBERHART 1955), since as a result of these changes in the bone the bony tissue on the healthy side of the pelvis may seem to be of a denser structure throughout and especially in those areas where the roentgen rays must pass through thick layers of bone, as for instance in the parasacroiliac region. As was mentioned above, arthrosis deformans and (in the male) ankylosis of the sacroiliac joint is relatively common and the present series may also contain some cases of this fully »normal arthrosis». The increased bone

density observed does not belong to the usual picture of joint ankylosis. The roentgenographic technique may also contain a possibility of error. Thus in the anteroposterior projection a lateral rotation of the pelvis, which automatically occurs especially in a unilaterally hypoplastic pelvis when the patient is supine, makes it necessary for the roentgen rays to pass in the parasacroiliac region through a longer distance of bone on one side than on the other side.

Examination of the cases with no unusual findings in the roentgenograms of the sacroiliac joints revealed that the oldest patient in this group, a woman aged 57 years, had since fracture of the head of the femur 16 months previously walked so little that no changes due to stress could have occurred. The following patient in respect to age, a man aged 54, had had a below-knee amputation 34 years previously. Despite flexion contracture of the knee the patient had not found the amputation or prosthesis a great drawback, especially as he was by occupation a tailor and was very little on his feet during working hours. Pelvic tilt or skoliosis was not present in this case. The other patients in the group with no roentgenographic findings were from 14 to 33 years of age and in their cases the absence of roentgenographic symptoms — in contradiction to the group of patients with positive findings in the roentgenograms — may be suggested to be due in the different cases to early age, relatively small stress on the lower extremities, or a slight mechanical disorder.

No explanation was found in 3 cases for the increased bone density in the parasacroiliac region on the side of the affected lower extremity.

Among the cases with a bilateral disorder of the lower extremities, cases No. 2—2 and 2—5 have already been discussed above. In the other 2 cases (Nos. 19—2 and 5—1) there were rather symmetrical disorders of the lower limbs, with no reactions reflected in the region of the sacroiliac joint.

CONTROL SERIES

The control series consisted of 86 hospitalised cases and out-patients who according to the case history as related by themselves had never suffered from back pain of such severity as to have made them incapable of working, even for short periods. There also had been no disease or other disorder of the lower limbs of long duration. The diagnoses pointing to the lower limbs which are listed in table 9 refer to the diagnosis of the acute trauma or disease which brought the patient to the clinic. Clinical and roentgenographic examinations were made of all the patients in the control series by the same methods and using the same criteria as in the cases described above. In no case was there a sacroiliac syndrome present.

A distribution of the control cases by age and sex is given in table 8.

TABLE 8. *Control Series Distributed according to Age and Sex*

Age, Yrs.	Number of Cases		
	Female	Male	Total
20—39	6	9	15
30—39	6	11	17
40—49	5	8	13
50—59	8	10	18
60—69	9	10	19
70—79		4	4
Total	34	52	86

In not a single case was there a roentgenological finding of markedly increased density of the parasacroiliac bone, and only a slight sclerosis of the ilium lateral to the sacroiliac joint was seen in 6 cases. The phenomenon was on the right side. The diagnoses in these 6 cases were as follows:

Thrombophlebitis parietis thoracis (male, 39 years),
 Struma nodosa (females, 57, 62 and 64 years),
 Periarthrosis humeroscapularis (male, 46 years),
 Luxatio habitualis humeri (male, 22 years).

TABLE 9. *Control Series Distributed according to Diagnosis*

No. of Cases	Diagnosis	Age, Yrs.	
		Female	Male
1	Fractura antebrachii		32
1	Stylus antebrachii post amputationem	27	
1	Fractura costae		62
1	Fissura sacri	27	
1	Fractura femoris et patellae		22
1	Fractura cruris	50	
2	Fractura calcanei		47, 48
1	Luxatio claviculae acromialis	41	
1	Luxatio habitualis humeri	22	
1	Laesio inveterata plexus brachialis		51
4	Laesio traumatica manus	55	32, 35, 41
2	Ruptura menisci genus		28, 29
1	Conquassatio pedis		39
1	Commotio cerebri		38
2	Vulnus sclopetorum thoracis		38, 39
1	Brachialgia		39
4	Periarthrosis humeroscapularis	63	46, 54, 63
1	Syndactylia manus		26
1	Osteoporosis universalis	63	
7	Lymphadenitis simplex s. tuberculosa axillae s. colli	28, 32, 33, 39, 63	51, 54
1	Tuberculosis sterni		22
1	Tuberculosis pulmonis		62
1	Bronchitis	42	
1	Tuberculosis urogenitalis		38
1	Appendicitis recidivans		49
1	Periproctitis		25
1	Thrombophlebitis parietis thoracis		39
1	Bursitis serosa		25
1	Cystopyelitis	58	
1	Fistula scroti		58
1	Haemangioma faciei		59
1	Carcinoma labii mandibularis		50
2	Carcinoma metastaticum colli		65, 69
6	Struma nodosa	30, 32, 57, 62, 64	37

TABLE 9 (*cont.*)

No. of Cases	Diagnosis	Age, Yrs.	
		Female	Male
1	Lipoma axillae	65	
1	Carcinoma pulmonis		63
4	Carcinoma oesophagi s. ventriculi	49, 57, 65	63
2	Tumor mammae	24, 55	
1	Tumor intraabdominalis	43	
1	Teratoma intrapelvinum	22	
6	Hypertrophia s. carcinoma prostatae		62, 65, 73, 73, 74, 74
1	Carcinoma recti		63
1	Cysta dermoidea sacralis		51
1	Atheroma perinei		45
1	Gastritis		27
2	Ulcus ventriculi s. duodeni		35, 58
1	Stenosis jejuni post resectionem ventriculi		45
3	Cholelithiasis	39, 51, 54	
1	Hernia ventralis	64	
1	Hernia femoralis	67	
1	Fistula ani		39
1	Prolapsus ani		58
1	Neurosis	45	

The control series, which comprises nearly twice as many patients as the second part of the clinical investigation (diseases, deformities or defects of the lower extremities) and which includes patients of both sexes and of various ages, gives evidence in support of the opinion that the increased density of the parasacroiliac bone seen in association with a disease or other disorder of a lower extremity is a result of asymmetric mechanics and statics of the lower limbs.

DISCUSSION AND CONCLUSIONS

The results obtained in the osteological section of the present investigation indicate that the sacroiliac joints are always more or less asymmetrical in respect to size, shape, direction of the articular slit and structure of the auricular surfaces. It was found that when the human body is in the erect posture the sacrum in the region of the anterior part of the sacroiliac joints is in most cases wedge-shaped, with the apex downwards. It was thus seen that by its anatomical constitution the sacrum is well suited for its function, contrary to the opinion of SICARD and MOULONGUET (1953). In the cases in which the articular slit of one of the sacroiliac joints is vertical, nearly vertical, or cranially inclined towards the median line in frontal section made through the antero-cranial portion of the joint, the ligaments of the joint are subjected to a greater stress than in cases in which the articular slit caudally inclines towards the median line. Nevertheless the cranially narrowing wedge which usually is seen in frontal section made at the level of the caudal portion of the sacroiliac joint counteracts the more or less great tendency of the cranial portion of the sacrum to tilt downwards and cause a strain on the ligaments. The lateral convexity of the articular slit in frontal section is the reason why the load, during the erect posture of the body, lies chiefly on the articular surfaces of the inferior portion of the articulation. The symmetry of the load, however, does not entirely depend upon the symmetry of the articular slits, but also on whether the sacrum and the ilium interlock by means of the irregularities in their articular surfaces equally firmly on both sacroiliac joints. These irregularities frequently are very marked but they also are asymmetric. The angle of inclination of the

auricular surfaces, and thus also of the sacroiliac joints, which angles are directly proportional to the posture of the sacrum, determine the proportion of the articular surfaces which bear the load. When the sacrum is vertical, a larger proportion of the surfaces participates in bearing the weight of the body than when the sacrum is horizontal. The downward tapering wedge form, which also is favourable for load-bearing, is more definite in the vertical than in the horizontal sacrum, the position of which may be a reason for the unfavourable upward tapering of the wedge and the greater than normal load on the ligaments. The irregularity of the articular surfaces and the numerous planes forming the auricular surfaces, as well as the exceptionally stiff joint capsule and the support afforded by the strongest ligaments of the body make it evident that no marked movement can occur in the sacroiliac joints. Especially can there be under normal conditions no simultaneous rotation in the same direction in the two joints. However, movement is probably somewhat freer when the ligaments and capsule are softened through hormonal action during pregnancy, and to a lesser degree during menstruation.

A macroscopic anatomical examination of the innervation of the sacroiliac joints showed that on the ventral aspect of the joint the nerves originated variably in the third lumbar to second sacral nerves, and on the dorsal aspect in the first and second sacral nerves. In not a single case was the obturator nerve found to send off a branch to the sacroiliac joint. This origin of the innervation, which is asymmetric in many cases, appears to be the cause of referred pain from the sacroiliac joint sensed in dorsal and lateral aspects of the lower extremities in different sites from the buttock to the foot.

Experimental roentgen examinations of anatomical specimens, in which the articular slit in some cases was outlined with a narrow lead strip, and comparison with cast models of articular slits gave reason to conclude that the roentgenograms in the usual projections will not enable us to obtain a clear idea of the structure and shape of a sacroiliac joint. Arthrographic experi-

ments made both with anatomical specimens and on clinical patients indicated that, for anatomical reasons, arthrography of the sacroiliac joints generally is not possible; the present technical possibilities of this method do not make it adequately serviceable for the examination of this narrow slit-like joint surrounded by thick bones and abundant soft tissues. In traumatic and other cases of instability of the sacroiliac joint the Chamberlain method of roentgenography may be serviceable.

In the series of out-patients studied, about 2.4 per cent of all disorders of the back were lesions of the sacroiliac joint, excluding those of infectious origin and cases of osteitis condensans ilei. Within the same period, over ten times as many cases of rupture of a lumbar intervertebral disc were examined. It is evident, however, that even this series of lesions of the sacroiliac joint included cases not properly belonging to it, such as lesions of lumbar intervertebral discs, spondylolisthesis, arthrosis and ankylosis of the sacroiliac joint, and others. The clinical picture of rupture of a lumbar intervertebral disc may include so many of the so-called sacroiliac symptoms that a diagnosis of the vastly more common disc lesions may inadvertently be made in cases of a lesion of the sacroiliac joint, and even *vice versa*. Evidence of this are the diagnoses described above which were corrected in the course of treatment, as well as the case in which low back pain treated without improvement as a sacroiliac joint lesion healed after extirpation of the protruded portion of a disc. A differential diagnosis is rendered difficult especially by the manifestation of referred pain. On the other hand, it is true that the reflex disorders and the cutaneous anaesthesia and hypesthesia caused by a ruptured disc are absent from the neurological symptoms of a sacroiliac joint lesion. The postural, mobility and roentgenological symptoms and the critical evaluation of the sacroiliac tests usually make the establishment of a differential diagnosis possible.

The series of hospitalised cases of non-infectious lesions of the sacroiliac joints totaled about 1/20th of the number of lesions of the intervertebral discs hospitalised in the same clinic during the same period. At the end of an observation period of 2 to 4 years

it may be concluded that the surgical treatment of these lesions of the sacroiliac joint was correctly indicated and resulted in improvement of the condition. The primary results were good in two-thirds of the cases treated conservatively. Following sacroiliac arthrodesis, no untoward effects were observed by any of the patients. This was indeed to be expected, as the mobility of the joint already normally is very slight and most of the patients in question were middle aged and thus had less need of great accommodation and mobility of the pelvis. In the case of delivery following sacroiliac arthrodesis, it may be presumed that the ankylosed sacroiliac joints are a disadvantage, at least in the presence of a narrow pelvis and especially if the arthrodesis was bilateral. No corset is able completely to immobilise the sacroiliac joints, and also for this reason arthrodesis is indicated to relieve a painful sacroiliac lesion of long duration or an invalidating instability of the joint.

Disturbed mechanics and statics of the lower extremities also produce disorders of the sacroiliac joints and exceptional stress which is greater on the joint on the same side as the limb subjected to a greater than normal load because of the impaired function of the other limb. In the cases studied in the present investigation the disorder of the lower limbs was not found to have given rise to a definite sacroiliac joint syndrome. The symptoms seen from the sacroiliac joint were in some cases on the side opposite to the joint in which roentgenological changes were present. In 76 per cent of the cases there was a roentgenological finding of increased density of parasacroiliac bone on the side opposite to the diseased limb; usually this was most marked in the inferior and lateral portion of the joint, simulating osteitis condensans ilii. The increased density is evidently a result of an increased compression between the ilium and the sacrum and/or of an increased muscular tension and increased stress on the bony tissue due to the muscular tension and to tautness of the ligaments because of the changed posture of the pelvis. Possibly the etiology of this phenomenon and that of osteitis condensans ilii have something in common. In the control series a similar phenome-

non was seen in less than 7 per cent of cases and it was of a milder form. A phenomenon analogous to this roentgenologically seen increased density is the frequently seen chondromalacia patellae of the intact leg observed by KALLIO (1947) in above-knee amputees. The increased density of the bone probably plays no part in the pain or other subjective symptoms but is chiefly of clinical interest with a view to differential diagnosis.

On the basis of the findings made in the present investigation the following conclusions may be drawn in answer to the questions posed in the beginning of this work:

1. Concerning the osteological structure of the sacroiliac joints it is not possible to summarise briefly the observations reported above. It is clearly evident that in respect to their position, size, shape and mutual relations and the nature of their articular surfaces the sacroiliac joints are greatly variable and more or less asymmetric in each individual;

2. The innervation of the sacroiliac joints has its origin in the third lumbar to the second sacral nerves;

3. As a result of their structure the sacroiliac joints are in most cases very stable and because of their asymmetry they frequently are asymmetrically subjected to normal or to pathologically increased stress. No marked movement is possible in the sacroiliac joint without preceding physiological or traumatic relaxation of the joint;

4. The present roentgenological methods are not adequately satisfactory for studying the instability of and degenerative changes in the sacroiliac joint. Tomography may be useful in some cases, and especially in traumatic and other cases of instability of the joint the Chamberlain method of roentgenography is of value;

5. In the investigated series, non-infectious lesions of the sacroiliac joint comprised about 2.4 per cent of the disorders of the back. The ratio of these lesions to lesions of lumbar intervertebral discs was 1.0:10.4;

6. In cases of instability and pain in the sacroiliac joints, surgical treatment was frequently indicated and performed, gave good results and had no untoward effects;

7. In association with the disturbed mechanics and statics of the lower extremities, the sacroiliac joint on the side opposite to the extremity with impaired or more greatly impaired function showed increased density of the bone due to the greater stress. The increased density was usually more marked on the iliac side and generally unassociated with subjective or clinically observed symptoms of a sacroiliac lesion.

SUMMARY

The first part of this investigation deals with the anatomy of the sacroiliac joint, specifically its osteology and innervation. The osteological study was carried out on 30 pelvis skeletons and it demonstrated the existence of articular types that vary greatly in shape and are subjected to mechanical load in different ways. However, frontal section through the cranial part of the sacrum showed that in 88.5 per cent of the pelves the sacrum had the wedge-shaped form of a downward-tapering keystone. — Innervation of the sacroiliac joints was examined macroscopically in 18 joints of 9 cadavers. The origin of the innervation on the ventral side was found to be variably L 3—S 2 and on the dorsal side S 1—S 2. Asymmetry was common in the innervation of the two sacroiliac joints. The obturator nerve did not participate in the innervation in any of the cases.

According to inferences on the statics and mechanics of the sacroiliac joint, one of the joints is in most cases considerably more exposed to strain and trauma than the other joint, due to the position and shape of the sacrum, or to the direction of the articular slit and position of the joint. A greater load is exerted upon the sacroiliac joint ligaments on the side with the narrower lateral mass of the sacrum, as well as on the sacroiliac joint whose lateral inclination in frontal section is smaller than that of the other joint. Furthermore a sacrum horizontale has the effect of increasing the load on the ligaments, and a joint with smooth and only slightly irregular articular surfaces tends to become dislocated more readily and lesion of the articular ligaments may here occur more easily.

Experimental roentgen examinations of anatomical specimens, using a lead strip to outline the articular slit and cast models of the articular slit for comparison, made it evident that roentgenograms of the sacroiliac joints made in the usual projections give but deficient and sometimes misleading information on the structure of the joint and the condition of its different parts. Frequently the CHAMBERLAIN method of roentgenography may be of considerable assistance, especially in traumatic and other cases of instability.

Experiments to perform arthrography on anatomical preparations and clinical patients demonstrated that this method of examination usually is not feasible owing to the impossibility of performing the puncture of the sacroiliac joint. The practical value of arthrography would furthermore be reduced by the very small amount of contrast medium that could be accommodated by the articular slit.

Study of a series of patients with back pain examined at a surgical outpatient department during a period of 5 1/3 years showed that low back pain had been ascribed to the sacroiliac joint in 3.5 per cent of all patients with affections of the back, totalling 6,895 patients. On basis of the diagnoses the ratio of incidence of sacroiliac joint affections to the incidence of lesions of lumbar intervertebral discs was 1.0 : 10.4. In a clinical series this ratio was 1.0 : 20.0. Diagnoses which later were corrected seem to indicate that lesions of the sacroiliac joint are still more infrequent. Study of the case series and of the results of treatment appears to provide evidence that non-infectious lesions of the sacroiliac joints do occur also without severe traumas and that their surgical treatment, where indicated, is successful.

In differential diagnosis consideration should be given to rupture of an intervertebral disc. In the present series cases were found in which a ruptured disc had originally been treated as a sacroiliac joint lesion, but there were no cases in which the reverse would have been true. The so-called sacroiliac tests generally are non-specific and most of them usually give seemingly positive results also in severe cases of ruptured intervertebral disc.

In 46 examined cases of asymmetrical lesions or diseases of a lower extremity it was found that disturbed mechanism or statics of the lower extremities had in 35 cases (75 per cent) caused stress on the sacroiliac joint on the healthy or less affected side. This resulted in an increased density of the parasacroiliac bone, roentgenologically frequently simulating osteitis condensans ilei. The pathological condition of the lower extremities was not found to have produced a clinically demonstrable sacroiliac joint syndrome, and the roentgenographical finding probably is of interest chiefly from the point of differential diagnosis.

Observations made in the present investigation provide evidence in support of the opinion that underestimation during the past 20 years of the significance of lesions of the sacroiliac joint due to traumatic or structural causes has gone too far. This *locus minoris resistentiae* of the pelvic girdle has a tendency to fatigue and traumas owing to certain characteristics and reactions observed also in this study, and since the sacroiliac joint embodies all the usual elements of an articulation it should also be held in mind as a source of subjective and objective symptoms and signs.

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