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# Nonoperative treatment of active spondylolysis in elite athletes with normal X-ray findings: literature review and results of conservative treatment

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**Abstract** The purpose of this study was to evaluate the healing capacity of fatigue fractures of the pars interarticularis in young elite athletes. Between 1991 and 2000, a fatigue fracture of the pars interarticularis was diagnosed in 34 highly competitive athletes. The study group included 28 athletes with a mean age of 17.2 years at diagnosis (range 12–27 years). The average time per week dedicated to sports was 10.9 h. Diagnosis was made with both planar and single-photon-emission computed tomographic (SPECT) bone scintigraphy and computed tomographic (CT) scan. Lesions were classified into three groups according to their distribution on the scintigram: unilateral, bilateral, or "pseudo-bilateral" (asymmetrical tracer uptake). The study was limited to athletes with subtle fractures, which means that they had normal radiographs and positive bone scans. All subjects were braced for a mean time of 15.9 weeks (range 12–32 weeks). We looked at healing of the fracture, subjective outcome, and sports resumption in the three groups. The athletes were reviewed after an average of 13.2 months (range 3–51 months), and a second CT scan was performed to evaluate osseous healing. Healing of the fracture was noted in all 11 athletes with a unilateral lesion, in five out of nine athletes with a bilateral lesion and in none of the eight athletes with a pseudo-bilateral lesion. Twenty-three athletes (82.2%) rated the outcome as excellent, three athletes (10.7%) as good, and two (7.1%) as fair. Twenty-five athletes (89.3%) managed to return to their same level of competitive activity within an average of 5.5 months after the onset of treatment. There was no difference in outcome or in sports resumption between the three groups. Our data suggest that osseous healing is most likely to occur in unilateral active spondylolysis. Chances of bony healing diminish when the fracture is bilateral, and diminish even further when it is pseudo-bilateral. Nonunion does not seem to compromise the overall outcome or sports resumption in the short term.

**Keywords** Spondylolysis · Fatigue fracture · Bracing · Fracture healing · Sports resumption

## Introduction

Low back pain accounts for 5–8% of athletic injuries [19]. Spondylolysis is one of the major causes of low back pain in young athletes [2, 8, 19, 47]. Incidences of spondylolysis of over 40% have been reported in studies among female gymnasts, football players, weightlifters, wrestlers, and divers [14, 24, 25, 33, 43]. In these studies, no distinction was made between acute and chronic spondylolysis. Spondylolytic stress fractures or acute spondylolysis of the pars interarticularis were found in 47% of 100 ado-

lescent athletes by Micheli and Wood [34]. In adolescent and young adult athletes, special attention should be paid to fatigue fractures of the pars interarticularis, because of their possible evolutive nature [8, 11, 16, 18, 34, 35, 48].

Although acute spondylolysis is to be considered a fatigue fracture, it differs in many respects from fatigue fractures elsewhere in the body [51].

Although genetic and racial factors may predispose an individual to spondylolysis [13, 15, 40], the most generally favored theory is that spondylolysis is a fracture caused by mechanical stress, and that the mode of failure is fatigue [6, 7, 21, 29, 41, 50, 51]. The mechanical etiology of this fatigue fracture is controversial, and many experimental studies have been carried out to determine the fatigue strength of the pars interarticularis and to delineate the movements causing failure [1, 10, 11, 12, 28, 32]. Experiments on cadaveric lumbar motion segments have shown that full flexion and extension movements bend the inferior articular process sufficiently to cause a fatigue fracture of the pars interarticularis [17]. The likelihood of fatigue failure would be greater in activities that require alternating flexion and extension of the lumbar spine, because this would involve large stress reversals in the pars interarticularis [17, 29]. Movements of this type occur in gymnastics, pole vaulting, volley ball, etc.

Athletes with spondylolysis present with pain during certain performance activities. The onset of pain can be either acute or progressive. The pain may become more chronic and dull with time. Clinical examination frequently reveals paraspinal muscle spasm and hamstring tightness [16].

Early radiographic features of spondylolysis and prespondylolytic stress reactions such as vertebral anisocoria have been described extensively [31, 45]. Nevertheless, the sensitivity of different lumbosacral radiographic views in the detection of spondylolysis is limited [4, 8, 20, 39]. Bone scintigraphy is the most sensitive tool for early diagnosis of acute spondylolysis in young athletes [3, 4, 6, 8, 20, 23, 26, 37, 42]. The scan is believed to show increased uptake for about 1 year after occurrence of the fracture, although firm data are lacking. With SPECT, spatial separation of overlapping bony structures is possible: the anatomic localisation of a hot spot is improved and sensitivity is increased [3, 20, 23, 25]. A scintigraphic active pars interarticularis defect is associated with a healing process that may be pain-eliciting, while a normal bone scan in the presence of a radiographically demonstrable pars defect is consistent with a healed (fibrous), non-pain-eliciting process [3, 20, 23, 26, 51]. The false-positive rate of SPECT bone scintigraphy is considerable when it comes to diagnosis of overt fractures [3, 8].

It may be assumed that a stress reaction, a micro-fracture, an overt fracture, and spondylolisthesis can be the consecutive stages of the same overuse injury at the pars interarticularis [4, 8, 16, 22, 23, 35]. No single imaging or scintigraphic technique allows differentiation between these stages. Several authors have distinguished between early, progressive and terminal stages, either with X-ray [35], CT scan [8], or magnetic resonance imaging (MRI) [22]. Rather than using the terms “acute” or “chronic”, “early” or “late”, we prefer using the terms “active” and “inactive”, related to the appearance on SPECT scintigraphy.

The question to be answered is whether nonoperative treatment can prevent evolution from a prespondylolytic stress reaction to active spondylolysis, and thus to inactive spondylolysis. Several findings throw some light on this question:

1. If diagnosis is made prior to the development of an overt fracture, the nonoperative treatment is more likely to succeed [16, 22, 35].
2. The longer the symptoms are present before treatment, the less likely it is that they will respond to nonoperative treatment [4, 5, 16, 38, 46].
3. The therapeutic window is probably limited at the time of the positive bone scintigraphy [49].
4. The therapeutic success may be different for unilateral lesions than for bilateral lesions, because each side can occur at a different moment in time in the latter.

The aim of this study is to look for any differences in healing potential or clinical outcome between unilateral and bilateral lesions.

## Materials and methods

Between 1991 and 2000 a fatigue fracture of the pars interarticularis was diagnosed in 34 highly competitive athletes presenting with low back pain. Thirty-one subjects were men. All of them were initially treated with bracing. One athlete presented for the first time after 18 months of inadequate bracing (intermittent bracing due to low compliance). He was treated operatively with posterior fusion because of persisting complaints. Five athletes were lost to follow-up.

Twenty-eight of the nonoperatively treated athletes were included in this study. They were reviewed with a CT scan performed after an average of 13.2 months (range 3–51 months) from the onset of treatment, and they were clinically assessed. The average age was 17.2 years (range 12–27 years). The most frequently performed sports were soccer, tennis, and volley ball (Table 1). The average time per week dedicated to sports was 10.9 h (range

**Table 1** Sports performed prior to symptoms and number of athletes involved

| Sports performed | *n* |
|---|---|
| Soccer | 11 |
| Tennis | 5 |
| Volley ball | 3 |
| Basket ball | 1 |
| Base ball | 1 |
| Hand ball | 1 |
| Decathlon | 1 |
| Hurdling | 1 |
| Boxing | 1 |
| Rugby | 1 |
| Gymnastics | 1 |
| Judo | 1 |

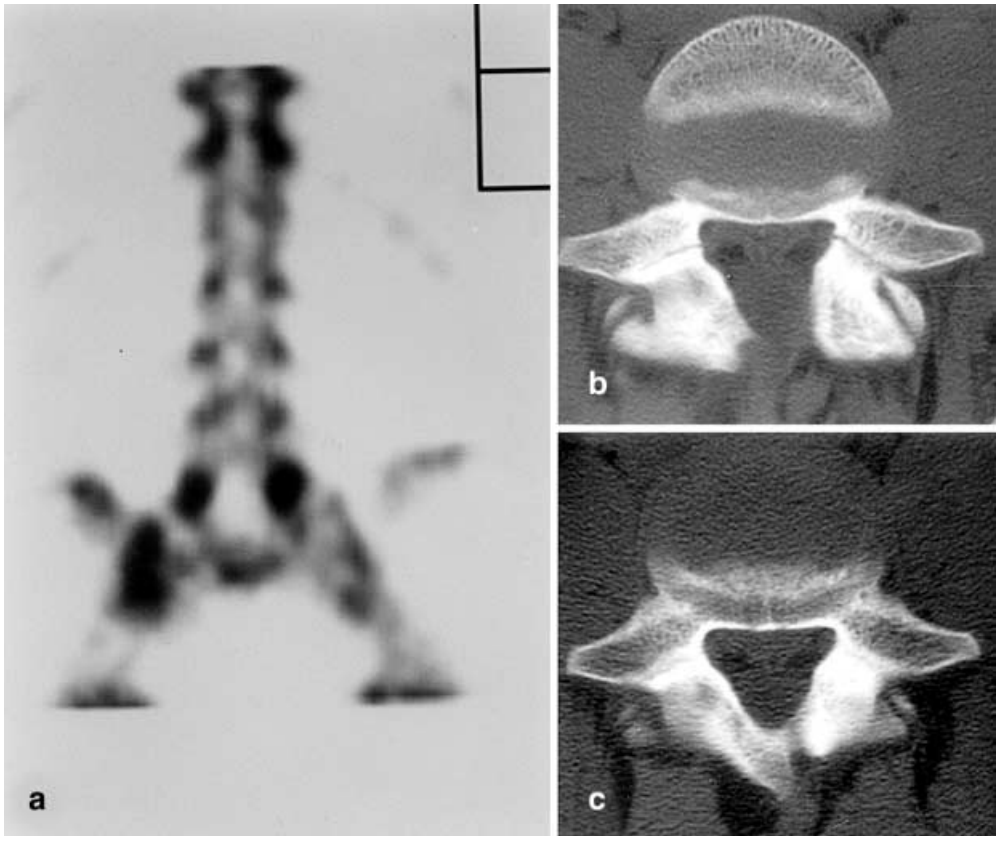


**Fig. 1 A–C** Example of a pseudo-bilateral lesion in a 16-year-old gymnast. **A** Coronal slide of a SPECT scintigram showing bilateral tracer uptake at L5. The uptake on the left side is more pronounced and suggests a more recent nature. **B** Computed tomographic (CT) scan at the time of diagnosis shows a recent fracture on the left side and a less recent fracture on the right side, marked by sclerosis and widening. **C** CT scan 4 months after the onset of treatment showing osseous healing of the left fracture. The fracture line on the right side is still visible

5–21 h). All athletes presented with the chief complaint of low back pain during performance activities. The onset of pain was acute in 13 athletes, progressive in 10 athletes, and progressive with sudden increase of pain symptoms in 5 athletes.

Antero-posterior, lateral, and oblique X-rays were taken in all athletes, as well as a CT scan and a bone scan with both planar and SPECT scintigrams. If a marked increased uptake was present, a recent fatigue fracture or stress reaction was suspected and bracing was initiated. The average delay between onset of symptoms and diagnosis was 11.3 weeks (range 2 weeks to 7 months). The fracture occurred at L5 in 19 athletes, at L4 in five athletes, at L3 in two athletes and at L2 in one athlete. In one other athlete, both L4 and L5 were involved.

All lesions were classified as either unilateral (group A), bilateral (group B), or pseudo-bilateral (group C), according to their scintigraphic appearance. When tracer uptake was present on both sides of one vertebra and uptake was clearly asymmetrical, the lesion was called "pseudo-bilateral" (Fig. 1). The relative number of counts at one side of the lesion was compared with the other side. The average count from ten transverse cuts was calculated for each side, with the center of the vertebral body as a reference. When the ratio [most active side/least active side] was between 0.8 and 1.19, the lesion was considered bilateral, and when the ratio was more than 2.0 the lesion was considered unilateral. Lesions with a ratio of between 1.2 and 2.0 were considered pseudo-bilateral. Athletes with this finding and a CT scan showing a recent lesion on the most active side and an older lesion on the opposite side were classified separately, because a distinct healing pattern became apparent throughout the course of this study. In pseudo-bilateral lesions, only one fracture was considered recent. Spondylolysis was unilateral in 11 athletes (Fig. 2), bilateral in nine athletes and pseudo-bilateral in eight athletes.

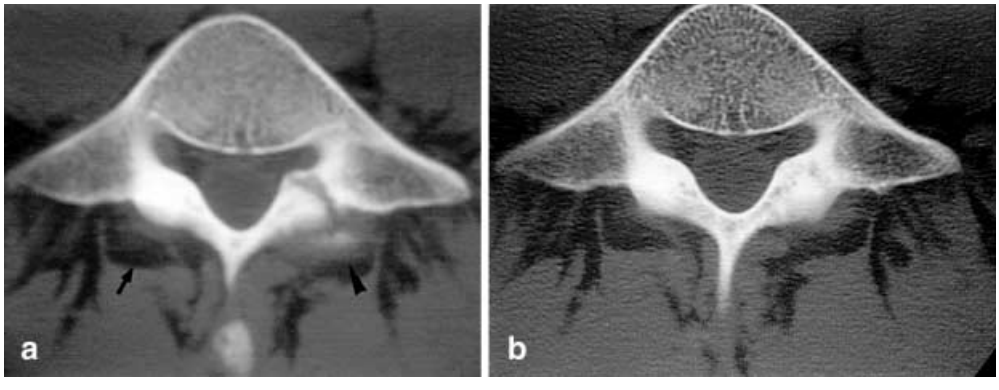


**Fig. 2 A, B** Example of a unilateral lesion in a 27-year-old volley-ball player. **A** CT scan at the time of diagnosis, showing a fatigue fracture at the left pars interarticularis of L5 (*arrowhead)*. There is a marked hyperostosis at the right pars interarticularis (*arrow*). **B** CT scan 23 months after the onset of treatment showing osseous healing

**Table 2** Criteria for clinical evaluation (reproduced by permission of ME Steiner and LJ Micheli)

| | |
|---|---|
| Excellent | No pain<br>No brace requirement<br>Full activities, including sports |
| Good | Occasional aching with vigorous activity<br>No brace requirement<br>Full activities, including sports |
| Fair | Pain with vigorous activity<br>Occasional use of brace<br>Activities of daily living without pain |
| Poor | Pain during activities of daily living even with brace |

The brace used was a Boston Overlap Brace with a hinged extension to the thigh. The hinge automatically locks into extension when the hip is extended, and can be unlocked manually when the athlete wants to sit down. Athletes were required to wear the brace 23 h/day. Hamstring stretching, abdominal strengthening exercises, and pelvic tilts were initiated when the athlete was pain free with daily activities.

After the initial evaluation. the same treatment was started in all athletes. Only bracing time was different, depending on the scintigraphic evolution in each athlete. Bracing was continued for 1 month after the last scintigram. The scintigram was done at 2, 4, and 6 months, so bracing was discontinued after 3, 5, or 7 months. In cases when the scintigram at 6 months remained unchanged, bracing was discontinued immediately, because no further result of bracing was expected.

Athletes with inactive spondylolysis were excluded from this study. These were treated with bracing for pain remission, but not for fracture healing.

The average time of bracing was 15.9 weeks (range 12–32 weeks).

When patients were last clinically reviewed, they were asked to rate the outcome as either “excellent”, “good”, “fair”, or “poor” in relation to their sports activities at that time and according to criteria described by Steiner and Micheli [46] (Table 2). A routine orthopedic examination was done, and a CT scan was performed in order to evaluate osseous healing of the fracture at the pars interarticularis. Scanning was done in two planes: parallel to the intervertebral disc space and parallel to the pars interarticularis (reverse gantry angled technique) [8]. Healing was judged by a single independent and blinded radiologist.

Fisher’s Exact Test was used to calculate the difference in fracture healing, outcome, sports resumption, mode of onset, and delay in diagnosis in the three groups of athletes. An $\alpha$ level of less than 0.05 ($P<0.05$) was considered significant.

## Results

CT scanning of the reviewed athletes after a mean of 13.2 months revealed complete or bilateral healing of the fracture in 16 athletes, unilateral healing in seven athletes, and non-union in five athletes. Osseous healing was complete in all athletes with a unilateral lesion, in five out of nine athletes with a bilateral lesion and in none of the athletes with a pseudo-bilateral lesion (Fig. 3). The difference in healing potential between unilateral lesions (group A) and bilateral lesions (group B) was statistically significant

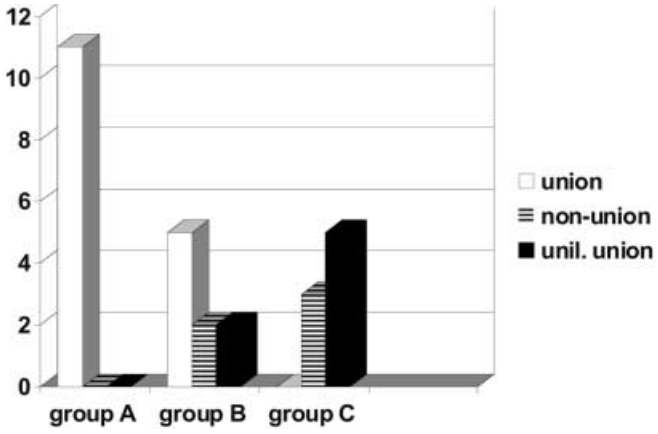


**Fig. 3** Union in the three groups: unilateral lesions (group A), bilateral lesions (group B) and pseudo-bilateral lesions (group C)

($P<0.05$), as was the difference in healing potential between unilateral lesions (group A) and pseudo-bilateral lesions (group C) ($P<0.05$) and the difference in healing potential between bilateral (group B) and pseudo-bilateral (group C) lesions ($P<0.05$). No difference was noted when comparing the two planes of scanning.

At last clinical review, 23 athletes (82.2%) rated the outcome as excellent, three (10.7%) as good, and two (7.1%) as fair. There were no differences in outcome between the three groups (Fig. 4).

Twenty-five athletes (89.3%) had managed to return to their same level of competitive activity within an average of 5.5 months after the onset of treatment. There were no differences in sports resumption between the three groups. Of the three athletes who did not return to the same level of activity, one resumed sports at a non-competitive level.

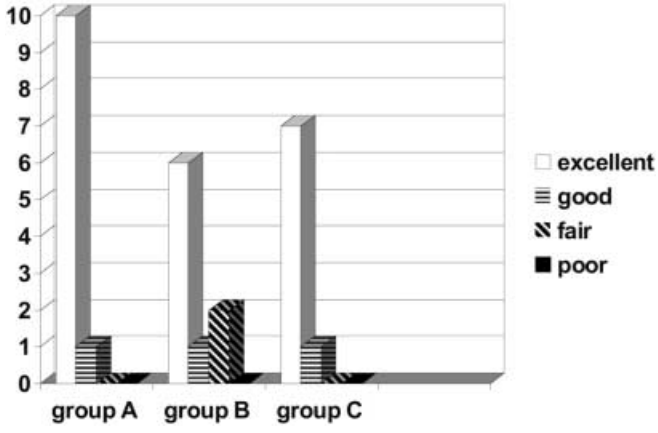


**Fig. 4** Subjective outcome in the three groups: unilateral lesions (group A), bilateral lesions (group B) and pseudo-bilateral lesions (group C)

He reported low back pain at maximal effort, although healing was complete on CT scan. Another athlete did not resume sports because of persistent low back pain with sub-maximal loading activity. CT scan showed non-union of his fracture. One patient in whom non-union was diagnosed was pain free during sports activities, but terminated competitive sports for other than medical reasons.

Of the 13 athletes who reported an acute onset of symptoms, nine achieved osseous healing (69%), compared to 6/10 (60%) in athletes with a progressive onset of symptoms and to 2/5 (40%) in athletes with a progressive onset and sudden increase of symptoms. These differences were not statistically significant.

There were no differences in delay in diagnosis between the three groups.

In 16 athletes, diagnosis was made at 10 weeks or less after the onset of symptoms. Twelve (75%) achieved union (both uni- and bilateral). Five out of six athletes (83%) who were diagnosed with acute spondylolysis more than 20 weeks after the onset of symptoms achieved union. Union was found in all six athletes (100%) in whom the diagnosis was made more than 10 but less than 20 weeks after the onset of symptoms.

## Discussion

The number of athletes in this series precludes a valid statistical analysis.

These data suggest that osseous healing is more likely to occur in unilateral active spondylolysis as compared to bilateral and pseudo-bilateral active spondylolysis. Blanda et al. found that healing was achieved in 87% of athletes with unilateral lesions, and that 87% of the athletes in whom non-union was diagnosed had bilateral defects [4]. The chances of osseous healing decrease when the fracture is bilateral, probably because one of the fractures is less recent, and thus less liable to healing [32].

Differentiation between bilateral and pseudo-bilateral spondylolysis has not been made in the past**.** A distinct healing pattern became apparent throughout the course of this study, and therefore we considered it a separate entity. In pseudo-bilateral spondylolysis, only the fracture with increased uptake on bone scintigraphy is considered recent or “active”. The fracture on the other side is considered a pseudarthrosis, and is an older or “scintigraphically inactive” lesion. These terms provide a better understanding of the true nature of the lesions. The term “acute” spondylolysis is related to the appearance of symptoms rather than to the age of the lesion(s). From this study we know that these do not always correlate.

Previous data suggest an association between early brace treatment and osseous healing: bony healing was noted more frequently in lesions that were diagnosed 1 month or less after the first appearance of symptoms [46]. We could not confirm this direct relation between the appearance of symptoms and healing pattern in the present study. Assuming that a stress reaction, an active fatigue fracture, inactive spondylolysis and (pseudo-) bilateral spondylolysis are the consecutive stages of untreated overuse at the pars interarticularis, this study still does confirm the importance of early diagnosis and treatment [4, 8, 16, 22, 23, 35].

Although it is impossible to determine the exact onset of a lesion and to really define a recent lesion, one may assume that lesions detectable on bone scintigraphy but not detectable on radiographs are recent. Congeni and coworkers reported that, after nonoperative treatment of those athletes with symptoms greater than 6 months, 80% were classified as chronic fractures on CT scan. Athletes with a shorter duration of symptoms had chronic as well as acute and incomplete fractures [8]. Blanda et al. found healing in 73% of early-stage defects, in 39% of progressive-stage defects, and in none of the terminal-stage defects [4]. Both Blanda et al. and Ciullo and Jackson found that the longer the symptoms were present before treatment, the more likely it was that surgical intervention would be needed [4, 5].

It is assumed that the clinical result in the athletic patient with active spondylolysis is improved if the pars fracture achieves osseous union [38, 46]. In this series, however, the short-term clinical result in athletes with non-union (fibrous union) was not worse.

Although early radiographic signs of fractures of the pars interarticularis have been described [31, 45], it is recommended that athletes with stress-related symptoms be screened using planar and SPECT scintigraphy in order to diagnose fatigue fractures in the presence of normal radiographs [6, 37, 42]. The disadvantage is a false-positive rate of 15%, indicating a prespondylolytic stress reaction [8]. Still, treatment with a rigid brace until remission of pain should be considered in these cases.

Information as to when a young athlete should return to competition could be provided with the use of SPECT [3], but CT scan remains the only tool to evaluate the completeness of healing [8]. If both bone scintigraphy and CT scan were to be performed for diagnosis and follow-up of pars interarticularis defects, the cost-benefit analysis would be very unattractive. The purpose of the authors is not to present a particular treatment and follow-up program, nor to show that both bone scintigraphy and CT scan are warranted steps in the diagnosis and follow-up of pars interarticularis lesions, but only to indicate that early treatment of these lesions is important and that both modes of examination can be helpful in understanding the nature of the lesion.

Non-union of a pars interarticularis defect does not mean that the segment is unstable. Fibrous healing occurs and may lead to a good clinical result [5, 25, 29]. Once chronic spondylolysis is noted, sports can be resumed, but repetitive activities with high demands on the lumbar spine should be avoided [9, 30]. Moderate low back pain

can be treated with rehabilitation of abdominal muscles [30, 36] and infiltration of local anesthetics and locally acting steroids at the site of non-union, which is also of diagnostic value.

Surgical intervention may be considered in athletes who have unremitting symptoms despite 6 months of conservative treatment [4, 9, 16]. Several methods of fixation have been described [27, 44].

## Conclusion

Early diagnosis of a fatigue fracture of the pars interarticularis is important because nonoperative treatment of active spondylolysis leads to excellent results and sports resumption within 6 months in the majority of athletes. Therefore, bone scintigraphy should be performed in a young elite athlete with persisting low back pain.

Bony healing is most likely to occur in unilateral spondylolysis. The likelihood of osseous healing diminishes when the fracture is bilateral and diminishes even further when it is pseudo-bilateral. Non-union does not seem to compromise the overall outcome or sports resumption in the short term.

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