



## Case Report

### A focused surgical case report: Managing scoliosis in Wolf–Hirschhorn syndrome

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#### ABSTRACT

**Introduction:** Wolf–Hirschhorn syndrome (WHS) is a genetic disorder from a chromosomal deletion on chromosome 4, leading to systemic pathologies including spinal deformities like scoliosis.

**Aim:** The objective of this publication is to present a case of scoliosis treatment in a patient with WHS, where the primary goal was to halt the progression of the curvature and achieve the most effective correction of the deformity, despite the guardians' refusal to extend the stabilization system to the pelvis.

**Case study:** Preoperative radiographs revealed a single-curve scoliosis of 64°, as measured by the Cobb method between Th11 and L5. Prior to the scheduled procedure, a magnetic resonance imaging examination of the spinal column was conducted to potentially visualize any spinal cord pathology. A corrective procedure, posterior spinal fusion, was performed using cobalt-chrome rods. A postoperative posturographic control examination was conducted, and follow-up outpatient visits were recommended.

**Results and discussion:** Despite not implementing the stabilization system to the pelvis, a reduction in deformation by 22° was achieved, resulting in 42° measured between Th11 and L5. In a follow-up examination 18 months post-operation, the degree of deformity remained stable, maintaining the curvature angle of 42° measured between Th11 and L5.

**Conclusions:** Treating scoliosis in patients with WHS requires a tailored approach, considering the specifics of their condition and utilizing optimal spinal stabilization methods. A multidisciplinary approach, integrating various therapeutic modalities, is crucial for enhancing the quality of life of WHS patients.

## 1. INTRODUCTION

Wolf–Hirschhorn syndrome (WHS) is a rare genetic disease caused by a chromosomal deletion of the distal end of chromosome 4, especially in the critical region (WHSCR) at 4p16.3.<sup>1</sup> The size and location of deletions can vary, which partly explains the variety of symptoms observed in patients. Often, this deletion is *de novo*, which means it appears spontaneously without a family history of the disease. Molecular techniques such as fluorescent *in situ* hybridization (FISH) or next generation sequencing (NGS) are used to identify damage.<sup>2</sup>

This disease is characterized by abnormalities typical for many systems of the organism, including abnormal development of various parts of the body, developmental delay, and intellectual disability. The prevalence of WHS has been estimated at 1 to 20,000–50,000 newborns, the occurrence of which is seen twice as often in females.<sup>3,4</sup> One of the most characteristic symptoms of WHS is the specific ‘Greek helmet’ sign on the face. This involves a narrow, inward-pointing forehead, widely spaced nasal bridge, characteristic ‘beak nose’ profile, protruding cheeks, and micrognathia (small jaw). At birth, children with WHS may have low body weight and small head circumference (microcephaly), and their growth and development may be delayed.<sup>5</sup>

In clinical characteristics, the most common disorders observed in patients with WHS are otolaryngological (e.g. dysplastic ears), gastroenterological (swallowing difficulties), neurological (e.g. seizures, epilepsy, muscular hypotonia) and other abnormalities, such as renal anomalies or congenital heart defects.<sup>5</sup>

Despite the extensive attempt to present the WHS phenotype, there is little literature data describing neuromuscular abnormalities in patients with WHS, especially in the field of spinal column pathology. Scoliosis as a component of WHS is estimated to occur with a frequency of approximately 49%–66%.<sup>4,6</sup>

Scoliosis, which is a deformation of the spine column, is described as a lateral curve of the spine above 10° as measured by the Cobb method.<sup>7</sup> It occurs in many disease entities, including genetic syndromes such as Rett syndrome or spinal muscular atrophy, adopting a characteristic, single-curve shape resembling the letter C.<sup>8,9</sup> Depending on the degree of advancement of scoliosis, various therapeutic approaches are applied. For the purposes of this article, we will generalize that according to the guidelines of the Scoliosis Research Society, the degree of scoliosis deformation between 20°–45° requires brace treatment. However, the literature often states that the indication for the use of a brace for the treatment of scoliosis is within the range of 20°–40°.<sup>10</sup> Deformations greater than those indicated above preliminarily qualify for surgical correction of scoliosis.<sup>11,12</sup> More comprehensive guidelines regarding the surgical treatment of scoliosis can be found in the AO Spine guidelines.<sup>13</sup>

Below we present a case of surgical treatment of single-curve scoliosis in a 16-year-old WHS patient. Due to the increasing progression of spinal deformity, the patient was

qualified for surgical correction despite brace treatment. In the following publication, we describe the preoperative procedure with radiographs, as well as the mid- and postoperative procedures with a follow-up period of 18 months after the procedure.

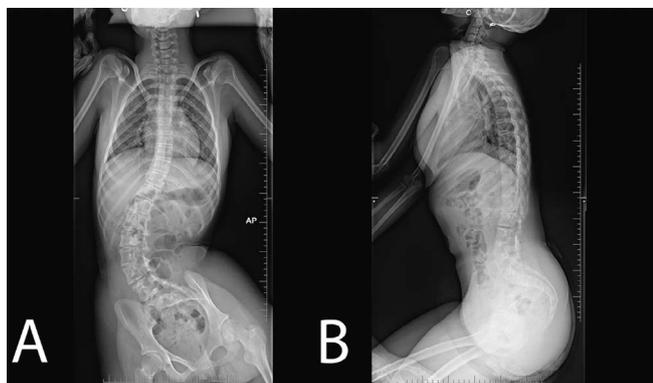
## 2. AIM

The objective of this article is to present a case of successful surgical intervention for right-sided single-curve thoracolumbar scoliosis in a patient with WHS. The primary aim was to halt the progression of the deformity and achieve the maximum possible correction within the current clinical constraints.

## 3. CASE STUDY

A 16-year-old female patient, psychomotor retarded, severely intellectually disabled, was admitted to the paediatric neurosurgery clinic for elective single-curve scoliosis correction surgery in the course of WHS. The child, who is in a lying position, is transported by a wheelchair and is periodically positioned upright in a static standing frame. Neurologically, a patient with quadriparesis, decreased muscle tone, accompanied by uncontrolled sphincters.

The girl was diagnosed with WHS associated with double chromosome imbalance: partial 4p deletion, spanning about 9.2 Mb and partial 8p trisomy, of about 8Mb. The child was treated for many systemic anomalies, including: ophthalmic problems (child with cataract on the left eye; corneal neovascularisation; ectopia lentis; iridocorneal adhesions of the right eye), neurology problems (sleep recording abnormal; paroxysmal lesions localized in the posterior regions; sporadically generalizing; epilepsy – partially complex seizures and secondary generalized), otolaryngological problems (condition after ventilation drainage of the tympanic cavities with restoration of the tear ducts under endoscope control; mixed bilateral deafness and sensorineural deafness were diagnosed), jaws and facial problems (surgically treated cleft palate). In magnetic resonance imaging (MRI) with contrast: within the white matter of both cerebral hemispheres, in the subcortical and periventricular regions, mainly in the vicinity of the posterior horns of the lateral ventricles, focal demyelinating lesions are visible, the Vergi cavity with a diameter of about 11 mm, convexing towards the lamina pouch. Cerebral fluid spaces in the supratentorial area widened mainly in the frontal areas, revealing narrow brain gyri. Pathological enhancement after the administration of the contrast agent was not detected. The reason for qualifying the patient to the scoliosis stabilization and correction surgery was the progressive deformation of the spinal column. The patient had previously been treated with a Cheneau-type corrective brace. The first posturographic image taken showed a right-sided single-curve of the spine, with the apex of the curve at the level of L3, resulting in a Cobb deformation degree of 64° measured be-



**Figure 1.** (A) Posturographic image of the spine in AP position showing single-curve scoliosis with a degree of deformation of  $64^\circ$  measured between Th11 and L5. The right pelvic plate is positioned 42 mm lower than the left (B). Posturographic image of the spine in a lateral position. The thoracic kyphosis, measured using the Cobb method, was approximately  $38^\circ$ .

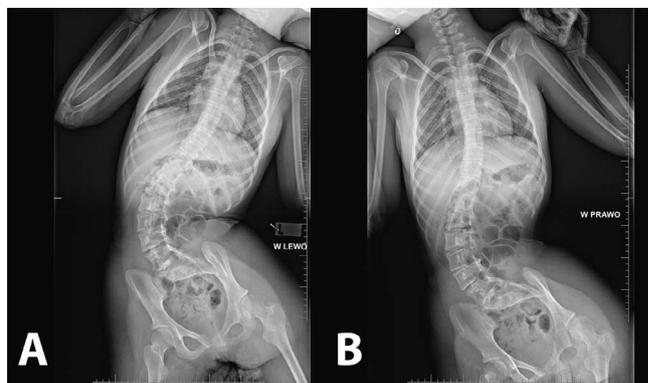
tween Th11 and L5 (Figure 1). The image was taken with the patient in a lying position.

Before the initial qualification of the procedure, MRI of the spine column was performed to assess the structures of the spinal cord. MRI showed no pathology of the spinal cord (Figure 2).

Before the planned surgical procedure, functional images were taken in the coronal plane (coronal bending) to assess the flexibility of the spinal curvature (Figure 3). The patient was also in a lying position while taking the X-ray.

On the day of admission, a functional examination of the spine in the frontal plane was performed to assess the structure and natural mobility of the spine segments.

The patient's family was fully informed about the procedure and its potential complications, thus obtaining informed consent for the surgery. The possibility of performing stabilization to the wings of the iliac bones, for which the



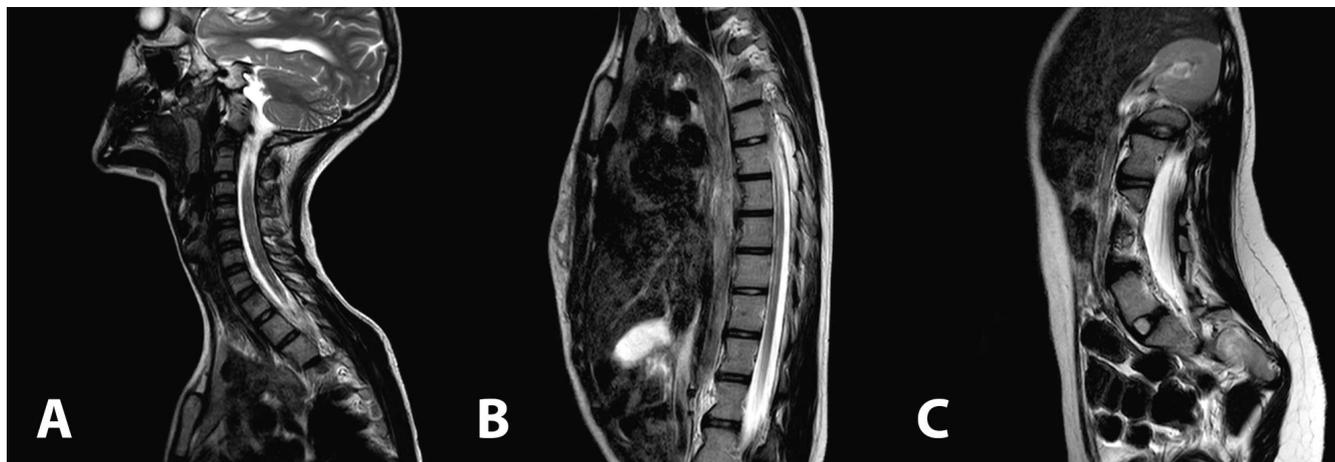
**Figure 3.** The functional X-ray image in the coronal plane: (A) the torso bending to the left; (B) the torso bending to the right.

patient's family has not consented at present, was presented. They were warned about the possibility of extending the stabilization system to the pelvic bones in the event of an unsatisfactory clinical effect or progression of pelvic deformity.

With the use of posturographic and X-ray functional examination of the spine, the degree of scoliosis was assessed, determining the Cobb angle and the natural mobility of the segments of the spine in the coronal plane (coronal bending).

After thorough consideration of the patient's guardians' perspective and the analysis of the rehabilitative plan, which included stages of verticalization in the treatment process, a decision was made to implement a stabilization system extending from the L4 to Th9 level. Cobalt-chrome rods were utilized to enhance the strength and stability of the system. This decision was informed by the long-term rehabilitative and functional improvement goals for the patient, with a focus on achieving optimal clinical and functional outcomes.

Following general anaesthesia, spinal cord monitoring electrodes were placed and secured to monitor motor and somatosensory evoked potentials (MEP and SEP, respective-



**Figure 2.** MRI examination presenting the spinal canal in the sagittal plane: (A) cervical segment, (B) thoracic segment, (C) lumbar segment. The signal of the spinal cord and vertebral bodies is normal. The spinal cord cone ends at the level of the intervertebral space L2/L3. In the thoracic segment of the spine, features of epidural lipomatosis are visible along the posterior outline of the spinal canal, up to a width of 4.5 mm. The contours of the spinal canal are smooth, without signs of stenosis.

ly). The patient was placed in the prone position on the operating table, identifying and securing additional pressure areas. Before starting the operating procedure the SEP and MEP standard recordings were made.

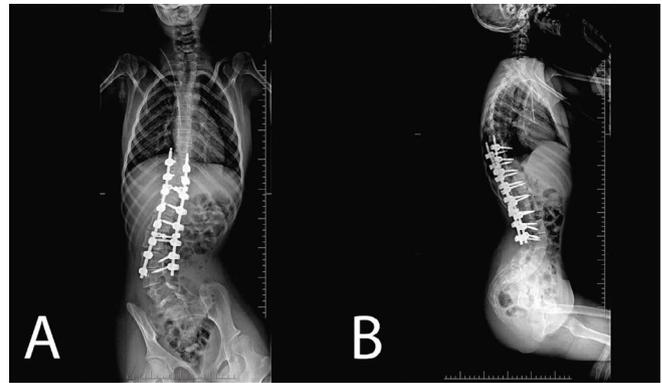
Using mono and bipolar diathermy, bone structures, including vertebral joints, were visualized. Transpedicular screws were fixed from L4 to Th9 using the freehand method. The placement of the screws was verified using a C-arm X-ray machine, and intraoperative monitoring was performed using neuromonitoring. A multi-level Ponte osteotomy was performed. Cobalt-chrome rods with a diameter of 5.5 mm were selected. The left rod was then appropriately bent to fit the thoracic and lumbar curvature. The rod was then secured, starting from the screw closest to the skull, successively connecting it to the next screws while adjusting the rod to the deformity. Without locking, a derotation of approximately  $90^\circ$  was performed using rod holders, correcting as much as the spinal flexibility and intraoperative neuromonitoring allowed. The last two distal screws were then locked to maintain the rod's position. Derotation extenders were placed along the apex of the curve and at the site of the convexity of the deformity. A derotation maneuver was performed at the apexes, and the screws were locked. Compression was performed on the convex side, followed by distraction on the concave side, locking the subsequent screws. The correction was further improved using coronal benders while monitoring the relationship of the secured screws in the vertebrae. A right cobalt-chrome rod was then prepared, appropriately fitted to the curves, and initially secured in the proximal screws. Using a rod holder, the rod was placed in the distal screws. Distraction was performed on the concave part, and compression on the convex part. The integrity of the stabilization system and its position were verified using the C-arm X-ray machine. Decortication was performed, bone graft was used, and transverse rod connectors were installed. A Redon drainage was placed and the tissues were sutured in layers after haemostasis was achieved.

There were no intraoperative complications during the procedure. There were no abnormalities in the monitoring of spinal cord function. The entire operation lasted 5 h and the blood loss was 300 mL.

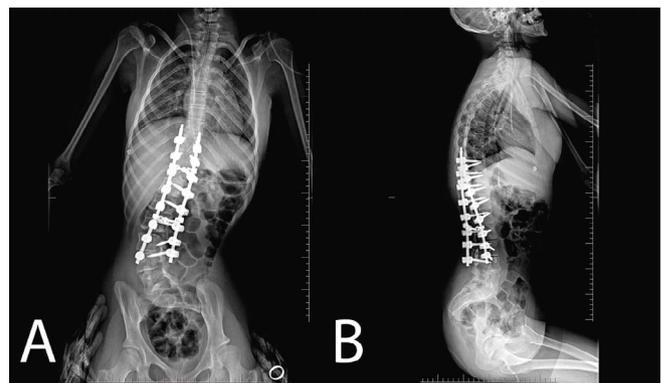
The patient was hospitalized for 5 days. After the surgery, the patient was transferred to the intensive care unit (ICU) as planned in order to monitor vital functions after the surgery. On the next day, the patient in good general condition, with cardiovascular respiratory efficiency, was transferred from the ICU to the neurosurgery clinic, keeping the lying position for the next 24 h. Next Redon drainage was removed and the thoracolumbar corset was selected. Patient was with no deterioration in neurological condition.

The postoperative wound was healing properly. On the day of discharge, a control X-ray posturographic examination of the spinal column was performed, obtaining a  $22^\circ$  Cobb correction between L5 and Th11 (from  $64^\circ$  to  $42^\circ$ ) (Figure 4).

Eighteen months after the correction of the spine column,



**Figure 4.** Posturographic image in the AP (A) and lateral (B) position showing the location of the stabilization system and showing the degree of deformation in the size of  $42^\circ$  measured between Th11 and L5. The right pelvic plate is positioned 35 mm lower than the left. The pelvis is set in significant rotation. The spinal stabilizer encompasses the spine from vertebrae Th9 to L4. The thoracic kyphosis, measured using the Cobb method, was approximately  $38^\circ$ .



**Figure 5.** AP posturographic (A) and lateral (B) image taken 18 months after the procedure. The thoracic kyphosis, measured using the Cobb method, was approximately  $38^\circ$ .

a posturographic control examination was performed, showing the correct location of the stabilizing system, thus maintaining the degree of correction by about  $22^\circ$  (Figure 5).

#### 4. DISCUSSION

We present for the first time the target treatment of C shape scoliosis deformity in a patient with WHS. The primary aim of our approach was primarily to halt the progression of scoliosis and to achieve the most effective correction of the deformity, despite the guardians' refusal to extend the stabilization system to the pelvis. The guardians argued their decision by stating that although the patient was mainly transported by wheelchair, she underwent rehabilitative treatment in a static standing frame and was transported short distances in it. Given the situation, we decided to

place the stabilization system up to the level of L4, explaining to the guardians that in the case of worsening deformity, it would be possible to extend the stabilizing system to the pelvis, thereby correcting its oblique positioning.

In the process of determining the levels of spinal fusion, standard practice involves identifying the terminal vertebrae, marking the Cobb angle, determining the center of curvature, defining the stabilization line, and analyzing sagittal balance, which is crucial in planning the placement of surgical hardware.<sup>14</sup> After an in-depth case analysis, considering limitations in achieving full stabilization, progression of deformity, and the plan for further rehabilitative management, we decided to place the stabilization system from L4 to Th9. We consciously did not extend the system to L5 to minimize the risk of advanced intervertebral disc degeneration, as supported by scientific literature.<sup>15</sup> Given the location of the curvature apex at L3, stabilization at this level was deemed inadvisable, also supported by professional literature.<sup>16</sup> Following detailed consultation and providing complete information to the patient's guardians, it was decided to terminate the fusion at the L4 level. Traditionally, in the stabilization of thoracolumbar curvatures, the Th10–Th11 level is most commonly used.<sup>17</sup> However, based on standard procedure, we decided to place the stem in the lower thoracic segment at Th9, on the last two terminal vertebrae, avoiding the termination of the stabilizing system at the apex of thoracic kyphosis. In our opinion, stabilization to higher segments was unnecessary due to the straight segment of the spine.

For our patient, we decided to use cobalt-chrome rods (CCM), arguing that the construction of these rods is significantly stronger than that of titanium rods (Ti). Since the parents did not agree to extend the stabilization system to the pelvis, thereby preventing the correction of the obliquely positioned pelvis, in our opinion, the use of CCM rods was appropriate, providing a more stable correction. The literature often emphasizes that CCM rods have higher rigidity compared to Ti. CCM rods also have greater potential for achieving scoliotic curve correction due to their stiffness.<sup>18</sup>

In our patient, we employed the classical rod derotation technique, first placing one rod on the concave side and then another on the convex side. We did not use the Simultaneous Double-Rod Rotation Technique (SDRRT) because of concerns that apical rotation might be exacerbated after the convex rod rotation maneuver. Such concerns are also confirmed by Violas et al., indicating that in SDRRT, there is an additional increase in the risk of iatrogenic injury due to the implantation of implants on the concave side. The authors suggest, to reduce the risk, forgoing implants on the concave side and assessing the possibility of deformity correction solely through a direct maneuver on the convex rod.<sup>19</sup> Our goal was to halt the progression of scoliosis, so we placed implants on both the concave and convex sides, and by using CCM rods, we increased the chance of halting the deformity and achieving the highest possible curve correction. In an 18-month follow-up, we see that this approach did not lead to a deepening of the deformity despite not ex-

tending the stabilization system to the pelvis and correcting its position.

It is worth mentioning that WHS is associated with various skeletal abnormalities, including spine anomalies, although such changes may vary among patients. We have more literature reports describing the pathology of the peripheral skeleton than the axial one.

According to the work of Battaglia et al. bone abnormalities occur in approximately 60%–70% of cases in patients diagnosed with WHS, and the incidence of scoliosis in these patients is estimated at approximately 49%–66%.<sup>6,20</sup> However, according to 2021 study, Battaglia describes that moderate to severe thoracic and lumbar scoliosis occurs in 49% of the described patients in the age range from 3 to 20 years old.<sup>4</sup>

Thomson mentions in his work that children with WHS who have the ability to walk and present pathological (ataxic) gait may have a possible tendency to be lordotic and have scoliosis.<sup>21</sup> Our case shows that this child with WHS who is fully unable to move independently may develop an advanced form of deformity in the form of single-curve scoliosis characteristic of neuromuscular scoliosis. Laurel et al. presents the prevalence of scoliosis in 66% of children with WHS. Unfortunately, the author does not focus on the column deformation characteristics in his works.<sup>6</sup> Stolarz also mentions scoliosis, describing it as an additional stating that a typical deformity in patients with WHS is sacral dimple.<sup>5</sup> The work of Battaglia from 1999 reports, the occurrence of kyphosis and scoliosis in patients with WHS and deformed vertebral bodies.<sup>22</sup>

There are also few reports describing an anomaly of the cervical segment in patients with WHS. The works present both the underdevelopment of the ossification centres of the cervical spine, the presence of C4 and C5 hypoplastic cervical vertebrae, as well as nonossified cervical vertebrae.<sup>23–25</sup> In the case of our patient, imaging tests did not reveal any developmental anomalies of the cervical vertebrae. As spinal abnormalities can have serious consequences for patients with WHS, it's important to detect and manage these conditions early. This can involve both non-pharmacological interventions, such as physical therapy, and pharmacological ones, and in some cases may require surgical intervention.

It's important to note that spinal anomalies in patients with WHS can vary and not every patient will present them. Understanding the specifics of WHS and the unique challenges associated with this disease is crucial for providing appropriate care for these patients.

It's crucial to understand that there is no cure for Wolf-Hirschhorn syndrome, and treatment is mainly supportive and aimed at managing symptoms. Speech therapy, physical therapy, occupational therapy, as well as educational interventions can help improve patients' quality of life. Depending on the occurrence of additional medical complications, such as cardiac or urinary system problems, additional medical interventions may be needed.

## 5. CONCLUSIONS

- (1) Innovative approach for WHS scoliosis: Introduction of a new method to treat C shape scoliosis in Wolf-Hirschhorn Syndrome (WHS), aiming to halt progression and correct deformity.
- (2) Surgical strategy: Stabilization system placement from L4 to Th9, avoiding pelvic extension due to the patient's specific needs and minimizing risk of disc degeneration.
- (3) Choice of materials: Use of cobalt-chrome rods (CCM) for their higher rigidity and effectiveness in scoliosis curve correction.
- (4) Rod derotation technique: Application of a classical rod derotation method, placing rods on both concave and convex sides to halt scoliosis progression.
- (5) 18-Month follow-up: Successful prevention of deformity progression, affirming the effectiveness of the chosen surgical approach.
- (6) Management and care in WHS: Emphasis on the necessity for individualized management of spinal anomalies in WHS, highlighting the absence of a cure and the importance of supportive therapies for improving quality of life.

### Conflict of interest

The authors declare no conflict of interest.

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### Ethics

The patient provided informed consent for the description and publication of the case.

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