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Paradigm for assessment and treatment of SIJ mechanical dysfunction

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Non-specific low back pain

Summary The sacroiliac joint (SIJ) is an integral part of both the lumbar spine and the pelvic girdle. It is frequently the source of low back pain and pelvic girdle pain. Recent research has permitted a deeper understanding of its function and assessment. The mechanical assessment of the SIJ as a transmitter of load between trunk and lower limbs, and as a means to absorb torsion stresses of the pelvis absorber of torsion is examined; history, clinical examination and imaging modalities are explored and the role of exercise and some interventional therapies are described in general terms.

Introduction

SIJ and Pelvic Girdle Pain in the context of ''non specific low back pain''

Low Back Pain (LBP) has been described as an epidemic of the 20th century, and the trend continues in the 21st century. In Australia up to 80% of the population will experience back pain in their lives, and 10% will experience significant disability as a result (Briggs and Buchbinder, 2009). The causes are not well understood, and therapies frequently fail. The very use of the term Low Back Pain as a ''quasi diagnosis'' — when pain is a symptom, not a disease — reflects a general lack of knowledge.

Lumbar spinal pain has been defined (Merskey and Bogduk, 1994) as pain perceived within a region bounded laterally by the lateral borders of the erector spinae, superiorly by an imaginary line through the T12 spinous process, and inferiorly by a line through the S1 spinous process. Sacral pain is defined as perceived pain within a region overlying the sacrum, bounded laterally by imaginary vertical lines through the posterior superior and posterior inferior iliac spines, superiorly by a line through the S1 spinous process, and inferiorly by a transverse line through the posterior sacrococcygeal joints. LBP is therefore pain arising from anywhere within the two areas described, independently of radiation to other areas of the body. It does not indicate at all the origin or cause of the pain.

The ability to make a specific diagnosis in patients with LBP is the subject of *debate*. Often the diagnosis depends on the professional background of the diagnostician. Some authors consider that definite pathology can only be diagnosed in 15% of patients with LBP (Waddell, 1998). Research

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on LBP has focused for a long time on anatomical structures with a nerve supply that could explain the origin of pain. The study of pain generators has yielded objective findings. Nerve block procedures have identified a structure responsible for the pain in over 50% of cases (Mc Gill, 2002)

The sacroiliac joint was first suggested as a source of lower back pain in 1905 by Goldthwaite and Osgood (1905) but largely ignored as the intervertebral disc became labelled as the major cause of back pain by Mixter and Barr in 1934. The sacro-iliac joint is a source of pain in the lower back and buttocks in up to 15–21% of the population (Dreyfuss et al., 1996). There is evidence that dysfunction of this joint could, similar to a herniated lumbar disc, produce pain along the same distribution as the sciatic nerve (Fortin et al., 1994a–c, 2003). Using anaesthetic blocks of the sacro-iliac joint, Schwarzer (Schwarzer et al., 1995b) investigated the contribution of the SIJ in a low back pain population. They found that 18.5% were considered to have pain from the SIJ. As injections were given into the synovial part of the joint and did not involve the posterior ligaments, it is possible that the SIJ is responsible for LBP in a higher proportion of subjects.

Identifying the anatomical source of pain does not automatically explain why a particular structure is painful. A functional diagnosis (understanding why tissues are painful) requires a different approach and a different model, with a focus on functional kinematic relations and the integration of structural constructs -bones, joints and ligaments- with movement generators and control systems -muscles, neural regulation- (Willard, 2007; Panjabi, 1992a, b; Lee, 2004). Willard (2007) provided the following description:

''The lumbosacral spinal column performs a key role in the transfer of weight from the torso and upper body into the lower extremities, both in static positions and during movement. The primary bone structures involved in this force transduction are: five lumbar vertebrae, a sacrum, two innominate bones and the two femoral heads. Critical to the stability of these bony components is a complex arrangement of dense connective tissue. Although typically described as separate entities in most textbooks of anatomy, these fibrous, soft-tissue structures actually form a continuous ligamentous stocking, in which the lumbar vertebrae and sacrum are positioned. The major muscles representing the prime movers in this region – such as the multifidus, gluteus maximus and biceps femoris – have various attachments to this elongated ligamentous stocking. The muscular and ligamentous relationships composing the lumbosacral connection are of extreme importance in stabilising the lumbar vertebrae and arrangement has been termed a 'self-bracing mechanism' (Snijders et al., 1993a, b) and, as such, its dysfunction is critical to the failure of the lower back''.

The pelvic girdle is a closed osteo-articular ring composed of six or seven bones and the joints between them. Acting as a unit it supports the abdomen as well as the pelvic organs. It also provides a dynamic link between the spine and the lower limbs (Lee, 2004).

Acknowledging the position of the pelvic girdle as the link between trunk and lower limbs can be the key to a better understanding of its function and the role of the structures that attach to it. The pelvis is part of both the trunk and as such of the spine and of the lower limbs. Structures that attach to it directly and indirectly span as far as the shoulder and the proximal humerus via latissimus dorsi, and to the lower limbs as far as the foot through a combination of muscles (gluteus maximus, hamstrings, peronei) and fascia (thoraco-lumbo-dorsal).

Pelvic girdle pain (PGP) is a specific form of low back pain that can occur separately or in conjunction with LBP (Vleeming et al., 2008). There is evidence that pelvic girdle pain in pregnancy was recognised in the ancient world. Hippocrates (circa 400 B.C.) mentioned symphysis pubis dysfunction in his theory of ''*disjunctio pelvica*''. PGP has been described by various authors in the past 20 years in the Scandinavian countries, United States, the Netherlands, South Africa, Israel, Australia and Nigeria. It generally arises in relation to pregnancy, trauma, osteoarthrosis and arthritis. Pain is experienced between the posterior iliac crest and the gluteal fold, particularly in the vicinity of the sacro-iliac joints (SIJ). It may radiate to the posterior thigh and can also occur with/or separately in the symphysis. The endurance capacity for standing, walking, and sitting is diminished. The diagnosis of PGP can be reached after exclusion of lumbar causes. The pain or functional disturbances in relation to PGP must be reproducible by specific clinical tests (Vleeming et al., 2008; Laslett et al., 2005). Three high quality prospective studies (Ostgaard et al., 1991; Larsen et al., 1999; Albert et al., 2000) report on incidence and point prevalence of PGP in pregnancy, in large cohorts totaling close to 2000 patients. The results indicate that around 20% of pregnant women suffer from PGP.

The situation is different in non-pregnant patients. A large retrospective study by Bernard and Kirkaldy-Willis found a 22.5% prevalence rate in 1293 adult patients presenting with LBP. Diagnoses in this series were based predominantly on physical examination (Bernard and Kirkaldy-Willis, 1987). There is a growing body of evidence that points to the SIJ as an important source of PGP. The prevalence of sacroiliac joint pain would appear to be at least 13% and perhaps as high as 30% (Schwarzer et al., 1995a; Maigne et al., 1996). In our own small case series of 25 patients treated with prolotherapy for ligamentous failure of the SIJ (Cusi et al., 2008), the clinical history suggests that two thirds of patients are post pregnancy, and the remaining third are post injury, usually falls or direct trauma to the buttock area.

The clinical diagnosis of pelvic girdle pain of SIJ origin is difficult, given the variety of clinical tests and the absence of a gold standard. Maigne claims that double anaesthetic blocks of the SIJ are the gold standard, but they are only effective to diagnose intra-articular pathology and do not cover the ligamentous apparatus that surrounds the joint, an important source of pain (Laslett et al., 2005). Murakami's study (Murakami et al., 2007) confirmed Laslett's opinion: following a pain provocation test, an intraarticular injection of local anesthetic (2% lidocaine) was performed on the first 25 consecutive patients with SIJ pain and a periarticular injection on another 25. The periarticular injections were given to one or more sections of the posterior periarticular area of the SIJ and to another section in the extraarticular portion. The periarticular injection was effective in all patients, but the intraarticular one was effective in only 9 of 25 patients.

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The sacro-iliac joint

Anatomical and functional considerations

A brief consideration of some anatomical functional and biomechanical aspects of the SIJ (Maigne et al., 1996; Van Der Wurff et al., 2000) will underpin the tests proposed for the clinical assessment of the SIJ, and recent developments in imaging studies.

The long dorsal sacroiliac ligament can be palpated directly distal to the posterior superior iliac spine and inner lip of the iliac crest as a thick band that attaches distally and medially to the lateral sacral crest of S3 and S4. It lies posterior to the interosseous ligament and is covered by the fascia of the gluteus maximus muscle. The fibre tension varies with the movement of the sacrum. It is slack during nutation (from the Latin *nutare* -to nod-) and becomes taut in counternutation; localised pain within the boundaries of the long ligament could indicate a spinal condition with sustained counternutation of the SIJ (Vleeming et al., 1996).

Nutation of the sacrum increases the tension of the major ligaments of the SIJ. In normal subjects it occurs in load-bearing situations (sitting, standing, walking, etc). Counternutation slackens them when the SIJ is minimally loaded (supine).

The structure of the sacro-iliac joint and its purpose have been controversial for a long time. The small range of movement (Jacob and Kissling, 1995; Sturesson et al., 1989, 1999), the absence muscles that execute active movements of the joint and its position in the pelvic ring suggest that its function is one of stress relief for torsional forces across the pelvis (Bogduk, 2005), such as rotation during the gait sequence. In addition, it must be strong and stable to transmit forces from the vertebral column to the lower limbs and vice versa. This is possible with a combination of complementary fitting surfaces and strong ligaments.

Pressure across the joint surfaces (compression) provides the stability that permits such load transfer. The amount of pressure required varies according to the functional activity undertaken. Different strategies are required to provide varying degrees of pressure across the joint surfaces. Excessive, or insufficient, pressure across the SIJ can be identified as causes of deficient function and provide diagnostic clues (Vleeming et al., 1990b; Pool-Goudzwaard et al., 1998; Mens et al., 1999; Hungerford et al., 2003; O'Sullivan and Beales, 2007; Willard, 2007).

Flat surfaces have been found to be best suited for transmission of large forces, but they are also less resistant to shear (Snijders et al., 1993a, b). Two mechanisms contribute to prevent shear. The cartilage is thicker and changes in the sacral surface are more prominent in women. This may be related to childbearing and to a different position of the centre of gravity in relation to the sacro-iliac joint. The ''keystone-like'' bony architecture of the sacrum, wedged between the two ilia, wider anteriorly and cranially than posteriorly and caudally, would be a second factor. Finally, Vleeming proposed the concepts of form and force closure of the sacro-iliac joint (Vleeming et al., 1990a, b). Shear is prevented by a combination of the specific anatomical features (form closure) and the compression generated by muscles and ligaments (force closure) that can accommodate to specific loading situations. Force closure (Figure 1) has been defined as the effect of changing joint reaction forces generated by tension in ligaments, fasciae, and muscles and ground reaction forces.

In the ideal situation, force closure provides compression in a perpendicular plane to the sacro-iliac joint to overcome the forces of gravity. This has been termed a self-bracing mechanism (Snijders et al., 1993a, b). In the pelvis the self-bracing mechanism relies on the nutation of the sacrum. This movement is an anticipation for joint loading. Hodges et al use the terminology ''preparatory motion'' for the same phenomenon in the lumbar spine (Hodges and Richardson, 1996). Nutation tightens most of the SIJ ligaments, among them the interosseous and short dorsal sacro-iliac ligaments. The posterior parts of the iliac bones are then pressed together, thus increasing compression across the joint (Vleeming et al., 2008).

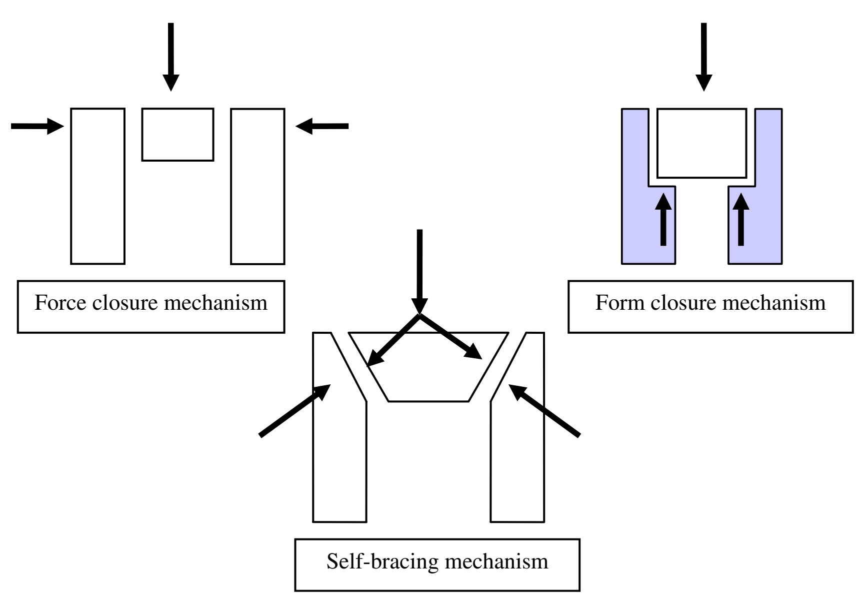

Figure 1 Diagrammatic representation of force closure, form closure and the self bracing mechanism of the SIJ.

Joint stability is the effective accommodation of the joints to each specific load through an adequately tailored joint compression, as a function of gravity, coordinated muscle and ligament forces, to produce effective joint reaction forces under changing conditions. Non optimal stability may be caused by altered laxity/stiffness of the joint, which results in increased joint translations or exaggerated joint compression.

Experienced clinicians can now confidently diagnose mechanical derangement of the sacro-iliac joint. The diagnosis is based on the assessment of function, rather than the traditional medical model of anatomical pathology, which has been impossible to demonstrate to date. The Integrated Model of Function (Figure 2) proposed by Lee and Vleeming (1998) is an elegant summary of present day thinking. It has been expanded to include motor control and emotions, which have been known clinically to influence the transfer of load across the joint (Moseley et al., 2004).

Mechanical assessment of the SIJ

Failure of load transfer through the SIJ (''SIJ instability'' or ''SIJ dysfunction'') can be diagnosed on the basis of history, clinical examination and imaging studies.

A. History

The typical presenting symptom is LBP (Vleeming et al., 2008; Merskey and Bogduk, 1994). Pain maps have identified the distribution of symptoms related to the sacro-iliac joint. It is never above the level of L5, and includes the overlying area, buttock and posterior aspect of thigh and lower leg. There is evidence that dysfunction of this joint could, similar to a herniated lumbar disc, produce pain along the same distribution as the sciatic nerve (Fortin et al., 1994a, b, 2003). The presenting symptom is often described by the patient as ''sciatica''. Episodes of pain are typically recurrent, triggered sometimes by trivial actions such as bending and twisting, without any substantial lifting involved. The initial episode can be either during or soon after pregnancy, or traumatic such as a fall, head on motor vehicle collision, 'hard braking' whilst driving a car or a transverse 'crushing' mechanism which compresses the pelvis. Pain is worse when the SIJ is loaded (sitting, standing, walking and negotiating stairs). Patients typically have difficulties turning in bed. Dyspareunia and changes in bladder habit are also common.

B. Clinical examination

Historically mechanical tests for the sacroiliac joint can be divided into two broad categories: pain provocation tests and palpation tests (for assessment of position and movement) There appears to be no single mechanical test for the sacro-iliac joint that provides sufficient reliable information. Studies have shown that if considered in 'clusters' their reliability increases (Laslett et al., 2005; Van Der Wurff et al., 2006; Robinson et al., 2007).

Manual tests attempt to identify structures and relationships that can give a clue to the cause of the pain. Manual tests rely heavily on the palpation skills of the examiner, and are ultimately ''operator dependent''.

Other tests assess the onset timing of muscle activity patterns around a joint, which in turn reflect motion patterns. There is a parallel situation in the assessment of patello-femoral joint as a cause of anterior knee pain (Cowan et al., 2001). For instance, transversus abdominis (TA) activation precedes independent arm movement in normal subjects, but it lags behind in patients with low back pain (Hodges and Richardson, 1996).

The following tests have been proven to appropriately assess different aspects of the function of the sacro-iliac joint.

1. The posterior pelvic pain provocation test (also known as thigh thrust) has been identified as reliable in the

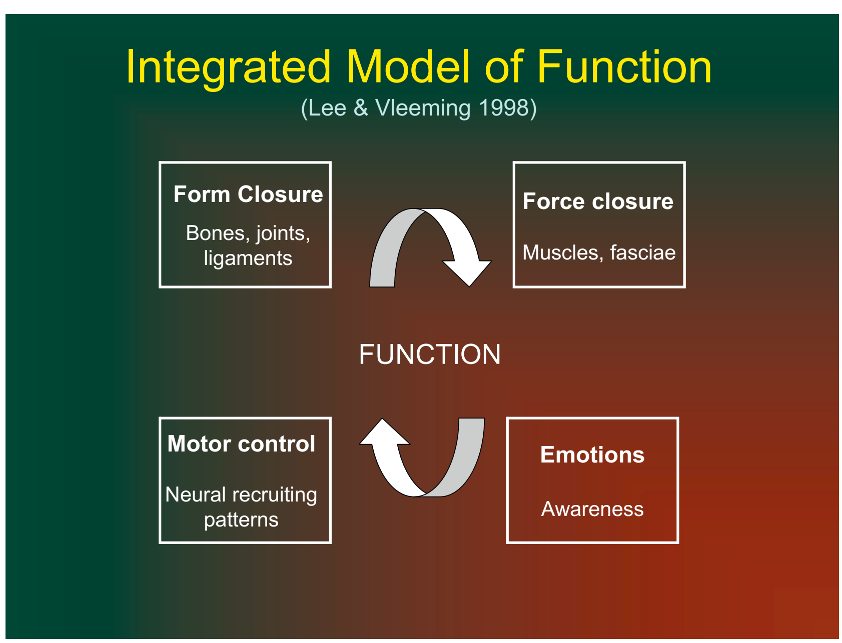

Figure 2 The integrated model of function of the SIJ (Lee and Vleeming, 1998).

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diagnosis of pelvic girdle pain in pregnant women (Ostgaard et al., 1994)
2. Palpation of the long dorsal sacro-iliac ligament (Vleeming et al., 1996, 2002). It becomes taut — and painful on palpation — when the sacrum is counter-nutated; it provides information on inappropriate patterns of relative motion between sacrum and ilium.
3. The Trendelenburg test in its different forms indicates poor muscle activity of gluteals (Malanga and Nadler, 2006).
4. The stork test (also known as Gillet test), assesses intra-pelvic motion (Hungerford et al., 2003, 2007; Cusi et al., 2008). More importantly, it recognises changes in muscle activation patterns in the action of weight transfer and elevation of the contra-lateral knee. In patients with sacro-iliac joint pain there is early activation of biceps femoris and delayed contraction of internal oblique and multifidus (the opposite of normal subjects).
5. The active straight leg raise (ASLR), tests the load transfer through the sacro-iliac joint, and has been shown to be reliable and reproducible (Mens et al., 1999, 2001, 2002, 1997; De Goot et al., 2008).
6. Patrick's Fabere and Gaenslen's test are also useful when used in clusters (Laslett et al., 2005).

Other clinical manouvres have been used by a large number of clinicians, and provide valuable information of intraarticular motion, when compared from side to side, particularly the SIJ glide test as described by Lee (Lee, 2007). A number of these clinical manouvres have been tested in pregnancy-related back and pelvic girdle pain (Albert et al., 2002) and confirmed that the joints of the pelvic ring can be examined reliably in a clinical setting.

C. Imaging

The sacro-iliac joint can be assessed with a variety of imaging modalities. Imaging of the SIJ has been traditionally based on the diagnosis of sacroiliitis. Sacroiliitis can be differentiated into ankylosing spondylitis, reactive arthritis, psoriatic arthritis, arthritis of chronic bowel inflammatory disease and undifferentiated spondyloarthropathy (Braun et al., 2000).

X-ray was historically the first modality used. Computerised Tomography (CT) scans are a superior modality to identify normal and pathological features (Lawson et al., 1982). However, degenerative changes are found sometimes in younger age group healthy individuals (Cohen et al., 1967). This questions whether normal development of symmetrical grooves and ridges can be considered as osteoarthritic changes, or rather normal changes within the life span (Dijkstra et al., 1989; Vleeming et al., 1992b).

Magnetic Resonance Imaging (MRI) scans provide further information that can be matched with scintigraphic uptake (Hanly et al., 2000). Description of findings in normal and pathological joints is available, and caution is required to avoid existing pitfalls especially in the diagnosis of sacroiliitis.

Nuclear medicine investigation is also a useful tool to assess the sacroiliac joint. Sacroiliitis, stress fractures and degenerative changes can be identified. Once again, caution is required because of the very low sensitivity and high specificity of nuclear imaging in the evaluation of ''sacroiliac joint syndrome'' (Slipman et al., 1996).

In summary, inflammatory processes, degenerative changes, fractures and stress fractures have been identified with sound use of the available imaging modalities, but it has not been possible to identify mechanical changes within the joint. Most research and clinical experience have concentrated on the anterior -synovial- and to a certain extent cartilaginous portions of the joint. However the ligamentous apparatus of the joint -that plays an important role in its function as a load transmitter- has resisted accurate imaging to date.

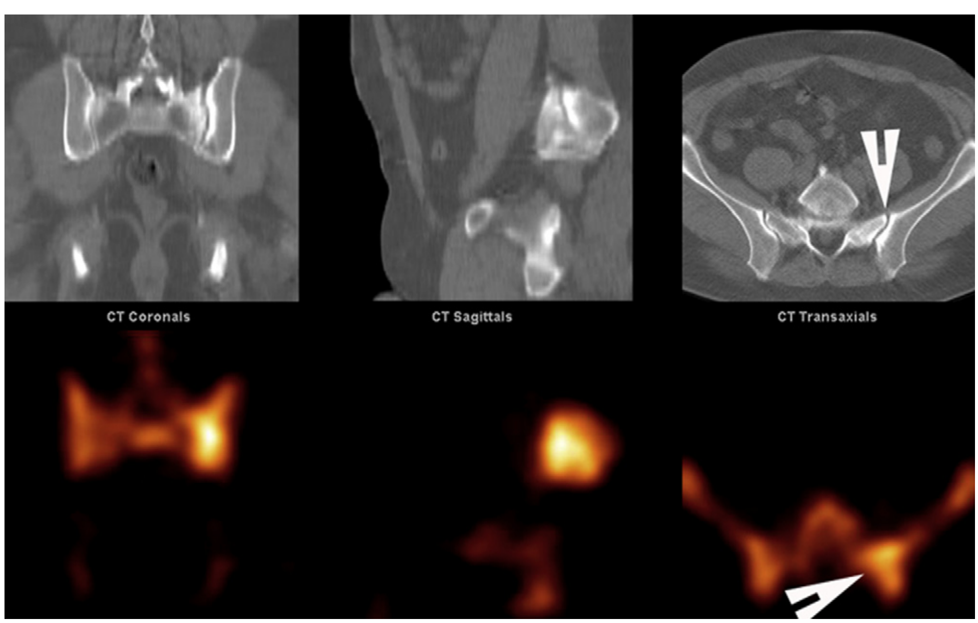

Figure 3 SPECT-CT of SIJ. Increased uptake in the left SIJ soft tissue region and the intense sclerosis of both sacral and ilial margins of the joint (arrows), indicative of mechanical stress. (image courtesy of M Cusi & H can der Wall).

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The combination of Single Photon Emission Tomography and CT scan (SPECT-CT, Figure 3) offers exciting possibilities. Early preliminary work undertaken by the author and colleagues suggest that SPECT-CT of the sacro-iliac joint can provide a specific set of images that matches the clinical diagnosis of failure of load transfer. Those changes include increased uptake in the ligamentous (posterior) portion of the joint and attachment of the interosseous ligament to the surface of the ilium and loss of the ''dumbell effect''. The pattern of contrast uptake is quite different to the images of degenerative changes or inflammatory disease of the sacro-iliac joint.

Improved understanding of the functional and biomechanical features of the sacroiliac joint provide the framework for the diagnosis of failure of load transfer through the sacroiliac joint, formerly termed 'instability'. In the author's opinion both terms could be used concurrently. Failure of load transfer is biomechanically more correct, but in a clinical setting the term instability refers to a constellation of signs and symptoms independent from the existing amount of movement within the joint, which is known to be minimal in any case (Sturesson et al., 1989).

Differential specific diagnosis

In the daily clinical setting the diagnosis of failure of the SIJ to transfer load does not indicate whether the failure is of force closure (altered neural drive, deficient muscle strength or dynamic ligamentous failure), or form closure failure (joint surfaces, capsule and passive ligaments as passive structures).

The specific diagnosis can only be made by exclusion, retrospectively. In cases where deficient stability of the sacro-iliac joint has been established, clinical experience suggests that exercise programs designed to increase appropriate compression have inconsistent results in terms of decreased pain and increased function. Exercise programs are successful when there is adequate ligamentous strength (Stuge et al., 2004, 2006). Patients who respond to a specific muscle strengthening program would qualify for the retrospective diagnosis of failure of force closure of neuromuscular origin. Response time can vary, but it can take three months for such programs to yield results (Stuge et al., 2004) (neuromuscular coordination, timing and onset of muscle activation and strength development).

Therapeutic alternatives

A. Exercise therapy. Assessment of levels, criteria for stage progression

Exercise therapy is considered the first therapeutic strategy once the diagnosis of load transfer failure has been made. A successful exercise programme needs to be specific, targeted and progressive (Hides et al., 2001; Mooney et al., 2001; Prather, 2003; Zelle et al., 2005). It can be divided into three stages (*Isolation, Combination, Function*). In each stage the patient learns to recruit the particular muscle or set of muscles being trained and develop both strength and endurance. Contractions are usually light (10% of a maximal voluntary contraction), as stabilising muscles will be active for long periods of time. Each stage needs to be completed before the patient can be progressed to the next stage in a safe and effective manner. The use of a sacro-iliac belt may assist some patients, especially in the early stages (Vleeming et al., 1992a).

Stage 1: isolation

Patients need to develop the ability to recruit the targeted group of muscles independently of other groups. The initial target is the so called ''inner unit'' and includes transversus abdominis (TA), deep multifidus and pelvic floor. Neuromuscular training is often the first strategy as it is necessary to change existing muscle recruitment pattern strategies that compensate for the relative inactivity of the deep stabilisers. Common compensation patterns are the use of internal and external obliques, hip adductors and hamstrings. These and other global muscles need to be ''downtrained'' (Lee, 2004). Re-training motor control is difficult for some patients. Real time ultrasound is a good teaching tool that gives patients a useful visual cue. Once recruitment is achieved strength and endurance are developed gradually, to prevent fatigue and inappropriate compensating muscle recruitment patterns.

Stage 2: combination

In the second stage those muscles are recruited in various combinations to develop endurance. This is usually achieved by adding 'challenging' elements to the contraction, and incorporating progressively activation of the larger superficial ''movement'' muscles. Examples of this would be non weight bearing, weight bearing, closed chain and open chain movements whilst maintaining controlled contraction of the deep muscles (TA, multifidus, pelvic floor) without unnecessary compensatory strategies such as isolating hip abduction from combined lateral trunk flexion and hip abduction. Added movements should be slow and measured initially, and become faster as control and endurance improve.

Stage 3: function

In the third stage the patient progresses to functional activities; daily living, work or sport physical requirements. It requires tailoring the exercise programme to the patients' needs and goals, whilst maintaining the guiding principles. It is always important to maintain good technique to prevent falling back to compensatory strategies. At higher level some muscles will change their mode of contraction from tonic to phasic, in keeping with functional demands (Saunders et al., 2005).

The specific exercises a patient does in each stage can vary according to what ''works for them'' that also works for the treating therapist. It is more important to adhere to the principles outlined above, and ensure that the patient is not compensating in some way by using 'the wrong muscles' to carry out the prescribed exercise.

In the author's experience, failure to respond to an exercise programme carried out along these three stages can be due to a variety of factors, intrinsic or extrinsic to the exercise programme. Intrinsic causes include:

- Poor design (exercises are not specific enough),
- Premature progression through the stages (neuromuscular patterns not established, insufficient endurance)
- Poor compliance
- Inappropriate exercise technique (exercises not done properly)

The treating clinician needs to be aware of these pitfalls to ensure that patients obtain benefit from the therapy.

Extrinsic causes are considered when a properly designed and executed exercise program is not sufficient to solve the problem, and the patient cannot reach the desired level of activity. It is reasonable to think that specific exercise programs fail when deficient ligament strength of the posterior elements of the sacro-iliac joint does not provide a sufficiently stable base to permit an effective muscle recruiting strategy (Pool-Goudzwaard et al., 1998). A mechanism that increases the passive stiffness of the joint would improve dynamic stability of the pelvis (force closure). In these cases the increased ligamentous stiffness would have the effect of providing a more stable anchor for specific strengthening programs to produce the desired outcome. Experimental work in rats indicates that prolotherapy may indeed be effective in building up collagen fibers and thus strengthening ligament (Dagenais et al., 2007a).

B. Prolotherapy

Prolotherapy is an injection therapy used to treat chronic ligament, joint, capsule, fascial and tendon injuries. The goal of this treatment is to stimulate proliferation of collagen at the fibro-osseous junctions to promote non-surgical soft tissue repair and to relieve pain (Klein and Eck, 1997). It has been defined by Hackett as ''the rehabilitation of an incompetent structure (such as a ligament or tendon) by the induced proliferation of new cells'' (Hackett, 1956). It is also called ''Regenerative Injection Therapy (RIT) (Reeves et al., 2008), ''Reconstructive Therapy'', ''Non-Surgical Tendon, Ligament, and Joint Reconstruction'' and ''Growth Factor Stimulation Injection''(Alderman, 2007).

The injection of various solutions aimed at producing a sclerosing effect to treat soft tissues injuries (e.g., inguinal hernia) has been used in modern times since the 1930s, when Schultz described a treatment for subluxation of the temporomandibular joint (Schultz, 1937).

Prolotherapy has been used extensively in the USA since the 1930s (over 450,000 patients) and in other countries around the world, but it is not a recognized 'main-stream' therapy. Indeed the question has been raised: ''Prolotherapy at the fringe of medical care, or is it at the frontier'' (Mooney, 2003). The abundance of case series studies and anecdotal evidence has not been supported by a large body of randomised controlled trials (Yelland et al., 2004a; Dagenais et al., 2007b). Two systematic reviews of the use of prolotherapy for chronic musculoskeletal pain (Rabago et al., 2005; Dagenais et al., 2005) have found a variety of randomised and non-randomised studies, but there is little standardisation of protocols, and generally limited high-quality data supporting the use of prolotherapy in the treatment of musculoskeletal pain or sport related soft tissue injuries.

Application to spinal pain

Prolotherapy is one of many interventional techniques applied to spinal pain. However, its published results have not been consistent (Klein et al., 1993; Yelland et al., 2004b; Linetsky and Manchikanti, 2005). A Cochrane Collaboration report concluded that: ''There was no evidence that prolotherapy injections alone were more effective than control injections alone, but in the presence of co-interventions, prolotherapy injections were more effective than control injections, more so when both injections and co-interventions were controlled concurrently'' (Yelland et al., 2004a). A large prospective, well designed randomised controlled trial of the injection of either normal saline or a mixture of 20% Dextrose with 0.2% lignocaine found that all patients with non-specific low back pain improved, irrespective of the solution injected or concurrent use of exercises (Dhillon, 1997; Yelland et al., 2004b).

Most studies that involve the use of prolotherapy in the treatment of spinal pain do not consider a specific clinical diagnosis for patient selection. They instead take a ''scatter-gun approach'' to treating all forms of low back pain without the initial establishment of a firm working diagnosis. Patient selection is based mainly on pain location, and the injections are given in the painful sites. Injected volumes depend on the number of sites injected, and the number of injections depends on symptom response.

A more functional approach has been used in a recently published case series. The population studied was 25 patients with failure of load transfer through the SIJ, who had not improved with a specific exercise programme along the guidelines outlined above. Patients underwent three CT guided injections of a small volume (1 ml) of 20% Dextrose in Bupivicaine 0.5% into the dorsal interosseous ligament. There was significant improvement both in the clinical examination parameters and in the functional questionnaires (Quebec Disability Scale, Roland Morris 24 and Roland Morris 24 Multi-form Questionnaires) at 3, 12 and 24 months (Cusi et al., 2008). This is a novel approach, as the indication for treatment was loss of function and a specific clinical diagnosis, not pain alone. The time between injections (six weeks) was based on the assumption that the inflammatory reaction and formation of collagen takes up to seven or eight weeks, and it is not necessary for the injections to follow each other closely. Three injections were considered sufficient to ensure a reasonable length of time for regeneration of collagen. This study suggests that

(a) It is possible to make a clinical diagnosis of SIJ deficient load transfer of ligamentous origin.
(b) Treatment with CT guided prolotherapy injections in the dorsal interosseous ligament of the affected SIJ — in combination with specific core stability training — can successfully correct the deficiency, reduce pain and improve function.

Further research is required to confirm these results with randomised control studies that compare prolotherapy to placebo injections.

C. Surgery

Surgical stabilisation has been advocated in patients with SI joint pain unresponsive to more conservative measures. Unfortunately, all published reports on SI joint fusion have been small case series or retrospective studies. Whereas the primary indications for SI joint fixation are either joint instability or fractures (Waisbrod et al., 1987), successful arthrodesis has also been reported for degenerative joint disease. It can be done as an open technique or percutaneously, with CT guidance (Arand et al., 2004). The success rate of SIJ arthrodesis is around 70%, regardless of the underlying pathology. In the case of instability it must be considered as a measure of last resort (Cohen, 2005).

Conclusion

The SIJ is potentially the source of LBP in a greater proportion of cases than previously anticipated. Mechanical assessment of the joint is now possible with a combination of specific historical findings, clinical manouvres and imaging tools. There are treatment strategies available to address mechanical dysfunction. A specific functional diagnosis is required to maximize their chance of successful outcomes.

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