

Bones and Joints

ISSN 1607-0763 (Print); ISSN 2408-9516 (Online)
<https://doi.org/10.24835/1607-0763-1571>



New possibilities of postural spine radiography

© Aleksander M. Orel*

S.I. Spasokukotsky Moscow Scientific and Practical Center for Medical Rehabilitation, Restorative and Sports Medicine;
53, Zemlyanoi Val str., Moscow 105120, Russian Federation

Digital radiography has solved the central problem of patient's radiation exposure. In addition, due to the high sensitivity of digital detector, the quality of the images obtained has significantly increased. The combination of the characteristics made it possible to obtain a single image of the entire spine as routine task. Spine radiographs are made with the patient in an upright position, so this investigation has called "postural radiography". The value of these images lies in the fact that, in addition to morphological features, they display the position of each vertebra, spine part, and a spine as a whole. It is widely used for the purpose of prognosis of orthopedic surgical interventions. The method of spine radiograph system analysis allows to register the data on a single examination protocol.

The purpose of this work was to demonstrate the possibilities of postural radiography and system analysis of spinal radiographs to study the morphological features and vertebra positions of all spine parts simultaneously.

Keywords: spine; postural radiography of the spine; system analysis of spine radiographs

Ethical expertise. The study was conducted in accordance with the Helsinki Declaration (adopted in June 1964, revised in October 2013), informed consent was obtained from each participant of the study.

Funding. The study was not funded by any source.

Conflict of interest. The author declares no obvious and potential conflict of interests related on the article publication.

For citation: Orel A.M. New possibilities of postural spine radiography. *Medical Visualization*. 2026; 30 (1): 49–60.
<https://doi.org/10.24835/1607-0763-1571>

Received: 01.06.2025.

Accepted for publication: 05.12.2025.

Published online: 11.02.2026.

X-ray examination is the gold standard in spine examination. It is important to say that a lot of Russian scientists in the 20th century made a significant contribution to the study of the central task – recognizing the morphological features of spine structures.

Traditionally the focus of orthopedists and surgeons was on identifying spinal diseases: inflammatory, benign and malignant tumors, tumor metastases, malignant vertebral fractures, traumatic spinal injuries, and diagnosing hereditary system diseases.

At the same time, normal anatomy, development and age-related changes of the spine have significant variations. Developmental anomalies, degenerative-dystrophic changes, and disturbances in the spatial position of structures are often detected. They have been described and classified in detail by famous Russian and foreign radiologists.

A major achievement of radiologists and morphologists was the separation of the totality of numerous nosological units associated with spinal suffering, which is based on lesion binding to morphological substrate. Before X-ray era, all spinal diseases of an inflammatory nature were called spondylitis, and non-

inflammatory diseases were called spondylosis. The work of Schmorl and Jungans [1–3] showed that spine dystrophic process occurs in response to a constantly acting disharmonious biomechanical load.

Joints may suffer and this is osteoarthritis. Intervertebral discs may suffer and, depending on the damage degree, this is either chondrosis (when only cartilaginous structures are damaged) or osteochondrosis (with damage involving cartilage and bone tissue of the intervertebral motor segment). Numerous beaked osteophytes spanning entire spine sections are described as fixing hyperostosis, named after Forestier.

Ligament damage is diagnosed as ligamentosis. The appearance of new joints that arise in response to spine biomechanics is called neoarthrosis, and the author who described them in the lumbar spine, Baastrup, gave the name to this nosological unit. Each of the conditions has its own specific X-ray picture.

The share of spondylosis remains the fixation of modified vertebrae with closing oblique brackets in the area of the anterior longitudinal ligament after injury, which is considered as a sign of stabilization for



the vertebral segment. Russian scientists have made significant contribution to the description of radiological manifestations typical for degenerative-dystrophic diseases [4], and others.

The question is natural: which of all the volume does a specialist need to know in order to work safely and effectively with a patient? The answer is simple – almost everything. Every little thing can be crucial. That is why it is at least imprudent to discount the achievements of our predecessors – teachers, great scientists of the older generation, and it is absolutely necessary to use the knowledge that they have passed on to us, modern doctors.

Today digital technologies have greatly simplified the art of radiography. Computed tomography, magnetic resonance imaging, ultrasound diagnostics, densitometry, scintigraphy, PET/CT, angiography – have significantly improved the diagnosis and expanded the range of diagnostic techniques that help identify morphological disease manifestations not only for bone structures, but also for radio-negative soft tissues.

Reliable diagnosis of not only a local lesion of the spine, but also the position of each individual vertebra, region and spine as a whole becomes urgent today. And in this regard the X-ray spine diagnosis by no means holds its position. Unlike other research methods, spine radiography can be performed with the patient in an upright position taking into account the physiological position and changes inherent in a standing person.

Postural radiography is a recognized visualising method and is widely used for the purpose of quantifying the interrelationships and position changes of various spine parts [5–11].

Digital radiography has made it possible to reduce the radiation dose tenfold, and the image quality has become such that we can confidently diagnose the condition of the transitional areas of the spine without prescribing additional special studies. A digital image of all spine structures can be obtained by gluing it together from individual images of each department. Modern X-ray machines are able to do this automatically when forming postural radiographs.

System analysis of spine radiograph (SASR): method features

It is important to say that obtaining X-ray image itself solves only part of the problem. An X-ray requires detailed examination. It contains a huge amount of visual information. However, a researcher who is not properly trained can see only the most general variants of the norm and/or pathology. This dictates the

need for a qualified examination of a patient, recording details and quantifying each feature.

The system analysis of spine radiographs (SASR) has been developed as a method that allows both recording in detail and in general and providing a detailed quantitative assessment of each spine structure available for examination on X-ray images in frontal and sagittal planes [12]. The method solves the task of registering the most significant morphological spine features and at the same time the position of each vertebra. A research protocol has been developed on which all significant signs are recorded in the form of a graphic image (picture) with verbal descriptions. Using conditional schematized images, the system spine model is formed according to the principle of “X-ray on paper”.

The examination protocol contains a special tool – a scheme for recording the lateral tilt, the position of spinous process vector relative to the vertebral body, and rotation direction for each vertebra. Each parameter is quantified. The set of schemes on the system model demonstrates the unique vertebra position at all spine levels. In addition, all the diagnosed morphological features of the vertebrae are recorded [12].

Application of SASR in rehabilitation medicine practice

The tasks solved using the method of system spine radiograph analysis can be divided into several areas:

1. Diagnosis of destructive diseases and degenerative-dystrophic conditions, covering all X ray-positive spine structures.
2. Planning for spinal correction methods by efforts of a multidisciplinary specialist team.
3. Spine change registration for a patient with short leg syndrome after heel pad installation

1. Diagnosis of destructive diseases and degenerative-dystrophic conditions, covering all X ray-positive spine structures

A special place is occupied by the diagnosis of destructive diseases at the level of entire spine. There are often unexpected radiological findings. For example, a pathological fracture with tumor metastases or an inflammatory process in the joints with Ankylosing spondylitis (Bechterew's disease). But such a previously undiagnosed disease is the exception rather than the rule. The most common for older people the system analysis of spine radiographs shows spinal changes in the form of compression vertebra fractures on the background of severe osteoporosis (Fig. 1, 2).

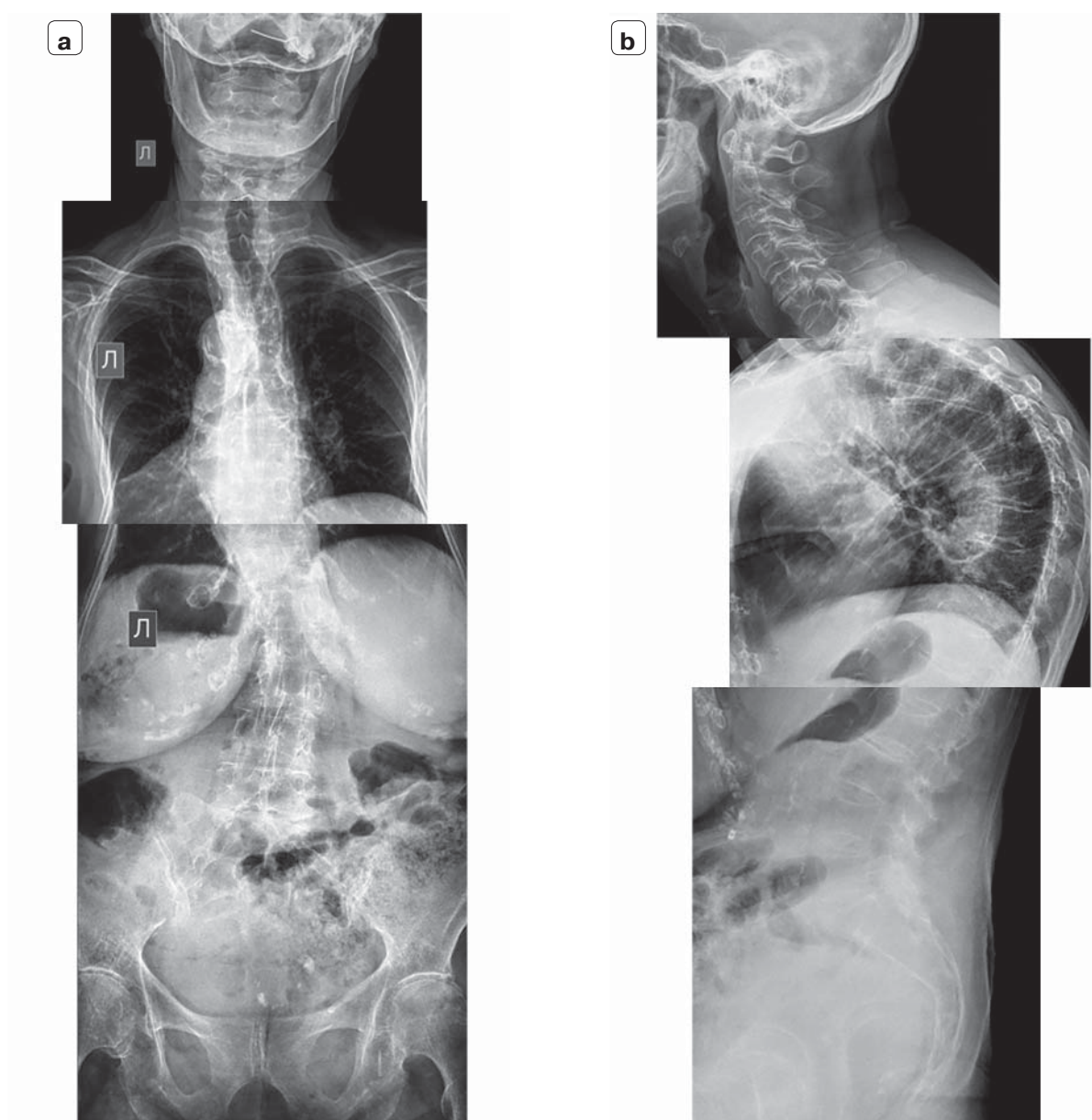
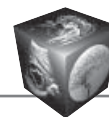


Fig. 1. Panoramic postural spine radiographs, patient K., 84 years. **a** – frontal plane; **b** – sagittal plane.

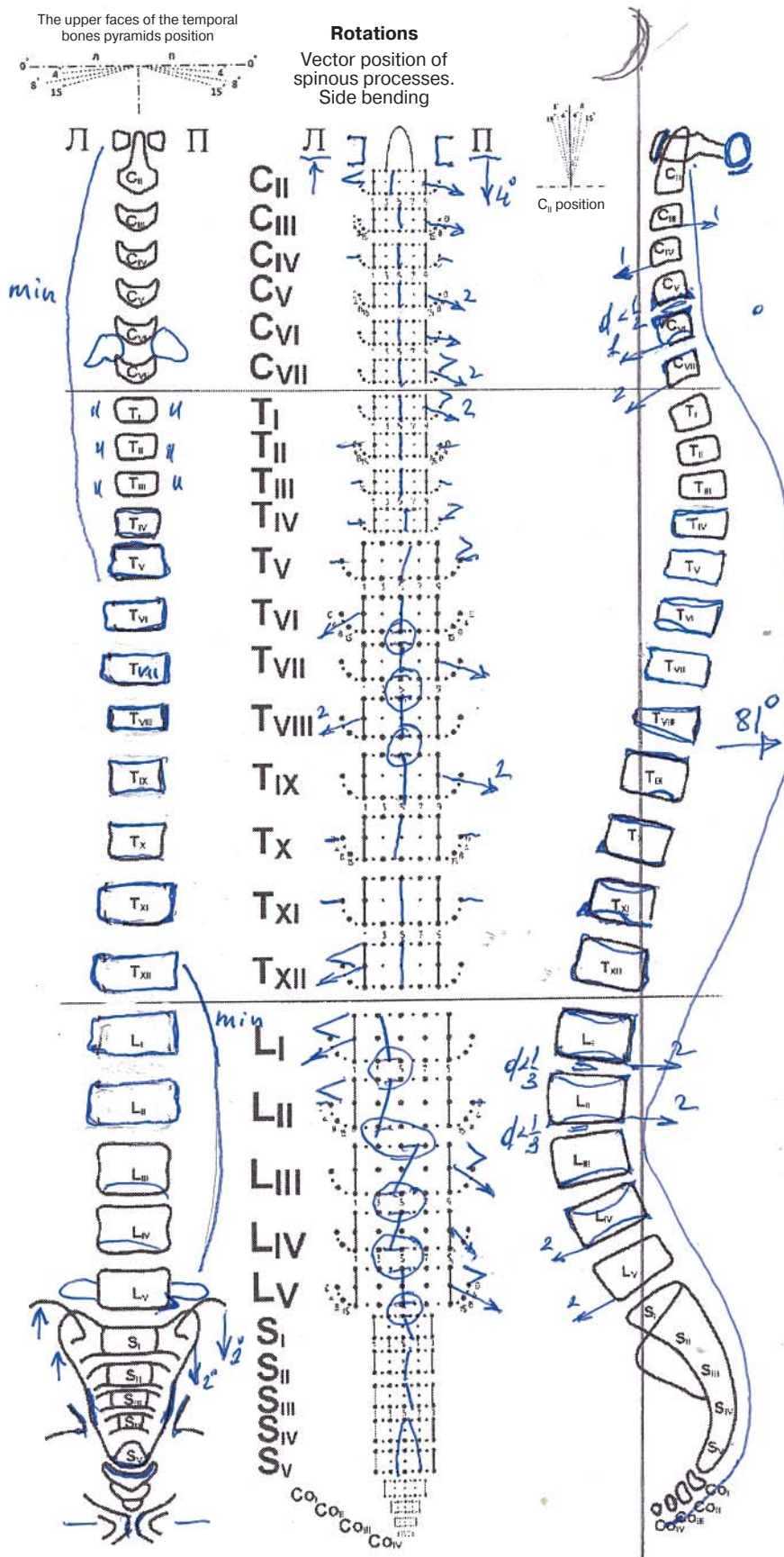
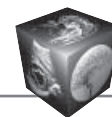


Fig. 2. The system model (SASR model), patient K., 84 years, reflects all the above-described signs.

**Example**

Radiographs of patient K., 84 years old (Fig. 1), show S-shaped scoliotic spine deformity against a background of pronounced involute osteoporosis (grade IV), thoracic kyphosis is sharply increased. Retrolisthesis C_{III} , L_I , L_{II} and antelisthesis $C_{IV}-C_{VII}$, L_{IV} , L_V are noted. There is a pronounced anterior wedge-shaped deformity of T_{VIII} vertebra body and a uniform decrease in the height of $T_{IV}-L_{II}$ bodies, deformations of C_{VI} , T_{VI} , T_{VIII} , T_{XI} , T_{XII} , L_I-L_{IV} bodies like “fish vertebrae” as manifestations of stage IV osteoporosis.

There are manifestations of degenerative-dystrophic conditions: osteochondrosis – subchondral osteosclerosis, structure unevenness of vertebral body closing plates in cervical, thoracic and lumbar sections, height decrease of the intervertebral spaces C_V-C_{VI} , L_I-L_{II} , $L_{II}-L_{III}$, an indirect sign of a herniated intervertebral disc in the form of a vacuum phenomenon was diagnosed at the C_V-C_{VI} level.

There are manifestations of widespread joint arthrosis: arched (all sections), atlanto-axial, rib-vertebral T_I-T_{III} , sternoclavicular, sacroiliac on both sides, sacrococcygeal, pubic, bilateral coxarthrosis, interosseous neoarthrosis – Baastrup symptom: C_I-C_{II} , $T_{VI}-T_{IX}$, L_I-S_I . There is an anomaly of development: the L_V right-sided sacralization.

The advantage of the system analysis of spine radiographs (SASR) method in this case is that it clearly demonstrates the full extent and severity of changes at all spine levels simultaneously. The system model (Fig. 2) demonstrates the localization of the most pronounced osteoporotic changes in the thoracic region. Treatment of such patients is usually difficult, but accurate knowledge about the location of critical lesions allows you to bypass these areas and offer patients help [12].

2. Planning for spinal correction methods by efforts of a multidisciplinary specialist team

The system model makes it possible to plan selective effects on certain vertebra groups as a part of overall restorative treatment task for a multidisciplinary team. A multidisciplinary team may include both doctors and other medical professionals of various specialties. When using the SASR model, specialists get an accurate picture of a patient's spine features, and a refined understanding is formed for steps to be done and the sequence. Clinical application of the approach makes it possible to achieve treatment effect with more gentle methods in a short time.

3. Spine change registration for a patient with short leg syndrome after heel pad installation

Simultaneous changes in spine structures were identified and recorded for a patient with anatomically short leg, after installing a heel pad under a short leg.

Short leg syndrome is most often caused by a functional or true anatomical shortening of one lower limb. Clinicians note that along with pelvic inclination, this syndrome includes functional scoliosis of spinal column, asymmetric tension of body skeletal muscles, facet syndrome, postural disorders and musculoskeletal pain of various localization [13].

Even a slight difference in the leg length, can be the main cause of recurrent pain in back and/or joints of the lower extremities. With an anatomical difference in leg length exceeding 10 mm, there are spasm, shortening and functional weakness detected when testing m. psoas (on the short leg side) and m. gluteus medius (on the long leg side) [13].

Functional assessment methods for pelvis and spine positions with anatomically short leg are proposed in order to predict the alignment degree during planned lift therapy [13].

In order to diagnose changes in the positions of pelvis structures, proximal thighs and vertebrae at the entire spine level, patient G., 11 years old, underwent postural radiography in upright position, first standing barefoot on the floor (Fig. 3, 4) and then repeated radiography, when a wooden block was placed under the shortened leg in order to fully compensate the difference in leg length (Fig. 5, 6).

The time difference between the X-ray examinations was 2 minutes.

The postural radiographs obtained in both cases, in frontal and sagittal projections (Fig. 3, 5), were described using the SASR model technology (Fig. 4, 6).

Spine examination protocol before heel pad correction

Both the postural radiograph in frontal projection and the SASR model of patient G., 11 years old, before the corrective heel pad installation showed: S-shaped scoliotic deformity of the lumbar and thoracic spine, which is accompanied by a right-sided wedge-shaped deformity of the body T_{VII} . The lower arc of magnitude 9° is located on the left at the level of the TS_I-L_V vertebrae, the upper arch is defined on the right at the level of $T_{III}-T_{IX}$. Lateral vertebra inclinations are noted: C_V , C_{VII} , $T_{II}-T_{VII}$ and $L_{III}-L_V$ – to the left; C_{II} , C_{III} , T_X-T_{XII} , L_I – to the right.

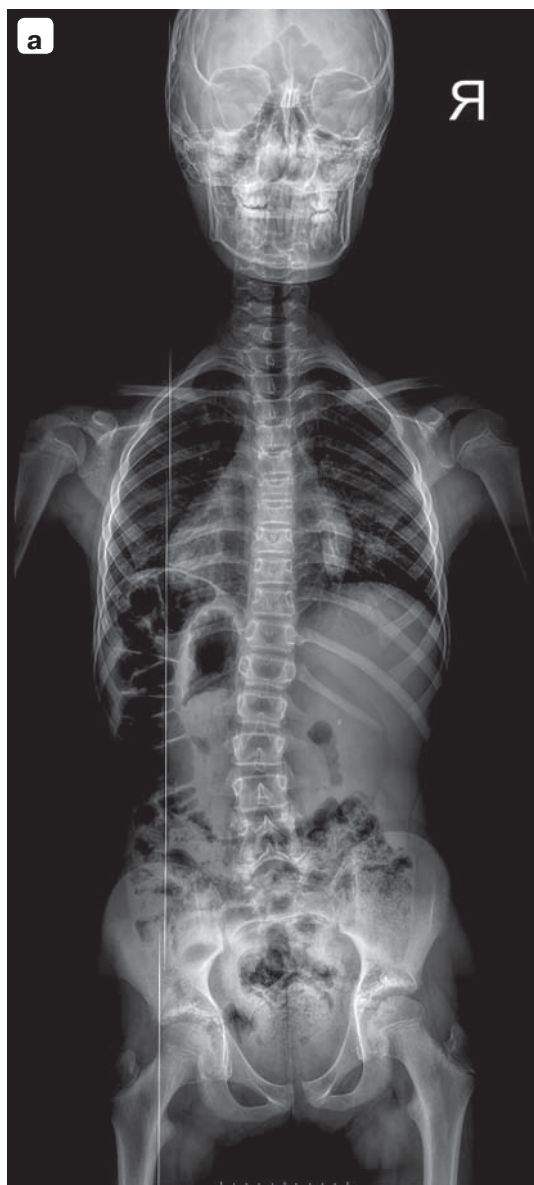


Fig. 3. The postural spine radiographs, frontal (a) and sagittal (b) projections, patient G., 11 years, before corrective heel pad installation. Diagnosis: anatomical left leg shortening.

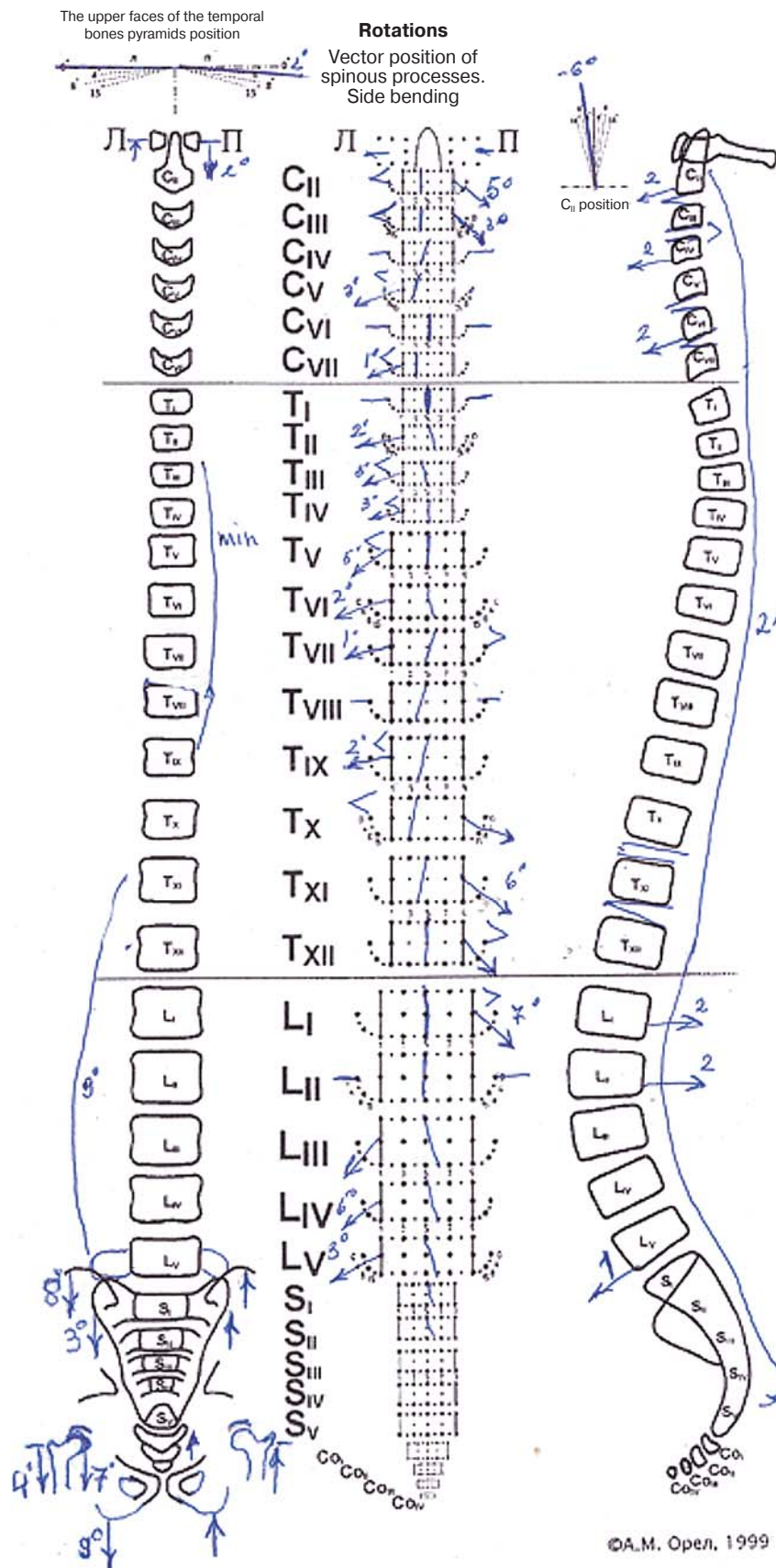


Fig. 4. The system spine model (SASR model), patient G., 11 years, before correction.



Fig. 5. The postural spine radiographs, frontal (a) and sagittal (b) projections, patient G., 11 years, after corrective heel pad installation under the left foot (+22 mm).

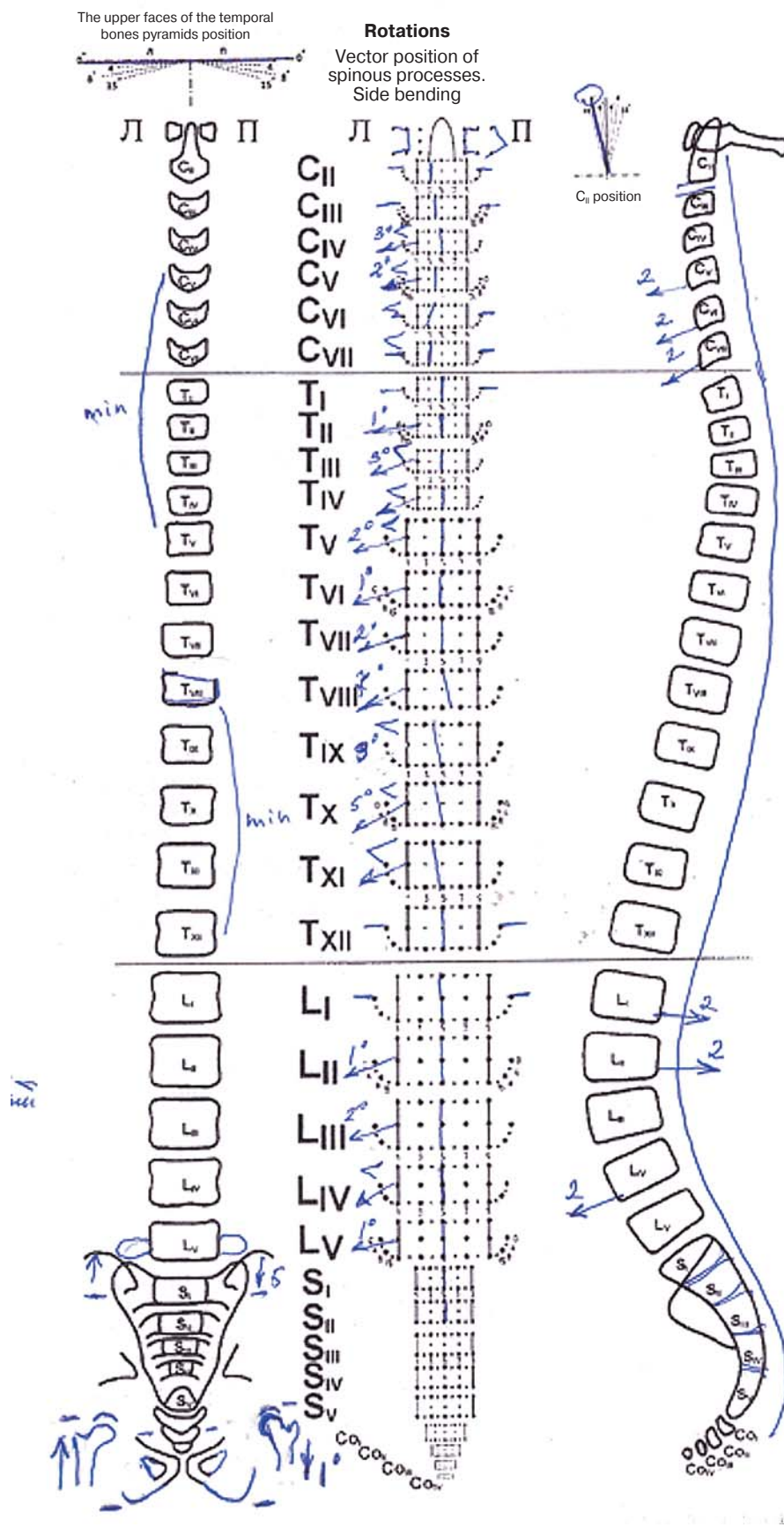


Fig. 6. The system spine model (SASR model), patient G., 11 years, after the left foot position correcting by the +22 mm heel pad.



The left half of the pelvis is tilted 8° relative to the right half, the sacrum is tilted 3° to the left. The roof of the left acetabulum is shifted down by 7° relative to the right one, and the large trochanter of the left thigh is 4° lower than the right one. In the pubic joint, the left pubic bone is located below the right one. The left tubercle of the sciatic bone is displaced downwards by 9° relative to the right one. The atlas is located asymmetrically and tilted to the right by 2° . The shoulder joints are raised, and the collarbones form an asymmetrical angle.

On the postural spine radiograph in sagittal projection: cervical lordosis is generally replaced by kyphosis. Thoracic kyphosis is flattened to 18° . The sacrum in sagittal plane occupies a horizontal position: $\angle\alpha = 52^\circ$, $\angle\delta = 27^\circ$. There is antelystesis (anterior displacement) of C_{II} , C_{IV} , C_{VII} and L_V vertebrae, as well as retrolistesis (posteriorly displacement) of L_I and L_{II} vertebrae.

Among the developmental anomalies, there are signs of bilateral symmetrical sacralization of L_V and skull base platybasia, grade I. Degenerative-dystrophic changes in spine structures have not been identified.

X-ray spine examination after foot correction by heel pad

Protocol of spine examination after corrective heel pad installation (Fig.5, 6)

In order to correct the anatomical size of the left limb, a 22 mm high heel pad was installed under the left foot.

On the postural radiograph, upon repeated examination (Fig. 5), the position of the sacrum, acetabulum, pubic bones and sciatic tubercles in the frontal projection became symmetrical, there was a slight twisting of the iliac bones to the right -5° , the large trochanter of the right femur dropped by 1° compared to the left one.

Scoliotic arches changed their positions and extent. The lower arc is now differentiated on the right and above at the $T_{VIII}-T_{XII}$ level, the upper arc is on the left at the C_V-T_V level.

The direction and severity of vertebra side bending have changed. Before correction the lateral slopes of vertebrae were differentiated: C_V , C_{VII} , $T_{II}-T_{VII}$ and $L_{III}-L_V$ – to the left; C_{II} , C_{III} , T_X-T_{XII} , L_I – to the right. After the correction: C_{VI} , C_V , $T_{II}-T_{XI}$ and $L_{II}-L_V$ vertebrae had a lateral tilt to the left; the lateral slopes of the vertebrae to the right were not determined.

The rotation of the atlas relative to the axis to the right has appeared, the previously existing lateral inclination is not determined. After the correction, the position of the collarbones became more sym-

metrical, the shoulder joints dropped and took a more correct position.

Postural radiographs in the sagittal plane revealed that axis forward tilt magnitude (kyphosis) increased to 8° (it was 6°). The position of the cervical vertebrae has changed. The cervical lordosis became straightened, there was kyphosis before correction. Thoracic kyphosis has acquired a more harmonious state, its magnitude is now within the normal range of 36° , it was flattened before the heel pad installation. The sacrum in the sagittal projection took the normal position $\angle\alpha = 40^\circ$, $\angle\delta = 40^\circ$. On the X-ray picture, the signs of antelystesis for C_V , C_{VI} , C_{VII} , and L_{IV} vertebrae are differentiated. Retrolistesis of vertebrae L_I and L_{II} is preserved.

Signs of right-sided wedge-shaped deformity of the T_{VIII} vertebral body, bilateral symmetrical sacralization L_V , and skull base flattening (platybasia, the first degree) are still differentiated.

After correcting the position of the left lower limb with 22 mm-high heel pad the patient has showed significant changes in the position of almost all vertebrae, both in the frontal and sagittal planes throughout the spine. The posture and position of the pelvis, sacrum and hips have become more symmetrical and harmonious.

Conclusions

1. Postural radiography supplemented with a description using the system analysis of spine radiographs (SASR method) is a useful tool for recording morphological features and vertebra positions in all spine parts.

2. Postural radiography is useful for diagnosis of destructive diseases throughout the spine.

3. The spine system models visually reflect the most important radiological signs of degenerative-dystrophic vertebra conditions at all spine levels simultaneously.

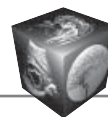
4. The method is useful for assessing changes in the position of spinal structures after corrective heel pad installation.

Authors' participation

Orel A.M. – concept and design of the study, collection and analysis of data, preparation and creation of the work.

References

1. Schmorl Ch.G., Junghanns H. Die gesunde und kranke Wirbelsäule im Röntgenbild. Leipzig, 1932.
2. Schmorl Ch.G., Junghans H. Die gesunde und die kranke Wirbelsäule im Röntgenbild und Klinik. Stuttgart, 1957.
3. Junghas H. Die Wirbelsäule unter den Einflüssen des taglichen Lebens, der Freireit, des Sports. Stuttgart: Hippokrates, 1986. 503 S.



4. Kosinskaya N.S. Degenerative and dystrophic lesions of the osteoarticular apparatus. Leningrad: Medgiz, 1961. 196 p. (In Russian)
5. Roussouly P., Gollogly S., Berthonnaud E., Dimnet J. Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position. *Spine (Phila Pa 1976)*. 2005; 30: 346–353. <https://doi.org/10.1097/01.brs.0000152379.54463.65>
6. O'Brien M.F., Kuklo T.R., Blanke K.M. et al. Radiographic Measurement Manual of Spinal Deformity Study Group. Medtronic Sofamor Danek USA, Inc., 2008. 110 p.
7. Mac-Thiong J.M., Roussouly P., Berthonnaud E., Guigui P. Sagittal parameters of global spinal balance: normative values from a prospective cohort of seven hundred nine Caucasian asymptomatic adults. *Spine (Phila Pa 1976)*. 2010; 35 (22): E1193–1198. <https://doi.org/10.1097/BRS.0b013e3181e50808>
8. Clément J.L., Solla F., Amorese V. et al. Lumbopelvic parameters can be used to predict thoracic kyphosis in adolescents. *Eur. Spine J.* 2020; 29: 2281–2286. <https://doi.org/10.1007/s00586-020-06373-z>
9. Bayat A., Pace D.F., Sekuboyina A. et al. Anatomy-Aware Inference of the 3D Standing Spine Posture from 2D Radiographs. *Tomography*. 2022; 8: 479–496. <https://doi.org/10.3390/tomography8010039>
10. Charles Y.P., Bauduin E., Pesenti S. et al. Variation of Global Sagittal Alignment Parameters According to Gender, Pelvic Incidence, and Age. *Clin. Spine Surg.* 2022; 35: E610–E620. <https://doi.org/10.1097/BSD.0000000000001321>
11. Solla F., Ilharreborde B., Blondel B. et al.; French Spine Surgery Society (SFCR). Can Lumbopelvic Parameters Be Used to Predict Thoracic Kyphosis at all Ages? A National Cross-Sectional Study. *Global Spine J.* 2024; 14 (4): 1116–1124. <https://doi.org/10.1177/21925682221134039>
12. Orel A.M. System analysis of spine radiographs in the practice of manual medicine. Moscow: Vidar-M Publishing House, 2018. 432 p. (In Russian)
13. Frolov V.A., Nechaev V.I., Nechaev E.V., Ivanov V.V. Short leg syndrome in clinical practice. *Russian Osteopathic Journal*. 2024; 2: 113–130. <https://doi.org/10.32885/2220-0975-2024-2-113-130> (In Russian)

Contact*: Alexander M. Orel – aorel@rambler.ru

Alexander M. Orel – Doct. of Sci. (Med.), Professor, Chief researcher of the Department of Medical Rehabilitation of Patients with Musculoskeletal System Diseases, S.I. Spasokukotsky Moscow Scientific and Practical Center for Medical Rehabilitation, Restorative and Sports Medicine, Moscow. <https://orcid.org/0000-0003-4129-524X>