COMPARISON OF RADIOLOGICAL AND OPTICAL METHODS FOR ASSESSING THE SPINO-PELVIC RELATIONSHIPS IN PATIENTS WITH CONGENITAL HIP DISLOCATION

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Objective. To determine the correlation between the data of sagittal radiography of the spine and computer optical topography (COMOT) results.

Material and Methods. The study included 47 patients (5 men, 42 women) who underwent the treatment for hip dysplasia in 2010–2018. The patients were divided into two groups: Group I included 26 patients with unilateral congenital hip dislocation, and Group II – 21 patients with bilateral dislocation. All patients underwent hip replacement with corrective osteotomy.

Results. An average value of the sacral slope was 46.4° ± 9.9°, which reflects the excessive sacral slope and exceeds the norm (39.6° ± 7.9°) by 10° in cases of maximum values. Global lumbar lordosis has an average value of 64.1° ± 13.5° and directly depends on the sacral slope. The COMOT parameters showed that physiological curves were less pronounced in patients of Group I (the height of the lumbar lordosis (HIL), 2.4 ± 0,7 sm, the height of the thoracic kyphosis (HIK), 2.7 ± 0.6 sm) than in patients of Group II (HIL, 3.0 ± 0.5 sm, HIK, 3.2 ± 0.5 sm). In Group II, there was an excessive inclination of the sacrum anteriorly (-33.9° ± 4.5°). In both groups, anterior torso inclination was observed, with greater statistical differences in Group I than in Group II: in Group I, the anterior inclination was -3.5° ± 3.6°, in Group II, -0.4° ± 2.7°.

Conclusion. The average correlation was found only between the parameters of the sacral slope and the integral index of the posture state in the sagittal plane (r = 0.513); in all other cases, only a moderate correlation was found.

Key Words: spino-pelvic balance, congenital dislocation of the hip, hip dysplasia, computer optical topography.

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Human and animal movements are described using a general concept of the "biomechanical system" that refers to a systemic set of the musculoskeletal system, energy-supplying systems, and components of the nervous system, which enable motor activities [1]. This system is constantly changing. Any movement activates certain resources depending on the task: leisurely walking or saving lives in a life-threatening situation.

The system is based on a biokinematic pair consisting of two adjacent body parts connected by a joint. Biokinematic pairs combined into successive interconnected units (links) form biokinematic chains that are classified into simple (finger) and branched (hand) as well as open (arm) and closed (hip joint) [1, 2].

In open chains, there is a free (end) link that is involved only in one pair. In closed biokinematic chains, there is no free (end) link. They provide a simple and effective mechanism with several applications and are increasingly being evaluated in animals, including humans. Each link of closed biokinematic chains is a part of each of two pairs, so, the motion involves other junctions (joints) [3].

When the hip joint has normal anatomy and function, the movements of biokinematic pair involved in the closed chain and of the hip joint itself are surely transmitted to the knee joint and to the lumbar spine. Considering the hip joint as a biokinematic pair in a closed biokinematic chain (lumbar spine – hip joint – knee joint), we suggest that it affects the upper and lower joints, and its pathology is associated with changes in the anatomorphological relationships [4, 5].

A break of the biokinematic pair (congenital hip dislocation) leads to structural and functional changes. A classic example is occult knee valgus associated with congenital hip dislocation, which is a break of the biokinematic pair in the hip joint, leading to pathology in a lower pair – the knee joint. If this situation has developed in a distal kinematic pair, pathological changes in the opposite direction, in proximal biokinematic pairs, may be suggested.

We found confirmation of this suggestion in an article by Morimoto et al. [6] devoted to the development of rapid destructive coxarthrosis in Japanese females, which describes changes in the lumbar spine in the form of kyphosis and, as a consequence, pelvis retroversion and anterior displacement of the femoral heads. According to the authors, this leads to reduced coverage of the femoral heads, decreased contact area, and increased stress on the heads, which, in the setting of osteoporosis, causes destruction of the femoral heads and requires hip replacement. This example illustrates the effect of pathological processes in a single kinematic pair on the development of pathology in other linked biokinematic pairs. These effects were the main impetus for conducting this study.

The study objective was to establish a correlation between sagittal spinal radiographic findings and computed optical topography (COMOT) data.

Material and Methods

The study involved 47 patients (5 males and 42 females) who were treated for hip dysplasia (Crowe IV) at the Novosibirsk Research Institute of Traumatology and Orthopaedics n.a. Ya.L. Tsivyan in 2010–2018. The mean age of patients was 42.4 ± 12.6 years.

The patients were divided into two groups: Group I included patients with unilateral congenital hip dislocation (n = 26); Group II consisted of patients with bilateral hip dislocation (n = 21). All patients underwent hip replacement and corrective osteotomy [7]. In Group II, only 17 patients underwent bilateral hip replacement; 4 patients refused contralateral arthroplasty after the 1st stage. Thus, 64 hip replacements were performed in 47 patients.

Radiological examination of patients was performed using Baccara-90/20 and Tur-1500 X-ray machines; image digitization and subsequent data analysis were performed using the K-PACS software.

Spine teleradiography was performed in the step mode, with the patient being in the upright position: the lower extremities and pelvis were examined in an anteroposterior view; the spine, from C1 to S1, with capture of the hip joints was studied in anteroposterior and lateral views. The examination was performed before and at day 5–7 after surgery. During outpatient follow-up, control X-ray was performed at week 24–48 after arthroplasty.

The following parameters were evaluated using spine radiographs:

1) global lumbar lordosis (GLL) – the Cobb angle between the L1 superior surface and the S1 superior surface;

2) pelvic inclination (PI) – the angle between a plumb-line drawn from the S1 cranial endplate center and a line drawn from this point to the center of the femoral heads;

3) sacral slope (SS) – the angle between the horizontal plane and the superior sacral surface;

4) pelvic tilt (PT) – the angle between a plumb-line and a line connecting the center of the superior sacral surface to the center of the femoral heads;

5) sagittal vertical axis (SVA) – the distance between a plumb-line drawn through the C7 body center and a parallel line drawn through the posterosuperior corner of the S1 cranial endplate (anterior or posterior deviation of the plumb-line is denoted by the plus or minus sign, respectively);

6) HA – the distance from SVA to a plumb-line drawn through the center of the femoral heads distance; anterior deviation of SVA from HA is denoted by the plus sign and is regarded as decompensation; posterior deviation is denoted by the minus sign (the norm).

The measured parameters (1–6) are schematically presented in Fig. 1.

The second examination method was COMOT performed on a 2nd generation TODP system, with the patient being in the orthostatic position. The examination was performed before and 24–48 weeks after surgery. The posterior trunk surface was assessed based on the following parameters:

1) FH, FP, and FT – shoulder girdle inclination, pelvic obliquity, and trunk inclination in the frontal plane, respectively;

2) GH, GP, and GT – shoulder girdle rotation, pelvis rotation, and shoulder girdle rotation relative to the pelvis in the horizontal plane, respectively;

3) SK, SN, ST, and SA1 – anterior/posterior inclination of the thoracic kyphosis apex, C7 point, trunk, and sacrum, respectively;

4) HIL and HIK – height of the lumbar lordosis and thoracic kyphosis curve, respectively;

5) MD – maximum lateral deviation of the spinous process line;

6) FDSC, FDC7, SDSC, and SDC7 – lateral deviation and anterior/posterior deviation of the SC point (apex of the intergluteal cleft) and C7 point relative to a point in the middle of the heel line;

7) LNG – the trunk length from the SC point (apex of the intergluteal cleft) to the C7 point;

8) RWL – the trunk width to length ratio;

9) PTI, PTI_F, PTI_G, and PTI_S – the general integral index for the postural status and integral indices for individual planes (frontal, horizontal, and sagittal); plus and minus signs denote the direction of deviation (plus: the right shoulder is higher, turned posteriorly, or the trunk is deviated posteriorly).

Correlations were analyzed using the Spearman method due to a small sample size. The degree of correlation was characterized using the following correlation coefficient (r) intervals: strong or close correlation, $r > 0.70$; medium correlation, $0.50 < r < 0.69$; moderate correlation, $0.30 < r < 0.49$; weak correlation, $0.20 < r < 0.29$; very weak correlation, $r < 0.19$. the correlation was considered significant at r with a statistical significance level of $p \leqslant 0.05$.

The IBM SPSS 21 software was used for statistical analysis.

Results and Discussion

The mean values of baseline parameters obtained from a study of the spinopelvic relationships in both subgroups are given in Table 1.

In Group I, radiological examinations were performed before surgery, in the early postoperative period, and 24–48 weeks after surgery (Table 2).

Patients with bilateral hip dysplasia (Crowe IV) underwent additional X-ray of the spine before and after the 2nd stage of surgical treatment (Table 3).

COMOT-based examinations were performed only before and 24–48 weeks after surgery (Table 4).

Before hip replacement in congenital hip dislocation, decoupling of hip joint bones leads to breaks of the biokinematic pair and closed biokinematic chains. Displacement of the hip center of rotation occurs as the femoral heads (in the case of unilateral dislocation – a femoral head) take an abnormal position and are supported by altered synovial tissues and gluteal muscles. This inevitably leads to displacement of the pelvic support point and gravity center, which is accompanied by compensatory changes. Investigation of these changes demonstrates that the mean SS is 46.4° ± 9.9°, which reflects an excessive sacral slope and exceeds the normal value (39.6° ± 7.9°) by 10° in cases of the greatest excess. The mean GLL is 64.1° ± 13.5° and directly depends on SS (GLL = SS + 25°), which is reflected in lumbar spine hyperlordosis. There is a close correlation between them (r = 0.787). The compensatory mechanisms cause pelvic anteversion accompanied by a PT shift to negative values (PT = -23.9° ± 35.0°), with a weak negative correlation between SS and PT (r = -0.22).

A comparative analysis of the data obtained in two groups reveals certain patterns. Patients of Groups I and II, as mentioned above, are prone to hyperlordosis, which is seen from large GLL values; the mean GLL is 61.0° ± 11.6° in Group I and 68.1° ± 14.9° in Group II. The SS values obtained in Group I (44.7° ± 7.7°) and Group II (48.6° ± 12.0°) correspond to the upper limits of the normal value. Pelvic anteversion (PT) reveals an excessive pelvic inclination (-2.7° ± 22.4°) in both Group I and Group II (-46.6° ± 31.9°). in this case, the number of negative PT cases is higher in Group II. There is a weak correlation between PI and SS (r = 0.11) and PI and GLL (r = 0.20). The PI angle decreases due to displacement of the femoral heads upwards and posteriorly; its mean value in Group I is 40.1° ± 22.7°; in Group II, the mean PI decreases to negative values (-9.5° ± 20.4°). There is a strong correlation between PI and PT landmarks (r = 0.73), which is explained by rigorous drawing of angles to the femoral head centers. In addition to this, the sagittal balance is equilibrated due to SVA displacement in different directions, from the sacral promontory (0 mm) within 79 mm along the vector (from 49 mm anteriorly to -79 mm posteriorly). In 6 patients, the SVA line ran posteriorly to the sacral promontory (from -13 to -79 mm); the femoral heads axis (HA) approached the SVA line, which indicated a compensated sagittal spinopelvic balance. In the remaining 42 patients, the SVA line occurred at the sacral promontory level or anteriorly from it, with the maximum displacement being 49 mm, HA was posteriorly from the SVA line, which meant decompensation of the sagittal spinopelvic balance. Accordingly, the patient's body occurred in a functionally unfavorable position. A medium negative correlation (r = -0.573) was found between HA and SVA as well as between SVA and GLL (r = -0.543). This is explained by a small group size. In the case of a large sample, this relationship should be stronger. In the early postoperative period after hip replacement in Group I (Tables 2 and 3), there was an imbalance in the spinopelvic relationships, which was characterized by displacement of the SVA line both anteriorly and posteriorly, with an increase in the distance from SVA to the sacral promontory (19.8 ± 28.3 mm). If we take the sacral promontory as 0, there is an even greater displacement of the SVA line anteriorly from the interfemoral head axis HA (-8.8 ± 36.6 mm). There was an increase in the PI angle (in this situation, we may talk about its recovery), which is natural because pelvic rotation shifted to the true acetabular region. There were no changes in GLL and SS parameters in the early postoperative period. An analysis of the values obtained from sagittal radiographs reveals the same manifestations in Group II despite prolonged surgical pauses between interventions.

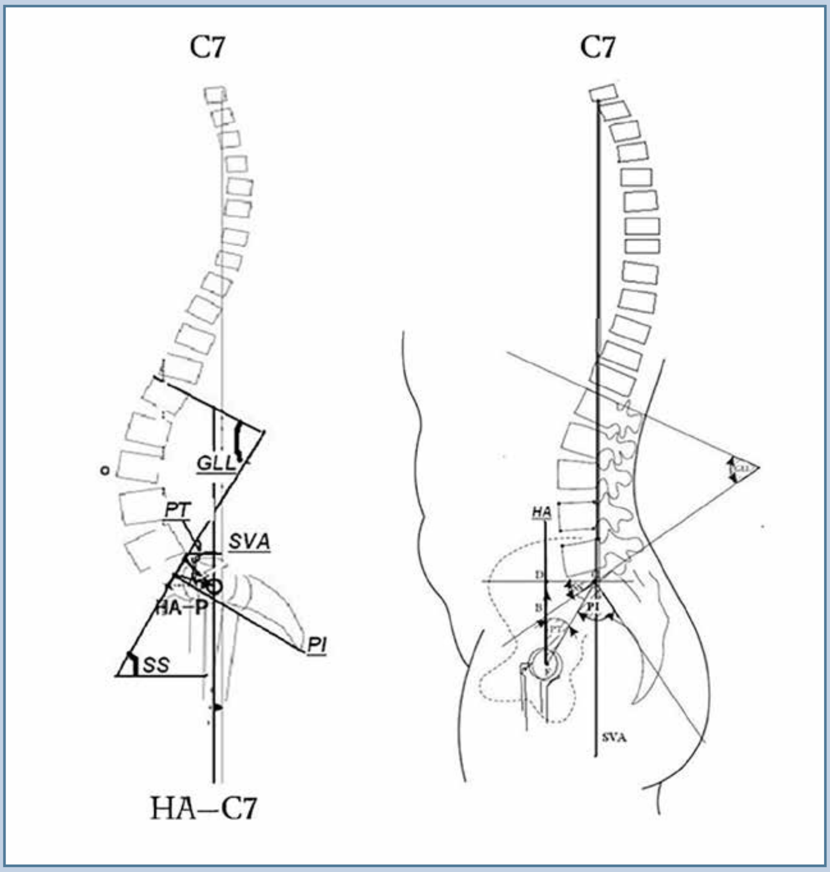

Fig. 1
A schematic of the sagittal spinopelvic balance angles (see description in the text)

In the early postoperative period after the first surgery, the distance from SVA to the sacral promontory in Group I was 66.1 ± 77.7 mm, and the mean HA was 52.6 ± 56.8 mm. These parameters were much smaller than those in Group II. This was probably associated with the need to rest upon the operated elongated lower extremity because the contralateral lower extremity was relatively shorter and did not act as support. Comparison of surgery in Group I and the 1st stage of surgery in Group II reveals more pronounced signs of decompensation in the latter case. This may be associated with the fact that the unaffected lower extremity in Group I acted as adequate support. Before the 2nd surgical stage in Group II, signs of decompensation of the spinopelvic relationships decreased (-20.2 ± 40.8 mm) and approached the preoperative values (-24.1 ± 40.3 mm). After the 2nd stage, decompensation increased again during the first week. In this case, the mean distance from SVA to the sacral promontory and HA was 42.9 ± 32.6 mm and 53.2 ± 53.0 mm, respectively. Therefore, the 2nd surgical stage was as effective as the 1st stage.

After 24–48 weeks, both groups developed improvement in the spinopelvic relationships due to displacement of the interfemoral head axis anterior to the SVA line (HA = 22.4 ± 37.8 mm and 24.8 ± 33.9 mm in Group I and Group II, respectively); in this case, HA values in both groups were stabilized due to approach of SVA to the sacral promontory: 0.1 ± 31.8 mm in Group I and -3.4 ± 23.1 mm in Group II. These changes result from a decrease in SS in both groups: 40.8° ± 11.1° in Group I and 39.0° ± 10.9° in Group II. It is worth noting an increase in the PT angle (6.5° ± 3.4°) in Group II. In both groups, the lumbar lordosis value decreased: 56.6° ± 12.3° in Group I and 55.2° ± 7.3° in Group II.

An analysis of the COMOT parameters for the posterior trunk surface before and after surgery revealed that the preoperative physiological curves in Group

Table 1

Baseline parameters of the sagittal spinopelvic balance in patients with hip dysplasia (Crowe IV)

Parameter	Mean value	Group I	Group II
Sacral slope, deg.	46.4 ± 9.9	45.0 ± 8.3	51.5 ± 9.2
Pelvic inclination, deg.	25.8 ± 26.3	38.4 ± 15.8	12.9 ± 17.7
Pelvic tilt, deg.	-23.9 ± 35.0	-5.5 ± 21.8	41.5 ± 25.8
Distance from the sagittal vertical axis to the interfemoral head axis, mm	-6.5 ± 41.0	6.3 ± 35.2	-14.2 ± 41.3
Distance from the sagittal vertical axis to the sacral promontory, mm	-14.1 ± 32.1	2.7 ± 17.2	-16.5 ± 37.2
Global lumbar lordosis, deg.	64.1 ± 13.5	66.8 ± 7.8	71.3 ± 13.0

Table 2

Parameters of the spinopelvic relationships in Group I

Parameter	Before surgery	1 week after surgery	24–48 weeks after surgery
Sacral slope, deg.	45.0 ± 8.3	46.5 ± 8.9	40.8 ± 11.1
Pelvic inclination, deg.	38.4 ± 15.8	46.8 ± 8.3	45.8 ± 7.0
Pelvic tilt, deg.	-5.5 ± 21.8	5.2 ± 9.8	5.8 ± 3.1
Distance from the sagittal vertical axis to the interfemoral head axis, mm	6.3 ± 35.2	-8.8 ± 36.6	22.4 ± 37.8
Sagittal vertical axis, mm	2.7 ± 17.2	19.8 ± 28.3	0.1 ± 31.8
Global lumbar lordosis, deg.	66.8 ± 7.8	65.2 ± 16.5	56.6 ± 12.3

Table 3

Parameters of the spinopelvic relationships in Group II

Параметры	Before surgery	1 week after surgery	Before the 2nd stage	1 week after the 2nd stage	24–48 weeks after surgery
Sacral slope, deg.	51.5 ± 9.2	57.4 ± 11.9	50.9 ± 8.7	56.6 ± 11.8	39.0 ± 10.9
Pelvic inclination, deg.	12.9 ± 17.7	33.9 ± 14.2	16.7 ± 17.5	35.2 ± 14.2	37.0 ± 10.3
Pelvic tilt, deg.	41.5 ± 25.8	-3.5 ± 32.8	-38.1 ± 24.7	-1.4 ± 31.2	6.5 ± 3.4
Distance from the sagittal vertical axis to the interfemoral head axis, mm	-14.2 ± 41.3	-66.1 ± 77.7	-20.2 ± 40.8	-53.2 ± 53.0	24.8 ± 33.9
Sagittal vertical axis, mm	-16.5 ± 37.2	52.6 ± 56.8	-7.5 ± 34.9	42.9 ± 32.6	-3.4 ± 23.1
Global lumbar lordosis, deg.	71.3 ± 13.0	69.6 ± 12.4	70.2 ± 12.4	68.9 ± 12.7	55.2 ± 7.3

Table 4
COMOT parameters of the posterior trunk surface before and after surgery (mean ± SD)

Parameter	Before surgery		24–48 weeks after surgery	
	Group I	Group II	Group I	Group II
Shoulder girdle inclination in the frontal plane, deg.	-1.8 ± 2.6	0.9 ± 1.8	-0.9 ± 2.1	-0.1 ± 2.4
Pelvic obliquity in the frontal plane, deg.	5.9 ± 4.4	1.0 ± 1.9	3.2 ± 9.4	-5.1 ± 10.5
Frontal trunk inclination, deg.	0.0 ± 2.2	0.4 ± 2.0	0.6 ± 1.8	0.9 ± 2.9
Shoulder girdle rotation in the horizontal plane, deg.	1.7 ± 4.7	3.2 ± 2.6	0.7 ± 3.7	-0.4 ± 3.4
Pelvic rotation in the horizontal plane, deg.	3.5 ± 7.4	3.5 ± 6.1	2.5 ± 8.3	-3.3 ± 3.6
Trunk twist in the horizontal plane, deg.	-1.8 ± 3.6	-0.2 ± 5.0	-1.8 ± 2.7	2.6 ± 6.3
Anterior/posterior inclination of the thoracic kyphosis apex relative to the intergluteal cleft, deg.	-4.4 ± 3.7	-1.4 ± 3.5	-4.1 ± 3.8	-5.8 ± 6.3
Anterior/posterior inclination of the C7 point relative to the lumbar lordosis apex, deg.	-2.6 ± 4.0	0.6 ± 2.1	-2.3 ± 3.8	-4.2 ± 4.7
Anterior/posterior sagittal trunk inclination, deg.	-3.5 ± 3.6	-0.4 ± 2.7	-3.2 ± 3.7	-5.0 ± 5.3
Anterior/posterior sagittal sacral inclination relative to the plumb-line, deg.	-33.2 ± 10.0	-33.9 ± 4.5	-33.0 ± 8.3	-31.8 ± 6.8
Height of lumbar lordosis, cm	2.4 ± 0.7	3.0 ± 0.5	2.5 ± 0.6	2.8 ± 0.4
Height of thoracic kyphosis, cm	2.7 ± 0.6	3.2 ± 0.5	2.8 ± 0.7	3.0 ± 0.7
Maximum lateral deviation of the spinous process line, mm	-9.5 ± 10.9	-0.7 ± 5.6	-4.6 ± 9.9	5.9 ± 13.3
Lateral pelvic tilt, mm	12.6 ± 28.0	-14.4 ± 16.0	9.3 ± 18.6	-10.0 ± 14.2
Lateral C7 tilt, mm	12.4 ± 31.0	-17.0 ± 15.0	7.4 ± 23.1	-15.3 ± 16.2
Anterior/posterior tilt of the intergluteal cleft apex, mm	62.7 ± 24.0	33.5 ± 23.5	35.9 ± 28.3	27.4 ± 16.8
Anterior/posterior C7 tilt, mm	-7.3 ± 2.0	-10.4 ± 2.4	-7.8 ± 3.2	-13.6 ± 16.4
Trunk length, mm	511.0 ± 33.0	452.5 ± 17.0	523.0 ± 39.3	489.0 ± 15.6
Trunk width to its length ratio, %	60.7 ± 6.3	65.1 ± 3.9	60.9 ± 6.8	62.3 ± 4.2
General integral postural status index	2.1 ± 0.5	1.5 ± 0.5	2.2 ± 0.4	2.0 ± 1.0
Integral index of the frontal postural status	2.4 ± 1.1	1.0 ± 0.6	2.1 ± 1.2	2.2 ± 1.5
Integral index of the horizontal postural status	1.8 ± 0.7	1.6 ± 0.6	1.6 ± 0.7	1.9 ± 1.0
Integral index of the sagittal postural status	1.6 ± 0.6	1.7 ± 0.4	1.6 ± 0.6	1.9 ± 0.5

I were less pronounced (HIL = 2.4 ± 0.7 cm, HIK = 2.7 ± 0.6 cm) than those in Group II with congenital hip dislocation (HIL = 3.0 ± 0.5 cm, HIK = 3.2 ± 0.5 cm). In this case, there was an excessive anterior sacral slope SA1 (-33.9° ± 4.5°), which exceeded the normal value by more than 15°. In both groups, there was anterior trunk tilt (ST), with statistical differences being greater in Group I than in Group II. The anterior inclination was −3.5° ± 3.6° in Group I and -0.4° ± 2.7° in Group II.

An analysis of the postural status index in the frontal plane demonstrated a larger PTI_F (2.4 ± 1.1) in Group I; in Group II, the index was 1.0 ± 0.6, mainly due to pelvic obliquity towards dislocation. The frontal trunk balance (FT) was not disturbed in both groups: it was 0.0° ± 2.2° in Group I and 0.4° ± 2.0° in Group II. In our opinion, this circumstance is due to the fact that shortening of the extremity in Group I was compensated by the lumbar countercurve and lateral deviation of the spinal axis towards the obliquity side (MD) -9.5 ± 10.9 mm, as well as by the shoulder girdle inclination (FH) -1.8° ± 2.6° to the opposite direction. In addition, patients of Group I had a pelvic displacement (FDSC) of 12.6 ± 28.0 mm and a C7 spinous process displacement of 12.4 ± 31.0 mm in the opposite direction. In Group II, FDSC was -14 ± 16.0 mm, and FDC7 was -17.0 ± 15.0 mm.

An analysis of the horizontal trunk balance revealed a slight increase in GT in Group I (by −1.8° ± 3.6°) and a minimum deviation in Group II (by -0.2° ± 5.0°), but these anomalies were statistically insignificant.

An analysis of the sagittal trunk balance revealed displacement of the pelvis posterior to the feet (SDSC). The mean displacement was 62.7 ± 24.0 mm in Group I and 33.5 ± 23.5 mm in Group II; these differences were significant. The SDC7 displacement anterior to the feet was -7.3 ± 2.0 mm in Group I and -10.4 ± 2.4 mm in Group II. There was also an increase in the sagittal lumbar lordosis and thoracic kyphosis. HIL was 2.4 ± 0.7 cm in Group I and 3.0 ± 0.5 cm in Group II; HIK amounted to 2.7 ± 0.6 cm in Group I and 3.2 ± 0.5 cm in Group II. The trunk in patients of Group II was also found to be wider (65.1 ± 3.9 %) and shorter (452.5 ± 17.0 mm) than that in patients of Group I: 60.7 ± 6.3 % and 511.0 ± 33.0 mm, respectively.

A follow-up examination after 24–48 weeks revealed no pronounced changes; in Group II, there was smoothing of the spinal curvatures (HIL = 2.8 ± 0.4 cm, HIK = 3.0 ± 0.7 cm) and a decrease in the sacral slope SA1 (-31.8° ± 6.8°). The integral index of frontal postural status (2.4 ± 1.1) in Group I improved due to a decrease in the pelvic inclination towards dislocation (2.1 ± 1.2); in this case, there was unilateral pelvic obliquity in Group II (PTI_F = 2.2 ± 1.5). In the postoperative period, the mean trunk lengthening due to flattening of the spinal curves was 12 mm in Group I and 27 mm in Group II.

Conclusion

Comparison of the two examination methods (sagittal spinal X-ray and COMOT of the posterior trunk surface) revealed a medium correlation only between SS and PTI_S (r = 0.513); in the other cases a moderate correlation was found, which may be associated with a small sample size. Of particular interest is a moderate correlation between PI and C7 inclination (r = -0.385), trunk inclination (r = -0.306), anterior sacral slope (r = 0.352), and sagittal lordosis (r = -0.399); the general integral postural status index correlates with the sacral slope (r = 0.304). Changes in the PI angle are reflected in the specific features of postural balance in patients with dysplasia (Crowe IV) and demonstrate the importance of compulsory restoration of the rotation center with placement of a pelvic component into the rudimentary (teepee-view) acetabulum for restoring balanced spinopelvic relationships.

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