The management of sacral stress fractures: current concepts

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Summary

Sacral stress fractures are an unusual but curable cause of low-back pain that should be considered in differential diagnosis, particularly in elderly osteoporotic patients. Rarely, they may occur in young women during the last trimester of pregnancy or a few weeks after delivery. Encompassing fatigue and insufficiency fractures, the occurrence of sacral stress fractures appears to be relatively under-reported, because of the general lack of awareness of this condition and the non-specificity of symptoms. Plain radiographs of the pelvis are the first exam performed but they are often inconclusive, whereas MRI and CT scans are the examinations of choice to establish the diagnosis. The purpose of this review is to increase awareness of this condition so that clinicians may consider sacral stress fracture in the differential diagnosis of low-back and pelvic pain, particularly in elderly patients without a history of trauma.

KEY WORDS: stress fractures; sacrum; insufficiency fractures.

Introduction

Currently, sacral stress fractures are considered an uncommon cause of low back pain, but their occurence is probably underestimated due to the lack of specific symptoms (1).
The diagnosis is often delayed or mistaken as there is limited awareness of this condition, leading physicians to perform unnecessary or even harmful exams.
The purpose of this review is to summarize the current concepts on these relatively unusual injuries and remind clinicians that sacral stress fractures must be considered as a differential diagnosis, particularly in elderly patients who are complaining of low back pain.
Laurie first described sacral stress fractures in 1982 (2). Nowadays, there is still little epidemiologic data, but the incidence of pelvic fractures in osteoporotic patients seems to be increasing – although this increase can be partially attributed to better imaging techniques.
Sacral stress fractures have been classified by Pentecost into two groups: fatigue and insufficiency fractures (3). The first category includes fractures occurring in a bone with normal elasticity and resistance exposed to abnormal or repetitive stresses, whereas insufficiency fractures occur in weakened bones under normal stress. Insufficiency fractures usually occur in elderly patients who have undergone radiotherapy or suffer from osteoporosis, rheumatoid arthritis, fibrous dysplasia, Paget's disease, osteogenesis imperfecta, osteomalacia and hyperparathyroidism. In addition, some rare cases are described in younger patients, with particular prevalence amongst long-distance runners and military personnel (4). Both fatigue and insufficiency sacral stress fractures have been occasionally reported during the last trimester of pregnancy and the early postpartal period (5, 6). Risk factors for sacral stress fractures during pregnancy or in the first weeks after delivery include vaginal delivery of a high-birth-weight infant, increased lumbar lordosis, excessive weight gain and rapid vaginal delivery. Other probable promoting factors could be vitamin D insufficiency, anticoagulant therapy with heparin and transient osteoporosis associated with pregnancy and lactation.

Fracture classification

No classification system thoroughly describes sacral insufficiency fractures. Nevertheless Denis et al. classified traumatic sacral fractures according to their location, subdividing them into 3 zones (7) (Figure 1). This system, even if it is not specific for sacral stress fractures, is still considered a useful method to predict potential complications of these lesions. Zone 1 fractures occur in the most lateral portion of the sacrum, the sacral wing. These injuries are not complicated by neurological symptoms, but occasionally nerve roots can be involved. Fractures in the second zone involve the sacral foramina, excluding the sacral canal. This condition is associated with unilateral lumbosacral radiculopathies. Zone 3 fractures occur in the body and in the canal of the sacrum; bilateral neurological symptoms, such as saddle anesthesia and loss of sphincter tone, are usually present.
The majority of sacral stress fractures occur predominantly in the sacral wing (zone 1) and they have a vertical course, running parallel to the sacroiliac joint. Rarely, severe stresses can cause additional transverse fractures involving the sacral body.

Clinical features

The clinical presentation is often variable. Patients usually complain of acute intractable low back or pelvic pain, associated with a severe reduction in mobility and a possible radiation to the leg, groin, buttocks and thighs without a history of trauma. Symptoms are exacerbated by weight-bearing activity, whereas they improve with rest and lying supine. Tenderness over the sacral area is a common and unspecific finding. Neurological defects are usually absent; they occur when the fracture involves the sacral body and they consist of radiculopathy, mielopathy, sphincter di-

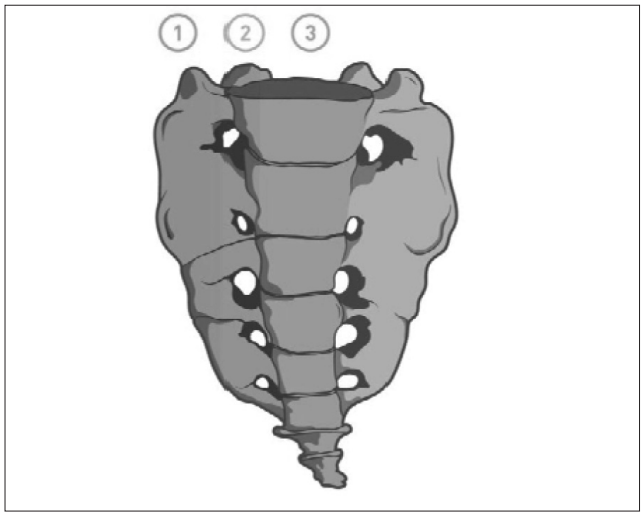

Figure 1 - Denis classification of sacral fractures (7).

sturbance and limb paraesthesia. The presence of these symptoms in combination with sacral stress fracture can be misleading and may contribute to the high number of misdiagnosed cases. Patients can also complain of tenderness over the parasymphysial area, due to the high incidence of pubic rami fractures in association with sacral stress fractures. Aretxabala et al. reported that 78% of patients with sacral stress fractures had a coexisting pubic rami fracture (8). Pelvis biomechanics dictate that the disruption of the pelvic ring at one side may increase stress on other parts of the ring itself, resulting in fracture (9).
Physical examination may reveal sacral tenderness on lateral compression; the flexion-abduction-external rotation (FABER) test, Gaenslen's test and the squish test are often positive (10). The FABER test is performed with the patient in supine position with the affected-side knee flexed to 90° and the foot leant on the controlateral knee. The examiner pushes the affected-side knee towards the examining table. If the action elicits pain, the test is positive. Gaenslen's test has the purpose to stress both sacroiliac joints simultaneously. With the patient lying on his back and the hip and the knee of the affected side flexed, the examiner hyperextends the opposite hip. Pain during the manoeuvre implies the positivity of the test. The squish test is performed with the patient in a supine position and the anterior-superior iliac spines are palpated. If pain is evoked the test is positive.
The results of neurological examination are often normal. Nerve root compression is uncommon but it may cause sphincter dysfunction and lower-limb paresthesias.

Laboratory findings

Laboratory data are usually unremarkable (11). In presence of reversible causes of secondary osteoporosis such as hyperthyroidism, hyperparathyroidism or osteomalacia, however, the presence of sacral stress fractures should be considered. Levels of thyroid-stimulating hormone (TSH), parathyroid hormone (PTH), calcium, phosphorus, albumin, 25-hydroxyvitamine D, urinary calcium, creatinine, full blood count, liver function tests, C-reactive protein (CRP) and erythrocyte sedimentation rate (ERS) must be investigated if secondary osteoporosis is suspected.
Serum levels of alkaline phosphatase (ALP), a marker of bone formation, are often slightly raised and this should lead clinicians to consider the differential diagnosis between stress fractures and an active form of Paget's disease.

Imaging

Radiographs
Plain anteroposterior and lateral radiographs of the pelvis, sacrum and lumbar spine are usually the first exam but they can detect only complete fractures (1). Unfortunately, early radiographs are often inconclusive also due to the presence of fecal material, vascular calcifications and bowel gas, which may overshadow the underlying fracture line. The fracture sometimes becomes evident only when the healing process is well underway.
Concomitant ipsilateral and controlateral pubic fractures may coexist and raise the suspicion of a fracture involving the posterior portion of the pelvic ring.
In case of multiple pelvic fractures, the radiographic appearance of the lesions could be misinterpreted as malignancy or metastatic disease due to the abundant osteoblastic reaction alternating with bone rarefaction.

Magnetic resonance imaging
According to many authors, magnetic resonance imaging (MRI) is the most sensitive screening methodology and it is considered the gold standard for the diagnosis of sacral stress fractures (1, 10, 11, 12). It can detect linear areas of low signal intensity on T_1 weighted images, which correspond to a stress fracture surrounded by bone marrow oedema, while T_2 weighted images demonstrate a high intensity signal region. T_2 weighted short tau inversion recovery (STIR) images are even more sensitive in showing the fracture line. In order to enhance MRI sensitivity, intravenous gadolinium may be used, but it is rarely necessary. When a horizontal component of the sacral stress fracture is suspected, coronal images are helpful. MRI is the investigation of choice also in pregnant or breast-feeding women because it does not require irradiation.

Computed tomography
Computed tomography (CT) is both sensitive and specific and it is a valid alternative to MRI in localising the fracture line. It can provide accurate images which highlight sclerotic healing or fresh fracture lines. The CT scan aspect varies depending on the degree of fracture healing. CT can be used together with MRI in order to rule out malignancy and osteomyelitis (10). Obviously, a CT scan cannot be performed during pregnancy and the lactation period.

Bone scintigraphy
Bone scintigraphy with technetium 99^m medronate methylene diphosphonate (MDP) is a sensitive technique for detecting sacral stress fractures. Nevertheless, since sacro-iliac joints have a physiological high MDP uptake, it can fail to reveal a bilateral fracture of the sacrum (10). In addition, the radioactive tracer needed to perform the exam limits its use in pregnant patients.

Treatment

Currently, there is no established best treatment for sacral stress fractures. In the past, therapy was limited to conservative management, including pain control, bed rest and physical therapy. Recently, new methods to promote fracture healing are under study. Here is our attempt to summarize recent advances in the diagnosis and treatment of these conditions.

Medication:

Pain control
The first step in the treatment of sacral stress fractures is pain control. A variety of analgesics that act centrally, such as paracetamol and opioids, are available in clinical practice and they should be used until pain resolves.

There are reasons of concern about the use of peripherally acting analgesics (NSAIDs) in fracture healing, because they block the activity of prostaglandins, especially PGE_2, which plays a significant role in bone healing (13). NSAIDs are associated with a high risk of delayed union or non-union of long bone fractures, even after surgical treatment (14). For this reason NSAIDs are not recommended for the therapy of sacral stress fractures.

Vitamin D and calcium
Vitamin D deficiency is a relatively common finding in the elderly. In the case of sacral fracture, a condition of vitamin D insufficiency must be suspected and an oral supplement of calcium and vitamin D should be prescribed. The International Osteoporosis Foundation has recently established the appropriate serum level of 25OHD for people over 60 years. It is approximately 75 nmol/L (30 ng/ml), which corresponds to a daily dose of 800-1000 IU of vitamin D (15).
Vitamin D can be administered as ergocalciferol (D_2) and cholecalciferol (D_3). Some studies considered these two forms equally effective, but the new international recommendations suggest that the latter should be preferred when available.

Bisphosphonates
Bisphosphonates are widely used for the treatment of osteoporosis. By binding to bone hydroxyapatite crystals and incorporating into sites of active remodelling, they inhibit bone resorption. In spite of their effectiveness in increasing BMD during the first months of therapy, there is a rising concern about long-term (more than 5 years) therapies. The decrease of bone resorption seems to severely alter the physiological sequence of bone turnover with a parodoxical effect of inhibition of bone formation (16). Experimental studies have shown non-compensated micro-damage as a result of reduced osteoblastic activity. In addition to this, a secondary hypermineralization may occur, with a significant production of brittle bone, which then predisposes the patient to further fractures. Another relatively rare side effect associated with bisphosphonate therapy is osteonecrosis of the jaw, although it seems to be more likely to occur during the treatment of malignancy than osteoporosis. These observations, together with the above-mentioned concerns, should be borne in mind by clinicians. The physician should consider interrupting a prolonged bisphosphonate therapy in patients with insufficiency fractures.
Clinical trails are needed to prove any effect of bisphosphonates on stress fracture healing in humans (17). Until these data are available, it is advisable to limit its employment in clinical practice.

Calcitonin
Calcitonin is licensed for the prevention and treatment of postmenopausal osteoporosis. It increases bone mass by reducing bone turnover and it reduces the risk of vertebral fractures. In addition, it is also an effective analgesic for bone pain. It can be given subcutaneously (100 U daily) or as a nasal spray (200 U daily).
Unfortunately, its low potency compared to other treatment options limits the use of calcitonin in clinical practice to patients who are unable to take other anti-osteoporotic agents.

Raloxifene
Raloxifene is a selective estrogen receptor modulator (SERM) adopted for the prevention and treatment of post-menopausal osteoporosis. Together with bisphosphonates and calcitonin, it belongs to the antiresorptive therapies. Treatment with raloxifene reduces vertebral fractures risk relative to placebo in post-menopausal women, while its efficacy has not been demonstrated on non-vertebral fractures (18).
Raloxifene may not be considered the first line therapy for osteoporosis due to the increasing risk of thromboembolic events.

Strontium ranelate
Strontium ranelate reduces bone resorption and increases bone formation by promoting the production of different cytokines, which down-regulate osteoclastogenesis and increase osteoblasts formation (19). It also has a protective effect on osteoblasts under stress. All these actions contribute to strontium ranelate's anabolic and anti-resorptive mechanism.
It represents an alternative to oral bisphosphonates, because it is better tolerated by patients.

Teriparatide
Teriparatide is a recombinant human PTH. It increases trabecular and cortical bone formation more than it inhibits bone resorption, especially at the beginning of the therapy (20), reducing the risk of vertebral and non-vertebral fractures. The maximum length of treatment with teriparatide is two years, because of the limited information on its effects beyond this period, and the increasing risk of developing an osteosarcoma.

Bed rest and early mobilization
An important question that arises with sacral stress fractures is whether to permit weight-bearing, or to treat patients with bed rest. Conservative management usually forces patients to stay in bed for 3-6 months, which may increase to a year in the case of poor bone healing. The risks of such a long immobilization are high and they may result in accelerated loss of bone mineral density, increased incidence of deep vein thrombosis, pulmonary embolus, loss of muscle strength, negative calcium balance, decubitis ulcer, pneumonia, reduced performance of the cardiovascular system, urinary tract complications and even worsening osteoporosis (21) – without considering the psychological side effects. In order to avoid or minimize these adverse effects, a rapid return to an active life style with an early mobilization for stable sacral stress fractures which don't require surgical intervention should be recommended. The advantage of an early rehabilitation is the stimulant effect of weight-bearing and muscle tension on osteoblastic activity, which results in bone formation, whereas a prolonged bed rest may cause unrestrained osteoclastic-mediated bone resorption.

Pulsed electromagnetic fields (PEMF) and low intensity pulsed ultrasound (LIPU)
The use of electrical stimulation to heal fractures has a long history. The basic principles underlying this therapy come from the observation that bone tissue has electrical properties. In fact, when bones are under compression they generate electronegative potentials, while areas of tension create electropositive potentials. These electric fields induce a reaction in bones: bone formation in electronegative regions and bone resorption in electropositive sites. Since electric fields modulate bone cell activity, the enhancement of bone formation can be achieved with electrical stimulation devices.
PEMF is an FDA approved, non-invasive tool which creates a magnetic field and a secondary electric impulse. It exerts its effects by increasing cytosolic concentration of calcium ions released by intracellular stores. This activates a series of enzyme reactions, which stimulate gene transcription of several growth factors (including BMPs and TGF-β) and some proteins such as calmodulin. The up-regulation of these physiological molecules contributes to bone cell proliferation and fracture healing.
It has been demonstrated that one of the main advantages of this physical stimulation is that it increases the production of different substances required for the physiological bone healing process. This has been compared to another therapy for fracture healing that consists of the local application of a single growth factor in the fracture site (22). The latter treatment showed side effects such as ectopic bone formation, antibody reaction and bone resorption,

whilst electromagnetic impulses have never given adverse effects. Low intensity pulsed ultrasound (LIPU) is another physical technique to stimulate bone cell activity. It seems to have a direct effect on ion channels, but at present a specific mechanoreceptor has not been identified (23).

Extracorporeal shock wave therapy

Shock waves (SW) are high-energy acoustic waves which pass through the body, and by their mechanical effect create a biological response in tissues. They generate a large amount of microbubbles (the cavitation effect) which are subjected to ultrasound and, undergoing compression cycles of negative and positive pressure, release energy, stimulating the production of different growth factors.

The aim of shock wave therapy in orthopedics is to enhance bone repair, by increasing mesenchymal stem cell recruitment and proliferation and their differentiation into osteoblasts, which lead to bone formation.

Although the biological mechanism of SW is still not completely understood, a recent study conducted on rats (24) with a segmental femoral defect showed that SW promote fracture healing, increasing the local concentration of TGF-β and VEGF. TGF-β acts as a potential chemotactic stimulator and mitogenic substance for mesenchymal stem cells, and VEGF as a modulator of angiogenesis, up-regulating blood flow in a fracture site.

These findings suggest the possible application of SW treatment as an alternative method to promote healing in sacral stress fractures (25).

Interventional methods under study

Vertebroplasty has recently been used to treat sacral stress fractures (sacroplasty) and it seems to be a simple and cost-effective method to treat these lesions. In spite of this, sacroplasty is nowadays limited to a reduced number of patients in specialized centres because there is still concern about the long-term outcome of this interventional treatment option.

In order to fill the fracture lines, small quantities of bone cement (polymethylmethacrylate -PMMA) are injected percutaneously under CT guidance by an interventional radiologist, with the patient prone and lightly sedated. After the procedure, the patient remains supine for 30 minutes, but he may sit up again after 2 hours and begin to re-mobilize the same day. Pain scores are significantly reduced within hours. Patients rehabilitate quickly and do not report significant pain at 6 months and 1 year follow-up. This technique is more widespread in the USA, where over 150 cases have been treated and so far no complications have been reported (21). Nevertheless, a caveat must be raised on the lack of long-term studies on the duration of bone stabilization, the possible adverse effects due to the exothermic reaction of PMMA on nerve vessels and bone (osteonecrosis), and the risk of nerve damage if the cement should spread.

Surgery

Surgery is not the first option in the management of sacral stress fractures. Patients usually undergo surgical treatment if there is instability or detectable motion at the fracture site, or if neurological defects or severe disruptions of sacrum alignment are present. Surgical treatment consists of osteosynthesis that can be achieved with the implantation of screws or hinge fixation.

Clinicians must bear in mind that sacral stress fractures are more often diagnosed in the elderly, who usually suffer from osteoporosis. The impaired quality of bone forces surgeons to reinforce sacroiliac osteosynthesis with supplementary cement (PMMA). At present, no adverse effect to this substance has been reported, but there are concerns about its use so close to neural structures.

Another problem is the lack of long-term studies on stability; currently there is only limited data on the risk of secondary dislocation of the implants (26).

Conclusion

Although uncommon, sacral stress fractures are an important and curable cause of low-back pain. They should be suspected in elderly patients suffering from low-back or pelvic pain without a history of trauma. Nevertheless, physicians should be aware that sacral stress fractures are not limited purely to older patients. A stress fracture diagnosis should be considered also in young women, who present a sudden onset of low-back and pelvic pain particularly during the last trimester of pregnancy and the first weeks after delivery, or if they received anticoagulant therapy with heparin during pregnancy.

So far, because of the lack of specificity of symptoms and because clinicians are not familiar with this condition, its occurrence is probably underestimated. MRI and CT are considered the most sensitive examinations for establishing the diagnosis. Although rest and several pharmacological agents can be used, there is an emerging role for biophysical stimulation therapies which have the advantage of minimal, or no side-effects. More studies are probably necessary before considering surgery a safe therapeutic tool for the treatment of sacral stress fractures.

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