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Comparative analysis of dynamics in thermal pain sensitivity after correction of severe and mild spine deformities in patients with idiopathic scoliosis

E.N. Shchurova, O.G. Prudnikova, S.O. Ryabykh, S.A. Lipin

Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation

Introduction Despite a great number of researches on idiopathic scoliosis reported there is still no instrumentation assessment of sensitivity before and after surgical correction of the curve found in literature. **The purpose** of the work was to explore dynamics in thermal pain sensitivity following correction of severe and mild spinal curves in patients with idiopathic scoliosis. **Material and methods** The work included results of examination of 25 patients with idiopathic scoliosis. Sampling population was divided into two groups depending on the extent of preoperative curve in major arch: Group I included patients with the curve of ≤ 60º (15 cases); Group II consisted of patients with the curve of > 60º (10 patients). Preoperative neurological examination showed no motor, reflex and sensory impairments. Acute deformity correction and spine stabilization with transpedicular systems were produced in all the cases. Thermal pain sensitivity was explored preoperatively and postoperatively at Th1-S2 dermatomes using electric esthesiometer. **Results** Disturbed thermal pain sensitivity of various extent was observed preoperatively in the study dermatomes of all patients with idiopathic scoliosis and was not shown to be dependent on the amount of the curve. Positive dynamics in thermal pain sensitivity revealed itself in reduced pain and heat thresholds and restored heat sensitivity and was observed in 41.5 to 54.1 % of the cases Group I following spine deformity correction. Deterioration was seen in 29.2 to 34.7 % of the cases. Group II showed negative dynamics in thermal pain sensitivity in 35.4 to 50 % of the cases with either increased or decreased pain threshold, enhanced heat threshold and loss of heat sensitivity. Sensitivity improved in 29.4 to 31.8 % of the patients. No changes in neurological status were noted in both groups after surgical correction with subclinical changes in thermal pain sensitivity to be considered. **Conclusion** Positive dynamics in thermal pain sensitivity prevailed in patients with idiopathic scoliosis following baseline curve correction of ≤ 60º. Negative dynamics in thermal pain sensitivity was seen in patients with baseline curve correction of > 60º with a greater risk of neurological complications.

Keywords: idiopathic scoliosis, thermal pain sensitivity, spinal deformity correction

INTRODUCTION

Impaired spinal cord and root function including conduction and segmental disorders is known to be a core component of idiopathic scoliosis [1–7]. Several authors report specific features of the central nervous system, the structure and function of motor cortex [8–11]. The majority of scientific publications describe changes in the nerves and muscles (motor control) that are not local but found beyond the level of spine curve [8]. Sensitivity in patients with idiopathic scoliosis remains under-reported. There are few publications that analyze deep (proprioception and vibration sensitivity) [1, 2, 12] and superficial (thermal pain) sensitivity [7].

Yatrogenic injury to the spinal cord is a severe complication of surgical correction of kyphoscoliosis. Neurological deficit is one of the most series complications that occur in 0.37 to 10 % of the cases [13, 14, 15]. Treatment of severe spinal curves (> 60°) [16, 17] remains a serious surgical problem [18] due to a risk of neurological deficit that is reported in 0.7 to 25.5 % of the cases [19, 20, 21].

There are no objective (rank) criteria to assess sensitivity. Pathogenesis of scoliosis (spinal curve, anatomical structures, spinal cord and the roots) results in polymorphism of disturbed sensitivity with curvature progression.

Correlation between the Scoliosis Research Society patient questionnaire (SRS-22) and patients' satisfaction with outcomes is rather low and fails to reflect objective changes in the parameters [22]. According to P.R. Rushton, M.P. Grevitt surgeons and patients must be aware of a limited evidence of such parameters as pain, function, activity after surgical correction of scoliosis, in particular [23]. Instrumental methods of evaluation are important for objective analysis of the pre- and postoperative functional status. Whereas postoperative instrumental evaluation of motor function (paraspinal muscles, muscle of lower limbs) is elucidated in several publications [4, 24, 25, 26], sensitivity is poorly reported.

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The purpose of the work was to explore dynamics in thermal pain sensitivity following correction of severe and mild spinal curves in patients with idiopathic scoliosis.

MATERIALS AND METHODS

The work included results of examination of 25 patients with idiopathic scoliosis. The patients' age ranged from 14 to 27 years with the mean age of 17.3 ± 0.8 years. There were three male and 22 female patients. Major curve measured from 35 to 86º (mean angle 60.1 ± 3.3º) and compensation curve ranged from 15 to 65º (mean angle 34.1 ± 4.1º). Most of the curves were Lenke types 3 (structural arches in the thoracic and lumbar spine; n = 13, 52 %). Lenke type 1 with major arch in the thoracic spine was diagnosed in 6 patients (24 %), type 5 with major arch in the lumbar spine found in 4 cases (16 %), type 2 (4 %) in one case and type 4 (4 %) in one patient. Greater majority of patients with Lenke types 1, 2, 3 and 4 had larger (structural) arch at Th8-Th10 vertebrae and at L1–L3 level in scoliosis type 5. Type B was detected in 20 patients (80 %), type A in 3 cases (12 %) and type C in 2 cases (8 %) using modifier of lumbar spine. Sagittal balance of the thoracic spine was evenly distributed among the types: hypokyphosis – 8 patients (32 %), normal balance – 9 cases (36 %) and hyperkyphosis – 8 cases (32 %).

Preoperative neurological status of the patients showed no motor, reflex and sensitivity disorders that indicated to the absence of vertebro-radiculo-medullary conflict. Vertebrogenic pain syndrome was seen in 9 patients with VAS score of 2.0 ± 0.42 (range, 2 to 3). No postoperative changes in neurological status were observed in the patients. Preoperative CT scan showed vertebral changes at the apex of the curve: arch thinning and deformed vertebral bodies. Neither decrease in the size of spinal canal nor compression of the structures was observed. No changes in the structure of the spinal canal (myelopathy, syringomyelia) were seen in MRI images.

Scoliosis was corrected acutely in all the cases and stabilized with transpedicular fixation systems. Osteosynthesis of the spine was conducted in accordance with the concept of Cotrel-Dubousset Instrumentation (CDI) with the fixation level determined by Lenke type. Free hand technique was used for introduction of pedicular screws. Smith-Peterson osteotomy of the spines was produced at the apex of the curve in all the cases. Three patients with severe scoliosis according to James classification underwent discectomy at 4–6 evels at the apex of the deformity to improve spine mobility at the first stage. The curve was corrected by adjusting longitudinal rods and derotation. Surgical procedures were accomplished with decortication of posterior vertebrae and auto- and allobone grafting in all the cases.

The mean surgery length was 222.9 ± 15.9 minutes (range, 150 to 490 min.), intraoperative blood loss measured 510.4 ± 60.0 ml (range, 300 to 1500 ml).

The investigation was approved by Ethics Committee of the Russian Ilizarov Scientific Center "Restorative Traumatology and Orthopaedics" Ministry of Health of the Russian Federation and performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments. Patients aged 18 years and older, parents of the children or their legal representatives provided written informed consent to conduct diagnostic examinations and publish the data without personal identification.

Thermal pain sensitivity was explored preoperatively and postoperatively at two to three weeks using electric esthesiometer (thermistor manufactured by "EPCOS Inc.", Germany) and skin temperature recorded with Termostar (Nihon Kohden, Japan). The methodology was based on assessment of thermal pain sensitivity as a response to local skin heating at the site of dermatoma of interest. Thermal sensations were graded as either warmth or heat pain. Contact area of thermal element was 1 cm2, temperature ranged from 10 to 50°, temperature increase rate was 2°/min. Thermal pain sensitivity was evaluated in accordance with established protocol in symmetrical points to the left and to the right at Th1-S2 dermatomes.

Statistical data analysis was performed using Microsoft Excel 2010 software customized with Attestat [27]. Kolmogorov, Smirnov statistical tests were used to evaluate the correlation between warmth and heat pain thresholds. Statistical analysis of variance was used to calculate the arithmetic mean (M), error of the arithmetic mean (m). The Student's

t-test ($p < 0.05$) was used to identify statistical significance of the variable in the comparable groups with normal distribution. Non-parametric Mann-Whitney test was used for small samples ($p < 0.05$).

RESULTS

Sampling population was divided into two groups depending on the extent of preoperative curve in major arch: Group I included patients with the curve of ≤ 60º (15 cases); Group II consisted of patients with the curve of > 60º (10 patients) (Tables 1, 2).

Impaired thermal pain sensitivity of different severity was observed preoperatively in dermatomas explored in Groups I and II (Tables 1, 2). Adverse changes showed as increased (hyperesthesia) or decreased (hypesthesia) pain thresholds, increased threshold and absent thermal sensitivity (thermoanesthesia).

Comparative analysis of thermal sensitivity in two groups insignificant differences in patients with normal thresholds (Group I, 14.0 ± 3.1 % and Group II, 10.3 ± 3.8 %), as well as in a type of distribution (absence of normal thresholds in dermatomas from L4 to S2). The ratio of patients with absent thermal sensitivity (thermoanesthesia) was nearly identical in Group I and Group II measuring 26.4 ± 2.5 % and 27.7 ± 2.1 %, correspondingly (Tables 1, 2). There was nearly an identical number of patients with increased thresholds in both groups (Group I, 59.0 ± 3.4 %, Group II, 61.8 ± 3.8 %). Increase in thresholds of thermal sensitivity ranged from 2 to 7 and measured 5.1 ± 0.4 degrees ($p < 0.05$) (Tables 3, 4).

There were no statistically significant differences in patients with normal thresholds (Group I, 35.5 ± 3.1 % and Group II, 36.3 ± 4.1 %) (Tables 1, 2). Decrease in thresholds of pain sensitivity was observed in 7 dermatomas of Group I and in 6 dermatomas out of 19 of Group II. The ratio of patients with increased thresholds was nearly equal in both groups (Group I, 62.0 ± 3.6 % and Group II, 60.0 ± 5.9 %). Changes in thresholds of pain sensitivity showed as either an increase by 2 to 8 degrees (4.6 ± 0.2 degrees on average, $p < 0.05$) or decrease by 2 to 5 degrees (3.9 ± 0.2 degrees on average, $p < 0.05$) (Tables 3, 4).

Therefore, preoperative impairments of thermal pain sensitivity were not local in patients with idiopathic scoliosis and appeared to be beyond the spinal curve level. They were not found to be dependent on the size of curvature and side of investigation.

Table 1

Percentage ratio of patients with idiopathic scoliosis of Group I with different impairments of thermal pain sensitivity (n = 15)

Dermatomas (n , number of measurements)	Thermal sensitivity			Pain sensitivity		
	normal threshold (%)	increased threshold (%)	absent (%)	normal threshold (%)	decreased threshold (%)	increased threshold (%)
Th1 (n = 30)	47	33	20	60	16.7	20
Th2(n = 30)	30	34.3	30	57	3.3	40
Th3(n = 30)	37	40	16.7	47	0	53
Th4(n = 30)	30	43.3	16.7	63	0	37
Th5(n = 30)	27	46	27	50	0	50
Th6(n = 30)	13	54	33	23	0	77
Th7(n = 30)	7	63	30	30	0	70
Th8(n = 30)	7	63	30	23	7	70
Th9 (n = 30)	7	63	30	23	7	70
Th10 (n = 30)	10	73	17	37	0	63
Th11(n = 30)	7	73	20	37	0	63
Th12 (n = 30)	10	57	33	33	3.3	63
L1 (n = 30)	10	79	20	27	0	73
L2(n = 30)	13	67	20	32	3.3	67
L3(n = 30)	10	63	27	30	3.3	67
L4(n = 30)	0	53	47	20	0	80
L5(n = 30)	0	50	50	20	0	80
S1(n = 30)	0	70	30	33	0	67
S2(n = 30)	0	95.5	4.5	32	0	68

Table 2

Percentage ratio of patients with idiopathic scoliosis of Group II with different impairments of thermal pain sensitivity (n = 10)

Dermatomas (n , number of measurements)	Thermal sensitivity			Pain sensitivity		
	normal threshold (%)	increased threshold (%)	absent (%)	normal threshold (%)	decreased threshold (%)	increased threshold (%)
Th1 (n = 20)	60	15	25	55	45	0
Th2 (n = 20)	45	30	20	60	15	25
Th3 (n = 20)	25	60	15	60	0	40
Th4 (n = 20)	15	60	25	70	0	30
Th5 (n = 20)	5	70	25	60	0	40
Th6 (n = 20)	10	65	25	60	0	40
Th7 (n = 20)	15	55	30	50	5	45
Th8 (n = 20)	5	70	25	40	0	60
Th9 (n = 20)	10	70	20	35	0	65
Th10 (n = 20)	0	75	25	20	0	80
Th11 (n = 20)	0	75	25	30	0	70
Th12 (n = 20)	5	60	40	25	5	70
L1 (n = 20)	0	60	40	15	5	80
L2 (n = 20)	0	70	25	35	5	60
L3 (n = 20)	0	90	10	30	0	70
L4 (n = 20)	0	65	35	20	0	80
L5 (n = 20)	0	55	45	10	0	90
S1 (n = 20)	0	60	40	15	0	85

Table 3

Measurements of thermal pain sensitivity (degrees) in patients with idiopathic scoliosis of Group I (M ± m, n = 15)

Dermatomas (n, number of measurements)	Skin temperature	Thermal sensitivity		Pain sensitivity		
		normal threshold	increased threshold	normal threshold	decreased threshold	increased threshold
Th1 (n = 30)	31.7 ± 0.2	32.5 ± 0.5	38.8 ± 1.0*	41.8 ± 0.2	38.0 ± 0.1*	45.0 ± 0.4*
Th2(n = 30)	32.8 ± 0.2	34.1 ± 0.4	38.7 ± 0.7*	40.7 ± 0.4	36.0 ± 0.1*	44.7 ± 0.4*
Th3(n = 30)	33.3 ± 0.2	34.8 ± 0.4	39.1 ± 0.9*	41.7 ± 0.4	–	46.3 ± 0.7*
Th4(n = 30)	33.9 ± 0.2	36.8 ± 1.0	39.1 ± 1.0*	42.0 ± 0.2	–	46.3 ± 1.3*
Th5(n = 30)	33.8 ± 0.2	36.6 ± 0.3	40.2 ± 1.2*	42.4 ± 0.3	–	46.0 ± 1.1*
Th6(n = 30)	34.1 ± 0.2	36.5 ± 0.1	40.1 ± 0.7*	42.3 ± 0.4	–	45.4 ± 0.6*
Th7(n = 30)	33.6 ± 0.2	36.5 ± 0.1	40.2 ± 0.8*	42.2 ± 0.3	–	45.6 ± 0.7*
Th8(n = 30)	33.4 ± 0.2	34.5 ± 0.1	41.3 ± 0.5*	42.3 ± 0.3	38.1 ± 0.1*	46.0 ± 0.7*
Th9 (n = 30)	33.4 ± 0.1	34.3 ± 0.8	41.7 ± 1.0*	40.6 ± 0.4	38.2 ± 0.1	46.2 ± 0.7*
Th10 (n = 30)	33.6 ± 0.3	35.0 ± 0.6	41.1 ± 0.9*	41.4 ± 0.6	–	46.5 ± 0.9*
Th11(n = 30)	33.5 ± 0.2	35.0	40.9 ± 0.9*	41.2 ± 0.9	–	46.1 ± 1.0*
Th12 (n = 30)	33.6 ± 0.3	34.0	41.4 ± 1.0*	41.2 ± 0.9	38.0	46.3 ± 0.9*
L1 (n = 30)	33.7 ± 0.2	35.0 ± 0.6	41.0 ± 0.8*	41.7 ± 0.5	–	47.0 ± 0.8*
L2(n = 30)	32.5 ± 0.2	34.5 ± 0.3	41.3 ± 1.2*	41.3 ± 0.5	38.0	47.4 ± 1.1*
L3(n = 30)	32.1 ± 0.2	34.3 ± 0.3	41.1 ± 0.4*	41.3 ± 0.4	38.0	46.4 ± 1.1*
L4(n = 30)	32.3 ± 0.2	–	40.8 ± 1.0*	42.3 ± 0.4	–	47.2 ± 0.9*
L5(n = 30)	32.2 ± 0.2	–	40.2 ± 0.9*	42.0 ± 0.5	–	47.1 ± 0.9*
S1(n = 30)	30.5 ± 0.3	–	41.0 ± 1.1*	41.5 ± 0.5	–	46.8 ± 1.0*
S2(n = 30)	32.4 ± 0.2	–	40.4 ± 0.9*	41.7 ± 0.4	–	46.2 ± 1.0*

Note: * – significant differences from normal measurements, $p < 0.05$.

Table 4

Measurements of thermal pain sensitivity (degrees) in patients with idiopathic scoliosis of Group II (M ± m, n = 10)

Dermatomas (n, number of measurements)	Skin temperature	Thermal sensitivity		Pain sensitivity		
		normal threshold	increased threshold	normal threshold	decreased threshold	increased threshold
Th1 (n = 20)	31.1 ± 0.3	33.3 ± 0.5	37.1 ± 0.1*	40.2 ± 0.4	36.7 ± 0.7*	-
Th2(n = 20)	32.3 ± 0.2	34.4 ± 0.9	39.1 ± 1.8*	40.5 ± 0.4	35.0 ± 2.3*	44.7 ± 0.7*
Th3(n = 20)	33.0 ± 0.2	33.0 ± 1.5	39.4 ± 0.6*	41.2 ± 0.3	–	45.2 ± 0.4*
Th4(n = 20)	33.1 ± 0.2	35.1 ± 0.8	40.0 ± 0.6*	41.1 ± 0.4	–	45.7 ± 0.6*
Th5(n = 20)	33.0 ± 0.2	34.0	39.5 ± 0.6*	41.6 ± 0.4	–	45.5 ± 0.5*
Th6(n = 20)	32.9 ± 0.2	37.0	39.5 ± 0.6*	41.6 ± 0.4	–	45.5 ± 0.5*
Th7(n = 20)	32.8 ± 0.2	36.5 ± 0.5	40.8 ± 0.8*	41.0 ± 0.5	37	45.8 ± 0.6*
Th8(n = 20)	32.8 ± 0.1	36.5 ± 0.1	40.1 ± 0.8*	40.6 ± 0.5	–	45.5 ± 0.5*
Th9 (n = 20)	32.8 ± 0.1	35.3 ± 0.6	40.5 ± 0.5*	41.0 ± 0.5	–	46.1 ± 0.5*
Th10 (n = 20)	32.3 ± 0.6	–	40.6 ± 0.5*	41.7 ± 0.6	–	46.7 ± 0.5*
Th11(n = 20)	32.9 ± 0.2	–	40.6 ± 0.6*	42.0 ± 0.6	–	46.8 ± 0.5*
Th12 (n = 20)	33.0 ± 0.1	–	40.0 ± 0.7*	42.0 ± 0.5	38.0	47.0 ± 0.5*
L1 (n = 20)	32.6 ± 0.2	–	41.2 ± 0.8*	41.3 ± 0.9	38.0	47.1 ± 0.6*
L2(n = 20)	30.9 ± 0.2	34.0	40.7 ± 0.9*	41.8 ± 0.5	38.0	46.3 ± 0.8*
L3(n = 20)	30.4 ± 0.2	–	40.2 ± 0.8*	41.7 ± 0.5	–	46.6 ± 0.8*
L4(n = 20)	30.9 ± 0.2	–	40.5 ± 1.0*	42.3 ± 0.3	–	46.6 ± 0.8*
L5(n = 20)	30.7 ± 0.2	–	41.8 ± 0.8*	43.0 ± 0.1	–	46.6 ± 0.6*
S1(n = 20)	29.1 ± 0.3	–	40.5 ± 0.8*	42.0 ± 0.1	–	46.8 ± 0.6*
S2(n = 20)	31.3 ± 0.2	–	41.3 ± 1.2*	42.0 ± 0.1	–	47.0 ± 0.8*

Note: * – significant differences from normal measurements, $p < 0.05$.

Acute deformity correction and spine stabilization with transpedicular systems were produced in all the cases during treatment. Amount of the deformity correction in compensatory arch was almost similar in both groups, and the measure in major arch was significantly greater by 21.1 % ($p < 0.05$) in Group I compared to that in Group II (Table 5).

It should be noted that three patients of Group II underwent discectomy at 4-6 levels to improve mobility of the spine. Blood loss was greater in Group II by 88.5 % compared to Group I measuring 383.1 ± 23.1 ml in Group I and 722.2 ± 128.8 ml in Group II, $p < 0.05$. No changes in neurological status of the patients were observed after the treatment. All changes in thermal pain sensitivity occurred on subclinical level.

Dynamics in pain sensitivity after deformity correction was of a special interest. There were more patients with positive dynamics in pain sensitivity (**Fig 1a**) by 84 % ($p \leq 0.01$) in group I compared to that in Group II measuring 54.1 ± 1.8 % in Group I and 29.4 ± 3.1 % in Group II, $p \leq 0.01$. Positive dynamics showed as decrease in pain threshold by 1) 1–9 degrees in Group I (3.0 ± 0.1 degrees on average, preoperative pain threshold measured 46.5 ± 0.2 degrees and 43.6 ± 0.2 degrees postoperatively, $p \leq 0{,}01$); 2) by 1–7 degrees in Group II (2.3 ± 0.1 degrees on average, preoperative pain threshold measured 45.2 ± 0.3 degrees and 43.0 ± 0.2 degrees postoperatively, $p \leq 0.05$). The mean decrease in pain threshold was significantly greater by 23.3 % ($p \leq 0.05$) in Group I as compared to that in Group II.

Table 5

Changes in measurements of the major and compensatory arches after spinal curve correction in patients with idiopathic scoliosis, M ± m, n = 25

Description	Study groups					
	Group I, n = 15			Group II, n = 10		
	pre-op	post treatment	amount of correction	pre-op	post treatment	amount of correction
Major arch (o)	48.5 ± 2.2 (range, 36–60)	10.1 ± 2.4* (range, 3–40)	81.1 ± 4.0# (range, 33–95)	77.7 ± 2.7 (range, 64–86)	29.0 ± 6.2* (range, 5–56)	63.5 ± 7.3 (range, 33–92)
Compensatory arch (o)	29.5 ± 4.9 (range, 15–43)	10.0 ± 2.6* (range, 0–15)	69.4 ± 7.9 (range, 50–100)	40.0 ± 6.6 (range, 30–65)	18.0 ± 8.1* (range, 5–40)	60.8 ± 12.4 (range, 39–87)

Note: * – significant differences from preoperative measurements, $p < 0.05$; # – significance of differences in measurements of Group I and Group II, $p < 0.05$.

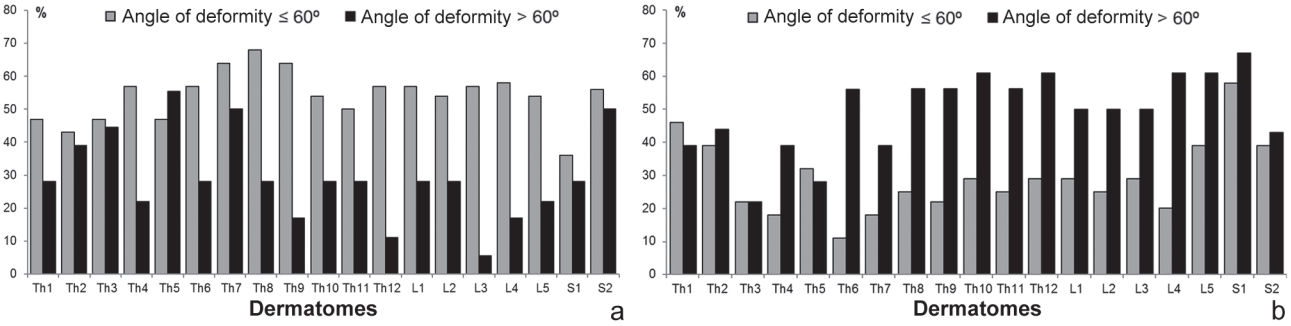

Fig. 1 The ratio of patients with idiopathic scoliosis measuring ≤ 60º and > 60º preoperatively, with positive (a) and negative (b) dynamics in pain sensitivity after surgical treatment

Group I with positive dynamics in pain sensitivity showed relatively smooth distribution in the chain of dermatomes (Fig. 1a) and several dermatomes of Group II demonstrated less improvement of pain sensitivity (Th9, Th12, L3, L4, L5 – 5.6–22 %).

Negative changes (increased/decreased thresholds) in pain sensitivity (Fig. 1b) was more expressed in Group II with the number of patients greater by 71.2 % ($p \leq 0.01$) as compared to those in Group I (Group I – 29.2 ± 2.6 %, Group II – 50.0 ± 2.8 %, $p \leq 0.01$). Negative changes showed as increase in pain threshold by (1) 1-9 degrees in Group I (3.1 ± 0.2 degrees on average, preoperative pain threshold measured 43.0 ± 0.2 degrees and 46.0 ± 0.1 degrees postoperatively, $p \leq 0.01$) and (2) by 1-10 degrees in Group II (3.5 ± 0.2 degrees on average, preoperative pain threshold measured 44.2 ± 0.2 degrees and 47.8 ± 0.2 degrees postoperatively, $p \leq 0.01$).

Decreased thresholds were seen in Th4, L1, L2, L3, S1 dermatomes of Group I accounting for 2 ± 0.3 cases per dermatome. Decrease in threshold was 4.8 ± 0.4 degrees on average measuring 42.1 ± 0.4 degrees preoperatively and 37.4 ± 0.2 degrees postoperatively. Group II showed such a dynamics in Th1 to Th6 dermatomes accounting for 3.5 ± 0.8 cases on average and measuring average decrease of 2.9 ± 0.3 degrees with 40.5 ± 0.3 degrees preoperatively and 37.8 ± 0.2 degrees postoperatively.

Pain sensitivity was shown to be dependent on an angle of major arch of the curve following surgical correction. Positive dynamics in pain sensitivity (54.1 % of the cases) was observed in preoperative spinal deformity of ≤ 60º. Aggravated pain sensitivity (50 % of the cases) was more common in patients with preoperative curve of > 60º than improved pain sensitivity (29.4 % of the cases).

Dynamics in thermal sensitivity in the groups was different from that in pain sensitivity (**Fig. 2**). An average rate of patients with positive dynamics in thermal sensitivity (**Fig. 2a**) that showed as decrease in threshold by 1-4 degrees and appearance of thermal sensitivity at the areas where it had been absent was greater by 30 % in Group I ($p \leq 0.05$) than in Group II measuring 41.5 ± 1.7 % in Group I and 31.8 ± 2.7 % in Group II. Thermal sensitivity developed at the sites where it had been absent in 1-7 cases (3.3 ± 0.4 on average in 16 out of 19 dermatomes (**Fig 3a**). Thermal sensitivity developed in 1-4 cases (1.9 ± 0.3 on average) in 15 out of 19 dermatomes of Group II.

Negative dynamics (**Fig. 2b**) in thermal sensitivity with increase in threshold by 1-5 degrees and lost thermal sensitivity was nearly identical in both groups measuring 34.7 ± 2.0 % in Group I and 35.4 ± 2.5 % in Group II. Lost thermal sensitivity (**Fig. 3b**) was observed in 18 out of 19 dermatomes of 2–6 cases (4.5 ± 0.3 cases on average) in Group I and 17 out of 19 dermatomes of 1–5 cases (2.6 ± 0.3 cases, on average) in Group II. Postoperative positive dynamics in thermal sensitivity was greater by 30 % in patients with preoperative curve of ≤ 60º compared to those with preoperative curve of > 60º. The rate of patients with negative dynamics was identical in both groups.

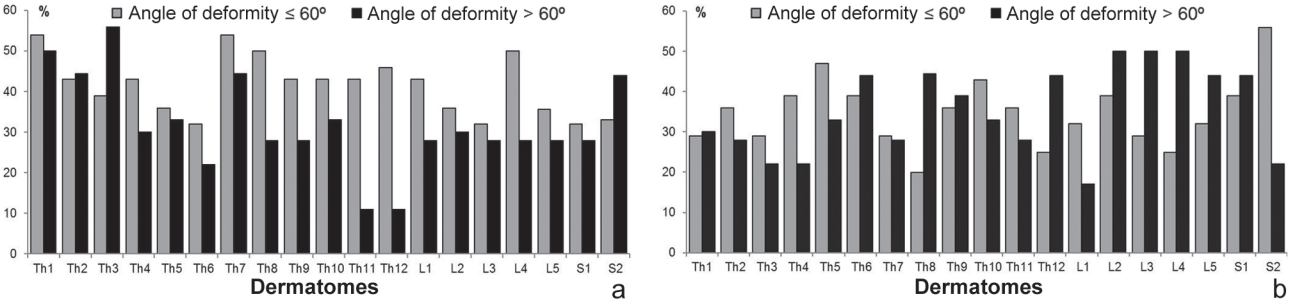

Fig. 2 The ratio of patients with idiopathic scoliosis measuring ≤ 60º and > 60º preoperatively, with positive (a) and negative (b) dynamics in thermal sensitivity after surgical treatment

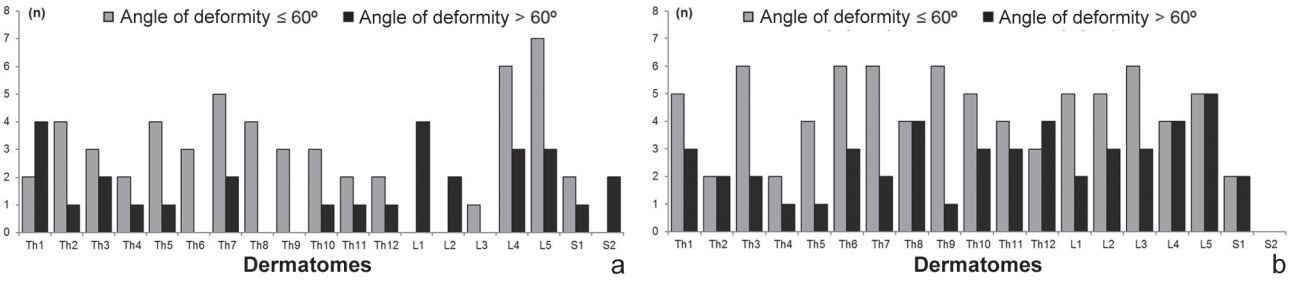

Fig. 3 Number of cases with recovered (a) and lost (b) thermal sensitivity after surgical treatment of idiopathic scoliosis with preoperative curve of ≤ 60º and > 60º

DISCUSSION

Factors that can preoperatively affect thermal pain sensitivity in patients with idiopathic scoliosis must be taken into consideration to enable analyze a response of sensory system to the correction of spinal curve.

Our findings and the literature data suggest that preoperative impairments of sensitivity in patients with idiopathic scoliosis are not local, found beyond the level of spinal curve and not dependent on the size of the curve and side of investigation [1, 2, 5, 7, 12].

R. Barrack et al. detected decreased thresholds of vibratory sensitivity in the lower and upper limbs in patients with idiopathic scoliosis [2]. The authors reported higher proprioception thresholds and absent asymmetry in the right and left lower limbs in other publications [1]. The researchers [7] described different types of thermal pain sensitivity including increased (hyperesthesia) or decreased (hypesthesia) pain thresholds, absent thermal sensitivity (thermoanesthesia) in Th1-S2 dermatomes in all examined patients with idiopathic scoliosis.

Analyzing the above factors we can conclude that preoperative disorders of thermal pain sensitivity can be caused by primary etiopathogenetic factor of idiopathic scoliosis that involves the central mechanism of impaired function of the posterior roots to the spinal cord [1, 5].

Augmented severity of disturbed thermal pain sensitivity at the apex of the curve and caudally [7] suggests that the fact of spinal deformity resulting in spinal cord and root tensioning, changes in the position of dorsal root ganglions and the worse functioning can be referred to etiopathogenetic factors [6].

In addition to that, thermal pain sensitivity is a sort of skin sensitivity, and the changes can be caused by impaired receptors' structure and function, changed structure of nerve fibers in the skin nerves due to tension, curvature and decreased skin thickness in idiopathic scoliosis [28, 29, 30].

Literature data of instrumentation assessment of the functional condition of patients with idiopathic scoliosis after surgical treatment primarily address motor component including paraspinal muscles (dynamics with EMG) [4, 24], reactivity and resistance of pyramidal structures of the spinal cord [26], specific and integrated characteristics of arbitrary and induced bioelectrical activity of muscles of lower limbs [4, 26]. Dynamics in sensitivity, thermal pain, in particular, after surgical correction with regard to preoperative curvature size is not elucidated in the literature.

Our findings showed different response of sensory system of thermal pain sensitivity to curvature correction at Th1-S2 dermatomes with preoperative curve of ≤ 60º (moderate) and > 60º (severe) in patients with idiopathic scoliosis.

Dynamics in pain sensitivity demonstrated different reaction of the sensory system. Patients with preoperative curve of ≤ 60º showed positive dynamics in pain sensitivity in 54.1 % of the cases with uniform distribution over the chain of dermatomes. Negative dynamics in pain sensitivity was observed in 29.2 % of the cases. Patients with the curve of > 60º exhibited negative dynamics in pain sensitivity (50 % of the cases). Positive dynamics was noted in 29.4 % of the cases.

Positive dynamics in thermal sensitivity indicated to an identical tendency observed with pain sensitivity. The number of patients with the curve of ≤ 60º showing positive dynamics in thermal sensitivity was greater by 30 % than those with the curve of > 60º. However, there was an identical number of patients with negative dynamics (Group I – 34.7 ± 2.0 % and Group II – 35.4 ± 2.5 %). Different nature of changes

in thermal and pain sensitivity could result from different pathways of these types of sensitivity.

Our findings are in line with the results of investigations of other authors. A.P. Shein et al. reported improved functional capabilities of sensory and motor apparatus of lower limbs following deformity correction with the same methods as described in our work [26]. I.A. Lomaga et al. noted an increase in motor-axonal conduction velocity with improved function of spinal muscles [4] and more balanced EMG measurements in lumbar spine, in particular [24].

Before giving considerations to the reasons of impaired or improved thermal pain sensitivity in patients with idiopathic scoliosis of ≤ 60º and > 60º we need to clarify etiological factors of disturbed thermal pain sensitivity effecting surgical correction of idiopathic scoliosis. Decrease in a major arch angle (Group I – by 81.1 ± 4.0 % and Group II by 63.5 ± 7.3 %) is likely to be a dominant factor that contributes to optimization in relations of the spine, spinal cord, spinal roots, intervertebral ganglions with improved skin tension and deformity. Positive dynamics in thermal pain sensitivity can also result from improved postoperative conditions of preoperatively tensed and compressed superficial membranous arteries [31] that entail better trophic and neural structures' functioning. Negative dynamics in thermal pain sensitivity can be associated with intraoperative spinal traction (derotation maneuver) when impaired function can be caused by an indirect impact on the spinal cord and reactive changes in vessels (microsurgical ischemic events) [32, 33]. In our study it was mostly evident after correction of the curve measuring > 60º despite the fact that the amount of deformity correction was less by 21.1 % in the group than that in patients with the curve of ≤ 60º. Elimination of severe spine curvatures was coupled with tremendous correction maneuvers that caused more reactive responses from the spinal cord with a greater risk of postoperative complications.

Meningospinal volumetric capillary blood flow is decreased by 27-57 % at the apex of the curve in patients with idiopathic scoliosis of III and IV grades (V.D.Chaklin's classification). Decreased blood flow is directly correlated with an angle of the spinal curve [34].

Meningospinal microcirculation is shown to improve after correction of moderate idiopathic scoliosis with Cotrel-Dubousset Instrumentation (CDI). There is a tendency of impaired circulation in deeper meninges observed in most severe curves gradually corrected with halo-pelvic system [35]. A.P.Shein et al. report negative postoperative trend in functional capabilities of sensory and motor apparatus of lower limbs increasing with aggravated severity of preoperative deformity [26].

CONCLUSION

Comparative analysis of dynamics in thermal pain sensitivity following correction of moderate and severe spinal curves in patients with idiopathic scoliosis showed more evident positive dynamics in thermal pain sensitivity in patients with the curve of ≤ 60º (41.5–54.1 % of the cases). Negative dynamics in thermal pain sensitivity was seen in patients with surgical curve correction of > 60º (35.4-50 % of the cases). Although no dynamics in postoperative neurological status was observed all patients were diagnosed with changes in sensitivity on subclinical level.

Acute correction of spinal deformity in patients with idiopathic scoliosis of more than 60° requires apprehensive attitude due to a high risk of neurological complications, prophylactic pharmacological measures for the prevention.

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Information about the authors:

1. Elena N. Shchurova, Ph.D. of Biological Sci.,
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation;
Email: elena.shurova@mail.ru
2. Oksana G. Prudnikova, M.D., Ph.D.,
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation
3. Sergey O. Ryabykh, M.D., Ph.D.,
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation
4. Sergey A. Lipin,
Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics, Kurgan, Russian Federation