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Radiosteriometric analysis of movement in the sacroiliac joint during a single-leg stance in patients with long-lasting pelvic girdle pain

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ABSTRACT

Background: Chamberlain's projections (anterior–posterior X-ray of the pubic symphysis) have been used to diagnose sacroiliac joint mobility during the single-leg stance test. This study examined the movement in the sacroiliac joint during the single-leg stance test with precise radiostereometric analysis.
Methods: Under general anesthesia, tantalum markers were inserted into the dorsal sacrum and the ilium of 11 patients with long-lasting and severe pelvic girdle pain. After two to three weeks, a radiostereometric analysis was conducted while the subjects performed a single-leg stance.
Findings: Small movements were detected in the sacroiliac joint during the single-leg stance. In both the standing- and hanging-leg sacroiliac join, a total of 0.5 degree rotation was observed; however, no translations were detected. There were no differences in total movement between the standing- and hanging-leg sacroiliac joint.
Interpretation: The movement in the sacroiliac joint during the single-leg stance is small and almost undetectable by the precise radiostereometric analysis. A complex movement pattern was seen during the test, with a combination of movements in the two joints. The interpretation of the results of this study is that, the Chamberlain examination likely is inadequate in the examination of sacroiliac joint movement in patients with pelvic girdle pain.

1. Introduction

The sacroiliac joint (SIJ) is a possible cause of pain in patients with low back and pelvic girdle pain (PGP), with a reported prevalence ranging from 10% to 60% depending on the patient population and choice of diagnostic criteria (Cohen et al., 2013; Simopoulos et al., 2012; Vleeming et al., 2008). A large amount of force is transferred from the spine to the legs through the pelvis and SIJ joints. In an upright position, when gravitational forces are transferred through the sacrum, the anatomy of the SIJ, ligaments and muscles locks the joint and stabilizes the pelvic girdle (Snijders et al., 1993). Locking occurs when the sacrum rotates forward (Sturesson et al., 1989) and is explained by the theory of form and force closure (Sturesson et al., 2000a). An increased movement in the SIJ might reduce stability and result in stress of the SIJ ligaments, impaired motor control and consequently pain (Mens et al., 2009; Siegel et al., 2008; Snijders et al., 1993). However, the exact movements that occur in the SIJ are still debated (Goode et al., 2008; Jacob and Kissling, 1995; Mens et al., 1999; Walker, 1992).

Despite the difficulty in measuring true movement of the SIJ, several attempts have been made using different experimental techniques, such as k-wires, CT, cadaver studies, skin markers, X-rays and radiostereometric analysis (RSA) (Hungerford et al., 2004; Jacob and Kissling, 1995; Lavignolle et al., 1983; Smidt et al., 1995; Sturesson et al., 1989; Sturesson et al., 1999; Sturesson et al., 2000a; Sturesson et al., 2000b). However, these techniques are impractical in a clinical practice. In 1930, Chamberlain described an easy and practical method to measure pubic movement on an anterior–posterior (AP) pelvic X-ray while the patient stands on one leg with the other leg hanging down (single-leg stance) (Chamberlain, 1930). In patients with SIJ pain, Chamberlain found that weight bearing caused a cranial displacement of the pubic bone on the side of the painful joint. This displacement was explained by a rotation around the axis that was perpendicular to the SIJ surface. The Chamberlain technique has since been used to examine pubic bone movement and indirect SIJ hypermobility (Mens et al., 1999).

Since the Chamberlain technique was first described, researchers have attempted to correlate pubic movement to SIJ pain (Anderson

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Table 1
Patient characteristics, n = 11.

	Mean	(Range)
Age (years)	39	(29–47)
Body mass index	24	(19–30)
Female/male	10/1	
Duration of symptoms (years)	8	(1.5–20)
Oswestry disability index	56	(26–76)
Evening VAS	75	(53–91)
Etiology (numbers)		
Post-pregnancy	6	
Trauma	4	
Idiopathic	1	
Bilateral pain/unilateral pain	7/4	

VAS = visual analog scale.

and Peterson, 1944; Mens et al., 1999; Siegel et al., 2008). Chamberlain found a clear pattern in his patients, but later Mens et al. (2009) found the exact opposite where the hanging leg caused a downward displacement of the pubic bone on the side of the painful joint. These differences have made it hard for clinicians to use the results of the test in the diagnosis of PGP, especially when normal variations of the movement in the pubic symphysis have proven to be large (Garras et al., 2008). Measurements of the movement in the SIJ during the single-leg stance have been done using k-wires, however only measured on healthy subjects without SIJ pain (Jacob and Kissling, 1995). As the Chamberlain technique is an indirect measure of SIJ movement, it is still unknown what really occurs in the SIJ during the single-leg stance test in patients with PGP.

In a systematic review Goode et al. (2008) concluded that the measurement techniques with the lowest level of error also reported the lowest values of movement in the SIJ. The RSA technique is highly accurate and precise (Kibsgard et al., 2012), but has not been utilized to examine SIJ movements during the single-leg stance test. Therefore, the aims of the present study were to measure movement in the SIJs during the single-leg stance test by using RSA, in patients with severe PGP and to identify whether there are any differences between movements in the SIJs of the standing leg and the hanging leg.

2. Methods

We used RSA to measure the in vivo movement of the SIJ in patients with PGP. All patients signed an informed consent, and the study was approved by the Regional Committee for Medical and Health Research Ethics (Number: 1.2006.1574).

2.1. Patients

From 2007 to 2010, 17 patients with severe PGP were assigned for SIJ fusion at two orthopedic centers, Oslo University Hospital, Norway and Ängelholm Hospital, Sweden. The inclusion criteria were long-lasting pain localized to one or both SIJs, minimum of two out of five positive SIJ tests (posterior pelvic pain provocation test, active straight leg raise, palpation of the long dorsal sacroiliac ligament, modified Trendelenburg test, palpation of the symphysis (Vleeming et al., 2008)) and a high degree of pain and disability as measured by the visual analog scale (VAS) and the Oswestry disability index (ODI). Patient characteristics at inclusion are presented in Table 1. All patients had normal spinal MRIs, and the patients had either CT scan or/and MRI of the SIJ. The pelvic MRI or CT was primary done to exclude patients with sacroiliitis. Seven out of 11 did not have any radiographic abnormalities. In three patients there were light unilateral degenerative changes in the side that were later operated on, and one had bilateral degenerative changes. Two out of these patients also had anterior osteophytes on the side that were operated. After evaluating the RSA data, six patients were excluded because of poor X-ray quality, leaving 11 patients for the final analysis (10 females and 1 male). The patients were excluded because of misplaced markers in the soft tissue or insufficient visualization of the markers on radiographs during the software analysis.

2.2. RSA protocol

Under general anesthesia, 1 mm RSA tantalum markers were inserted into the dorsal sacrum and the ilium with a marker gun through small skin incisions. An imaging intensifier was used to assure proper placement. RSA X-rays were taken after 2–3 weeks. Three pairs of X-rays were taken under the following conditions: 1) standing on both legs, 2) standing on the right leg and 3) standing on the left leg, with full weight bearing according to Chamberlain examination procedure (Fig. 1). Each pair of radiographs was taken with two X-ray tubes. As we used the standard set-ups in Norway and Sweden respectively, the RSA set-ups were slightly differently in the two centers. The software program has, however, the ability to compensate for the deviation automatically because its retrograde calculates the position of the tubes depending on the control markers in calibration cage. In Norway, X-ray tubes from the GE system (GE Healthcare, Piscataway, NJ, USA) and Philips OPTIMUS (Philips Healthcare, Best, The Netherlands) were used. The tubes were at an approximately 40° angle to each other, with a film-focus distance of 155 cm, an exposure of 133 kV and 6.5 to 8 mAs using UmRSA Calibration Cage number 43. In Sweden, two GE systems (GE Healthcare, Piscataway, NJ, USA) tubes were used. The tubes were at a 30° angle to each other, with a film-focus distance of 130 cm, an exposure of 125 kV and 13 mAs using UmRSA Calibration Cage number 41. The digital images were analyzed using UmRSA Version 6.0 software (UmRSA Biomedical), and the markers were identified with user-assisted edge detection (UmRSA digital measure). The RSA software calculates the translation and rotations in a x,y,z

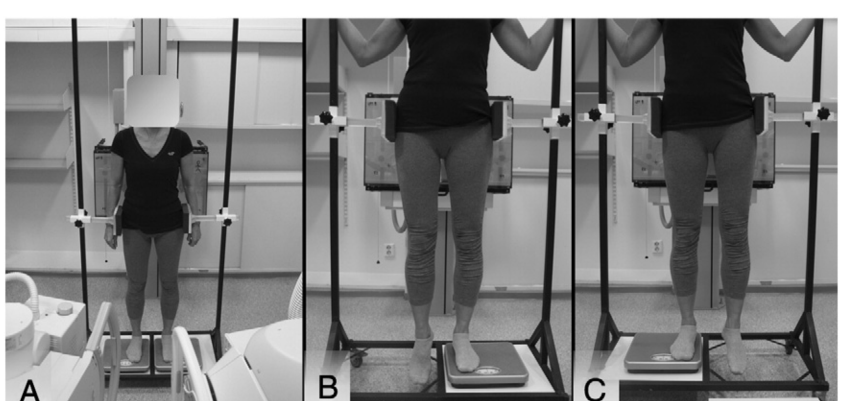

Fig. 1. RSA setup. A—Patient standing on both feet, B—Patient standing on left leg with the right leg hanging down, C—Patient standing on right leg with the left leg hanging down.