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Mobility of the pubic symphysis

Measurements by an electromechanical method

Two pins were inserted, one on each side of the symphysis in 15 volunteers and four cadavers. Movements between the pins were registered by two transducers.
Symphyseal movements were small. Translations in the transverse and sagittal directions were around or below 1 mm. Rotations in the frontal and sagittal planes were below 1.5 degrees. Movements in the vertical direction were around 2 mm in both sexes. Higher values were observed in multiparous than in nulliparous volunteers.

Key words: measurement of motion; pelvic instability; pelvic relaxation; pubic symphysis; symphysiolysis; symphysis

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Pelvic instability is regarded by many authors as an increased mobility causing pain in one or more pelvic joints (Kamieth & Reinhardt 1955, Caviezel 1973, Hagen 1974, LaBan et al. 1978, Tanaka 1981, Richenbacher et al. 1982). Direct measurement of the mobility of the symphysis in the normal pelvis has scarcely been reported in the literature. The clinical method mostly used to assess stability was described by Chamberlain in 1930. It involves radiographic measuring of the symphyseal mobility and further indirect assessment of mobility of the sacroiliac joints. The vertical mobility of the symphysis is measured on radiographic AP views with the patient standing on one leg with the other hanging freely. This method is still the only one in clinical use to assess pelvic instability and the limits of normal values recommended by Chamberlain have been generally adopted. He set the upper normal limit at 2 mm.

Kamieth, in 1957, described a further development of Chamberlain's methods. This allows radiographic measuring of the symphyseal mobility not only in the vertical but also in the sagittal direction, as well as of rotatory movement in the sagittal plane ("torsion"). However, he did not state any values. Pitkin (1947) calculated the rotation between the innominate bones (flexion-extension). He claimed that the axis of innominate motion is a transverse line through the symphysis and put the average range of rotation in young adult males at 5.5 degrees.

In order to demonstrate any increase in mobility, it is essential that normal mobility be established and its limits known. It would be an advantage if a reliable, and preferably also direct measuring method could be introduced. The aim of this investigation has been to ascertain normal mobility of the symphysis, using a new electromechanical measuring method, described by Walheim in 1980.

Material and methods

Tests were performed on four cadavers and on 15 healthy volunteers. On two male and two female cadavers the symphyseal mobility was measured. None of these had any diagnosed skeletal disease involving the pelvis. The volunteer group consisted of six healthy males aged between 21 and 27 years, six nulliparous females aged between 22 and 26 years and three multiparous females aged between 24 and 40 years.

The mobility of the symphysis was measured by an electromechanical method allowing registration of the movements between two parallel, 150 mm-long steel pins of 3 mm diameter inserted on either side of the symphysis at the upper margin of the corpus ossis pubis. They were driven about 20 mm into the bone with a distance of 30–40 mm in between. Prior to the insertion, an incision of about 1 cm was made under local anaesthesia to avoid straining of the skin. The movements between the pins, i.e. at the symphysis, were recorded at different provocative tests using electric transducers fitted to the pins and connected to a recorder (type Rikadenki B 34).

Resistive transducers

Two resistive transducers (SWEMA – model RLP 25A/05) with a length of stroke of ±15 mm were fitted to one pin, so that their axes exerted a slight spring pressure with continuous contact with two discs fitted to the other pin. These transducers can be fitted in three different ways and can record movements in three directions (Figures 1–3). By using two transducers, it was possible to measure both translational and rotational movements in two planes.

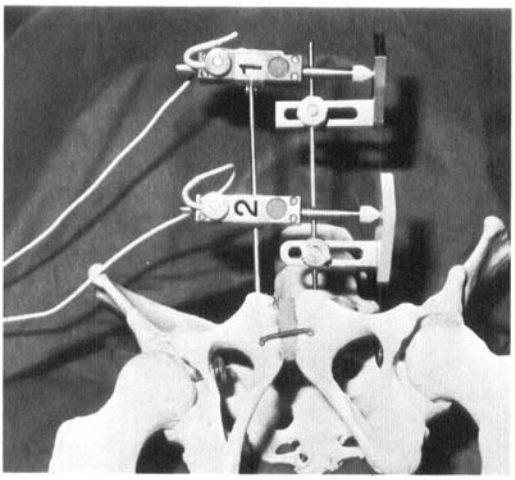

Figure 1. Registration of translation in transverse direction (X) and rotation in the frontal plane (XY) with two transducers. The mobile axes of transducers 1 and 2 are in continuous contact with the discs fitted to the other pin. At a widening of the symphysis (X), the transducers register the translation of both axes. At any rotation in the frontal plane (XY), there will be different recordings in the transducers 1 and 2 (see also Figure 5).

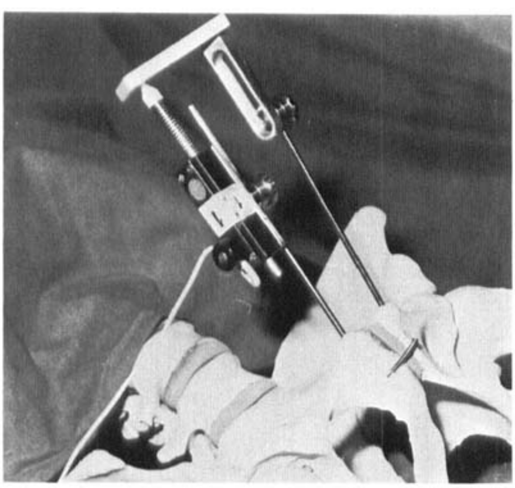

Figure 2. Registration of translation in vertical direction (Y).

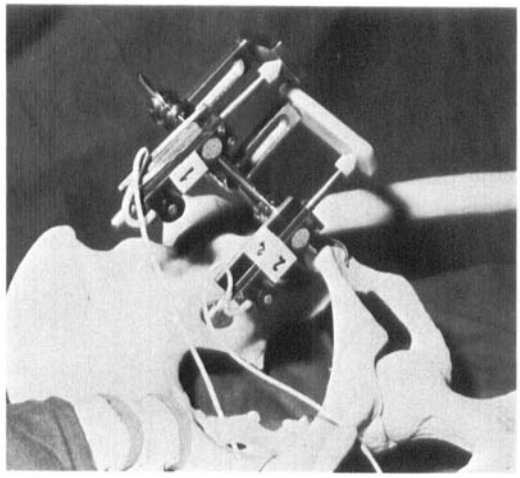

Figure 3. Registration of translation in sagittal direction (Z) and rotation in the sagittal plane (YZ).

Coordinate systems

For presentation of translations and rotations, a three-dimensional rectangular coordinate system was adopted, in conformity with usage in biomechanics (Williams & Lissner 1962, Panjabi et al. 1974). X, Y and Z denote the transverse, vertical and sagittal direction, respectively. Planes are defined by two directions: XY-plane = frontal plane, XZ-plane = transverse plane, and YZ-plane = sagittal plane. The axis of rotation in the frontal (XY) plane is the sagittal (Z) axis; in the transverse (XZ) plane it is the vertical (Y) axis, and in the sagittal (YX) plane the transverse (X) axis.

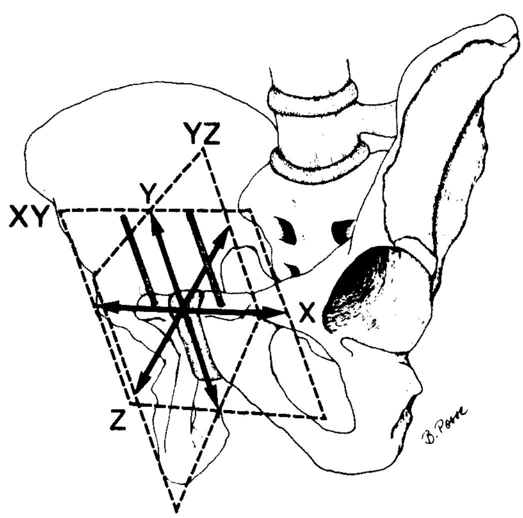

Figure 4. Coordinate system used in this presentation with an inclination forward/downward of some 45 degrees to the vertical plane.

In the present context the XY-plane will be defined as the plane containing the symphyseal pins. Thus, due to the forward pelvic tilt, the XY-plane and, consequently, the Y- and Z-axes will slant forward/downward about 45 degrees in relation to the originally defined frontal plate and vertical and sagittal directions, respectively (Figure 4).

Assessment of recorded deviations

The individual transverse deviations of the transducers (X_1 and X_2) and the real movement (translation) at the upper margin of the symphysis (X) form the base of three similar triangles (Figure 5). The translation (X) at the upper margin of the symphysis and the XY-rotation angle (α) can then be calculated.

The translation in the Z-direction and corresponding rotation in the sagittal (YZ) plane, about the X-axis, are calculated from identical formulas, with X replaced by Z (Figures 3 and 5).

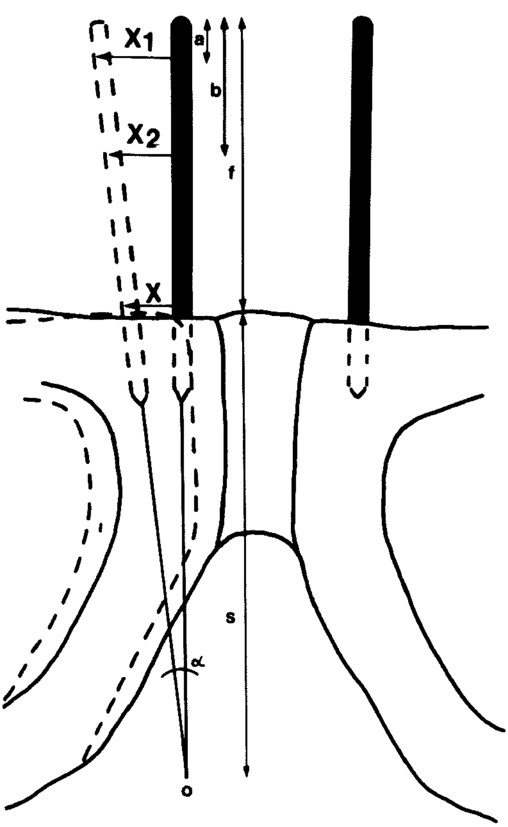

Figure 5. Schematic description of the movement in the frontal plane (XY). X_1 and X_2 = the recordings from the transducers, a and b = the distances between them and the top end point of the pin, f = the free length of the pin, s = the distance between the symphyseal upper margin and the rotation axis (o). α = rotation angle and X = the actual symphyseal translation (at the upper margin).

Vertical (Y) translation was directly registered with only one transducer (Figure 2).

Detachment of the pins from the bone was disclosed on the graph by increasingly large deviations and a marked deviation from the initial value after unloading.

The deviation of the pins caused by the load of the transducers was considered constant on the various measuring occasions, as merely a small central part of the stroke length of the spring was utilized and only the difference in position was recorded.

As the gauging device was mounted on the inserted pins, the movement in one direction could affect the deviation in another. By means of trigonometry, the error in the vertical direction (Y) was calculated. A rotation movement of 2 degrees in the sagittal plane (YZ) gives an error in the Y-direction of only 0.1 mm.

In spite of following guidelines, the pins might not be parallel, with an error of 1–2 degrees.

The precision of the transducer-recorder system was tested vs a micrometer gauge and was found to be <0.05 mm for both transducers.

Loading conditions

The symphyseal mobility was analyzed on cadavers with an intact symphysis. The movement in the X-direction was provoked by maximum abduction of flexed hip joints with the feet resting on a 25 cm high box and secured. Strings, suspended from both knees, were loaded with weights increasing gradually from 1 to 5 kg, respectively. Movements in the Y- and Z-directions were provoked by placing the cadaver on a mobile stretcher with drawhooks around the left and right ramus superior ossis pubis and pulling in the superior and inferior directions with forces of 100, 200 and 300 N.

Symphyseal motion measured in the volunteers was provoked as follows. In the supine position the hips were flexed 90 degrees and then abducted maximally. The tests were then continued in a standing position with the body weight on alternate legs. Continuous recording was also made during normal gait.

Results

Reproducibility

When performing measurements in the test series – the load left/right being identical, during gait, for instance – the reproducibility was excellent (Figure 6). In repeated tests with constant loading no difference exceeding 0.3 mm

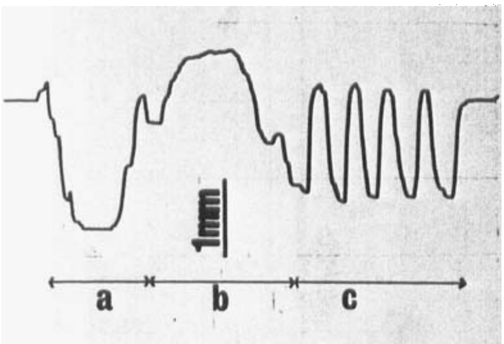

Figure 6. Registration of Y: reproducibility. a = standing on the left leg, b = standing on the right leg and c = walking.

and 0.2 degrees was registered, and the precision was 0.08 mm and 0.08 degrees (13 and 9 degrees of freedom, respectively).

Symphyseal mobility

The mobility of the symphysis measured at the superior margin in three planes is presented in Table 1. As regards the translations in the X-direction and rotations in the XY-plane, only the values obtained at abduction of flexed hip joints are reported. The remaining values present the total deviation recorded with load on the left/right leg of the volunteers in a standing position and with a unilateral tensile force of 300 N on the specimens.

Transverse movement (X). The mean value of the symphyseal widening at the upper margin (X) in the volunteers was 0.5 mm for males and 0.9 mm for females. Although the majority had only about 0.5 mm mobility, the values for the females were significantly higher ($p < 0.025$ in the one-tailed Mann-Whitney U-test).

Vertical movement (Y). The values of the movements in the Y-direction, i.e. corresponding to Chamberlain's technique, were considerably higher than in the X-direction – mean for live males 1.0 mm and for females 1.6 mm. This difference was, however, not significant.

Sagittal movement (Z). The movement in the sagittal direction (Z) showed no significant difference between live males and females in this limited series.

Rotation in the frontal plane (XY). The mean value of rotations in the frontal plane of live males and females was 0.4 degrees, revealing no statistical difference in this material.

In one multiparous volunteer the symphyseal movement was also measured in the frontal plane when raised from the supine to the standing position. No translation could then be recorded in the X-direction, but there was an external rotation of 0.5 degrees in the XY-plane with the rotation axis situated caudal to the

Table 1. Total symphyseal movements registered in 15 volunteers and four cadavers

	X (mm)		Y (mm)		Z (mm)		XY (degr.)		YZ (degr.)	
	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Male										
Volunteers (n=6)	0.5	0.1–0.7	1.0	0.5–1.9	0.7	0.2–1.3	0.4	0.1–0.6	0.3	0.0–0.9
Cadavers (n=2)	0.3	0.1–0.5	0.1	0.0–0.1	0.9	0.6–1.2	0.3	0.3–0.4	0.4	0.4–0.4
Female										
Volunteers										
Nulliparous (n=6)	1.0	0.5–2.0	1.3	0.8–2.6	0.4	0.0–0.5	0.3	0.1–0.5	0.5	0.1–1.6
Multiparous (n=3)	0.6	0.5–0.7	2.1	1.6–3.1	1.1	0.8–1.3	0.7	0.5–0.8	0.8	0.2–1.5
Significance*		n.s.		0.048		0.012		0.048		n.s.
Cadavers										
Nulliparous (n=1)		0.3		0.4		0.9		0.5		0.1
Para 1 (n=1)		0.6		0.6		1.0		1.1		2.0

*Comparison between nulli-parous and multiparous volunteers (Mann-Whitney). One-sided alternative hypothesis: Multiparous > Nulliparous.

symphysis, i.e. an outward angulation of the iliac wings.

Rotation in the sagittal plane (YZ). The rotation in the sagittal plane (YZ) revealed no significant difference between live males and females in this material. In one of the female cadavers this rotation was abnormally high owing to the probable effect of the draw hooks.

Discussion

X- and Z-translations and XY- and YZ-rotations in the symphysis

The results of measurements in the X- and Z-directions and the XY- and YZ-planes showed good accordance between the volunteers of both sexes. All the values for translations were around or below 2 mm and rotation was <1.5 degrees. The mean rotation in the YZ-plane for the eight males was only 0.3 degrees, in contrast to the value of 5.5 degrees reported by Pitkin (1947). There was no appreciable difference for the three multiparous women either. On the other hand, the rotation in the YZ-plane in one of the female specimens seemed excessive – probably the hooks caused torsion of the ramus superior, which resulted in values not representative of the symphyseal mobility.

Y-translation in the symphysis

Movements in the vertical direction (Y) revealed somewhat higher values, still with only slight difference between the sexes and mostly less than 2 mm. Y-translation is the movement which principally corresponds to that shown by Chamberlain's roentgen method and he states the following normal values: adult male 0–0.5 mm, adult nulliparous female 0–1.0 mm, and multiparous female 0–2.0 mm. All his cases with symphyseal mobility >2 mm had pain in the pelvic joints. Most authors who have used Chamberlain's technique have also set the upper normal limit of vertical mobility at 2 mm. Steiner et al. (1977), however, increased the limit to 4 mm and Hagen (1974) to 5 mm. Frigerio et al. (1974) reported mobility of the symphysis up to 23.1 mm, but this can probably be explained by an imperfect method.

The present results for women were in fairly good accordance with the normal values stated by Chamberlain, although in two cases they were around 3 mm. However, it seems that he has underestimated the symphyseal mobility in adult males, which in this investigation reached the same magnitude as that of the females. Both in the vertical (Y) and the sagittal (Z) directions, multiparous females had significantly greater mobility as compared to the nulliparous. Four of the six nulliparous women had Y-values above the upper normal limit (1 mm) indicated by Chamberlain. No radiographic measurement was carried out for comparison.

Comparison between supine and standing position

Feneis (1939) in several loading experiments on pelvic specimens found that the upper portion of the pelvic halves rotated towards each other. Egund et al. (1978) reported this in one of four subjects only. In this investigation one volunteer subjected to load in a standing position revealed external rotation. This emphasises the disadvantage of using pelvic specimens, as the muscular forces are not taken into consideration.

In summary, the present results indicate that symphyseal mobility is largest in the Y-direction. These values were roughly in accordance with those stated by Chamberlain. His method, no doubt, contains some sources of error. For one thing the reference points in the pubis change with the pelvic position. Moreover, an AP-projection will not show a frontal view of the symphysis owing to the forward pelvic tilt, which will cause the real symphyseal mobility to be underrated. The Z-translation will also influence Chamberlain's method. However, the method is uncomplicated and non-invasive and fully suitable for rough clinical screening.

The electromechanical method described here excludes most of the sources of error mentioned in Chamberlain's roentgenological method, but it is invasive and, consequently, involves certain discomfort. Although technically complicated and unsuitable as a routine method, it could probably be useful for research purposes in measuring small movements in other parts of the body. Continuous direct registration even during ambulation is an advantage not offered by any other reported method.

Acknowledgements

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