

Back pain during growth

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Summary

It is wrong to believe that back pain only burdens adults: the yearly incidence during growth ranges from 10–20%, continuously increasing from childhood to adolescence. Rapid growth-related muscular dysbalance and insufficiency, poor physical condition in an increasingly sedentary adolescent community or – vice versa – high level sports activities, account for the most prevalent functional pain syndromes. In contrast to adults the correlation of radiographic findings with pain is high: the younger the patient, the higher the probability to establish a rare morphologic cause such as benign or malignant tumours, congenital malformations and infections. In children younger than 5 years old, the likelihood is more than 50%. The following red flags should lower the threshold for a quick in-depth analysis of the problem: Age of the patient <5 years, acute trauma, functional limitation for daily activities, irradiating pain, loss of weight, duration >4 weeks, history of tumour, exposition to tuberculosis, night pain and fever.

High level sport equals a biomechanical field test which reveals the biologic individual response of the growing spine to the sports-related forces. Symptomatic or asymptomatic inhibitory or stimulatory growth disturbances like Scheuermann disease, scoliosis or fatigue fractures represent the most frequent pathomorphologies. They usually occur at the disk-growth plate compound: intraspongious disk herniation, diminution of anterior growth with vertebral wedging and apophyseal ring fractures often occur when the biomechanical impacts exceed the mechanical resistance of the cartilaginous endplates. Spondylolysis is a benign condition which rarely becomes symptomatic and responds well to conservative measures. Associated slippage of L5 on S1 is frequent but rarely progresses. The pubertal spinal growth spurt is the main risk factor for further slippage, whereas sports activity – even at a high level – is *not*. Therefore, the athlete should only be precluded from training if pain persists or in case of high grade slips. Perturbation of the sagittal profile with increase of lumbar lordosis, flattening of the thoracic spine and retroflexion of the pelvis with hamstrings contractures are strong signs for a grade IV olisthesis or spondyloptosis with subsequent lumbosacral kyphosis. Idiopathic scoliosis is not related to pain unless it is a marked (thoraco-) lumbar curve or if there is an underlying spinal cord pathology.

Chronic back pain is an under recognised entity characterised by its duration (>3 months or recurrence within 3 months) and its social impacts such as isolation and absence from school or work. It represents an independent disease, uncoupled from any initial trigger. Multimodal therapeutic strategies are more successful than isolated, somatising orthopaedic treatment.

Primary and secondary preventive active measures for the physically passive adolescents, regular sports medical check-up's for the young high level athletes, the awareness for the rare but potentially disastrous pathologies and the recognition of chronic pain syndromes are the cornerstones for successful treatment of back pain during growth.

Key words: back pain; children; adolescents; growth

Epidemiology

Degenerative spine problems and pain represent more than 50% of all chronic pain problems in developed countries and account for most of the estimated 5 billion Swiss francs spent on chronic pain in Switzerland per year [1]. This includes costs for working incapacities, premature pension and associated health costs (rehabilitation, surgery). The future demographic development with an increasing portion of older people will further accentuate that issue.

The lifetime prevalence for a human being is 60–80%, the 1-year prevalence for a middle-aged individual 40%, the day-prevalence 14% and the recurrence rate around 70% [2, 3].

The general impression of paediatric spine specialists is an increasing number of predominantly adolescents presenting with back pain related to static physical actions like long standing, sitting or lifting weights during daily activities. The yearly incidence of back pain during growth increases from 12% at the age of 11 years to 22% at the age of 15 years, the lifetime prevalence from 12% to 50%.[4] In 2002, 1,400,000 children and adolescent were encoded under back pain in Germany (Dorsalgie M54, population of Germany is around 82 millions) causing treatment costs of 100s of millions of Euros. Data regarding the role of body height, body mass index and back packs are contradictory [5–9]. The clarification of the role of high level sports activities is important regarding therapy, risk assessment, natural history, career counselling and long-term outcome.

In natural history studies a positive link between sports and back pain holds true for boys [4]. However, the biomechanical impact of a specific sports activity, the amount of trainings hours and the age-related mechanical resistance is more relevant than the gender: In a large epidemiological study (n = 26,766) weekly training >6 hours led to more back pain than no or moderate sports (30%) and even more (40%) with >12 hours [7]. Back pain in an athlete may

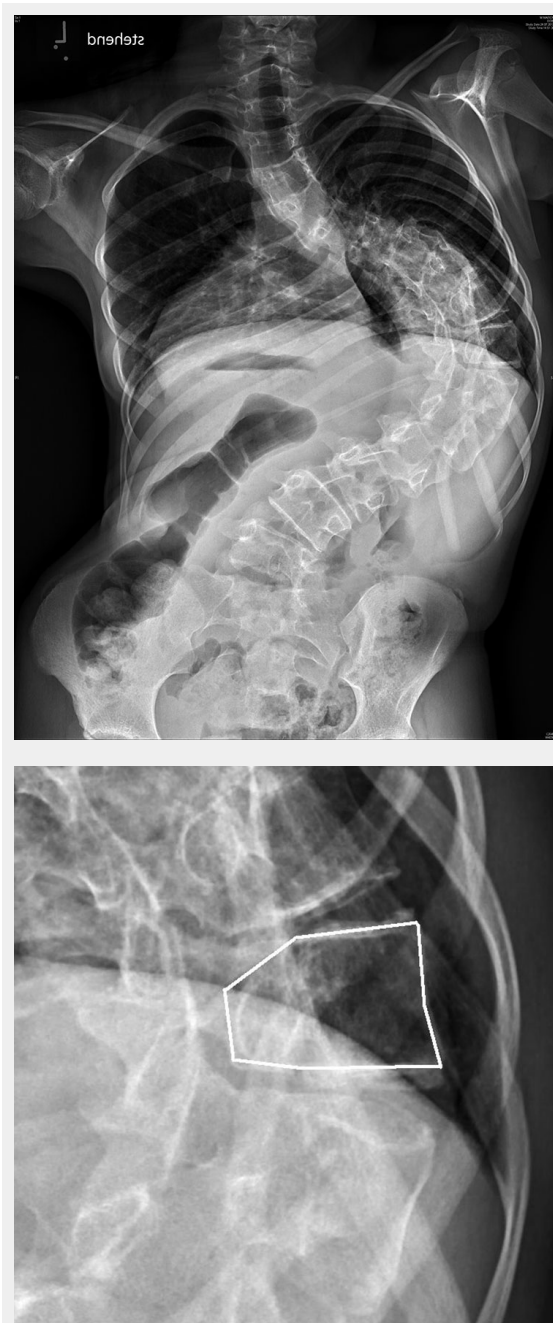


Figure 1

A 12-year old otherwise healthy girl with an idiopathic adolescent scoliosis: 130° right convex thoracic curve with elevation of the right shoulder and pelvic asymmetry. The patient and her family sought a doctor's advice because of a prominent right thorax (rib hump) and a flattened right waist line. Pain was not an issue, nor was there any neurological compromise.

B High loads on a growth plate leads to diminution of growth and vice versa [25]. A typical example is the wedge shaped apical vertebra in a scoliotic curve due to high load on the concave (inner) side of the curve.

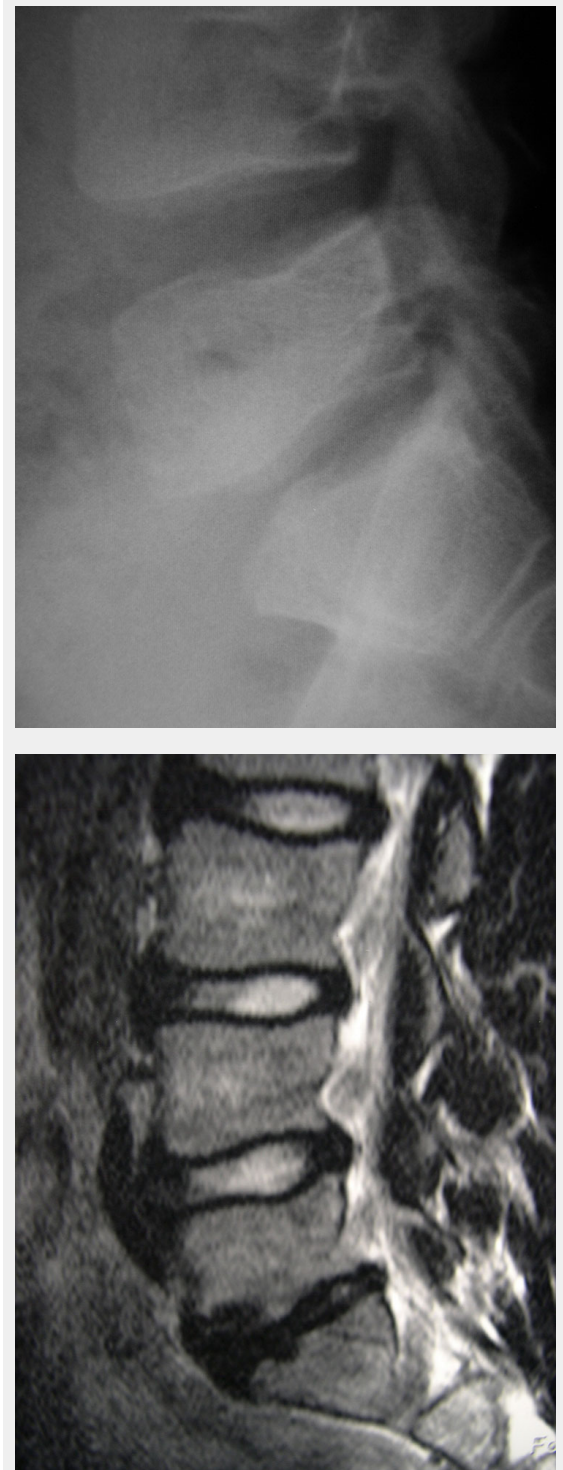


Figure 2

A Lumbosacral stress response in a 14-year-old adolescent high level mountain bike downhill racer with a 12 month history of activity-related lumbar back pain which did not respond to physiotherapy. Refrain from sport, an intense physiotherapy programme and a lumbar brace led to complete pain relief.

A standard lateral standing radiograph of the lower lumbar spine: Disk space narrowing at the level L5/S1. Endplate irregularities of the fifth lumbar vertebra and the first sacral vertebra. Normal sagittal spinal contour. The anteroposterior radiograph was found to be normal. **B** T2 weighted Magnetic Resonance Image. Lateral sagittal plane. Dehydration of disk L5/S1 with subsequent disk space narrowing and posterior bulging of the disk. Anterior osseous destruction of the first sacral vertebra. Marked anterior Schmorl's nodes at the lower endplate of L5 and upper endplate of S1.

be independent of sports, or partially or fully caused by it. High elite sports including lumbar hyperextension-rotation moments (gymnastics, golf, rugby, badminton, volleyball) bears the highest risk [7]. A 7 week prospective study in elite rhythmic gymnasts revealed new occurring back pain in 86% of all athletes [10].

Spinal growth

A thorough understanding of spinal growth anatomy and physiology is a *conditio sine qua non* when seeing young patients with back pain since most back problems of children and adolescents are related to it. Longitudinal spine growth is orchestrated by 48 growth plates in total. Similar to long bone growth, enchondral ossification occurs at the top and bottom endplate of each vertebral body. High activity takes place immediately after birth until the age of 5 and later during the pubertal growth spurt around menarche in girls and voice breakage in boys. In total, sitting height multiplies by a factor 2.6 from birth to adulthood. The spine peak growth velocity accounts for several centimetres growth per year [11]. Since the extremities undergo an earlier growth spurt and also stop earlier to grow (girls at the age of 14 years, boys at 16 years) than the spine

and thorax, the body proportions change continuously as do body weight, muscle force and muscle length. So to speak, there is an ongoing change of the individual biomechanical situation particularly during the pubertal growth spurt. Though there is no evidence, we may assume that the muscle force and the proprioceptive capacities are always a step behind the bony driving force of growth.

As a consequence, and not surprisingly, adolescents in particular seem to be more susceptible to muscular overload and functional pain if the demands are high (elite sports) or the individual physical condition is bad (high TV or PC time). Beyond those dynamic biomechanical pathogenetic factors, the growth zones themselves also become a *locus minoris resistentiae* in puberty since they are mechanically less resistant than in the years before. As the load on the anterior spinal column increases, particularly in high level sports with axial load and forward bending such as in alpine skiing, gymnastics or rowing and due to a higher training intensity during puberty (and also the willingness to take risks, mainly boys), disk herniation through the growth plate, avulsion fractures or growth modulating effects (fig. 1) may become apparent with a much higher incidence in high level athletes. It should be noted that – in contrast to bone – the cartilaginous growth plate's mechanical resistance does not change with sports but is determined by the individual genetic prerequisites.

The interaction between biomechanical impact and a growing spine

Based on daily experience in the author's paediatric spine clinic, recurrent back pain related to incredibly poor fitness is an arising issue among adolescents. The lack of self-awareness and the difficulty to install regular physical activities in our increasingly sedentary young population

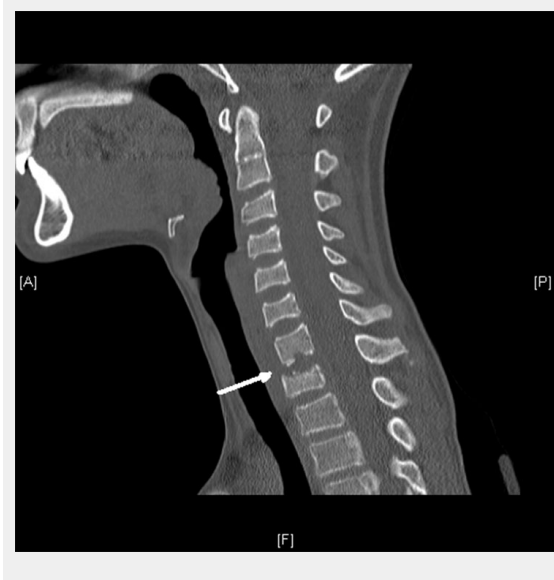


Figure 3

Figure 3 **A** 15-year-old female presenting with posterior thigh pain and an increasing stiffness. She shows a vertical sacrum, flattening of the thoracic and lumbar spine and an inability to round her back and to bend over.

B Spondylolisthesis L5/S1 Meyerding grade IV with sacral rounding, umbosacral kyphosis and trapezoidal shape of vertebral body L5. Spondylolysis L5. In the ap. view there is a free sight into the spinal canal L5 due to the pathologic inclination of L5.

may become a healthcare time bomb. On the other side, intense athletic training is a known risk factor for the development of back pain [12]. Nevertheless, in the long run, only rarely incurable damage occurs and the benefits of sports activity during growth as a trigger for lifelong moderate activity may prevail [13, 14]. Most patients present with a several weeks history of back pain with sitting or after sports without morphologic radiographic correlate (functional pain). The clinical exam may reveal several indurated areas in the erector trunci muscle (myogelosis) and the lumbopelvic region.



Primarily a two to three weeks course of conservative therapy is usually successful to ease the pain: adaption of physical activities, massage and muscle reinforcement. However, in case of functional pain and bad physical fitness, the symptoms may initially even worsen with physiotherapy. The challenge therefore is to keep the patient compliant and to install a programme with supervised home exercises. This second period usually lasts several months. In the long run, secondary preventive, further reaching measures such as a change of lifestyle including involvement in regular, lifelong physical activity, weight control, optimised nutrition and the withdrawal from smoking are mandatory.

If there is no improvement over a 2–3 months course of conservative therapy, one should question the initial diagnosis, re-examine the patient and expand the diagnostic workup.

The development of the musculoskeletal system in growing individuals is strongly influenced by sport-specific external forces which – in conjunction with genetic factors – provoke a biologic response (organic disease) of the growing spine which may or may not be painful.

Vertebrae are loaded by two types of forces: *a.* any muscles directly inserting onto them and *b.* forces and moments applied to the vertebral centrum by the intervertebral disk above and below it. This results in flexion and extension moments, compressive forces, shear forces, fall related impacts, rapid accelerations/decelerations with varying magnitude and number of repetitions in a given interval. The sequelae of high forces acting upon the growth-plate-disk compound account for most of the back problems during growth: *Scheuermann disease, diskopathies, spondylolysis, fractures and scoliosis.*

Increased pressure on the anterior margin of the growth zone is responsible for disorganised endochondral ossifica-



Figure 4

11.5-year-old boy with a T1 compression fracture after a fall (hyperflexion mechanism) with his bike (A). Segmental kyphosis may be underestimated on a CT scan (B) in supine position. He presented with neck pain, without neurologic compromise but with difficulties to swallow due to a prevertebral haematoma as visible on the MRI (C). 3 months in a halo followed by 4 weeks in a supportive collar led to full recovery.

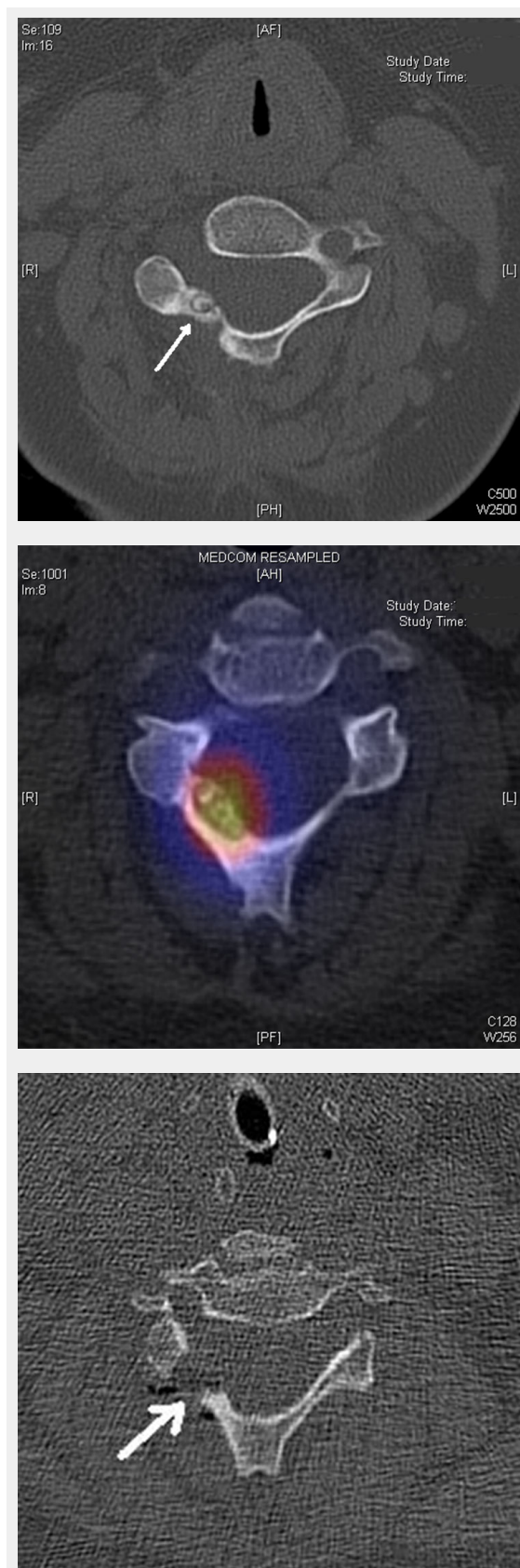


Figure 5

9-year-old boy with a several months long history of right arm and intermittent neck pain – predominantly during the night – which did not respond to physiotherapy. The initial radiograph was found to be normal. A CT scan (A) and a SPECT (B) revealed an osteoid osteoma in the right lamina of C4. Partial laminectomy led to immediate pain relief (C).

tion similar to that noted in Blount's disease, a pathogenetic principle which has been proved in animal experiments [15, 16]. Strenuous physical activity may cause structural abnormalities: the incidence of back pain, MRI abnormalities and larger angles of thoracic kyphosis and lumbar lordosis are associated with greater cumulative training time and the type of sports: gymnasts display the biggest changes, whereas a lack of sports participation displays the smallest changes [13, 17]. Ligamentous laxity and a low individual physiologic maximum of lower segment lumbar extension mobility in sports with maximal lumbar extension are further risk factors [18]. Moreover, spondylolysis, disk space narrowing or instabilities have proven to be risk factors for low back pain in athletes [19].

Excessive repetitive high axial loading of a forward-bended growing spine, in extremis in high-performance adolescent alpine skiers, may exceed the mechanical resistance of the growth zones, resulting in ischaemic necrosis beneath the cartilaginous endplate and in disk herniation into the vertebral body (Schmorl'sch nodes), anterior endplate lesions and disk space narrowing, called Scheuermann disease [20]. Clinically thoracic hyperkyphosis or flattening of the lumbar spine is seen. There is a high incidence of back pain in case of such visible radiographic abnormalities, mainly if they occur in the lower thoracic and lumbar spine [21].

A normal thoracic kyphosis should not exceed more than 45–50° in angulation and should be able to straighten with full activation of the trunk extensors or passive manipulation, for example by raising the trunk in a prone position. Bad posture is characterised by full correctibility to normal. Clinical hyperkyphosis is observed in 15%, and radiologically in 6%. In contrast to its mostly “aesthetical” aspect in the thoracic spine, lumbar Scheuermann disease is less frequent but painful more often, associated with lumbosacral anomalies (e.g., spina bifida occulta) and its occurrence is influenced by physical activities. Studies in twins relate to the hereditary and sports related factors of lumbar localised Scheuermann's disease [22, 23]. In the lumbar spine the radiographic and clinical picture was termed “atypical Scheuermann's disease” since it contrasts with the “classic Scheuermann's disease” of the thoracic spine in terms of association to excessive strain, to back pain and to limitation to only one or two vertebrae [24]. Unusual Scheuermann manifestation at the lumbosacral junction prove the impact of strenuous sports activities on the growing spine [24] (fig. 2). In an individual case the relation between the biomechanical impact of the specific activity (motion patterns, range of motion, peak loads etc) compared to the athletes genetic prerequisites (vertebral anatomy, bone density, muscle power, proprioception) may be decisive for the final biologic response (growth modulation, pain) [25, 26]. In water ski jumpers for example, there is radiologic evidence of anterior column damage in 100% (!) in cases of a history of more than 9 years of strenuous involvement during growth [27]. Young elite alpine downhill skiers who experience repetitive axial strains on a flexed spine and in ski jumpers who undergo high single impacts in a relatively straight spine when landing display radiographic abnormalities in 50% compared to 20% in a control group [27, 28]. The loss of lumbar lordosis (lumbar Scheuermann) with re-

lative shortening of the anterior column is compensated for by active flattening of the thoracic spine leading to an overall “flatback” and pain.

Loss of disk height, alterations of disk signal intensity and disk displacement is common in asymptomatic individuals but also more frequent in athletes [13, 29]. Correlation between disk degeneration, Schmorl’s nodes and back pain is more often observed in the (thoraco-) lumbar spine [30]. *Acute* symptomatic changes like lumbar ring apophyseal fracture [31] or acute disk injuries rarely occur under high loads, for example in weight lifters or gymnasts.

In case of significant remaining growth (Risser 0–II, <1 year postmenarchal), a brace may stop or even partially reverse the process of anterior growth inhibition and wedge formation provided that the orthoses is well manufactured to unload the anterior column and is worn for more than 20 hours daily. Although there are scarce scientific data, our clinical experience suggests brace treatment in progressive cases and/or back pain. A thoraco-lumbar-sacral orthoses TSLO passively extends the thoracic spine. In a relatively flexible spine and with a compliant, strong patient a short lumbar brace (Becker brace) is a valuable active alternative in case of thoracic Scheuermann: by slight reduction of the lumbar lordosis (anterior belly bad), the patient needs to actively extend the thoracic spine to keep the sagittal balance. For lumbar Scheuermann’s disease a brace in maximal lumbar lordosis usually offers quick pain relief and stimulates anterior vertebral growth.

Spondylolysis (defect in the cartilaginous anlage of the interarticular portion) is present in 5–8% of the western population (male to female ratio 3:1) acquired in early childhood [32]. The high incidence in certain geographic regions (e.g., up to 50% in Inuits) must be due to predisposing genetic factors. There is a strong association with spina bifida occulta, dysplastic vertebral arch, and big inferior facet L4. It most commonly affects the fifth lumbar vertebra in independent bipedal walkers as a tribute to upright gait (lumbar lordosis), and is therefore not observed in non-ambulators and quadruped animals. A painful, scintigraphically hyperactive fatigue fracture, pars elongation or a pseudarthrotic defect may result. It usually remains asymptomatic. Low lumbar pain typically occurs in about 10% of all affected with long standing, walking or during sports but responds well to conservative measures such as physiotherapy, temporary modification of or refrain from strenuous sports and bracing in an acute setting.

Clinical testing in lumbar hyperextension is pain provocative: a lateral radiograph centred at the lumbosacral area displays elongation of the pars or local sclerosis indicative for local mechanical stress, a lysis and reveals associated slippage of L5 on S1.

MRI is indicated in case of non-responsiveness to conservative measures, radicular nerve roots symptoms and diagnostic uncertainty. Only rarely is an operative intervention justified, either direct pars repair or L5S1 fusion depending on the absence or presence of disk degeneration and high gradeolisthesis. Lumbar hyperextension and rotation of the spine is a common manoeuvre in various sports resulting in higher incidences of spondylolysis than in controls (gymnastics, figure skating, ballet, trampoline, triple jump, wrestling, judo, javelin, golf, basketball, rowing, volley-

ball, swimming breast stroke and butterfly, weight lifting) [33]. Moreover, unphysiologic sacral loading may provoke local growth disturbances, sacral dome rounding, stress fracture of the sacrum, facets and lumbar pedicles [22, 34, 35]. A episode of painful spondylolysis *per se* is not an exclusion criteria for high level sport as long as it is not associated with a high-grade (III, IV) slip or a severe disk pathology. Up to 30–80% of young individuals with a spondylolysis of L5 show an anterior slippage of L5 on S1, half of them grade I (less than one quarter of the sacral plateau) [32, 36]. Unilateral defects never lead to slippage. The main risk factor is the pubertal spinal growth spurt and probably some not clearly defined anatomic factors such as sacral anatomy and position and presence/structure of the iliolumbar ligament, but it is *not* related to the type or level of sports activities [32]. Progression slows with each decade of life.

There is *no* association of slip progression and low back pain which is a diagnostic challenge [37]. Accordingly individuals with higher grade slips may remain asymptomatic and unrecognised for a long time. Close observance with regular radiographic follow-up (yearly) is mandatory during the pubertal spinal growth spurts. If the slip is stable, low grade (II or less) and if the patient is asymptomatic, follow-up can be stopped two years post menarche (Risser IV, V).

Patients with high grade slippage (III, IV) display major static perturbation. Once the vertebral body L5 has reached a grade III slip, it will lose balance on the sacral plateau and tilt into kyphosis, as does the whole spine above resulting in anterior loss of sagittal balance. In rare, extreme cases (fig. 3) the vertebral body L5 falls off the sacral cliff and lies anterior to the sacrum (spondyloptosis). In order to bring back the head over the sacrum, the patient activates all compensatory mechanisms: hyperlordosis of the lumbar spine, extension (flattening) of the thoracic spine, extension of the pelvis. High tension of the trunk extensor and permanent high activity of the ischiocrural muscles (Mm.biceps femoris, semimembranosus and semitendinosus) may cause back and thigh pain, hamstrings shortening and a loss of ability to bend forward. Rarely the nerve root L5 will cause pain or loss of motor activity (drop foot) since the stretching occurs slowly and the nerve root adapts. However, eager surgical reduction is known to bear a considerable risk of neurologic deficit. Fusion *in situ* or gentle partial reduction only is recommended.

Vertebral *fractures* are relatively rare in childhood due to the still relative flexible spine and the rare high speed traumas. Usually the patients present with a clear history of an adequate trauma and an easy to diagnose fracture. However, the detection of fractures in patients with skeletal dysplasias and at the cervico-thoracic junction (fig. 4) may be more challenging.

Scoliosis is a three-dimensional deformity of the spine with lateral curvature, mostly flattening of the sagittal profile (anterior overgrowth) [38] and rotation in the transverse plane. The latter leads to a rib or lumbar prominence on the convex (outer) side of the curve. Loss of coronal or sagittal balance, shoulder height difference and pelvic distortion may also occur. Most scoliosis cases (90%) are idiopathic (unknown aetiology), are diagnosed in puberty (adoles-

cent), affect girls (4:1 ratio) and commonly show a curve pattern which includes a right thoracic curve. However, multiple curve patterns exist. Pain is *not* a typical feature, not even in severe curves. Significant pain in association with a scoliotic deformity should raise awareness: the scoliosis may be caused by pain of any source (reactive), may occur in association with an underlying spinal cord (syrinx, neurofibroma, tumour) or spine (spondylolysis) pathology or may itself be the cause of pain: marked thoracolumbar and/or lumbar scoliosis may be painful due to asymmetric muscular load.

Sports- or athlete related factors like repetitive forced lumbar hyperextension, delayed bony maturation in amenorrhoeic female athletes and ligamentous laxity may promote growth disturbance and biomechanical instability (weak bones and ligaments, altered growth). This – as an example – may explain a 10 fold higher incidence of scoliosis found in elite rhythmic gymnasts (n = 100, 12% vs 1.1%) [39].

Further differential diagnosis

The diagnosis of rare, but severe and potentially disabling or even lethal causes of back pain during growth requires a high index of suspicion, a thorough history taking and a clinical examination focusing on the characteristics of pain, deformity and neurologic deficits. Most growing patients with back pain show a normal spine upon clinical examination.

Specific emphasis must be put on neurologic deficits (missing abdominal reflexes), particularly on bladder and bowel dysfunction. Young patients primarily diagnosed with muscular pain not responding to conservative measure within 1–2 weeks must be re-assessed.

Most pathologies are acquired. However, in rare cases a congenital spine problem – be it osseous (failure of formation), diskal (failure of segmentation) or at the spinal cord may be causative. Congenital problems commonly manifest themselves early in life. Lumbar cutaneous changes like naevi, hairy patches and skin dimples may indicate a malformation of the spine and/or spinal cord. Occult spinal cord abnormalities may lead to unexplained back pain, atypical scoliosis (thoracic left convex), gait abnormality, limb pain or weakness and – above all – rigid or recurrent foot deformity [40].

Red flags for diagnosis other than muscular pain, Scheuermann disease, spondylolysis and scoliosis are age of the patient <5 years, acute trauma, functional limitation for activities of daily living, irradiating pain, loss of weight, duration >4 weeks, history of tumour, exposition to tuberculosis, night pain and fever [41].

Tumours of the spine and spinal cord are rare and only occasionally visible on conventional X-rays (fig. 5). Most of them are *benign* (Osteoidosteomas, osteblastomas, aneurysmatic bone cysts, giant cell tumours, Langerhans cell histiocytosis, osteochondromas). As the less frequent *malignant* tumours (Ewing sarcoma/PNET, osteosarcomas), they do not occur in preferred regions. The most important alternative diagnosis to *tumour* is spondylitis and spondylodiscitis. As with tumours, patients often present with pain not related to activities or with night pain. Negative labor-

atory results (C-reactive protein, erythrocyte sedimentation rate, white blood cell count) does not rule out infection and positive results do not exclude a tumour (Ewing sarcoma!). Sometimes only (repeat) biopsies assessed by an experienced pathologist reveal the underlying pathology.

Rare but potentially lethal causes of back pain are chronic retrocecal appendicitis, necrotising fasciitis, psoas abscess and aneurysms in patients with connective tissue diseases like Marfan syndromes [42, 43].

Chronic pain

Chronic pain during growth needs to be taken seriously in the light of its potential transition to a lifelong burden for the patient but also for the community: About every 5th (!) European adult suffers from chronic pain. A natural history survey on adults reveal the disastrous impact of chronic pain on social and work life: apart from frequent doctor's visits and the consumption of non-prescription treatment such as massage, acupuncture and physical therapy, over the counter NSAID, paracetamol and weak opioids, almost two thirds of the patients show limited work capacities, 13% needed to change jobs, 19% lose their job and two thirds take prescription medicine, but only 2% are under treatment of a pain management specialist [44]. It is an alerting thought that children suffering from chronic pain might transfer their health-problem, their altered social behaviour and a potentially impaired education into adulthood. Actually there is no evidence that chronic pain during growth paves the way for a life long costly pain career but it may well be so. One might not expect that chronic pain is also a (growing?) issue in paediatric healthcare. However, there is current lack in adequate perception, facilities, treatment and research. Back pain is the number three symptom behind headache and belly ache in young patients with chronic pain.

Chronic means that pain has lasted for more than 3 months or recurs within 3 months [45]. In addition to this time-based definition, there are some more important features which should raise awareness if present in children and adolescents with back pain: it is an independent disease, uncoupled from any initial trigger (such as trauma, inflammation, growth disturbance, tumour etc.), the duration of pain is longer than expected in view of the primary underlying pathology, the intensity does not correlate with the stimulus, it appears to be a therapeutic challenge, does not respond to usual therapeutic measures and it requires a multidisciplinary approach.

Chronic pain grading does not focus on the level of pain as a symptom but on its sequelae: it may have no impact on daily activities (level 1), prevent involvement in sports activities (level 2) or cause absence from school (level 3) [9].

In Germany 5–6% of children (400,000 out of 7.2 million in the age group 8–16 years!) suffer from high intensity pain with severe to very severe limitation in daily life [46]. In Switzerland this would equal 27,500 out of 500,000.

Our traditional approach has been admittance for an intense 3–4 weeks period of physiotherapy guided rehabilitation. The mainstay of 2–3 physiotherapy sessions per day was complemented with psychological, psychiatric, social and

pain service support if deemed necessary. Medication comprised muscle relaxing agents and non-steroidal antiinflammatories.

Though successful in many cases, mainly in high level athletes with muscular dysbalance but clearset personal goals and strategies, we observed many patients with uncontrollable situations, permanent high pain level, discordance between clinical picture and findings, low success and high recurrence rates. We therefore questioned our approach which was based on the decision making of the primarily involved orthopaedic team. The patient's perception was therefore focused on a somatic curable problem. Admittance to an orthopaedic ward further fuels this attitude. A radical change in strategy was stimulated by a concept developed by the German foundation for pain therapy in children (University and Children's Hospital Witten/Herdecke, Prof. Zernikow). So far chronic pain patients have almost exclusively been an issue in adult medicine. In paediatrics and paediatric orthopaedics – oncological patients excepted – it has not gained wide attention so far. In contrast to the traditional concept with the orthopaedic surgeon as the (somatising) driving force, a modern strategy is multimodal including simultaneous psychotherapeutic and somatic methods [47]. It aims at breaking the vicious cycle of long-lasting pain, psychological changes, altered pain perception, social degradation and neglect as further triggers. The main goal is *not* pain eradication but coping with it. Prior to admittance the patient and his/her family have to fill out an age-adapted questionnaire which reveals if he/she qualifies for this process [48]. In summary pain duration >6 months, permanent pain >5 on a numeric rating scale (0–10), peak pain 8 or more at least two times per week, more than 5 out 20 days absence from school and a pain related score of at least 36 on the paediatric pain disability index are the core variables.

Training of pain coping strategies, treatment of psychiatric co-morbidities, systemic and family interventions, optional intervention and prophylaxis of recurrences form the modular build-up of a successful inpatient treatment. Pain level, pain related disability and absence from school are significantly reduced [49]. The prevention of recurrences includes a close follow-up after discharge and a second series of inpatient treatment in most cases [50]: all core variables show significant improvement after 3 months. A total of 73% of all adolescents report on significant changes in pain intensity although they demonstrate higher disability and more passive pain coping than children [50]. Almost 60% keep their level at the one year follow-up mark. Interestingly girls have higher pain intensity and higher school absence. The awareness for chronic pain, particularly back pain in children and adolescents is currently being raised among paediatric orthopaedic surgeons, family doctors, general

practitioners and paediatrician. The setup of according networks for the detection, inpatient facilities and future research on the epidemiology, the risk factors, development of innovative treatment strategies and the determination of their efficacy, effectiveness, cost-benefit ratio as well as their long-term effects in adulthood merits a high social, medical and economic priority.

Conclusions

Poor physical fitness or high level sports seem to be risk factors for the development of the most prevalent functional back pain, particularly during the pubertal growth spurt. Boys and certain sport activities which include repetitive lumbar hyperextension-rotation moments or high axial loads have a higher risk. In most cases, pain in adolescent athletes is acquired. High forces acting upon the susceptible, relative weak disk-growth plate compound often results in a defined pathomorphologic pain correlate. Regular routine sportsmedical check-ups are therefore mandatory in active athletes. Moreover, one should always remain vigilant for pain unrelated to physical activities and any changes of the sagittal profile. It should be kept in mind that younger age and red flag symptoms may indicate infections or tumours, to prevent disastrous diagnostic and therapeutic lapses. Chronic pain should be recognised and treated as a separate entity warranting multimodal strategies including psychologists and psychiatrists.

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Table 1: Pain features: Differential diagnosis

Night pain	Tumor, infection
Acute	Spondylolysis, fracture
	Diskal herniation
Chronic	Scheuermann's disease
	Psychological problem
With flexion	Diskal herniation
Extension	Spondylolysis / Olisthesis

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Figures (large format)



Figure 1

A 12-year old otherwise healthy girl with an idiopathic adolescent scoliosis: 130° right convex thoracic curve with elevation of the right shoulder and pelvic asymmetry. The patient and her family sought a doctor's advice because of a prominent right thorax (rib hump) and a flattened right waist line. Pain was not an issue, nor was there any neurological compromise.

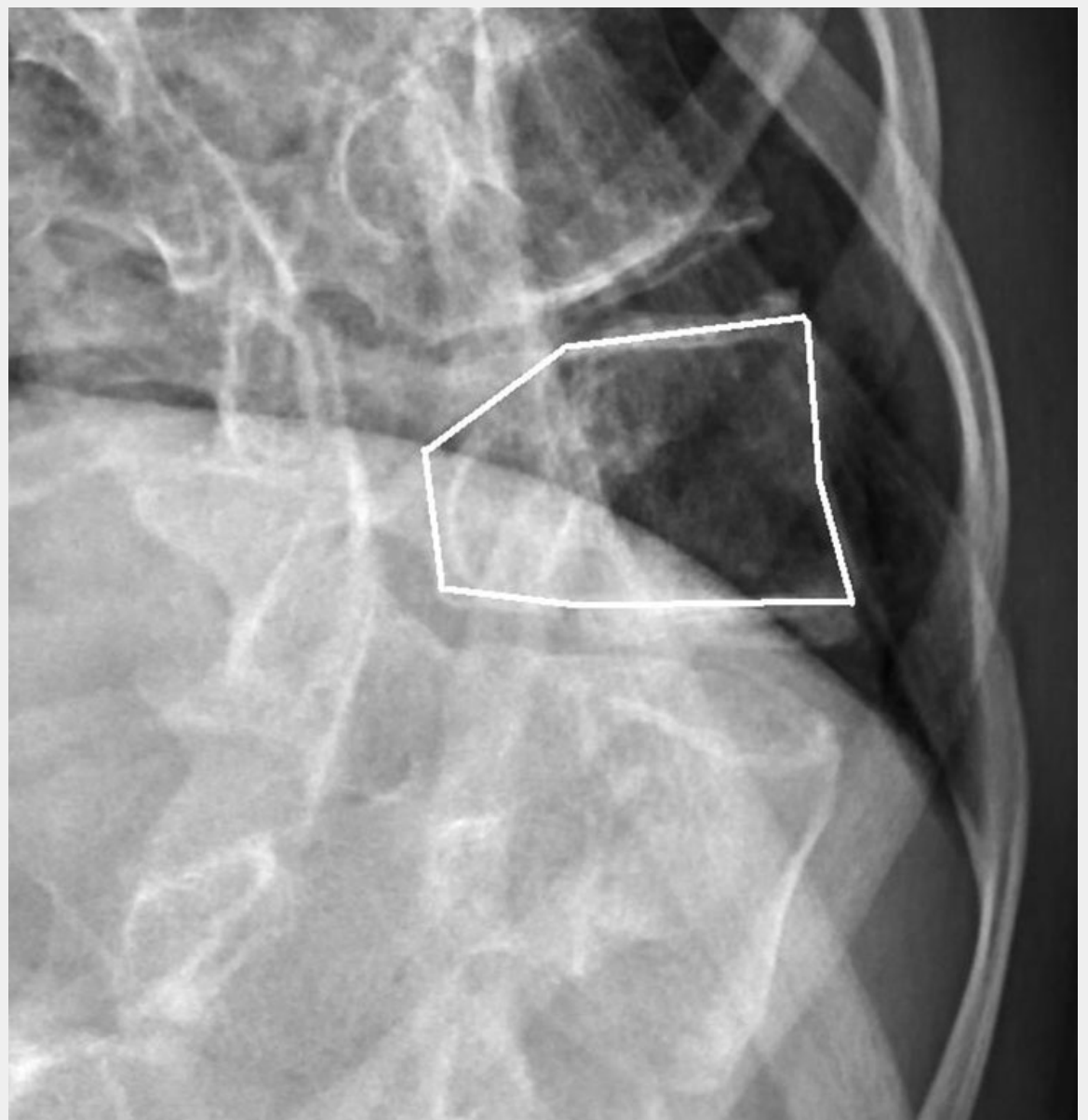


Figure 1

B High loads on a growth plate leads to diminution of growth and vice versa [25]. A typical example is the wedge shaped apical vertebra in a scoliotic curve due to high load on the concave (inner) side of the curve.



Figure 2

Lumbosacral stress response in a 14-year-old adolescent high level mountain bike downhill racer with a 12 month history of activity-related lumbar back pain which did not respond to physiotherapy. Refrain from sport, an intense physiotherapy programme and a lumbar brace led to complete pain relief. A standard lateral standing radiograph of the lower lumbar spine: Disk space narrowing at the level L5/S1. Endplate irregularities of the fifth lumbar vertebra and the first sacral vertebra. Normal sagittal spinal contour. The anteroposterior radiograph was found to be normal.



Figure 2

B T2 weighted Magnetic Resonance Image. Lateral sagittal plane. Dehydration of disk L5/S1 with subsequent disk space narrowing and posterior bulging of the disk. Anterior osseous destruction of the first sacral vertebra. Marked anterior Schmorl's nodes at the lower endplate of L5 and upper endplate of S1.



Figure 3

A 15-year-old female presenting with posterior thigh pain and an increasing stiffness. She shows a vertical sacrum, flattening of the thoracic and lumbar spine and an inability to round her back and to bend over.

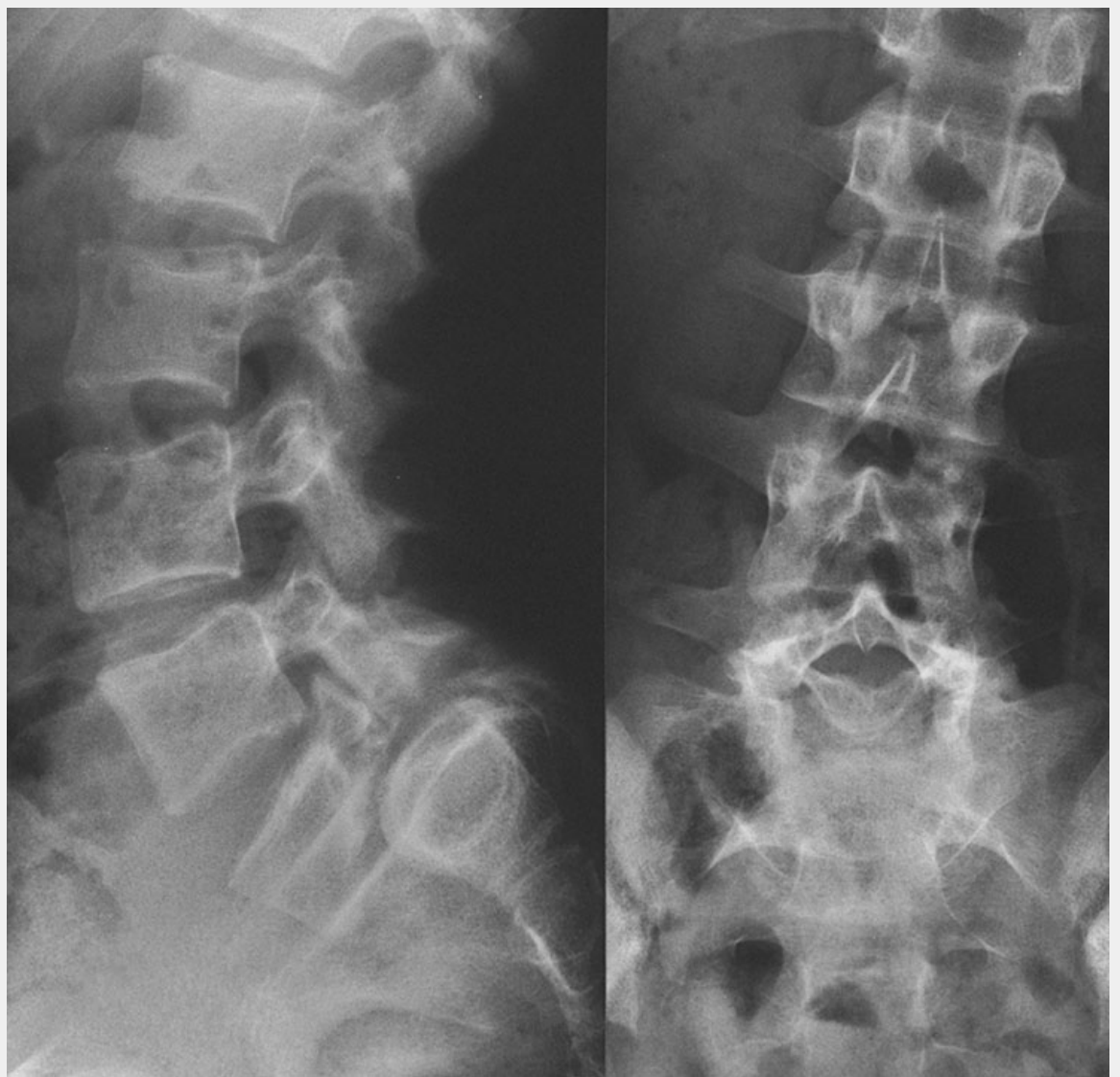


Figure 3

B Spondylolisthesis L5/S1 Meyerding grade IV with sacral rounding, lumbosacral kyphosis and trapezoidal shape of vertebral body L5. Spondylolysis L5. In the ap. view there is a free sight into the spinal canal L5 due to the pathologic inclination of L5



Figure 4

11.5-year-old boy with a T1 compression fracture after a fall (hyperflexion mechanism) with his bike (A). Segmental kyphosis may be underestimated on a CT scan

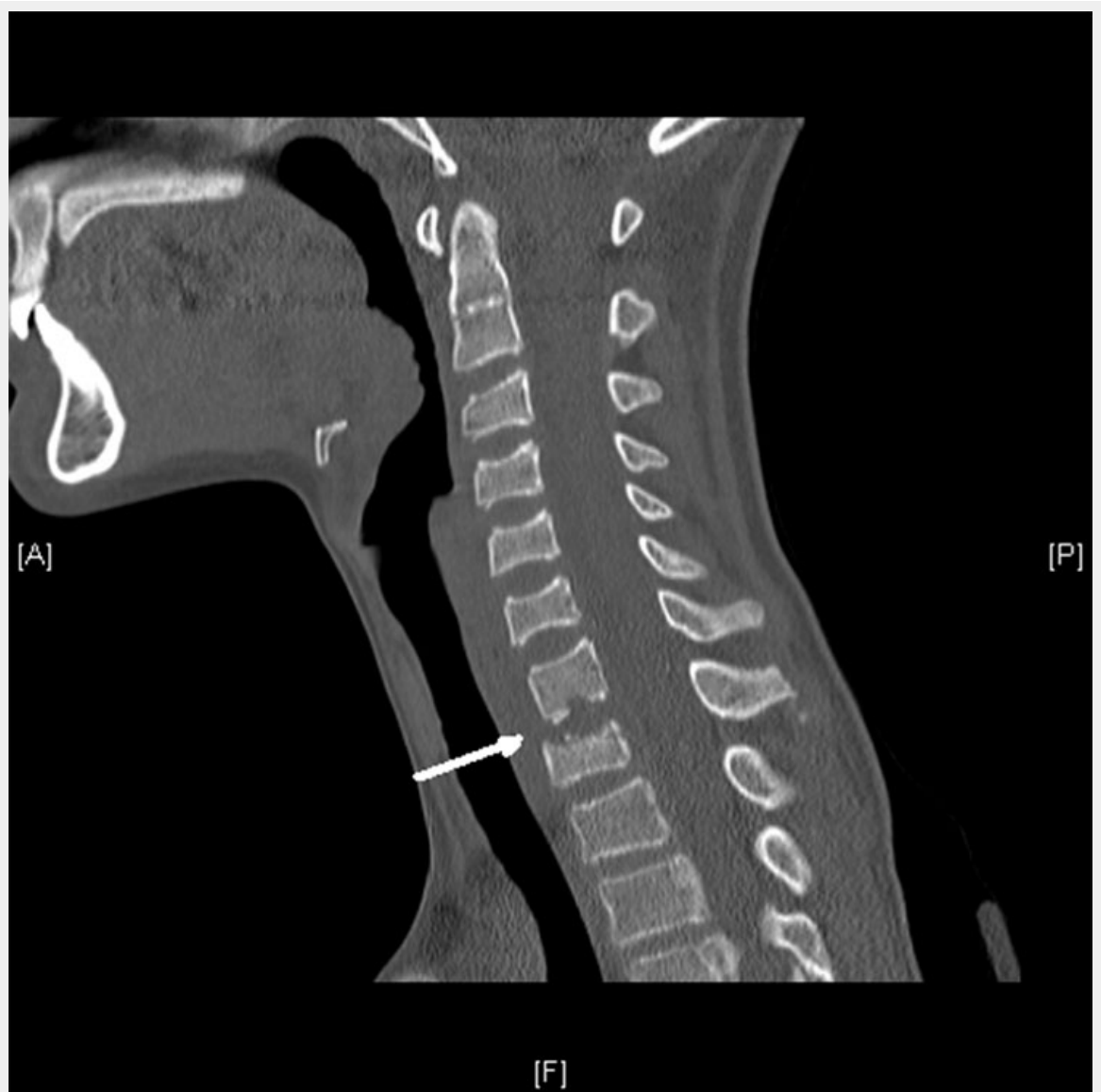


Figure 4

(B) in supine position. He presented with neck pain, without neurologic compromise but with difficulties to swallow due to a prevertebral haematoma as visible on the MRI (C). 3 months in a halo followed by 4 weeks in a supportive collar led to full recovery.



Figure 4

(C). 3 months in a halo followed by 4 weeks in a supportive collar led to full recovery.

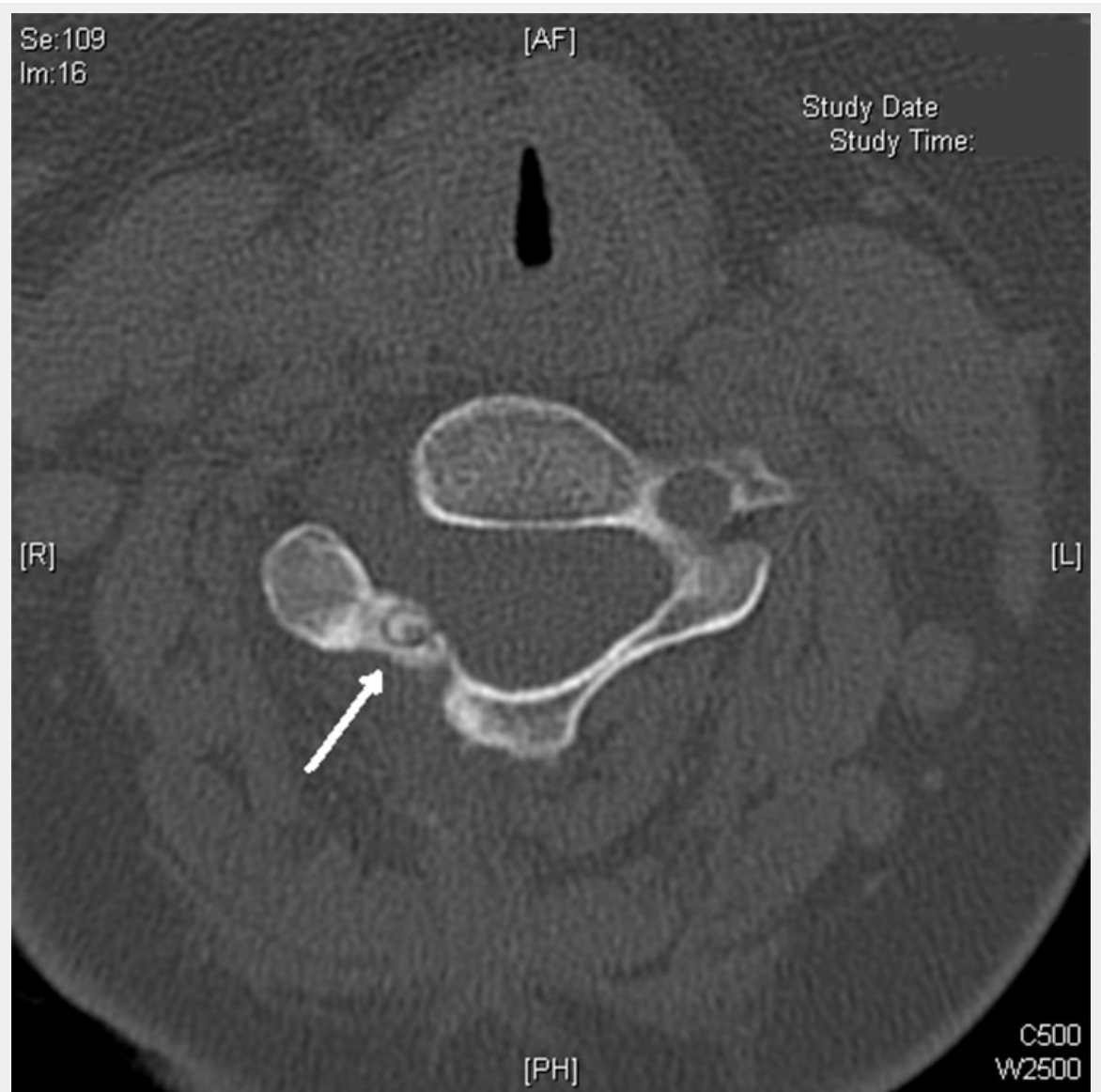


Figure 5

9-year-old boy with a several months long history of right arm and intermittent neck pain – predominantly during the night – which did not respond to physiotherapy. The initial radiograph was found to be normal. A CT scan (A) and a SPECT

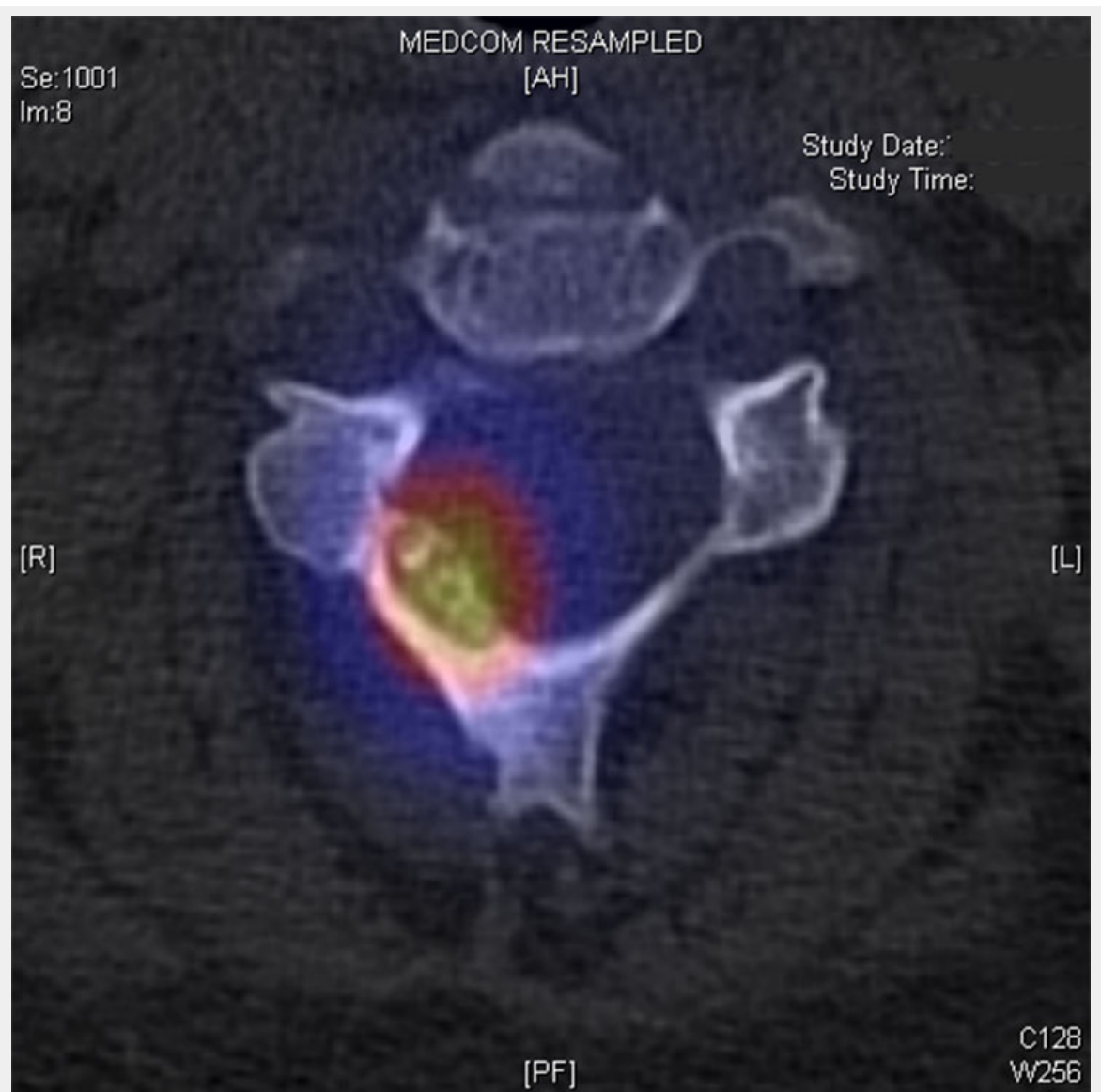


Figure 5
(B) revealed an osteoidosteoma in the right lamina of C4. Partial laminectomy led to immediate pain relief (C).

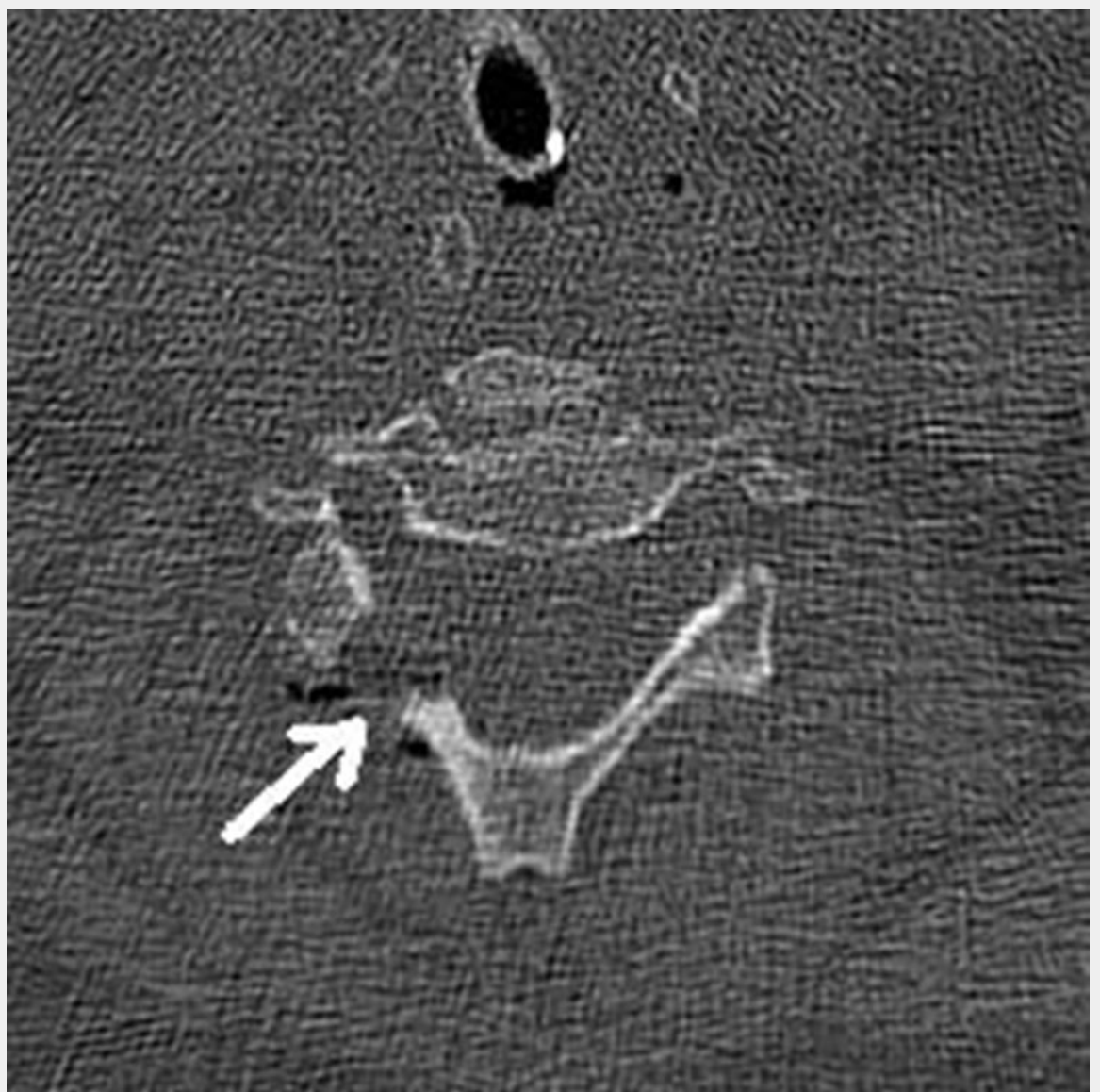


Figure 5
Partial laminectomy led to immediate pain relief (C).