SURGICAL STRATEGIES IN THE TREATMENT OF ASEPTIC NECROSIS OF THE FEMORAL HEAD IN CHILDREN

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ABSTRACT

This abstract presents the results of a study analyzing the immediate outcomes of surgical treatment in 72 children, aged 7 to 12 years, who presented with multilane deformities of the proximal femur and aseptic necrosis of the femoral head following bloodless reduction of congenital hip dislocation. The study examines different surgical approaches employed in the treatment, including extra-articular or open centering of the femoral head with intervertebral detorsion-varizing or devarizing, rotational osteotomy of the femur with apophysiodesis, and reduction of the large trochanter in the caudal direction.

The results indicate that all patients experienced the disappearance of pain and lameness, along with improved internal rotation of the lower extremities during walking and increased range of motion in the hip joint. Radiometric indicators assessing the ratios of the acetabulum and femoral head, as well as the angular values of the hip joint and proximal femur, demonstrated improvement. Corrective intervertebral rotational osteotomies of the femur with apophysiodesis or transposition of the great trochanter proved to be successful in treating multi-plane deformities of the proximal femur following bloodless reduction of congenital hip

dislocation in children. These surgical interventions effectively altered the spatial position of the femoral head and neck in three planes and normalized the position of the large trochanter.

In conclusion, the findings of this study highlight the efficacy of specific surgical techniques in addressing complex deformities of the proximal femur in children with aseptic necrosis after congenital hip dislocation. The described operations not only relieved pain and improved functional outcomes but also brought about positive radiometric changes. These results contribute to the understanding of treatment options and provide valuable insights for orthopedic surgeons and pediatric traumatologists in managing similar cases.

KEYWORDS: aseptic necrosis, avascular necrosis, femoral head, children, surgical tactics, core decompression, osteotomy, hip arthroplasty.

INTRODUCTION

Aseptic necrosis of the femoral head (ANFH) is a common and severe complication that occurs after reduction of congenital hip dislocation in children. It leads to early development of dysplastic coxarthrosis, significantly prolongs the healing period for children, and largely determines the functional and anatomical outcomes [1,3,5,8]. According to the literature, the frequency of this complication following closed reduction of hip dislocation varies from 10% to 60% [13,18,20]. Approximately 60-80% of patients experience a chronic course of the disease, resulting in the development of gross anatomical deformations in the proximal part of the femur. Undoubtedly, repeated unsuccessful attempts at reduction, regardless of the cause, combined with prolonged immobilization in a cast in an antiphysiological position of the lower extremities, lead to iatrogenic damage to the joint structure and vascular disorders, ultimately initiating the development of various deformations of the femoral head [2,3,4,6,9,15,19]. Deformations of the proximal part of the femur

(PPF) in children following ANFH are not uncommon and often require complex surgical interventions [11,17,21]. The severity of residual deformations, according to Luhmann S.J. et al. and Herold H.Z., depends on the severity of the involvement of the ossification center of the femoral head epiphysis at the onset of the pathological process [16,20]. It is believed that type II deformity according to Kalamchi is the most common, accounting for 25% to 61% of cases [17,19]. Often, in this type of pathology, in addition to the aforementioned problems, multidirectional deformations of the PPF develop [4]. The treatment of type II deformity of the PPF according to Kalamchi-MacEwen is extremely challenging, with the correction of multidirectional deformations considered the most difficult. The primary goal of the intervention is to normalize all deviations "as much as possible" [22], and the literature dedicated to it is scarce [19]. The issue of treating ANFH and the consequences of lateral part growth plate disturbance in the proximal femur do not always lead to satisfactory results [7,11,12,17,22]. Surgical methods are the only means to normalize joint relations, with N. Clarke emphasizing the importance of "minimizing deformations surgically," and Yu.I. Pozdnikin considering the "restoration of joint shape and function" as the ideal treatment [9]. Surgical correction methods for PPF deformations should be applied differentially in different age groups, considering the results of comprehensive assessment of the hip joint's condition and biomechanical prognosis for its development after the planned reconstruction. These interventions are performed in patients older than two years with pronounced residual deformations of the proximal femur following ANFH after conservative treatment of congenital hip dislocation, in the outcome stage, when there are clear signs of decentralization and incongruity of joint surfaces.

MATERIALS AND METHODS

The immediate treatment outcomes of 72 children, aged 7 to 12 years, with multidirectional deformations of the proximal part of the femur following aseptic necrosis of the femoral head (ANFH) after bloodless reduction of congenital hip

dislocation, were analyzed. All patients presented with multidirectional deformations of the proximal end of the femur, including subluxation of the hip, varus or valgus deformity, shortening of the femoral neck, valgus deviation of the epiphysis, high position of the greater trochanter, and a negative articulotrochanteric distance. Radiographic examination of the hip joints was performed in anteroposterior projection with the hips in a neutral position, with internal rotation and abduction of the lower limb. Radiographic measurements were taken to assess the angular parameters of the hip joint and the proximal part of the femur, including the vertical tilt angle of the acetabulum, vertical congruence angle, acetabular angle, neck-shaft angle, anteversion angle, Alsborg angle, bone coverage coefficient, and parameters characterizing the relationship between the femoral head and the greater trochanter in the frontal plane, such as articulotrochanteric distance, trochanter-trochanter distance, and articulomalovertal distance (Fig. 1).

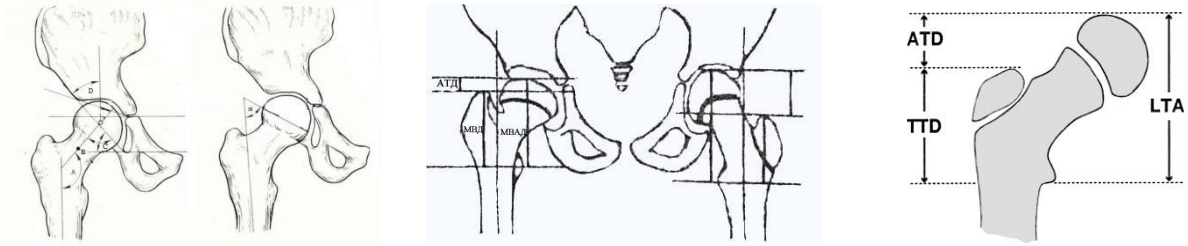

Fig. 1. Radiographic parameters of the hip joint.

The indication for corrective osteotomies was based on a combination of clinical and radiographic data, including limping, malalignment of the lower limbs, significant limitation of hip abduction, weakness of the gluteal muscles, disruption of the hip joint relationship, hip subluxation, and deformations of the proximal part of the femur, such as valgus deformity (caudal position of the greater trochanter), varus deformity (cranial position of the greater trochanter), breva deformity, relative overgrowth of the greater trochanter, and magna deformity, rather than simple lower limb shortening. The following types of surgical treatments were employed: extra-articular or open reduction of the femoral head with intertrochanteric detorsion-varizing or detorsion-devarizing and rotational osteotomies of the femur with

"apophyseodesis" or downward transposition of the greater trochanter in a caudal direction. In cases of acetabular dysplasia, corrective intertrochanteric rotational osteotomies were combined with acetabuloplasty, which was performed simultaneously with the femoral osteotomy. The treatment outcomes were analyzed within a period ranging from 8 months to 3 years. The clinical outcomes were assessed using the McKeever criteria.

Clinical Case No. 1. Patient F.N., 13 years old. On August 12, 2019, she was admitted to the department with complaints of walking with internal rotation of the lower limbs, rapid fatigue, leg tiredness, increased lumbar lordosis, and pelvic tilt. From the medical history: congenital hip dislocation was diagnosed at the age of 4 months. A plaster bandage was applied using the Shepton method for a period of 3 months. After the removal of the plaster bandage, the Vilensky splint was applied to the lower limbs. The patient began walking one year later. Aseptic necrosis of the femoral heads was diagnosed in the follow-up. A year ago, the child started limping on the right leg. According to the parents, the intensity of the aforementioned complaints increased over time, and subsequently, she developed pain in the right hip joint. In August 2019, she sought medical attention at the Regional Center for Diagnosis and Orthopedics (RCDO) with the aforementioned complaints. After examination, the diagnosis of Congenital Hip Dislocation was made. Status post-bloodless reduction. Residual hip subluxation due to aseptic necrosis of the femoral heads. Deformation of the proximal part of the femur according to Kalamchi's classification, Type IV: coxa vara, coxa breva et antetorsia, high position of the greater trochanter. Fig. 4(a).

Clinical findings: The patient walks independently but limps on the right leg. The alignment of the lower limbs is normal. The right greater trochanter is located above the Roser-Nelaton line, while the left greater trochanter is on the Roser-Nelaton line. The Trendelenburg sign is positive. Range of motion in the hip joints: extension - 180 degrees/0 degrees/180 degrees, flexion - 120 degrees/0 degrees/120

degrees, abduction - 30 degrees/0 degrees/40 degrees, internal rotation - 70 degrees/0 degrees/60 degrees, external rotation - 30 degrees/0 degrees/40 degrees. The Trendelenburg sign is positive on the left side.

Radiographic findings: The classic deformity of the proximal ends of the femurs is observed, characterized by significant shortening of the femoral neck (breva deformity), rotation of the proximal part of the femur (antetorsia), and high position of the greater trochanter. Joint stability is reduced. The articulotrochanteric distance is 1100/1200, with the tip of the right greater trochanter located above the joint space (negative value). The tip of the left greater trochanter is in line with the joint space. There is a 1 cm discontinuity in the Shenton's line, and incongruence of the joint surfaces is noted. Fig. 1(a).

Fig. 1 (a)

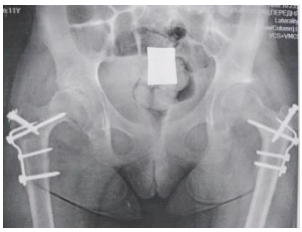

Fig. 1 (b)

Fig. 1 (c)

Fig. 1(a): Classic deformity of the proximal ends of the femurs: hip subluxation, significant shortening of the femoral neck (breva deformity), rotation of the proximal part of the femur (antetorsia), high position of the greater trochanter of the femur (ATD is negatively valued at -10mm on the right, while on the left, the tip of the greater trochanter is slightly closer to the upper pole of the femoral head, and the ATD is 2mm). Joint stability is reduced. Articulotrochanteric distance is 1100/1200, with a 1.0 cm discontinuity in the Shenton's line, and incongruence of the joint surfaces is noted.

On April 15, 2019, surgical intervention was performed: Extra-articular centration of the left femoral head with intertrochanteric detorsion-valgus-external rotation osteotomy of the femur and transposition of the greater trochanter. Fig. 1(b).

After receiving two courses of rehabilitation treatment, on December 5, 2019, surgical intervention was performed: Extra-articular centration of the right femoral head with intertrochanteric detorsion-valgus-external rotation osteotomy of the femur and transposition of the greater trochanter. Fig. 1(b).

Fig. 1(b): Postoperative outcome: The femoral heads are centered on the acetabular fossae, the femoral necks are elongated, the joint surfaces are congruent, and the position of the greater trochanters is normalized (ATD measures 25mm/23mm). The continuity of the Shenton's line is restored.

Six months after the surgical treatment, on June 4, 2020, removal of the metal construct from the proximal part of the femurs was performed.

Two years after the surgery, the patient walks independently without limping. The length of the lower limbs is equal, and the alignment is normal. The greater trochanters of the femurs are on the Roser-Nelaton line. The Trendelenburg sign is negative. Range of motion in the hip joints: extension - 180 degrees/0 degrees/180 degrees, flexion - 120 degrees/0 degrees/120 degrees, abduction - 500 degrees/0 degrees/500 degrees, internal rotation - 400 degrees/0 degrees/40 degrees, external rotation - 300 degrees/0 degrees/300 degrees. Fig. 1(c).

Fig. 1(c): Postoperative radiographic result after two years: The femoral heads are centered on the acetabular fossae, the femoral necks are elongated, the joint surfaces are congruent, the position of the greater trochanters is normalized, and the continuity of the Shenton's line is restored. The position of the greater trochanters of the femurs is normalized (ATD measures 25mm/23mm). The achieved joint relationships after the osteotomy are maintained, and the joint space is of sufficient height.

Clinical Case Study #2. Patient N.M. was admitted to the department with complaints of walking with internal rotation of the lower limbs, rapid fatigue during prolonged walks, leg fatigue, increased lumbar lordosis, and pelvic tilt. From the medical history: congenital hip dislocation was diagnosed at 6 months of age. Treatment included the application of a plaster cast using the Sheptun method for a

duration of 2 months. After the removal of the plaster cast, a Vilensky splint was applied to the lower limbs. The patient started walking after 2 years. Over time, she developed Aseptic Necrosis of the Femoral Heads, which resulted in residual hip subluxation. She received inpatient treatment at the N.K. Krupskaya Sanatorium for 3 years due to this condition. In 2020, she presented with the aforementioned complaints at the Regional Center for Diagnosis and Treatment of Orthopedic Diseases (RCDO). According to the parents, the intensity of the aforementioned complaints increased over time. After examination, the diagnosis was established as Congenital Hip Dislocation. Condition after bloodless reduction. Residual hip subluxation due to aseptic necrosis of the femoral heads. Deformation of the proximal section of the femur, classified as Type IV according to Kalamchi's classification: coxa vara, coxa breva et antetorsia, and a high position of the greater trochanter.

Clinical findings: the patient walks with internal rotation of the lower limbs, limping on the right leg, increased lumbar lordosis, and pelvic tilt. The length of the lower limbs is equal, with a straight axis. The Trendelenburg sign is positive. Range of motion in the hip joints: extension - 180°/0°/180°, flexion - 120°/0°/120°, abduction - 40°/0°/50°, internal rotation - 70°/0°/60°, external rotation - 40°/0°/40°.

Radiologically: classical deformation of the proximal section of the femur is observed, characterized by shortening of the femoral neck (coxa breva), anterior rotation of the proximal section of the femur (antetorsia), and a high position of the greater trochanter (relative overgrowth of the greater trochanter). Joint stability is reduced, the femoral head and neck are shortened. Shenton's line disruption is observed by 1.0 cm. The tops of the greater trochanters are positioned above the joint space (ATD: with a negative value of -25mm/8mm), and there is incongruity of the joint surfaces and multiplanar deformation of the proximal section of the femur. Fig. 2(a).

Fig. 2(a). X-ray and CT scan of the hip joints: deformation of the proximal section of the femur, characterized by shortening of the femoral neck (coxa breva), anterior rotation of the proximal section of the femur (antetorsia), and a high position of the greater trochanter (relative overgrowth of the greater trochanter). Joint stability is reduced, the femoral head and neck are shortened. SHDU: 1000/1100, the tops of the greater trochanters are positioned above the joint space (ATD: with a negative value), Shenton's line disruption is observed by 1.0 cm, there is incongruity of the joint surfaces and multiplanar deformation of the proximal section of the femur.

On September 16, 2020, a surgical intervention was performed: extra-articular centration of the left femoral head with intertrochanteric detorsional-valgus-rotational osteotomy of the femur and transposition of the greater trochanter. Fig. 2(b).

Fig. 2 (a) Fig. 2 (b) Fig. 2 (c) Fig. 2 (d)

Рис. 2(b): Surgical procedure performed: corrective intertrochanteric osteotomy of the left femur with fixation of bone fragments using a Blount-type fixator and three screws. The left femoral head is centered in the acetabulum, the femoral neck is lengthened, the joint surfaces are congruent, the joint space is of sufficient height, and the position of the greater trochanter is normalized by being lowered caudally with the fixation of two screws. SHDU: 1250, ATD: 25mm. The continuity of Shenton's line is restored.

After receiving two courses of rehabilitation treatment, another surgical intervention was performed on the right hip joint on February 16, 2021: extra-articular centration of the right femoral head with intertrochanteric detorsional-valgus-rotational osteotomy of the femur and transposition of the greater trochanter. Fig. #2(c).

Fig. 2(c): Surgical procedure performed: corrective intertrochanteric osteotomy of the right femur with fixation of bone fragments using a Blount-type fixator and three screws. The right femoral head is centered in the acetabulum, the femoral neck is lengthened, the joint surfaces are congruent, the joint space is of sufficient height, and the position of the greater trochanter is normalized by being lowered caudally with the fixation of two screws. SHDU: 1250, ATD: 22mm. The continuity of Shenton's line is restored.

After 8 months of postoperative treatment, the patient walks with the help of crutches. She continues to receive scheduled rehabilitation treatment. Range of motion in the hip joints: extension - $180^0/0^0/180^0$, flexion - $100^0/0^0/100^0$, abduction - $50^0/0^0/60^0$, internal rotation - $30^0/0^0/40^0$, external rotation - $30^0/0^0/40^0$. Fig. 2(d).

Fig. 2(d): After 18 months of postoperative treatment: the femoral heads are centered in the acetabula, with good coverage of the roof of the acetabulum, SHDU: 1250/1250, ATD: 8mm. The intervention allowed for the restoration of the centration of the femoral heads, neck-diaphyseal angles, improved congruence of the joint surfaces, normalized position of the greater trochanters, improved joint biomechanics, lengthened femoral necks, and overall improvement in the limb.

Clinical Case #3: Patient E.E., born on July 24, 2011, presented to the clinic with complaints of pain and fatigue in the left hip joint after physical exertion. Previously treated conservatively for congenital dislocation of the left hip. Diagnosis: Congenital dislocation of the left hip. Status post closed reduction. Residual subluxation of the left hip due to aseptic necrosis of the femoral head. Deformation of the proximal section of the femur, classified as Type II according to Kalamchi: coxa vara, coxa breva, and antetorsia, high position of the greater trochanter. Acetabular dysplasia.

Clinical presentation: walks independently, limping on the left lower limb. Range of motion in the hip joints in the sagittal plane is normal: extension - $180^0/0^0/180^0$, flexion - $120^0/0^0/120^0$, abduction - $50^0/0^0/30^0$, internal rotation - $40^0/0^0/60^0$, external rotation - $30^0/0^0/30^0$. Trendelenburg sign is positive on the left side.

Fig. 3 (a)

Fig. 3 (b)

Fig. 3 (c)

Fig. 3 (d)

Radiologically, there is noted a classical deformation of the proximal part of the left femur bone, classified as type II: shortening of the femoral neck (coxa breva), anterior rotation of the proximal femur (antetorsion), and hypertrophy of the greater trochanter. Joint stability is reduced, with significant shortening of the femoral head and neck. The hip-to-diaphysis angle is $130^0/125^0$, and the apex of the greater trochanter of the left femur bone is positioned slightly closer to the upper pole of the head (left anterior displacement of 10 mm) with a Shenton's line discontinuity of 1.0 cm. See Figure 3(a,b).

Figure No. 3(a): Radiograph of the hip joints showing a subluxation of the left femoral head, classical deformation of the proximal part of the left femur bone with femoral neck shortening (coxa breva), anterior rotation of the proximal femur (antetorsion), and hypertrophy of the greater trochanter. Joint stability is reduced, with significant shortening of the femoral head and neck. The hip-to-diaphysis angle is $130^0/100^0$, and the apex of the greater trochanter of the left femur bone is positioned slightly closer to the upper pole of the head (left anterior displacement of 10 mm) with a Shenton's line discontinuity of 1.0 cm.

Figure No. 3(b): Radiograph in the position of internal rotation of the left lower extremity, showing shortened and thickened femoral head and neck, centered on the acetabulum floor. The hip-to-diaphysis angle is 100^0, with an anterior displacement

of 10 mm. There is a Shenton's line discontinuity of 1.0 cm, indicating acetabular dysplasia.

On February 22, 2019, a surgical intervention was performed, involving extra-articular centration of the left femoral head with intertrochanteric detorsion-valgization-posterior rotation osteotomy of the femur, greater trochanter apophyseodesis, and Pemberton's plastic surgery of the acetabular roof. See Figure No. 3(c).

Figure No. 3(c): Postoperative status after two years, the left femoral head is centered on the acetabular floor, and there is an intertrochanteric correction of the femur with fixation of bone fragments using a "G" plate and three screws, greater trochanter apophyseodesis with two screws, pericapsular plastic surgery of the acetabular roof with distal fragment inclination anteriorly, laterally, and downwards, including the insertion of an autograft transplant into the formed slot and synthesis with a wire. The hip-to-diaphysis angle is $130^0/130^0$.

On August 8, 2019, a surgical intervention was performed to remove the metal construction from the proximal part of the left femur and the wing of the ilium.

Figure No. 3(d): Result after two years of operative treatment, the left femoral head is centered on the acetabular floor, with good coverage of the acetabular roof. The hip-to-diaphysis angle is 1300/1300, with an anterior displacement of 8 mm. The intervention allowed for the restoration of the centration of the left femoral head, the cervicodiaphyseal angle, improved congruence of the joint surfaces, normalization of the position of the greater trochanter, improved joint biomechanics, and lengthening of the femoral neck and the extremity as a whole.

RESULTS AND DISCUSSION

Disruption of growth and formation of the proximal end of the femur depends on the premature closure of the growth plate, its "epiphysiodesis," in one or another segment after non-traumatic reduction of congenital hip dislocation. Patients presented to the clinic with complaints of pain and fatigue in the hip joint after

physical exertion. They had previously received conservative treatment for congenital hip dislocation. During the follow-up, aseptic necrosis of the femoral head was diagnosed, leading to various deformations of the proximal femur depending on the child's age and the anatomical condition of the hip joint at that time. Most patients sought hospitalization due to walking with internal rotation of the lower limbs, limping, and rapid fatigue during prolonged walks and leg fatigue. We evaluated radiographic criteria for stability, centration of the femoral head in the acetabulum, and congruence of the affected hip joints. Radiographic monitoring was conducted at 3-6-12 months after surgery and then annually. The proposed methods for surgical correction of deformations in the proximal femur are effective interventions that improve clinical and radiographic indicators of the hip joint, thereby expanding the possibilities of reconstructive and restorative surgery in this group of children. Analysis of the results of surgical treatment showed that correction of secondary anatomical changes in the proximal femur and joint relationships has a positive effect on the reparative processes and prevents further progression of pathology.

CONCLUSION

Surgical intervention in childhood should take into account not only existing deviations but also the deformations that inevitably occur due to the continued functioning of the damaged growth zones in the proximal femur. Dystrophic lesions after non-traumatic reduction of congenital hip dislocation can affect the femoral head in combination with involvement of the growth plate of the femoral neck. Disruption of growth and formation of the proximal femur depends on the premature closure of the growth plate, either partially or completely, in one or another segment after non-traumatic reduction. Deformation often accompanies joint instability, both due to valgus deviation of the femoral head and secondary dysplasia of the acetabulum, displacement of the femoral head, incongruity of the joint surfaces, and

proximal migration of the greater trochanter. Each type of deformity requires correction of its inherent deviations, including multi-planar ones. Corrective intertrochanteric rotational osteotomies of the femur with transposition of the greater trochanter can be successfully used in the treatment of multi-planar deformations of the proximal femur in children, as they allow for changes in the spatial position of the femoral head and neck in three planes and normalize the position of the greater trochanter. In cases of acetabular dysplasia, they can be complemented by acetabular reconstruction.

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