Failure Load and Displacement of the Human Sacroiliac Joint Under In Vitro Loading*

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Summary. The stability of the sacroiliac joint was studied using an in vitro loading system. Forty-nine sacroiliac joints taken from fresh cadavers were examined. The ligamentous structures of the joint disrupted at 3368 ± 923 N under transverse loading. Higher disruption forces were observed under ventrocranial (4933 ± 1038 N) and dorsocranial (5150 ± 947 N) loading. At joint failure the displacement in loading direction ranged from 5.5 ± 2.3 mm in the transverse to 6.6 ± 2.3 mm in the dorsocranial direction. In some experiments the interlocking effect between the articular surfaces of the sacrum and ilium were examined. The best interlocking capacity was observed under dorsocranial loading. This capacity is much higher than the friction in other human joints. The study shows that correct anatomical reconstruction without displacement increases the stability of the disrupted sacroiliac joint.

The conservative treatment of ligamentous pelvic ring disruption causes many problems in nursing, and a high incidence of persistent pelvic asymmetry and low back pain is found when the patients are followed up. These problems are observed especially in patients with a rupture of both sacroiliac joints or a rupture of the pubic symphysis and one sacroiliac joint [2, 11]. Various operative methods are used to stabilize sacroiliac joint disruption such as external fixation with various frame configurations and internal fixation with screws and plates [1, 3, 5, 10]. Protruding external frameworks are able to stabilize disrupted sacroiliac joints [4], but these external fixations cause more problems in nursing than internal stabilization methods do.

Little is known about the strength of the intact joint. Some systems for loading the sacroiliac joint have been described. In their investigation on devices for external stabilization Brown et al. [4] and Rubash et al. [9] loaded the whole pelvic skeleton in a longitudinal direction through the first sacral disk. In the test the pelvis was supported according to the standing or sitting position. Some intact pelves were loaded up to 800 N and the displacement was observed.


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Gunterberg et al. [7] reported the loading of five pelvis up to failure in a similar test system. Using these methods, a loading of the sacroiliac joint is not possible in directions other than those occurring in vivo, and the failure of an isolated joint cannot be determined. In the present study, therefore, a holding device was developed to test the strength of the isolated joint in different directions up to failure. The device should also be suitable for investigating the strength of internal joint fixations in future.

Materials and Methods

Fresh unembalmed pelvis were used from 19 male and nine female subjects. They had died of intoxication, circulatory break down, brain injuries, or other causes unrelated to the skeletal system. None of the patients had been hospitalized for more than 1 day. Their average age was 36.8 ± 15.1 years. The pelvis were cleaned of muscles and soft connective tissue. The pubic rami and the ischium were dissected above the acetabulum.

Forty-nine sacroiliac joints from the 28 pelvis were examined in four different ways. All experiments were carried out with a Zwick testing machine (Zwick Nr. 1361, Zwick & Co. KG, Einsingen/Ulm (Donau), FRG), and a special holding device was used. The upper two pairs of the sacral foramina were enlarged to 10 mm in diameter. Steel pins of the same diameter were fitted into these foramina and into the two intervertebral foramina between the fifth lumbar vertebra and the sacrum. These six pins were fixed at each end onto two plates with the sacrum between them. The iliac bone was clamped with screws and a bar in the greater sciatic notch. A clamp was added to fix the superior posterior iliac spine. The holding device was fitted into the testing machine. The load-induced displacement in the loading direction was continuously recorded with an electro-mechanical transducer (No. B 3004 a 363, Novotechnik KG, Ostfildern, FRG) near the ventral joint space. Curves showing load against displacement were recorded on the x-y recorder of the testing machine. In addition, the distance between the two parts of the holding device was continuously registered. This is called „clamp distance”. The displacement of the joint and the clamp distance were measured in the same direction. With this technique a slip of the sacrum or the ilium in the holding device could be observed.

Three different directions were selected for loading on the iliac side of the intact sacroiliac joint: transverse distraction and ventrocranial and dorsocranial loading (Fig. 1). Because of the pelvic tilt, the ventrocranial direction is along the sacrum and the dorsocranial direction is perpendicular to it. These test directions correspond to the orientation of the two dorsal groups of sacroiliac ligaments [13]. The specimens were subjected to quasi-static traction at a speed of 15 mm/min. In the transverse direction the ligamentous structures of the sacroiliac joint were tested; in the other two directions the joint loading was similar to that in vivo. In these experiments 43 sacroiliac joints were examined.

In the other six joints the forces which hold the sacrum and ilium together were examined. An attempt was made to differentiate between the influence of the ligamentous structures and that of the articular surface of the sacrum and ilium on sacroiliac joint stability. The ligamentous structures of these joints were dissected and the articular surfaces of the sacrum and ilium were increasingly compressed by various forces. Three of these sacroiliac joints were loaded in a ventrocranial and the other three in a dorsocranial direction (Fig. 2). When the joint displacement in the loading direction reached 1 mm, loading was stopped. After relief of the test system and repositioning of the joint, the next loading was started with a higher compression force. In a load versus compression diagram the relationship between the loading forces and the compression was calculated. All results are given as mean values ± standard deviation.

Results

Continuous recording of the distance between the clamps and the joint displacement showed slip of the sacrum in the holding device (slip = clamp distance minus joint displacement). Under transverse loading