A Radiostereometric Analysis of the Movements of the Sacroiliac Joints in the Reciprocal Straddle Position

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Study Design. A Radiostereometric analysis of the reciprocal straddle position.

Objectives. To evaluate the magnitude of rotation in the sacroiliac joints in the reciprocal straddle position.

Summary of Background Data. The reciprocal straddle position has been objectified in different studies, using different techniques, to show a sacroiliac motion between 5° and 36°. Previous studies with radiostereometric analysis during different provocations reported much smaller movements.

Methods. Six women with posterior pelvic pain of long duration after pregnancy (n = 5) and sacroiliitis (n = 1) underwent radiostereometric analysis in the sustained reciprocal straddle position.

Results. A reciprocal movement could be demonstrated in the sacroiliac joints in the reciprocal straddle position. However, the movements were 10 times smaller than reported in earlier studies of the reciprocal straddle position.

Conclusions. It was possible to demonstrate reciprocal movements of the sacroiliac joints in the straddle position. However, the radiostereometric analysis technique showed the movements to be small, as reported in other mobility studies. [Key words: low back pain, pelvic pain, radiostereometric analysis, sacroiliac joint] **Spine 2000; 25:214–217**

Excellent motion analysis of the sacroiliac joints (SIJs) has been performed, both in cadaver studies[3,12] and in living persons.[1,2,10] In general, all studies show that similar small movements occur on both sides. In the study in fresh cadavers by Miller et al,[3] all muscular tissue and the symphysial part of the pelvis were removed. Each ilium was fixed into a block of acrylic cement. With both ilia fixed, the mean rotation of the sacrum around the x-axis was 3.2° (flexion + extension); with only one ilium fixed, the mean rotation was 6.2°. In the study by Vleeming et al[12] both the symphysis and the ligaments around the sacroiliac joints were intact; the maximal rotation observed was 4°. In a radiostereometric analysis (RSA) of four patients, Egund et al[1] demonstrated a maximal rotation of 2° in the SIJs. With RSA of patients changing from supine to standing position, Sturesson et al[11] demonstrated that the innominates rotate as a unit around the sacrum a mean of 2.5° (range, 1.6—3.9°). During hyperextension of one hip, the SIJ on the provoked side rotated 0.5° more than that on the nonprovoked side. The mobility of both sides was also the same in 17 patients with unilateral symptoms.[11] Kissling et al[2] used a stereophotogrammetric method in healthy volunteers. Using stainless steel rods in the ilia and the sacrum, they showed approximately 3° of movement in the SIJs between maximal flexion and extension of the spine.

Recently, in two *in vivo* studies using a sustained reciprocal straddle position, Smidt et al registered a sacroiliac motion of 9° in one study[7] and 22° to 36° the other,[9] around "an oblique sagittal axis," by using skin landmarks. In a fresh cadaver study,[8] with computed tomography the same investigators reported a "total SIJ motion" between extreme hip extension and flexion of 7° around the sagittal axis (x-axis) on the left side and 8° on the right side. Testing in the reciprocal straddle position showed 5° SIJ movement on the left side and 8° on the right side. However, little is known about movements in the SIJs in patients with posterior pelvic pain after birth and in patients with inflammatory disease.

The purpose of the present study was to evaluate with RSA the movements in the SIJs during a sustained reciprocal straddle position in patients with posterior pelvic pain and to compare results with those of Smidt et al.[7–9] It was hypothesized that use of the RSA would show that much smaller movements occur in the reciprocal straddle position than have previously been reported.

Patients and Methods

The study group comprised six women aged 28–35 years referred to the county hospital in Ängelholm, Sweden, with disabling posterior pelvic pain: five patients were referred 3–9 years after pregnancy, and the sixth patient had an inflammatory disease of 18 months' duration (Table 1). In this latter patient, magnetic resonance imaging (MRI) examination showed significant inflammatory changes in the bone on the iliac side, whereas MRI showed no abnormalities in the SIJs in the other five women.

An RSA was performed in all patients as a preoperative step before sacroiliac fusion. Tantalum balls with a diameter of 0.8 mm were inserted percutaneously in subjects under spinal anesthesia using fluoroscopy. At least four markers were inserted into each ilium, close to the SIJs and the sacrum, as described earlier in detail.[10] Approximately 14 days later, the examination was performed in a radiography room especially equipped for RSA. At that time no patient felt any pain or movement restrictions at the site where the tantalum balls were inserted. The patients were analyzed in the following positions: standing, supine, prone with the left leg hyperextended, prone with the right leg hyperextended, standing in the sustained recipro-

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Table 1. Clinical Data of the Patients

Patient	Age	Diagnosis	Parity	Height	Weight
1	30	P	M	165 cm	60 kg
2	35	P	M	173 cm	72 kg
3	34	P	M	168 cm	58 kg
4	28	A	N	170 cm	58 kg
5	32	P	M	165 cm	68 kg
6	32	P	M	170 cm	78 kg

A = arthritis; P = posterior pelvic postpartum pain; N = nullipara; M = multipara.

cal straddle position with the left hip maximally flexed, and standing in the sustained reciprocal straddle position with the right hip maximally flexed (Figure 1). Standing in the reciprocal straddle position was sustained for approximately 2 minutes.

The sacrum was defined as the fixed segment, and the movements were described as a rotation around the three axes in a body-oriented coordinate system (Figure 2), as well as a helical axis rotation (screw axis rotation)—that is, the axis around which the rotation actually occurs. When comparing the innominates, the left ilium was defined as the fixed segment. The RSA calculations were performed as described by Selvik et al[4-6] using the computer programs Kinlab, Kinerr and X-RAY 90 (RSA Biomedical Innovations AB, Umeå, Sweden).

The error of measurements was assessed using a plastic pelvic model with a similar pattern of implanted tantalum markers, as previously described in detail by Sturesson et al.[11] The plastic pelvic model had tantalum balls implanted in the same number and configuration as in the patients. The relative movements, assumed to be zero in the fixed SIJs of the plastic pelvic model, were analyzed 20 times between the supine and standing position. The precision was assessed as a 99% confidence limit for each degree of freedom, based on the standard deviations from zero and the two-sided Student's distribution ($2P$ = 0.01 and v = 20). The smallest significant movement of rotation was 0.3°, 0.4°, 0.1°, and 0.4° for the transverse (x), longitudinal (y), sagittal (z), and helical axes, respectively.[11]

■ Results

The group of patients in the present study was similar to those in another group who also underwent evaluation

Figure 1. The examination position for radiostereometric analysis when standing in sustained reciprocal straddle with the left hip maximally flexed.

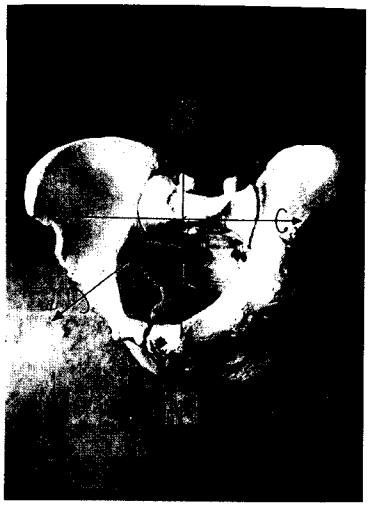

Figure 2. The pelvis with the rotational axes.

of SIJ movement.[10] In standard SIJ measurements—i.e. supine to standing and standing to prone with hyperextension—the results were similar to the results in previous RSA studies[10,11] (Table 2; Figure 3).

The results in Table 3 show that the left and right ilium rotate around the sacrum during changed in position from standing with left hip maximally extended and right hip maximally flexed, to standing with right hip maximally extended and left hip maximally flexed in the straddle position (Figure 1). Table 3 also shows that there was a reciprocal rotation around the x-axis that followed a uniform pattern. Table 4 shows that the movement between the innominates over both SIJs was almost 2° around the x-axis. Similarly, the movement pattern around the y- and z-axes also showed a uniform pattern, with the exception of one patient. The sacrum rotated on the y-axis in a positive direction, as did the right ilium when the ilia were compared. There was almost no rotation around the z-axis when comparing the ilia; however, the sacrum rotated between the ilia with torsional movement against the direction of the z-axis rotation (negative value).

■ Discussion

The patients included in this study all had experienced disabling posterior pelvic pain. Five of the six cases can be considered as persistent postpregnancy pain; one hypothesis for the cause of the pain is pelvic instability. When analyzing the standard positions: supine to standing, standing to prone with hyperextension of the left leg and standing to prone with hyperextension of the right leg, all data were comparable to data from a similar previous study[10] as were the mean values in both groups[10] (Figure 3). However, one patient in the present study had extremely high values for SIJ movement, that

Table 2. Movements of the Sacroiliac Joints (Sacrum is the Fixed Segment)

Rotation (degrees) around the axes	Joint	N	A Mean	A Range	B Mean	B Range	C Mean	C Range
x-axis	left	6	−1.1	−2.2 to −0.5	1.7	0.9 to 3.9	1.8	0.8 to 3.0
	right	6	−1.1	−2.5 to −0.2	1.5	0.8 to 3.4	1.3	0.2 to 2.8
y-axis	left	6	0.7	0.1 to 1.6	−0.1	−0.8 to 1.0	−0.2	−0.9 to 0.8
	right	6	0.2	0.0 to 0.5	−0.8	−2.0 to −0.1	−0.7	−1.2 to −0.1
z-axis	left	6	−0.3	−1.0 to 0.2	−0.4	−0.9 to 0.1	0.1	−0.1 to 0.6
	right	6	0.3	0.0 to 0.7	−0.5	−0.6 to −0.2	−0.4	−0.8 to 0.2
Helical axis	left	6	1.4	1.0 to 2.3	1.9	1.1 to 3.9	1.9	1.0 to 3.1
	right	6	1.2	0.5 to 2.6	1.8	1.1 to 4.0	1.7	0.6 to 3.1

A = when changing from supine to standing position; B = when changing position from standing to prone with the left leg hyperextended; C = when changing position from standing to prone with the right leg hyperextended; N = number of joints.

patients had values close to the mean, and two had small values for movement, compared with results in the previous study by Sturesson et al.[10]

The current study was designed to create a test situation analogous to that in the study of Smidt et al[7]; in the latter study, however, young healthy volunteers were tested. Smidt et al reported a mean value of 9° in the reciprocal straddle position. With gymnasts in a half-kneeling reciprocal straddle position a mean value of 36° of motion between the innominate was reported.[9] The values reported by Smidt et al[7] are five times higher than the current results. Movements of the SIJs could not be shown in the reciprocal straddle position that were comparable to the results of Smidt et al, although, logically, it could be expected in this group of patients with long-lasting pain after pregnancy, to find at least some patients with "instability" and findings in accordance with the those of Smidt et al.[7].

However, the incongruity between the current results and those of Smidt et al cannot be explained by the fact that healthy volunteers differ so greatly from patients with pain, because the reported rotations by Smidt et al correspond to movements of the symphysis of 2.5–8 cm. Moreover, in the current study it was assumed that the reported large displacements of the SIJs could not occur without severe damage to the symphysis. A rotation of 10° in the SIJ would imply that the left and right os pubis move 2.5 cm relative to each other in the symphysis, with an estimated distance of 15 cm from the center of rotation of the SIJ to the symphysis.

The center of rotation in the sagittal plane for the sacroiliac joint is calculated by Egund et al[1] to be approximately 50 mm posterior to the SIJ. With this knowledge it can be determined that 1° of angulation corresponds to 1 mm of translation for a part of the SIJ surface with a distance of 50 mm to the axis. According to the *in vitro* data presented by Smidt et al[8] this indicates a gliding in the SIJ of at least 7–8 mm at the joint margin with a strenuous effect on ligamentous structures. The *in vivo* data from various positions indicate a SIJ motion of 18°, implying a subluxation of the joint.

Miller et al,[3] in a study in which all muscular tissue around the sacroiliac joint and part of the dorsal ligament were dissected, the left ilium fixed, and a load of 42 Nm directly applied to the sacrum, showed a displacement of approximately 2.7° in flexion and 3.5° in extension. This corresponded to severe damage of the pelvis with separated symphysis and rupture of the sacrotuberal and sacrospinous ligaments. With both ilia fixed, the corresponding values were 1.3° and 1.9°. These data are in accordance with the results of the current study.

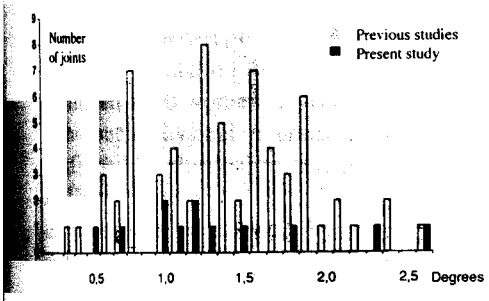

Figure 3. The rotation of the ilium in relation to the sacrum around the helical axis between the positions supine or standing. The data from the current study are compared with data from previous radiostereometric analysis studies.[10,11]

Table 3. Movements of the Sacroiliac Joints When Alternating the Straddle Position From Standing With Left Hip Maximally Extended and Right Hip Maximally Flexed, to Standing With the Right Hip Maximally Extended and Left Hip Maximally Flexed (Sacrum is the Fixed Segment)

Rotation (degrees) around the axes	Joint	N	Mean	Range
x-axis	left	6	−1.0	−0.3 to −1.6
	right	6	0.9	0.8 to 1.1
y-axis	left	6	0.3	−0.8 to 1.0
	right	6	0.4	0.2 to 0.8
z-axis	left	6	−0.5	−1.4 to 0.0
	right	6	−0.4	−1.0 to 0.0
Helical axis	left	6	1.3	0.7 to 2.1
	right	6	1.2	0.9 to 1.3

N = number of patients.

Table 4. Movements of the Innominates When Alternating the Straddle Position From Standing With Left Hip Maximally Extended and Right Hip Maximally Flexed, to Standing With the Right Hip Maximally Extended and Left Hip Maximally Flexed (the Left Ilium is Selected as Fixed Segment)

Rotation (degrees) around the axes	N	Mean	Range
x-axis	6	1.9	1.3–2.4
y-axis	6	0.2	−0.5–1.6
z-axis	6	0.1	−0.2–0.4
Helical axis	6	2.0	1.3–2.4

N = number of patients.

In conclusion, it is possible to demonstrate reciprocal movements of the SIJ in the straddle position. However, the RSA technique shows the movements to be small, as reported in other movement studies; these data are in contrast to the reports of Smidt et al.[7–9]

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