

## MOTION OF THE PUBIC SYMPHYSIS IN PELVIC INSTABILITY

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**ABSTRACT.** Pelvic instability is a term widely used to describe a clinical entity characterized by pain localized to the pubic symphysis and/or sacroiliac joints. The pain often radiates down the leg. Hypermobility of the pelvic joints has been suggested as the cause of pain. Apart from several clinical stress tests, attempts at establishing objective evidence of such mobility have mainly consisted in radiologic measurement of motion of the pubic symphysis by a method which allowed only vertical movement to be recorded (5). In the present study symphyseal mobility was measured by an electromechanical method by which direct interosseous movement could be recorded in three directions and two different planes. Measurements were performed in a series of 15 patients with a tentative diagnosis of pelvic instability and the results compared to the results of radiologic measurement and to the normal values obtained in an earlier study of healthy volunteers (31). The results of this study would seem to refute the theory of symphyseal hypermobility being pathognomonic of so-called pelvic instability. It has moreover shown that radiologic measurement may be used for rough screening purposes, but is not sufficiently reliable for more exact measurements.

**Key words:** Electromechanical measuring method, pelvic instability, pelvic relaxation, pubic symphysis, symphyseal mobility

Pelvic instability is a term used for conditions with pain and discomfort at the pelvic joints, often associated with radiation of pain like sciatica into the leg. Various terms have been suggested like pelvic insufficiency, pelvic (ring) relaxation, pelvic hypermobility, chronic symphysiolysis, sacroiliac relaxation, sacroiliac slip, and sacroiliac joint syndrome.

### REVIEW OF THE LITERATURE

Low back pain and sciatica have been considered to have their origin in the sacroiliac joints. Once Mixter & Barr 1934 (21) had published their study on herniation of the nucleus pulposus the sacroiliac joints were no longer believed to cause low back pain and sciatica (28). Low back complaints may nevertheless be explained by disorders of these joints (20, 22, 29, 30).

### Causes

The cause of pelvic instability has most frequently been associated with pregnancy and parturition (e.g. 9, 23). Berezin (2) believed both hormonal factors and trauma in connection with delivery to be involved. Mild forms of pelvic instability have also been claimed to occur in connection with menstruation and during puberty (25), and following contraceptive medication (14).

Pelvic instability following pelvic fractures has been pointed out by several authors (24, 26). Instability may develop in connection with posttraumatic diastasis of the pubis (16), repeated minor traumata in athletes (12), and iatrogenic damage to the sacroiliac ligaments following bone graft removal from the posterior iliac crest (6). Postural strain and static disorders may produce symptoms (1, 25).

### Symptoms

The most common complaint is pain located in the sacroiliac region (e.g. 27). Painful locking of the sacroiliac joint has been described (4). Pain localized at the symphysis has been reported as unusual by some authors (18, 29). Others, however, claim that pain often appears in the inguinal region (11, 30). Symptoms like sciatica may be associated with mild signs of neurologic impairment (19).

Other typical symptoms are a sensation of the pelvis giving way, a limping or waddling gait and crepitations (6, 19). Painful symptoms may be evoked by asymmetrical and monotonous movements, walking stairs, lifting, and coitus (30), whereas light exertion has on the contrary been claimed to alleviate symptoms (22).

### Signs

Tenderness on palpation of the sacroiliac joints has been reported (11, 28). Bucholz (3) found that quite a number of Malgaigne's fractures resulted in tenderness at the sacroiliac joints, despite the absence



of radiologic evidence of any injuries in this region. Cyriax (7) refuted the existence of fixed sacroiliac subluxation and regarded palpation of the sacroiliac joints or their posterior ligaments as anatomically impossible. A high frequency of tenderness on palpation over the pubic symphysis has been found by some authors (4, 11).

Tönnis et al. (30) and Grieve (10) emphasized that the pain in the sacroiliac joint elicited by straight-leg raising is due to rotatory motion and not of radicular origin, nor did they consider signs of neurologic impairment in the legs to form part of the clinical picture.

Several authors have described the patients' gait as either straddlelegged and waddling or close-legged with short steps, while Trendelenburg's sign has been claimed often to be positive (11).

Several sacroiliac stress tests have been developed, designed to provoke painful movement at the sacroiliac joints (e.g. 7, 12). A so-called sacroiliac or trochanteric belt can be used both as part of the treatment and as a useful diagnostic aid in pelvic instability (e.g. 29).

### *Radiography*

Pelvic instability has been reported to be associated with radiographic changes in the pubic symphysis not unlike osteoarthritis (19). Signs of instability have been a symphyseal width exceeding 10 mm or a difference in the level of the pubic bones (18). Symphyseal torsion has been claimed to be demonstrated by one side of the pubic rami being lower in the AP view, when the patient is standing on one leg (17). Osteoarthritic changes and instability could be demonstrated radiographically in the sacroiliac joints (8).

### *Methods of measuring motion at the pubic symphysis*

According to Chamberlain (5) no direct evidence of sacroiliac joint motion can be obtained by radiographic examination, but motion is reflected by the vertical displacement of the pubic symphysis "where it is magnified and measurable". With the patient standing and bearing full bodyweight on alternate legs a comparison is made of anterior projections of the symphysis. Vertical symphyseal motion in the normal adult male varied from 0–0.5 mm and in nulliparous women 0–1.0 mm. For multiparous women the motion was occasionally up to 2.0 mm. He stated that all women with a symphy-

seal mobility exceeding 2 mm had sacroiliac symptoms. In using Chamberlain's method most authors also have put the upper limit of normal variation at 2 mm. The limit was raised by Hagen (11) to 5 mm.

An electromechanical method allowing measurement of symphyseal motion in several directions has been developed by Walheim et al. (31).

## AIM OF THE STUDY

If "pelvic instability" is to be accepted as a condition characterized by certain symptoms, described under this term in the literature, the question remains whether instability in the pelvic joints is present and if so, where and to what extent. The aim of the present study was to examine the mobility of the symphysis by means of the electromechanical method developed by Walheim et al. (31). This method implies direct registration of interosseous movements by measurement of the movements of two pins inserted into the pubic bones. Further, the measurements would be related to subjective symptoms and objective signs including radiologic changes. Finally, a comparison would be made with Chamberlain's method.

## PATIENTS

The study included 15 patients referred to the Department of Orthopaedic Surgery, Karolinska Hospital, for pain involving one or several of the pelvic joints. Prior to referral they had undergone thorough examinations and several had also received treatment. Two of the patients were men, aged 31 and 52, and 13 were women with a mean age of 34 years (range 20–54 years). The average duration of symptoms was 7 years (range 9 months–18 years). The patient series is presented in Table I.

### *Causes*

In 7 of the women the painful symptoms had started after childbirth. Five of them had been on contraceptive medication for periods varying from 6 months to 8 years.

Five women had pain of more uncertain cause:

One uniparous woman had felt slight symptoms occasionally during pregnancy, and began to experience more severe complaints 4 years later. She had never used oral contraceptives (Patient 13).

In one biparous woman symptoms had coincided with falling during her first pregnancy. A second pregnancy was uneventful. Disabling symptoms appeared however 5 years later, during which time she had taken contraceptive pills (Patient 2).

One biparous woman developed symptoms when she fell 25 years after her last delivery. She had been on contraceptive and oestrogen medication for more than 5 years (Patient 6).



Table I. Patient series (n=15)

Pat. no.	Age (yrs.)	Sex	No. of births/abortions	Duration of contraceptive medication (yrs.)	Probable cause of symptoms	Duration of symptoms (yrs.)
1	37	F	2/-	-	Unknown	17
2	30	F	2/-	9	Childbirth? Trauma?	11
3	36	F	2/1	-	Childbirth?	0.75
4	52	M	-	-	Trauma	3
5	36	F	1/1	8	Childbirth	16
6	54	F	3/1	5	Trauma?	2.5
7	45	F	2/-	-	Childbirth	18
8	42	F	3/-	0.5	Childbirth	6
9	22	F	-/-	2	Unknown	2
10	28	F	2/1	3	Childbirth	3
11	20	F	-/1	-	Trauma	1
12	31	M	-	-	Trauma	5
13	37	F	1/-	-	Unknown	6
14	26	F	2/-	1	Childbirth	2
15	37	F	4/-	0.5	Childbirth	13
$\bar{X}$	35					7

In one nulliparous professional ballet dancer, who had started training at the age of 10, the symptoms developed 3 months after she had started taking contraceptive pills (Patient 9).

One biparous 37-year-old woman had had symptoms ever since she was 20 years old, without any previous trauma or other apparent cause. The symptoms were aggravated during her subsequent pregnancies. She had never taken contraceptive pills (Patient 1).

Three patients, two men and one woman, had symptoms following severe pelvic injuries.

One man had 5 years previously overturned on a tractor and among other injuries sustained a fracture-dislocation of the left sacroiliac joint, fractures of the superior and inferior rami of the right pubis, and symphysiolysis. Reduction of the pelvic fractures was inadequate (Patient 12).

The second man had 3 years previously been crushed between the buffers of two railway carriages and sustained dislocations with widening of the space of the symphysis and the right sacroiliac joint. He was treated in a pelvic sling for 6 weeks and after a further 3 weeks mobilized with a pelvic belt. Because of persisting pain in the right sacroiliac joint more than one year later, a Smith-Petersen arthrodesis (27) of this joint was done, but the patient still had pain two years postoperatively (Patient 4).

One woman had one year before referral been crushed under a horse and among other injuries sustained a dislocation of the left sacroiliac joint with widening of the joint space, separation of the symphysis, and bilateral comminuted fractures of the superior and inferior pubic rami. At the time of the accident the patient was 3 months pregnant. She had never used oral contraceptives. The symphysis was reapproximated with 0/0 Dexon suture, followed by external fixation of the pelvis by means of a crosswise frame mounted without compression between pins inserted into the iliac crest on both sides. Twelve

days after the accident curettage was performed for missed abortion. After 6 weeks cautious mobilization was started and after 10 weeks the external fixation was removed. Arthrodesis of the left sacroiliac joint by the Smith-Petersen technique complemented by 3 transarticular compression screws was performed 13 weeks after the accident because of residual pain in the joint. The instability of the sacroiliac joint noted at operation was eliminated by the screw fixation. Eleven months after the accident some of the patient's pain had recurred (Patient 11).

#### Subjective symptoms

Thirteen of the 15 patients had pain in the pubic symphysis and/or the inguinal region. All patients had pain localized to one or both sacroiliac joints. Twelve had sciatic pain. Three patients also experienced crepitations in the symphyseal region and 7 patients, including all three whose symptoms were of traumatic origin, in the sacroiliac joints. Three patients had experienced a sensation of locking or jamming of the painful sacroiliac joint, which according to the referring physician had been "reducible".

In the majority of cases the patient's symptoms were brought on by movements while lying down, by prolonged sitting or standing, by walking, especially on stairs, and by other exertion. Seven of the 13 women had difficulties with sexual intercourse. Ten patients reported limping during their painful spells, and 8 had constantly or periodically used a cane. All patients had tried a so-called sacroiliac or trochanteric belt, which in 11 cases had provided at least some relief of symptoms.

#### Signs

Ten patients manifested tenderness on palpation over the symphysis or in the inguinal region, 14 patients over one or both sacroiliac joints. Compression of the iliac crest provoked pain in the symphyseal area in 2 patients and in



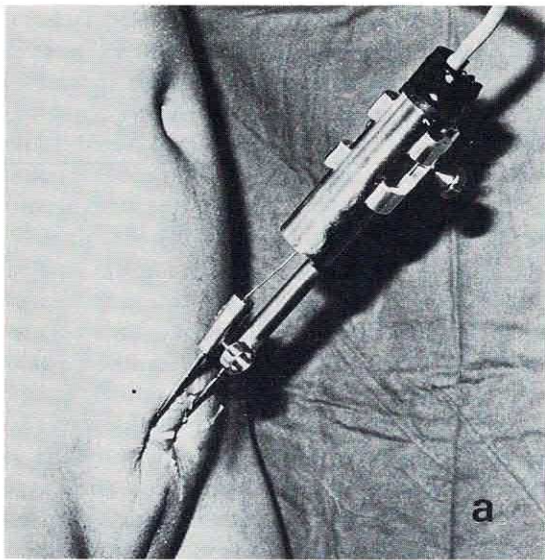


Fig. 1 a. Inductive transducer (Jernberg model) fitted between two AO-pins inserted one on either side of the pubic symphysis.

the sacroiliac joint region in 3, but in one patient this provocative test instead produced relief of pain. Abduction of the hip joints in flexion produced pain in the region of the sacroiliac joints in 4 patients, standing on one leg in 8 patients. Trendelenburg's sign was positive in 5 patients. Lasègue's sign was moderately positive on one or both sides in 10 patients, and mild signs of neurologic impairment could be objectively verified in 3 patients.

#### Radiographic findings

Four patients had radiographic changes in the pubic symphysis, including all three patients with a condition of traumatic origin. The fourth patient showed slight symphyseal widening and erosions. Pathologic symphyseal mobility as defined by Chamberlain 1932 (5), i.e. vertical mobility exceeding 2 mm, was found in 7 patients.

Eleven patients had radiographic changes in the sacroiliac joint manifested by sclerosis, narrowing of the joint space, erosions, etc. In 4 patients the radiographs were normal. Scintigraphy of the sacroiliac joint was performed in 5 patients. Two had increased uptake. Myelography was performed in 3 patients and in one of them also lumbar phlebography. Disc rupture was not disclosed in any case.

#### METHOD

The electromechanical measuring method was used for the determination of mobility at the symphysis. Two parallel 150 mm long AO-pins of 3 mm diameter are inserted into the pubic bones, one on either side of the symphysis. One or two position transducers are attached to one of the pins. The shaft of the sensory component on each transducer exert a slight pressure on a smooth disc attached to

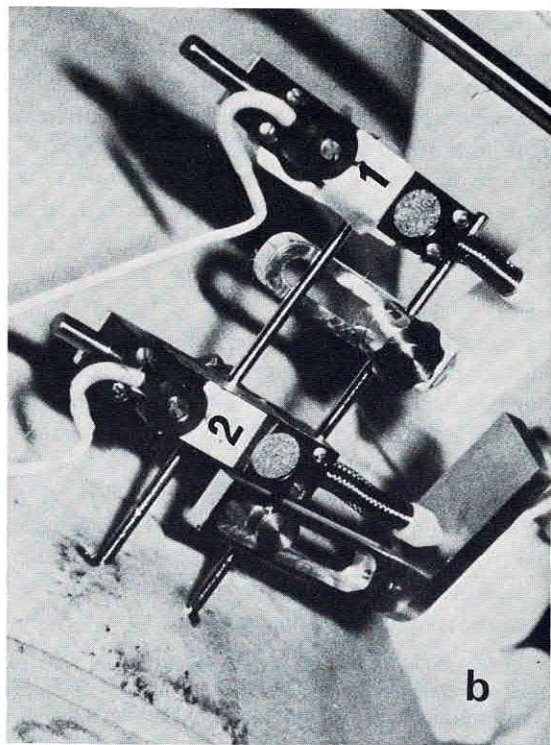


Fig. 1 b. Two resistive transducers allowing registration of both translation and rotation.

the other pin. The movements of the pins reflect the movements provoked at the symphysis. The movements are registered by the transducers which are connected to a recorder (type Rikadenki 834). To provoke translation in the transverse direction and rotation in the frontal plane forced abduction was done of the flexed hips in the supine position. To provoke translations in the vertical and sagittal directions and rotation in the sagittal plane standing was done on alternate legs.

One transducer only was used in measuring motion in the vertical direction, permitting comparison with the method of Chamberlain (1930). In 2 patients an inductive position transducer (Bofors Type RLL-1) described by Jernberger (15) was used, and in 12 measurements a specially constructed resistive transducer (Swema-model RLP 25A/0.5) described by Walheim et al. (31), which was lighter and less cumbersome (Figs. 1 a-b).

In 10 patients measurements were also made with two identical position transducers of the resistive type fitted in alternately the transverse and the sagittal direction, which allowed registration both of translations in these different directions, and of rotations in the frontal and sagittal planes.

The coordinate system used was the one earlier described by Williams & Lissner (32), in which X denotes transverse, Y vertical, and Z sagittal motion, while XY defines the frontal and YZ the sagittal plane. In the present study the pelvic inclination had to be taken into ac-



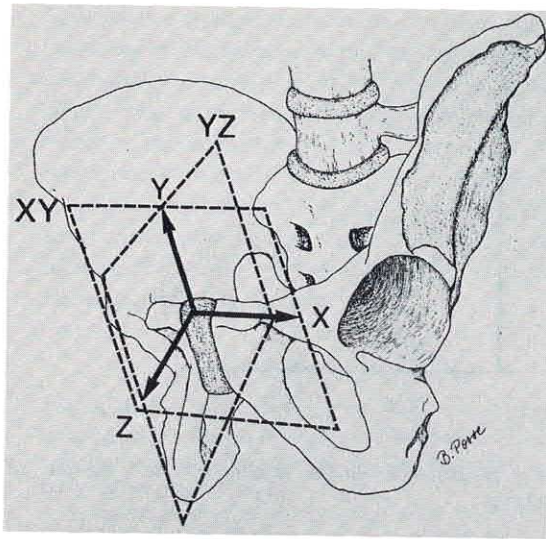


Fig. 2. Coordinate system.

count, involving a modification in that the frontal (XY) plane is approximately a tangential plane to the pubic rami, slanting forwards-downwards at an angle of about 45° (Fig. 2).

## RESULTS

In one woman with a history of pelvic trauma the pubic bones were so osteoporotic that it proved impossible to obtain firm fixation of the pins (Patient 11). For the 4 patients included only in the measurements made with one transducer, only motion in the vertical direction (Y-translations) are presented. For the remaining 10 patients results are presented both for translations in three directions (X, Y and Z) and for rotations in the frontal (XY) and sagittal (YZ) planes (Figs. 3, 4).

The mean values for movements in the X and Z directions did not exceed 1.0 and 1.1 mm, respectively. Only one measurement for each of these directions showed a translation of about 2.0 mm, whereas the remainder was <1.5 mm.

Rotation measured in the XY and YZ planes was also very slight, with mean values of 0.5° in both planes. Only one measurement in each plane showed rotation of more than 1°.

In the vertical (Y) direction translations were considerably larger, showing a mean value of 2.8 mm for the entire measured series (range 1.1–10.0 mm). Extreme values were obtained for 2 patients, 10 mm in a man with a history of pelvic trauma

(Patient 4), and 7 mm in a woman (Patient 8) (Table II).

There were no significant correlations (Spearman correlation, two-tailed test) between the variables.

## DISCUSSION

In this study 15 patients with pelvic instability have been examined. In many ways their symptoms have been suggestive of low-back pain and sciatica. However, certain features in the patients' history and clinical condition, including a positive reaction to several provocative tests, made the tentative diagnosis of pelvic instability acceptable.

Most authors who have discussed pelvic instability consider the symptoms to be elicited by increased mobility of the pelvic joints, demonstrated at the pubic symphysis by Chamberlain's radiologic technique. The majority of authors have put the upper limit for normal vertical motion at 2 mm. No reports have been found in the literature of in vivo measurement of symphyseal motion in other directions. In 7 patients of this series vertical symphyseal mobility exceeding 2 mm could be radiologically demonstrated.

In 14 patients of this study symphyseal translation in the vertical (Y) direction was also measured by the *electromechanical measuring* method, and in

Table II. Vertical mobility at the pubic symphysis measured by the *electromechanical method* (EM) ( $n=14$ ) and *Chamberlain's radiologic technique* (X-ray) ( $n=15$ ) in the patient series

	Pat. no.	EM	X-ray
Men	12	0.4	0
	4	10.0	10
Nulliparous women	9	1.1	2
	11	—	10
Multiparous women	6	1.2	0
	1	1.3	5
	2	1.6	0
	14	2.0	8
	13	2.2	0
	5	2.3	0
	15	2.3	0
	10	2.5	0
	3	2.8	5
	7	2.8	7
	8	7.0	5
$\bar{X}$		2.5	

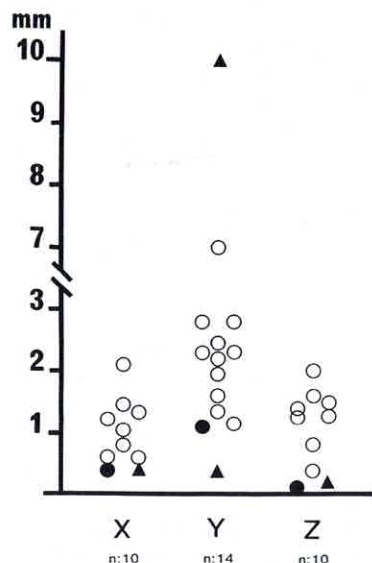


Fig. 3. Translations in the transverse (X), vertical (Y), and sagittal (Z) directions. ▲, men; ●, nulliparous; ○, multiparous women.

ten of them moreover in the transverse (X) and sagittal (Z) directions, as well as rotation in the frontal (XY) and sagittal (YZ) planes. The fifteenth patient was a woman who could not be measured by this method as mentioned above. She is therefore excluded from the subsequent discussion. All but one of the 12 remaining women in the series had given birth.

In an earlier study of 6 male and 9 female normal volunteers, the largest translations were recorded in the vertical (Y) direction (31). The same results were obtained in this patient series. Deviating values indicating pathological mobility were recorded in only two patients, 7 mm in a woman and 10 mm in a man. These were also the only individuals in whom widening of the symphysis had been radiographically demonstrated.

No statistical conclusions should be drawn about X-translation and XY-rotation as forced abduction of the hip joints cannot be considered as a constant loading. However, no deviating values were registered in the patient series compared with the values for the volunteers.

The values recorded for the other male patient did not differ in any direction or plane from those found for the 6 male volunteers.

No statistical conclusions can be drawn as to whether the female patients in the present series

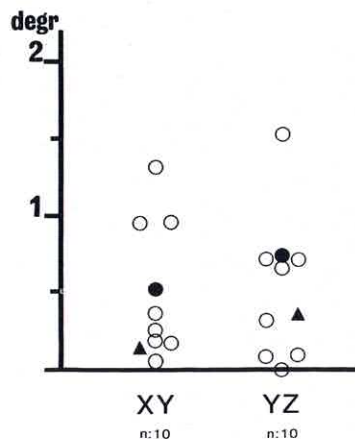


Fig. 4. Rotations in the frontal (XY) and sagittal (YZ) planes.

differed from multiparous healthy women with respect to motion in the sagittal (Z) direction (mean values 1.3 mm as compared to 1.1 mm).

With respect to rotation in the sagittal (XY) plane none of the female patients in this series exceeded the upper normal limit (95%).

Summary: the study has demonstrated pathological vertical mobility at the symphysis in only 2 of the 14 measured patients with a tentative diagnosis of pelvic instability.

Eight of the female patients had used contraceptive medication, but the significance of this as an etiologic factor cannot be assessed.

In the 2 patients in which the electromechanical method recorded pathological values for vertical (Y) motion (7 and 10 mm, respectively), this had also been demonstrated by radiologic measurement (5 and 10 mm, respectively). Nevertheless, there was considerable divergence between the results obtained at the radiologic analysis of vertical mobility and by the electromechanical method. The Chamberlain technique in 4 cases failed to demonstrate mobility exceeding 2.0 mm, and in 4 other patients mobility was overestimated by as much as 2.2–6.0 mm (Table II). This may be explained by the fact that the tilting of the pelvis when the patient transfers weightbearing from one foot to the other in the Chamberlain technique probably causes the reference points on the pubic bones to shift.

The results of the present study suggest that so-called pelvic instability is associated with increased symphyseal mobility only in occasional cases.



There was a notable correlation, however, between widening of the symphysis and the increased vertical mobility recorded in 2 of the measured patients. There was, moreover, a conspicuously high incidence of radiologic changes in the sacroiliac joints, which were observed in 11 of the 15 patients. As sacroiliac mobility was not measured, no conclusions can be drawn as to the possible significance of increased mobility of these joints as a factor in eliciting painful symptoms.

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A more comprehensive review of the literature and detailed analysis of the patient series in English, and a more extensive list of References is available in Xerox copy.

### REFERENCES

1. Aalam, M. & Hoffman, P. 1975. Beeinträchtigung der Beckenfugen durch einseitige schwere Hüftgelenksleiden. *Arch Orthop Unfall-Chir* 82, 257-262.
2. Berezin, D. 1954. Pelvic insufficiency during pregnancy and after parturition. *Acta Obstet Gynecol Scand* 33, Suppl. 3.
3. Bucholz, R. W. 1981. The pathological anatomy of Malgaigne fracture-dislocations of the pelvis. *J Bone Joint Surg* 63-A, 400-404.
4. Caviezel, H. 1973. Beitrag zur Kenntnis des Iliosakralsyndroms. *Manuelle Medizin* 5, 102-108.
5. Chamberlain, W. E. 1932. The X-ray examination of the sacroiliac joint. *Delaware Med J* 4, 195-201.
6. Coventry, M. B. & Tapper, E. M. 1972. Pelvic instability. A consequence of removing iliac bone for grafting. *J Bone Joint Surg* 54-A, 83-101.
7. Cyriax, J. 1982. Textbook of orthopaedic medicine. 8th ed., pp. 360-374. Baillière Tindall, London.
8. Dihlmann, W. 1978. Röntgendiagnostik der Sakroiliacalgelenke und ihrer nahe Umgebung. 2nd ed., pp. 13-16, 93-107. Thieme, Stuttgart.
9. Goldthwait, J. E. & Osgood, R. B. 1905. A consideration of the pelvic articulations from an anatomical, pathological and clinical standpoint. *Boston Med Surg J CL II*, 593-601.
10. Grieve, G. P. 1976. The sacro-iliac joint. *Physiotherapy* 62, 384-400.
11. Hagen, R. 1974. Pelvic girdle relaxation from an orthopaedic point of view. *Acta Orthop Scand* 45, 550-563.
12. Hallgrímsson, I. G. 1980. Smärta från sakroiliakaladen. *Läkartidningen* 77, 3656-3658.
13. Harris, N. H. & Murray, R. O. 1974. Lesions of the symphysis in athletes. *Br Med J* 4, 211-214.
14. Insulander, B. 1978. Kan p-piller ge ett instabilt bäcken? *Sjukgymnasten* 8, 27-28.
15. Jernberger, A. 1970. Measurement of stability of tibial fractures. A mechanical method. *Acta Orthop Scand*, Suppl. 135.
16. Kamhin, M., Ganel, A., Salai, M. & Horosowski, H. 1980. Rigid fixation in diastasis of symphysis pubis. *J Trauma* 20, 523-525.
17. Kamieth, H. 1957. Die Mechanik der Beckenringlockerung und ihre statischen Rückwirkungen auf die Wirbelsäule. *Fortschr Röntgenstr* 87, 499-511.
18. Kamieth, H. & Reinhart, K. 1955. Der ungleiche Symphysenstand. Ein wichtiges Symptom der Beckenringlockerung. *Fortschr Röntgenstr* 83, 530-546.
19. LaBan, M. M., Meerschaert, J. R., Taylor, R. S. & Tabor, H. D. 1978. Symphyseal and sacroiliac joint pain associated with pubic symphysis instability. *Arch Phys Med Rehabil* 59, 470-472.
20. Metz, B. 1970. Arthrose des Iliosakralgelenks und Indikation für seine Arthrodese. Eigene operative Technik. *Z Orthop* 107, 315-334.
21. Mixter, W. J. & Barr, J. S. 1934. Rupture of the intervertebral disc with involvement of the spinal canal. *N Engl J Med* 26, 210-215.
22. Neumann, H. D. 1977. Funktionsstörungen der Iliosakralgelenke bei Hypermobilität. *Orthop Praxis* 13, 665-666.
23. Olerud, S. & Grevsten, S. 1974. Chronic pubic symphyseolysis. A case report. *J Bone Joint Surg* 56-A, 799-802.
24. Pennal, G. F. & Massiah, K. A. 1980. Nonunion and delayed union of fractures of the pelvis. *Clin Orthop* 151, 124-129.
25. Pitkin, H. C. 1937. Sacroarthrogenetic telalgia. V. A plan for treatment. *J Bone Joint Surg* 19, 169-184.
26. Räf, L. 1966. Double vertical fractures of the pelvis. *Acta Chir Scand* 131, 298-305.
27. Smith-Petersen, M. N. & Rogers, W. A. 1926. End-result study of arthrodesis of the sacro-iliac joint for arthritis—traumatic and nontraumatic. *J Bone Joint Surg* 8, 118-136.
28. Solonen, K. A. 1957. The sacroiliac joint in the light of anatomical, roentgenological and clinical studies. *Acta Orthop Scand*, Suppl. 27.
29. Tanaka, H. 1981. Pelvic ring instability. Clinical and anatomical studies. *Nippon Seikeigeka Gokkai Zasshi* 55, 281-294 (in Japanese).
30. Tönnis, D., Hördegen, K. & Bär, H.-W. 1970. Reizzustände des Iliosakralgelenkes, ihre Symptomatik und Behandlung. *Arch Orthop Unfall-Chir* 68, 358-369.
31. Walheim, G. G., Olerud, S. & Ribbe, T. 1984. Mobility of the pubic symphysis. Measurements by an electromechanical method. *Acta Orthop Scand* 55, 203-208.
32. Williams, M. & Lissner, H. R. 1962. Biomechanics of human motion. W. B. Saunders Co, Philadelphia.

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