



LONG-TERM RESULTS OF SURGERY FOR IDIOPATHIC SCOLIOSIS IN ADOLESCENTS: A META-ANALYSIS

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The paper presents an analysis of the English-language literature on the results of surgical treatment of adolescent idiopathic scoliosis observed in the period from 5 to 30 years after surgery. Seventy-one selected publications were analyzed after division into two groups according to the used endocorrector: the Harrington distractor or CD instrumentation and other 3rd generation instrumentation. The 3rd generation instrumentation provides better deformity correction and its maintenance. Pseudarthrosis following fusion and complications associated with implants are approximately equipresent in both groups. Surgical wound suppuration is more frequent in CDI Group, and reoperation – in the Harrington Group. Reproductive function of women after surgery does not differ from that in the general population. Health-related quality of life does not change depending on the remoteness of intervention. No significant dependence of pain syndrome on the location of lower instrumented vertebra and the time after surgery was observed.

Key Words: adolescent idiopathic scoliosis, long-term results.

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Adolescent idiopathic scoliosis is the most common of all known spinal deformities. It is a three-dimensional deformity and its origin is not fully explored, although there are substantial grounds for believing that the disease is genetically determined [1]. As far as we know, the term “idiopathic scoliosis” was introduced by Whitman [2] in 1922. His work also provides a detailed description of the dorsal fusion technique, which dominated in orthopedic clinics around the world until the development of Harrington instrumentation [3]. More than half a century passed from that moment, a period long enough to assess progress.

Systems for correction of spinal deformities travelled a very long way. Despite the well-known fundamental differences between the Harrington distractor and segmental instrumentation, they have a key common feature, namely formation of bone-metal block along the significant portion of the spine. Given the fact that this operation is performed in the second decade of life, when formation of the musculoskeletal system

is not yet complete, the surgeon must consider the impact of the surgery on the further course of the patient's life. For this reason, there is a huge number of publications that focus on the long-term results of treatment of adolescent idiopathic scoliosis. Since the authors use various methodological approaches, the emergence of articles based on meta-analysis principles and including the analysis of the results of maximum available number of publications is not surprising [4–7]. Unfortunately, such studies have not been found in Russian literature.

When starting our own research of the literature, we tried to avoid repeating the efforts already made by other authors, although in a sense it is inevitable. We would like to draw attention of our colleagues to two aspects of long-term results of surgery for adolescent idiopathic scoliosis: incidence of pain syndrome and its dependence on the location of the lower instrumented vertebra and the dynamics of the results of surveying patients using SRS questionnaire.

Material and Methods

The search for the sources was carried out using PubMed MEDLINE electronic database (Medical Literature Analysis and Retrieval System online), wherein (as well as in the reference lists) we found more than 1,200 publications that complied with the following inclusion criteria:

- 1) surgical treatment of patients with adolescent idiopathic scoliosis;
- 2) publication in English;
- 3) postoperative follow-up for at least 5 years;
- 4) at least 12 patients in the group under study;
- 5) age of patients 10 to 21 years by the time of the operation;
- 6) the use of endocorrector.

When different articles discussed the same clinical material, it was studied only once (for example, articles of Danielsson et al.). In total, we found and analyzed 71 articles published between 1980 and 2015, containing information about 5969 patients. Long-term results of the use of Harrington distractor are reported in 31 articles [8–38] (3378

patients), the results of the use of 3rd generation segmental instrumentation (CDI, Isola, TSRH, transpedicular and hybrid fixation, ventral tools) in 2591 patients – in 40 articles [39–78]. We did not include publications, which analyzed the results of fusion without the use of endocorrector [79–82].

We analysed the results in the following two groups: patients who were operated on using Harrington distractor (Harri group), and patients who were operated on using CDI and other 3rd generation instrumentation, including ventral one (CDI Group). This clustering was determined by the fact that all options of segmental instrumentation (both ventral and dorsal ones) have fundamental advantages compared to Harrington distractors: flexible rods, multipoint fixation, the possibility of the use of derotating force, and, ultimately, three-dimensional correction.

We analyzed the following parameters:

- age at the time of surgery;
- age at the time of the last examination;
- follow-up period;
- preoperative Cobb angle (primary and secondary curve);
- postoperative Cobb angle (primary and secondary curve);
- Cobb angle at the time of the last examination (primary and secondary curve);
- preoperative thoracic kyphosis;
- postoperative thoracic kyphosis;
- thoracic kyphosis at the time of the last examination;
- preoperative lumbar lordosis;
- postoperative lumbar lordosis;
- lumbar lordosis at the time of the last examination;
- number of complications: suppuration, pseudarthrosis, implant-related complications, neurological symptoms, and number of reoperations;
- presence and incidence of pain;
- relationship between pain and location of the lower instrumented vertebra;
- the frequency of pregnancies and births;
- health-related quality of life.

Results

In Harri group, the age of primary surgical treatment ranges from 14 to 21 years (13 publications), the age of the last examination – 20.4 to 49.9 years (9 publications). Therefore, follow-up period was 5 to 33 years (32 publications).

In the group treated using 3rd generation endocorrectors, average age of operated patients was 13 to 17 years (32 publications), the age at the time of the last examination was 23 to 44 years (12 publications), postoperative follow-up period was 5 to 28 years (42 publications).

Roentgenometry. In both groups, initial average value of the primary curve varied in a relatively narrow range, 62.6° (Harri group) and 56.5° (CDI Group). Corrective intervention reduced this value: in Harri group, 35.3° immediately after surgery, in CDI group, 20.5°. The achieved correction was 30.4° in Harri group and 35.8° in CDI group, that is, the deformity was improved by 47.2 % and 62.6 %, respectively. Over the entire follow-up period, curve value increased by 8.5° in Harri group and 5.1° in CDI group, i.e. correction loss was 13.6 % and 9.1 %, respectively. At the time of the last examination, the primary curve value was 40.1° in Harri group and 25.8° in CDI group (Table 1).

Comparison of the counter curve, thoracic kyphosis, and lumbar lordosis over time in the two groups is complicated by the fact that there is not enough data in Harri group. Among all analyzed studies, only three publications included all the required information, and only 9–10 studies reported final values of thoracic kyphosis and lumbar lordosis. We can only say that final values of lumbar lordosis (data from 10 publications) were within the normal range, which is rather indicative of a certain flatness of the latter.

In CDI group, operation reduced counter curve from 40.8° to 18.5° and postoperative progression was no more than 3.0°. Thoracic kyphosis value was close to the lower tolerance limit before surgery, then increased (from 23.7° to 26.3°), and at the end of the follow-up period it was as high as 29.3°.

Complications. In many papers dealing with the problem under discussion, surgical complications are either not mentioned at all, or this information is casual and incomplete. Therefore, we decided to analyze the number of complications based on the material of the articles, where there is a special sub-section or several paragraphs, which identify and discuss complications.

As can be seen from Table 2, the incidence of pseudoarthrosis and implant-related complications (fractures, endocorrector displacement, fractures of the bone bearing points) was approximately the same. At the same time, postoperative wound suppuration (early and late) were more common in CDI group, reoperations – in Harri group.

Pregnancy and childbirth. It is well known that adolescent idiopathic scoliosis is mostly female disease, therefore, future marriage, normal pregnancies, and childbirths is one of the most urgent issues, when discussing the indications for surgery with the patient and her parents. A number of publications [12, 18, 19, 29, 32, 34, 55, 56, 75, 85] focus on this problem. In our opinion, analysis of these articles suggests that surgical correction of spinal deformity (regardless of instrumentation type) has no significant effect on patients' reproductive function. The number of pregnancies and births generally corresponds to these values in the population, where operated young females belong. Number of Caesarean sections is highly variable, but there is no clear indication that the frequency of these operations correlated with the state of the spinal column. Only one out of ten papers mentions certain decrease in sexual activity [18], which, however, had no effect on the number of pregnancies and births in the studied group of patients (Table 3).

Health-related quality of life. There is a viewpoint that it is a measure of patient's health and the importance that the patient attaches to his/her medical condition [83]. According to Westrick et al. [7], it is a subjective multidimensional structure, which includes the impact of medical conditions, including both disease and its treatment, on physical,

Table 1

Primary and secondary curve value, thoracic kyphosis and lumbar lordosis over time

Parameters	Harrington	Number of papers (patients), n	3rd generation endocorrectors	Number of papers (patients), n
Preoperative Cobb angle of the primary curve, deg.	62.6 (54–76)	17 (1570)	56.5 (49–65)	27 (1700)
Postoperative Cobb angle of the primary curve, deg.	35.3 (20–42)	17 (1570)	20.5 (4–34)	27 (1700)
Primary curve correction, deg.	30.4 (15–47)	17 (1570)	35.8 (27–48)	27 (1700)
Correction, %	47.2 (28–62)	17 (1570)	62.6 (47–86)	36 (2241)
Postoperative progression of deformity, deg.	8.5 (1,6–20)	17 (1570)	5.1 (2–29)	36 (2241)
Lost correction, %	13.6 (28–35)	17 (1570)	9.1 (3–29)	36 (2241)
Cobb angle of the primary curve during last examination, deg.	40.1 (26–52)	17 (1570)	25.8 (16–39)	36 (2241)
Preoperative Cobb angle of the secondary curve, deg.	52.3 (36–68)	3 (328)	40.8 (30–57)	36 (2241)
Postoperative Cobb angle of the secondary curve, deg.	24.0 (21–27)	2 (284)	18.5 (9–29)	36 (2241)
Cobb angle of the secondary curve during last examination, deg.	34.0 (28–43)	3 (284)	21.1 (10–29)	36 (2241)
Preoperative thoracic kyphosis, deg.	25.6 (23–28)	3 (438)	23.7 (12–45)	21 (1044)
Postoperative thoracic kyphosis, deg.	25.5 (22–29)	2 (86)	26.3 (13–41)	21 (1044)
Thoracic kyphosis during last examination, deg.	28.2 (20–32)	9 (934)	29.3 (15–46)	21 (1044)
Preoperative lumbar lordosis, deg.	54.0	1 (35)	48.0 (25–59)	19 (1165)
Postoperative lumbar lordosis, deg.	51.0	1 (35)	48.1 (33–57)	19 (1165)
Lumbar lordosis during last examination, deg.	38.0 (22–50)	10 (927)	50.3 (29–65)	19 (1165)

psychological, and social functions. It is common practice to assess this parameter based on patient's survey data using various questionnaires [84], and various modifications of SRS tool is the most widely used one. When analyzing the literature, we found 11 articles containing the results of questionnaire survey obtained at different times after scoliosis correction, from 5.4 to 31.5 years. The values obtained by authors are summarized in the table, which gives some idea of how patients rate their condition (horizontal) and the difference between these estimates depending on the duration of postoperative follow-up period

(vertical). It is noteworthy that patients' rating of their own state varies quite significantly; however, the overall satisfaction with the results usually prevails over other parameters. At the same time, no significant changes in the results depending on the duration of follow-up period could be detected. In order to compare the results to normal values in general population, we used the results obtained by Baldus et al. [85] in the questionnaire survey of females (most patients with scoliosis) aged 20–39 years (the vast majority of the operated patients in the studied publications). This comparison also shows no significant differ-

ences between the operated patients and healthy individuals of appropriate age and gender (Table 4).

Eight papers report only overall HRQOL value (SRS score). These data are summarized in a separate table (follow-up period 5.0 to 22.9 years) and lead to the same conclusion: there is no significant difference in the quality of life of patients in different periods after surgery (Table 5).

Pain and the level of the lower instrumented vertebra (LIV). Cochran et al. [12] were the first who attempted to find relationship between LIV level and severity of postoperative pain. The authors

came to the unequivocal conclusion: the more caudal LIV and, therefore, fewer segments between the fusion area and sacrum, the greater the likelihood of pain syndrome. In many cases, subsequent studies have not confirmed this hypothesis. In 20 studies, authors analyzed the relationship between the location of LIV and pain syndrome and came to diametrically opposite conclusions, which virtually eliminate the possibility of unambiguous interpretation of the results. We can only say that the conclusion about the absence of the aforementioned relationship is usually reported in the studies with longer follow-up period (Table 6).

The incidence and severity of pain. These characteristics were found in 26 publications and summarized in two tables. The data were sorted by duration of follow-up period (Table 7, 8), taking into account the used endocorrector, Harrington distractor or 3rd generation

Table 2

Complications of surgical correction of adolescent idiopathic scoliosis, n (%)

Complications	Harrington (articles – 14, patients – 1637)	III generation endocorrector (articles – 25, patients – 1488)
Suppuration	7 (0.42)	31 (2.80)
False joints	35 (2.13)	32 (2.15)
Implant-related	91 (5.50)	97 (6.51)
Neurological	2 (0.12)	15 (1.00)
Reoperations	204 (12.50)	72 (4.83)

endocorrectors. In both groups, no correlation with time elapsed after the intervention was observed. There is also no significant correlation between the characteristics of pain syndrome and endocorrector type.

Discussion

The first attempt of meta-analysis of outcomes of surgical correction of adolescent idiopathic scoliosis was made by Maher et al. [4] in 1993. They collected data on 139 groups of patients (a total of 10 989 patients), who were operated on during 35 years, from 1958 to 1993. The

Table 3

Characteristics of reproductive function after surgical correction of adolescent idiopathic scoliosis

Authors	Instrumentation	Number of females	Number of children	Caesarean section	Additional information
Cochran et al. [12]	Harrington	30	46	12	More than in Swedish population
Dickson et al. [19]	Harrington	206	No data	No data	The number of children is lower than in the control group
Paonessa et al. [34]	Harrington	103	No data	No data	Uneventful
Danielsson et al. [17]	Harrington	136	1.80 children per female	19.0 %	Sexual activity was limited in 33 % of cases
Michel et al. [29]	Harrington	Operated 209, married 124, gave birth 99	1 to 4	4 cases	Problems during childbirth in 10 cases
Orvomaa et al. [32]	Harrington	Operated 146, gave birth 79	1 to 4 (total – 142)	23.0 % (15.0 % of the general population in Finland)	—
Kelly et al. [55]	Ventral	Operated 18, married 16, gave birth 11	No data	No data	—
Takayama et al. [75]	Dorsal segmental	75 % of operated patients are married	1.83 children per female	22.7 %	Similar to general Japanese population
Otani et al. [65]	Ventral	Operated 53, married 75 %, gave birth 27 (77 %)	No data	18.0 %	Above the level of the Japanese population
Kohler et al. [56]	Ventral	Operated 16, gave birth 10	No data	3 cases	No sexual problems were observed

average postoperative follow-up period was 6.8 years, Harrington distractor was used in 85 % of cases, dorsal fusion alone – 2.9 %. In others cases, various options of segmental instrumentation, either dorsal or ventral, were used.

Statistical analysis showed that there is significant correlation between patient's satisfaction with treatment outcome and the value of scoliotic curve correction. The achieved correction, initial curvature, and King's deformity type do not correlate with the degree of patient's satisfaction.

Westrick and Ward [7] analyzed the long-term (5 to 20 years) results of surgical correction of idiopathic scoliosis with a specific perspective: whether surgery is advantageous over the natural course of the disease? The authors proceeded

from the fact (confirmed by literature data) that the natural history of the disease is not so tragic, as it is commonly believed. This applies to pain, functional activity, cardiopulmonary state, mortality, etc. The authors studied and analyzed 47 articles with follow-up of at least 5 years and overall number of cases of 3401. The patients were operated on using metal implants (Harrington, Isola, Wisconsin, hook, pedicle, and hybrid systems). The decrease in Cobb angle of the primary curve ranged 34.0 % (Harrington) to 69.5 % (pedicle systems), correction loss was from 3.0 % (Isola-hybrid) to 17.5 % (Harrington).

Suppurative complications most often occurred after Harrington distraction (6.5 %), followed by Wisconsin (5.7 %), hook, and hybrid structures

(2.2 %), and pedicle systems (1.4 %). In the cases, where ventral structures were used, false joints were formed in 15.1 % of cases, pedicle systems – 7.1 %, Isola-hybrid – 2.2 %. After Harrington distraction, implant-related complications were reported in 15.8% of cases, hook systems – 3.9 %, pedicle systems – 7.1 %. The rate of reoperations was approximately the same.

Only 40 % of the sources include the results of questionnaire survey of patients (SRS tool to assess HRQOL), and these data are virtually equivalent to those obtained in the study of the control group (the same age, no scoliosis).

In 80 % of publications, the authors found no relationship between the level of the lower instrumented vertebra and lumbar pain. This also applies to the

Table 4

Survey of patients using SRS questionnaire

Authors	Follow-up, years (number of patients, n)	Instrumentation	Function	Pain	Appearance	Mental health	Satisfaction	Average
Upasani et al. [76]	5.4 (49)	Ventral	4.00	3.90	3.40	—	4.30	—
Newton et al. [63]	6 (41)	Ventral	4.10	4.40	4.40	—	—	—
Asher et al. [40]	6.1 (185)	Isola	4.20	4.00	4.20	4.10	4.50	—
Burton et al. [47]	5–9 (14)	Transpedicular fixation	4.00	3.80	4.10	3.80	4.50	4.10
Burton et al. [47]	5–9 (14)	Ventral	4.40	4.10	4.30	4.00	4.50	4.30
Benly et al. [43]	11.3 (109)	TSRH	4.00	3.60	3.80	3.60	4.60	—
Enercan et al. [51]	11.4 (25)	Transpedicular fixation	4.75	4.41	4.27	3.95	4.77	4.34
Green et al. [52]	11.8 (20)	Dorsal segmental	4.50	4.30	—	—	—	4.30
Sudo et al. [72]	17.2 (30)	Ventral	4.40	4.50	3.70	4.50	3.90	4.20
Larsson et al. [58]	20.0 (12)	CDI	3.10 (?)	3.90	3.10	—	4.00	—
Iida et al. [37]	22.5 (51)	Harrington — Luque	4.50	4.20	3.70	3.90	4.10	—
Akazawa et al. [9]	31.5	Harrington — Luque	4.30	4.30	3.00	3.90	3.60	—
Baldus et al. [85]	20–39	Averaged values over the population	4.30	4.40	4.22	4.06	Not determined, since examined patients were not operated on	—

Table 5

Summarized quality of life values

Authors	Follow-up period, years (number of patients, n)	Instrumentation type	SRS score
Edwards et al. [50]	5 (24)	Ventral	97.0
Remes et al. [68]	8–13 (112)	CDI	97.0
Perez-Grueso et al. [66]	10 (35)	CDI	96.7
Mueller et al. [62]	10,1 (49)	Dorsal titanium	95.8
Helenius et al. [53]	13 (57)	CDI	97.0
Kelly et al. [55]	17 (31)	Ventral	98.0
Helenius et al. [23]	20 (78)	Harrington	97.0
Mariconda et al. [28]	22.9 (24)	Harrington	100.0

Table 6

Correlation between the level of the lower instrumented vertebra (LIV) and pain syndrome

Authors	Instrumentation	Patients, n	Follow-up, years	Correlation between LIV and pain syndrome	Additional remarks
Cochran et al. [12]	Harrington	95	9.9	Yes	—
Michel et al. [29]	Harrington	209	13.9	Yes	The more caudal to L3–L4 level, the less pain
Fabry et al. [21]	Harrington	182	7	Yes	—
Dickson et al. [19]	Harrington	206	21	No	—
Large et al. [26]	Harrington	44	10	Yes	Less than 2–3 free segments — pain syndrome
Paonessa et al. [34]	Harrington	103	8.1	Yes	—
Willers et al. [38]	Harrington	22	10.8	Yes	—
Poitras et al. [35]	Harrington	555	13	No	—
Connolly et al. [13]	Harrington	83	12	Yes	Threshold level L2–L4
Danielsson et al. [14–17]	Harrington	136	23	No	—
Padua et al. [33]	Harrington	70	15–28	No	—
Helenius et al. [23]	Harrington	78	20.8	No	—
Gotze et al. [22]	Harrington	82	16.7	No	—
Nimeyer et al. [31]	Harrington	41	23	No	—
Upasani et al. [76]	CDI	49	5.4	No	—
Bartie et al. [11]	Harrington	171	19	No	—
Carreon et al. [48]	CDI	135	5	No	—
Beltran et al. [42]	CDI	50	—	No	—
Iida et al. [37]	Harrington	51	22.5	No	—
Lonstein et al. [27]	Harrington	26	33.3	No	—

severity of lumbar lordosis, and degenerative disc changes. Patients were satisfied with the results of treatment using Harrington distraction in 86.6 % of cases, hook system – 96.2 %. Satisfaction with the result was not related to the extent of achieved correction. Researchers believe that there are no long-term prospective, controlled studies supporting

the hypothesis that surgical treatment of idiopathic scoliosis is advantageous over the natural development of the disease. However, the surgeon may not underestimate the psychological state of the patient with deformed spine. The main findings of another review of the literature on the problem published in 2012 by Kepler et al. [5] are as follows:

- patients who underwent dorsal spinal fusion surgery for idiopathic scoliosis generally appreciate the effect achieved and survey results are statistically indistinguishable from those of individuals without scoliosis;
- residual anterior spinal deformity usually does not affect the evaluation of surgical treatment outcomes, while sag-

Table 7

Characteristics of pain syndrome in patients who were operated on using Harrington distractor

Authors	Follow-up period, years	Patients, n	Characteristics of pain syndrome
Fabry et al. [20]	4.9	64	Regular complaints of pain 23.6 %
Jeng et al. [25]	6.3	35	Severe pain — 16 %
Fabry et al. [21]	7.0	182	Complaints of pain — 66 %
Paonessa et al. [34]	8.1	103	The incidence of pain is higher compared to the control group
Cochran et al. [12]	9.9	95	Complaints of pain having various location and severity — 55 %
Humke et al. [24]	12.4	72	Severe pain syndrome — 10 %
Michel et al. [29]	13.9	209	Pain syndrome — 21.3 %
Gotze et al. [22]	16.7	82	No pain or rare pain — 79 %
Bartie et al. [11]	19.0	171	Pain in 75 % of patients and 65% persons in the control group
Helenius et al. [23]	20.8	78	Sever or frequent pain — 13 %
Dickson et al. [19]	21.0	206	Moderate or severe pain — 26 %
Niemeyer et al. [31]	23.0	41	No complaints of pain — 28, continuous pain — 3, recurring pain — 10

Table 8

Characteristics of pain syndrome in patients who were operated on using 3rd generation endocorrectors

Authors	Follow-up period, years	Patients, n	Characteristics of pain syndrome
Upasani et al. [76]	5.4	49	Pain increases during the period from 2 to 5 years after the operation
Newton et al. [63]	6	41	Pain increases during the period from 2 to 5 years after the operation
Lenke et al. [60]	5–10	76	Moderate pain in 38 % of cases without decrease in working and educational activities
Violas et al. [77]	6	25	No complaints of pain in 100 % of cases
Boos et al. [46]	9	52	Moderate recurring pain in 10 patients
Kohler et al. [56]	10	21	Frequent pain in 2 patients
Perez-Grueso [66]	10	35	Pain increases — 24 %, decreased — 32 % of cases
Lawborne et al. [59]	11.8	20	Pain incidence similar to that in general population
Green et al. [52]	11.8	20	Nonsteroidal drug intake — 3 patients
Humke et al. [24]	12.4	21	Severe pain syndrome — 5 % of cases
Remes et al. [68]	8–13	112	Frequent pain in 6 patients
Helenius et al. [53]	13	57	Frequent pain in 6 % of cases
Otani et al. [65]	14.6	53	No pain in 98% of cases
Kelly et al. [55]	17	31	Pain hinders working activity — 1 patient

ittal imbalance, especially positive one (forward bend of the body), is poorly tolerated by patients and adversely affects the evaluation of intervention results;

– in patients who underwent dorsal correction surgery and spinal fusion, MRI study shows enhanced degeneration of the intervertebral discs, but these findings do not correlate with the clinical presentation, i.e. they are not accompa-

nied by stronger and more frequent lumbar pain.

The authors make a logical conclusion, that further investigation of the state of the intervertebral discs and clinical symptoms for more than 20 years after the intervention is required.

In 2013, Lykissas et al. [6] reported the results of a meta-analysis of dorsal intervention outcomes in patients with idiopathic scoliosis. The minimum follow-

up period was 5 years. The outcomes of surgical correction using Harrington distractor (1613 patients), CD instrumentation (361 patients), and pedicle fixation (298 patients) were summarized in 27 publications. Mean follow-up period was 14.9 years. The main results of the meta-analysis are as follows: CDI provides significantly greater anterior correction than pedicle fixation, which is in turn more effective than Harrington

rod. In the sagittal plane, CDI and pedicle fixation contribute to increase in thoracic kyphosis and lumbar lordosis, while Harrington rod flattens the physiological curves of the spine. As for postoperative complications, false joints were observed in 1.9 % of cases and they were more common in the case of Harrington distractor. Suppuration was observed in 3.6 % of cases: it was less common with pedicle screws (1.18 %), and more common with Harrington correction (5.5 %). When using pedicle screws, there were no reoperations. Neurological complications were reported only in two cases (0.17 %). The authors did not report the analysis of the quality of life in the postoperative period due to the relatively short follow-up period after pedicle fixation.

We consider this study as a small piece of the overall picture that gradually emerges and eventually will take its final form. Since it was carried out after the aforementioned studies, it is obviously based on a larger number of publications. Our findings are quite expectable. First of all, this applies to the extent of correction and postoperative loss of correction. Modern segmental instrumentation provides greater and more durable correction compared to the Harrington rod.

It is quite natural that complications occurred in both groups, but sometimes the differences could not be explained. Thus, it is not clear, why suppuration and neurological complications are more common in the group with 3rd generation endocorrectors.

The results reported in 10 publications suggest that reproductive function of females who underwent spinal surgery in the second decade of life is almost intact.

We believe that comparative study of the data obtained in the survey of patients at various time intervals after surgical correction of adolescent idiopathic scoliosis are of particular interest. The available data were summarized in the table and intercompared, which led to conclusion that various instrumentation options and duration of the follow-up period (up to 31.5 years) have practically no impact on patients' quality of life.

Assessment of the impact of the level of the lower instrumented vertebra on the development of pain syndrome results in interesting findings. On the one hand, there are two opposing viewpoints, either this effect exists or not. On the other hand, the analysis of available data shows that the conclusion about existing relationship was made in the studies published from 1983 to 1995 with follow-up period ranging from 7 to 12 years. In later publications, this relationship was denied, although the follow-up period was much longer, up to 33 years.

When trying to assess the incidence and severity of postoperative pain, the resulting picture will be even more colorful. In any case, we could not objectively evaluate the incidence and severity of pain based on published data since each group of authors reported the material according to their own criteria. Meanwhile, there is no reason to believe that operated patients develop pain syndrome more frequently and pain is more

severe in these patients than in the general population.

According to the generally accepted definition [83], meta-analysis is a review, where data of several studies are summarized using quantitative method and the final result is represented as a weighted average. Unfortunately, we were not always able to determine the weighted average for the reason mentioned above. This is an objective limitation, which can be eliminated only with the course of time provided that more or less uniform methods will be developed in order to assess the results of treatment of adolescent idiopathic scoliosis.

Conclusion

Tens of thousands of surgical interventions for adolescent idiopathic scoliosis are annually conducted around the world. This is a major surgery aimed at significant improvement of patient's quality of life. How does the surgical intervention, carried out in the second decade of life, affect patient's remote future? We studied the data reported in numerous literary sources and so did the authors of previously published meta-analyses. These data suggest that surgery is beneficial, since the life of the operated patients does not differ much from the life of females and males from the general population. In most articles, the authors suggest that research should be continued. We fully agree with that opinion and this prompted us to carry out the present study.

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