Clinical and radiographic dependences of functional status, indices of the hip joint and femur migration in patients with cerebral palsy

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Abstract: Relevance. Significant incidence of hip pathology in different groups of patients with cerebral palsy and factors that may affect its formation are relevant objects of the study.

The goal of the study. To establish the features of the hip joint’s formation, examining the clinical and radiographic dependences of the functional status and indices of the hip joint in patients with cerebral palsy.

Materials and methods. The total number of patients was 47 persons (86 joints). We conducted a clinical and radiographic examination of the hip joints using our own methods and standard anterior-posterior radiography, as well as a statistical analysis of hip parameters and factors that may have influenced their formation.

Results. Correlation relationships have been established between hip parameters and factors that may affect them: Gross Motor Function Classification System (GMFCS), gait function, level of lesion, developmental dysplasia of the hip, and adductor myotomy in medical history.

Conclusions. The Reimers’ index showed greater reliability compared to the Wiberg angle. Positioning of the patient’s body using our own method way can be used to screen the hip joints in cerebral palsy based upon the Reimers index while obtaining the true parameters of the femoral neck–shaft angle and torsion of the femur.

Keywords: cerebral palsy, hip joint, radiogrammetrical indices, Reimers’ index, Wiberg angle.

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1. Introduction

Pediatric orthopedists pay special attention to the determination of instability in the hip joint (HJ) in patients with cerebral palsy (CP). Its timely detection is the basis of many screening systems, as HJ plays an important role in the biomechanics of the lower extremity. Ambulation function and static-motor function in patients with cerebral palsy affects the formation of HJ. In addition to bone morphology, there are other factors that affect the quality of gait, so they should be considered before therapeutic decisions [1]. Imbalance of muscle activity, as well as bone and joint pathology leads to decentralization of the femoral head and the progression of instability in the HJ.

The mentioned above features encourage researchers to look for factors underlying the pathogenesis of spastic femoral head (FH) dislocation to detect pathological changes in HJ among patients with cerebral palsy in a timely manner to move from conservative to surgical treatment.

Modern radiological systems for HJ screening in patients with cerebral palsy are focused on ascertaining the fact of spastic dislocation and the dynamics of instability and do not yield researchers the precise parameters of this joint. Accurate parameters of the HJ make it possible to select patients, assess the quality of surgery and are the key to successful surgical interventions aimed at stabilizing the hip joint in cerebral palsy [2]. We have developed our own method for determining the clinical and radiographic parameters of HJ [3], that has been used in the examination of patients with cerebral palsy.

The obtained true parameters of the HJ prompted us to a more detailed study of the dependencies that may have an impact on the formation of instability in this joint referring to age norms.

The goal of the study is to establish the features of the formation of the hip joint, examining the clinical and radiographic dependences of the functional status and indices of the hip joint in patients with cerebral palsy.

2. Materials and Methods

Our research is based upon the study of clinical cases of 47 patients (86 joints) with pathology of the hip joints in cerebral palsy who have been treated in the Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine during 2018-2020. The gender of the patient was not taken into account, as previous studies did not report significant differences between the sexes [4]. No patient had a history of bone surgery. We investigated various factors that may influence the formation of parameters responsible for the relationship between the proximal femur and the acetabulum, the Wiberg angle (WA) and the Reimers index (RI). Age, Gross Motor Function Classification System (GMFCS) [5], level of lesions (paraparesis, tetraparesis, hemiparesis), ambulatory status (ambulating, non-ambulating), adductor myotomy (AM) and developmental dysplasia of the hip(DDH) in the medical history were taken into account. We also looked for the dependences of the influence of the proximal femur (PF) pathology (neck-shaft angle (NSA), femoral torsion (FT), acetabular angle (AA) and Sharp's angle (SA)) upon WA and RI. The age of patients ranged between 3 and 30 years: up to 4 years (5 patients), 4-6 years (10 patients), 7-9 years (10 patients), 10-12 years (8 patients), 13-16 years (13 patients), 30 years (1 patient). According to the GMFCS II level was observed in 11 patients, III level in 16 patients, IV level in 12 patients. The sample in this study consisted mainly of patients with spastic tetraparesis (30 patients), spastic paraparesis (9 patients) and hemiparesis (8 patients). Each hip joint was evaluated separately, in patients with hemiparesis only the affected side was taken into account. 33 of our patients were ambulating, and 14 patients were non-ambulating at the moment of the examination, but we considered them promising in terms of verticalization, or gait function was lost due to spastic hip dislocation. AM was performed in 8 patients. Hip radiographs (performed at the age 3 months) were preserved in 15 patients: 8 patients were diagnosed with DDH, 7 patients were born with healthy hips. Data on whether DDH was treated before the age 1 year were not taken into account due to their absence.

In order to avoid exposure of healthy children, the normal indices were taken from Kutsenok Ya.B. (Table 1) [6]. The Reimers index up to 33% was considered as a stable joint, subluxation (more than 33%) as a pathology.

Table 1: normal indices of the hip joint referring to age according to Kutsenok Ya.B.

Age (years)	Up to 4	4-6	7-9	10-12	13-16
Acetabular angle	17.2 +/- 0.45	17.3 +/- 0.27	16.45+/- 0.47	14.23 +/- 0.76	------
Sharp's angle	46.88 +/- 0.61	45.76 +/- 0.31	44.79 +/- 0.81	47.51 +/- 0.43	49.31 +/- 0.57
NSA	137.16 +/- 1.52	134.96+/- 0.86	132.54 +/- 0.98	131.23 +/- 1.09	128.61 +/- 1.98
Torsion of femur	37.6 +/- 1.44	36.67 +/- 0.98	33.23 +/- 1.53	27,11 +/- 2.09	19.86 +/- 1.37
Wiberg angle	25.61 +/- 1.43	27.12 +/- 0.74	29.91 +/- 0.82	33.35 +/- 0.88	37.92 +/- 0.72

All patients underwent: clinical evaluation of FT by Ruwe [7]; standard anterior-posterior radiography of the HJ (standard positioning (SP)); posterior-anterior radiography of the HJ using positioning according to our own method (PATOOM) (Fig. 1a, b), where the true parameters were obtained [1]. The absence of significant differences in the acetabular parameters (p>0.05) between the two positionings, as well as the high accuracy of measurement of FT and NSA using our original method compared to intraoperative data, were described by us in previous works [8].

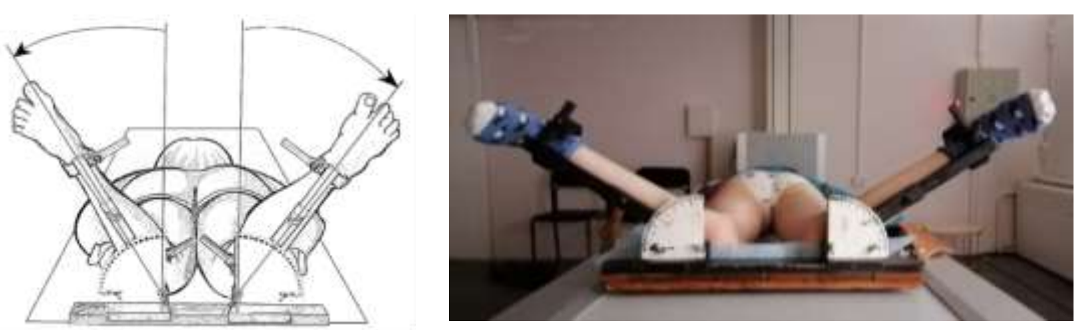

Fig. 1 Method for determining clinical and radiological parameters of the hip joint in patients with pathology of the latter [9] (patient's positioning and fixation with an orthopedic console [10]).

In this study, we used the true parameters of NSA and FT obtained from positioning using our original method [9], and all the rest from both positionings.

In the study, the results of the analysis are presented in the form of distributions of clinical parameters (in %), arithmetic mean and standard deviation (M ± SD). Comparisons between groups were performed using the Chi-squared test and analysis of variance (ANOVA) for the respective data types. Pearson's correlation coefficient was used to find the relationship between the indices. STATA 14 statistical software package was used for analysis.

3. Results

The subjects of this study were the parameters of the hip joint in patients with cerebral palsy. We analyzed the Wiberg angle and the Reimers index depending on various factors, as well as the parameters of the hip joint (NSA, torsion of the femur, acetabular angle, Sharp's angle) to demonstrate how the former affect the latter. Most patients had stable hips and were able to ambulate. 30 hips displayed a migration rate >33%.

In comparison with groups of patients by age in SP in 8 joints (9.41%) the WA average M=35.6±4.8 that was within normal limits, in 77 joints (90.59%) M=14.6±16.3 and there was a WA decrease. The frequency of detection of reduced WA did not differ significantly by age groups (p>0.05, p=0.95). With normal WA (p>0.05, p=0.073), the difference between the groups was statistically insignificant, and with reduced WA (p<0.05, p=0.0001), significant differences were observed between age groups. In PATOOM in 6 joints (7.06%) the WA average M=35.86±5.2 was within normal limits, in 79 joints (92.94%) M=17.2±12.1 and there was a WA decrease. The frequency of detection of reduced WA in PATOOM did not differ significantly by age groups (p>0.05, p=0.84). With normal WA in PATOOM (p>0.05, p=0.054) the difference between age groups was statistically insignificant, with a decrease of WA (p<0.05, p=0.001) there were significant differences between groups. In the comparison of patients' groups by age in SP in 53 joints (61.63%) the average RI values M=16.7±6.6 were within normal limits, in 33 joints (38.37%) M=50.2±17.2 and there was RI increase. A statistically significant change in the frequency of detection of increased R in the SP depending on age (p<0.05 p=0.005) was revealed. In non-increased RI (p>0.05, p=0.13) the difference between the groups was statistically insignificant, and in increased RI (p<0.05, p=0.002) significant differences were observed between age groups. In PATOOM in 61 joints (70.93%) the RI average M=18.36±7.1 was within normal limits, in 25 joints (29.07%) M=45.5±16.0 and there was an increase of RI. There was a statistically significant change in the frequency of detection of increased RI in PATOOM depending on age (p<0.05, p=0,022). With non-increased RI in PATOOM (p>0.05, p=0.35) the difference between age groups was statistically insignificant, with increased RI (p<0.05, p=0.037) there were significant inter-group differences.

In comparison with groups of patients according GMFCS (II, III, IV levels) in SP in 7 joints (8.97%) the WA average M=35.6±4.8 was within normal limits, in 71 joints (91.03%) M=14.6±16.3 and there was a WA decrease. There was a statistically significant increase in the frequency of detection of reduced WA in SP depending on the increase of GMFCS levels (p<0.05, p=0,003). In normal WA (p>0.05, p=0.55) the difference between groups was statistically insignificant, and in its reduction (p<0.05, p=0.0033) significant differences between groups were observed. In PATOOM in 6 joints (7.69%) the WA average values M=35.86±5.2 were within the norm, in 72 joints (92.31%) M=17.2±12.1 and there was a WA decrease. There was a statistically significant increase in the frequency of reduced WA detection in PATOOM depending on the increase GMFCS level (p<0.05, p=0.01). With normal WA in PATOOM (p>0.05, p=0.47) the difference between the groups was statistically insignificant, with a decrease in the angle (p<0.05, p=0.0039) there were significant inter-group differences. In comparison with groups of patients according to GMFCS (II, III, IV levels) in SP in 47 joints (59.49%) the RI average M=16.7±6.6 was within normal limits, in 32 joints (40.51%) M=50.2±17.2 and there was an RI increase. There was a statistically significant increase in the frequency of detection of increased RI in PATOOM depending on the increase of GMFCS levels (p<0.05, p=0,000). In non-increased RI and in its increase (p>0.05) the difference between the groups was statistically insignificant. In PATOOM in 55 joints (69.62%) the RI average values M=18.3±7.1 were within the normal, in 24 joints (30.38%) M=45.5±16.0 and there was a RI increase. There was a statistically significant increase in the frequency of increased RI detection in PATOOM depending on the increase of GMFCS levels (p<0.05, p=0,000). Significant differences between the groups were observed with non-increased RI in PATOOM (p<0.05, p=0.0002), and the difference between the groups was statistically insignificant in increased RI (p>0.05, p=0.49).

While patients were divided into tetraparesis, paraparesis and hemiparesis group, in SP in 8 joints (9.41%) the WA average M=35.6±4.8 was within normal limits, in 77 joints (90.59%) M=14.6±16.3 and there was a WA decrease. The frequency of reduced WA detection in SP did not differ significantly in these groups (p>0.05, p=0.432). In normal WA (p>0.05, p=0.325) and in its reduction (p>0.05, p=0.314), the difference between the groups was statistically insignificant. In PATOOM in 6 joints (7.06%) WA average M=35.8±5.2 was within normal limits, in 79 joints (92.94%) M=17.2±12.1 and there was a WA decrease. The frequency of reduced WA detection in PATOOM did not differ significantly between these groups (p>0.05, p=0.175). In normal WA (p>0.05, p=0.516) and in its reduction (p>0.05, p=0.449), the difference between the groups was statistically insignificant. When dividing patients into tetraparesis, paraparesis and hemiparesis groups, in SP in 53 joints (61.63%) the RI average M=16.7±6.6 was within normal limits, in 33 joints (38.37%) M=50.2±17.2 and there was a RI increase. There was a statistically significant increase in the frequency of increased RI detection in the SP depending on the separated group (p<0.05, p=0.003). In non-increased RI (p<0.05, p=0.028) significant differences between groups were observed, and in its increase (p>0.05, p=0.49) the inter-group difference was statistically insignificant. In PATOOM in 61 joints (70.93%) RI average M=18.3±7.1 was within normal limits, in 25 joints (29.07%) M=45.5±16.0 and there was a RI increase. There was a statistically significant increase in the frequency of increased RI detection in PATOOM depending on the separated group ($p<0.05$, $p=0.015$). In non-increased RI ($p<0.05$, $p=0.025$) significant differences were observed between groups, and in its increase ($p>0.05$, $p=0.30$) the inter-group differences were statistically insignificant.

In a comparison of groups of patients by ambulation status (ambulating, non-ambulating) in SP in 8 joints (9.41%) WA average M=35.6±4.8 was within the norm, in 77 joints (90.59%) M=14.6±16.3 and there was a decrease of WA. There were statistically significant differences in WA in SP by groups ($p<0.05$, $p=0.043$). When observing reduced WA ($p<0.05$, $p=0.0009$), significant differences were observed between groups. WA in PATOOM in 6 joints (7.06%) average values M=35.8±5.2 were within the normal, in 79 joints (92.94%) M=17.2±12.1 and there was a WA decrease. Statistically insignificant differences in WA in PATOOM by groups ($p<0.05$, $p=0.083$) were found. Significant differences between groups were observed in a WA decrease ($p<0.05$, $p=0.001$). In comparison with groups of patients by ambulatory status (ambulating, non-ambulating) RI in SP in 53 joints (61.63%) average values M=16.7±6.6 were within normal limits, in 33 joints (38.37%) M=50.2±17.2 and there was a RI increase. Statistically significant differences in RI in the SP by groups ($p<0.05$, $p=0.000$) were revealed. In non-increased IR ($p>0.05$, $p=0.07$) and in its increase ($p>0.05$, $p=0.944$), the difference between the groups was statistically insignificant. RI in PATOOM in 61 joints (70.93%) average M =18.3±7.1 was within the normal, in 25 joints (29.07%) M=45.5±16.0 and there was a RI increase. Statistically significant differences in RI in PATOOM by groups ($p<0.05$, $p=0.000$) were revealed. In non-increased RI ($p<0.05$, $p=0.0001$) significant differences were observed between groups, and in its increase ($p>0.05$, $p=0.66$) the inter-group difference was statistically insignificant.

In the comparison of groups of patients who had an AM in the medical history and patients who did not have it, in the SP in 8 joints (9.41%) the WA average M = 35.6 ± 4.8 was within normal limits, in 77 joints (90.59%) M=14.6±16.3 and there was a WA decrease. Statistically insignificant differences of WA in SP by groups ($p<0.05$, $p=0.156$) were found. In normal WA ($p>0.05$, $p=0.29$) the difference between groups was statistically insignificant, and in its reduction ($p<0.05$, $p=0.004$) significant inter-group differences were observed. In PATOOM in 6 joints (7.06%) average WA values M=35.8±5.2 were within the normal, in 79 joints (92.94%) M=17.2±12.1 and there was a WA decrease. Statistically insignificant differences of WA in PATOOM by groups ($p<0.05$, $p=0.346$) were found. Significant differences between groups were observed in normal WA ($p<0.05$, $p=0.048$) and in its reduction ($p<0.05$, $p=0.037$). In comparison with the groups of patients who had a history of AM and patients who did not have it in SP in 53 joints (61.63%) RI mean M=16.7±6.6 was within normal limits, in 33 joints (38.37%) M=50.2±17.2 and there was a RI increase. There were statistically significant differences in RI in the SP by groups ($p<0.05$, $p=0.018$). In non-increased RI ($p>0.05$, $p=0.79$) and in its increase ($p>0.05$, $p=0.98$) the difference between the groups was statistically insignificant. In PATOOM in 61 joints (70.93%) RI average M=18.3±7.1 was within normal limits, in 25 joints (29.07%) M=45.5±16.0 and there was a RI increase. There were statistically insignificant differences of RI in PATOOM by groups ($p<0.05$, $p=0.106$). In non-increased RI ($p>0.05$, $p=0.86$) and in its increase ($p>0.05$, $p=0.75$) the inter-group difference was statistically insignificant.

In comparison with groups of patients with confirmed data on DDH (DDH, healthy joints at birth) in SP in 2 joints (7.41%) the WA average M=35.6±4.8 was within normal limits, in 25 joints (92.59%) M=14.6±16.3 and there was a WA decrease. Statistically insignificant differences of WA in SP by groups ($p<0.05$, $p=0.10$) were found. In normal WA ($p>0.05$, $p=0.29$) and in its reduction ($p>0.05$, $p=0.23$) the difference between the groups was statistically insignificant. WA in PATOOM in 1 joint (3.70%) average values M=35.8±5.2 were within the normal, in 26 joints (96.30%) M=17.2±12.1 and there was a WA decrease. Statistically insignificant differences of WA in PATOOM by groups ($p>0.05$, $p=0.255$) were found. In normal WA ($p>0.05$, $p=0.19$) and in its reduction ($p>0.05$, $p=0.22$) the difference between the groups was statistically insignificant. In comparison with groups of patients with confirmed data on DDH (DDH, healthy joints at birth) in SP in 13 joints (48.15%) the RI average M=16.7±6.6 was within normal limits, in 14 joints (51.85%) M=50.2±17.2 and there was a RI increase. Statistically significant differences of RI in SP by groups ($p<0.05$, $p=0.013$) were found. In non-increased RI ($p>0.05$, $p=0.13$) and in its increase ($p>0.05$, $p=0.26$), the difference between the groups was statistically insignificant. In PATOOM in 19 joints (70.37%) the RI average M=18.3±7.1 was within normal limits, in 8 joints (29.63%) M=45.5±16.0 and there was a RI increase. There were statistically insignificant differences of RI in PATOOM by groups ($p<0.05$, $p=0.637$). In non-increased RI ($p<0.05$, $p=0.008$) significant differences were observed between groups, and in its increase ($p>0.05$, $p=0.63$) the infer-group difference was statistically insignificant.

When comparing SP and PATOOM ($p<0.05$, $p=0.000$) coincidence was observed in both positionings - normal WA in 5 joints (5.88%), reduced WA in 76 joints (89.41%). Using Pearson correlation method, a reliable, strong, direct correlation was found between the WA measured in both positioning ($R=0.9098$, $p<0.05$).

In normal NSA the frequency of pathological WA detection in SP was 23 cases (82.14%), in NSA increase in statistically insignificant way ($p>0.05$, $p=0.62$) the frequency of pathological WA detection increases in 54 cases (94,74%). Using Pearson's correlation method, a significant, medium-strength inverse correlation was found between NSA and WA in SP ($R=-0.4181$, $p<0.05$). In PATOOM with normal NSA, the frequency of pathological WA detection was 25 (89.29%) cases, with an increase in NSA in statistically insignificant way ($p>0.05$, $p=0.35$) increases the frequency of pathological WA in 54 cases (94.74%). Using Pearson's correlation method, a significant, medium-strength, inverse correlation was found between NSA and WA in PATOOM (R=-0.3582, p<0.05).

In normal FT the frequency of pathological WA detection in SP was 2 (66,67%) cases, in increase of FT in statistically insignificant way (p>0.05, p=0.14) the frequency of pathological WA detection increases in 75 cases (91.46%). Using Pearson's correlation method, a significant, medium-strength, inverse correlation was found between FT and WA in SP (R=-0.3896, p<0.05). In PATOOM with normal FT, the frequency of pathological WA detection was 2 (66.67%) cases, with an increase of FT in statistically insignificant way (p>0.05, p=0.07) increases the frequency of pathological WA in 77 cases (93.90%). Using Pearson correlation method, a significant, medium-strength, inverse correlation was found between FT and WA in PATOOM (R=-0.3125, p<0.05).

Using Pearson correlation method, a reliable, strong, direct correlation was found between the AA measured in both positionings (R=0.7641, p<0.05). With normal AA in PATOOM, the frequency of pathological WA detection in SP was 33 (82.50%) cases, with increasing of AA in statistically significant way (p<0.05, p=0.01) increases the frequency of pathological WA in 44 (97.78%) cases. Using Pearson correlation method, a reliable, strong, inverse correlation was found between AA and WA in SP (R=-0.7364, p<0.05). In the PATOOM with normal AA, the frequency of pathological WA detection was 35 (87.50%) cases, with an AA increase in statistically insignificant way (p>0.05, p=0.06) increases the frequency of pathological WA in 44 (97.78%) cases. Using Pearson correlation method, a reliable, strong, inverse correlation between AA and WA was found in the PATOOM (R=-0.7108, p<0.05).

Using Pearson correlation method, a reliable, strong, direct correlation was found between the SA measured in both positioning (R=0.7851, p<0.05). In the normal SA the frequency of pathological WA detection in SP was 24 (80.0%) cases, in increase of SA in statistically significant way (p<0,05, p=0,01) frequency of pathological WA detection in 53 (96,36%) cases increases. Using Pearson correlation method, a significant, medium-strength inverse correlation was found between SA and WA in SP (R=-0.6857, p<0.05). In the PATOOM in the normal SA, the frequency of pathological WA detection was 26 (86.67%) cases, with an SA increase in statistically insignificant way (p>0.05, p=0.09) increases the frequency of pathological WA detection in 53 (96.36%) cases. Using Pearson ccorrelation method, a reliable, strong, inverse correlation between SA and WA was found in the PATOOM (R=-0.7716, p<0.05).

When comparing the RI in the SP and PATOOM (p<0.05, p=0.000) coincidence was observed in both positionings of non-increased RI in 52 (60.46%) joints and increased RI in 24 (27.90%) joints. Using Pearson correlation method, a significant strong direct correlation was found between the RI measured in both positionings (R=0.9037, p<0.05).

In normal NSA the frequency of pathological RI detection in SP was 3 (10.71%) cases, with increasing of NSA in statistically significant way (p<0.05, p=0.000) increases the frequency of pathological RI detection in 30 (51.72%) cases. Using Pearson correlation method, a reliable, medium-strength, direct correlation between NSA and RI in SP (R=0.4131, p<0.05) was detected. In the PATOOM and normal NSA, the frequency of pathological RI detection was 1 (3.57%) cases, with increasing of NSA in statistically significant way (p<0.05, p=0.000) increases the frequency of pathological RI detection in 24 (41.38%) cases (Fig. 2). Using Pearson correlation method, a reliable, weak, direct correlation between NSA and RI was found in the PATOOM (R=0.2985, p<0.05).

In normal FT, the frequency of pathological RI detection in SP was 0 (0.0%) cases, with an increase of FT in statistically insignificant way (p>0.05, p=0.16) increases the frequency of pathological RI detection in 33 (39.76%) cases. Using Pearson correlation method, a reliable, medium-strength, direct correlation between FT and RI in SP was found (R=0.3916, p<0.05). In the PATOOM with normal FT, the frequency of pathological RI detection was 0 (0.0%), with an increase of FT in statistically insignificant way (p>0.05, p=0.25) increases the frequency of pathological RI detection in 25 (30.12%) cases (Fig. 3). Using Pearson correlation method, a reliable, medium-strength, direct correlation between FT and RI was found in the PATOOM (R=0.3304, p<0.05).

With normal AA, the frequency of pathological RI detection in SP was 6 (14.63%) cases, with an increase of AA in statistically significant way (p<0.05, p=0.000) increases the frequency of pathological RI detection in 27 (60.0%) cases. Using Pearson correlation method, a reliable, medium-strength, direct correlation between AA and RI in SP was found (R=0.6608, p<0.05). In the PATOOM with normal AA the frequency of pathological RI detection was 5 (12.20%) cases, with an increase of AA in statistically significant way (p<0.05, p=0.000) increases the frequency of pathological RI in 20 (44.44%) cases (Fig. 4). Using Pearson correlation method, a reliable, medium-strength, direct correlation between AA and RI was found in the PATOOM (R=0.6101, p<0.05).

In normal SA, the frequency of pathological RI detection in SP was 2 (6.45%) cases, with an increase of SA in statistically significant way (p<0.05, p=0.000) increases the frequency of pathological RI detection in 31 (56.36%) cases. Using Pearson correlation method, a reliable, medium-strength, direct correlation between SA and RI in SP was found (R=0.4951, p<0.05). In the PATOOM with normal SA, the frequency of pathological RI detection was 2 (6.45%) cases, with an increase of SA in statistically significant way (p<0.05, p=0.000) increases the incidence of pathological RI in 23 (41.82%) cases (Fig. 5). Using Pearson correlation method, a reliable, medium-strength, direct correlation between SA and RI was found in the PATOOM (R=0.5072, p<0.05).

In normal FT the frequency of pathological NSA detection was 2 (66.67%) cases, in increase of FT in statistically insignificant way (p>0.05, p=0.97) the frequency of detection of the increased NSA increases in 56 (67.47%) cases. Using Pearson correlation method it was revealed an unreliable, weak, direct correlation between FT and NSA in the PATOOM (R=0.166, p>0.05).

With normal AA, the frequency of pathological NSA detection was 23 (56.10%) cases, with an increase of AA in statistically significant way ($p<0.05$, $p=0.03$) increases the frequency of increased NSA detection in 35 (77.78%) cases (Fig. 6). Using Pearson correlation method, reliable, medium-strength, direct correlations between AA and NSA in SP ($R=0.6072$, $p<0.05$) and in the PATOOM ($R=0.3888$, $p<0.05$) were revealed.

In the normal SA the frequency of pathological NSA detection was 17 (54.84%) cases, in increased SA in statistically insignificant way ($p>0.05$, $p=0.06$) frequency of increased NSA detection increases in 41 (74.55%) cases. Using Pearson correlation method, reliable, medium-strength, direct correlations between SA and NSA in SP ($R=0.5979$, $p<0.05$) and in the PATOOM ($R=0.3703$, $p<0.05$) were revealed.

In normal AA the frequency of pathological FT detection was 38 (92.68%) cases, in increase of AK in statistically insignificant way ($p>0.05$, $p=0.06$) the frequency of detection of the increased FT in 45 (100.0%) cases increases as well (Fig. 7). Using Pearson correlation method, reliable, weak, direct correlations between AA and FT in SP ($R=0.2409$, $p<0.05$) and in the PATOOM ($R=0.2640$, $p<0.05$) were revealed.

In normal SA the frequency of pathological FT detection was 30 (96.77%) cases, in increase of SA in statistically insignificant way ($p>0.05$, $p=0.92$) the frequency of detection of the increased FT in 53 (96.36%) cases increases. Using Pearson correlation method, unreliable, weak, direct correlations between SA and FT in SP ($R=0.1698$, $p>0.05$) and in the PATOOM ($R=0.1867$, $p>0.05$) were revealed.

In normal SA the frequency of pathological AA detection was 8 (25.81%) cases, in increase of SA in statistically significant way ($p<0.05$, $p=0,000$) the frequency of detection of the increased AA in 37 (67.27%) cases increases. Using

Pearson correlation method, a reliable, strong, direct correlation between SA and AA in SP ($R=0.8428$, $p<0.05$) was revealed as well as a reliable, medium, direct correlation between SA and AA in the PATOOM ($R=0.6618$, $p<0.05$). additional retrieval parameters. This search category contains the most information in the form of review articles and descriptions of the use of certain drug categories.

The results were combined because the search categories for the key phrases “Drug/Medicine AND Periodontal disease” and “Pharmacotherapy AND Periodontal disease” contain quite a lot of repetitions.

The 4 main areas of research were established in the analysed volume of literature:

1. Research on the herbal remedies, folk remedies, remedies provided in national medical systems at different stages of the therapeutic process of periodontal diseases.
2. Studies on the use of antibiotics at different stages of the therapeutic process of periodontal diseases.
3. Research on nanotechnology in dentistry.
4. Other categories of research describing the use of odontoprotectors at different stages of the therapeutic process of periodontal diseases.

The distribution of publications in the established areas is illustrated in Figure 4.

As Figure 4 shows, the largest share of scientific publications is related to the description of the use of particular drugs, both in the form of review articles and in the form of case studies.

4. Discussion

We did not conduct a total screening of all patients with cerebral palsy, but performed examinations of the hip joints of patients who sought specialized care in the Institute of Traumatology and Orthopedics of the National Academy of Medical Sciences of Ukraine. Most patients did not ambulate on their own in the younger age groups, but we considered them promising in terms of verticalization. The older age groups were dominated by patients who could ambulate independently. Severe forms of cerebral palsy were less common in older patients, which may provoke a debate about the validity of the parametric analysis interpretation. WA was within the age norms only in 8 joints, normal FT was observed only in 3 joints. In almost all groups, were presented the hip joints, regardless of divisions, criteria and factors.

No relationship was found between WA in both positionings and age. It should be noted that WA in SP was within the norm only in 8 (9.41%) joints. This may indicate a violation of the relationship between the proximal femur and the acetabulum and can be observed in different age groups among patients with cerebral palsy. Significant differences between the age groups of increased RI in both positionings may suggest that instability in HJ among patients with cerebral palsy may occur during growth. As the number of patients examined increases, the data will be updated. Most patients had stable HJ, in 53 (61.63%) joints the RI in SP was <33%. Increased RI in the studied patients with cerebral palsy was more often observed in younger and middle age groups, when, according to the literature, spastic femoral head (FH) dislocation is more common.

WA and RI dependencies were found in both positionings depending on the GMFCS. The frequency of detection of WA and RI pathology increased in statistically significant fashion depending on the increase of the GMFCS level. This confirms the trends in the world literature that in mild forms of cerebral palsy the risk of spastic FH dislocation is much lower.

No relationships were found between WA in both positionings and the level of lesion (tetraparesis, paraparesis, hemiparesis), while in the study of RI significant differences between groups were observed in both positionings. According to the literature, instability in HJ in hemiparesis is very rare, the most severe form of cerebral palsy according to the level of lesion is tetraparesis. Neurologically intact upper extremities are actively involved in the movement of patients with cerebral palsy, so all our patients with hemiparesis and paraparesis were able to move independently.

In the comparison of groups of patients by ambulatory status (ambulating, non-ambulating) no differences were found between groups of patients on WA in the PATOOM, while in the SP dependencies were revealed. Dependencies were also found in both positionings between the study groups and according to RI. The function of ambulation has a great importance for the formation of the hip joints in patients with cerebral palsy and is dependent on the stability in the HJ. When spastic FH dislocation occurs, the ambulation function is lost.

Analyzing WA in both positionings among patients with cerebral palsy who had an AM in their medical history and patients who did not have it, we did not find a statistically significant inter-group difference. The dependences between the RI and the studied groups in the SP and the absence of dependence in the PATOOM were established. Such differences may be controversial, but as the number of joints examined increases, the data will be refined. The purpose of this surgical treatment is to weaken the abductor muscles and redistribute the strength of the antagonist muscles. This may explain the decrease in the frequency of spastic FH dislocation among patients with cerebral palsy after this operation. Only clinical indications for AM are used, often without taking into account the bone pathology of the hip joint. Our studies show that AM does not affect WA (the relationship between PF and the acetabulum) in patients with cerebral palsy, and there are some dependences on the effect upon RI (stability index) in standart positioning.

We did not find statistically significant differences when analyzing WA in both positionings in the groups of patients with DDH and patients born with healthy hip joints confirmed by radiographs of these joints in infancy. RI in SP when comparing these groups of dependencies are observed, and in the PATOOM the inter-group difference was statistically insignificant. These data may provoke discussion due to the small sample, as well as the lack of data on whether DDH was treated before the age up to one year. In addition, analyzing the indices of the acetabulum, DDH of the HJ could be present in a much larger proportion of our patients [11].

We have established reliable, strong, direct correlations between WA and RI, measured in both positionings, indicative of the fact that the PATOOM can replace the SP in the examination and screening of hip joints in cerebral palsy, as indices of the relationship between PF and acetabulum display statistically minor changes. In this case, the indices of PF in the PATOOM are true, not projective ones [8].

A reliable, medium-strength, inverse correlation was found between NSA and WA in both positionings. There was a significant, moderate, direct correlation between NSA and RI in SP, and in the PATOOM there was a reliable, weak, direct correlation, which may indicate the impact of pathological NSA upon the relationship indices in the hip joint. There is a tendency to increase regarding the frequency of pathological WA detection in pathologic NSA, and pathological RI increases in statistically significant way in pathology of NSA. At the same time, an unreliable, weak, direct correlation between NSA and FT was found, and the frequency of pathological NSA detection in pathological FT increases in statistically scarce fashion. Significant, medium-strength, direct correlations between AA and NSA, SA and NSA in both positionings were also found, and the frequency of increased AA detection increases in statistically significant way with increasing NSA. These data may indicate an increase in the incidence of spastic FH dislocation in dysplastic HJ among patients with cerebral palsy. Increased NSA is often found in severe forms of cerebral palsy, respectively, they are more likely to have spastic FH dislocation.

Significant, medium-strength, inverse correlations between FT and WA in both positionings and reliable, medium-strength, direct correlations between FT and RI in both positionings were found. At the same time, with increasing FT, the frequency of pathological WA and RI detection in both positionings increases in statistically insignificant way. Reliable, weak, direct correlations exist between AA and FT in both positionings, and unreliable, weak, direct correlations take place between SA and FT. FT has an effect on the relationship's indices between PF and the acetabulum, but has no significant effect on the acetabulum in the frontal plane. Ambulating and non-ambulating patients with cerebral palsy compensate pathological FT by internal rotation of the thighs, thus minimizing its impact upon the acetabulum, but this position contributes to the most common posterolateral spastic FH dislocation.

A reliable, strong, inverse correlation between AA and WA in both positionings and a reliable, medium, direct correlation between AA and RI in both positionings were found. With increasing AA in statistically significant way increases the frequency of of pathological WA detection in SP, and slightly – in the PATOOM. At the same time the frequency of pathological RI detection increases in statistically significant fashion together with increasing AA in both postionings. A reliable, medium-strength, inverse correlation relationship between SA and WA in SP was revealed, and a reliable, strong, inverse correlation relationship was observed in the PATOOM. A reliable, medium-strength, direct correlation between SA and RI in both positionings was found. With an increase of SA, the frequency of pathological WA detection in the SP increases in statistically significant way, and slightly - in the PATOOM. With increasing SA in statistically significant way increases the frequency of pathological RI detection in both positionings. These data may suggest a close relationship between dysplastic acetabulum and spastic FH dislocation. RI demonstrated reliability and similar results in both positionings, and revealed more dependencies on the studied parameters of the HJ compared to the WA. This can be explained by the difficulty of correctly establishing the FH center in patients with cerebral palsy due to delayed ossification or deformation of FH. According to Tonnis, large deviations can occur when measuring HF during the determination of the HF center, which significantly limits the usage of this parameter for diagnosis in children in age less than 5 years [12]. When calculating the data in our study, we noticed that difficulties with determining the HF center may occur in patients with cerebral palsy older than 5 years. This is partly due to the lag of bone age relative to the passport age. When analyzing HF in both positionings, we noticed that the shape of the HF changes due to the epiphysis, as we bring its loaded surface into the frontal plane. We noticed that the HF center, which we determined in both positionings in the same joints, changed even in stable HJ (RI<33%), so in the future we will prefer RI. The latter has the highest inter-expert reliability [13].

J. Reimers recommends measuring the index on the anterior-posterior radiographs of the hip joints with a strict horizontal placement of the patellas. In the 1980's it was believed that the knee joint when ambulating should work in the sagittal plane, thus the author chose this positioning. Although the author did not deny the measurement of RI in other positionings and noted the minimum percentage of error [14].

5. Conclusions

The Reimers' index showed greater reliability compared to the Wiberg angle in the study of pathology of the hip joint in cerebral palsy. PATOOM can be used to screen the hip joints in cerebral palsy based upon the Reimers index while obtaining the true parameters of NSA and FT. There is a direct relationship between an increase in the Reimers index and an increase in the proximal femur's (FT and NSA) and the acetabulum's (AA and SA) indices. FT did not have a significant effect upon the acetabular parameters in the frontal plane, but there were significant, moderate, inverse correlations between FT and WA and direct correlations between FT and RI.

6. Conflict of Interest

The authors state no conflict of interest during the preparation of this article.

7. Gratitude

the authors express their gratitude for the fruiFTul cooperation of a friend, teacher and colleague V. Hoshko (08.04.1949 - 09.28.2020).

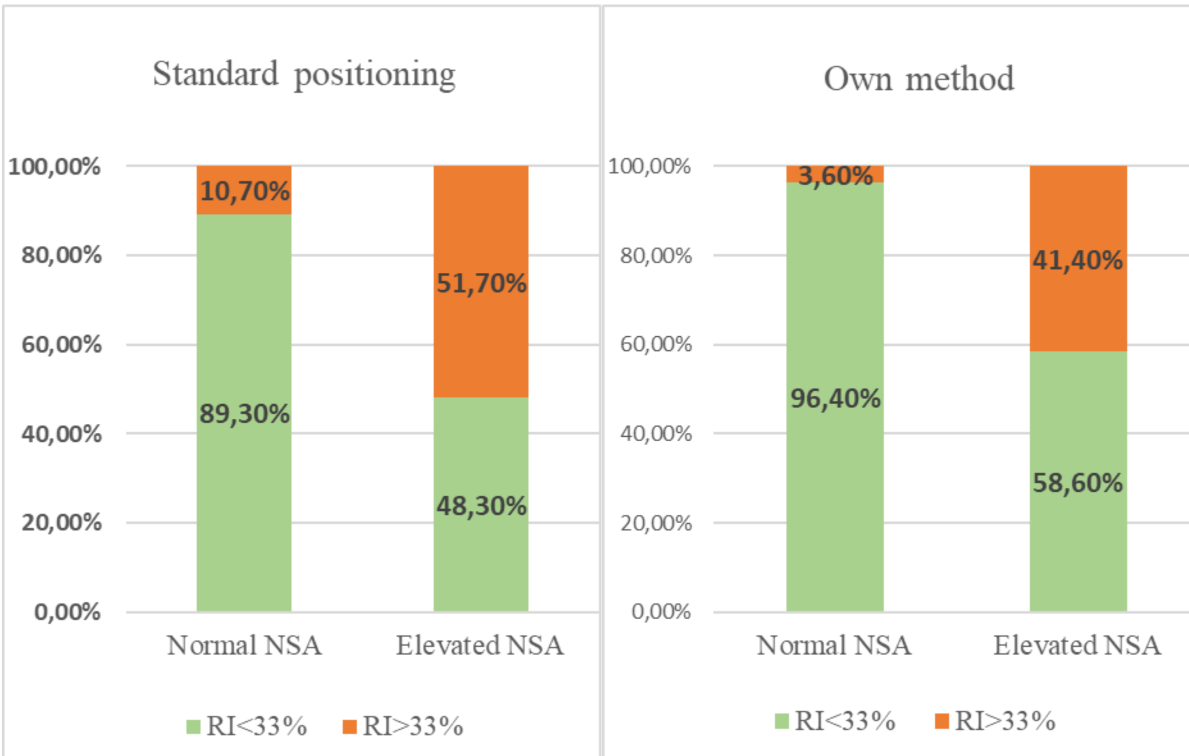

Fig. 2 The association of detection of the normal and pathologixal neck-shaft angle (NSA) and Reimers' index (RI) in the standard positioning (SP) and positioning according to our own method (PATOOM).

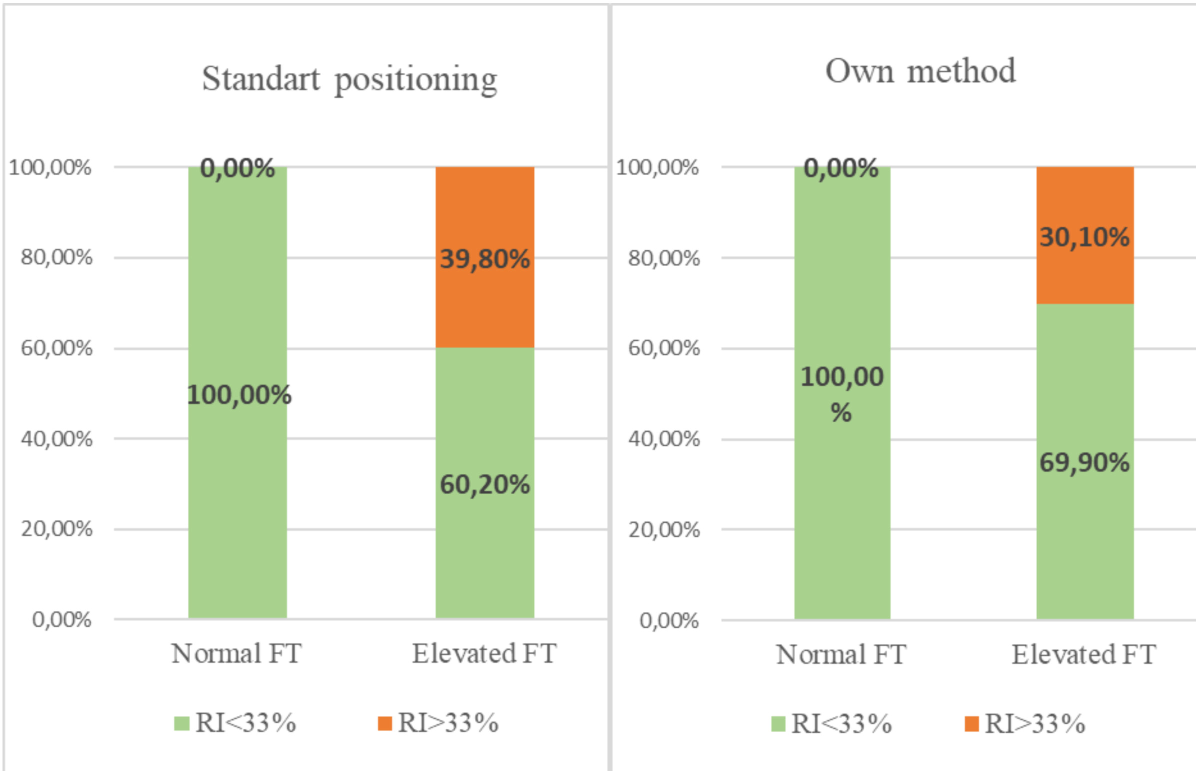

Fig. 3 Association of detection of normal and pathological femoral torsion (FT) and Reimers' index (RI) in the standard positioning (SP) and positioning according to our own method (PATOOM).

Fig. 4 The association between the detection of the normal and pathological acetabular angle (AA) and Reimers' index (RI) in the standard positioning (SP) and positioning according to our own method (PATOOM).

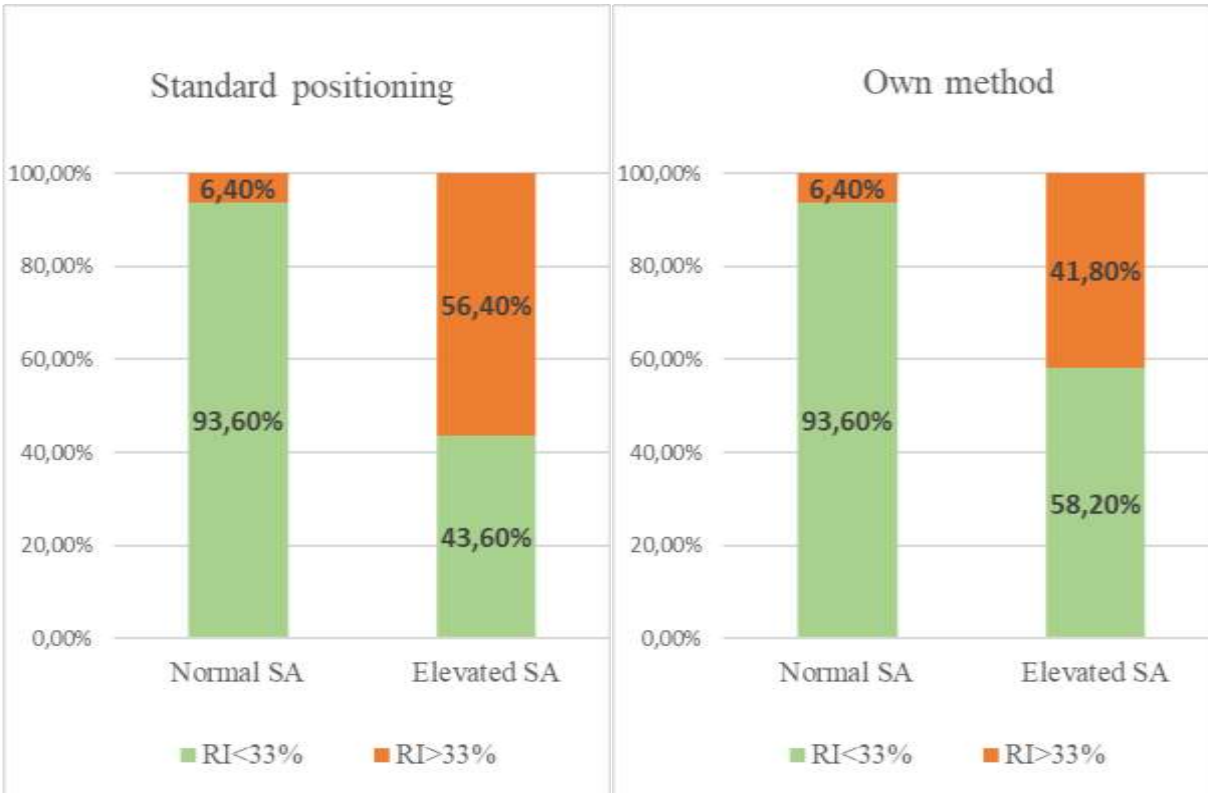

Fig. 5 Association of detection of normal and pathological Sharp's angle (SA) and Reimers' index (RI) in the standard positioning (SP) and positioning according to our own method (PATOOM).

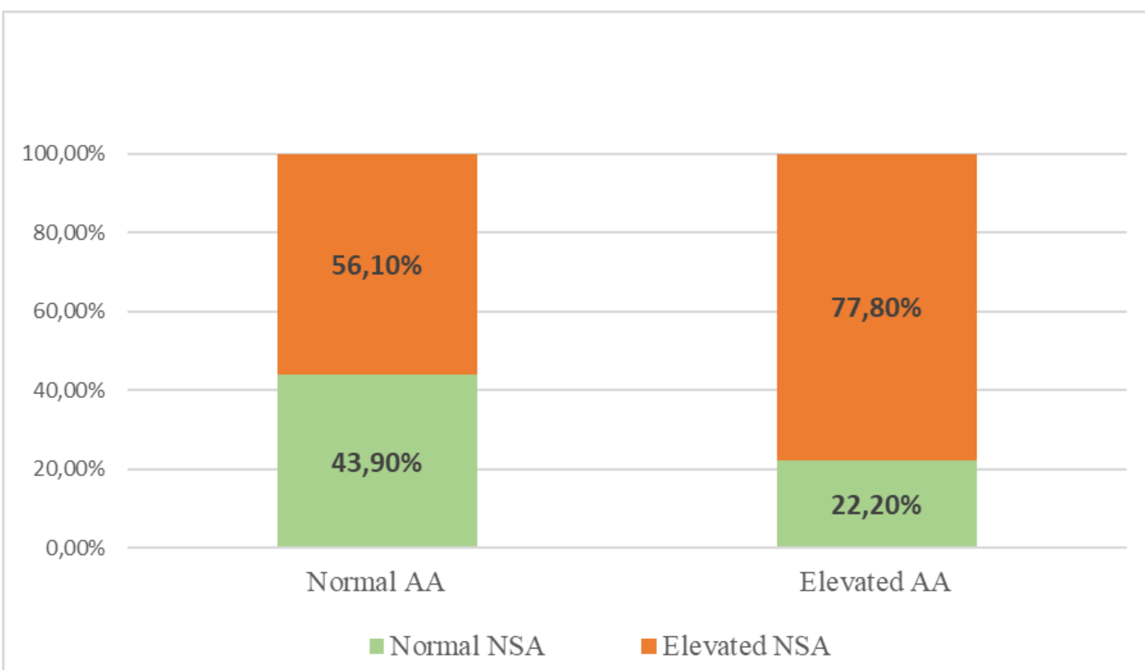

Fig. 6 The association of detection of the normal and pathological neck-shaft angle (NSA) and acetabular angle (AA) in the positioning according to our own method (PATOOM).

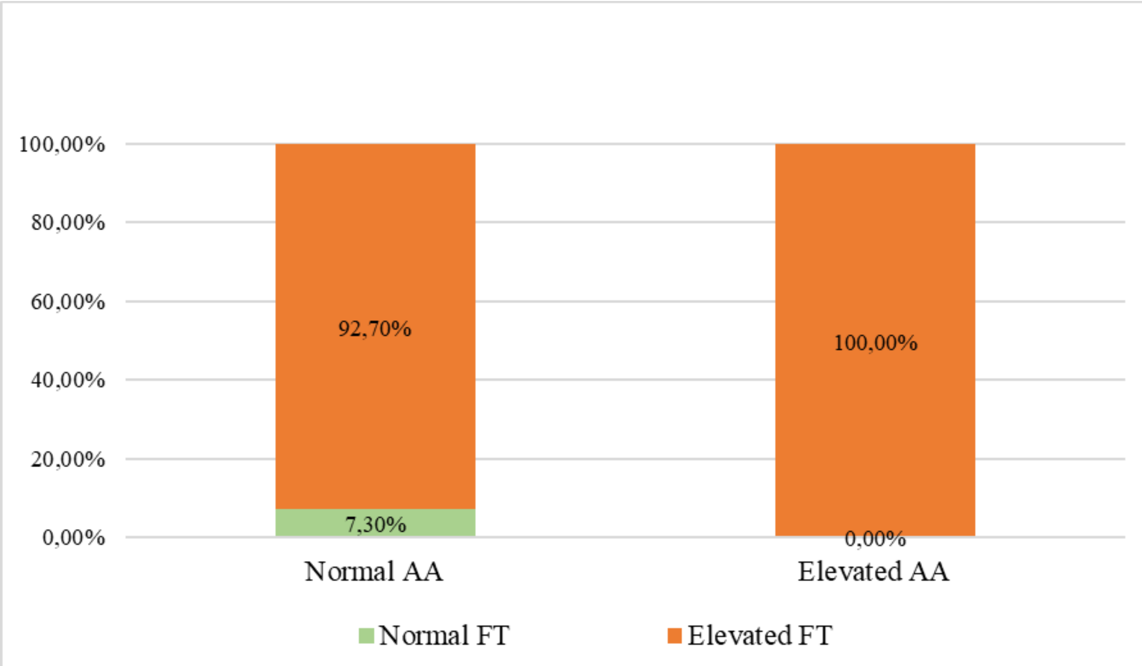

Fig. 7 Association of detection of normal and pathological femoral torsion (FT) and acetabular angle (AA) in the positioning according to our own method (PATOOM).

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