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## MRI – WHAT IMPORTANT FINDINGS CAN IT SHOW IN CHILDREN WITH BACK PAIN?

### BADANIE MR – JAKIE ISTOTNE PATOLOGIE MOŻNA W NIM WYKAZAĆ U DZIECI Z BÓLAMI KRĘGOSŁUPA?

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#### Abstract

**Introduction:** The percentage of school-age children who have already had an episode of back pain can be as high as 51%, and the incidence of the disease increases with age and physical activity. This paper summarizes the MR examinations of children with back pain carried out at the Institute of Mother and Child in Warsaw and highlights pathological findings, which have been shown in them.

**Materials and method:** Analyses were done of 121 MR examinations carried out because of back pain in children. All of them were performed with a GE Signa HDxt 1.5 T scanner according to routine protocol: SE/T1-weighted images in sagittal and axial plane, FSE/T2-weighted images in sagittal and axial plane, STIR sequence in sagittal plane. If necessary, coronal plane was added and contrast agent was administered.

**Results:** Negative results - no changes - were obtained in 91 children (75.2%). Positive results were found in 30 children, which accounts for 24.8%. Among the lesions there were degenerative changes of intervertebral disks as an isolated finding in 9 children (7.4%), Scheuermann's disease in 2 (1.7%), intervertebral disks herniations in 13 (10.7%), spondylolisthesis in 2 (1.7%), sacroiliitis in 1 (0.8%), intervertebral facet joint arthritis in 1 (0.8%), tumors in 2 (1.7%).

**Conclusion:** Back pain in children is a growing problem, and in ¼ of the cases is reflected by pathological changes visible on MRI, which is the best method of imaging the causes of back pain in children and adolescents.

**Key words:** magnetic resonance imaging (MRI), vertebral column, pain, children

#### Streszczenie

**Wprowadzenie:** Odsetek dzieci w wieku szkolnym, które mają już za sobą epizod bólu kręgosłupa może wynosić aż 51%, a częstość występowania tej dolegliwości wzrasta wraz z wiekiem i aktywnością fizyczną. W pracy podsumowano badania MR dzieci z bólami kręgosłupa wykonane w Instytucie Matki i Dziecka w Warszawie i zebrano patologiczne znaleziska, jakie zostały w nich uwidocznione.

**Materiał i metoda:** Przeanalizowano 121 badań MR wykonanych z powodu bólów kręgosłupa u dzieci. Wszystkie badania wykonano aparatem GE Signa HDxt o natężeniu pola magnetycznego 1,5T według rutynowego protokołu: sekwencja SE, obrazy T1-zależne, projekcja strzałkowa i poprzeczna, sekwencja FSE, obrazy T2-zależne, projekcja strzałkowa i poprzeczna, sekwencja STIR, projekcja strzałkowa. W razie potrzeby badanie uzupełniano o projekcję czołową i podanie środka kontrastowego.

**Wyniki:** Wyniki ujemne - brak odchyżeń od stanu prawidłowego - uzyskano u 91 dzieci (75,2%). Dodatnie stwierdzono u 30 dzieci, co stanowi 24,8%. Wśród zmian patologicznych były: zmiany zwyrodnieniowe krążków międzykręgowych jako izolowane znalezisko u 9 dzieci (7,4%), choroba Scheuermanna u 2 (1,7%), przepukliny krążków międzykręgowych u 13 (10,7%), kręgozmyk u 2 (1,7%), zapalenie stawu krzyżowo-biodrowego u 1 (0,8%), zapalenie stawów międzywyrostkowych u 1 (0,8%), guzy nowotworowe u 2 (1,7%).

**Wniosek:** Bóle kręgosłupa u dzieci stanowią narastający problem i w ¼ przypadków mają istotne podłoże, widoczne w badaniu MR, które jest najlepszą metodą obrazowania przyczyn dolegliwości bólowych kręgosłupa w populacji wieku rozwojowego.

**Słowa kluczowe:** rezonans magnetyczny (MR), kręgosłup, ból, dzieci

## INTRODUCTION

As it is clear from the author's own observations, low back pain is a less frequent reason for referring children to imaging than headaches. According to *Bhatia et al* (1), the previously prevailing point of view has changed: that even in as many as 84% of cases there is a serious reason for chronic back pain in children (2) has been changed. In a prospective study, these above authors did not find any deviations from the normal state in the imaging and laboratory studies in 78% of patients with back pain lasting for more than three months, while in the remaining 22% there was spondylolysis with or without spondylolisthesis as the most common change (17%), and single cases of Scheuermann's disease, disc herniation, and osteoid osteoma.

The same authors reported that as many as 36% of children have already had an episode of low back pain at the age of 15 years. According to *Faingold et al* (3) this percentage in school-aged patients may be as high as 51%, and the incidence of back pain increases with age and physical activity. Competitive sports are a separate issue, they generate significantly more injuries and pain than recreational sports, according to *Keller* (4).

In Polish literature there is a broad study of the etiology, epidemiology and standards of management of back pain in childhood conducted by a team of physiotherapists and radiologists from the Medical University of Białystok; they also made an attempt to determine the place of diagnostic imaging (5, 6). The author summed up MR examinations of the spine in children performed at the Institute of Mother and Child in Warsaw due to back pain and described the pathological findings, which they revealed.

## MATERIALS AND METHOD

121 MR examinations performed in children due to back pain were analysed. It should be noted that with one exception this group did not include children with pre-existing significant scoliosis or with other known congenital spinal anomalies. All the examinations were performed using a 1.5 T GE Signa HDxt scanner according to routine protocol: SE sequence, T1-weighted images (T1-WI), sagittal and axial projection, FSE sequence, T2-WI, sagittal and axial projection, STIR sequence, sagittal plane. If necessary, coronal plane and contrast medium administration were added.

## RESULTS

Negative results – no deviation from the normal condition – were obtained in 91 children (75.2%). Positive results were found in 30 children, which accounts for 24.8% of the material. The types of pathology found are shown in Table I.

## DISCUSSION

Plain film is the easiest, cheapest and most widely available method of imaging the spine. It adequately demonstrates bone lesions, especially congenital vertebral anomalies in children. Such changes, however, have been excluded from the analysed material except one case of the coexisting congenital defect and herniated intervertebral disc (fig. 1).

The phase of rapid growth in teenagers is the time when degeneration of the intervertebral discs begin and may be accompanied by pain. X-ray is not a sensitive method of detection of these most common changes

Table I. Pathological changes in the vertebral column in the analysed material.

Tabela I. Patologiczne zmiany w kręgosłupie w badaniu MR w analizowanym materiale.

Kind of lesion <i>Patologia</i>	Number of patients <i>Liczba pacjentów</i>	% <i>Odsetek</i>
Intervertebral discs' degeneration as an isolated finding <i>Zmiany zwyrodnieniowe krążków międzykręgowych jako izolowane znalezisko</i>	9	7.4
Scheuermann's disease <i>Choroba Scheuermanna</i>	2	1.7
Disc's hernation <i>Przepuklina/-y krążka/-ów międzykręgowego/-ych</i>	13	10.7
Retrolisthesis <i>Kręgozmyk</i>	2	1.7
Sacroiliitis <i>Zapalenie stawu krzyżowo-biodrowego</i>	1	0.8
Intervertebral facet joint arthritis <i>Zapalenie stawów międzywyrostkowych</i>	1	0.8
Tumours <i>Guzy</i>	2	1.7
<b>Total/Razem</b>	<b>30</b>	<b>24.8</b>

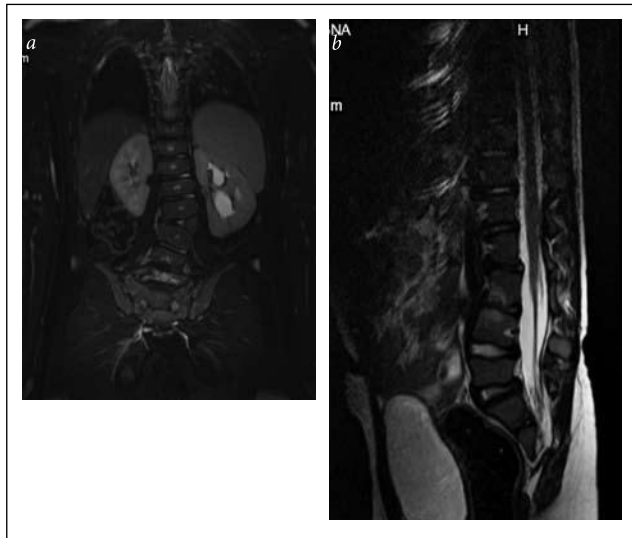


Fig. 1. Complex congenital anomalies: left-sided hydronephrosis, vertebral anomalies (hemivertebra causing scoliosis) – a. imperforate anus, sacral and coccygeal hypoplasia, tethered cord – b. Figure b also shows degenerative changes of the intervertebral disks L2/L3 and L3/L4 and protrusion of L2/L3 disk with dural sac compression.

Ryc. 1. Zespół wad wrodzonych: lewostronne wodonercze, wady kręgow (widoczny półkręgi powodujący skoliozę) – a, zarośnięcie odbytu, niedorozwój kości krzyżowej i guzicznej, zakotwiczenie rdzenia kręgowego – b. Na ryc. b widoczne są także zmiany zwyrodnieniowe krążków międzykręgowych L2/L3 i L3/L4 oraz wypuklina krążka międzykręgowego L2/L3, uciskająca worek opony twardej.

that can be found in the spine. It reflects only the late phase of disc disease when it is lowered. Computed tomography does not add much more here, and delivers a much higher dose of radiation to the patient. Magnetic resonance imaging is a method of choice for imaging the intervertebral disc and its changes. It is the best way to show the anatomy, is not based on ionizing radiation, and the dependence of signal intensity on nucleus pulposus hydration makes it possible to reveal the early stages of disc disease. T2-weighted images in (F)SE and STIR sequences are particularly useful. A properly hydrated intervertebral disc displays high signal intensity, which decreases with progressive dehydration (fig. 2).

Similarly, in Scheuermann disease, MRI shows the changes earlier than X-ray (fig. 3). Scheuermann's disease is usually the cause of kyphosis in the thoracic part of the vertebral column, and it is more painful in the lumbar part (2). On the imaging studies the disease is reflected by irregular endplates, intravertebral disc herniations (Schmorl nodes), narrowing of the intervertebral spaces and vertebral wedging (2, 3, 7).

Herniated intervertebral discs in children are considered rare pathology (1), although in the study by Sienkiewicz et al (6) the prevalence is high and reaches 15.9%. Also in the presented material, they account for the largest group of changes – 10.7%. It seems that this can be explained on the one hand by deliberately referring children with back pain to imaging, on the other hand one can also



Fig. 2. A 15-year-old girl. MRI, sagittal plane. SE/T1-weighted image (T1WI) (a) shows similar height of the intervertebral disks in the lumbar part of the vertebral column; the height of the disks does not show their degeneration at any level. FSE/T2WI reveals signal hypointensity of L4/L5 and L5/S1 disks which is compatible with their dehydration.

Ryc. 2. Dziewczynka 15-letnia. Badanie MR, projekcja strzałkowa. Obraz SE/T1-zależny (a) pokazuje, że poszczególne krążki międzykręgowy w odcinku lędźwiowym mają podobną wysokość, ta cecha nie wskazuje na chorobę dyskową na żadnym poziomie. W obrazie FSE/T2-zależnym (b) krążki L4/L5 i L5/S1 mają wyraźnie obniżoną intensywność sygnału w porównaniu z pozostałymi, co świadczy o ich odwodnieniu.



Fig. 3. A 14-year-old boy. MRI, sagittal plane. SE/T1WI (a) shows discrete end-plate irregularities in the thoracic vertebrae. The degenerative changes of two intervertebral disks are well seen on a FSE/T2WI (b). These changes have no impact on the spinal cord.

Ryc. 3. Chłopiec 14-letni. Badanie MR, projekcja strzałkowa. Obraz SE/T1-zależny (a) pokazuje już dyskretne nierówności płytek granicznych trzonów kręgow piersiowych. W obrazie FSE/T2- (b) bardzo wyraźnie są widoczne zmiany zwyrodnieniowe dwóch krążków m-kręgowych i brak wpływu tych zmian na rdzeń kręgowy.

conclude that the incidence of these changes is increasing. Intervertebral discs herniations are seen in the paediatric population mainly in three situations:

- sporting activities (fig. 4),
- excessive strain / injury (fig. 5),
- obesity (fig. 6)



Fig. 4. A 13-year-old girl, volley-ball player who started feeling back pain during training. STIR sequence in sagittal plane shows two disk herniations: at the level of Th11/Th12 and L1/L2. The fracture of the upper end-plate of Th12 vertebral body is also seen (a). FSE/T2WI in axial plane reveals thecal sac compression by the cranially displaced fragment of the L1/L2 nucleus pulposus under the posterior longitudinal ligament (b).

Ryc. 4. 13-letnia dziewczynka, trenująca piłkę siatkową. Poczula ból w czasie treningu. Sekwencja STIR w projekcji strzałkowej uwidaczniają dwie przepukliny krążków międzykręgowych: Th11/Th12 oraz L1/L2. Widoczne jest też złamanie blaszki granicznej górnej trzonu kręgu Th12 (a). Obraz FSE/T2-w płaszczyźnie poprzecznej pokazuje ucisk worka opony twardej przez przemieszczony pod więzadłem podłużnym tylnym w kierunku dogłowowym fragment wypadniętego jądra miazdżystego krążka międzykręgowego L1/L2 (b).

and concern mainly the lumbar spine (L-S), similarly to the problem of back pain. The thoracic part of the vertebral column (Th) is the second most frequent location of changes, while the least affected is the cervical part (C) (8). Such findings were confirmed in the material analysed in which herniated L-S discs were found in 10 children, Th - in three and C - in one (fig. 7) (one child had herniated discs in both Th and L-S - fig. 4).

In children with spondylolisthesis or discs herniations pain may not be the only symptom, therefore neurological examination, which is necessary in every case, may reveal the signs of compression or injury of spinal nerve roots or of the spinal cord. In this situation, magnetic resonance imaging is also a method of choice for evaluation of the spinal cord and spinal nerve roots (fig. 8).

Back pain of sudden onset, fever, and laboratory parameters of inflammation indicate the inflammatory nature of the cause. Intervertebral discitis is more common in children under 10 years of age. X-rays may long remain silent, and MRI is the method of choice also in this case. The presence of fluid within the intervertebral disc, blurring of disc-vertebral bodies interface, pathological paraspinous mass, both outside the spine and in the spinal



Fig. 5. A 14-year-old boy who helped in his grandmother's shop, carrying carpets. FSE/T2WIs in sagittal (a) and axial (b) planes reveal a big central L4/L5 disk herniation compressing dural sac and nerve roots in the lateral recesses of the vertebral canal. The intervertebral disks' shape indicates Scheuermann's disease.

Ryc. 5. Chłopiec 14-letni, pomagając w sklepie babci, dźwigając dywany. Obrazy FSE/T2-zależne w projekcji strzałkowej (a) i poprzecznej (b) uwidaczniają dużą centralną przepuklinę krążka międzykręgowego L4/L5 ze znacznym stopniem ucisku worka opony twardej i korzeni nerwów rdzeniowych w zachyłkach bocznych kanału kręgowego. Jednocześnie kształt krążków międzykręgowych wskazuje na chorobę Scheuermanna.



Fig. 6. An 11-year-old boy weighing 60 kg with the height of 146 cm. His body mass index (BMI) is 29, which - taking into account age and gender - places him above the 95th percentile and means obesity. FSE/T2WIs in sagittal (a) and axial (b) planes show Th12/L1 protrusion compressing dural sac and modeling conus medullaris.

Ryc. 6. Chłopiec 11-letni o masie ciała 60 kg i wzroście 146 cm. Jego body mass index (BMI) wynosi 29, co - uwzględniając wiek i płeć - sytuuje go powyżej 95. centyla i oznacza otyłość. Obrazy FSE/T2-zależne w płaszczyźnie strzałkowej (a) i poprzecznej (b) wykazują obecność wypukliny krążka międzykręgowego Th12/L1, uciskającej worek opony twardej i modelującej stożek rdzenia kręgowego.



Fig. 7. A 5-year-old girl with neurofibromatosis type 1 (a neurofibroma is seen in the suboccipital region) and neck pain. FSE/T2WI reveals C5/C6 and C6/C7 protrusions.

Ryc. 7. 5-letnia dziewczynka z rozpoznaną narwiakowłóknistością typu 1 (widoczny nerwiakowłókniak w okolicy podpotylicznej) i bólami kręgosłupa szyjnego. Obraz FSE/T2-zależny uwidacznia wypukliny krążków międzykręgowych C5/C6 i C6/C7.

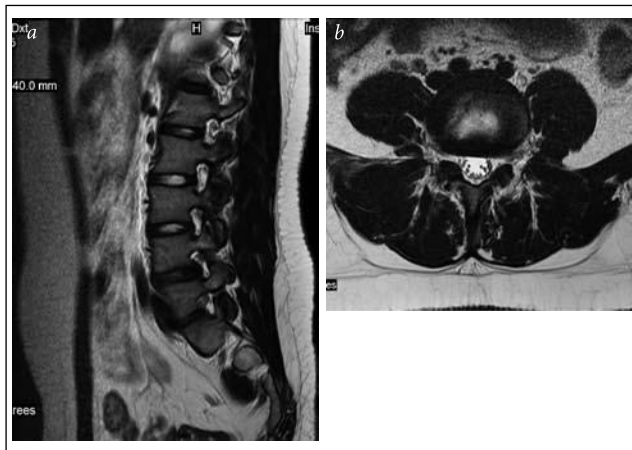


Fig. 8. A 15-year-old girl with low back pain with bilateral root pathway. FSE/T2WIs in sagittal (a) and axial (b) planes show grade I L4/L5 spondylolisthesis with characteristic narrowing of the intervertebral foramina and compression of nerve roots within them.

Ryc. 8. 15-letnia dziewczynka z bólem kręgosłupa z obu-stronnym torem korzeniowym. Obrazy FSE/T2-zależne w projekcji strzałkowej (a) i poprzecznej (b) pokazują niewielki kręgozmyk I stopnia na poziomie L4/L5 z charakterystycznym zwężeniem otworów międzykręgowych i uciskiem korzeni nerwów rdzeniowych L4 w ich obrębie.

canal are typical of osteodiscitis (7), which was not found in the material analysed because only these examinations were taken into account that were caused by isolated back pain, without other symptoms. However, in one case facet joints arthritis was found in a 16-year-old football player who suddenly experienced severe back pain without root pathway and fever (fig. 9). It was an unusual cause of pain in contrast to the fairly typical image of overload injury, which is also found in the posterior column and also displays increased signal intensity on STIR sequence – but it concerns vertebral arches and reflects partial stress fracture. This lesion occurs without trauma, especially in children training gymnastics from an early age. In the later stages the disease can lead to fractures and spondylolisthesis (3, 9). In the patient described above, the appearance of back pain was not associated with trauma, and changes were found in the facet joints and surrounding tissues.

With its large field of view MRI can also show changes located outside the vertebral column but felt by the sick



Fig. 9. A 16-year-old boy with the intervertebral facet joints inflammation at the level of L3/L4 and L4/L5. STIR sequence in a sagittal plane (a) reveals hyperintensity of L4 arch, L3/L4 facet joint and the adjacent tissues as well as fluid in the L4/L5 facet joint. FSE/T1WI in an axial plane (b) shows blurred contours of L3/L4 facet joints and of spinal nerve roots L3 in the intervertebral foramina. After gadolinium administration (c) strong contrast enhancement of the inflamed tissues is appreciated.

Ryc. 9. Chłopiec 16-letni z zapaleniem stawów międzywyrostkowych L3/L4 i L4/L5. Sekwencja STIR w projekcji strzałkowej (a) uwidacznia hiperintensywny sygnał z łuku kręgu L4 i stawu L3/L4 oraz otaczających tkanek miękkich, jak również obecność płynu w stawie L4/L5. W obrazie FSE/T1-zależnym w projekcji poprzecznej (b) widoczne jest zatarcie zarysów stawów L3/L4, a także korzeni nerwów rdzeniowych L3 w otworach międzykręgowych. Po podaniu gadolinu (c) widoczne jest silne wzmocnienie kontrastowe zmienionych zapalnie tkanek.

child as back pain. In the material analysed there was a case of unilateral sacroiliitis (fig. 10).

Finally, back pain can be a symptom of benign or malignant bone tumor or another tumour in the spinal/paraspinal location, which is rare. In the spine one can find osteoid osteoma and osteoblastoma, aneurysmal bone cyst, eosinophilic granuloma, Ewing's sarcoma (2, 3). Furthermore, it is believed that back pain may be a symptom of spinal tumor in 20-30% of cases these changes. In the material presented there was one case of Ewing's sarcoma, which was manifested one week before MRI as extremely severe back pain that prevented the child from taking any other position than sitting. After a few days micturition disorders and paraplegia also became present (fig. 11).

In children with a history of malignancy, the recurrence or metastases should always be taken into account. In the material analysed there was one case of Ewing's sarcoma metastasis to the spine. Thoracic and lumbar pain had persisted in the patient affected for two years. Imaging studies were performed many times for this reason – X-ray, CT scan, bone scan and MRI were carried out and successively revealed: increased meningeal tracer uptake in Th11/L2, Schmorl node at the same level, increased tracer uptake at the level of L5/S1, L4/L5 disc herniation. At the end of the second year of follow-up metastasis to Th11 vertebral body with spinal cord compression was found (fig. 12).

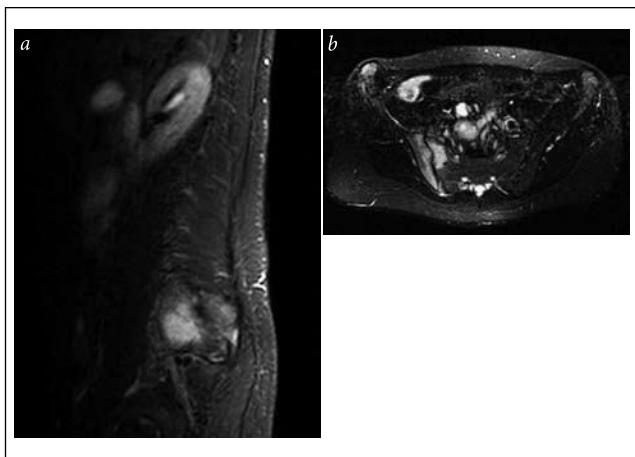


Fig. 10. A 14-year-old boy with low back pain without neurological signs and symptoms. The images of the vertebral column were normal while in the most lateral slice in the sagittal plane abnormally increased signal in the STIR sequence from the sacrum was noticed (a). The examination of the sacroiliac joints in STIR sequence, axial plane revealed right-sided sacroiliitis (b).

Ryc. 10. 14-letni chłopiec z bólami lędźwiowo-krzyżowego odcinka kręgosłupa, bez objawów neurologicznych. W badaniu MR kręgosłupa przedstawiał się prawidłowo, natomiast w skrajnej warstwie w projekcji strzałkowej uwidoczniono nieprawidłowo wzmożony sygnał w sekwencji STIR z kości krzyżowej (a). Pełne badanie celowane na stawy krzyżowobiodrowe wykazało zapalenie stawu po stronie prawej. Sekwencja STIR w projekcji poprzecznej (b) przedstawia pełny obraz zmian w kości krzyżowej i biodrowej.

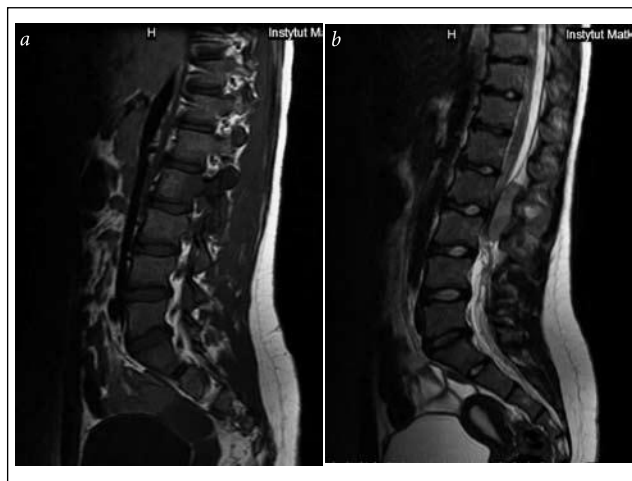


Fig. 11. A 14-year-old girl with histologically proved Ewing sarcoma. MRI, sagittal plane. The tumour involves both bony elements – vertebral arch and partially L2 body (a) and spinal canal at the level L1-L3 (b), and invades the surrounding tissues.

Ryc. 11. Dziewczynka 14-letnia z potwierdzonym histopatologicznie mięsakiem Ewinga. Badanie MR, projekcja strzałkowa. Widoczne jest zajęcie zarówno elementów kostnych – łuku kręgu i częściowo trzonu L2 (a), jak i masa wewnątrzkanałowa w odcinku L1-L3 (b) oraz nacieki otaczających tkanek.

Obviously, possible lesions in children with back pain should also be considered in the context of geography. The changes and MRI images described above relate to the Polish population. If we considered this problem for example in South Africa, back pain in children would suggest first of all spinal tuberculosis - so great is this problem in this part of the world.

## CONCLUSION

Back pain in children is a growing problem, and ¼ of the cases have significant ground, visible on MRI, which is the best method for imaging the causes of back pain in the developmental period.

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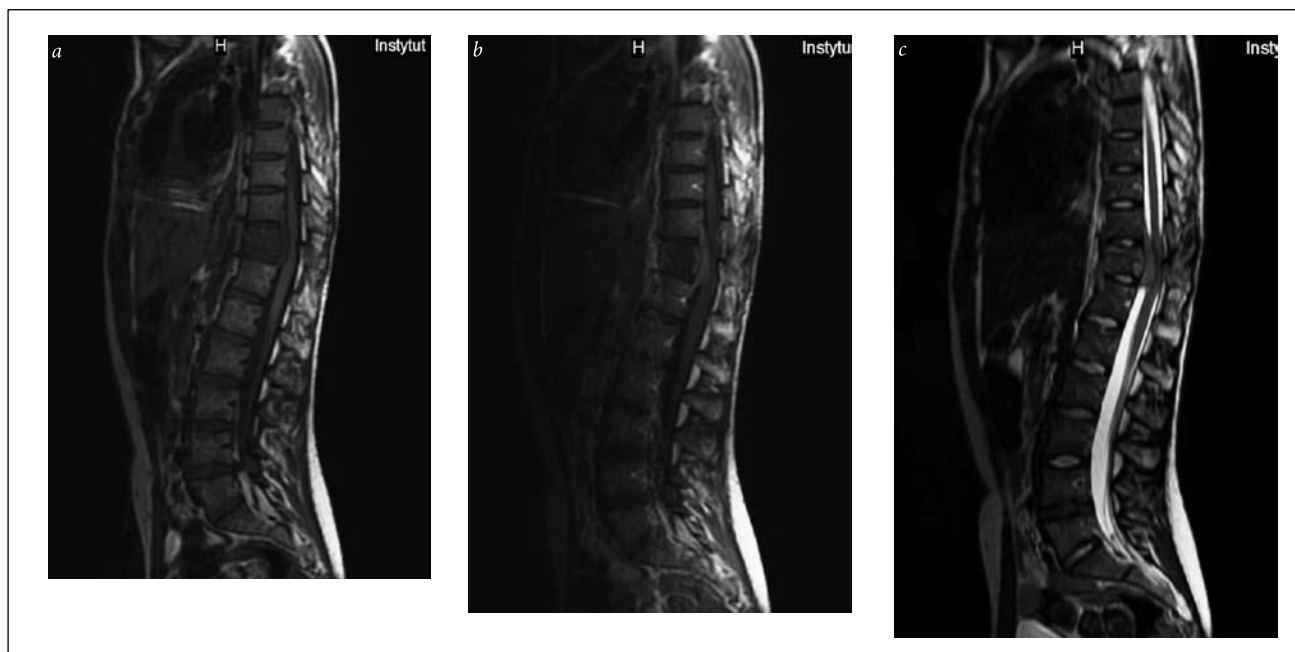


Fig. 12. An 18-year-old girl with Ewing sarcoma of the right scapula, after the resection of the scapula and lung metastases a few years before this examination. MRI, sagittal plane: SE/T1WI before (a) and after gadolinium administration (b), FSE/T2WI (c). Metastasis to the vertebral body Th11 with a mass protruding to the spinal canal. Besides there are degenerative changes of the intervertebral disk L4/L5 and its protrusion.

Ryc. 12. Dziewczynka 18-letnia z mięsakiem Ewinga prawej łopatki, po resekcji łopatki i przerzutów do płuc przed kilkoma laty. Badanie MR, projekcja strzałkowa: obrazy SE/T1-zależne przed (a) i po podaniu środka kontrastowego (b), obraz FSE/T2-zależny (c). Przerzut do trzonu kręgu Th11 z masą wewnątrzkręgową. Ponadto widoczne są zmiany zwyrodnieniowe krążka międzykręgowego L4/L5 i jego wypuklina.

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#### Conflicts of interest/Konflikt interesu

The Author declares no conflict of interest.  
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