Chronic Pelvic Pain Persisting after Childbirth

Diagnosis and Implications for Treatment

THOMAS TORSTENSSON
Abstract

**Objectives:** To explore the pain mechanism and the origin of the pain and to evaluate a short-term pain relief treatment in women suffering from CPP persisting after childbirth in order to enable physiotherapeutic intervention.

**Material and methods:** Thirty-six parous women with chronic pelvic pain persisting after childbirth were recruited at the Department of Physiotherapy, Sundsvall Hospital and by advertisements in newspapers and 29 parous women without chronic pelvic pain were recruited from an organized gynaecological screening at a midwifery surgery. All women were provoked by intra-pelvic palpation of 13 predetermined intra-pelvic landmarks. The provoked pain distribution was expressed in pain drawings and the pain intensity verbally on a Likert scale. Also, in a randomised controlled trial the 36 women with chronic pelvic pain were allocated to bilateral injection treatment with either triamcinolone or saline solutions, given once on the ischial spine with follow-up after four weeks.

**Results:** Referred pain provoked on intra-pelvic landmarks follows a specific pattern. In general, pain provoked by palpation of the posterior intra-pelvic landmarks was mostly referred to the sacral region and pain provoked by palpation of the ischial and pubic bones was mostly referred to the groin and pubic regions. In women with chronic pelvic pain the provoked pain distribution area and pain intensity were magnified as compared to women without chronic pelvic pain.

In the clinical trial decreased pain intensity, decreased distribution of pain and improved physical function was achieved among the triamcinolone treatment group as compared to the saline treatment group. Also, a positive correlation was shown between reduced pain intensity and improved function.

**Conclusions:** Referred pain patterns provoked on intra-pelvic landmarks in women with chronic pelvic pain persisting after childbirth are consistent with sclerotomal sensory innervations and indicates allodynia and central sensitisation. This suggests that pain mapping can be used to evaluate and confirm the pain experience and contribute to diagnosis. Also, the pain intensity provoked by stimulation of the intra-pelvic landmarks is suggested to be useful to differentiate women with chronic pelvic pain from those without. Corticosteroid treatment to the ischial spine resulted in decreased pain and increased function.

**Keywords:** Chronic pelvic pain, corticosteroid, injection, pain mapping, pelvic pain, physical function, physiotherapy, pregnancy, randomised controlled trial, referred pain, sensitisation

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To my Mother and Father
I could not have done this without your firm and gentle hands which made me what I am ......
all my respect and love ......always......
List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.


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**Abbreviations**

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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>CPP</td>
<td>Chronic Pelvic Pain</td>
</tr>
<tr>
<td>IASP</td>
<td>International Association for the Study of Pain</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>VAS</td>
<td>Visual Analogue Scale</td>
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<tr>
<td>SLR</td>
<td>Straight Leg Raising test</td>
</tr>
<tr>
<td>DRI</td>
<td>Disability Rating Index</td>
</tr>
<tr>
<td>SF-36</td>
<td>Short Form 36 health survey</td>
</tr>
<tr>
<td>PCS</td>
<td>Physical Component Summary</td>
</tr>
<tr>
<td>MCS</td>
<td>Mental Component Summary</td>
</tr>
<tr>
<td>P4</td>
<td>Posterior Pelvic Pain Provocation</td>
</tr>
<tr>
<td>6MWT</td>
<td>Six Minute Walk Test</td>
</tr>
<tr>
<td>DNIC</td>
<td>Diffuse Noxious Inhibitory Control</td>
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<tr>
<td>ATR</td>
<td>Achilles Tendon Reflex</td>
</tr>
<tr>
<td>PTR</td>
<td>Patellar Tendon Reflex</td>
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</tbody>
</table>
“To the woman he said, I will make your pains in childbearing very severe; with painful labour you will give birth to children.”

The quotation is from The Bible and it seems to have, consciously or unconsciously, set the tone of the western culture’s attitude to childbearing.

When I started to work with women suffering from pregnancy-related low back and pelvic pain I was surprised at how much pain and physical limitations some women with a newborn baby endured. It is possible that pain and physical limitations in pregnancy are so integrated into our culture that many women think: “This is how it is to have a baby”.

The more women with chronic pelvic pain I had contact with, the more I learned. For me it is a challenge to try to explain the persistence of chronic pelvic pain after childbirth and possible to find a way to treat it.
Introduction

Pregnancy-related low back and pelvic pain is common and appears worldwide.\textsuperscript{1-9} In most women the pain disappears within six months after delivery, but 2 to 5\% of all women who given birth experience disabling pain 2 to 3 years after childbirth,\textsuperscript{10, 11} figure 1. Low back and pelvic pain affects women’s activities in daily living, leisure activities and their work situation.\textsuperscript{10-18} In general, persistent or chronic pain is a major problem in Sweden as well as in other countries, and it impacts on socio-economics and healthcare systems.\textsuperscript{19-21} Living with persistent pain can cause suffering of major proportions and have a significant impact on the individual’s daily life. It also increases sick-leave and reduces well-being.\textsuperscript{21, 22} Persistent pregnancy-related low back and pelvic pain negatively affects the women, their families and society, and it has to be considered as a major health issue for women.\textsuperscript{10, 15, 23-26}

When women with pregnancy-related low back and pelvic pain are in contact with the healthcare system during pregnancy or after childbirth, some of them experience mistrust regarding the severity of their disability.\textsuperscript{27, 28} In some cases the women even start doubting themselves and start to question their own experiences. In social media sites such as Facebook and blogspots some women shared their problems like this:\textsuperscript{29}

“Knowledge among physicians and personnel in prenatal care is non-existent. During pregnancy you get the information that the pain will subside after childbirth and the treatment offered is a belt and/or crutches. After you have given birth there are no options at all - it is up to you to try to help yourself.” (Marie)

“Where do you go if you want to know any more than that you should walk with small steps and that the pain eventually disappears..? It feels like nobody knows anything and nobody really cares.” (Lotta)

Thus, it is essential to find causes of pregnancy-related low back and pelvic pain and to develop effective treatment strategies.
Figure 1. The proportion of women in the four classification groups having symptoms and objective findings 1, 3, 6, 12, 18 and 24 months after childbirth. Albert H, Godskesen M, Westergaard J. Prognosis in four syndromes of pregnancy-related pelvic pain. *Acta Obstet Gynecol Scand* 2001; 80(6): 505-10. With permission from Acta Obstet Gynecol Scand.

Pain

For the purpose of this thesis, the definitions and statements of the International Association for the Study of Pain (IASP) are referred to.\textsuperscript{30, 31} The definition of pain, according to the IASP is: *An unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage.* This means that pain is always subjective: if patients regard their experience as pain it should be accepted as pain. Pain as a phenomenon can be divided into acute or persistent (chronic) pain. Persistent pain is defined as continuing for more than three to six months duration from onset. Pain is not a disease it is a symptom that has to be examined and addressed in an adequate manner. Some IASP terms are of special interest:

- *Allodynia* - Pain in response to a non-nociceptive stimulus. The stimulus leads to an unexpectedly painful response. Allodynia involves a change in the quality of a sensation of any sort.
- *Hyperalgesia* - Increased pain sensitivity. Hyperalgesia can occur as a consequence of a disturbance in the nociceptive system with peripheral or central sensitization, or both.
- *Neuralgia* - Pain in the distribution of a nerve or nerves.
- **Neuropathic pain** - Pain caused by a lesion or disease of the somatosensory nervous system.
- **Neuropathy** - A disturbance of function or pathological change in a nerve or nerves.
- **Nociceptive pain** - Pain that arises from actual or threatened damage to non-neural tissue and is due to the activation of nociceptors. Pain occurring with a normally functioning somatosensory nervous system.
- **Noxious stimulus** - A stimulus that is damaging or threatens damage to normal tissues.
- **Referred pain** - Pain perceived at a location that is not the origin of the pain.
- **Sensitization** - Increased responsiveness of nociceptive neurons to their normal input, and/or recruitment of a response to normally subthreshold inputs. Clinically, sensitization may only be inferred indirectly from phenomena such as hyperalgesia or allodynia.
- **Central sensitization** - Increased responsiveness of nociceptive neurons in the central nervous system to their normal or subthreshold afferent input. Peripheral neurons are functioning normally.
- **Peripheral sensitization** - Increased responsiveness and reduced threshold of nociceptive neurons in the periphery to the stimulation of their receptive fields.
- **Somatosensory** - information about the body including visceral organs, concerns the conscious perception of touch, pressure, pain, temperature, position, movement, and vibration, which arise from the muscles, joints, skin, and the connective tissues.

**A biopsychosocial perspective on chronic pain**

In the context of an independent life, chronic pain is a limitation and it affects approximately 19% of adult Europeans. The biopsychosocial model, introduced by Engel in the late 1970’s, states that biological, psychological and social factors play a significant role in human functioning in the context of disease or illness. The model has in many ways provided a new approach to the human dimension in clinical as well as in research context, especially in treating patients with chronic pain. Factors such as self-efficacy, kinesiophobia and catastrophising have shown to have an effect on the experience of pain. To fully comprehend the difficulties in treating chronic pain there are also some authors who state that in discussion of causes of non-specific low back pain, the physical aspect (“bio”) has been forgotten in favour of only psychosocial factors.
Connective tissue

Connective tissue such as ligaments, tendons and fascia is essential for joint stability as well as the transmission of forces between muscles and storage of energy.\textsuperscript{40-42} Connective tissue appears in different forms in different parts of the body, and in the last decade there have been theories of a fascial network connecting the physical components of the body. Hardening of connective tissue within muscles, fascia and tendons is a slow process and need to be addressed in exercise therapy.\textsuperscript{43, 44} Degeneration, hormonal levels and inflammatory processes also negatively affect connective tissue as does the fact that women have more fragile connective tissue than men. This issue has to be addressed during the rehabilitation of women with persistent pregnancy-related low back and pelvic pain.\textsuperscript{45-47}

Aetiology and risk factors

The origin of pregnancy-related low back and pelvic pain is poorly understood and there are many hypotheses regarding causes: biomechanical, degenerative, inflammatory, hormonal, and behavioural or a combination of these. In practice, a variety of manifestations occur and the idea of one and only one cause of pain is not realistic; most clinicians are of the opinion that non-specific back pain consists of subgroups.\textsuperscript{48} In review articles there is an agreement of multifactorial causes of pregnancy-related low back and pelvic pain but there is a lack of specific diagnostic tools for subgrouping.\textsuperscript{49-54}

Many studies have concentrated on pain during pregnancy and the twelve weeks following delivery, while others have focused on risk factors for developing pregnancy-related low back and pelvic pain but overall there is no consensus about pain origin or treatment.\textsuperscript{10, 14, 17, 27, 55-59} Even if there is no specific cause of the pain, there are a number of events and features with impact on the risk of developing pregnancy-related low back and pelvic pain. Risk factors for low back and pelvic pain either during or after delivery are events such as previous low back pain, previous history of pregnancy-related low back and pelvic pain, strenuous work and previous trauma to the pelvis.\textsuperscript{16, 17, 55, 60, 61} Multiparity, mode of delivery, high BMI, the habit of smoking, catastrophising, joint hypermobility and diseases of the connective tissue are also mentioned as possible risk factors.\textsuperscript{55, 56, 62-69}

Pregnancy-related low back and pelvic pain is mostly associated with symptoms and signs indicating pain deriving from structures in the lower back and pelvis, the symphysis or the sacroiliac joints as the pregnancy itself has a direct influence on these areas.\textsuperscript{8, 70-82}
There is also a possibility of degeneration, inflammation or trauma to the sacroiliac joints or the symphysis. Pain deriving from spinal disorders for example conditions affecting nerve structures are considered to be rare for example disc hernia is estimated to affect 1 in 10 000 pregnancies. Dysfunction in the somatosensory system can also explain some of the causes of persistent pain. Central sensitisation has also been defined as pain hypersensitivity by changing the sensory response elicited by normal inputs and explains dysfunction in standing, walking and other normally non-noxious stimuli in chronic pain conditions. It is possible that central sensitisation is involved in persistent pain after childbirth as it is in other, similar, pain conditions with major impact on daily activities.

Biomechanical causes

Gravitational and locomotor forces are transferred between different parts of the body through the muscles and the connective tissue. The lower back, pelvis and the lower limbs are connected by joints, ligaments and muscles that have to work as one unit to control the locomotor system. The sacroiliac joints depend on the so called ‘form and force closure’, which describes a self-locking response to weight bearing. When this fails the smaller ligaments of the pelvic floor are exposed to forces beyond their capacity. There is also evidence of an increased mobility in the symphysis among multiparous women compared to men and nulliparous women.

To support the biomechanical hypothesis, there are indications that women with dysfunctional connective tissue, i.e. women with Ehlers-Danlos syndrome or Marfan syndrome have more severe pain during pregnancy than other women. Also, women with physically strenuous work have an increased risk of pelvic pain during, and three months after, pregnancy.

Degenerative causes

Symptoms from sacroiliac joint affection include back pain, buttock pain and sometimes pain radiating in the legs, much like some of the complaints from women suffering from pregnancy-related low back and pelvic pain. Degenerative changes in sacroiliac joints were found in 24 % of patients with non-specific back pain in a study in a primary care setting. The condition was more common among women than men.
Inflammatory causes
Inflammation in muscles and/or ligaments has been proposed as one possible cause of the pain, which is diffuse and often increases during walking, prolonged standing, lifting and bending, i.e. groin pain among athletes and hip pain in patients with capsular laxity.\textsuperscript{100, 101} Inflammatory back pain is common, 5 \%, among patients with non-specific back pain,\textsuperscript{84, 102, 103} but pregnancy-related low back and pelvic pain as a sub-group is not yet examined in this perspective. Pain of possible inflammatory origin in the pelvic region has been successfully treated with corticosteroid injections.\textsuperscript{104-106} To support the theory of inflammation in over-used tissue there is evidence for decreased sacroiliac ligament stiffness leading to both increased joint motion and stress.\textsuperscript{107} Neurogenic inflammation as a source of chronic pelvic pain has also been suggested.\textsuperscript{108}

Hormonal causes
In early pregnancy the woman undergoes physiological changes and there is a high incidence of pregnancy-related low back and pelvic pain during the first trimester.\textsuperscript{8} One hypothesis is that these physiological changes affect the metabolism in the connective tissue of ligaments leading to an increased risk of pain in weight-bearing daily activities.\textsuperscript{73} Supporting this theory is an association between pregnancy-related low back and pelvic pain and hormonal levels,\textsuperscript{13} the use of hormonal contraceptives before pregnancy,\textsuperscript{109, 110} diabetes mellitus type I,\textsuperscript{111} in-vitro fertilization\textsuperscript{112} and menarche at an early age.\textsuperscript{113, 114}

Behavioural causes
In pregnancy-related low back and pelvic pain a few studies have covered the biopsychosocial perspective.\textsuperscript{67, 68, 115-118} Women with back pain during pregnancy have been shown to catastrophise more and have higher levels of fear-avoidance beliefs than women without back pain, but if negative thoughts were a result of the pain, or pain was the result of negative thoughts, was not determined.\textsuperscript{116} Catastrophising among women during pregnancy and six months postpartum can change over time.\textsuperscript{67} Also catastrophising and low physical activity in mid-pregnancy have been shown to predict the risk of pain six months postpartum, indicating the importance of biopsychosocial factors and to address them from each woman’s perspective.\textsuperscript{117}
Treatment

Recommended treatment for pregnancy-related low back and pelvic pain differ during and after pregnancy. During pregnancy there is evidence for the use of hydrotherapy, acupuncture and the wearing of a supportive belt. Evidence regarding physical exercise is not conclusive. After pregnancy, treatment for persistent pain is limited. There is some evidence for individualised exercise with the focus on stabilization, group intervention and acupuncture.

Terminology

There have been numerous terms to describe pregnancy-related low back and pelvic pain. In a review by Wu et al. they found at least 24 different terms used since the beginning of the 20th century. In Papers I to IV three different terms have been used: “long-lasting sacral low back pain with onset during pregnancy”, “persistent pregnancy-related pelvic pain” and “chronic pelvic pain”. The titles in certain papers reflect the fact that ideas concerning this particular pain condition have changed over time. Pelvic pain can be described differently depending on the context and in what situation the health professional meets the patient.

At the end of the day it is not important to the woman what the healthcare system calls her pain unless it affects the treatment. Whatever triggers the pain, a specific event or of a combination, the pain mechanism and the dysfunction still have to be addressed. In a Cochrane review by Pennick and Liddle in 2013 on the subject of low back and pelvic pain during pregnancy they concluded: “Future research would benefit from the introduction of an agreed classification system that can be used to categorise women according to presenting symptoms”. For many “pelvic girdle pain” excludes obvious gynaecological diseases and ordinary low back pain but the tests for pelvic girdle pain are somewhat inconclusive and need further research. In Papers I and II the focus is on the similarities in clinical manifestations between pregnancy-related pelvic pain and women with chronic pelvic pain (CPP).

The term CPP refers to a non-specific pelvic pain persisting for more than 3 to 6 months where CPP persisting after childbirth counts as a subgroup. There may be different views as to what the “best” term should be and many authors have proposed trying to find an agreement on how to categorize pregnancy-related low back and pelvic pain.
Aims

To explore the pain mechanism and the origin of the pain and to evaluate a short-term pain relief treatment in women suffering from CPP persisting after childbirth in order to enable physiotherapy intervention.

Specific aims

- To study referred pain patterns provoked from intra-pelvic structures among women with and without CPP persisting after childbirth.
- To study pain intensity provoked from intra-pelvic structures among women with and without CPP persisting after childbirth.
- To study the short-term effect of corticosteroid injection treatment to the ischial spine on pain experience among women with CPP persisting after childbirth.
- To study the short-term effect of corticosteroid injection treatment to the ischial spine on physical function among women with CPP persisting after childbirth.
Study population and methods

This thesis is based on two groups of women – women “with CPP” in Papers I to IV and women “without CPP” in Papers I and II, figure 2.

In Papers I and II the women with CPP were compared to women without CPP with reference to referred pain patterns, pain distribution areas and provoked pain intensity.

In Papers III and IV the CPP women were divided into two treatment groups. Baseline data and follow-up data for the groups were compared with reference to levels of pain and physical function.

Study population

Women with CPP

Women with ongoing low back and/or pelvic pain with onset during pregnancy were recruited from the waiting list at the Department of Physiotherapy, Sundsvall Hospital, or recruited by advertisement in the local press, after which they were consecutively and prospectively assessed for eligibility. Thirty-six women, 7 in 2004, 22 in 2005 and 7 in 2007, fulfilled the inclusion criteria, and were examined after they had given written informed consent.

Inclusion criteria were: 1) reported ongoing pain in the sacral region (including buttocks) with onset during pregnancy which persisted 6 months to 7 years after delivery, 2) reported pain intensity at present on a horizontal visual analogue scale (VAS) between 30 and 70 mm where 0 is “no pain” and 100 mm is “worst possible pain”, 3) at least one positive pelvic pain provocation test out of three, 4) having recognisable ipsilateral pain provoked by vaginal palpation at the ischial spine at least unilaterally and 5) the ability to understand Swedish. Exclusion criteria were: 1) ongoing low back pain with onset before pregnancy, 2) previous back surgery, 3) a positive straight leg raising test (SLR) and 4) loss of tendon reflex in the legs.

In Papers III and IV the CPP women were randomised into two treatment groups, one receiving corticosteroid (triamcinolone) injections (n=18) and one receiving saline injections (n=18), figure 2.
Women without CPP

In order to recruit a control group of parous women without CPP, 44 women from an organised gynaecological screening at a midwifery surgery in a Primary Health Care Centre were consecutively assessed for eligibility. Eight women were recruited from 2005 to 2008, 14 in 2011 and 22 in 2013. For blinding purposes i.e. blinded for those who performed the pain mapping procedure this group was a mix of women with and without low back and pelvic pain who were both parous and non-parous. An initial assessment procedure was carried out by a physiotherapist not involved in the pain mapping procedure. After the initial assessment and the pain mapping procedure 15 women were excluded (12 women with low back or pelvic pain and three non-parous) as they did not meet the inclusion criteria: 1) having given birth at least once but not within the last six months, 2) no reported low back or pelvic pain on a pain drawing or elicited by pain provocation tests and 3) ability to understand Swedish. Thus, the control group consisted of 29 women, henceforth denoted as women “without CPP”.

* after exclusion of the 15 women participating for blinding reasons

Figure 2. Flowchart Papers I to IV
Methods

Papers I and II

Women with CPP and women without CPP underwent an initial assessment procedure including a questionnaire, an external physical examination and a pain mapping procedure, table 1.

Initial assessment procedure

The questionnaire included questions regarding date of birth, time of onset of the ongoing sacral low back pain (only for those with CPP), number of previous pregnancies and deliveries, smoking habits at present (no/yes), educational level (≤12 years/>12 years). Furthermore, the women assessed their back pain intensity at present and the worst pain during the past week on VAS. They also completed a pain drawing of pain distribution at the time on inclusion. The actual pain distributions were coded into twelve anatomic locations, figure 3. Finally, the women completed the Disability Rating Index (DRI). DRI was calculated as the mean value of twelve assessments on twelve different horizontal VAS ranging from 0 to 100 mm, where lower values represent higher function.

Figure 3. Initial pain drawing. Body region borders were concealed for the women

In the external physical examination, pain provocation tests were performed both on the pelvis and the low back, in addition tests for neurological signs was performed, appendix 1.
Table 1. Schedule of measured variables by study appointments in Papers I to IV

<table>
<thead>
<tr>
<th>At study start / Baseline appointment</th>
<th>With CPP</th>
<th>Without CPP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
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<tr>
<td><strong>Initial assessment procedure</strong></td>
<td></td>
<td></td>
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<tr>
<td>Questionnaire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date of birth</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Time of onset of ongoing low back or pelvic pain</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Number of previous deliveries</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Number of previous pregnancies</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Date of last delivery</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Mode of last delivery</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Smoking habits</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Educational level</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Sick leave owing to back pain</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Low back pain before pregnancy</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Disability rating index (DRI)</td>
<td>x</td>
<td>x</td>
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<tr>
<td><strong>Short Form 36 (SF-36) health survey</strong></td>
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<tr>
<td>Physical Component Score (PCS)</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Mental Component Score (MCS)</td>
<td>x</td>
<td>x</td>
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<tr>
<td><strong>Pain intensity</strong></td>
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<tr>
<td>At present (VAS)</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Worst during past week (VAS)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Pain drawing at time for inclusion</td>
<td>x</td>
<td>x</td>
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<tr>
<td><strong>External physical examination</strong></td>
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<tr>
<td>Pain provocation tests of the pelvis</td>
<td></td>
<td></td>
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<tr>
<td>Menell</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Patrick</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Posterior Pelvic Pain Provocation (P4)</td>
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<td>x</td>
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<td><strong>Pain provocation tests of the low back</strong></td>
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<tr>
<td>Maximum flexion/extension</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Paravertebral palpation of low back and iliolumbar ligaments</td>
<td>x</td>
<td>x</td>
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<tr>
<td><strong>Neurological signs</strong></td>
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<tr>
<td>Straight leg raising (SLR)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Loss of ATR and PTR reflexes</td>
<td>x</td>
<td>x</td>
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<tr>
<td><strong>Tests for physical function</strong></td>
<td></td>
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<tr>
<td>Six-minute walk test (6MWT)</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Isometric trunk extension</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Isometric trunk flexion</td>
<td>x</td>
<td>x</td>
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<tr>
<td><strong>Pain mapping procedure</strong></td>
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<tr>
<td>Cartoons from 13 predetermined intra-pelvic anatomical landmarks</td>
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<td>x</td>
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<tr>
<td><strong>Randomization into injection procedure</strong></td>
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<tr>
<td>Injection procedure: corticosteroid or saline solution</td>
<td>x</td>
<td>x</td>
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</table>
### Continuation of table 1

<table>
<thead>
<tr>
<th></th>
<th>With CPP</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td><strong>1 day after injection</strong></td>
<td></td>
<td></td>
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<tr>
<td>Telephone interview about adverse effects</td>
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<tr>
<td><strong>Follow-up 4 weeks after injection</strong></td>
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<tr>
<td>Interview – about adverse effects</td>
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<tr>
<td><strong>Variables equal to the initial assessment</strong></td>
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</tr>
<tr>
<td>Disability rating index (DRI)</td>
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<td></td>
</tr>
<tr>
<td><strong>Short Form 36 (SF-36) health survey</strong></td>
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<tr>
<td>Physical Component Score (PCS)</td>
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<tr>
<td>Mental Component Score (MCS)</td>
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</tr>
<tr>
<td><strong>Pain intensity</strong></td>
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<td></td>
</tr>
<tr>
<td>At present (VAS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worst during past week (VAS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain drawing</td>
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<tr>
<td><strong>External physical examination</strong></td>
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</tr>
<tr>
<td><strong>Pain provocation tests of the pelvis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Menell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patrick</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior Pelvic Pain Provocation (P4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Neurological signs</strong></td>
<td></td>
<td></td>
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<tr>
<td>Straight leg raising (SLR)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Tests for physical function</strong></td>
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<td></td>
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<tr>
<td>Six-minute walk test (6MWT)</td>
<td></td>
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<tr>
<td>Isometric trunk extension</td>
<td></td>
<td></td>
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<tr>
<td>Isometric trunk flexion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The pelvic pain provocation tests were considered positive if provoking pain and included Menell’s test,\textsuperscript{75} Patrick’s test\textsuperscript{49} and the Posterior Pelvic Pain Provocation (P4) test:\textsuperscript{49}

- Menell’s test: each leg was moved into 30° abduction and 10° flexion in the hip joint and in that position pushed toward and then pulled away from the pelvis, causing sagittal movement
- Patrick’s test: each leg was flexed, abducted, and rotated externally so that the heel rested on the opposite knee. The assessor pressed gently on the superior aspect of the knee joint
- The P4 test was modified to a semi-quantitative test with a load of 1 kg, 5 kg, or 10 kg applied to the knee while the femur was in 90° flexion of the hip. The test was considered negative when no pain was elicited despite a maximum load of 10 kg
The pain provocation tests of the low back were considered positive if provoking recognisable pain with or without radiation.
- extension/rotation/lateral flexion of the back when standing, observing both restricted range of motion and pain
- paravertebral palpation of the low back and the iliolumbar ligaments
- percussion of the spinous processes of the low back

In testing for neurological signs, tests of reflexes and straight leg raising (SLR) were used. Loss of Achilles tendon reflex (ATR) or patellar tendon reflex (PTR) was considered positive. SLR was tested passively in both legs with the women in the supine position and was considered positive if neurological symptoms occurred and/or radiating pain was provoked.

**Pain mapping procedure**
The vaginal palpation was performed by a physician with the women in the supine lithotomy position without stirrups. The women’s recording in pain drawings was aided by a physiotherapist, figure 4. Neither of them had information of the examination test result from the initial assessment procedure done by another physiotherapist. Ischial spine on both sides was localized so that women with CPP could confirm a recognisable ipsilateral pain elicited at least unilaterally.
Pain mapping is a method to investigate referred pain patterns. In Papers I and II it was defined as the reported pain distribution provoked by vaginal palpation of 13 predetermined intra-pelvic anatomical landmarks and expressed in separate pain drawings of the lower part of the body, figure 5. Body region borders and their numbers, used in the analyses, were not shown to the women. The division into body regions in figure 5 was done arbitrarily from a clinical point of view as the most common pain among women with CPP persisting after childbirth is pain in the back below the iliac crista to the upper part of the thigh (region 3 and 4) and pain in the front below the umbilicus, including the groin and extending to the upper part of the thigh (region 5 and 6). The predetermined anatomical landmarks and their examination order were: os coccyx, the lateral part of sacrum at the insertion of the sacrospinous ligament, the middle part of the sacrospinous ligament, the insertion of the sacrospinous ligament at the ischial spine, the ischium inferior to the ilio-ischial fusion and the lateral and medial part of the pubic bone, figure 6 (named in short in figure). All the landmarks were examined bilaterally except the coccyx and always in the same order.

Pain was provoked by a light manual pressure on each of the landmarks. The women were asked to draw the distribution of perceived pain or other sensations on a cartoon, resulting in a total of 845 pain drawings (65 women x 13 landmarks). In addition they reported the pain intensity on a Likert scale 0-2, (0 = no pain, 1 = moderate pain and 2 = intense pain). The provoked pain intensity from the 13 landmarks was summed up in a score with a possible range of 0 to 26. They were also told to freely express their experience verbally and this was afterwards categorized by four descriptors: “Blank” = no sensation at all, “Other” = non-painful referred sensations, “Diffuse” = hard to draw in pain drawing and “Distinct” = well defined pain in pain drawing, table 2.
Figure 6. Thirteen predetermined intra-pelvic anatomical landmarks in examination order. 1: os coccyx, 2 and 8: os sacrum laterally, 3 and 9: sacrospinous ligament, 4 and 10: ischial spine, 5 and 11: os ischii, 6 and 12: os pubis laterally and 7 and 13: os pubis medially

Composite pictures and area calculation
All pain drawings from the initial assessment (n=65) were accounted for whereas drawings from the pain mapping procedure were taken into consideration according to the Likert scale. After the exclusion of pain drawings without indicated pain (Likert scale = 0) 421 of 468 pain drawings from women with CPP and 111 of 377 from women without CPP remained. All remaining pain drawings were scanned to images of 250 millimetres from head to toe and 50 millimetres from hip to hip.

To produce composite pictures each scanned pain drawing was digitally transformed by replacing the markings on the cartoon with approximately one dot (12 pixels) per mm$^2$ using Adobe Photoshop®. Subsequently, the digitalised pain drawings from all women were superimposed to get composite pictures. This resulted in one composite picture from the initial assessment and 13 composite pictures (pain maps), one from each of the landmarks, resulting from the vaginal palpation.

The area of provoked pain distribution was calculated by using Image Measurement®. On every scanned image the drawn pain area was manually outlined. Subsequently, the program calculated the outlined area on the cartoon drawing in mm$^2$. Pain marked by the women as a cross in pain drawings was transformed into a circular area with the smallest arm of the cross as the radius.

The results of the composite pictures and the calculated areas were analysed separately for the two groups: women with and without CPP.
Papers III and IV

For women with CPP information from the initial assessment was used as baseline data. A randomisation into two treatment groups was done. In a follow-up after four weeks some of the measurements from baseline were repeated, table 1.

At baseline

Gathered data from the questionnaire, the external physical examination of the pelvis and low back and the DRI from the initial assessment in Papers I and II were also used in Papers III and IV. Some initial variables were added to this data file: date of last delivery, mode of last delivery (vaginal/Caesarean), ongoing sick leave, low back pain before pregnancy, SF-36 and tests for physical function, table 1.

The tests for physical function were six minute walk test (6MWT) and isometric trunk extension and flexion tests.\(^{138-140}\) The 6MWT measured physical function capacity in terms of gait speed and endurance and was performed on a treadmill in a horizontal position. The treadmill speed was adjusted to a walking speed of the woman’s own choice, and the score recorded was the total distance covered during the six-minute walk. The strength and endurance of trunk muscles were tested with isometric trunk extensor and flexor tests. The trunk extensors were tested with the women lying prone and trunk flexors were tested with the women lying supine with legs flexed 90\(^\circ\) at the knees. In both tests the women were asked to hold their upper body in a predefined isometric position and remain in that position for as long as possible but at maximum of 180 and 90 seconds, respectively.

Randomisation procedure

A computer generated random allocation sequence, with a block size of 4, concealed from the investigators until study closure, was made by a person not engaged in the study. It was held by a pharmacist who prepared and delivered the allocated treatment, after a facsimile message from the study centre indicated which women were included in the study. The pharmacist conducted this blinding performance successfully.

The women with CPP were randomised to receive an injection treatment of either a compound of 1 mL triamcinolone, 20 mg/mL (Lederspan, Meda AB, Solna, Sweden), and 1 mL lidocaine hydrochloride 10 mg/mL (Xylocain, Astra Zeneca, Södertälje, Sweden) or 0.99 mL saline solution 9 mg/mL, 1 mL lidocaine hydrochloride, and 0.01 mL fat emulsion (Intralipid, Fresenius Kabi, Uppsala, Sweden), the latter to make the solution opalescent as Lederspan.
Injection procedure
After thorough localisation of the ischial spine the physician injected the allocated treatment around the sacrospinous ligament insertion bilaterally through the vaginal wall with the woman in supine position using a 200 mm long, 21-gauge needle inserted in a Franzén needle guide, figure 7. None of the participants, the physician who gave the injection or the assessing physiotherapist had information about what treatment was given.

All women were told to try to maintain the same level of activity between baseline and follow-up as they had before the studies. In addition, the physiotherapist interviewed the women by telephone about adverse effects one day after the injection treatment. The physiotherapists did the same at the follow-up which was performed four weeks after the injection treatment.

Follow-up
The same physiotherapist that performed the initial assessment at baseline also performed the follow-up four weeks after the injection. Some baseline assessments were repeated: the pain drawing and pain intensity at present and worst past week on VAS, SF-36, the three pelvic pain provocation tests (Menell’s, Patrick’s and P4), SLR, DRI and the physical function tests (6MWT and the isometric trunk tests), table 1.

Outcome measurements
Outcome measurements in Papers I and II were: referred pain patterns, pain distribution areas and pain intensity when provoking 13 intra-pelvic structures among women with and without CPP, respectively.

Outcome measurements in Papers III and IV were: pain intensity ‘at present’ and ‘worst pain during past week’, changes in number of pain locations and pain provocations tests (Menells’s, Patrick’s, P4 or either of them), DRI, SF-36 subscales PCS and MSC, 6MWT and isometric trunk flexion and extension tests.
Ethical considerations

It is important to acknowledge the patient’s possibility to make independent decisions not least when treating persistent pain, even more when you ask a patient to participate in a study and there is a risk of increased pain. Taking into consideration the possible unpleasantness of vaginal palpation (Papers I to IV) and injections (Papers III and IV) it was important to clarify to the women the possibility of withdrawal at every new phase of the studies. Even if the women gave their written informed consent before inclusion, they were reminded of their possibilities to withdraw before the vaginal palpation (all women in Papers I to IV) and before injection treatment (Papers III and IV). Also in Papers III and IV the physician interviewed the women by telephone about adverse effects one day after the injection treatment and the physiotherapists did the same at the follow-up four weeks after the injection.

The trials were approved by the medical ethics committee of the University of Umeå and the Medical Products Agency, Uppsala, Sweden.

Statistical considerations

Characteristic and clinical variables were expressed as frequencies and medians. When applicable, the results were presented as 25th and 75th percentiles. Summary statistics were computed using standard methods. Because of the small number of observations, possible statistical differences between the groups were tested with nonparametric tests: Fisher exact test for categorical data, Wilcoxon rank sum to compare median values of continuous data, and Wilcoxon signed rank test for paired comparisons.

Pain and function in Papers III and IV were given as differences in absolute and relative values between follow-up and baseline. The relative measurement was calculated as a quotient for ((follow-up – baseline)/baseline). For correlation analysis, Spearman’s regression coefficient and p-values was used. When applicable, the results are presented as 25th and 75th percentile. For regression analyses the general linear model was used. The simple and the multiple regression analyses with the sum of provoked pain intensity scores as dependent variable in relation to potentially modifying variables were shown with their effect β-estimates, R² and p-values. Two-sided probability tests were used and p-values less than 5% were regarded as statistically significant. Very small p-values were indicated as <0.0001.

To estimate the sample size for two independent treatment groups in Paper III the ordinal outcome measure VAS was used to detect a 20 % difference. When power was set to 0.80, the significance level to 0.05, the standard deviation to 85 a study population of 34 women was needed. The calculation was performed with t-test sample size for independent groups.
To estimate the sample size in Paper IV the outcome measure 6MWT was used. 6MWT is a continuous variable and there are two independent groups. With a power of 0.80, a significance level of 0.05, standard deviation of 85 and a clinically acceptable difference of walk distance between the groups of 80 m a study population of 36 women were needed.

In Papers I and II study size calculation was not performed since those were descriptive and comparative studies.

The statistical analysis was performed using the SAS program package version 9.1 to 9.3 (SAS Institute, Cary, NC, USA).
Results

Characteristics

In Papers I and II the 36 women with CPP were younger, had higher pain intensity and lower functioning level than the 29 women without CPP, table 2.

In Papers III and IV the 36 women were divided into two treatment groups: 18 in the triamcinolone group and 18 in the saline group. There was no significant difference in baseline characteristics between the treatment groups, except for a higher number of previous pregnancies among women in the triamcinolone treatment group as compared with women in the saline treatment group, table 3.

Table 2. Characteristics of women with and without chronic pelvic pain (CPP). Figures are median (25th to 75th percentiles) and numbers (%)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>With CPP n=36</th>
<th>Without CPP n=29</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>32.2 (29.0 to 37.1)</td>
<td>44.0 (38.3 to 0.001)</td>
<td>0.001</td>
</tr>
<tr>
<td>No. of previous pregnancies</td>
<td>2 (2 to 3)</td>
<td>2 (2 to 3)</td>
<td>0.69</td>
</tr>
<tr>
<td>No. of previous deliveries</td>
<td>2 (2 to 2)</td>
<td>2 (2 to 2)</td>
<td>0.99</td>
</tr>
<tr>
<td>Non smokers (%)</td>
<td>32 (88.9)</td>
<td>24 (92.3)</td>
<td>1.00</td>
</tr>
<tr>
<td>Education &gt;12 years (%)</td>
<td>16 (44.4)</td>
<td>16 (61.5)</td>
<td>0.21</td>
</tr>
<tr>
<td>Pain intensity at present&lt;sup&gt;2&lt;/sup&gt; (mm)</td>
<td>34.0 (27.5 to 50.5)</td>
<td>0 (0 to 0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pain intensity worst during past week&lt;sup&gt;3&lt;/sup&gt; (mm)</td>
<td>59.5 (43.0 to 75.0)</td>
<td>0 (0 to 8.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>No. of pain locations</td>
<td>6 (5 to 8)</td>
<td>0 (0 to 0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Disability rating index, DRI (mm)</td>
<td>53.3 (38.0 to 66.5)</td>
<td>1.9 (0 to 6.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Duration of pain (years)</td>
<td>4.2 (2.4 to 6.4)</td>
<td>Not applicable</td>
<td>-</td>
</tr>
</tbody>
</table>

<sup>1</sup>n=26  <sup>2</sup>Visual Analogue Scale, VAS

Papers I and II

Among women with CPP the initial pain drawings showed that high density pain distribution was displayed in the sacral, buttock, groin and symphyseal areas and lower density pain distribution in the thoracic and lumbar back, lower abdominal areas and the legs. Low density pain distribution was shown on the shoulders, low back, right hip and knees among women without CPP, figure 8.
Table 3. Baseline characteristics of participants by treatment groups in medians and frequencies (25th to 75th percentiles)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Triamcinolone group n=18</th>
<th>Saline group n=18</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>32.3 (28.1 to 37.9)</td>
<td>32.2 (29.5 to 36.3)</td>
<td>1.00</td>
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<tr>
<td>No. of previous pregnancies</td>
<td>3 (2 to 4)</td>
<td>2 (2 to 3)</td>
<td>0.02</td>
</tr>
<tr>
<td>No. of previous deliveries</td>
<td>2 (2 to 3)</td>
<td>2 (2 to 2)</td>
<td>0.09</td>
</tr>
<tr>
<td>Time of sacral low back pain (years)</td>
<td>4.3 (2.3 to 6.5)</td>
<td>4.1 (2.7 to 6.4)</td>
<td>0.84</td>
</tr>
<tr>
<td>Time since last delivery (years)</td>
<td>1.9 (1.0 to 2.5)</td>
<td>2.9 (1.1 to 3.9)</td>
<td>0.15</td>
</tr>
<tr>
<td>Non smokers (n)</td>
<td>16</td>
<td>16</td>
<td>0.98</td>
</tr>
<tr>
<td>Last delivery as Caesarean (n)</td>
<td>4</td>
<td>2</td>
<td>0.39</td>
</tr>
<tr>
<td>Low back pain before pregnancy (n)</td>
<td>8</td>
<td>6</td>
<td>0.51</td>
</tr>
<tr>
<td>Ongoing sick leave for back pain (n)</td>
<td>8</td>
<td>6</td>
<td>0.60</td>
</tr>
<tr>
<td>Pain intensity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At present (mm)</td>
<td>31.0 (27.0 to 49.0)</td>
<td>38.5 (30.0 to 51.0)</td>
<td>0.46</td>
</tr>
<tr>
<td>Worst during past week (mm)</td>
<td>69.5 (42.0 to 75.0)</td>
<td>55.0 (44.0 to 69.0)</td>
<td>0.27</td>
</tr>
<tr>
<td>Disability rating index (mm)</td>
<td>56.1 (46.1 to 63.6)</td>
<td>49 (36 to 69.7)</td>
<td>0.96</td>
</tr>
<tr>
<td>SF36, physical component score</td>
<td>31.4 (26.6 to 41.0)</td>
<td>32.0 (23.4 to 40.5)</td>
<td>0.62</td>
</tr>
<tr>
<td>SF36, mental component score</td>
<td>41.3 (33.7 to 54.1)</td>
<td>46.7 (37.5 to 59.2)</td>
<td>0.32</td>
</tr>
<tr>
<td>6MWT, walk distance (m)</td>
<td>250 (136 to 324)</td>
<td>275 (131 to 350)</td>
<td>0.66</td>
</tr>
<tr>
<td>Isometric trunk extension (s)</td>
<td>35.5 (17 to 69)</td>
<td>42 (12 to 96)</td>
<td>0.72</td>
</tr>
<tr>
<td>Isometric trunk flexion (s)</td>
<td>19.1 (3 to 35)</td>
<td>26.7 (5 to 40)</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Figure 8. Distribution of reported pain at study inclusion among women with and without chronic pelvic pain. Women with CPP are presented on the left side.

Distribution of pain provoked from the right-sided intra-pelvic landmarks including the coccyx in women with and without CPP is displayed on the pain maps, figures 9a-g. For both groups, the referred pain patterns on the right side were almost identical to those from the left side (data not shown). In general, pain provoked by palpation on the posterior intra-pelvic land-
marks most often manifested in the sacral and buttock regions, and pain provoked by palpation on the lateral and anterior intra-pelvic landmarks usually manifested in the groin and pubic regions, sometimes with referred pain down the ipsilateral leg.

Intra-pelvic provoked referred sensations were mainly confined to the sacral and the groin regions. Diffuse and distinct referred pain was mostly experienced by women with CPP while non-painful referred sensations were mostly experienced by women without CPP, table 4. Provoked sensations from the lower back and abdomen showed similar differences although with lower frequency. Sensations in the legs were perceived by only a few women with CPP and were limited to distinct pain.

Of the 845 pain drawings from the vaginal palpation ‘no sensation at all’ or “non-painful referred sensations” were provoked in 9% and 71% respectively, among women with and without CPP (data not shown).

In women with CPP the average provoked pain distribution area (mm²) at all 13 anatomical landmarks was approximately tenfold in women with CPP as compared to women without CPP, p<0.0001, table 5. The largest pain distribution areas were provoked on the ischial spine and on the ischium inferior to the ilio-ischial fusion, with decreasing areas of pain the longer the distance from these landmarks, <0.0001<p<0.009, (data not shown).

Scores of pain intensity (Likert scores) provoked on each intra-pelvic anatomical landmark was significantly higher among women with CPP than those without, table 6. The median sum of pain intensity scores provoked on all 13 intra-pelvic landmarks was 17 among women with CPP in comparison with 3 among women without CPP (p<0.0001), table 6. The highest pain intensity score was provoked on the ischial spine among women with CPP and on the ischium inferior to the ilio-ischial fusion among women without CPP. The pain intensity score decreased significantly in both directions further away from the respective landmark (p<0.0001 among women with CPP and 0.002<p<0.03 among women without CPP) except for the difference between pain provoked on the ischial spine and os ischii (p=0.17).

The cumulative proportion of the individual sum of pain intensity scores provoked on all 13 intra-pelvic landmarks among women with and without CPP is displayed in figure 10. The minimum and maximum of this score among women with CPP was 4 and 26 and among women without CPP 0 and 13. The maximum score of 13 for women without CPP was exceeded by all but 5 women with CPP.
Figure 9a-g. Distribution of referred pain provoked by palpation at the respective intra-pelvic anatomical landmark on the right side and coccyx, among women with and without chronic pelvic pain (CPP). Women with CPP are presented on the left side in every figure.
Table 4. Number (%) of women with perceived sensation provoked on 13 intra-pelvic anatomical landmarks and referred to different body regions\(^1\), expressed in pain drawings among women with and without chronic pelvic pain (CPP)

<table>
<thead>
<tr>
<th>Body regions</th>
<th>With CPP n=36</th>
<th>Without CPP n=29</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Blank</td>
<td>Other</td>
</tr>
<tr>
<td>None</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Lumbar</td>
<td>1 (2.8)</td>
<td>1 (2.8)</td>
</tr>
<tr>
<td>Abdomen</td>
<td>1 (2.8)</td>
<td>6 (16.7)</td>
</tr>
<tr>
<td>Sacral left</td>
<td>7 (19.4)</td>
<td>11 (30.6)</td>
</tr>
<tr>
<td>Sacral right</td>
<td>5 (13.9)</td>
<td>14 (38.9)</td>
</tr>
<tr>
<td>Groin left</td>
<td>6 (16.7)</td>
<td>10 (27.8)</td>
</tr>
<tr>
<td>Groin right</td>
<td>4 (11.1)</td>
<td>12 (33.3)</td>
</tr>
<tr>
<td>Leg back, left</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Leg back right</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Leg front left</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Leg front right</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

“Blank” = no sensation, at all, “Other” = non-painful referred sensations “Diffuse” = hard to draw in pain drawing, “Distinct” = well defined pain in pain drawing.

\(^1\)Refers to figure 2
Table 5. Pain distribution areas on pain drawings (mm^2) provoked by palpation of 13 intra-pelvic anatomical landmarks, among women with and without chronic pelvic pain (CPP). The sum and average of all 13 anatomical landmarks, the average of symmetric landmarks and os coccyx are presented as medians (25th to 75th percentiles)

<table>
<thead>
<tr>
<th>Anatomical landmark</th>
<th>With CPP n=36</th>
<th>Without CPP n=29</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of all 13</td>
<td>394.2 (249.6 to 698.6)</td>
<td>41.3 (12.8 to 66.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Average of all 13</td>
<td>30.3 (19.2 to 53.7)</td>
<td>3.2 (1.0 to 5.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os sacrum laterally</td>
<td>18.4 (7.1 to 43.1)</td>
<td>0 (0 to 0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sacrospinous ligament</td>
<td>28.5 (17.6 to 44.8)</td>
<td>0 (0 to 3.8)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ischial spine</td>
<td>42.1 (23.6 to 61.7)</td>
<td>0 (0 to 5.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os ischii</td>
<td>38.2 (20.8 to 50.6)</td>
<td>4.4 (0 to 9.6)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os pubis laterally</td>
<td>25.7 (12.4 to 49.9)</td>
<td>0 (0 to 4.2)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os pubis medially</td>
<td>16.6 (8.6 to 45.8)</td>
<td>0 (0 to 2.4)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os coccyx</td>
<td>22.8 (12.0 to 43.9)</td>
<td>0 (0 to 0)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Table 6. Score of pain intensity (0-1-2) provoked by palpation of 13 intra-pelvic anatomical landmarks, among women with and without chronic pelvic pain (CPP). The sum and average score of all 13 landmarks, the average score of symmetric landmarks and os coccyx are presented as medians (25th to 75th percentiles)

<table>
<thead>
<tr>
<th>Anatomical landmark</th>
<th>With CPP n=36</th>
<th>Without CPP n=29</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum of all 13</td>
<td>17.0 (14.0 to 21.0)</td>
<td>3.0 (2.0 to 6.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Average of all 13</td>
<td>1.3 (1.1 to 1.6)</td>
<td>0.23 (0.2 to 0.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os sacrum laterally</td>
<td>1.0 (1.0 to 1.5)</td>
<td>0 (0 to 0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sacrospinous ligament</td>
<td>1.2 (1.0 to 1.5)</td>
<td>0 (0 to 0.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ischial spine</td>
<td>2.0 (1.5 to 2.0)</td>
<td>0 (0 to 0.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os ischii</td>
<td>1.8 (1.0 to 2.0)</td>
<td>0.5 (0 to 1.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os pubis laterally</td>
<td>1.3 (1.0 to 1.5)</td>
<td>0 (0 to 0.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os pubis medially</td>
<td>1.0 (0.8 to 1.8)</td>
<td>0 (0 to 0.5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Os coccyx</td>
<td>1.0 (1.0 to 2.0)</td>
<td>0 (0 to 0)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
The impact of possible factors influencing the individual sum of pain intensity scores provoked on the 13 intra-pelvic landmarks is displayed in table 7. In the simple regression analyses age was negatively associated with the pain intensity score. However pain intensity ‘worst during past week’, the number of pain locations and the DRI were all positively associated with the individual sum of provoked pain intensity score. To find factors that independently had an impact on the individual sum of provoked intensity score a multiple linear regression analysis was performed. Pain intensity ‘worst during past week’ and the number of pain locations was positively, significantly and independently associated with the pain intensity score, table 7. With this model, the sum of the pain intensity score increased by 1.1 for each 10 mm increase of pain intensity ‘worst during past week’ and by 0.66 for each additional reported pain location.

Table 7. Associations of different characteristics on the individual sum of pain intensity scores sum of reported pain intensity provoked on 13 intra-pelvic landmarks in several simple linear regression analyses and one multiple linear regression analysis (n=65). $R^2$ of the full model was 0.68

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Simple linear regression</th>
<th>Multiple linear regression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$-coefficient</td>
<td>$R^2$</td>
</tr>
<tr>
<td>Age (years)</td>
<td>-0.52</td>
<td>0.24</td>
</tr>
<tr>
<td>No. of previous pregnancies</td>
<td>1.0</td>
<td>0.02</td>
</tr>
<tr>
<td>Smoking (no/yes)</td>
<td>0.34</td>
<td>0.00</td>
</tr>
<tr>
<td>Educational level (&lt;12/&gt;12 years)</td>
<td>-2.5</td>
<td>0.02</td>
</tr>
<tr>
<td>Pain intensity ‘worst during past week’</td>
<td>0.19</td>
<td>0.63</td>
</tr>
<tr>
<td>No. of pain locations</td>
<td>1.65</td>
<td>0.51</td>
</tr>
<tr>
<td>Disability rating index (mm)</td>
<td>0.21</td>
<td>0.54</td>
</tr>
</tbody>
</table>
Papers III and IV

Pain

In the triamcinolone treatment group the absolute median change of VAS between follow-up and baseline was -24 mm, and in the saline group +4.5 mm, table 8. The difference between the groups was significant (p<0.05). The relative change of median VAS in the triamcinolone group of -31% and in the saline group +9% was not significant. Furthermore, the intra-treatment group change in absolute and relative median pain intensity worst during past week between follow up and baseline was significant for the triamcinolone group (p<0.001 and p<0.01, respectively). However, the change was not significant for the saline group (p=0.92 and p=0.67, respectively).

Table 8. Median pain intensity (VAS) at baseline and follow up. Medians and (25th to 75th percentile)

<table>
<thead>
<tr>
<th></th>
<th>Triamcinolone n=18</th>
<th>Saline n=18</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VAS (mm)</td>
<td>VAS (mm)</td>
<td></td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At present</td>
<td>31.0 (27.0-49.0)</td>
<td>38.5 (30.0-51.0)</td>
<td>0.46</td>
</tr>
<tr>
<td>Worst during past week</td>
<td>69.5 (42.0-75.0)</td>
<td>55.0 (44.0-69.0)</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>Follow up</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At present</td>
<td>20.5 (9.0-34.0)</td>
<td>31.5 (19.0-54.0)</td>
<td>0.13</td>
</tr>
<tr>
<td>Worst during past week</td>
<td>47.0 (36.0-57.0)</td>
<td>65.0 (29.0-76.0)</td>
<td>0.18</td>
</tr>
<tr>
<td><strong>Difference baseline to follow-up</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At present</td>
<td>16.0 (0.0-27.0)</td>
<td>7.0 (-10.0-16.0)</td>
<td>0.36</td>
</tr>
<tr>
<td>Worst during past week</td>
<td>24.0 (12.0-26.0)</td>
<td>-4.5 (-20.0-25.0)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Ratio</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At present, follow up/baseline</td>
<td>0.42 (0.0-0.76)</td>
<td>0.12 (-0.28-0.47)</td>
<td>0.25</td>
</tr>
<tr>
<td>Worst during past week, follow up/baseline</td>
<td>0.31 (0.19-0.43)</td>
<td>-0.09 (-0.45-0.38)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Table 9. Number of women with improved pain provocation test result, separately or either of the tests, at follow-up as compared with baseline by treatment groups

<table>
<thead>
<tr>
<th></th>
<th>Triamcinolone n=18</th>
<th>Saline n=18</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Improved test result (n)</td>
<td>Improved test result (n)</td>
<td></td>
</tr>
<tr>
<td>P4 test</td>
<td>13</td>
<td>7</td>
<td>0.04</td>
</tr>
<tr>
<td>Menell’s test</td>
<td>7</td>
<td>2</td>
<td>0.12</td>
</tr>
<tr>
<td>Patrick’s test</td>
<td>7</td>
<td>4</td>
<td>0.47</td>
</tr>
<tr>
<td>Either of the tests</td>
<td>17</td>
<td>9</td>
<td>0.007</td>
</tr>
</tbody>
</table>
At follow-up, a reduced number of pain drawing locations was indicated by 16 women in the triamcinolone group as compared with 10 in the saline group, figure 11. No one in the triamcinolone group but three women in the saline group reported an increased number of pain locations. The difference between the treatment groups was significant, $p<0.05$. There was no significant difference of the change in any reported pain location between the treatment groups. However, within the triamcinolone group significantly fewer women reported pain at follow-up than at baseline. This was the pain from the thoracolumbar spine ($p<0.01$), symphysis ($p<0.01$), legs front ($p<0.05$), and legs rear ($p<0.001$). In the saline group, significantly fewer women reported pain from thoracolumbar spine ($p<0.01$) and legs rear ($p<0.01$). In the triamcinolone group, there was a significantly higher number of women with an improved P4 test at follow-up as compared with the saline group ($p<0.04$). The same tendency was shown for Menell’s and Patrick’s tests, although this was not significant. When all three tests were used in combination there was a significant improvement in the test results in the triamcinolone group as compared with the saline group ($p=0.007$), table 9.

![Figure 11. Change in number of pain locations](image)

**Function**

The DRI displayed a 14.6 mm decrease among women in the triamcinolone group between follow-up and baseline, which was significantly different from the decrease of 1 mm in the saline group ($p=0.046$), although the relative differences of 28% and 3% were not significant, table 10. In the triamcinolone group the decreased DRI was correlated to decreased pain intensity (Spearman’s $r=0.48$, $p=0.045$) (data not shown).
There was no significant difference in SF-36 scores between the treatment groups. In the triamcinolone group the median PCS and MCS showed an increase of 4.5 and 1.5 respectively, as compared with the PCS and MCS in the saline group of 1.5 and 0.5 respectively. In the triamcinolone group the median PCS was significantly higher at follow-up compared with baseline (p=0.045), but not in the saline group (data not shown). In the triamcinolone group the increased SF-36 correlated to decreased pain intensity (Spearman’s r= -0.52, p=0.014).

In the 6MWT the median walk distance between baseline and follow-up increased by 54.5 m in the triamcinolone group, which was significantly different from the decrease of 3.5 m in the saline group (p=0.016). The relative changes of an increase of 24% and a decrease of 1% were not significant, table 10. Also, in the triamcinolone group, the increased walk distance was significantly correlated to decreased pain intensity (Spearman’s r=0.82, p=0.0001), figure 12.

In the isometric trunk extensor test the median time increased by 19.5 seconds in the triamcinolone group and decreased by 3.5 seconds in the saline group. The absolute difference between groups was significant (p=0.004). The difference in the relative increase of median time in the isometric trunk extensor test of 44% in the triamcinolone group and the decrease of 8% in the saline group were also significant (p=0.016), table 10.

The median time of the isometric trunk flexor test increased by 3.6 seconds in the triamcinolone group and 5.6 seconds in the saline group (data not shown). The difference between the groups was not significant.

In telephone interview one day after injection treatment four women, two from each treatment group, reported transient vaginal bleeding and one woman reported a fever for two days after the injection. At follow up four weeks after treatment no serious adverse event, including sensitivity disturbance was reported.
Table 10. Ability to perform daily activities according to median Disability Rating Index (DRI), the median walk distance at six minutes walk test (6MWT) and the median time (seconds) of isometric trunk extensor test at baseline and at four weeks follow-up and absolute and relative change between follow up and baseline by the triamcinolone and saline treatment groups. (25th to 75th percentile)

<table>
<thead>
<tr>
<th></th>
<th>Triamcinolone</th>
<th>Saline</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=18</td>
<td>n=18</td>
<td></td>
</tr>
<tr>
<td><strong>DRI (mm)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>56.1 (46.1 to 63.6)</td>
<td>49.0 (36.0 to 69.7)</td>
<td>0.96</td>
</tr>
<tr>
<td>Follow up</td>
<td>38.0 (24.0 to 52.3)</td>
<td>50.9 (29.8 to 68.6)</td>
<td>0.29</td>
</tr>
<tr>
<td>Follow up – baseline</td>
<td>-14.6 (-26.6 to -3.7)</td>
<td>-1.0 (-11.5 to 5.3)</td>
<td>0.046</td>
</tr>
<tr>
<td>(Follow up - baseline) / baseline</td>
<td>-0.28 (-0.56 to -0.05)</td>
<td>-0.03 (-0.17 to 0.08)</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>6MWT, distance (m)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>250 (136 to 324)</td>
<td>275 (131 to 350)</td>
<td>0.66</td>
</tr>
<tr>
<td>Follow up</td>
<td>255.5 (191 to 389)</td>
<td>240 (73 to 368)</td>
<td>0.38</td>
</tr>
<tr>
<td>Follow up – baseline</td>
<td>54.5 (-8 to 104)</td>
<td>-3.5 (-58 to 30)</td>
<td>0.016</td>
</tr>
<tr>
<td>(Follow up - baseline) / baseline</td>
<td>0.24 (-0.07 to 0.42)</td>
<td>-0.01 (-0.44 to 0.20)</td>
<td>0.11</td>
</tr>
<tr>
<td><strong>Trunk extensor test (s)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>35.5 (17 to 69)</td>
<td>42 (12 to 96)</td>
<td>0.72</td>
</tr>
<tr>
<td>Follow up</td>
<td>58.5 (42 to 97)</td>
<td>42.5 (18 to 65)</td>
<td>0.12</td>
</tr>
<tr>
<td>Follow up – baseline</td>
<td>19.5 (3 to 38)</td>
<td>-3.5 (-28 to 9)</td>
<td>0.004</td>
</tr>
<tr>
<td>(Follow up - baseline) / baseline</td>
<td>0.44 (0.14 to 1.4)</td>
<td>-0.08 (-0.47 to 0.29)</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Figure 12. Correlation between change in walk distance and decreased pain intensity in the triamcinolone treatment group
Discussion

Papers I and II

Referred pain patterns provoked from intra-pelvic landmarks in women with CPP persisting after childbirth were consistent with sclerotomal sensory innervation and magnification of the patterns in those with CPP over those without CPP indicated allodynia and central sensitisation.

The light, manual pressure to intra-pelvic structures can provoke referred pain in predictable patterns and has the capacity to distinguish women with CPP persisting after childbirth from those without CPP.

In women with CPP there were similarities in pain location elicited by history and the location of provoked pain although women without CPP experienced only minor, localized discomfort when intra-pelvic landmarks were provoked. Women with CPP had significantly larger areas of referred pain than women without CPP. Although the study gave limited evaluation of sclerotomal structures within the pelvis, it provided strong evidence that pain can be generated from non-visceral intra-pelvic structures and that these are probable origins of at least some of the symptoms of women with CPP persisting after childbirth. In the case of those CPP sufferers where no visceral pathology can be found, this new finding offers an explanation of where the pain can be diagnosed as “functional”.

Interestingly there was a close similarity in the location and size of the areas provoked by pressure in the CPP cohort and the sclerotomal mapping done by Inman and colleagues in the 1940’s. Inman et al. used various nociceptive stimuli with the intent to elicit referred pain and used the referred pain areas to identify the nervous innervations of sclerotomal structures. That study concluded that the referred pain pattern indicated that the sclerotomal structures were innervated by spinal nerves subserving the cutaneous area mapped during stimulation. In comparing the similarities in referred pain patterns between Inman et al. and results from Paper I, it became obvious that a mild pressure stimulus in women with CPP had similar effects as noxious stimuli in volunteers who had no chronic pain. This is indirect evidence for central sensitisation in the women with CPP who demonstrate allodynia to light pressure on intra-pelvic sclerotomal structures and expanded receptor fields in the referral areas. Referred pain patterns from pelvic floor muscles have been described in The Trigger Point Manual by Travell and Simons, and are somewhat similar to the distribution of referral
patterns demonstrated in Paper I. However, there were also major differences implying another pain mechanism than that originated only from muscles. When provoking the internal female genital organs, pain responses are vague, both in intensity and location and, contrary to findings in Paper I, do not elicit pain in the low back or thigh. As with visceral provocation, the participating women could not identify the precise site of the provocation, whether or not they had CPP.

Referred pain patterns are common phenomena with complex backgrounds that have both central and peripheral mechanisms depending on the source. There are theories with experimental support, and there is consensus in the fact that referred pain exists and can be useful in diagnostics. One well-accepted theory to explain the existence of referred pain is the physiological fact of convergence and divergence of peripheral nerve fibres to and from the spinal cord. Convergence refers to the fact that a single dorsal horn cell can receive input from a wide variety of structures over a large area of the body. Divergence refers to the fact that information from a restricted area in the periphery can enter the spinal cord at several different levels. Peripheral and central sensitisation of the somatosensory system can contribute to an expansion of the receptor fields of dorsal horn neurons and to allodynia in the periphery. Peripheral sensitisation is the increased response from nociceptors when exposed to inflammatory mediators and/or damaged tissue, restricted to the site of tissue injury, while central sensitisation refers to changes in the central nervous system.

Central sensitisation is a major contributor to persistent and chronic pain of various etiologies and is described as pain hypersensitivity by changing the sensory response elicited by normal inputs. Receptor field expansion by priming the sensory system with acute pain has been demonstrated by studies done by Gillette, Kramis and Roberts. Although theirs was an acute animal model, it showed that the onset of acute pain can expand the receptor fields of single dorsal horn neurons when musculoskeletal structures are stimulated by mildly noxious stimuli. The women with CPP responded to mild, focal pressure on sclerotomal structures in the pelvis with both a perceived increase in the area of referred pain and an increased level of perceived pain when compared with women in the control group without CPP. It is possible that an acute pain stimulus under pregnancy and/or during delivery had the same effect to “prime” the somatosensory system but that effect persisted after the resolution of the acute event. Why some individuals continue to experience pain and others do not is the subject for further studies. Since the usual pain in women with CPP persisting after childbirth is provoked by ordinary non-noxious activities that provoke intra- and extra-pelvic structures such as prolonged sitting, prolonged standing and walking, sensitisation must be inferred. The highest pain intensity provoked on the ischial spines, as compared to the other intra-pelvic structures, might indicate this area as biomechanically vulnerable.
One can debate which type of tissue is the pain generator in CPP persisting after childbirth but the importance of the present studies is that it provides evidence that non-visceral structures can contribute to CPP. The studies focus on the pain mechanism of a group of women with significant suffering and limitations in daily living. If the pain is provoked from muscles, connective tissue or skeletal structures or a combination, this is not an issue for the women unless the treatment depends on the source of the pain.

As far as known this is the first time a study of this size have produced pain maps and explored the importance of intra-pelvic structures in relation to CPP persisting after childbirth. The diagnostic method was safe and did not give either of the groups any adverse effects except for the unpleasantness from the vaginal examination approach. The use of pain drawing cartoons to construct composite pictures of referred pain patterns was a methodological strength as was the blinding procedure to recruit women without CPP. Also the analyse procedure of all pain drawings was verified by a person not involved in the study.

The presence of co-morbidities that might be involved in the pain mechanism is a limitation in the study even if serious illness was excluded and visceral pathology had been ruled out. Also, it is possible that intra-pelvic structures other than those provoked in these studies were involved as pain generators but this was not tested. If this was the case, the mechanisms can be assumed to be similar but treatment might be different. The light pressure added on each anatomical landmark was meant to be equal and the use of an instrument to measure this pressure was considered. However, it was not used because of the difference in resistance of the tissue inside the pelvis, i.e. periosteum versus ligament. Intra-examiner variability cannot be ruled out but the blinding procedure minimised this risk.

Papers III-IV

In all women with CPP persisting after childbirth pain duration was long, while the pain intensity and DRI was high. Self-reported median physical and mental health scores, median walk distance and median time of isometric trunk extensor and flexor tests were low. In total, these findings indicated very low levels of physical function.

Reduced pain and improved function was achieved among women in the triamcinolone group as compared with the saline group. After a single corticosteroid injection given at the sacrospinous ligament insertion on the ischial spine the women experienced reduced pain intensity, decreased number of pain locations, positive pain provocation test results and improved function at short-term follow-up. This indicates that these structures might be one source of pain in women with CPP persisting after childbirth and that pain relieving treatment to specific intra-pelvic structures can be used in order to
enable physiotherapy intervention. Short-term efficacy of corticosteroid injection of tendinopathy to other locations is well documented, although the long-term efficacy is low, if any.  

The strengths of Papers III and IV were the experimental design that included random allocation to the treatment groups, a blinded treatment that decreased the influence of confounding factors on the results and assessment procedure, the use of validated tests for inclusion and follow-up, clinically relevant outcome measures and no drop-outs.

The strict inclusion and exclusion criteria, lead to a homogenous study population and a prolonged inclusion period. In addition, the injection technique involved a thorough identification of the injection target, the ischial spine, and as the women confirmed the provoked pain so the treatment could be given with precision. Another strength was that only one person gave the injection treatment. The small number of women included was a potential limitation of the studies from the perspective of generalisation of the results.

The aspiration technique of egg retrieval in in vitro fertilisation treatment is routinely used and the frequency of adverse events is low and we believe injection treatment through the vaginal wall could safely be used in further clinical studies. The extent of the effects of treatment was moderate, although the size of the effect was parallel to levels found in a previous small study of injection treatment on low back pain with short follow-up time. The moderate positive effect must also be seen from the perspective that just one of several painful intra-pelvic structures was treated with corticosteroid and the pain duration among the included women was 4.2 years. In addition, the triamcinolone effect might have been more obvious if compared with a non-treatment group, since the saline injection may have induced positive treatment effects in itself, for example by influence of Diffuse Noxious Inhibitory Control, DNIC.

The findings may have further therapeutic implications, as previous studies have proposed several pelvic ligaments as a source of pain. One treatment might be physiotherapy focusing on specific functional restoration after short-term anti-inflammatory treatment given systematically or locally at several ligament insertions. Both alternatives may also be tried in combination with selective rest. The anti-inflammatory treatment may give the patient the pain-relief necessary to start supervised exercise therapy.

In open studies where intra-articular diagnostic blocks of the sacroiliac joint were used as a gold standard, pain provocation tests failed to reveal patients with sacroiliac joint syndrome. This speaks in favour of extra-articular structures being an important source of pain from the sacral region. Papers III and IV gives additional support to that view by the decreased pain in the triamcinolone treatment group when treating the sacrospinous ligament insertion at the ischial spine.
Previous studies have disputed the effect of pain provocation tests to rule adequately in sacral patients with low back pain. However, the results in Papers III and IV supports a combination of external pain provocation tests as being able to identify women with sacral pain, since all the women included also had provoked pain at the ligament insertion of the ischial spine, as determined by internal examination. It is uncertain, although possible that the external tests elicited pain from intra-pelvic structures.

One possible explanation for the effects of the corticosteroid could be an anti-inflammatory effect on an enthesopathy at the insertion of the sacrospinous ligament. It does not seem possible that there is a systemic effect rather than a local anti-inflammatory effect on the ligament insertion. The corticosteroid effect, on short-term follow-up, with the associated low frequency of adverse events, is in agreement with previous studies on tendinopathies. However, an opposite effect in the intermediate and long-term was not evaluated in Papers III and IV. The long-term effect of corticosteroids was not in focus in these studies because the purpose was to find a way to enable physiotherapy treatment with reduced pain.

A strong ligament system provides stability of the low back and pelvic regions. This includes the very strong sacroiliac and interosseous ligaments as well as the weaker sacrospinous ligament, which has a merely proprioceptive role with low tensile strength. Changed biomechanical properties of the pelvic load transmission with overload and creep may be one hypothesis about the cause of pain in the region of the sacrospinous ligament insertion and the woman’s gradually decreased function. In these and other studies, this view is supported by the correlation between decreased pain intensity and increased physical function, e.g. increased walking tolerance with using of pain relieving braces and increased isometric lumbar extension strength resulting in decreased low back pain.

The explanation for the contradictory results of improved isometric trunk extensor test and virtually unchanged trunk flexor tests between baseline and follow-up is uncertain and there is, as far as known, no previous study of this kind involving women with CPP persisting after childbirth.

In Paper IV, women in the triamcinolone treatment group had improved extensor endurance, which can be explained in terms of pain relief after the injection treatment. With the same reasoning, the absence of improved endurance in the trunk flexor test may indicate that the pain relieving effect of the injection treatment did not engage the parts of the pelvis that are loaded during that test. Also, trunk extensor muscles are postural to a higher extent than the trunk flexor muscles, which makes the trunk flexor test more sensitive to an absence of exercise which could apply to many of these women.

The women with CPP persisting after childbirth had highly deteriorated physical function at baseline and their reported DRI was similar to that of pregnant women reporting the highest back pain intensities. Also, in 6MWT women with CPP had 60% less walking distance than healthy women of the
same ages and 48% less than patients with hip osteoarthritis. In addition, their walking speed capacity of 0.7 m/s was similar to the 0.8 m/s reported in a previous study of women with persistent pregnancy-related pelvic pain.

From these perspectives, the decreased pain and improved function described in Papers III and IV following a single bilateral corticosteroid injection to one ligament insertion is intriguing and it indicates progress in the understanding of CPP persisting after childbirth and contributes in developing new treatment strategies. Developing an environment where women with CPP persisting after childbirth have an opportunity to participate in graded exercise therapy with the emphasis on improving stability would be of great importance.

**General discussion**

Women suffering from pregnancy-related low back and pelvic pain sometimes experience mistrust from healthcare providers, even if pain affects many women during pregnancy and persists for two to three years in two to five percent of all women who given birth. Thus, pregnancy-related low back and pelvic pain results in substantial impairment of quality of life and must be considered a major woman’s health issue. In spite of this some health providers considers this to be a “fashionable diagnosis” among other such as fibromyalgia, whiplash disorders, postpartum depression and repetitive strain injury. Over time such scepticism can be proven wrong and a medical explanation for the condition emerges. Why healthcare providers choose to mistrust new diagnoses can be a result of biases in judgement resulting from uncertainty, i.e. in the absence of knowledge, medical professional may use heuristics to handle a situation. This can maybe be useful temporarily but can also lead to severe and systematic errors in the long run.

Pain is a symptom and an experience, not a measurable entity and as such multifactorial and individual. When examining the results from Papers I to IV one reasonable hypothesis for one pain mechanism causing severe CPP persisting after childbirth is central sensitisation. Due to bodily changes during pregnancy such as the stress of pregnancy itself, influences on musculoskeletal tissue and hormonal changes it is possible that vulnerability increases and some women might develop persistent pain. Sensitisation of the somatosensory system may explain why daily activities such as walking, prolonged standing and lifting can be painful.

In this thesis an origin of severe pain and a possible pain mechanism and a strategy for examination was suggested (Papers I and II). Also the short-term effect of corticosteroid injections can be used as a ‘therapeutic window’ to enable physiotherapeutic intervention (Papers III and IV). In clinic it is
important to appreciate the influence of all factors affecting a woman with chronic pelvic pain and suggest a treatment plan from her specific circumstances. If the origin of pain primarily is caused by vulnerability in musculoskeletal tissue or sensitisation can be of importance regarding medical treatment but the physiotherapeutic strategy is similar. Thorough examination, confirmation of pain experience, information of findings and exercise therapy with emphasis on the individual’s situation and conditions.

From the physiotherapeutic perspective the results of this thesis a treatment strategy in the rehabilitation of severe CPP persisting after childbirth can be suggested.

A treatment strategy should include:

I An examination consisting of:
   o a thorough medical history including biopsychosocial factors and pain drawing
   o pain provocations tests to confirm pelvic pain
   o vaginal palpation to confirm the woman’s pain experience both in terms of intensity and referred pain pattern

II Considering short-term pain relief to intra-pelvic structures such as corticosteroid injections

III Starting individualised physiotherapy to treat both the musculoskeletal dysfunction and the central sensitisation.\(^{173}\)
   o Exercises with focus on neuromuscular control and motor learning to enhance functional recovery.\(^{174}\)
   o Graded activity or motor control exercises on a daily basis, starting at low intensity to strengthen musculoskeletal structures without increasing central sensitisation.\(^{175}\)
Conclusion

In this thesis it has been shown that:

- referred pain provoked from non-visceral intra-pelvic structures follows a specific pattern and are consistent with sclerotomal sensory innervations. Magnification of referred pain patterns in women with CPP persisting after childbirth compared to women without CPP indicates allodynia and central sensitisation.

- high pain intensity was provoked by a light pressure on intra-pelvic structures among women with CPP persisting after childbirth in comparison with women without CPP. Intra-pelvic examination can contribute to diagnosis in CPP persisting after childbirth.

- decreased pain intensity and distribution was achieved among women with CPP persisting after childbirth at short-term follow-up after a single corticosteroid injection treatment at the ischial spine, indicating this region as a source of pain.

- improved function was achieved among women with CPP persisting after childbirth at short-term follow-up after a single corticosteroid injection treatment. The magnitude of the effect was positively correlated to the reduced pain intensity.
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Graviditetsrelaterad rygg- och bäckensmärta är ett globalt problem som upplevs av en majoritet av kvinnor under graviditeten. Hos de flesta kvinnor försvinner denna smärta inom sex månader efter förlossningen, men hos två till fem procent av alla kvinnor som föder barn kvarstår besvären minst två år efter förlossningen. Smärttillståndet har då genomgripande konsekvenser med förändringar i dagliga aktiviteter såsom svårigheter att gå, sitta och ligga längre stunder och det medför ofta långvarig sjukfrånvaro samt sätter ner det allmänna välbefinnandet.

Långvarig graviditetsrelaterad rygg- och bäckensmärta har en negativ inverkan på kvinnors hälsa i ett globalt perspektiv, med stora konsekvenser för kvinnan, hennes familj och samhället. När hälso- och sjukvården möter kvinnor med långvarig graviditetsrelaterad rygg- och bäckensmärta upplever kvinnorna ofta en skepsis från vårdgivare både angående orsaken till smärtan och hur ont de har. Inte sällan upplever sig kvinnorna så ifrågasatta att de själva börjar tvivla på sina besvär.

Trots att graviditetsrelaterad rygg- och bäckensmärta är ett stort problem råder det stor osäkerhet angående smärtans ursprung och hur den ska behandlas. Vissa riskfaktorer är kända och det förekommer teorier om andra. Behandlingsmetoderna är få för såväl smärta under som efter graviditeten. För att hjälpa de kvinnor som har långvariga besvär är förståelse för uppkomsten av och mekanismen bakom den långvariga bäckensmärtan av grundläggande betydelse för att kunna utveckla effektiva behandlingsstrategier för detta outforskade och svårbehandlade tillstånd.

**Delarbete I och II**


Syftet med delarbete I och II var att undersöka förekomsten av refererad smärta och smärtintensitet hos kvinnor med långvarig graviditetsrelaterad...
bäckensmärta i jämförelse med kvinnor utan ländryggs- och bäckensmärta. Ett syfte var att undersöka om det fanns ett generellt mönster som kunde beskrivas på smärtkartor, ett annat om smärtutbredningens area skiljde sig mellan grupperna och ett tredje om smärtintensiteten skiljde sig mellan grupperna.

I studierna inkluderades 36 kvinnor med långvarig, i medeltal 4,2 år, gravitetsrelaterad bäckensmärta och som kontrollgrupp inkluderades 29 ryggfriska kvinnor som besökte gynekologiska hälsokontrollen för rutinundersökning.

Kvinnorna undersöcktes med ett lätt tryck på tretton förutbestämda punkter inuti bäckenet. De tretton punkterna sträckte sig från svanskotan till blygdbensfogen längs fästen för bäckenbottens strukturer, sex punkter på var sida plus svanskotan. Kvinnorna ritade sin upplevelse av trycket på en smärtteckning för var och en av de tretton punkterna; de angav också om trycket framkallade smärta och beskrev även sin upplevelse av smärten verbalt.

Varje smärtteckning skannades och användes för att skapa en smärtkarta för var och en av de tretton punkterna. De skannade teckningarna användes också för att mäta smärtutbredningens area.


Smärtintensiteten analyserades med hjälp av en tregradig skala där 0 motsvarade ingen smärta, 1 lite smärta och 2 mycket smärta. Varje kvinna kunde alltså ha mellan 0-26 poäng vid sammanräkning av alla 13 punkter.

Samtliga variabler sammanställdes och jämfördes för kvinnor med respektive utan bäckensmärta.

Slutsatserna var att det fanns ett specifikt mönster för kvinnor med gravitetsrelaterad bäckensmärta och att det skiljde sig markant från ryggfriska kvinnors mönster. Det pekade också på att kvinnorna med bäckensmärta hade alldodyni, dvs smärta orsakad av normalt icke smärtsam beröring och ett sensitiset (överretat) smärtsystem. Smärtintensiteten vid provokation på de tretton punkterna skiljde sig markant där alla utom fem kvinnor med bäckensmärta hade högre totalpoäng (0-26) än högsta poängen bland ryggfriska kvinnor. Dessutom visade totalpoängen en korrelation med graden av funktionsnedsättning och kvinnornas vardagliga smärta.
Delarbete III och IV


I delarbete III och IV undersöktes den kortsiktiga behandlingseffekten av en kortisoninjektion på ett specifikt ledbandsfäste på båda sidor inuti bäckenet. I delarbete III undersöktes effekten på smärtintensitet och smärtutbredning och i delarbete IV effekten på fysisk funktion.

De 36 kvinnorna från delarbete I och II lottades till två behandlingsgrupper; 18 kvinnor fick en kortisoninjektion och 18 kvinnor fick en koksaltinjektion. De fick ingen annan behandling och uppmanades att fortsätta leva som innan injektionen.

Vid uppföljning efter fyra veckor konstaterades att kvinnorna som fått kortisonbehandling blivit förbättrade i jämförelse med dem som fått koksalt. Kortisongruppen hade signifikant lägre smärtintensitet och mindre utbredd smärta. De hade också förbättrat gångförmågan och ökat ryggstyrkan samt skattade sin allmänna funktion högre.

Slutsatserna var att ledbandsfästen i bäckenet har ett samband med långvarig graviditetsrelaterad bäckensmärta och att direkt riktad behandling mot strukturer i bäckenbotten kan ge en möjlighet till smärtlindring och funktionsökning som bör användas i fortsatt rehabilitering.

En möjlig behandlingsstrategi:

1. En noggrann kroppslig undersökning som består av:
   a. Kvinnans egen berättelse, hennes livssituation inklusive kända biopsykosociala faktorer samt en smärteckning
   b. Yttre provokationstester för att bekräfta bäckensmärten
   c. Inre provokationstester för att bekräfta smärtintensitet och smärtmönster
2. Överväg möjligheten att använda kortisoninjektioner som kortsiktigt smärtlindring
3. Påbörja individualiserad fysioterapi utifrån att behandla både biomekaniska dysfunktionen och det sensitiserade smärtsystemet:
   a. Funktionell träning med fokus på neuromuskulär kontroll
   b. Daglig träning som startar på låg nivå och successivt trappas upp utan att reta det sensitiserade smärtsystemet t.ex enligt metoden för kvoterad träning.
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A doctoral dissertation from the Faculty of Medicine, Uppsala University, is usually a summary of a number of papers. A few copies of the complete dissertation are kept at major Swedish research libraries, while the summary alone is distributed internationally through the series Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Medicine.