RESULTS OF SURGICAL TREATMENT OF PATIENTS WITH HIP-SPINE SYNDROME: APPROBATION OF THE ALGORITHM OF RATIONAL SURGICAL TACTICS

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Objective. To present comparative analysis of mid- and long-term results of surgical treatment in patients with hip-spine syndrome operated on using conventional approaches and the developed algorithm.
Material and Methods. The study included 175 patients aged 54.4 ± 12.7 years with grade III coxarthrosis combined with degenerative disease of the spine and vertebrogenic pain syndrome, who were admitted at the clinic for hip replacement. The study (n = 94) and comparison (n = 81) groups were identified. In the study group, the developed algorithm of rational surgical tactics was applied, and in the comparison group, standard approaches to the choice of surgical tactics were used. Results of surgical treatment in 134 patients were achieved, on average, in 9 months after surgery. Long-term results were evaluated in 55 patients, on average, in 61 months after hip replacement.
Results. Using the developed algorithm allowed to increase the number of patients with good clinical and functional results, and to achieve better performance of the hip joint. The analysis of changes in patients' satisfaction with the results of treatment demonstrated significantly higher rating of long-term outcomes as compared to mid-term. Analysis of pelvis-spine relationships confirmed the effect of hip replacement on the sagittal and frontal trunk balance.
Conclusion. The developed approaches to the choice of rational surgical tactics in patients with hip-spine syndrome allows reliable improving of mid- and long-term results of surgical treatment.
Key Words: hip-spine syndrome, tactics of surgical treatment.

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Surgical treatment of patients with a combination of degenerative-dystrophic disease of the hip joint and spine is a relevant medical issue, despite the significant number of research papers focused on this topic [1, 12, 23]. The significant occurrence rate of hip-spine syndrome was shown among patients with prevalent clinical and radiographic signs of deforming hip joint arthrosis (22–95 %) as well as patients with more marked symptoms of degenerative disease of the spine (DDS; 10–15 %) [2, 8, 14].

Some authors believe a spinal disease to be a possible cause of deforming hip joint arthrosis [17]. Other researchers mention the possibility of DDS development due to progressive coxarthrosis [23]. The consensus is that morphological (constant) and positional (variable) characteristics of the pelvis affect the formation of frontal and sagittal spinopelvic balance [3, 6, 16, 17, 18]. Single studies focused on treatment tactics of patients with hip-spine syndrome (HSS) do not contain a detailed analysis of the frontal and sagittal trunk balance and the proposed approaches only involve surgical intervention in the first place on the segment that is mostly changed and disturbing a patient [1, 9, 13, 15, 19, 22].

The literature lacks particular recommendations for the treatment of such patients that would describe nuanced surgical tactics and procedure for performing operations on the spine and hip joint in terms of postural compensation of the trunk. There are only a few studies reporting treatment outcomes for patients with HSS [12, 15]. Almost no attention is paid to achieving the results in dynamics and to analysis of reasons for patient dissatisfaction with outcomes of surgical treatment on the hip joint and spine.

The aim of this study is a comparative analysis of the mid-term and long-term surgical outcomes in patients with HSS operated on using traditional approaches and the developed algorithm of rational surgical tactics.

Material and Methods

The study included 175 patients (98 men and 77 women) with hip-spine syndrome (HSS) aged 54.4 ± 12.7 years, who underwent total hip replacement for combined degenerative-dystrophic disease of one or two hip joints (coxarthrosis grade III) and lumbosacral spine. Exclusion criteria from the study were isolated vertebrogenic pain syndrome, coxarthrosis without low back pain, dysplastic scoliosis and spondylolisthesis, Scheuermann's disease, spine trauma, inflammatory diseases of the hip joint and spine, tumors, dysplasia, and spinal malformations.

Standard approaches to hip joint replacement and spine surgery were used in the comparison group (n = 81). The developed algorithm of rational surgical tactics was used in study group (n = 94). The compared samples were similar by age (study group – 53.5 ± 12.6 years, comparison group – 55.5 ± 12.5 years), gender (study group – 49 men and 45 women, comparison group – 49 men and 32 women), and distribution of patients according to etiology of coxarthrosis (Fig. 1).

Clinical and neurological assessment of the subjects was standard [5]; during a radiographic examination, we additionally performed standing radiographs of the spinopelvic complex and functional radiographs of the lumbosacral spine [10].

The angle of Pelvic obliquity (PO) and magnitude of scoliotic deformity of the lumbosacral spine – Cobb angle (CA) were measured on frontal radiographs of the trunk. The pelvic parameters: Pelvic incidence (PI), Sacral slope (SS), and Pelvic tilt (PT) were measured on sagittal images. In addition, we studied spinal parameters: Global lumbar lordosis (GLL), Apex of lumbar lordosis (AL), Upper arc of lumbar lordosis (UA), Lower arc of lordosis (LA), the highest point of the lumbar lordosis (the place where the lordosis curve turns in thoracic kyphosis) – Inflection point (IP), Lordosis tilt (LT; Fig. 2a).

In addition, flexion and extension functional radiographs were performed in order to assess the mobility of the lumbosacral spine and diagnose instability (hypermobility) of spinal motion segments in patients of the compared samples (Fig. 2b). The data in total permit identifying the capacity of the spine to compensate for changes in the position of the pelvis that occur after hip replacement. The criterion of rigidity was the change in magnitude of lumbar lordosis by less than 10°.

No statistically significant differences in magnitudes of the studied parameters were found in the compared samples ($p > 0.05$) and the data were comparable.

The first follow-up examination was held in approximately 9 months after hip replacement in 134 patients (comparison group – 60 people, study group – 74). Repeated follow-up examination was held in approximately 61 months in 55 patients (comparison group – 26, study group – 29). The control examinations included comprehensive clinical and radiographic examination, assessment of hip joint function and quality of life of patients according to Harris and Oswestry questionnaires, assessment of patient-reported satisfaction with treatment outcomes.

The outcomes were compared between the groups, and the achieved mid-term and long-term results of surgical treatment were analyzed between the groups. Statistical analysis was performed using Statistica 8.0 software and recommendations for medical and biological statistics [7, 11]. The following procedures and methods of statistical analysis were used: estimation of numerical variables, hypothesis testing on difference significance for quantitative variables in independent samples using Mann – Whitney U-test; quantitative variables in dependent samples were estimated using Wilcoxon test, relative frequencies in independent samples were estimated using two-sided exact Fisher's test and using Mac-Nemar test in dependent samples.

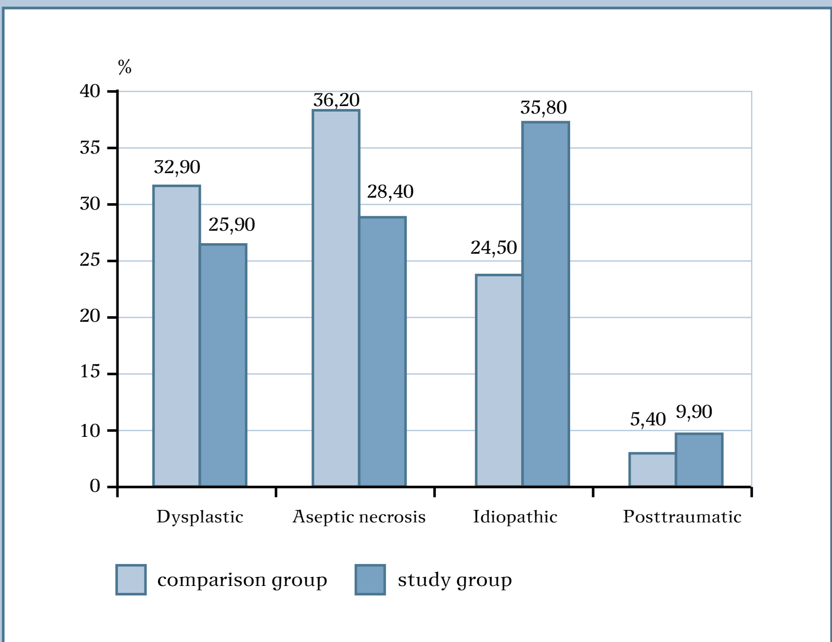

Fig. 1
Distribution of patients in the compared groups according to etiology of coxarthrosis

Results and Discussion

The mid-term surgical outcomes for 60 patients of the comparison group were analyzed, and patient-reported satisfaction with treatment was as follows: good – in 16 (26.7 %) patients, satisfactory – in 28 (46.6 %), unsatisfactory – in 16 (26.7 %). In these subgroups, Harris scores were 82 ± 11, 71 ± 14, and 68 ± 19, respectively. The quality of life according to the Oswestry questionnaire was estimated to be 5.8 ± 4.7 %, 21 ± 20.6 %, and 22.6 ± 16.7 % in these subgroups, respectively. Each clinical case from the comparison group was analyzed in terms of spinopelvic relationships, which allowed us to identify 6 variants of prerequisites for unsatisfactory surgical outcomes in patients with HSS. These were diagnostic errors – 2 (3.3 %), DDS decompensation in fixed spinal deformity – 4 (6.6 %), DDS decompensation in spinal motion segment hypermobility – 4 (6.6 %), failure to restore sagittal spinopelvic balance in spinal surgery and subsequent implantation of endoprosthesis cup without taking into account vertical pelvic position – 1 (1.7 %), lengthening of the leg in people with rigid spinal deformity – 4 (6.6 %), failure to restore normal spinopelvic relationships in patients with dysplastic coxarthrosis but with ability of spine to compensation – 1 (1.7 %).

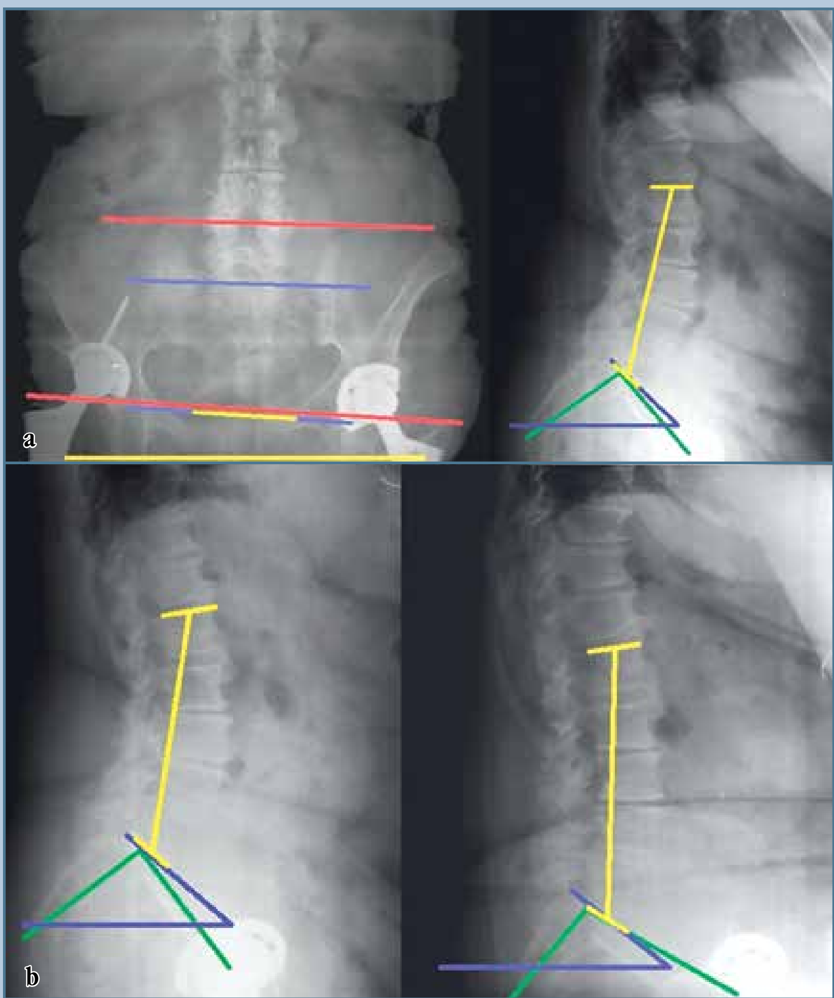

Fig. 2
Standing radiographs of the spine and pelvis of the female patient P., 76 years in 70 months after surgery: **a** – spinopelvic complex (estimation of frontal and sagittal balance parameters); **b** – spinal column (maintenances of mobility: difference of lumbar lordosis in flexion and extension is more than 10°)

Case report 1. A female patient R., 75 years old, was treated at the Military Medical Academy n.a. S.M. Kirov, (St Petersburg) for DDS of the lumbosacral spine, multilevel degenerative spinal stenosis, intervertebral disc herniation at L3–L4, L4–L5, L5–S1, bilateral radiculopathy at L4, L5 and S1 with pain syndrome, deforming left hip joint arthrosis grade II. Decompressive interlaminectomy facetectomy, removal of intervertebral disc herniations and transpedicular fixation at the L3–L4, L4–L5, L5–S1 levels were performed (Fig. 3a).

A year after surgery, the patient underwent total hip replacement (Fig. 3b) and was examined in 9 months after surgery (Harris score – 38, Oswestry – 18 %). She complained of pain in the lumbosacral spine and in the projection of the greater trochanter due to arthroplasty, a sensation of different heights of the legs and the need to correct the length of the healthy leg with a 1.9 cm orthopedic insole, impaired posture in form of trunk obliquity to the healthy side in frontal plane, the need to stand and walk leaning forward, claudication and inability to fully stand on the left leg, the need to use a cane, and presence of two closed endoprosthesis dislocations after the second stage of surgical treatment (Fig. 3c).

An assessment of sagittal spinopelvic profile revealed an imbalance in form of pelvic retroversion and flattening of lumbar lordosis (Fig. 3d). The analysis of frontal radiographs showed pelvic obliquity (5°) and lateral deviation of instrumented spine (Fig. 3e, f).

In this case report, we failed to achieve correction of sagittal profile of the trunk to reach estimated values at the first stage of surgical treatment. At the second stage, acetabular component was implanted without taking into account the fixed position of the pelvis in the retroversion in the standing position. This resulted in the cup position change from inclination to excessive anteversion, and hence the impingement between the posterior edge of the acetabular component and endoprosthesis neck occurred with recurrent endoprosthesis dislocations. In addition, the endoprosthesis stem was implanted above the planned position, which caused the lengthening of the left leg and frontal imbalance of the trunk with pelvic obliquity and lateral deviation of instrumented spine. A positive Trendelenburg's sign and the corresponding complaints in this case report are linked to insufficient tension of the middle and small gluteal muscles due to small offset. The combination of these factors led to an unsatisfactory outcome of surgical treatment in the patient.

An analysis of treatment outcomes of the comparison group patients allowed developing recommendations for the diagnosis and treatment of HSS that underlie the algorithm of rational surgical tactics. The clinical approbation was performed during treating patients of the study group. This algorithm is based on the assessment of compensatory capacities of the spine in patients with HSS using a complex of clinical, neurological, and radiographic techniques [10].

In HSS with a predominance of DDS events and progressive neurological deficit, it is necessary to consult a vertebrologist for prescription of conservative therapy aimed at relief of neurological symptoms. In case of failed conservative treatment, the first stage of surgical treatment is performed involving decompression or decompression and stabilization surgery on the spine; the second stage includes hip replacement.

With the prevalence of coxarthrosis symptoms (grade III) in patients with flexible spinal deformity and preservation of spine compensatory capacities, the first stage of surgical treatment should involve standard hip replacement with restoration of the anatomical rotation center, the length of the leg and offset.

For patients with coxarthrosis grade III and marked osteochondrosis symptoms with long existing fixed deformity of the spine, hip replacement with preservation of existing accustomed spinopelvic relationships is possible. For this purpose, in various types of frontal deformity of the spinopelvic complex, such types of operations as endoprosthesis insertion with cup implantation above the anatomical rotation center (up to 2.5 cm) and lengthening of the leg (up to 1.0 cm); in case of complete hip dislocation (Crow III–IV) – endoprosthesis implantation with femoral osteotomy and shortening are used.

In the case of competing diagnoses of the hip joint pathology and spine disease (coxarthrosis grade III in combination with DDS associated with neurological deficit), hip replacement with restoration of the anatomical rotation center, the length of the leg and offset is recommended at the first stage allowing to normalize the spatial position of the pelvis. Spinal surgery is advisable as the second stage treatment. When planning spine surgery, it is necessary to take into account the sagittal pelvic parameters (PI, SS, PT) achieved after hip replacement. Magnitude of lumbar lordosis and lower arc of lordosis are estimated using the following formulas: GLL = PI + 9°; GLL = 0.5 PI + 27°; GLL = SS + 15° (±1.2°) [3, 18, 21]. Decompression only can be performed when the patient's sagittal spinal parameters correspond to calculated magnitudes, segmental instability signs are absent; in case of sagittal imbalance, correction and spinal fixation are indicated [4].

Comparison of initial and mid-term follow-up radiographs of the spinopelvic complex in patients of the comparison group revealed significant differences in parameters PT ($p = 0.019$), PO and CA ($p < 0.001$). These data indicate the restoration of the frontal spinopelvic balance in majority of patients after total hip replacement (Fig. 4a, b).

Comparison of initial and mid-term follow-up radiographs in the study group showed significant ($p < 0.05$) differences in the frontal radiographic parameters PO, SO and CA. Comparison of sagittal spinal and pelvic parameters before and 9 months after hip replacement revealed significant differences in magnitudes of PL ($p < 0.001$), SS ($p = 0.006$), LA ($p = 0.006$), which indicates restoration of the spinal sagittal profile after hip replacement by means of reduced pelvic anteversion and lumbar lordosis (Fig. 4c, d).

Comparative results of two follow-up radiography studies of 20 patients are given in Table. The analysis of the presented data did not reveal significant ($p < 0.05$) intergroup differences in magnitudes of almost most spinal and pelvic parameters. The data show that frontal and sagittal spinopelvic relationships achieved after total hip replacement did not change significantly at follow-up examination in approximately 9 months after surgery.

Significant differences ($p < 0.05$) in magnitudes of pelvic parameters PT and PL show a gradual rotation of the pelvis backward around the bicoxofemoral axis, which may indicate continued compensation of the spinopelvic complex in the sagittal plane due to consequences of hip joint replacement. Meanwhile, an increase in PT with advancing age (increasing pelvic retroversion) is fully consistent with the known data on the mechanisms of compensation for age-related changes in the spinal column under quite constant gravity line location [3, 20].

Harris scores strongly demonstrated a significant improvement in parameters in the late postoperative period compared to Harris scores obtained prior to hip replacement and compared to the results of Harris scores observed in 9 months after surgery. The initial Harris scores were 52.0 [36.0; 56.0] and at control follow-up visit in 9 months after surgery the Harris score was 78.0 [67.0; 80.0] ($p < 0.001$), in the long-term postoperative period – 92.0 [85.0; 96.0] scores, being significantly higher than the mid-term and preoperative scores ($p < 0,001$). The proportion of patients with excellent results in study group was 69.0 % (20 patients) versus 53.8 %

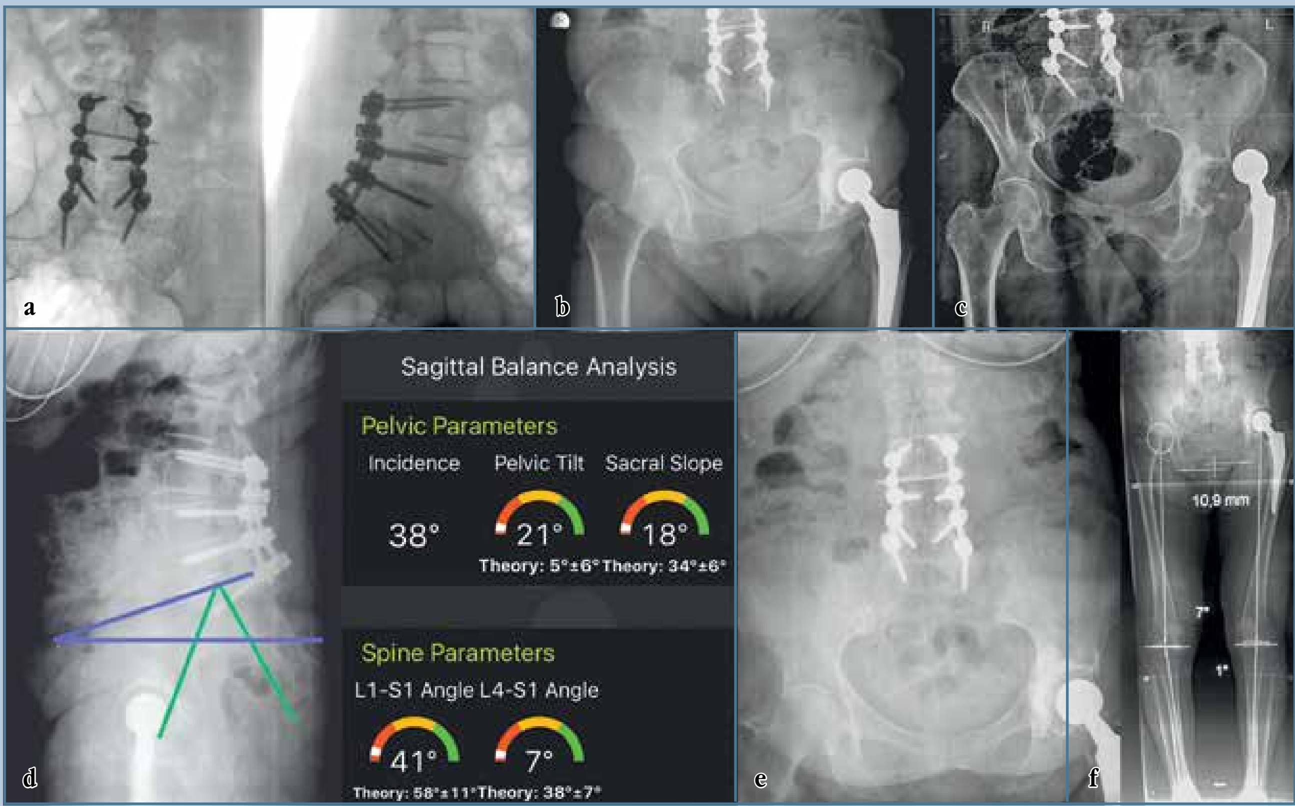

Fig. 3
Standing radiographs of the spine, pelvis and legs of the female patient P., 75 years: a – after spinal surgery; **b** – after the left hip replacement; **c** – endoprosthesis dislocation; **d** – sagittal imbalance and its analysis; **e** – frontal imbalance; **f** – different length of the legs and pelvic obliquity

in control group (14 patients; $p < 0.05$; Fig. 5).

Oswestry scores also showed a significant improvement in the quality of life of the patients under study over time. The preoperative initial Oswestry score was 40.0 % [34.0; 50.0], at control follow-up 61 months after surgery it was 11.0 % [0.0; 18.0]; $p < 0.001$. A comparative analysis of Oswestry scores assessing the achieved quality of life of patients in the long-term period after surgical treatment did not reveal significant differences between the compared samples.

The number of patients satisfied with the long-term surgical outcomes in the study group was 28 (96.6 %) people, in retrospective – 25 (96.1 %). Distribution of the patients in the compared samples by level of the achieved correction is as follows: in the prospective group, good results were in 26 (89.6 %) cases, satisfactory – in 2 (7.0 %), and unsatisfactory – in 1 (3.4 %). In the retrospective group, good results were achieved in 21 (80.8 %) cases, satisfactory – in 4 (15.4 %), and unsatisfactory – in 1 (3.8 %; Fig. 6).

Among patients of the compared groups, 19 patients (14 – study group, 5 – comparison group) had an improved parameters in the long-term period compared to the mid-term results. We link the positive dynamics in patient-reported assessment of outcomes to a gradual compensation of the biomechanical conditions changed after hip replacement and patient adaptation.

A decrease in satisfaction with achieved long-term outcome compared to mid-term result (3 patients: 2 – study group, 1 – comparison group) was associated with pain in the operated hip joint (1 patient from the prospective sample) and increased pain syndrome in the lumbar spine (one patient in each of the compared groups).

Case report 2. A female patient P., 76 years old, with HSS; the first stage of surgical treatment involved decompressive surgery (interlaminectomy facetectomy, discectomy, posterolateral spinal fusion at L3–L4, L5–S1 levels) for DDS, intervertebral disc hernias at L3–L4, L5–S1, progressive radiculopathy at L5, S1. The second stage in 3 years was the right hip replacement, and after 2 years – the left hip replacement (Fig. 7a). In addition, despite the retained compensatory capacities of the spine according to functional radiography, at control examination (Fig. 2c, d), implantation of the right acetabular component was shown to be performed 2.7 cm higher of the anatomical rotation center of the right hip joint. During the entire postoperative period, the patient compensated for the difference in the length of the legs using a corrective insole, which allowed preserving the frontal balance of the trunk (Fig. 7b).

An analysis of the sagittal profile at control follow-up 70 months after the right hip replacement indicated sagittal imbalance (Fig. 7c, d). Impaired sagittal spinopelvic relationships contributed to the development of extensive degenerative-dystrophic changes in the intervertebral discs of the four lower lumbar segments accompanied by pain.

Conclusion

The inter-group analysis of the parameters characterizing self-reported satisfaction with the achieved outcomes of treatment as well as scores of the Harris questionnaire in patients with hip-spine syndrome in the long-term period after hip replacement show a significant prevalence of good long-term outcomes in HSS patients using the developed algorithm of rational surgical tactics and confirm its effectiveness.

A comparative analysis of the mid-term and long-term surgical outcomes in patients has shown that best results dominate in 61 months after surgery, which indicates a gradual adaptation of patients to the biomechanical conditions created after hip replacement.

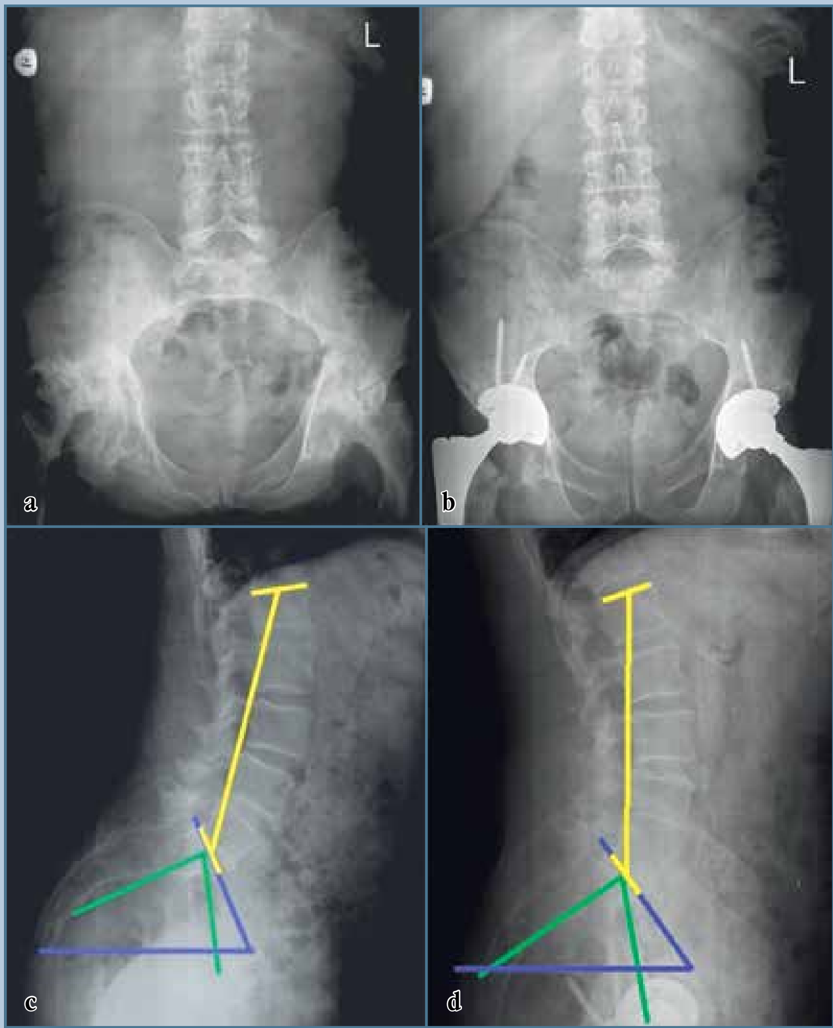

Fig. 4
Standing radiographs of spinopelvic complex of the patient D., 56 years: **a, b** – before hip replacement; **c, d** – in 9 months after hip replacement

Table

The results of radiographic examination of the spinopelvic complex in patients with hip-spine syndrome after hip replacement, degrees

Parameters	In 9 months (n = 18)	In 61 months (n = 18)	Difference significance
Pelvic			
Pelvic incidence	52.0 [48.0; 55.0]	53.0 [49.0; 55.0]	$p > 0.05$
Sacral slope	40.5 [38.0; 42.0]	37.0 [33.0; 42.0]	$p > 0.05$
Pelvic tilt	10.0 [8.0; 18.0]	18.0 [10.0; 29.0]	$p = 0.004$
Pelvic slope	16.5 [10.0; 20.0]	32.0 [23.0; 39.0]	$p < 0.001$
Pelvic obliquity	0.0 [0.0; 1.0]	2.5 [2.0; 3.0]	$p = 0.001$
Sacral obliquity	1.0 [0.0; 2.0]	2.0 [1.0; 3.0]	$p > 0.05$
Spinal			
Lumbar lordosis	48.5 [45.0; 56.0]	55.5 [49.0; 62.0]	$p > 0.05$
Lower arc of lordosis	36.5 [31.0; 41.0]	37.5 [34.0; 42.0]	$p > 0.05$
Scoliotic deformity	2.0 [0.0; 6.6]	2.0 [2.0; 3.0]	$p > 0.05$

Me [Q25; Q75 %]; n — number of patients who underwent control radiographic examination in 9 and 61 months after hip replacement.

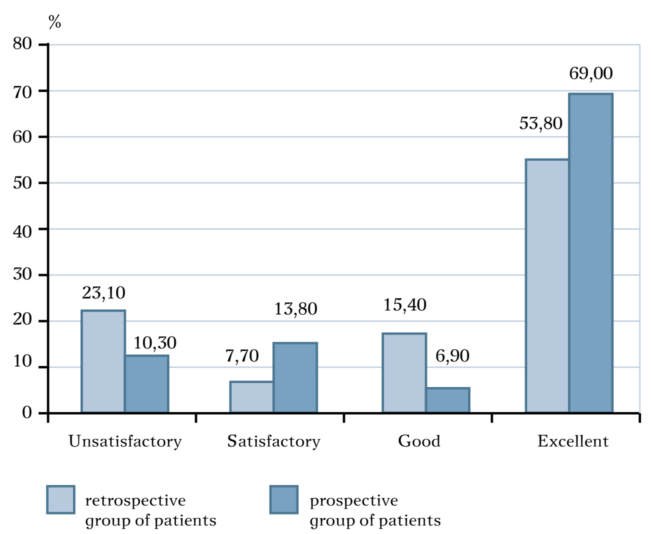

Fig. 5
Qualitative assessment of the long-term surgical outcomes in the patients in 61 months after hip replacement according to the Harris score

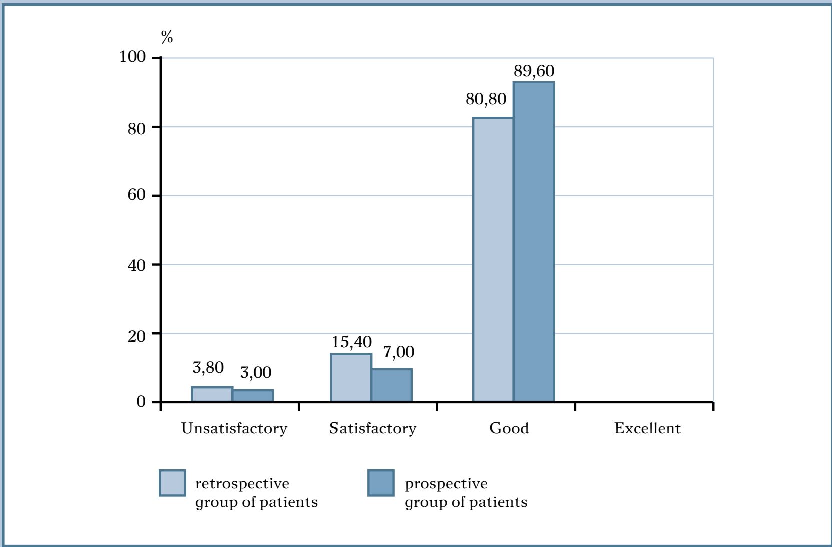

Fig. 6
Qualitative complex assessment of surgical outcomes in the patients in 61 months after hip replacement

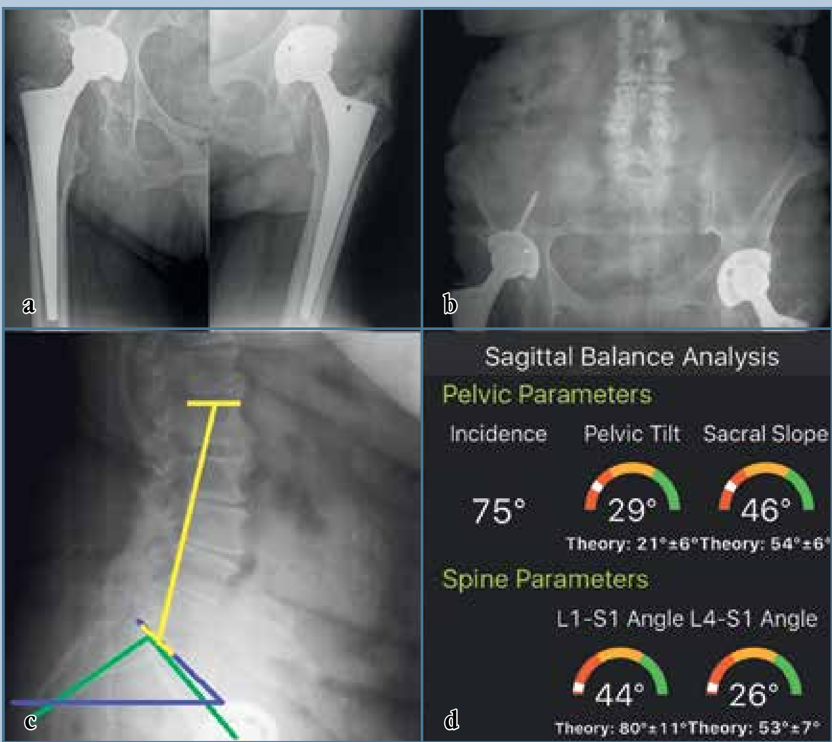

Fig. 7
Standing radiographs of the spine and pelvis of the patient P., 76 years in 70 months after surgery: **a** – hip joints; **b, c** – spinopelvic complex (frontal balance and sagittal imbalance); **d** – estimation of sagittal parameters

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