THE VERTEBRAL GROWTH AFTER LATERAL AND POSTEROLATERAL HEMIVERTEBRA EXCISION IN PRESCHOOL AGE CHILDREN*

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Objective. To study the dynamics of vertebrae adjacent to the removed hemivertebra growth depending to the extensions of instrumentaition and osteoplastic fusion.
Material and Methods. The growth of fused vertebra was studied by X-ray measurements (roentgenometry) in 39 patients divided into groups depending on a level of hemivertebra and a type of surgery. Thirty five patients were operated on at the age under 5 years, and 4 — older than 5. The long-term results were followed up in 35 patients during the first growth-spurt period, in 7 patients during the growth-plane period, and in 5 patients during the second growth-spurt.
Results. Growth of the fused vertebrae after hemivertebra excision decreased less than 10 % in compared with theoretically estimated one. The less number of vertebral motion segments involved in the anterior and/or posterior fusion did growth of the blocked vertebrae closer to the normal. The vertebral growth is not influenced by the extension of instrumented fixation.
Conclusion. Comprehensive approach to excision technique of hemivertebrae in the lower thoracic and lumbar spine of young children provides favorable conditions for spine growth.
Key Words: spine, spinal abnormalities, congenital deformities, vertebral malformation, surgical treatment, postoperative growth.

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A lot of publications have been devoted to the natural progression of congenital scoliosis. They analyze the dependence of deformaty process from the type of abnormality, its localization, the number and combination of abnormal vertebrae, the presence of active growth plates, and the initial stage of scoliosis. In several cases of deformities, it is not reasonable to perform a long-term dynamic follow-up because of a high risk of progression. One of the most frequent reason for congenital deformities with unfavorable prognosis is associated with hemivertebrae. Early active manipulation with hemivertebrae was believed to be necessary by Tsivjan [5]. Excision of vertebrae followed by deformity correction with a compression construct and osteoplastic fixation in patients aged from 1 to 5–6 years is considered to be the optimal method for managing scoliosis and kyphoscoliosis caused by hemivertebrae [6–10]. A new structural unit consisting of fused vertebrae is formed at the site of corporodesis and (or) fusion within 6–8 months (when using autografts) or 1 year (in the case of alloplasty) after the surgery [1]. The growth of a new vertebra is based on endosteal osteogenesis and the residual distal and proximal epiphyseal plates. No studies devoted to the analysis of vertebral growth after this type of surgery in small children.

The objective was to study the growth dynamics of the vertebrae adjacent to the removed hemivertebra depending on the extension of instrumentation and osteoplastic fusion.

Material and Methods

We performed over 100 hemivertebra excisions in thoracolumbar and lumbar spine followed by deformity correction with a contractor and anterior and posterior fusion [4, 10]. The indications for surgery included X-ray confirmation of increasing deformity or detection of the following symptoms indicating the unfavorable trend with high accuracy:

- scoliotic deformity in the lateral hemivertebra greater than 25–30°;
- kyphotic component between 7 and 56° (posterolateral hemivertebrae) accompanying the scoliosis above 20°;
- pelvis distortion (lumbar hemivertebrae).

Over the past 10 years, several changes have been introduced to the surgical procedure: the previously used allogeneic bone was replaced to autologous bone; interbody fusion started to be used instead of anterolateral fusion of 2–3 spinal motion segments; posterior fusion length was reduced to 1 spinal motion segment; the duration of fixation with a contractor was reduced to 1–2 years (instead of 1.5–3 years).

39 patients (17 girls and 22 boys) were selected for the present study. Precise X-ray measurements were per-

formed for the height of vertebral bodies and the artificial vertebral fusion over the period of follow-up. The criteria for inclusion were one surgeon, who operated all patients (E.V. Ulrich); the modern approaches for the surgery: hemivertebra excision, deformity correction with a contractor, and short-segment osteoplasty; all radiological data with minimal FU more than one year; preschool age at the operation time: 35 children were operated before 5 years old and 4 – between 5 and 7 years old. The data concerning hemivertebrae localization in operated children are shown in Fig. 1.

Long-term outcome was observed during the first growth spurt period in all 35 patients operated during this period, with an average follow-up time of 24 months; 7 children were examined during the growth plateau (average FU time – 3 yrs 2 mns) and 5 children were examined during the second growth spurt period (average FU – 10 yrs 2 mns) (Table 1).

In order to reduce the radiation exposure, X-ray spondylography was performed only during routine control examinations.

Vertebral growth was studied by measurements based on the AP and lateral X-ray in lying position. The height of each vertebral body was measured starting at Th4 level in caudal direction followed by calculation of the mean (individual) increase in distal direction. The height of the artificial vertebral fusion was also measured.

In accordance to the Rokhlin-Finkelstein rule [3], the height of vertebrae increases in caudal direction with arithmetic progression by a strictly defined value that is individual for each person (Fig. 2a). We used this rule to measure the proper theoretical height of the vertebrae in the instrumented and fusion area. The procedure was as follows: the body heights of all vertebrae between Th4 and the hemivertebra were measured; the resulting data were used to calculate the mean increase in vertebral height for each segment; the proper height of the vertebral bodies included in the fusion during the surgery was theoretically calculated.

The theoretically calculated height of vertebral fusion is an abstract concept and corresponds to the height of normally developed vertebrae in the absence of deformity and correction surgery. This artificially introduced value is individual for each patient and allows one to judge the growth of vertebral fusion after surgical treatment and to compare the outcomes.

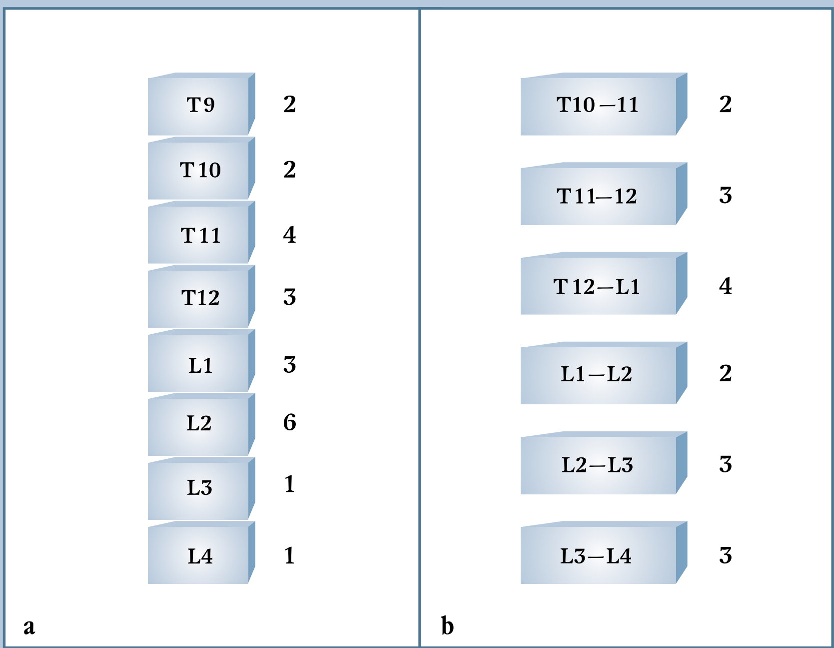

Fig. 1
Number and localization of the excised hemivertebrae: **a** – normal number of hemivertebrae; **b** – extra hemivertebrae

Table 1
Summarized data about patients included in the study

Data	Mean value	Range
Age at the time of surgery	2 yrs 8 mns	7 mns. – 8 yrs 1 mns.
Number of instrumented functional spinal units	3.3	2–5
Number of fused vertebrae:		
anterior column	1.5	1–4
posterior column	3.5	2–8

Results and Discussion

It was found that the height of vertebral bodies along the spine in patients with normal spine development with single hemivertebrae changed accordingly to Rokhlin–Finkelstein rule only in one case.

The difference in body height between the adjacent vertebrae in each segment ranged between 0 and 0.83 mm (average 0.37 mm) in patients under 5 yrs of age (Table 2). In all patients, dysplasia of the vertebrae below the hemivertebra was more severe. Two types of vertebral development, which can be regarded as dysplasia symptoms, were observed. The first type corresponds to growth arrest of segments at one or several spine sections (Fig. 2b); howev-

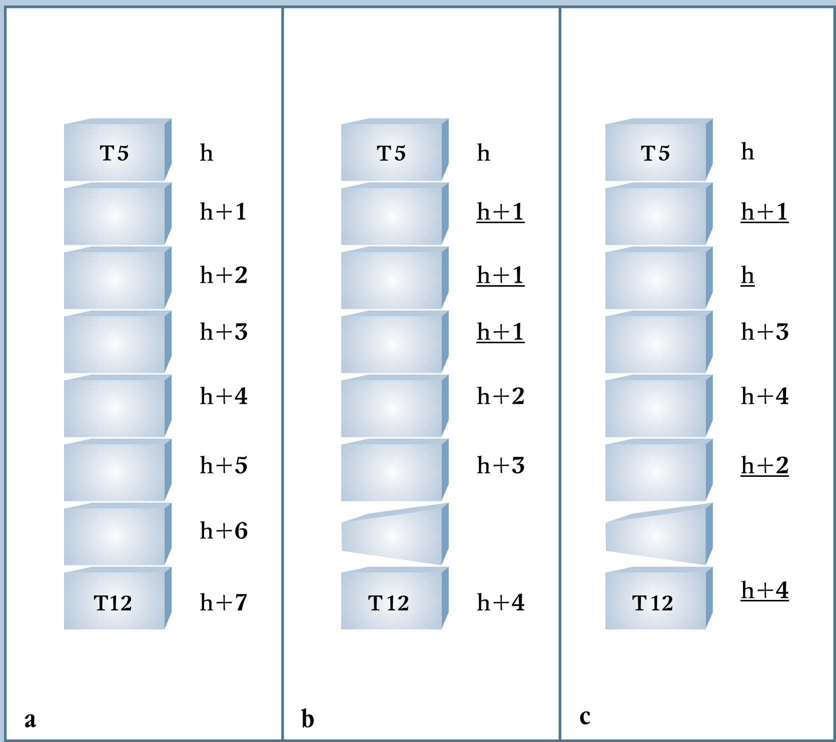

Fig. 2
Violation of the Rokhlin-Finkelstein rule in patients with single abnormalities of vertebral development: **a** – normal development in accordance with the rule (only one case among 39 children with abnormalities); **b** – segmental growth retardation at one or several spine levels; **c** – mosaic growth defect of several vertebrae

Table 2
Growth of the vertebral body height in each segment from the T4 vertebra in caudal direction in patients operated on for the lower thoracic and lumbar spine (n = 27)

Period of observation	Growth, mm	
	Average	Range
Before surgery (mean age – 2 years and 8 months)	0.37	0.00–0.83
After surgery (21 month after surgery on average)	0.50	0.00–1.20

Table 3
Difference between the theoretically calculated fusion height and the sum of heights of two upper-lying vertebrae

Type of height ratio	Number of observations	Average difference, %	Range, %
Equal heights	4	–	–
Fusion height less than calculated ones	4	-8.7	3.9–13.5
Fusion height exceed the calculated ones	23	+17.3	3.4–109.0

er, of the general trend towards increasing size of vertebrae in the craniocaudal direction is retained. The second type is characterized by more severe changes in height in different directions as compared to the upper vertebrae (Fig. 2c).

After surgery (within the period ranging from 4 months to 12 years), the individual growth profiles remained unchanged in most patients; however, the mean gain in the vertebra height in distal direction slightly increased (from 0.37 to 0.50 mm).

In most patients, the vertebral growth profile was similar to the profile of vertebral fusion formed after hemivertebra excision. This profile complied with the Rokhlin-Finkelstein rule, but the total height of the vertebral fusion was less than the theoretically calculated one.

The fused vertebrae typically show no deficiency in height as compared to the sum of heights of the two upper-lying vertebrae (Table 3), exceeding it by 4.9 % on average. Nevertheless, the fusion turned out to be shorter than it was expected to be in accordance with the growth rule. The difference between the theoretically calculated height of the fusion and the sum of heights of the two upper-lying vertebrae was relatively small during first growth spurt the period, while having increased by the end of this period and during the growth plateau.

The numbers of patients who has the actual height of the fused vertebrae smaller or greater than the theoretically calculated were almost identical (Table 4). The attempt at finding a correlation between the increase (or decrease) in the fusion growth rate and a number of functional spinal units fixed with a contractor failed: the same number of vertebrae were instrumentally fixed in both groups. Meanwhile, the number of segments included in the area of osteoplastic fusion differed between the groups: the average number of functional spinal units included in anterior and posterior fusion in patients with the actual fusion size being larger than the theoretical parameters – 1.2 and 2.8, respectively.

An analysis of our data demonstrated that the current approach to hemivertebra excision in the lower thoracic

Table 4

Difference between the theoretical and measured heights of the vertebral fusion in different patient groups

Group	Average FU period, months	Range, %	Mean difference, %
Height of the vertebrae is lower than the theoretically calculated	30	from -0.6 to -30.4	10.4
Height of the vertebrae is higher than the theoretically calculated	12	from +0.7 to +103.5	18.5

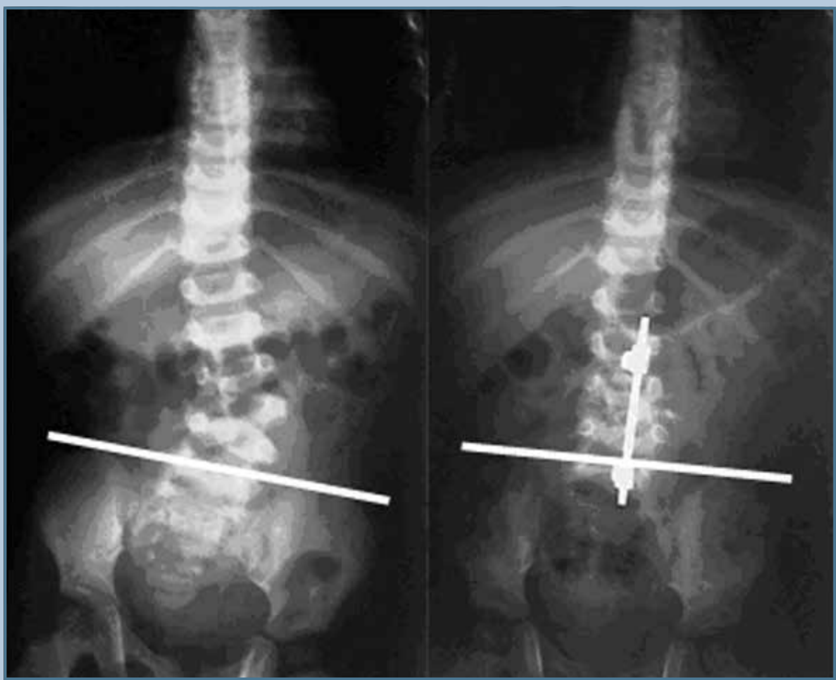

Fig. 3
Pelvis distortion in a two-year-old patient with a lumbar hemivertebra: **a** – before surgery (26° scoliotic deformity); **b** – one month after surgery (7° scoliotic deformity, 74% correction)

and lumbar spine in young age children provides favorable conditions for spine growth (Fig. 3). The surgical intervention does not affect proportional development; however, it slightly reduces the growth of fused vertebrae. This decrease never exceeds 10 % of the theoretically calculated proper vertebral growth rate.

Early deformity correction promotes proper spine development, which is particularly valid for complete or partial correction of pelvis distortion, which often accompanies lumbar hemivertebrae (Fig. 3).

Conclusion

Scoliosis increased in the more than 45 % of children [2] with congenital deformities during the first growth plateau and especially during the second spurt period. This threat should not prevent early correction of congenital deformities and more consistent development of a child during the first years of life. It is beyond any doubt that progression of congenital scoliosis will cause more severe cosmetic and functional abnormalities if it develops together with the rigid congenital deformity or pelvis distortion.

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