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Tactics of Surgical Treatment of Slipped Capital Femoral Epiphysis Associated With Mild Chronic Epiphyseal Displacement

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Background. The appearing of data on cam-type FAI in patients with sequelae of slipped capital femoral epiphysis characterized by mild chronic epiphyseal displacement suggests that along with fixation of the proximal femoral epiphysis, modeling of the head-neck transition and restoration of the femoral offsets using arthroscopic techniques should be performed. Meanwhile, it is well known that after epiphyseal fixation, complete remodeling of the epimetaphysis and, consequently, disappearance of the morphological substrate of potential FAI can occur due to the ongoing enchondral and echondral growth. In this regard, the issue of indications for intraarticular interventions in studied patients remains currently open.
The aim of the study was to determine the incidence of FAI in the postoperative period in patients with slipped capital femoral epiphysis characterized by mild chronic epiphyseal displacement, and to estimate the requirement of further surgical treatment.
Methods. The results of the examination of 32 patients with mild chronic epiphyseal displacement in the typical posterior inferior direction who underwent cannulated epiphyseal screw fixation were analyzed for the severity of epimetaphysis remodeling and the presence of FAI in the postoperative period. Clinical, radiological, magnetic resonance, and statistical methods were used.
Results. At the age of 18-19 years, FAI with pain syndrome in everyday life was found in 9 (28.1%) patients — 8 of them did not have even partial remodeling of the femoral component of the joint, another 9 (28.1%) patients did not suffer from pain syndrome in everyday life, but had other clinical, radiological and MR signs of cam-type FAI. Complete or almost complete remodeling of the proximal femoral epimetaphysis occurred in 14 (43.8%) patients.
Conclusion. In our opinion, therapeutic and diagnostic arthroscopy of the hip joint for the purpose of modeling the head-neck transition at the age of 18-19 years is indicated for more than one quarter (28.1%) of the investigated patients because of the presence of reliable signs of FAI.

Keywords: slipped capital femoral epiphysis, hip joint, femoroacetabular impingement, hip arthroscopy.

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Тактика хирургического лечения пациентов с юношеским эпифизеолизом головки бедренной кости при хроническом смещении эпифиза легкой степени

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Актуальность. Появление данных о феморо-ацетабулярном импинджменте (ФАИ) cam-типа у пациентов с последствиями юношеского эпифизеолиза головки бедренной кости, характеризующегося хроническим смещением эпифиза легкой степени, требует, наряду с фиксацией проксимального эпифиза бедренной кости, моделирования перехода «головка – шейка» с использованием артроскопической техники. Однако после фиксации эпифиза вследствие продолжающегося энхондрального и экхондрального роста может произойти полное ремоделирование эпиметафиза и, следовательно, исчезновение морфологического субстрата потенциального ФАИ. В связи с этим вопрос о показаниях к внутрисуставным вмешательствам у пациентов с юношеским эпифизеолизом головки бедренной кости и его последствиями на сегодняшний день остается открытым.

Цель исследования — определить частоту встречаемости феморо-ацетабулярного импинджмента в послеоперационном периоде у пациентов с юношеским эпифизеолизом головки бедренной кости, характеризующимся хроническим смещением эпифиза легкой степени, и оценить потребность в проведении последующего хирургического лечения.

Материал и методы. Проанализированы результаты обследования 32 больных с хроническим смещением эпифиза легкой степени в типичном направлении кзади книзу, которым выполнена фиксация эпифиза канюлированным винтом, на предмет выраженности ремоделирования эпиметафиза и наличия ФАИ в послеоперационном периоде. В работе использованы клинический, рентгенологический, магнитно-резонансный и статистический методы исследования.

Результаты. В возрасте 18–19 лет ФАИ обнаружен у 9 (28,1%) пациентов, у 8 из них не произошло даже частичное ремоделирование бедренного компонента сустава, еще 9 (28,1%) больных не страдали от болевого синдрома в повседневной жизни, но имели иные клинические, а также рентгенологические и МР-признаки деформации cam-типа. Полное или практически полное ремоделирование проксимального эпиметафиза бедренной кости произошло у 14 (43,8%) пациентов.

Заключение. По нашему мнению, лечебно-диагностическая артроскопия тазобедренного сустава с целью моделирования перехода «головка – шейка» в возрасте 18–19 лет показана более чем одной четверти (28,1%) обследованных ввиду наличия у них достоверных признаков ФАИ.

Ключевые слова: юношеский эпифизеолиз головки бедренной кости, тазобедренный сустав, феморо-ацетабулярный импинджмент, фиксация проксимального эпифиза бедренной кости, канюлированный винт, артроскопия тазобедренного сустава.

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BACKGROUND

In most clinical cases slipped capital femoral epiphysis (SCFE) is associated with chronic epiphyseal displacement in the typical posterior inferior or just posterior directions. This displacement is divided into mild, moderate or severe according to its severity. Mild severity, as a rule, supposes anatomical situation with the displacement in posterior direction that does not exceed 30° [1, 2, 3].

According to the opinion of most surgeons, formed for the last several decades, mild chronic epiphyseal displacements in typical directions do not require space attitude restoration of epiphysis, so that its fixation in situ is sufficient [4, 5, 6, 7]. Meanwhile, many authors proved in their studies that at the first sight even insignificant deformity of the proximal femoral epimetaphysis might cause the cam-type femoroacetabular impingement (FAI) and contribute to the hip osteoarthritis [8, 9, 10, 11, 12, 13]. That is why nowadays scientists have resumed the search for the most optimal tactics of treating this type of patients that on the one hand will enable to prevent prominent degenerative changes in the affected joint at a young age and on the other hand to avoid unreasonable extension of the surgery in case of mild epiphyseal displacement. Some specialists offer to complement the epiphysis fixation in situ with the arthroscopic modeling of the femoral neck, particularly in the zone of its transition to the head in order to exclude chronic labrum acetabuli damages [14, 15, 16]. Other authors still do not recommend to perform intraarticular procedures expecting the remodeling of the femoral component after the epiphysis fixation during its ongoing growth [17, 18, 19]. Current discussions can be concluded only after answering the following questions: how often does the complete postoperative remodeling of epimetaphysis occur in the joints with unreduced mild chronic epiphyseal displacement; at what age does the pain syndrome typical for FAI begin in case of incomplete remodeling (or no remodeling); how often do degenerative changes in the affected joint progressively worsen?

Aim of study – to determine the incidence of FAI in the postoperative period in patients with slipped capital femoral epiphysis characterized by mild chronic epiphyseal displacement, and to estimate the requirement of further surgical treatment.

METHODS

A retrospective analysis of pre- and postoperative examination was performed in 32 patients (22 boys and 10 girls) who suffer from SCFE associated with mild chronic epiphyseal displacement in the typical posterior inferior direction on the one hand and without epiphyseal displacement on the other hand, concerning the severity of postoperative remodeling of the proximal femoral epitemaphysis as well as the presence of FAI in the postoperative period.

Inclusion criteria:

– age from 13 to 15 years old;

– no proximal femur epiphyseal fusion (partial or complete) at the growth plate level on both sides;

– chronic epiphyseal displacement in the typical posterior inferior direction with the posterior one of more than 15° (from 16° to 30°) and the inferior one of more than 5° (from 6° to 15°);

– bony prominence on the anterior surface of the femoral neck visualized on the hip X-ray in the Lauenstein view;

– positive “segment” symptom on the hip X-rays in the anteroposterior view implying that the tangent line to the superior surface of the femoral neck extended upwards does not cut out the lateral epiphyseal segment as it happens in the norm;

– no early complications of disease (hip chondrolysis and aseptic necrosis of the femoral head);

– initial stage of disease (preslipping) in the contralateral joint;

– no prior surgical treatment;

– no technical surgical mistakes.

Exclusion criteria:

– age less than 13 years old and more that 15 years old;

– complete or partial proximal femur epiphyseal fusion at the level of growth plate on one or both sides;

– chronic epiphyseal displacement in the typical posterior inferior direction without the combination of posterior displacement of more than 15° (from 16° to 30°) and inferior displacement of more that 5° (from 6° to 15°);

– chronic epiphyseal displacement in the typical posterior direction only and in atypical directions;

– acute epiphyseal displacement (primary and secondary to the chronic one).

Thus, all 32 patients had mild epiphyseal displacement and at the same time the lowest remodeling potential due to their age (no less than 13 years old) and maximal severity of anatomic disorders in combination with mild displacement.

Surgical technique

All children underwent surgical treatment that consisted of fixation of the proximal epiphyses of both femurs under C-arm fluoroscopy. Self-tapping cannulated screws 7.0 mm with external thread for ¼ of their overall length were used. The screw was introduced into the epiphysis from the anteroexternal surface of the femur through its neck and the center of the growth plate so that the screw head was not based on the cortical layer and was spaced away by 5-10 mm (Fig. 1).

All in all, 64 surgeries were performed. Each patient underwent procedures on both hip joints at one surgical session. In all cases the implants were removed after the epiphyseal fusion at the age from 17 to 18 years old.

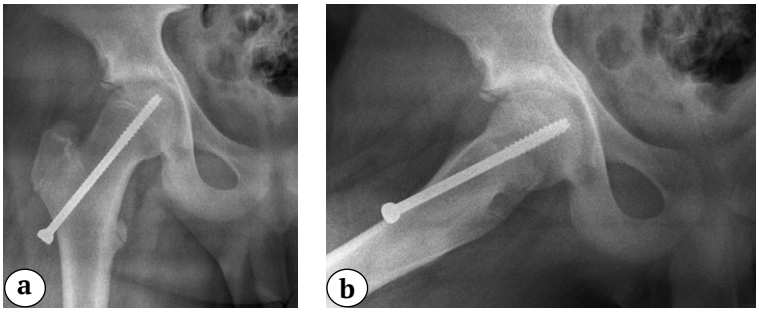

Fig. 1. X-rays of the right hip in the anteroposterior projection (a) and in the Lauenstein projection (b) of patient 13 years 11 months old, immediately after surgery. Interpretation is in the text

Preoperative examination

In the preoperative period all children had clinical and radiological examination that included X-ray and multislice spiral computed tomography (CT) of the hip joints. At the clinical examination performed in the horizontal position of a patient the main attention was paid to the hip range of motions, particularly to the presence and intensity of the Drehmann sign. The FADIR test was not performed due to a high risk of epiphysis avulsion.

The values of projection caput-collum-diaphyseal angle (CCDA), projection epiphyseal-diaphyseal angle (EDA) and epiphyseal angle (EA) were measured on both sides in X-rays in the anteroposterior and Lauenstein views. The signs of partial or complete epiphyseal fusion at the growth plate level were also excluded. The values of posterior and inferior epiphyseal displacement angles were measured on the deformed side. The presence of positive "segment" symptom, the bony prominence on the anterior surface of the femoral neck and the absence of epiphyseal displacement on the contralateral side were confirmed (Fig. 2).

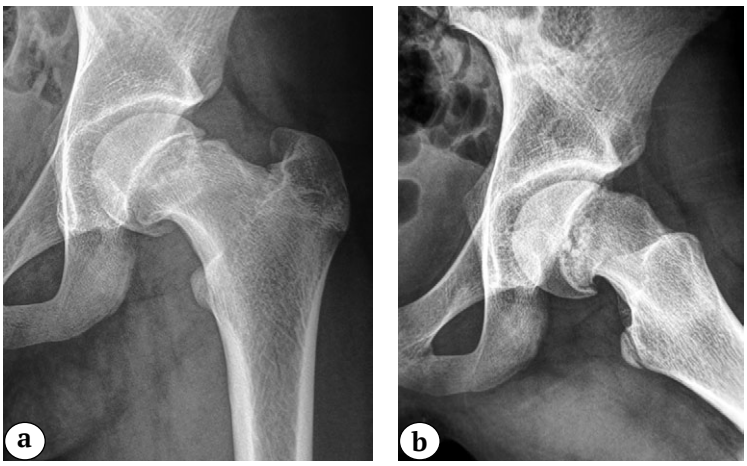

Fig. 2. X-rays of the right hip in the anteroposterior (a) and the Lauenstein projection (b) of patient 14 years 9 months old, before the surgery: no signs of synostosis at the level of the epiphyseal growth plate, positive "segment" symptom, bone prominence on the anterior surface of the femoral neck

Posterior epiphyseal displacement angle was measured evaluating the difference between the EA in the joint with no displacement (individual norm) and in the joint with displacement. Inferior epiphyseal displacement angle was measured evaluating the difference between the CCDA and the EDA in the joint with displacement.

Multislice spiral CT was performed in order to detect the signs of partial epiphyseal fusion that gave causes to cancel surgical treatment and exclude patient from the study.

In the postoperative period the clinical and radiological examination except multislice spiral CT was performed immediately after the surgery; in 3, 6 and 12 months; at least once in 18 months before reaching the age of 19 years old. Opposed to the preoperative period, this time the clinical examination included the FADIR test and the radiological examination included assessment of stability of epiphysis fixation. At the age of 18-19 years old besides the clinical and X-ray examination all patients had hip MRIs to exclude MR signs of cam-type FAI in the joint with mild epiphyseal displacement.

Stability of epiphysis fixation was evaluated by comparing the values of projection EDA and EA in the X-rays in the views mentioned above and taken on the operating table right after the surgery and at the time of appearance of the first signs of epiphyseal fusion at the growth plate level at the age from 13.5 to 15.5 years old depending on the age of a child at the moment of the surgery.

It is known that the initial MR sign of cam-type FAI is the deformity of the head-neck transitional zone defined by the excess of osteochondral mass in its anterosuperior part that leads to the disappearance of the normal concavity of transitional zone and abnormality of the spherical shape of the femoral head. That deformity was visualized in the oblique axial plane including the axis of the femoral neck as well as in the radial slices at the corresponding level perpendicular to the axis of the neck. The anterosuperior α angle was measured for the quantitative assessment of deformity of the head-neck transitional zone. Besides, the absence or the presence of uni- or multilocular cysts (the so called fibrocysts) situated along the anterosuperior margin of the femoral neck at the edge of its articular surface in the area of the contact. During the MRI examination some cam-type FAI signs in the acetabular component of the affected joint were also excluded or confirmed. These signs included the dissociation of the anterosuperior part of the acetabular labrum from the acetabular tectorial cartilage at the level of the chondrolabral transitional zone; hyaline cartilage thinning in the anterosuperior quadrant of acetabulum and its defect (cleft); acetabular labrum degeneration and rupture.

Statistical analysis

Accumulation and systematization of initial data were performed in Microsoft Office Excel 2016 tables. Statistical analysis was carried out using STATISTICA v.13.3 software. Quantitative data distribution was assessed for normality with the use of the Shapiro-Wilk test. Mean value (M) and standard deviation (SD) were calculated to describe the quantitative data that matched normal distribution. Results are represented as M±SD. Quantitative values with non-normal distribution were described as median value (Me) and lower and upper quartiles (Q1-Q3). Nominal data were reported as absolute values and percentage. The Wilcoxon test was used to determine the significance of differences between compared paired samples. For independent samples the Mann-Whitney U-test was applied. Obtained values were compared to the critical value at the level of significance p=0.05. If calculated value was less than or equal to the critical one, it was concluded that the differences between compared samples were statistically significant. Comparison of two groups by quantitative values that had normal distribution was performed using the Welch's t-test.

RESULTS

Preoperative clinical study showed that all children had intermittent pain on the side of displacement associated with walking and located in the knee joint (18 cases, 56.3 %), thigh (8 cases, 25.0%) or hip joint (6 cases, 18.7%) areas. In all cases the patients had no or limited range of internal hip rotation that are 23 (71.9%) and 9 (28.1%) examinations respectively. Nineteen (59.4%) of 23 patients with no internal rotation had positive Drehmann sign. All children had no pain syndrome on the contralateral side, while hip range of motions was within the norm and the Drehmann sign was negative.

Table 1

Preoperative values of projection CCDA, EDA and EA and angles of posterior and inferior epiphyseal displacement, Me (Q1–Q3)

Hip joint	Average angle values, deg.				
	Projection CCDA (n = 64)	Projection EDA (n = 64)	EA (n = 64)	Angle of posterior displacement (n = 32)	Angle of inferior displacement (n = 32)
Without epiphyseal displacement (n = 32)	136 (132–138)	136 (132–138)	82 (80–84)	–	–
With epiphyseal displacement (n = 32)	142 (138–144)	134 (131–137)	63 (60–64)	21 (18–24)	10 (8–12)

Table 1 data show that the average posterior epiphyseal displacement was 21 (18-24)°, the average inferior displacement was 10 (8-12)°. Average value of projection CCDA in the joint with epiphyseal displacement was higher than in the joints with no displacement by 6°, that is caused by improper setup of the corresponding extremity (unavoidable external rotation) in children with positive Drehmann sign. None of 32 cases (64 joints) revealed the signs of partial epiphyseal fusion in multislice spiral CT.

Thus, before surgical treatment all children had pain syndrome, limited hip range of motions, typical mild posterior and inferior epiphyseal displacement, bony prominence on the anterior surface of the femoral neck and positive "segment" symptom on the side of displacement.

Postoperative X-rays showed that epiphysis fixation resulted stable in all cases. None of 64 joints revealed statistically significant decrease of projection EDA ($p>0.05$) and/or EA ($p>0.05$) that attests the presence of displacement or its progression.

Analyzing MRIs taken in the 19th year of life, it was defined that the above-mentioned deformity of the head-neck transitional zone of different severity was present in 25 (78.1%) of 32 joints with epiphyseal displacement, while the value of the anterosuperior α angle varied from 46° to 71°, with 60.6±7.7° in average (Figs. 3, 4).

Fibrocysts were clearly visualized in our studies in 8 (25.0%) of 32 joints with epiphyseal displacement, the anterosuperior α angle in each of 8 joints surpassed 55° (Fig. 5).

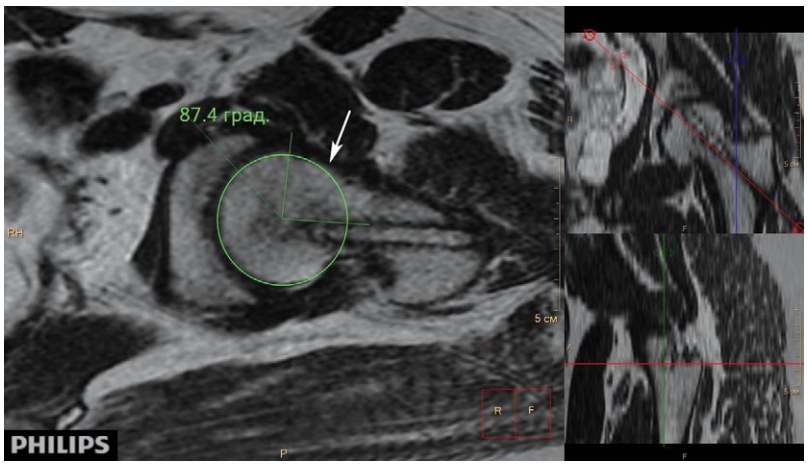

Fig. 3. MRI of the left hip (oblique axial projection, T2 weighted image) of patient 18 years 2 months old, 4 years 7 months after surgery. Deformation of head-neck junction (indicated by an arrow) — lack of normal concavity of transition and increased anterior-superior angle α to 87.4°

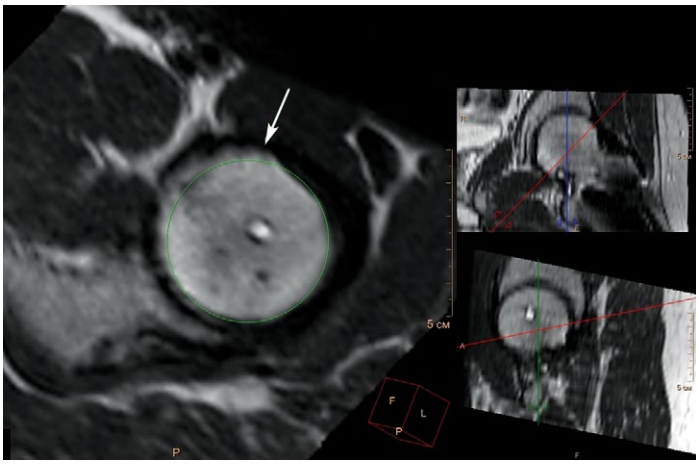

Fig. 4. MRI of the left hip (radial section at the level of head-neck junction perpendicular to the femoral neck axis, T2 weighted image) of patient 18 years 7 months old; 5 years 2 months after surgery: deformation of head-neck junction (indicated by an arrow)— excess bone mass in the anterior-superior part of the transition, which damages sphericity
of the femoral head

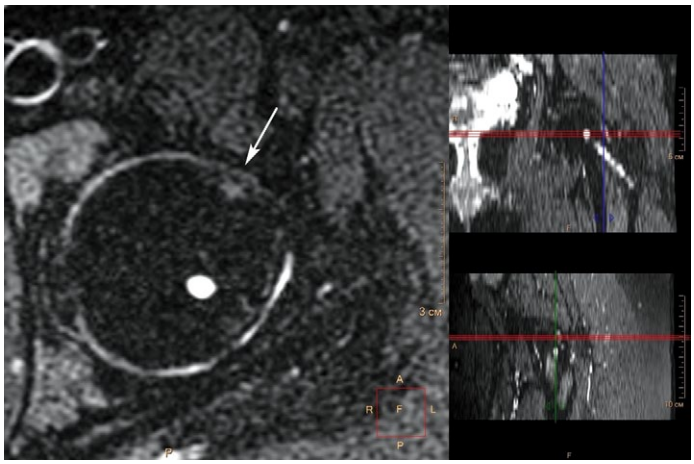

Fig. 5. MRI of the left hip (axial projection, fat suppression image) of patient 18 years 4 months old, 4 years 5 months after surgery: fibrocyst (indicated by an arrow) localized at the anterior superior margin of the femoral neck at the edge of the articular surface (at the area of impact)

As for all above-mentioned signs of cam-type FAI in the pelvic component we observed only the hyaline cartilage thinning in the anterosuperior quadrant of acetabulum in 3 (9.4%) of 32 joints with epiphyseal displacement. Value of anterosuperior α angle in each of these 3 joints surpassed 65°.

During the last examination in the 19th year of life when the signs of complete epiphyseal fusion at the growth plate level were defined, all patients were divided into 4 groups according to remodeling intensity and shape of the proximal femoral epimetaphysis on the side of displacement:

– Group I included 7 (21.9%) children with complete remodeling and no deformity (the value of the anterosuperior α angle in the MRI is 40–45°);

– Group II included 7 (21.9%) children with incomplete remodeling and insignificant residual deformity (the value of the anterosuperior α angle in the MRI is 46–55°);

– Group III included 10 (31.2%) children with incomplete remodeling and significant residual deformity (the value of the anterosuperior α angle in the MRI is 56–65°);

– Group IV included 8 (25.0%) children with no remodeling and residual deformity with the same severity (the value of the anterosuperior α angle in the MRI is 66–71°).

Each group was characterized by the combination of features.

Group I included the absence of pain syndrome in everyday life (regular excessive physical exercises such as running, weight lifting and jumping were prohibited), normal hip range of motions, negative FADIR test, negative “segment” symptom, the absence of bony prominence on the anterior surface of the femoral neck and the absence of cam-type deformity signs in the MRI (the average value of the anterosuperior α angle was 42.9±1.7°).

Group II included the absence of pain syndrome in everyday life, normal hip range of

motions (4 of 7 children) or barely noticeable (within 10°) limited internal rotation (3 of 7 children), negative FADIR test, negative "segment" symptom, the absence of bony prominence on the anterior surface of the femoral neck, unreliable signs of cam-type deformity in the MRI (the average value of the anterosuperior α angle was 50.1±3.3°).

Group III included the absence of pain syndrome in everyday life (9 of 10 children), limited hip range of motions, positive FADIR test, positive "segment" symptom, the presence of bony prominence on the anterior surface of the femoral neck (5 of 10 children had the same prominence size, other 5 children had reduced prominence), reliable signs of cam-type deformity in the MRI with significant changes of the head-neck transitional zone (the average value of the anterosuperior α angle was 61.9±3.0°) and the presence of fibrocysts (3 of 10 children).

Group IV included the presence pf pain syndrome in everyday life, limited hip range of motions, positive FADIR test, positive "segment" symptom, the presence of bony prominence on the anterior surface of the femoral neck (with the same prominence size), reliable signs of cam-type deformity in the MRI with significant changes of the head-neck transitional zone (the average value of the anterosuperior α angle was 68.3±1.5°), the presence of fibrocysts (5 of 8 children) and hyaline cartilage thinning in the anterosuperior quadrant of acetabulum (3 of 8 children). Analysis of dependence between the value of the anterosuperior α angle, FADIR test results and the presence of pain syndrome in everyday life was performed (Tab. 2).

This table shows that the pain syndrome occured in patients with positive FADIR test only ($p<0.001$). These patients who declared the presence of pain syndrome had increased α angle value ($p<0.001$). All patients with the $\alpha\geq56°$ angle had positive FADIR test ($p<0.001$), and the great majority of them suffered from pain syndrome ($p<0.001$).

The shape of proximal femoral epimataphysis was normal in all 32 cases. Postoperative X-rays of one patient of the Group IV may serve as an illustration of the absence of the proximal femoral epimetaphysis remodeling (Fig. 6). His preoperative X-rays reveal posterior epiphyseal displacement by 17° and inferior displacement by 8°, positive "segment" symptom and bony prominence on the anterior surface of the femoral neck. X-rays taken in the 19th year of life show typical cam-type deformity as well as persisted positive "segment" symptom and bony prominence on the anterior surface of the femoral neck of initial size.

Thus, FAI was confirmed in 9 (28.1%) of 32 examined patients. It is worth noticing that 8 of these 9 children had even no partial femoral component remodeling and were enrolled in the Group IV. All these 9 patients were recommended to undergo complete examination to determine the necessity of hip arthroscopy in order to remove the morphological substrate of FAI. Other 9 patients from the Group III who did not suffer from pain syndrome in everyday life but had other clinical, radiological and MR signs of cam-type deformity continued to be examined in dynamics. Complete or nearly complete remodeling of the proximal femoral epimetaphysis occured in 14 (43.8%) of 32 joints with epiphyseal displacement in patients of Groups I and II.

Table 2

Anterosuperior α angle value, FADIR test results and presence of pain syndrome in everyday life in examined patients

Feature		n	Anterosuperior α angle, deg. M±SD (min, max)	*p*	Pain syndrome «+» / «-»	*p*
FADIR test	«-»	14	46.5±4.6 (40.55)	<0.001	0/14	<0.001
	«+»	18	64.7±4.0 (56.71)		9/9	
Pain syndrome	«-»	23	52.4±8.5 (40.65)	<0.001	–	–
	«+»	9	67.9±1.8 (65.71)		–	

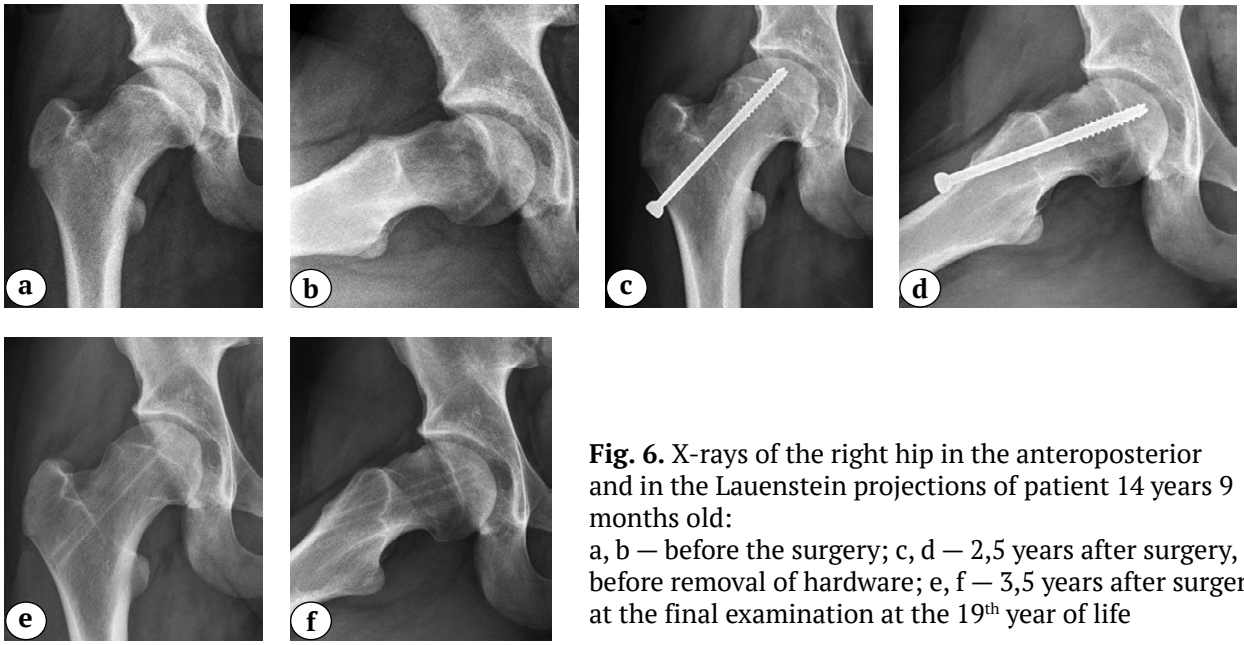

Fig. 6. X-rays of the right hip in the anteroposterior and in the Lauenstein projections of patient 14 years 9 months old:
a, b — before the surgery; c, d — 2,5 years after surgery, before removal of hardware; e, f — 3,5 years after surgery, at the final examination at the 19th year of life

DISCUSSION

Remodeling mechanism of the proximal femoral epimetaphysis in case of slipped capital femoral epiphysis due to ecchondral and enchondral growth was discovered in the middle of the past century [20, 21]. We discussed them in our pervious publications [22, 23]. Meanwhile, literature data concerning the incidence and intensity of remodeling are contradictory and rare [24, 25]. Discovered details about cam-type FAI that occurs in joints with mild residual deformity of epimetaphysis after SCFE, bring surgeons to think about the elimination of morphological substrate of FAI, specifically about arthroscopic modeling of the head-neck transitional zone in order to restore its normal concavity. Notably some authors suggest performing this remodeling right after the fixation of epiphysis [26, 27], while the others express opinion that it should be done at the second stage after the end of epiphyseal fusion at the growth plate level [28, 29]. However, FAI problem is still disregarded in the majority of publications on the topic of discussion [30, 31, 32, 33]. Current study data been analyzed, we made the conclusion that it was advisable to perform treatment and diagnostic arthroscopy of the affected joint differentially as a subsequent stage of surgical treatment. According to our findings more than one fourth of patients aged 18-19 years require this procedure.

MR signs of cam-type FAI in adult patients, particularly the studied head-neck transitional zone deformity characterized by the excess of osteochondral mass in the anterosuperior part of the zone, are described in modern literature in details [8, 9, 10, 34]. It is defined that fibrocysts located along the anterosuperior margin of the femoral neck can have a size of 2 to 15 mm, while their maximal number is registered in the joints with higher α angle values [34]. Nowadays it is proved that the anterosuperior part of acetabular labrum of the affected joint may start detaching over time from the acetabular tectorial cartilage at the level of chondrolabral transitional zone due to its chronic traumatization. Moreover, the hyaline cartilage thinning and its defect formation (cleft) may also occur in the anterosuperior quadrant of acetabulum, that, as a result, can lead to the detachment of tectorial cartilage from the underlying bone with the flap formation. Degeneration of acetabular labrum and its rupture may be observed significantly later in case of cam-type FAI as they are more typical for pincer-type impingement [6, 8, 16]. The abovementioned MR signs of cam-type FAI in the pelvic component of the joint are more often detected in adult patients. As for children, these signs usually need more time to manifest fully because of a short period of presence of femoral component deformity, that is definitely confirmed in our study. That is probably why the FAI clinical signs can be rather poor in children. Insufficient attention to the problem of cam-type deformity in children with SCFE associated with mild

chronic epiphyseal displacement seems to be caused by the absence of typical pain syndrome in the majority of young patients. We found no available data on the FAI frequency in studied cohort of patients. According to our findings, reliable MR signs of cam-type deformity are found in 56.2% of patients aged 18-19 years, while 28.1% of patients with this deformity report on pain syndrome during everyday activity, that is typical for FAI.

It should be reminded that out of all children with mild epiphyseal displacement we enrolled in our study those who had the lowest remodeling potential of epimetaphysis due to their age (no less than 13 years old) and the most severe anatomic dysmorphology.

CONCLUSION

Complete or partial remodeling of the proximal femoral epimetaphysis in case of slipped capital femoral epiphysis associated with mild chronic epiphyseal displacement was determined after its fixation with self-tapping cannulated screws in 75.0% of clinical cases (Groups I, II and III). There was no remodeling in 25.0% of cases (Group IV).

Reliable signs of cam-type deformity in hip joint MRIs taken in the 19th year of life were identified in 56.2% of clinical cases (Groups III and IV). Meanwhile, this deformity manifested in everyday life with pain syndrome typical for FAI only in 28.1% of cases (Group IV and 1 patient of the Group III).

Treatment and diagnostic hip arthroscopy consisted of remodeling of the head-neck transitional zone for recovering its normal concavity at the age of 18-19 years old is indicated for 28.1% of patients (Group IV and 1 patient from the Group III) with reliable clinical, radiological and MR signs of FAI, while 21.9% of patients (Group I) do not need this surgery due to complete remodeling of the proximal femoral epimetaphysis.

DISCLAIMERS

Author contribution

Barsukov D.B. — study design, collection and processing of data, literature review, writing the draft.

Bortulev P.I. — text editing, collection and processing of material.

Baskov V.E. — collection and processing of data.

Pozdnikin I.Yu. — collection and processing of data.

Murashko T.V. — collection and processing of data.

Baskaeva T.V. — collection and processing of data.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

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