——————————— ORIGINAL ARTICLE ———————————

Possible role of the long dorsal sacroiliac ligament in women with peripartum pelvic pain

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Background. To enhance the understanding of the pathophysiology of women with peripartum pelvic pain, it is necessary to couple anatomical insights with relevant clinical research. In this context, the long dorsal sacroiliac ligament is especially of interest because it was noticed that women diagnosed with peripartum pelvic pain frequently experience pain within the boundaries of this ligament.
Njoo (1) found a high intertester reliability and a high specificity for long dorsal sacroiliac ligament pain. The present article focuses on the possible role of the long dorsal sacroiliac ligament in the pain pattern of women with peripartum pelvic pain. The diagnostic and therapeutic consequences are considered.
Study design. A cross-sectional analysis was performed in a homogenous group of women meeting strict criteria for posterior pelvic pain since pregnancy, diagnosed as having peripartum pelvic pain and excluded for any history of fracture, neoplasm or previous surgery of the lumbar spine, the pelvic girdle, the hip joint or the femur. The patients were also excluded for signs indicating radiculopathy: asymmetric Achilles tendon reflex and/or (passive) straight leg raising restricted by pain in the lower leg.
Methods. The study group comprised 178 women diagnosed with peripartum pelvic pain, selected from the outpatient clinic of a specialized rehabilitation center. Selection was based on criteria enabling a strict division between lumbar and pelvic complaints. Pain in the long dorsal sacroiliac ligament was detected by standardized palpation of the long dorsal sacroiliac ligament by specifically trained physicians and scored on a modified scale. Comparisons with the posterior pelvic pain provocation test and the active straight leg raise test was carried out.
Results. The present study confirms that the long dorsal sacroiliac ligament frequently shows tenderness on palpation in patients with peripartum pelvic pain. Sensitivity was 76%. Sensitivity in a group of 133 women of the study group that scored positive on both active straight leg raise and posterior pelvic pain provocation tests was 86%. When only severe pelvic patients were included, sensitivity increased to 98%.
In comparisons between the posterior pelvic pain provocation and the long dorsal sacroiliac ligament tests on the left and right side, Pearson's correlation coefficient was 0.33 and 0.41, respectively. In comparisons between the active straight leg raise and the long dorsal sacroiliac ligament tests on the left and right side, Pearson's correlation coefficient was 0.35 and 0.41, respectively.
Conclusions. The present study, carried out on a group of peripartum pelvic pain patients with strict in- and exclusion criteria, attempts to further elucidate the pathophysiology of patients with peripartum pelvic pain by adding a simple pain provocation test. It is concluded that the combination of the active straight leg raise, the posterior pelvic pain provocation and the long dorsal sacroiliac ligament pain tests combined with the proposed in- and exclusion criteria seems promising in differentiating between mainly lumbar and pelvic complaints.
Although the sensitivity of the long dorsal sacroiliac ligament pain test seems promising, further clinical study is necessary in targeting specifically the long dorsal sacroiliac ligament. It is suggested that studies initiated to show the prevalence of sacroiliac joint pain in patients presenting nonspecific lumbopelvic pain, by using intra-articularly double block injection techniques, should include a peripheral injection of at least the long dorsal sacroiliac ligament.

To gain a better understanding of the anatomy and biomechanics of the pelvis, several studies were initiated that describe how spine, pelvis and legs are coupled and forces are transferred. Studies directed to the sacroiliac joint (SIJ) revealed that the amount of friction between the articular surfaces of the SIJ is related to the degree of macroscopic roughening of the articular surfaces (2, 3). It was concluded that, in general, this roughening is a normal process. Articular surfaces with both coarse texture and ridges, grooves and depressions showed high friction coefficients (3). To illustrate the importance of friction in the SIJ, the principles of form and force closure were introduced (4–6).

To further validate the mechanism of form and force closure and hence the stability of the SIJ, research was focussed on SIJ ligaments such as the sacrotuberous ligament (STL) and the long dorsal sacroiliac ligament (LDL; Fig. 1) (7–10).

The STL showed extensive connections with the gluteus maximus muscle, the long head of the biceps femoris muscle, and the sacrospinous ligament, but also anterior with extensive connections to the iliococcygeus muscle. It was shown that incremental loading of the STL restricts the amount of nutation (slight posterior rotation of the ilium (hipbone) relative to the sacrum) in the SIJ. Induced movement in the direction of nutation in the SIJ leads to increased tension of the STL and counter nutation (slight anterior rotation of the ilium (hipbone) relative to the sacrum) slackens the ligament (8).

The LDL, normally missed during manual examination of patients, can be palpated directly caudal to the posterior superior iliac spine, as a taut superficial structure; frequently mimicking the feeling of a bony structure. Although the LDL is a superficially located structure, experience shows that adequate training in anatomy *in vivo* of this area is a necessity to properly locate the ligament.

The LDL runs to the lateral crest of the third and fourth sacral segments, and in some specimens fibers pass also to the fifth sacral segment. The length, measured between the posterior–superior iliac spine and the third and fourth sacral segments, varies between 42 and 75 mm. The width is 15–30 mm. The LDL has close relations with, among others, the aponeurosis of the erector spinae muscle, the posterior layer of the thoracolumbar fascia, and the STL (9). Counternutation in the SIJ increases tension in the LDL whereas nutation slackens it.

Therefore, tension applied to the STL or the LDL appears to restrict contrary movements in the SIJ. Both ligaments are partially connected (8, 9).

The present study focuses on impaired lumbopelvic function of patients specifically included for peripartum pelvic pain. The above mentioned model of load transfer of the pelvis is clinically applied. The LDL is of special interest because it is noticed that women with peripartum pelvic pain frequently experience pain within the boundaries of this ligament (9).

Njoo found a high intertester reliability for LDL testing (0.76 kappa; range, 0.64–0.88; (1) and a high specificity. However, in this study, no strict distinction was made between lumbar and pelvic pain.

The present study centers therefore around the question of how many women diagnosed with peripartum pelvic pain indicate pain on palpation of the LDL? If pain during palpation in the LDL occurs among this group of patients, a second question arises: is it possible to further validate our knowledge about the relation between pain in the LDL and the occurrence of a counternutated position (slightly anterior rotation of the ilium relative to the sacrum) of the SIJ in this group of patients, as indicated in a former study. This study shows
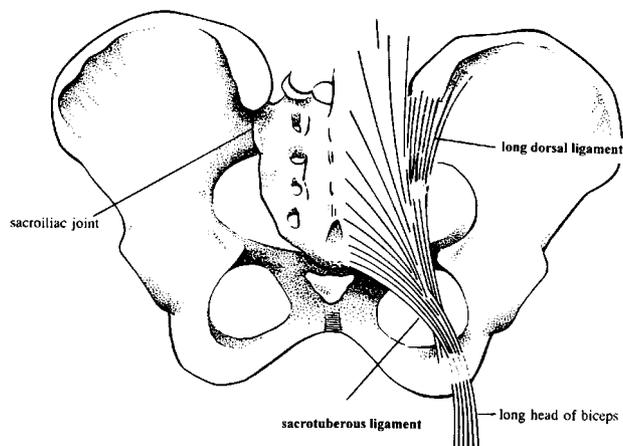

Fig. 1. Schematic drawing of the relations between the pelvis, sacrotuberous ligament and long dorsal sacroiliac ligament.

that the ilium tends to slightly rotate anteriorly (counternutation) in patients with peripartum pelvic pain (11). Following an *in-vitro* study of LDL function (9) it is now hypothezised that LDL pain could be the result of repetitive anterior rotation of the ilium relative to the sacrum, increasing the tension in the LDL, similar like studied *in vitro* (9). To be able to test this hypothesis, two formerly described and validated tests used for diagnosing peripartum pelvic pain were compared with the LDL test.

Materials and methods

Study population

Over a period of 15 months, 178 patients who fulfilled the primary inclusion criteria were initially included. The mean age of the patients was 32.7 ± 3.4 years. Parity ranged from 1 to 6 with a median of 2. The postpartum period ranged from 0.5 to 4.8 years with a median of 1.7 years. The patients were selected from the outpatient clinic of a rehabilitation center that specialized in the treatment of patients with chronic lumbopelvic pain. The selection was based on the following criteria, which enabled a strict division between lumbar and pelvic complaints: only patients with chronic pelvic complaints since pregnancy and with little or no positive results from former rehabilitation were referred to the clinic.

Primary inclusion and exclusion criteria

Inclusion criteria:

1) Pain in the lumbopelvic region, defined as pain experienced between the upper level of the iliac crests and the gluteal fold.
2) Pain beginning during pregnancy or within 3 weeks after delivery.
3) The patient was not pregnant and the last delivery was 6 months to 5 years previously.
4) Aged 20–40 years.

Exclusion criteria:

1) A history of fracture, neoplasm or previous surgery of the lumbar spine, the pelvic girdle, the hip joint or the femur.
2) Signs indicating radiculopathy: asymmetric Achilles tendon reflex and/or (passive) straight leg raising restricted by pain in the lower leg.
3) A systemic disease of the locomotor system.
4) Insufficient knowledge of the Dutch language to complete the appropriate forms, or any restriction interfering with the diagnostic process.

Secondary inclusion measurements

The following validated pelvic tests were bilaterally performed:

1) The posterior pelvic pain provocation test (PPPP test) was performed as described by Östgaard *et al.* (12) with additional grading of tender points: 'The PPPP test was performed with the patient supine and the hip flexed to an angle of 90 degrees on the examined side. A light manual pressure was applied on the patient's flexed knee along the longitudinal axis of the femur. The test was positive when the patient felt a familiar, well localized deep pain in the gluteal area on the provoked side'. The PPPP test was performed at both sides and scored in the same way as the LDL test described below.
2) The active straight leg raise test (ASLR test) was performed in a supine position with straight legs and feet 20 cm apart (11). The test was performed after the instruction: 'Try to raise your legs, one after the other, above the couch for 20 cm without bending the knee'. The patient was asked to score impairment on a six-point scale: not difficult at all = 0; minimally difficult = 1; somewhat difficult = 2; fairly difficult = 3; very difficult = 4; unable to do = 5. The scores of both sides were added, so that the summed score ranged from 0 to 10.

The test-retest reliability of the ASLR test was 0.83. The intraclass correlation coefficient between the scores of the patient and the scores of a blinded assessor was 0.78. The sensitivity of the test was 0.87 and specificity was 0.94 (13).

Added test procedure

The patients were tested on tenderness on bilateral palpation of the LDL (LDL test) (1, 9). A skilled examiner scored pain. The LDL tests were scored on a modification of the scale proposed by the American College of Rheumatology to grade tender points in fibromyalgia: no pain = 0; complaint of pain without grimace, flinch, or withdrawal = 1 (mild); pain plus grimace or flinch = 2 (moderate); the examiner is not able to complete the test because of withdrawal = 3 (unbearable). The scores of both sides were added, so that the summed score ranged from 0 to 6.

Njoo found a high intertester reliability for LDL testing; therefore in the present study LDL tenderness was scored by one trained examiner (0.76 kappa; range 0.64–0.88) (1).

To be able to reduce examiner bias, the present

study was blinded so that the principal examiner was not informed of the objectives of this study and the specific clustering of the diagnostic criteria. The examiners were trained for specific anatomical palpation of the LDL.

Statistical analysis

SPSS statistical software (Chicago, IL) was used for data analysis. Pearson's correlation coefficient was used to investigate the correlation between the LDL test and the PPPP and ASLR tests. $p < 0.05$ was considered significant.

Results

In the group of 178 patients with peripartum pelvic pain, 133 patients (74%) scored positive on both the PPPP test and ASLR test, at least on one side. In 35 patients (20%) the ASLR test was positive while the PPPP test was negative, and in three patients (2%) the PPPP test was positive while the ASLR test was negative. In seven patients (4%) both the PPPP test and ASLR test were negative (Table I).

Sensitivity of the long dorsal sacroiliac ligament test

In the group of 178 patients, 136 (76%) indicated pain on LDL palpation (Table II). However, if the cut-off score for inclusion of peripartum pelvic pain patients is raised to include both a positive ASLR and PPPP tests (fulfilling the secondary inclusion criteria) at least on one side, the sensitivity of the LDL test was 114/133 * 100 = 86%. In this group of 133 patients, 14% scored negative on the

LDL test. In the group of 45 patients scoring negative on the PPPP and/or ASLR tests, at least on one side, sensitivity of the LDL test was 22/45 * 100 = 49%. If the cut-off score for inclusion of peri-partum pelvic pain patients is further raised, to include severe pelvic patients only (ASLR test ≥ 3 and PPPP test ≥ 2 at least one sided), the sensitivity of the LDL test was 53/54 * 100 = 98% (Table II).

Comparison with the posterior pelvic pain provocation test

Pearson's correlation coefficient between the PPPP and LDL tests on the left side and right side was 0.33 ($p < 0.01$) and 0.41 ($p < 0.01$), respectively.

Comparison with the active straight leg raise test

Pearson's correlation coefficient between the ASLR and LDL tests on the left and right side was 0.35 ($p < 0.01$) and 0.41 ($p < 0.01$), respectively.

Graded PPPP test compared with ASLR and LDL tests

Table III shows the relation between the PPPP test and the ASLR and LDL tests. Mean scores on the ASLR and LDL tests were higher when the PPPP test was graded higher.

Discussion

To effectively transfer load from spine to pelvis and legs and vice versa, nutation of the SIJ (posterior rotated ilium (hipbone) relative to the sacrum) seems crucial. Nutation winds up and tenses the largest SIJ ligaments, among them the sacrotuberous, sacrospinous and interosseous ligaments (7, 8, 10). The latter ligaments are located between sacrum and ilium bones, directly posterior to the main articular surfaces of the SIJ. As a result of tension sacrospinous, sacrotuberous and interosseous ligaments, and partially because of their muscular connections, the resulting generated compression (force closure) brings the posterior parts of the iliac bones together and stiffens and braces (compression) the SIJ (4–6).

Nutation of the SIJ could be the result of loading the spine and hence tilting the sacrum forwards, combined with the reaction force of the legs acting on the hip joints, posteriorly rotating the ilia: these forces create a force couple to nutate the sacrum relative to the ilia.

In recent studies by Sturesson *et al.* the above-mentioned model is further substantiated. It was demonstrated that loading the spine by increasing

Table I. Score on ASLR and PPPP tests

ASLR test	PPPP test	n	(%)
+	+	133	(74)
+	–	35	(20)
–	+	3	(2)
–	–	7	(4)
		178	(100)

ASLR, active straight leg raise; PPPP, posterior pelvic pain provocation.

Table II. Sensitivity of the long dorsal sacroiliac ligament test

	n	Sensitivity
All studied patients with peripartum pelvic pain	178	0.76
Patients with ASLR test >0 and PPPP test >0	133	0.86
Patients with ASLR test ≥ 3 and PPPP test ≥ 2	54	0.98

ASLR, active straight leg raise; PPPP, posterior pelvic pain provocation.

Table III. The relation of a graded posterior pelvic pain provocation test on a 4-point scale with mean scores of the active straight leg raise and long dorsal sacroiliac ligament tests

	Scale	Mean score ASLR test	Mean score LDL test	*n*
PPPP test: left side	0	1.39	0.84	64
	1	2.36	1.07	42
	2	2.55	1.31	55
	3	3.82	1.82	17
PPPP test: right side	0	1.70	0.67	70
	1	1.91	0.95	55
	2	2.50	1.35	40
	3	4.08	2.00	13

ASLR, active straight leg raise; LDL, long dorsal sacroiliac ligament; PPPP, posterior pelvic pain provocation.

the lever of the spine, like in stooped postures, results in bracing and stiffening of the SIJ through nutation (14, 15).

The focus of the present study is on impaired pelvic function in a group of women diagnosed with peripartum pelvic pain and the possible diagnostic and clinical consequences.

Mens *et al.* demonstrated that in peripartum pelvic pain patients testing positive on the ASLR test, shown on X-rays, with the impaired painful side with the leg freely hanging down, the pubic bone appears smaller in the craniocaudal direction compared with the other pubic bone. It is concluded that this caudal displacement is caused by an anterior rotation of the ilium about a horizontal axis near the SIJ leading to a counternutated SIJ (11). It has been anatomically demonstrated that a very small amount of counter nutation of the SIJ, increases the tension of the already normally taut LDL (9).

The results of the present study indicate that the LDL frequently shows tenderness on palpation in peripartum pelvic pain patients, scoring positive in 76% of the study population. However, if the cut-off score for inclusion of peripartum pelvic pain patients is raised to include both a positive ASLR and PPPP tests at least on one side, 86% of the peripartum pelvic pain patients score positive on the LDL test. If the cut-off score for inclusion of peripartum pelvic pain patients is further raised to include ASLR test ≥3 and PPPP test ≥2 at least on one side, sensitivity of the LDL test was 98%.

Based on the finding of Mens *et al.* it is speculated that the presented positive pain on palpation of the LDL in patients with peripartum pelvic pain in the present study is the result of straining the LDL because of an anterior rotated ilium, which counters nutation in the SIJ (11).

If this speculation on a counter nutated SIJ position and subsequently strained LDL is feasible, it confirms the work of DonTigny who describes clinically the phenomenon of manually demon-strated anterior rotation of the ilium in patients with pelvic problems (16).

Another consideration is that the frequent positive testing of the PPPP test (Östgaard *et al.*) in women with peripartum pelvic pain could be partially explained by the generated anterior rotation of the ilium because of the test procedure (12). The examiner applies dorsal pressure along the longitudinal axis of the femur. With this procedure an axial force is introduced through the ilium, anteriorly rotating the ilia on the tested side and stressing the LDL ligament at the same side.

A comparison of the PPPP and LDL test showed a significant positive low correlation between the two tests. Pearson's correlation coefficient between the PPPP and LDL tests on the left and right side was 0.33 and 0.41, respectively. The pain experienced during the PPPP test could be (partially) a result of pain in the LDL. It is noteworthy that the PPPP test is a specific movement procedure designed to elicit pain, while the LDL test is a simple localized pain test. It is not clear which structures are provoked when the PPPP test is executed: whether only the LDL is provoked or several ligaments are strained. Further clinical testing is necessary. In case new studies reveal specifically that the LDL is provoked by the PPPP test, it seems reasonable to assume that the amount of straining by the PPPP test on the LDL will differ from direct palpation of the LDL. Therefore, straining of the LDL during the PPPP test does not necessarily imply that the results of the LDL and the PPPP tests will coincide.

A comparison of the ASLR and LDL tests also showed a significant positive low correlation between the two tests. Pearson's correlation coefficient between the ASLR and LDL tests on the left and right side was 0.35 and 0.41, respectively. The same argument mentioned for the PPPP test seems valid also for the ASLR test: LDL palpation cannot reasonably be performed during the ASLR test. This implies that the presented counternu-

tated position seen in patients testing positive on this procedure, is not necessarily provoked during the LDL test when the patient is lying prone. Thus, as with the provocation test, the LDL and ASLR tests results do not necessarily have to concur either on the left or right side or bilateral.

It is speculated that the ASLR, PPPP and LDL tests are by nature procedures that focus, respectively, on the functional load capacity of the pelvis, the ligament strain testing and the specific pain testing of a ligament. Mens *et al.* hypothesize that the ASLR test measures the decreased function to transfer loads from legs to trunk and that the PPPP test shows whether the pelvic system has been previously overloaded. Based on the present findings, it seems useful to combine three tests to measure different aspects of peripartum pelvic pain.

Njoo tested 61 patients with nonspecific low back pain and 63 controls for tenderness of the LDL (1). Of the patients with low back pain, 13 (21%) presented localized tenderness with an almost equal distribution of men and women. In the control group only one person (2%) tested positive. However, in this study, no strict distinction was made between lumbar and pelvic pain. This implies that the outcome for LDL testing of the control group is useful, but that the results of the low back pain group in the study of Njoo are not applicable for a comparison with patients with pelvic pain because of the possible inclusion of pelvic pain patients. Compared with the present study, which included patients with strict criteria for peripartum pelvic pain, the difference in the findings of Njoo for LDL testing in a nonspecific group of low back pain patients is striking.

Kristiansson and colleagues, studying 200 women attending an antenatal clinic, showed that the discriminatory power of a pain test is better in the lower part of the lumbar spine and pelvis than in the upper part (17). In the sacral region, applying pressure over the posterior-superior iliac spines provoked pain. This test showed the highest predictive value in the pelvic region. However, no anatomical distinction was made between the posterior superior iliac spine and the LDL ligament which caudally connects to it (9).

It is feasible that the palpation of the posterior superior iliac spine in the latter study in fact corresponds partially or completely with LDL palpation.

The prevalence of SIJ pain in chronic low back pain has been analyzed in several studies.

Schwarzer *et al.* investigated 43 patients with low back pain felt maximally below L5–S1 (18). The SIJ was blocked with lidocaine under image intensification, and arthrographic abnormalities were described. It was concluded that 30% of the patients obtained satisfying pain relief after blocking the SIJ. Furthermore, the authors report that the estimated prevalence rate obtained from this study should constitute minimum values because the study was biased against finding the condition.

Maigne uses a SIJ double-block procedure, comprising a short-acting block followed by a long-acting block, on a selected group of patients ($n = 40$) with expected SIJ problems (19). A first screening block was given to relieve the pain in the SIJ indicated by several tests. If the first block gave a positive relief, the second block with a long-acting anesthetic was performed 1 week later. Out of 40 patients, 12 patients had pain relief after the first screening block; of these, five patients had total pain relief by the second confirmatory anesthetic block. These latter patients (12.5%) were considered to have pain of true SIJ origin.

The advanced techniques and methods described in the reports of Schwarzer *et al.* (18), Maigne (19) and others (20, 21) in studying the occurrence of SIJ pain, could have one shortcoming: the SIJ is mainly studied on an articular level and extra-articular ligaments such as the LDL, located peripherally, are in all probability, insufficiently anesthetized with these techniques.

Based on the present findings it is suggested that to effectively study the prevalence of SIJ pain, besides intra-articular injections, a peripheral anesthetic block of especially the LDL should be included.

The present finding that the LDL seems frequently involved in pelvic and pelvic girdle pain does not substantiate that the LDL has to be treated selectively. It is a symptom as a consequence of failed load transfer. DonTigny, who first explained the mechanism of an anterior rotated ilium in patients with SIJ problems, suggests some simple manual techniques to minimize the pelvic pain (16).

To make a proper evaluation of patients with peripartum pelvic pain, reproducible testing procedures are essential. Reproducibility for SIJ motion and displacement tests is low, while pain provocation tests give acceptable results (22, 23) and a better level of sensitivity (17).

Östgaard *et al.* report that they prefer the term posterior pelvic pain, instead of SIJ pain, as it is not yet completely understood how functional pelvic impairment relates to anatomical structures (12).

The findings of the present study indicate that knowledge of the anatomy and function of the LDL and the simple use of a pain provocation test for this ligament, could be helpful in gaining a

better understanding of peripartum pelvic pain. The relation between a positive LDL pain test and the occurrence of an anterior rotated ilium during the ASLR test deserves further exploration.

Conclusion

The present study attempts to elucidate the pathophysiology of patients with peripartum pelvic pain by adding a simple pain test.

It is suggested that pain in the LDL could be related to a strained LDL as a result of a repeated or sustained counternutated position in the SIJ, and that the LDL is one of the explicit painful structures in the pelvic region. Also, that the pain experienced during PPPP test could be (partially) a result of pain in the LDL.

It is concluded that the combination of the ASLR, the PPPP and LDL pain tests combined with the proposed in- and exclusion criteria seems promising to differentiate between mainly lumbar and pelvic complaints.

Although the sensitivity of the LDL pain test seems promising, further clinical study is necessary, targeting specifically the LDL. Also a drawback of the LDL test is the difficulty many examiners experience in properly locating the caudal side of the posterior-superior iliac spine, which complicates the accurate *in-vivo* determination of this superficially located ligament.

It is suggested that studies initiated to show the prevalence of SIJ pain in chronic low back pain, by using intra-articularly double block injection techniques, should include a peripheral injection of at least the LDL (18–21).

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