REVISION SURGERY FOR CHRONIC PYOGENIC SPONDYLITIS: ANALYSIS OF A MONOCENTER COHORT WITH A MINIMUM 1 YEAR FOLLOW-UP

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Objective. To analyze the structure of complications and follow-up results of revision surgeries in patients operated on for chronic nonspecific spondylitis (CNS).

Material and Methods. Revision interventions due to the development of complications corresponding to type IIIB according to Clavien – Dindo classification were performed in 78 patients (mean age 58 years 6 months ± 11 years 2 months) with CNS who had previously undergone reconstructive surgery on the spine. The timing of complications was analyzed according to Prinz classification. The structure of complications and factors potentially influencing their development were evaluated. Predictors of infectious and orthopedic complications were differentiated. Follow-up period was at least 1 year (M ± m = 3 years 3 months ± 1 year 2 months). Statistical analysis was performed using SPSS, version 22.0.

Results. The estimated frequency of Clavien – Dindo grade IIIB complications after surgical treatment of CNS was 11.3 %. In 44 (56.4 %) of 78 cases, indications for revision surgery were due to infectious complications, and in 34 (43.6 %) – to orthopedic complications. The Charlson comorbidity index was 4.5 ± 1.8 with no intergroup differences between infectious and orthopedic complications ($p = 0.052$). The duration of primary interventions ($p < 0.001$) and blood loss ($p = 0.010$) were higher in patients with infectious complications. The average preoperative ODI was 48.3 ± 13, with a higher value in the infectious complications group ($F = 5.146$, $p = 0.026$). The timing of complications and the location of primary reconstruction influenced both the ODI score ($F = 6.622$, $p < 0.001$) and the type of complications (Pearson's $\chi^2 = 14.224$, $p = 0.014$). The patient age had no effect on the location of complications ($p = 0.349$, F value = 1.137). Preoperative neurologic deficit was noted in 23 patients, regression was recorded in 11 cases, including complete in 6 and within the same functional class in 5 cases. The complication rate in the long-term period after revision surgery was 14.1 %.

Conclusion. Infectious complications of primary interventions in patients with chronic nonspecific spondylitis prevail over orthopedic ones. Significant predictors of the development of complications are the patient age > 55 years, the Charlson comorbidity index > 3, duration of surgery > 2 hours 30 minutes, and blood loss volume > 250 ml.

Key words: chronic nonspecific spondylitis; complications; revision surgery.

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Chronic nonspecific spondylitis is an etiologically heterogeneous group of inflammatory spine disorders with destruction of vertebrae, intervertebral discs and involvement of the epidural space [1, 2]. It is marked by a high level of pathogen drug resistance reaching 30.3–60.0 %, and the formation of rigid deformities with the development of the three-column spine instability [3–5]. Unlike acute spondylodiscitis, which guidelines of diagnosis, classification, and strategies of conservative and surgical treatment are reflected in sufficient details in recent articles [6, 7], in chronic processes, the therapeutic pause may range from 3 months to several years. To achieve clinical outcome and improve the quality of life of patients, correction of local deformity and three-column reconstruction of the spine are often essential, along with antibiotic therapy, resection of affected vertebrae, and debridement of soft tissue structures [8, 9]. In contrast to acute processes, these surgeries are associated with a greater extent of injury and duration of surgery, blood loss volume, and the need for resection of bone structures involved in the infectious process [10, 11].

The infectious complications are the most important in the structure of postoperative complications of reconstructive surgeries: superficial and deep surgical site infection (SSI), peri-implant bone resorption associated with persistent infection, including those caused by low-pathogenic flora (low-grade infection), and the development of secondary spondylodiscitis of adjacent segments [12–14]. According to the Clavien – Dindo (2004) classification, these complications correspond to grade IIIB and require revision surgeries, the need for which in chronic nonspecific spondylitis reaches 21–34 % [15–17].

Analysis of the literature suggests limited information on the structure and frequency of complications of surgeries performed for chronic nonspecific spondylitis, as well as the strategy of their revision surgery. The experience of the Saint-Petersburg Research Institute of Phthisiopulmonology clinic provides an opportunity to systematize the data on the issue under consideration and to present the results of our own study.

Study design: single-center cohort study corresponding to class III according to Burns et al. [18].

The objective is to analyze the structure of complications and long-term outcomes of revision surgeries in patients operated on for chronic nonspecific spondylitis (CNS).

Material and Methods

Patients were included in the study according to the following criteria:

- presence of etiological verification of chronic nonspecific spondylitis at the time of primary surgery according to bacteriologic, molecular genetics, and/or histopathological methods;
- development of a complication after the primary surgery, corresponding to grade IIIB according to Clavien–Dindo et al., and requiring revision surgery;
- case histories from January 1, 2018 to December 31, 2022, inclusive;
- patient aged 18 or older;
- follow-up of 12 months or more.

Exclusion criteria:

- planned staged surgeries in patients with chronic nonspecific spondylitis;
- early postoperative complications corresponding to Clavien – Dindo grades I and II not affecting the course of the main process, including technical complications (malposition of pedicle screws) and superficial SSI not requiring revision surgery and/or negative pressure wound therapy (NPWT).

The analyzed cohort consisted of 78 sequentially operated patients with chronic nonspecific spondylitis who developed complications requiring revision surgeries after previous ones. 47 (60.3 %) patients underwent primary surgery in our hospital; 31 (39.7 %) were admitted after treatment in other medical facilities of the Russian Federation.

The mean age of the patients at the time of revision surgery was 58 years 6 months ± 11 years 2 months (min 33 years; max 83 years). The follow-up period was 3 years 3 months ± 1 year 2 months (min 12 months; max 5 years 1 month).

Cervical revision surgeries were performed in 9 cases, cervicothoracic ones – in 3 cases, thoracic – in 15 cases, thoracolumbar – in 12 cases, lumbar – in 29 cases, and lumbosacral – in 10 cases. The indications for surgery were divided into two groups:

– infectious, including superficial and deep SSI, pleural empyema, and peri-implant resorption in combination with signs of systemic inflammation; division into periods of complications considering the time from the primary surgery was performed according to Prinz et al. [17] with the separation of early (⩽6 weeks), delayed (>6 weeks), and late (>12 months) complications;

– orthopedic: deformity progression, segmental instability (including pseudoarthrosis of the anterior column), and fracture of the supporting elements of the posterior instrumentation.

During the analysis of medical records, we studied the Charlson comorbidity index of each patient, timing of complication development after the primary surgery, results of culturing of surgical specimen (type of microorganism, susceptibility to antibacterial medication), ODI (Oswestry Disability Index), quality of life according to the SF-12 questionnaire (physical and mental component) before and after revision surgery, and neurological status according to the Frankel score.

Analysis of predictors of postoperative complications was performed for the following parameters: gender and age of the patient, localization of primary reconstruction, Charlson comorbidity index, and neurological status according to the Frankel score. The surgery duration and the blood loss volume were additionally studied in patients initially operated on in our hospital.

To define the odds ratio (OR), comparable groups were formed using the propensity score matching, paired design: 1:1. The group of patients with complications was paired with a control group of patients without complications operated on in our hospital in 2019–2022. All surgeries in the control group were performed by the same surgeon. The final number of cases in the study and control groups for analysis of complications predictors was 100.

The study diagram is given in Fig. 1.

Statistical analysis was performed in Statistical Package for the Social Sciences (SPSS), version 22.0 (SPSS Inc., Chicago, IL). The sample was checked for normality of distribution using the Kolmogorov–Smirnov test. The asymptotic significance for some of the analyzed parameters (patient age, blood loss, ODI before and after surgery, and SF-12 before and after surgery) was $p > 0.05$, indicating the normality of the sample distribution; and it was $p < 0.05$ for the others (Charlson comorbidity index, surgery duration), non-normal distribution. During the first stage, the influence of quantitative (one-way analysis of variance ANOVA) and qualitative (Pearson's chi-squared test with construction of contingency tables) parameters on the nature and timing of complications development was assessed in the cohort of patients who required revision treatment [20].

At the second stage, factor analysis of predictors of postoperative complications was performed using regression analysis. The above parameters were used as co-founders. Differences were considered statistically significant at two-sided $p < 0.05$. The results are expressed as M ± SD (min; max), where M is the mean value, SD is the standard deviation, min is the minimum, and max is the maximum value of the parameter. The OR is given by the lower and upper limits of the 95 % confidence interval (CI).

Results

Considering the number of patients who underwent primary and revision surgeries in the hospital for chronic nonspecific spondylitis, the revision

rate was 11.3 % (47 revisions out of 416 primary surgeries), of them: 61.7 % infectious complications and 38.3 % orthopedic complications.

Two groups of surgeries were formed according to the nature of revision surgeries: simultaneous (n_1 = 29; 37.2 %) and staged (n_2 = 49; 62.8 %), and the following types of surgeries were performed considering the type of complication:

– in infectious complications: surgical debridement without removal of instrumentation (including minimally invasive and endovideo surgical ones); with removal and simultaneous replacement; with removal and staged replacement, including NPWT;

– in orthopedic complications: extension of posterior instrumental fixation to adjacent segments; extension of posterior instrumental fixation in combination with anterior column repeated fusion; isolated anterior column repeated fusion.

The Charlson comorbidity index in the study cohort was 4.5 ± 1.8 points, including 5.5 ± 1.5 points in patients with infectious complications and 3.1 ± 1.1 points in patients with orthopedic complications (p = 0.052). Type 2 diabetes mellitus (n_1 = 16), chronic Hepatitis B infection (n_2 = 8), and HIV infection (n_3 = 9) were noted as comorbidities. In comparison with the control group, the Charlson comorbidity index with its threshold value of 3 [OR = 6.667; 95 % CI: 3.188; 13.941] and the age of patients over 55 years [OR = 7.400; 95 % CI: 3.244; 16.880] were significant predictors of complications.

Neurologic deficit evaluated by Frankel score before revision surgery was found in 23 patients, including 2 of type A; 3 of type B; 6 of type C; 8 of type D; and 4 of type R (radicular pain syndrome). Regression of the deficit after surgery was recorded in 11 patients: 6 patients achieved complete recovery with initial type C in one type D in 5 patients; 5 patients showed improvements of neurological status within one functional class with initial type A in one case, type B in two patients, and type D in three patients.

Significant differences for the development of delayed complications were found when evaluating the surgery duration and the blood loss volume in primary reconstructions performed in our hospital (Table 1).

Blood loss volume over 250 mL [OR = 4.973; 95% CI: 2.690; 9.293] and surgery duration over 2 h 30 min [OR = 12.333; 95% CI: 4.139; 36.752] had a significant effect on the risk of postoperative complications.

ODI before revision surgery was 48.3 ± 13.0 points (min – 25, max – 82) and was higher in patients with infectious complications (51.2 ± 15.0 points) than with orthopedic complications (44.6 ± 8.0 points; F = 5.146; p = 0.026). Its reduction after revision surgeries was noted up to 29 ± 9 points for infectious complications and 23 ± 6 points for orthopedic complications, respectively (F = 3.143; p = 0.080).

The evaluation of the influence of the development timing and localization of complications on ODI scores before and after revision surgeries resulted in the following statistically significant differences:

1) the worst preoperative ODI scores were found in patients with early complications (F = 4.850; p = 0.010) in the cervicothoracic and thoracic spine departments (F = 11.139; p < 0.001);

2) the positive trend in ODI was higher after revision surgeries performed for delayed and late complications (F = 3.347; p < 0.041) in the thoracolumbar, lumbar and lumbosacral spine departments (F = 6.622; p < 0.001).

The quality of life of patients with infectious and orthopedic complications, evaluated before surgery using the SF-12 questionnaire, did not differ in the physical component with 27.6 ± 3.4 points and 29.1 ± 3.2 points (F = 0.081; p = 0.776), respectively, as opposed to the mental component with 26.4 ± 4.4 points and 33.4 ± 6.9 points (F = 29.530; p < 0.001), respectively. In the postoperative period, improvement in both physical (48.2 ± 7.7 points) and mental (54.1 ± 9.6 points) components of quality of life was reached.

Significant differences in the nature of complications depending on the age of patients were identified: e.g., infectious complications were more frequent in the older age group (62 years 3 months ± 9 years 8 months, 95% CI: 59 years 3 months; 65 years 3 months), orthopedic complications were more frequent in younger patients (53 years 8 months ± 11 years 3 months, 95 % CI: 47 years 9 months; 56 years 9 months); p = 0.001; F value = 12.567. Meanwhile, there was no significant impact of age on the localization of complications (p = 0.349; F value = 1.137).

When the influence of the timing of complications (Table 2) on their nature was assessed, we found that infectious complications developed significantly more frequently in the early and delayed periods, whereas orthopedic complications developed more frequently in the late period (Pearson's chi-squared test = 31.698; p < 0.001).

Microbial examination of the surgical specimen collected during revision surgery revealed the causative agent of SSI in 27 (61.4 %) cases, 17 of which were noted in the early, 6 in the delayed and 4 in the late postoperative period. Gram-positive multidrug-resistant strains of *Staph. Aureus* (n_4 = 13) and *Staph. Epidermidis* (n_5 = 5) prevailed in the structure of early and delayed complications. Gram-negative extreme resistant strains of *Klebsiella spp.* (n_6 = 2), *Acinetobacter spp.* (n_7 = 2) and pan-resistant strains (n_8 = 1) were identified less frequently. In a cohort of patients with late orthopedic complications, we observed an increase in Gram-positive multidrug-resistant strains of *Staph. Aureus* (n_9 = 3) and *Staph. Epidermidis* (n_{10} = 1).

The incidence of complications after revision surgery was 14.1 % (n_1 = 11), including superficial SSI (n_2 = 4) in the early postoperative period and deep SSI (n_3 = 2), proximal junctional kyphosis (n_4 = 2), progression of kyphosis within the instrumentation area (n_5 = 2), and support rod fracture (n_6 = 1) in the late postoperative period.

In one (1.3 %) case, there was a fatal outcome on day 24 after revision L3-S1 360° reconstruction associated with late deep SSI with three-column involvement, development of mixed bacterial-fungal (MRSE, *Candida glabrata, Candida albi-*

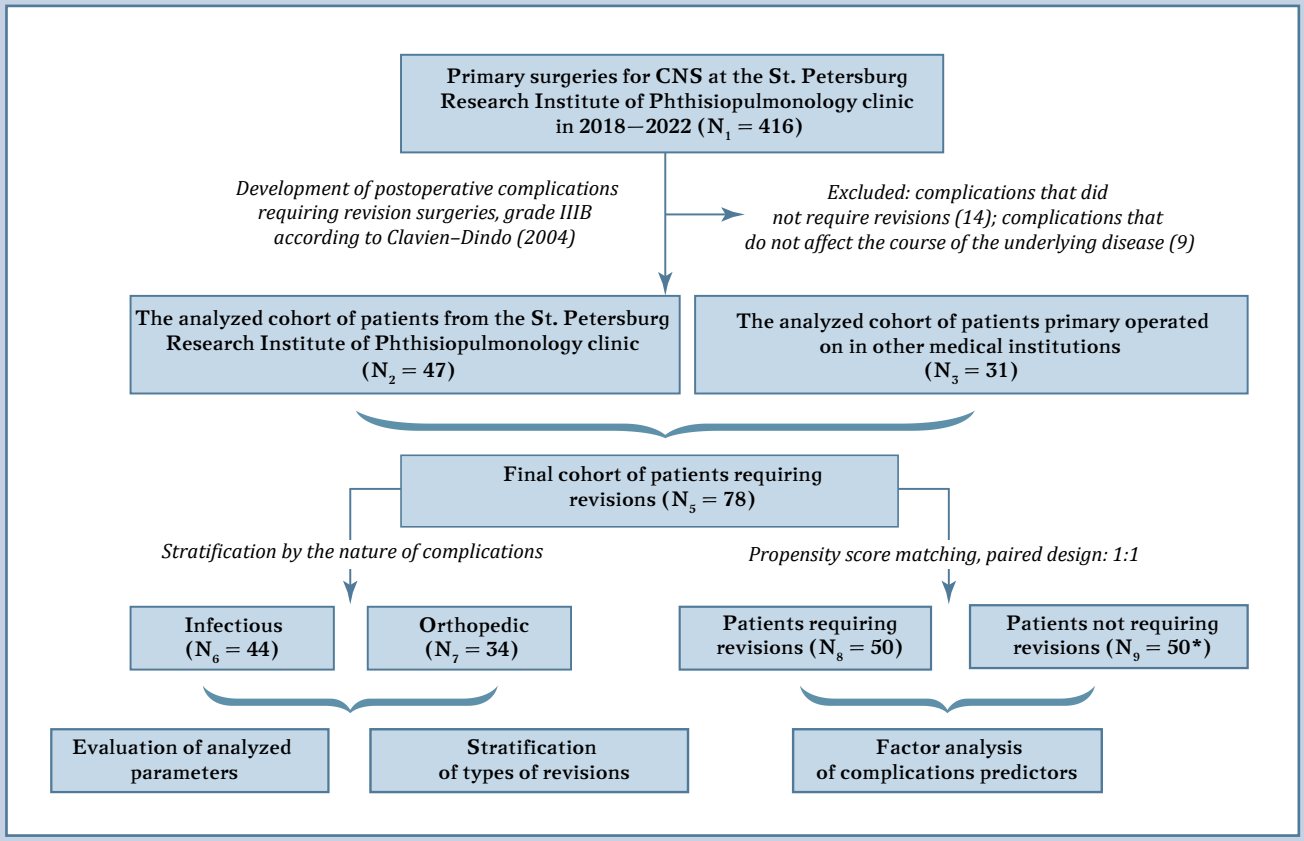

Fig. 1
Study design: CNS – chronic nonspecific spondylitis; * the control group was formed for 2019–2022 inclusive, all patients were operated on by the same surgeon

cans) sepsis, and multiple organ dysfunction syndrome.

Discussion

Revision surgery for spinal pathology has become one of the most frequently performed procedures in the last decade [18, 19]. According to Barbanti-Brodano et al. [23], the complication rate in spine surgery reaches 15.3–22.2 %, with the specific complication rate in the cohort of patients with infectious diseases accounting for 20 %. Meta-analysis by Zhou et al. [21] includes 22,000 patients, with the incidence of infectious complications ranging from 2.3 to 14.0 %. It should be pointed out that the rate of postoperative complications is rapidly increasing: the largest multicenter study published by Smith et al. [13] showed the incidence of SSI within 5.4 % that is 4 times less than in recent years. According to the data of our hospital, the frequency of complications of primary surgeries in chronic nonspecific spondylitis of all grades by Clavien – Dindo reaches 18.8 %, in the structure of which the infectious ones account for 10.6 % and orthopedic ones for 8.2 %.

Previously published papers predominantly analyze the outcomes of primary clean surgeries, while the evaluation of postoperative complications in spondylitis remains beyond the pale of research. Although attempts have been made to algorithmize the strategy of primary reconstructions in acute spondylitis, their adaptation for chronic spondylitis has proven to have low interrater consistency [4, 6, 14, 15, 22], and studies of revision surgeries in this cohort are generally unavailable.

One of the goals of our study was to develop an algorithm for selecting a revision surgical option in chronic nonspecific spondylitis. The basic criteria for stratification were the period of development and type of complication. In the case of SSI, it is important to be aware of its depth, which is a key factor in deciding whether the instrumentation can be preserved. In deep SSI, we preferred staged surgeries with NPWT, the use of which in all (n = 9) cases allowed us to achieve local control of the infection process and perform staged extrafocal instrumental fixation with closure of the wound

Table 1
Duration of surgery and blood loss

Timing	Infectious complications (M ± SD)	Orthopedic complications (M ± SD)	p_1*	p_2**
Early	3 h 13 min ± 19 min 279 ± 98 mL	3 h 20 min ± 14 min 270 ± 42 mL	0.923	0.918
Delayed	3 h ± 21 min 348 ± 72 mL	2 h 21 min ± 11 min 243 ± 54 mL	<0.001	0.009
Late	2 h 47 min ± 14 min 270 ± 34 mL	2 h 44 min ± 28 min 234 ± 68 mL	0.294	0.401
Total	3 h 15 min ± 19 min 305 ± 89 mL	2 h 40 min ± 25 min 240 ± 63 mL	<0.001	0.010

* Test of significance of differences using the Mann-Whitney U test (duration of surgery); ** test of significance of differences using the t-test for independent samples (blood loss volume).

defect. Reconstructions of the thoracic spine performed by transthoracic approach were complicated by pleural empyema in the early postoperative period in five cases. Elimination of the empyema was achieved by videothoracoscopic debridement and drainage of the pleural cavity.

Chronic nonspecific spondylitis of the lumbar and lumbosacral spine with the development of bilateral psoas and presacral abscesses in the delayed postoperative period is a separate issue. In our cohort, nine of these complications were treated with contralateral and presacral debridement using tubular retractors ($n_1 = 6$) and endovideo surgical assistance ($n_2 = 3$). In all cases of infectious complications at the stage of preparation for revision surgery, a trephine biopsy and aspiration of the contents with subsequent culturing in the presence of the fistula process were performed. Verification of the causative agent was achieved in 61.4 % of cases, with the percentage of successful verification progressively reducing as the time of complications development increased. The duration of antibacterial therapy in revision surgeries for chronic nonspecific spondylitis reached 6–8 weeks; parenteral administration of drugs was used during 4 of these weeks.

Radiological evaluation of the primary reconstruction area was based on the CT and MRI data: the CT data were used to evaluate the implant stability (signs of peri-implant bone resorption), and the MRI data were used to evaluate the localization and prevalence of abscesses.

The strategic algorithm for choosing an option of revision surgery depending on the type and timing of complications is given in Fig. 2.

It is necessary to point out that the presented algorithm, developed using our own clinical material, is a pilot one for the considered cohort of patients and necessitates further multicenter validation.

Conclusion

1) The incidence of all postoperative complications in surgical treatment of chronic nonspecific spondylitis is 18.8 %, and those requiring revision surgeries (Clavien–Dindo grade IIIB) is 11.3 %.

2) Infectious complications predominate over orthopedic complications in the structure of indications for revision surgeries, though they are not dominant.

3) The significant predictors of complications were patient age over 55, Charlson comorbidity index more than 3, surgery duration more than 2 h 30 min, and volume of surgical blood loss more than 250 mL.

4) The use of a strategic algorithm for selecting a revision surgery option depending on the time of development and type of complication proves good long-term outcomes both in terms of infection process control and correction of orthopedic complications.

Limitation of the veracity of the results. Calculation of the incidence and

Table 2
Timing of complications development

Complication nature	Early complications, n (%)	Delayed complications, n (%)	Late complications, n (%)	Σ, n (%)
Infectious	18 (40.9)	21 (47.7)	5 (11.4)	44 (100.0)
Orthopedic	1 (2.9)	9 (26.5)	24 (70.6)	34 (100.0)
Total	19 (24.3)	30 (38.5)	29 (37.2)	78 (100.0)

Pearson's chi-squared = 31.698; $p < 0.001$.

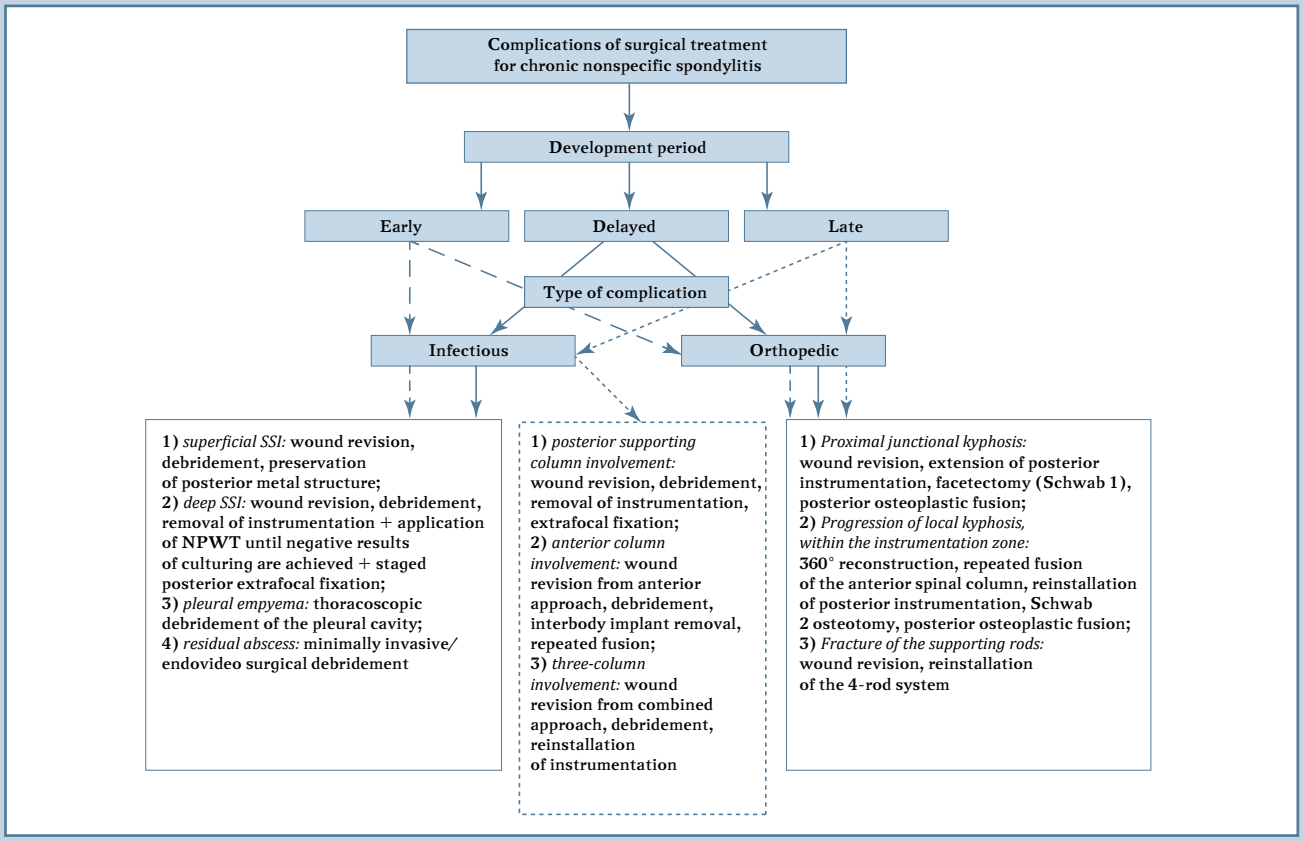

Fig. 2
Algorithm of revisions

structure of complications of surgery for chronic nonspecific spondylitis was conducted only in patients initially operated on in our hospital. Considering the traditional field of activity of the institute hospitals in the treatment of infectious spondylitis, we are not able to assert that the same treatment principles are fully fulfilled in other institutions of the Russian Federation, and, accordingly, the number of complications matches that reported in the hospital.

The study had no sponsors. The authors declare that they have no conflict of interest.
The study was approved by the local ethics committees of the institutions. All authors contributed significantly to the research and preparation of the article, read and approved the final version before publication.

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