REVIEW

Spondylolysis in young tennis players

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The general aetiology, diagnosis, and treatment of spondylolysis, a bone defect in the pars interarticularis of the vertebra, are reviewed. A retrospective study of young tennis players diagnosed between 2000 and 2004 with spondylolysis with or without spondylolisthesis, assessed by radiography and planar bone scintigraphy, is described. If the radiographic results were negative, computed tomography was performed. Sixty six cases were evaluated: 53 L5 lesions, eight L4 lesions, two L3 lesions, and one bilateral lesion at the L2 level. Two more lesions at two levels were found (bilateral L5 and unilateral L4 and L3 on the right side). Classification, treatment, and outcome of the cases are reported. A combination of radiography, planar bone scintigraphy, and SPECT is useful for evaluating spondylolysis in tennis players and recommending treatment. Use of a brace did not appear to achieve significant results.

spondylolisthesis. This permits greaterolisthesis and associated dysplastic disorders, primarily spina bifida occulta, trapezoid appearance of the vertebra, and an S-shaped curve in the upper sacrum.

ISTHMIC LESION AND SPORT

The prevalence of an isthmic lesion is 10–20% higher in athletes than in white people who are not athletes.^{5 14–17 31} In most of the references consulted, the calculation is based on athletes with low back pain. The study by Soler and Calderon¹⁸ is noteworthy as it was performed on Spanish athletes, whether or not they had a history of low back pain. According to these authors, the prevalence is 8.02%. This figure is slightly lower than that cited in other literature.

Isthmic lesion is observed in sports in which flexoextension predominates—for example, gymnastics^{16 18 32–35} and butterfly style swimming.^{36 37} In some cases it is associated with rotation—for example, tennis^{15–18} and high jump³⁶—and/or simultaneous loading—for example, weightlifting, ski jumping, taekwondo.^{38–40}

Isthmic lesion and tennis

In tennis, the specific actions that cause overloading of the posterior arch of the vertebra are hyperextension when serving and the combined movement of extension with forced rotation during the forehand. It should be pointed out that, up until about 10 years ago, the forehand was performed from a stance lateral to the trajectory of the ball. In this position, the shift in weight came from the ascending torsion of the legs, which passed through the trunk until it reached the shoulders and, from there, to the racket. In our judgment, performing this action did not cause overloading at the level of the pars. Performing the forehand stroke from a stance facing the trajectory of the ball, as is common these days, leads to a biomechanical increase in the speed of the ball. However, it is also associated with more lesions at the level of the pars. In this type of forehand stroke, the legs are in semiflexion, and, from this stance, the hips undergo sudden anteversion with sudden hyperextension of the lumbar region. The weight transfer reaches the shoulder from this stance. As a result of this, and the fact that the speed of the tennis ball achieved these days is much higher than a decade ago, the forehand stroke must in most cases be performed from a forward

Spondylolysis is a bone defect in the pars interarticularis of the vertebra. It usually presents bilaterally and affects L5 (85–95%). An injury in the proximal lumbar vertebrae is less common.^{1–3} Unilateral isthmic spondylolysis is observed in 14–30% of cases.^{4–6} It may be associated with injuries at other levels⁷ or with lysis on the contralateral side, which develops over time.⁸ Although it is rare, it may affect several levels simultaneously.⁹ Spondylolisthesis is defined as displacement of a vertebra over the vertebra immediately below. It occurs during childhood and does not increase significantly in adults.¹⁰ The isthmic lesion affects men more than women,^{1 10} although the latter seem to develop greater olisthesis.^{11 12} Spondylolysis has been detected in 3–6%^{1 4} of the white population. There is increased prevalence in specific ethnic,⁹ sports,^{5 6 14–18} and family^{19–22} groups.

AETIOPATHOLOGY AND CLASSIFICATION

Spondylolysis is considered to be an overload fracture^{23–25} with some predisposing factors: inheritance,^{19–22} age and sex,^{9 26–28} race,^{9–13} and structure of the pars interarticularis²⁹ and the spine.

The current classification of spondylolisthesis was proposed by Wiltse *et al.*³⁰ It considers five types. The type found most often in sports injuries is type II (isthmic). In some cases, dysplastic (type I) spondylolisthesis is detected. The basic difference between them is the presence of S1 joint aplasia in type I

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Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging; PBS, planar bone scintigraphy; SPECT, single photon emission computed tomography

Figure 1 Right unilateral developing spondylolysis at L5. (A) and (B) 45° angle right and left radiographs do not show lesion of the pars. Tomographic scintigraphy images (SPECT) of the lumbar region: (C) axial cross section; (D) coronal cross section; (E) right sagittal cross section. Bilateral enhancement of osteogenic activity can be seen at the level of each right pars.

facing stance. This type of stroke is performed at very early ages, when spines are still developing. This is precisely the period of onset of this lesion.

PRECISE DIAGNOSIS

Four complementary tests are usually performed, each of which has different properties and characteristics. In all cases, a combination of these tests provides a specific idea of the point in the natural history of the lesion.

- (1) Conventional radiology. This test is not very sensitive but is highly specific.⁴¹ Its limitations are partly due to the spatial orientation of the defect.⁴² In tennis players with lumbar pain for more than one week, radiographs with posteroanterior, sagittal, and 45° angle right and left views are requested. Olisthesis is evaluated using the Meyerding proportional system,²⁸ as it is clinically very useful.
- (2) Planar bone scintigraphy (PBS) and single photon emission computed tomography (SPECT). PBS is highly sensitive but not very specific.^{42–45} SPECT improves sensitivity as well as specificity of PBS and simple radiographic study.^{41 44 47} Comparative studies between PBS and conventional radiology have shown that scintigraphy is more sensitive.^{43 45} We request this test for adolescent athletes with pronounced back pain that persists for more than two weeks.^{46 47} Bone scintigraphy provides information on the metabolic activity of the lesion, and whether it is an old or a recent lesion.^{44 45 48–50} According to authors such as Lusins *et al*⁷⁰ and Lowe *et al*⁴⁶ SPECT is positive in cases of acute or recent spondylolysis, whereas it is negative in chronic cases. In cases in which spondylolysis is developing and progressing, SPECT is once again positive, although the tracer captured is more anterior and diffuse.
- (3) Computed tomography (CT). The CT scan is considered to be more sensitive than conventional radiology and with greater specificity than SPECT.^{12 41 42 51 52} Regardless of the type of cross sectional image used, the CT scan provides information on the condition of the defect (acute fracture, unconsolidated defect with geodes and sclerosis, pars in process of consolidation or repair).⁵³ Moreover, the “reverse gantry” view can evaluate this condition better. We request a CT scan when the radiographic and isotopic study are positive, and we want to evaluate the exact condition of the lesion edges to determine whether or not a lumbosacral brace should be recommended.
- (4) Magnetic resonance imaging (MRI). This technique shows pronounced changes in the signal at the level of

the pars. This is identified as "stress reaction" and can be classified into five different degrees of activity.⁵⁴ MRI can be useful for evaluating elements that stabilise isthmic lesions, such as intervertebral disk, common anterior ligament, and associated lesions.⁵⁵⁻⁵⁶ We only request MRI when we consider that associated lesions should be assessed, or in the few cases in which surgery has been recommended.

TREATMENT

Reconstruction of the pars can be attempted by using different types of brace.⁵⁷ Braces may be rigid⁵⁸⁻⁶¹ or elastic²³⁻⁶²; moreover, they may provide lumbosacral support for the spine⁶³ or simply limit lumbar extension.⁶⁴ Reconstruction has also been achieved by performing lumbar recovery exercises only⁴³⁻⁵⁵⁻⁶² with associated electrostimulation techniques.⁶⁵⁻⁶⁶ It seems that the isthmic lesion consolidates more easily when it is unilateral. Such different results lead us to question the role of rigid braces, whether or not they are lumbosacral, in the treatment of isthmic lesions.

Another question is for how long the brace should be worn. Some studies recommend immobilisation for two to three months,⁵⁹⁻⁶⁴⁻⁶⁷ or even less,⁵⁸ whereas others recommend up to six months.⁵⁸⁻⁶⁰⁻⁶¹ Moreover, it must be taken into account that, in many cases, excellent clinical results are obtained without reconstruction of the pars.⁶¹⁻⁶⁴ This is shown on radiographs, even though isotopic tests do not show activity. The pars interarticularis fuses more easily at younger ages. In any case, some stabilisation of the spine can be achieved and it will once again be asymptomatic.

All authors agree that, in an isthmic lesion that produces symptoms, there should be rest from sports activity, and activities that produce increased lumbar pain should be avoided. Moreover, lumbar rehabilitation exercises should be performed.⁴³⁻⁵⁵⁻⁶²

When conservative treatment fails, surgical treatment is indicated⁵⁷⁻⁶¹⁻⁶⁴—that is, cases in which slippage is progressive, pain is untreatable, and lumbar pain is associated with neurological deficits or vertebral instability.⁴³⁻⁶⁸ In young athletes, surgery should seek to allow the athlete to return to the same level of sports activity.²¹

Clinical entities and treatment

We have classified isthmic lesions as developing lysis (positive SPECT, negative radiograph; fig 1), active lysis (positive SPECT, positive radiograph; fig 2), and silent or established lysis (positive radiograph, negative SPECT). Fitting this classification to the different studies researched, we found that reconstruction of isthmic lesions was achieved in developing lesions, was practically non-existent in silent or established lysis, and was possible in some cases of active lysis.²³⁻⁶¹⁻⁶²⁻⁶⁴⁻⁶⁷⁻⁶⁹⁻⁷⁰ However, it seems that reconstruction is more readily achievable in unilateral lesions.²³⁻⁶²⁻⁶⁴

METHOD

We retrospectively evaluated results obtained in the diagnosis and treatment of 66 young tennis players under the Real Federación Española de Tenis and the Federació Catalana de Tennis in whom spondylolysis with or without spondylolisthesis was diagnosed between 2002 and 2004. All performed over 15 hours of physical activity a week. Cases in which an isthmic lesion had been diagnosed before admission to these federations or an isthmic lesion was diagnosed in adult tennis players were excluded. Moreover, we did not consider cases in which all the supplementary test results were not available or these tests were not controlled exclusively by our work group.

In tennis players with low back pain for more than one week, a radiograph was taken. If continuous pain persisted for two weeks, PBS/bone SPECT was requested. As a result, lesions were recorded as established lysis, developing lysis, or active lysis. In the last case, a CT scan was requested to assess the bony borders of the lesion. MRI was requested in cases in which olisthesis was observed, in order to evaluate disk condition.

We prescribed a lumbosacral brace in cases of developing lysis and active lysis with acute fracture edges visible on the CT scan. We recommended a lumbosacral brace in a group of patients that was random, as the tennis player, parents, or coaches were responsible for the final decision.

From the clinical history, we determined how long the symptoms of low back pain had lasted and the time of medical discharge.

RESULTS

A total of 66 cases of spondylolysis were studied, 42 men and 24 women with a mean age of 14.8 years (range 12–21): 53 (80%) cases were at L5, eight (12%) at L4, two (3%) at L3, and one (1%) bilateral case was at L2. Two more two level cases were found (bilateral L5, and unilateral L4 and L3 on the right side).

The injured tennis players with pathological entities were classified on the basis of their performance in supplementary tests: 27 (mean age 15.1 years (range 12–21); 17 men and 10 women) had developing spondylolysis (negative radiograph, positive PBS/SPECT); 20 (mean age 14.8 years (range 12–18); 12 men and eight women) had active lysis (positive radiograph, positive PBS/SPECT); 19 (mean age 16.6 years (range 14–20); 13 men and six women) had established spondylolysis (positive radiograph, negative PBS/SPECT).

A CT scan was performed in 15 of the 20 cases of active spondylolysis. Six of them had free, thin, sharp fracture edges. In the remaining nine, there were sclerotic edges and geodes that translated into chronicity of the lesion. Consolidation of the pars fracture was not achieved in any of these cases.

A brace was prescribed in only 15 cases, seven with active spondylolysis and eight with developing spondylolysis. We were able to assist in healing of the isthmic lesion in only three of the cases of developing lysis. One unilateral lesion was completely healed. The other two cases were bilateral lesions: in one case, a single pars was healed, and in the other case both pars were healed.

We were able to help in the healing of the pars in seven cases (11%), all of which were developing spondylolysis (28%).

As regards the initial decrease in low back pain, developing lysis was asymptomatic 24.6 days (range 13–68) after the onset of pain, active spondylolysis at 29.1 days (19–43), and established spondylolysis at 20.1 days (14–36). Elimination of painful symptoms in the lysis group was achieved in 20.7 days (14–28) in those patients who used a brace and in 27.1 days (13–43) in those who did not.

Sports activity was resumed at 4.5 months (range 2.5–7) in patients with developing lysis, at 3.9 months (1–5.5) in those with active lysis, and at 1.7 months (0.5–3) in those with established lysis.

DISCUSSION

In our study the distribution of vertebrae with lesions (80% at L5) was similar to that described in the literature. The mean age of 14.8 years (12–21) indicates a young study group, a period in which players are perfecting or developing tennis techniques. In Spain, Barcelona has the highest number of young tennis players who are growing and subjected to maximum sports demands for this age.

Figure 2 Bilateral active spondylolysis at L4. (A) and (B) Right and left angle radiographs that both show spondylolysis at L4. (C), (D), and (E) Axial, coronal, and sagittal tomographic scintigraphy images (SPECT) which show very pronounced increase in osteogenic activity on the left side and moderate increase on the right side. (F), (G), and (H) Computed tomography image. Two dimensional reconstruction of axial, coronal, and sagittal cross section that shows a lesion with very acute appearance in the right pars, and a fracture in a state of advanced consolidation in which the defect is still visible on the left side.

The mean age of young tennis players with developing spondylolysis (15.1 years) and active spondylolysis (14.8 years) was similar, whereas the mean age of established spondylolysis (16.6 years) was slightly higher. This is logical as the latter are more developed isthmic lesions.

We only treated seven cases in which the pars was healed. It is noteworthy that a lumbosacral brace was only used in three of the cases. The other four cases were treated successfully with rest and the conventional therapy of pelvic stabilisation. Therefore, although our series of cases is limited, we agree with authors who consider that use of a brace is not effective in the treatment of lysis.^{50 58 59}

On the other hand, the condition of the edges of the isthmic lesion shown by CT scan was not a determining factor in successful treatment of the lesion, as this was not achieved in any of the cases. In the three cases in which the edges were clean and a brace was used, healing was not achieved either. Therefore the only factor that seems to favour consolidation of the pars is developing lysis (negative radiograph, positive PBS/SPECT), particularly if the lesion is unilateral.^{23 62 71}

After diagnosis, the patients took complete rest from sports activity, received the conventional treatment for pelvic stabilisation, and, in some cases, a lumbosacral brace was used. We observed an initial decrease in pain at 20.1 days (range 14–36) in cases of established spondylolysis. This

figure is clearly lower than that for developing spondylolysis (29.1 days) and active spondylolysis (29.1 days). Established spondylolysis is visible on a radiograph, but it is not metabolically active (PBS/SPECT). As established spondylolysis has been detected, this leads us to think that detection of lysis in a patient with low back pain may be fortuitous in some cases.^{46 47 69 70}

Using a brace at the time of diagnosis of metabolically active lysis seems to be important: the mean time to the initial decrease in pain was less in cases in which a brace was used (20.7–14/28 days) than in those in which a brace was not used (27.1–13/43 days). Some authors prescribe the use of a brace in cases in which rest is not sufficient to achieve complete pain relief.⁷²

On the other hand, we attempted to use a brace in very painful cases of active spondylolysis and cases of developing spondylolysis. In some cases, it was difficult to achieve compliance with this treatment because of the characteristics of the group. Nevertheless, although it does not achieve specific intersegmental immobilisation of the lower lumbar column, the brace does seem to prevent extensive movement in the column.⁷³ These two factors together may be partially responsible for the failure of treatment with a lumbosacral brace.

In the group with established spondylolysis, the period of time with no sports activity was 1.7 months (range 0.5–3)

What is already known on this topic

- The prevalence of spondylolysis is much higher in athletes than in the non-athletic population; it is more likely to be found in certain sports: gymnastics, athletic throwing events, butterfly swimming, weightlifting, and, of course, tennis
- The different pathological entities of spondylolysis/ololysis in young athletes can be defined on the basis of the tests conducted, but there is no consensus on the treatment of these entities

less than in the other two groups: 4.5 months in patients with developing lysis, and 3.9 months (1–5.5) in the cases of active lysis. These values agree with those of authors who consider that when lysis is not metabolically active (positive PBS, negative SPECT), low back pain should not be attributed to the isthmic lesion^{46 47 69 70} but to other unrelated causes.

We were surprised by the minor difference between developing lysis (4.5 months) and active lysis (3.9 months). Our results cannot be compared with the excellent study by Standaert,⁷² who recommended that athletes with acute lesions resume competition in 5–7 months and those with established pars defect lesions resume competition in 2–5 months. In our study, the former would be equivalent to developing spondylolysis, and the latter would refer to active spondylolysis. Our results are slightly lower. However, if we had performed a CT scan in the group with developing lysis, we think that our results would probably be more similar to those of Standaert,⁷² as we would have detected more occult fractures and this would have led to redistribution of the groups.

CONCLUSIONS

The combined movement of extension with forced rotation during the forehand stroke may be a coadjuvant factor in the onset of isthmic lesions in young tennis players. Although introduction of a stance facing the trajectory of the ball seems to have increased the speed of the stroke, it has also increased overloading of the posterior arch.

Although uniform diagnostic tests were not used in our study, from a practical point of view, the combination of radiography with PBS/SPECT shows us the point of evolution in the natural history of spondylolysis in young tennis players. However, increased use of CT would improve the view of fractures not visible on radiographs and therefore would change the treatment prescribed. The results suggest that use of a brace does not produce significant results in consolidation of developing lysis or active lysis, although it does alleviate initial symptoms more rapidly.

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What this study adds

- Very competitive tennis is a risk factor for spondylolysis
- Different treatments are compared on the basis of results from radiographic and scintigraphic studies (with SPECT) as well as, in some cases, scanners

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COMMENTARY

I commend the authors of this paper for their attempt at analysing the condition of spondylolysis in young tennis players. To my knowledge, this is the first study of its kind that focuses on this specific pathology in tennis players. The 66 cases detected over five years is a testament to the high prevalence of this condition in young athletes who undertake repetitive flexion/extension and rotation activities. It is interesting that the authors have alluded to the open stance forehand as a possible cause of the high number of cases. In my experience, the increasing popularity of the kick serve with repetitive extension and rotation may also be a contributing factor.

Notwithstanding some of the limitations of this study (such as lack of a control group), the paper outlines concepts that are increasingly recognised in the treatment of spondylolysis, namely, that bracing does not effect fracture healing and that early stress changes have a better prognosis. In the light of limitations in cricket bowling and baseball pitching in young athletes, more study should be performed on the proposed aetiology of spondylolysis in young tennis players. There may be a certain threshold of duration or intensity of training that may predispose to acute fracture.

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