TRAUMATIC SPONDYLOLYSIS IN A HEPTATHLETE: A CASE HISTORY AND REVIEW

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ABSTRACT

Objective: To summarize the literature on stress fractures amongst athletes and to present an unusual case of an L2 stress fracture in a heptathlete who was successfully treated initially with chiropractic care and then aggravated by it.

Clinical features: An elite heptathlete was diagnosed with bilateral pars interarticularis stress fractures of the L2 vertebrae. She initially presented for chiropractic treatment with unremitting low back pain. This followed previous successful treatment for back pain. After a series of unsuccessful treatments a second opinion (chiropractor) was sought. After a thorough history and examination, a series of radiographs were performed. Single photon emission computed tomography (SPECT) imaging confirmed the presence of bilateral spondylolysis at L2.

Intervention and outcome: The patient began a graduated return to function that was initially based in rest and avoidance of all extension and rotational movement of the lumbar spine. Management gradually returned the patient to general activity followed by more progressive and sport specific activity after the fracture had sufficient time to heal.

Conclusions: This case highlights the importance of considering the type of pain, its location, the mechanism of injury, imaging studies and the result of the treatment in the short and medium term in establishing an accurate diagnosis of stress fracture of the pars interarticularis. (*J Chiropr Med* 2005;4:89–96)

Key Indexing Terms: Chiropractic; Fractures, Stress; Low Back Pain

INTRODUCTION

A stress fracture is a partial or complete bone fracture. It results from repeated application of a stress lower than the stress required in order to fracture the bone in a single loading.¹ Stress fractures represent overuse injuries of bone and have been increasing as a problem over the past two decades.² It has been said by Brukner et al³ that the cause for the increase has been the trend towards increased volume of training in all sports. Most literature on stress fractures is focused on elite or competitive level athletes. There are also numerous studies in which stress fracture rates in basic training military populations are reported.^{4,5}

The history of the patient with a stress fracture is typically one of insidious onset of pain with activity. As the athlete continues to exercise, the pain generally becomes more severe. On physical examination there is localized bony tenderness or occasionally redness, swelling or periosteal thickening at the site of the stress fracture. The majority of stress fractures are diagnosed clinically and various imaging techniques can be used to confirm the diagnosis.⁶ The case below highlights the issues associated with making a diagnosis of stress fracture in the lumbar spine. It highlights key issues in the diagnostic protocol.

CASE REPORT

A 21-year-old elite female heptathlete with 4 years of training experience complained of low back pain that was worse on the right side. The pain began during the second day of a heptathlon event (heptathlon consists of 100m hurdles, high-jump, shot-put, 200m, long-jump, javelin and 800m events in two consecutive days) while competing in the javelin. She felt sharp pain in the mid lumbar area of her back when she stood up to complete her final throw. After a few days of rest the pain reduced to a dull ache.

During the next 2 months she trained and competed intensely and experienced periods of mid-lumbar pain after and during her training session. She re-

ceived treatment consisting of deep tissue massage and the application of hot and cold packs. These modalities provided temporary relief to the region for a day or two but returned after training sessions. Unfortunately, the above treatments did not aid her recovery and the dull low back pain became worse. During the 2 month period, the low back pain progressed with increased muscle spasm of the right mid lumbar area. She complained of decreased overall flexibility and pain made worse during prolonged sitting. Standing up from a sitting position was also very painful. Episodes of night pain were also present.

At this stage she stopped competing and training completely. She denied radicular symptoms, paresthesia, dysesthesia, numbness, weakness or changes in bowel and bladder function. Her medical history was otherwise unremarkable. She had normal menstruation and a healthy diet. She did mention experiencing a hyperextension fall while training 2 weeks before the onset of pain. This fall produced mild discomfort for a day or two and then resolved after a week of rest.

On presentation to a manual therapist (8 weeks after the javelin throw and 10 weeks after the fall) her examination was significant for bilateral lumbar paravertebral muscle spasm and right quadratus lumborum muscle spasm. There was increased pain on extension and to a lesser degree flexion. Right and left Kemp's test produced pain; this pain was sharp extending over the mid lumbar area. Motion restriction was noted on palpation at the L4 and L5 vertebrae. Deep tendon reflexes and sensory and motor testing were normal.

A lumbar manipulation was performed with the intention to aid movement of the L4 and L5 vertebrae. The aim of the manipulation was to improve facet mobility as it was thought that the history was indicative of possible L5 facet capsulitis. Sharp pain and discomfort was felt during and after the manipulation. All movements following the adjustment were painful. Ice was applied intermittently over a 48-hour period but there was only mild pain relief. A week later further manipulations were performed (after negative provocation testing) and mild relief was achieved. Non-prescription analgesics were taken for a few days with no significant improvement.

After consultation with a chiropractic practitioner who took the above history, a preliminary diagnosis

of stress fracture of the pars interarticularis was made. Lumbar spine radiographs were taken to determine if there was a stress fracture present. The oblique lumbar films vaguely indicated a fracture line through the pars interarticularis of the L2 vertebrae on the right side (Fig 1). It was less clear from the x-ray if the left side was affected (Fig 2). A bone scan was performed demonstrating increased uptake of the L2 posterior elements (Fig 3). A diagnosis of L2 bilateral pars interarticularis stress fracture was made. The fracture was described by the radiologist as being moderately recent (ie, 2–3 months old).

The patient was advised to rest completely for 6 weeks. A course of anti-inflammatory medications and cryotherapy was recommended for a period of 5 days, which decreased the inflammation and pain. A program of gentle stretching and light upper body weights commenced approximately four weeks after the diagnosis was made. She also began non-weight bearing running in the pool and other gentle swimming sessions. She was advised to avoid any activity

Figure 1. The right pelvic oblique shows a well defined defect with a sclerotic margin in the pars interarticularis, indicative of an old fracture.

Figure 2. This image demonstrates a less well-demarcated defect is observed in the corresponding area in the left pars interarticularis (compared with Figure 1).

Figure 3. Frame 10 of the SPECT bone scan illustrates increased metabolic activity in the posterior elements of L2 bilaterally.

involving hyperextension of the spine and to avoid painful movements. She was told to avoid any activity that caused pain.

Another bone scan was taken 3 months after the initial bone scan (6 months after the initial injury) to assess whether any healing had taken place. Unfortunately the scan did not show any change from

the previous one. During the next 6 months she gradually increased her training program. Most of the training sessions consisted of a general strength and conditioning program such as weights and long runs. Occasionally she felt intermittent low back pain after sitting for long periods. Approximately 9 months after the initial injury she received manipulation of the L4/5 lumbar segment which provided relief to the intermittent pain she was experiencing.

Ten months after the initial injury she began technique training focusing on the long-jump and shot-put only. She began competing 12 months post injury and placed 6th and 7th respectively in a State Championship. During her first long-jump of the competition she felt mild pain in her low back, but it only lasted a few minutes. Her performances were not far from her previous best in those two events. Currently she continues to train for long-jump only. She intends to focus on that event in the future. She has decided to avoid the heptathlon due to the ongoing strain that events such as javelin and high-jump place on her low back.

DISCUSSION

Stress fractures are usually limited to the lower extremity weight bearing bones but they can also occur in non-weight bearing bones such as the ribs and the upper limb.^{2,3} They have been reported to occur in most bones including the femur, pelvis, talus, tarsals, navicular, spine, fibula, calcaneus, and radius.²

A study of 180 cases of stress fractures found that dancers had the largest number of metatarsal stress fractures, track and distance runners sustained the most tibial stress fractures and both runners and dancers had the most fibula stress fractures.⁷ Navicular stress fractures were most common among track athletes. Pars interarticularis stress fractures were seen among athletes in field events, racket sports, cricket, dancing and basketball. Rossi⁸ found that divers, weightlifters, wrestlers and gymnasts were also prone to spondylolysis. Other sports are associated with specific stress fractures such as rowing and golf (rib stress fractures),⁹ pitching (humeral stress fractures) and gymnasts (pars stress fractures).¹⁰ Although various sports are more commonly associated with specific stress fractures, virtually any stress fracture can occur in almost any sport.³

Risk factors for developing a stress fracture are multifactorial and may be dependant on a number of factors, including the patient's gender, age, type and level of activity.¹¹ Low bone density could be a factor in the development of stress fractures due to the reduction in bone strength, which increases the micro-damage that occurs when repetitive loading takes place.¹² It is also thought that bone geometry is a factor, such that bones with a larger cross-sectional area and in which bone tissue is distributed further away from the neutral axis will be stronger when subjected to load.¹³ Brukner et al³ suggest that another risk factor in developing a stress fracture is poor skeletal alignment, as it is thought that mis-alignment may create stress areas in bone or promote muscle fatigue.³ According to research by Brukner et al⁶ and Bennel et al¹⁴ stress fractures may be more common among female athletes who have menstrual disturbance. There are many extrinsic factors that can influence the development of stress fractures including training errors, hard or soft training surfaces, inappropriate shoes or equipment.³ A family history of osteoporosis is considered to be a risk factor for low bone density and osteoporosis in both men and women.^{15,16}

Spondylolysis refers to a stress fracture through one or both sides of the pars interarticularis, the narrow portion of bone that lies between the superior and inferior articular facets of the vertebral arch.^{17,18} The term spondylolisthesis refers to complete bilateral defects in the pars interarticularis and anterior displacement of one vertebra on another due to removal of the bony support from the vertebrae.⁹ Approximately 90% of spondylolyses occur at L5.^{3,17} The remaining 10% are found throughout the other lumbar and cervical vertebrae. It has been shown that 5% occur at L4, 3% at L1, L2, L3 and 2% at C5, C6, C7.¹⁹ Since most cases occur in the lumbar spine, which is subject to much stress in the erect position, it is possible that spondylolysis represents either a stress fracture from repeated stress or an ordinary fracture from a single injury.²⁰⁻²⁴

Incidence and Etiology

Spondylolysis may develop early in life but has not been shown to be present from birth.²¹ In a study by Fredrickson et al²¹ the incidence of spondylolysis at the age of six years was 4.4 % and increased to 6 % in adulthood. In almost all cases the children are completely pain free especially before the age of 10. After the age of 10, incidence of spondylolysis in-

creases, especially among people involved in athletics.¹⁰ They are most commonly diagnosed between the ages of 10 and 15.¹⁹ The incidence of spondylolysis varies greatly from study to study. A study by Micheli and Wood²⁵ of 100 adolescent athletes presenting to Boston Sports Medicine Hospital with low back pain and 100 adults with low back pain found that 47% of the 100 adolescents had a spondylolysis stress fracture of the pars interarticularis. By contrast, 5% of the adult subjects were found to have spondylolysis associated with low back pain.²⁵ This indicates that adolescent athletes have a much higher incidence of spondylolysis than the general population.

A report by Rossi²⁶ in 1978 reviewed 1430 lumbar spine radiographs of athletes aged 16 to 27. Of the athletes studied 16.7% were found to have spondylolysis and/or spondylolisthesis. This was significantly high compared with the incidence in the general population. Further studies by Jackson et al²⁷ have found that the incidence of spondylolysis in the female gymnast is four times as high as that in the general population.

One of the major causes of spondylolysis can be classified under the category of acquired stress fractures. Wiltse et al²⁸ have proposed that spondylolysis is a fatigue fracture caused by recurrent mechanical stress. Yochum and Rowe¹⁹ suggest that the upright posture of humans, combined with additional repetitive hyperextension mechanical stress, would appear to be a significant etiological factor. This theory is supported by the fact that the earliest reported cases of spondylolysis are shortly after walking begins in the toddler.^{29,30} Newman and Stone³¹ imply that there may be a correlation between the onset of the pars defect, development of the lumbar lordosis, and infant falls especially if premature walking occurs. These falls can place great strain on the posterior vertebral structures of the immature skeleton, although no definitive conclusion can be made about causation.

Secondly, there appears to be an increased prevalence of pars interarticularis stress fractures in athletes that participate in certain sports that involve stressful movements of the lumbar spine.¹⁹ Research by Alexander²³ has concluded that there are three major movements and the sports associated with the movements that increase risk of spondylolysis. This includes sports that involve axial loading of the spine, such as weightlifting and powerlifting,

and sports where there is repetitive rotation such as squash, racket ball, tennis, baseball and golf. Thirdly, sports that involve arching or extending the spine such as skiing, tennis, badminton, American football, volleyball, basketball, rowing, gymnastics, cricket fast bowling, swimming and diving are associated with an increased risk of spondylolysis.

It is thought that there are some genetic factors that may predispose an individual to develop a defect.^{19,21} If the defect is purely mechanical in origin, the amount and distribution of cortical bone within the pars interarticularis must be important.¹⁹ The presence of a thin pars interarticularis may be due to genetic factors. Architectural abnormalities such as lumbarization, sacralization, and spina bifida occulta have been associated with spondylolysis in varying degrees.²¹

Acute trauma can also cause a spondylolysis to occur. It is thought that it is rare for an acute traumatic fracture to occur through the pars area, creating a spondylolysis without fracture in another part of the vertebrae (ie, compression fracture).¹⁹ A case reported by Klinghoffer and Morton³² did report a pars defect following a car accident. This case is considered to be a rarity. There are various disease processes such as osteoporosis, osteopetrosis, metastatic carcinoma and Paget's disease, which may also cause spondylolysis.¹⁹

It is thought that pars stress fractures are caused by repetitive extension,²⁰ or flexion and extension combined with rotation;^{24,33} this results in excessive anterior shear forces on the spine. As the shear forces increase, pressure is transmitted from the facet joints to the pars interarticularis.³ The biomechanics of the lumbar spine concentrates shear forces on the pars interarticularis and rarely affects the pedicles or the articular facets.²⁶ This explains the high incidence of stress fracture to the pars interarticularis compared to other vertebral elements. The pars is also believed to be mechanically weaker than the pedicles.²⁶ In young people the pars is thin, the neural arch is not strong and the intervertebral disc is least resistant to shear.^{34,35}

The serious gymnast who has been training for a number of years can develop the syndrome that leads to spondylolysis.^{36,37} The excessive mobility that a gymnast must develop results in the overstretching of the stabilizing system of the spine. When this occurs, there is static and dynamic strain

placed on the lumbar spine, especially during hyperextension. Such hyperextension can lead to hyperlordosis.³⁸ This mechanism of injury implies that great strain is placed on the posterior structures of the vertebrae.

Imaging

Radiographic evaluation and bone scintigraphy can be used to diagnose the presence of spondylolysis.³⁹ More recent imaging techniques such as computed tomography (CT), single photon emission computed tomography (SPECT) and magnetic resonance imaging (MRI) are more sensitive in the diagnosis of a pars lesion than plain films.⁴⁰ The most definitive imaging modality to characterize the pars defect is computerized tomography.^{19,26}

The radiographic evaluation should include anteroposterior, lateral and oblique views of the spine. The oblique view is the best view for diagnosing pars abnormalities above L5 and should be performed bilaterally.¹⁹ A pars defect will appear as an irregular linear radiolucency in the area of the pars. The bony margins of the defect may be sclerotic if the defect is chronic. Importantly, stress fractures characteristically have a 'sub-radiological' period during which the radiographs will appear normal. The time taken to develop the radiological defect may be several months.⁴¹ This makes it necessary to use other modalities in order to diagnose the early stages of the spondylolytic defect.

A method called planar technetium-99 will show bony remodeling ahead of radiographic changes, but cannot detect the earliest changes that are diagnosable with SPECT scanning.^{42,43} Due to its limited resolution, planar technetium-99 is not capable of distinguishing spinal elements or may miss less active sites.⁴² SPECT scanning provides high specificity and sensitivity in diagnosing stress injuries to the posterior vertebral elements.^{42,44,45} It is a more sensitive indicator of bone remodeling than planar technetium-99, and by the virtue of multiplanar tomography, anatomic localization is greatly enhanced.⁴² The posterior neural arch is easily separated from the vertebral body, and so acute stress reactions of the body, pedicles, pars or lamina may be localized. The major advantage of the SPECT technique over planar imaging is that it is a three dimensional imaging technique compared to the two-dimensional planar technique.^{19,46}

If a stress fracture of the pars interarticularis is diagnosed, a CT scan can be used to characterize the pars interarticularis stress fracture and rule out pedicle involvement.⁴¹ CT can be used to assess the appearance of the bony lesion, determine the type of fracture and the treatment course. It can determine whether the fracture is acute or chronic. A repeat CT scan to assess healing should be considered. A normal CT scan as well as a reverse-gantry angled CT scan can be performed. The reason for the reverse-gantry angled CT scan is the belief that spondylolysis is difficult to diagnose with regular CT scanning because the plane of the scanning may be parallel to the fracture.⁴⁷

MRI is another modality that can be used to view spondylolysis. According to Yochum and Rowe,¹⁹ sagittal T1- and proton density weighted images are the most accurate for demonstrating the pars defect because they permit better differentiation between cortical and medullary bone. An abnormally high signal within the area of the defect suggests bone marrow edema, the precursor of the development of spondylolysis. MR imaging with SPECT scanning can be used to confirm the presence of active spondylolysis. To date, there are no studies completed to directly compare the use of MRI, CT and SPECT.⁴⁰

Case Analysis

The main challenge with this case was determining whether the etiology of the pars defect was mechanical stress due to overuse or trauma. This athlete was involved in intensive training and competition in high-jump and javelin, which involve axial loading, rotation and hyperextension movements of the spine. This would place great mechanical stress on the spine and possibly induce a stress fracture. There was also a traumatic event 10 weeks prior to presentation when the pars stress fracture was first diagnosed. The fall occurred while she was running down a steep sand hill in training and she described that a "cracking noise" was heard at the time. It was a head first fall with the legs coming over her head causing extreme hyperextension of the spine. Another possible hypothesis is that the stress fracture was long standing and that the fall aggravated it.

The x-ray findings support the theory that the fracture was caused by the traumatic event. The x-ray showed a clear fracture line on the right pars at L2 but not on the left. In most instances it has been shown that patients with bilateral, well corticated

smooth pars defects have had these lesions prior to any recent traumatic event.¹⁹ It is obvious by observing the x-ray that the stress fracture did not show clear cortical margins on both sides. According to research, a positive SPECT scan should confirm a direct cause and effect relationship between the trauma and the patient's lumbar pain.¹⁹ This patient had a positive SPECT scan indicating that the hyperextension injury was most likely to be the cause of the injury.

The location of the pars defect at the L2 vertebrae also suggests that the aetiology of the pars stress fracture was trauma. Most spondylolyses occur in the neural arch of the fifth lumbar vertebrae.^{10,17,19} According to Hutton et al¹⁰ high force is transmitted across the L5-S1 intervertebral disc and the apophyseal joints. This is due to the abrupt change in rigidity across the lumbosacral junction where the flexible spine meets the rigid pelvis. So, in the case of the heptathlete with a pars defect you would assume that a stress fracture due to mechanical stress would occur at L5 rather than L2. It would be more likely that a traumatic event would produce a stress fracture at the L2 vertebrae.

Assuming that the cause of the stress fracture was trauma, it was necessary to highlight the need for a thorough history to diagnose the condition earlier. The type of pain associated with spondylolysis was mild low back pain associated with athletic activity. These symptoms may be associated with vertebral fractures, disc injury, tumor, infection, congenital abnormalities, facet syndrome and sacroiliac syndrome.¹⁷ By determining key history findings, such as the presence of night pain, the athletic events performed by the athlete, and the previous traumatic event, a more probable diagnosis of pars interarticularis stress fracture was made. The pain increased progressively with activity, also a classic sign of stress fracture. Early recognition of spondylolysis and appropriate early treatment in the acute phase leads to enhanced therapeutic results.¹⁷

This case demonstrated an alternative treatment of pars interarticularis stress fracture. The classic treatment for pars interarticularis stress fracture is a modified Boston brace for a period of six months for 23 of 24 hours a day or until the SPECT scan becomes negative.^{17,48} In this case the patient chose not to wear a brace but rested for a period of six weeks and then began a period of rehabilitation. Such approaches to management are common but

relatively unsupported by the literature.⁴⁹ This included non-weight bearing exercise such as light upper body weights and stretching exercises. She also performed some pool work consisting of cycling in the water while holding onto the edge of the pool and kicking in the water while lying on her back (to reduce extension). She continued this program for approximately 8 weeks. During this time she avoided any hyperextension movements of the spine. She gradually increased her training sessions and began specific back strengthening exercises and light running approximately 5 months after the initial diagnosis was made. At approximately 6 months after the initial diagnosis, she received manipulation of the L4/5 lumbar segment (after negative provocation) that relieved some low back pain she was experiencing at the time.

The athlete returned to competition within 9 months of being diagnosed with the pars defect following the treatment and rehabilitation described in this case. She did not return to the heptathlon for fear of aggravating her back further. She did return to one of the heptathlon events, the long jump.

CONCLUSIONS

This case highlights the importance of considering the type of pain, its location, the mechanism of injury and the result of the injury in establishing an accurate diagnosis. The history highlighted the nature of the pain (constant, dull and aggravated by activity), its presence at night and that it was aggravated by most movements of the lumbar spine (especially manipulation). It is likely that lumbar extension (especially the standing single leg hyperextension test), compression and percussion testing would help establish the provisional diagnosis of stress fracture. The diagnosis can be confirmed by appropriate imaging (SPECT scan).

Given the similarity of presentation of facet joint injuries that are amenable to manipulation and the pars stress fracture that is contra-indicated to manipulation, those practitioners utilizing manipulation are cautioned to consider the diagnosis of stress fracture. This is essential when individuals present with a hyperextension injury.

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