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CORRECTION OF FEMORAL DEFORMITIES OF INFLAMMATORY GENESIS (OSTEOMYELITIS SEQUALAE) IN CHILDREN: AN ANALYSIS OF THE TREATMENT RESULTS OF 76 PATIENTS

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Background. In most cases, haematogenic osteomyelitis affects the long bones of the skeleton. Predominantly, the centers of destruction are located in the lower extremities. The orthopedic complications of haematogenic osteomyelitis were observed (according to different data) in 22%–71.2% of childhood cases. In 16.2%–53.7% of cases, the complications can lead to childhood (nascent) disability.
Aim. The purpose of the research is to conduct a retrospective analysis of femoral deformity correction results in children with haematogenic osteomyelitis consequences by applying both an Ortho-SUV Frame™ (based on passive computer navigation) and following the Ilizarov method.
Materials and methods. The study examined 76 patients of both genders aged between 8 and 17 years old who were experiencing the consequences of haematogenic osteomyelitis in the long bones of the lower extremities. A comparative assessment of the parameters reflecting the effectiveness of circular external fixation in combination with an Ortho-SUV Frame™ and the Ilizarov method was conducted. Reference lines and angles before and after surgery, elongation size, distraction time, deformity correction period, external fixation index, number of complications, and the functional result were all considered.
Results. All the children underwent deformity correction surgery, and the length of the afflicted lower extremity segment was reconstructed (restored). The use of the repositioning unit enabled a higher correction accuracy (94.45%) of the femur in comparison with the Ilizarov frame (30%). The frequency of excellent functional results in the first group of patients was more than 1.5 times higher than in the second group, whereas the satisfactory results turned out to be almost twice as low. Fewer complications were observed while using the Ortho-SUV hexapod.
Conclusions. The application of the Ortho-SUV Frame™ at the long-bone-deformity-correction stage facilitates an increase in the efficiency of the circular external fixation method.

Keywords: haematogenic osteomyelitis consequences; deformity correction; hexapods.

КОРРЕКЦИЯ ДЕФОРМАЦИЙ БЕДРЕННЫХ КОСТЕЙ ОСТЕОМИЕЛИТИЧЕСКОГО ГЕНЕЗА У ДЕТЕЙ: АНАЛИЗ РЕЗУЛЬТАТОВ ЛЕЧЕНИЯ 76 ПАЦИЕНТОВ

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Обоснование. Острый гематогенный остеомиелит в большинстве случаев поражает длинные кости скелета. Преимущественно очаги поражения локализуются в нижних конечностях. Ортопедические осложнения гематогенного остеомиелита наблюдаются у 22–71,2 % детей и у 16,2–53,7 % приводят к ранней инвалидности.

Цель — провести ретроспективный анализ результатов коррекции деформаций бедренных костей у детей с последствиями гематогенного остеомиелита с использованием основанного на пассивной компьютерной навигации репозиционного узла Орто-СУВ и по методике Илизарова.

Материалы и методы. Обследованы 76 пациентов обоего пола в возрасте от 8 до 17 лет с последствиями гематогенного остеомиелита длинных костей нижних конечностей. Проведена сравнительная оценка параметров, отражающих эффективность методики чрескостного остеосинтеза в сочетании с аппаратом Орто-СУВ и по методике Илизарова. Учитывали значения референтных линий и углов до и после операции, величину удлинения, длительность дистракции, период коррекции деформации, индекс внешней фиксации, а также количество осложнений и функциональный результат.

Результаты. Всем детям была выполнена коррекция деформаций и восстановлена длина пораженного сегмента нижней конечности. При применении репозиционного узла была достигнута более высокая точность коррекции (94,45 %) бедренной кости по сравнению с аппаратом Илизарова (30 %). Частота отличных функциональных результатов в 1-й группе больных была более чем в полтора раза выше, чем во 2-й группе, а удовлетворительных — почти в два раза ниже. При использовании гексапода Орто-СУВ наблюдалось меньшее число осложнений.

Заключение. Применение на этапах коррекции деформации бедренных костей аппарата Орто-СУВ позволяет повысить эффективность методики чрескостного остеосинтеза.

Ключевые слова: последствия гематогенного остеомиелита; коррекция деформаций; гексаподы.

Acute hematogenous osteomyelitis most often affects long tubular bones of the lower extremities [1, 2] and causes the development of orthopedic complications in 22%–71.2% of patients [3]. Due to the immaturity of the metaepiphyseal growth zones of long bones in young pediatric patients, as well as the presence of transphysial blood vessels, the inflammatory process can spread from the metaphysis to the epiphysis and lead to lesions therein of varying severity [4].

However, osteomyelitis does not always lead to significant or complete destruction of the bone and cartilage tissue of the epiphysis. In some cases, to one degree or another, it only slows down the ossification processes. In this case, the inflammatory process can affect the metaepiphyseal growth zone of the bone. Under these conditions, the growth plate itself may be subject to partial or complete destruction, due to which its function decreases or is completely disrupted with the development of a deformity of varying direction or shortening of the affected bone [5]. During the child's growth period, deformities of long bones change over time and cause a persistent disorder of the support ability of the lower limbs.

Waldegger et al. (2001) characterized the development of angular deformities of the knee joint as a severe complication after damage to growth zones and noted that they occurred in 35% of cases after partial damage to the distal growth zone of the femur and in 30% of cases of the proximal growth zone of the tibia [6]. In past studies, there have also been indications that a change in the physiological mechanical axis of the limb and normal orientation of the joints shifts the load vector on the hip, knee, and ankle joints and creates the prerequisites for degenerative and dystrophic changes [7]. All of the above necessitate the prompt surgical correction of lower limb bone deformities in pediatric patients.

It is known that multicomponent, multiplane deformities of long bones, accompanied by shortening, can be treated only with the use of external fixation devices (EFD), which enable the elimination of all components of the deformity proportioned in time and restoration of limb length [8]. The use of devices is also indicated for patients with simple types of deformities, which is especially important for osteomyelitis occurring due to significant cicatricial changes in soft tissues and circulatory disorders in the affected segment [9].

Recently, hexapods have become widespread for the correction of multiplanar limb deformities. They exclude the need for a staged replacement of unified nodes, which results in their increasing demand [10]. One of the prominent representatives of the aforementioned devices is the Ortho-SUV apparatus, which is a universal reposition unit, the mechanics of which are based on computer navigation, which enables not only elimination of a deformity in three planes simultaneously but also the achievement of a high correction accuracy [11]. Despite the rather frequent use of the Ortho-SUV apparatus in the treatment of adult deformities, its use in pediatric practice is not yet widespread [12]. The available literature does not cover the issues of correction of deformities of long bones of the lower extremities in pediatric patients after an inflammatory process with the combined use of these surgical techniques.

This work aimed to perform a retrospective analysis of the results of correction of femoral deformities in pediatric patients with the consequences of hematogenous osteomyelitis, using the Ortho-SUV repositional node based on passive computer navigation and in accordance with the Ilizarov method.

Materials and methods

The study was based on a preliminary, comprehensive examination and treatment of 76 pediatric patients aged 8 to 17 years with the consequences of hematogenous osteomyelitis of the lower extremities and was conducted in the period from 2014 to 2017 in the Department of Bone Pathology. Group 1 included 40 patients whose treatment included the use of transosseous osteosynthesis followed by the use of the Ortho-SUV reposition unit, and group 2 included 36 patients who underwent deformity correction according to the Ilizarov method.

At the age of 8–15 years, functional growth zones remain in patients, which in some cases affects the possibility of deformity relapse. The groups were comparable by gender and age (Tab. 1, 2). Based on Table 3, there were more common deformities in group 2, and moderately complex and complex deformities were revealed more often in group 1.

All patients in group 1 underwent panoramic radiography of the lower extremities in two projections before and after surgery. Based on X-ray patterns, correction of the femoral deformity was planned according to the generally accepted algorithm, and deformity characteristics were determined (reference lines and angles (RLA)

Table 1

Gender distribution of patients

Group	Gender		Total
	male	female	
	n (%)	*n* (%)	*n* (%)
1	21 (52.5)	19 (47.5)	40 (100)
2	22 (61)	14 (39)	36 (100)

Table 2

Patient distribution by age

Group	Age, years		Total (%)	$M \pm m$
	8–15	16–17		
	n (%)	*n* (%)	*n* (%)	
1	32 (80)	8 (20)	40 (100)	12.25 ± 2.88
2	27 (75)	9 (25)	36 (100)	12.58 ± 2.92

Table 3

Distribution of deformities by degree of complexity in accordance with the practical classification of deformities of long tubular bones [13]

Group	Type of deformity			
	common	moderate	complex	total
	n (%)	*n* (%)	*n* (%)	*n* (%)
1	5 (12.5)	24 (60)	11 (27.5)	40 (100)
2	9 (25)	20 (55.5)	7 (19.5)	36 (100)

Note. n — number of cases, % — percentage ratio.

Table 4

Type and indicators of deformity (preoperative data)

Type of deformity (normal values)	Group 1 $M \pm m$	Group 2 $M \pm m$	p
Shortening, cm	4.01 ± 0.81	3.91 ± 0.98	>0.05
Valgus of mLDFA (85–90°)	79.55 ± 2.97	78.53 ± 2.03	>0.05
mLPFA (85–95°)	80.38 ± 2.91	99.21 ± 2.45	>0.05
MAD (0–9.7 ± 6.8 mm inwards)	6.27 ± 1.96 outwards	6.86 ± 1.24 outwards	>0.05
Varus of mLDFA (85–90°)	94.5 ± 2.1	96 ± 2.21	>0.05
mLPFA (85–95°)	78.73 ± 2.68	101.75 ± 3.27	<0.05
MAD (0–9.7 ± 6.8 mm inwards)	5.14 ± 1.51 inwards	6 ± 1.34 inwards	>0.05
Antecurvature of aPDFA (79–87°)	75.27 ± 1.84	73.2 ± 1.87	<0.05
Recurvation of aPDFA (79–87°)	91 ± 1.6	94.75 ± 1.7	<0.05

Note. mLPFA — mechanical lateral proximal femoral angle; mLDFA — mechanical lateral distal femoral angle; MAD — mechanical axis deviation; aPDFA — anatomical posterior distal femoral angle.

were used) [14] (Table 4). The data on patients from group 2 were archival material; their X-ray examination was performed in a similar way. The groups differed significantly in terms of varus, antecurvational, and recurvational deformities, while deformities were more pronounced in the patients of group 1.

In group 1, surgical interventions included the application of an EFD on the hip, a single-level osteotomy of the femur at the apex of the deformity, followed by lengthening of this segment along the distraction rods in the standard mode, and final correction of the deformity using the Ortho-SUV module. Patients of group 2 underwent simultaneous correction of the deformity intraoperatively with further lengthening (24 patients) or correction using standardized units of the Ilizarov apparatus (12 patients) in the postoperative period. To prevent recurrence of the femoral deformity during partial closure of the distal growth zone, in some cases, surgical intervention was supplemented with epiphysiodesis of the remaining intact part by drilling, and in the process of using the Ortho-SUV repositional node, hypercorrection was performed within the limits of the extreme normal values of the RLA (group 1). Hypercorrection was not performed in patients of group 2.

The results were analyzed by X-ray data based on RLA, including the mechanical axis deviation (MAD). The results obtained were compared with the values obtained before surgery and with normal values. The MAD was evaluated only in cases of monosegmental deformity. In the remaining patients (2 patients with polysegmental deformities), only the RLA of the femur were considered. We also evaluated the timing of consolidation, the number and nature of complications, and the outcome of treatment using the Lower Extremity Functional Scale (LEFS). The terms for evaluating long-term results ranged from 1 year to 3 years.

All complications were divided into three categories according to J. Caton [15].

Category 1 included patients treated without complications or with minimal complications that did not affect the treatment outcome (residual deformities of the femur that do not change the axis of the limb, contractures of mild joints adjacent to the elongated segment, inflammation of the soft tissues around transosseous elements and traction neuropathy, completely eliminated by conservative treatment methods).

Category 2 included patients with complications that required additional surgical interventions but did not affect the final outcome (premature consolidation of the femur during elongation, deformity or fracture at the regenerate level with the possibility of closed reposition or re-osteotomy with restoration of the length and axis of the limb, achieved after the main stage of surgical treatment, inflammation of the soft tissues around the transosseous elements, requiring their repeated installation).

Category 3 included significant complications that required additional surgical interventions and affected the final result of treatment, in patients whose planned treatment aim was not achieved or in whom there was a complication in the long-term follow-up period, that eliminated the result achieved (fractures and deformities of the femur at the regenerate level with the inability to eliminate the deformity and restore the reached limb length using reposition).

Statistical processing of the material was performed using the Statistica for Windows software system (version 13).

Results

All pediatric patients underwent correction of a deformity and restoration of the length of the affected segment of the lower limb. The external fixation apparatus was removed after a sufficient density of the distraction regenerate of the femur was reached, which corresponded to stages IIIb–IV of its formation [16]. The effectiveness of treatment was evaluated by taking into account a number of indicators, which included the accuracy of correction, the duration of distraction, the elongation amount, the period of correction of the deformity, the index of external fixation, and the number of complications. The accuracy of the correction of a deformity of the femoral segment was determined by the RLA indices (Table 5).

In group 2, attention was drawn to the relatively high accuracy of MAD correction for varus (75%) and the low degree of correction of the varus deformity itself (16.66%), which is explained by the permissible norms of the mechanical axis deviation (0–9.7 ± 6.8 mm inwards) with its initial medial position. The results of deformity correction in group 2 in some cases were characterized by a small (within a few degrees) deviation from the range of

Table 5

Deformity correction results (reference lines and angles)

Type of deformity (normal values)	Group 1 $M \pm m$	CA, %	Group 2 $M \pm m$	CA, %	p
Valgus of mLDFA (85–90°)	87.11 ± 1.99	94.45	85.4 ± 6.45	26.66	>0.05
mLPFA (85–95°)	88.66 ± 3.81		86.13 ± 6.58		<0.05
MAD (0–9.7 ± 6.8 mm inwards)	4.66 ± 3.14 outwards	88.89	9.2 ± 2.59 outwards	13.3	>0.05
Varus of mLDFA (85–90°)	87.35 ± 1.94	92.86	94.58 ± 4.46	16.66	<0.01
mLPFA (85–95°)	92.14 ± 2.79	–	99.58 ± 3.55		<0.01
MAD (0–9.7 ± 6.8 mm inwards)	3.71 ± 2.58 inwards	85.72	9.58 ± 3.17 inwards	75	<0.01
Antecurvature of aPDFA (79–87°)	82.81 ± 2.71	91.67	80.3 ± 5.53	30	>0.05
Recurvation of aPDFA (79–87°)	85.5 ± 2.13	87.50	90.25 ± 3.59	25	<0.05

Note. AC — correction accuracy. See notes to Table 4.

Table 6

Indicators of transosseous osteosynthesis

Index	Group 1 $M \pm m$	Group 2 $M \pm m$	p
Amount of elongation, cm	4.16 ± 0.83	3.83 ± 0.94	>0.05
Duration of distraction, days	41.5 ± 9.82	40.94 ± 10.36	>0.05
Deformity correction period, days	9.52 ± 2.97	–	
Index of external fixation, days/cm	35.9 ± 6	40.26 ± 9.21	<0.05

normal RLA values. As a result, the average value of this sample did not differ from the average value of the sample in group 1; nevertheless, the number of cases beyond the limits of normal indicators corresponded to low results of correction accuracy.

In all cases in group 1, a high accuracy of deformity correction in the frontal and sagittal planes was achieved, reaching 94.45%.

Table 6 shows the indicators of transosseous osteosynthesis in the groups as a result of treatment.

The Table 6 data indicate that with comparable elongation and duration of distraction, the external fixation index was significantly lower in group 1. The period of deformity correction in group 2 was not indicated, since in the vast majority of cases, correction was performed simultaneously, directly in the process of surgery.

Data indicating the functional state of the lower limb in the groups before and after treatment are presented in Table 7.

The difference in this indicator between the groups before and after treatment was insignificant. However, the frequency of excellent results in group 1 was more than 1.5 times higher than that in group 2, and that of satisfactory results was almost 2 times lower (Table 8).

A clinical example of a patient from group 1 is illustrated in Fig. 1–3.

The nature and frequency of complications are presented in Table 9.

Soft-tissue inflammation around transosseous elements were found in both groups in the vast majority of patients with the same frequency (they were stopped by conservative measures such as changing antiseptics and antibacterial therapy). Fractures of transosseous elements, which can be attributed to the first category of complications, represented a violation of the integrity of the wires, the removal of which did not affect the stability of the EFD, and a case from category 2 of complications in group 2 led to the repeated installation of the rod due to a decrease in structural rigidity.

Contractures of the knee joints formed during distraction, despite the prescription of physiotherapy exercises, and in all cases they were noted in patients in the 15–17-year age group. Probably, the volume and, therefore, the resistance of the soft tissues affected it. Due to the additional course of exercise therapy and physiotherapy, it was possible to eliminate contractures, with the exception of two cases (one in each group) requiring surgical intervention (myotomy of the intermediate vastus muscle).

In groups 1 and 2, 1 and 2 cases of traction neuropathy, respectively, were recorded, which were caused by acceleration of the rate of distraction at a certain stage to prevent premature bone consolidation. Despite the achievement of the aim, it was necessary to reduce temporarily the rate of distraction or to suspend it and conduct neurological drug therapy. In cases when it was still not possible to prevent premature consolidation, a re-osteotomy was performed at the regeneration level (three patients).

In group 2, three cases of the formation of a hypoplastic regenerate were noted, due to which, in two cases, so-called “dynamization” of the EFD was performed, and in one case, autoplasty of the

Table 7

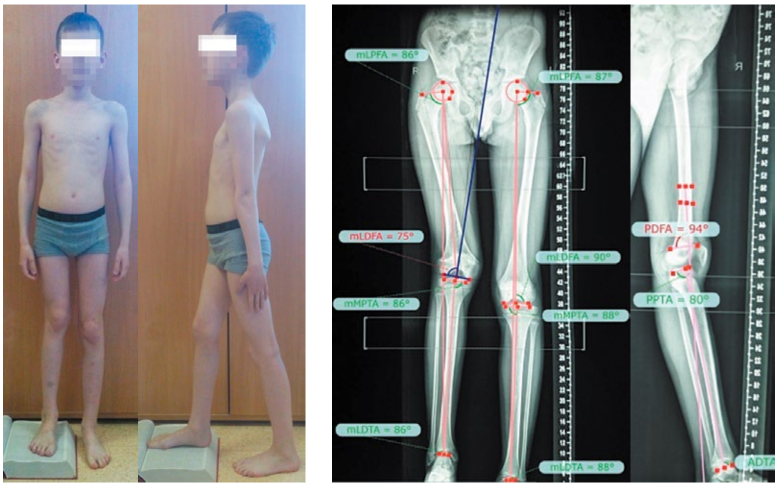
Functional state of the lower limb according to the LEFS scale

Examination period	Group 1, points $M \pm m$	Group 2, points $M \pm m$	p
Before treatment	45.55 ± 11.07	44.94 ± 9.8	>0.05
One year after treatment	64.3 ± 9.5	61.38 ± 9.73	>0.05

Table 8

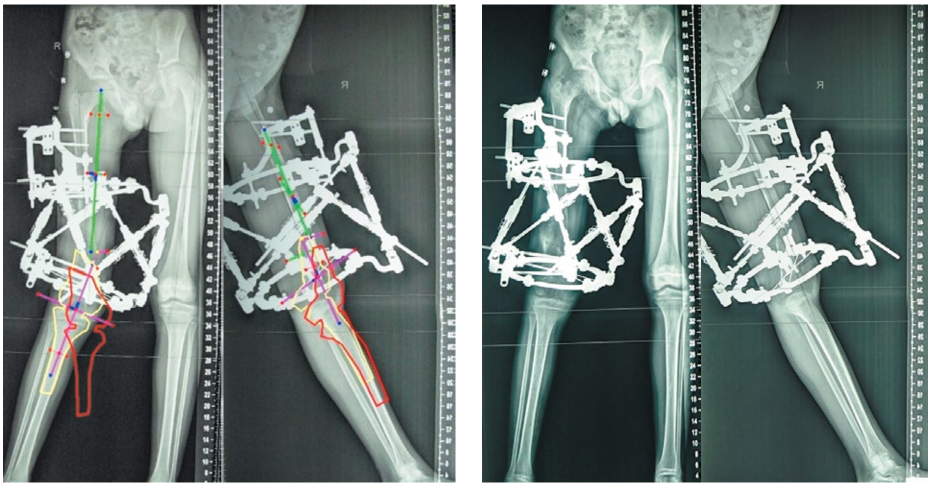
Frequency of excellent, good, and satisfactory treatment outcomes in groups

Group	Excellent results (70–80 points), %	Good results (51–69 points), %	Satisfactory results (45–50 points), %
1	32.5	57.5	10
2	19.5	61	19.5



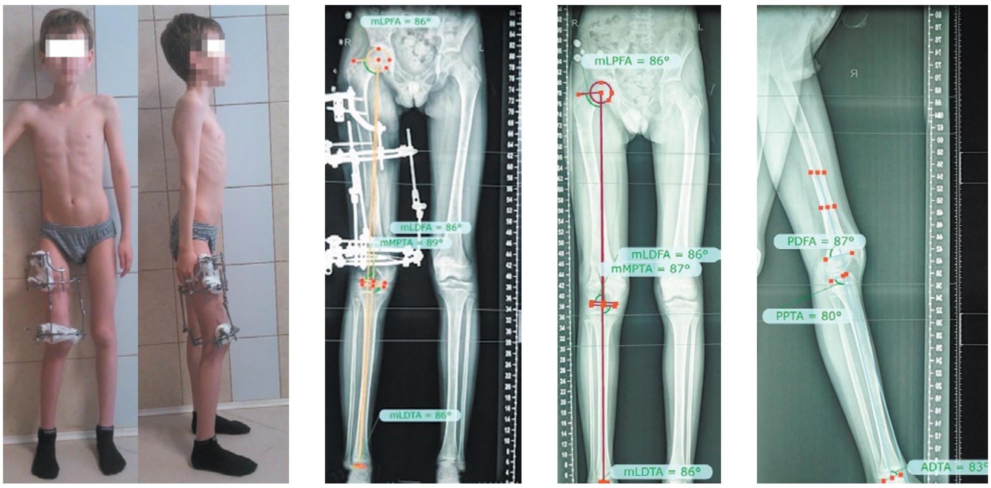
a *b*

Fig. 1. Patient G., 12 years old, with the consequences of hematogenous osteomyelitis of the right hip, before treatment: *a* — appearance; *b* — panoramic radiographs of the lower extremities, mechanical axes of the proximal and distal sections are drawn



a *b*

Fig. 2. Patient G., 12 years old, with consequences of hematogenous osteomyelitis of the right hip. Stage of planning and correction of the deformity: *a* — planning of deformity correction in the computer program of the Ortho-SUV apparatus; *b* — after deformity correction



a *b* *c* *d*

Fig. 3. Patient G., 12 years old, with consequences of hematogenous osteomyelitis of the right hip. After treatment: *a* — appearance; *b* — panoramic radiograph before removal of the external fixation device; *c, d* — panoramic radiographs 1 year after treatment, the mechanical axes of the proximal and distal sections correspond to normal values

Table 9

Categories and number of complications in groups

Complication	Group 1, *n* (%)	Group 2, *n* (%)	*p*
Category 1			
Soft-tissue inflammation around transosseous elements	37 (92.5)	32 (88.9)	<0.05
Knee joint contracture	3 (7.5)	5 (13.9)	>0.05
Fracture of transosseous elements	1 (2.5)	2 (5.5)	>0.05
Traction neuropathy	1 (2.5)	2 (5.5)	>0.05
Total	42 (105)	41 (114)	<0.05
Category 2			
Soft-tissue inflammation around transosseous elements	1 (2.5)	2 (5.5)	>0.05
Fracture of transosseous elements	0 (0)	1 (2.8)	>0.05
Premature regenerate consolidation	2 (5)	1 (2.8)	>0.05
Knee joint contracture	1 (2.5)	1 (2.8)	>0.05
Hypoplastic regenerate, delayed consolidation	0 (0)	3 (8.3)	>0.05
Total	4 (10)	8 (22.2)	>0.05
Category 3			
Regenerate fracture with loss of correction and segment length	0 (0)	1 (2.8)	>0.05
Total	0 (0)	1 (2.8)	>0.05
Total	46 (115)	50 (139)	<0.05

zone of delayed consolidation was conducted, which ultimately led to an increase in the external fixation index.

In group 2, the only case of category 3 complications was identified in the form of a regenerate fracture with loss of correction and segment length (5 cm) due to trauma in the EFD. After remounting of the EFD, its stabilization and subsequent consolidation of the femur, the patient was hospitalized for repeated surgery.

The frequency of each type of complication, taken separately, did not differ between the groups. However, category 2 complications were registered in the control group twice as often as in the main group. The only category 3 complication was the result of an injury and did not reflect the technique.

In group 1, in three cases, to prevent recurrence of the deformity during partial closure of the distal growth zone, the surgical intervention was supplemented with epiphysiodesis of the remaining intact part by reaming, and in four patients, hypercorrection was performed within the extreme normal RLA values, which is possible only with the use of a hexapod. Despite the measures taken, in the long-term follow-up period (from 1 to 3 years), some patients experienced relapses of femoral deformities due to continued growth. In group 1, one case was recorded, probably due to an insufficiently effective epiphysiodesis, and in group 2, there were three cases due to the fact that epiphysiosis was not used.

Discussion

The data obtained are consistent with the literature, indicating that the use of the Ortho-SUV reposition unit avoids multiple remounting of the EFD to eliminate each of the deformity components. In the Ilizarov apparatus, if it is impossible to eliminate the deformity simultaneously, it is necessary to change repeatedly (3-5 times) the structure using unified nodes [10, 17, 18]. When using the Ortho-SUV apparatus, it is possible to reduce the time for correction of the deformity due to the absence of the need for multiple remounting of the EFD.

The literature presents data reflecting the duration of treatment of deformities with the Taylor Spatial Frame (TSF) apparatus in comparison with other apparatuses; periods of osteosynthesis with the TSF, the Ilizarov apparatus, and the Orthofix monolateral apparatus are compared. The period of osteosynthesis using the TSF apparatus was less than with the Ilizarov apparatus and Orthofix apparatus, and the osteosynthesis index was not significantly different among the three groups [19]. In our study, only the external fixation index was significantly different, which turned out to be lower when using the Ortho-SUV apparatus. Along with the correction speed, the device is very accurate [20]. In the work of D. Dammerer (2011), a comparative assessment of the accuracy of correction by three different devices was performed. The author reports that the average values of the indicators at the end of the correction did not differ significantly. However, in our work, the use of the reposition unit enabled us to obtain significantly higher correction accuracy (94.45%) of the femur compared with the use of the Ilizarov apparatus (30%), which was due to technical aspects of the latter.

It was revealed that the duration of deformity correction by the Ortho-SUV module did not depend on its complexity and was much shorter for medium and complex deformities in comparison with the Ilizarov apparatus, but in the case of common deformities, the advantages were not so obvious [21]. Indeed, in the correction of medium and complex deformities, the Ortho-SUV has obvious advantages due to the ability to eliminate simultaneously all components of these deformities, and the decrease in the external fixation index is probably due to the fact that correction with the Ortho-SUV apparatus is performed along a single, integral path, which affects positively the properties of the distraction regenerate.

The term "complication" in transosseous osteosynthesis is interpreted ambiguously, and various options for determining and classifying complications can be revealed [22–25]. The data on complications in elongation and/or correction of femoral deformities by various methods also differ significantly and range from 39.6% [26] to 100% [27]. The J. Caton classification of complications (1991) is the most informative, as it sufficiently evaluates the outcome of treatment. Soft-tissue inflammation around transosseous elements, according to various authors, ranges from 8.2% to 96% [8, 19, 23, 25, 26]. In our study, the high percentage of complications of category 1 (>100%) is explained by the fact that one patient had several of them, while the total number of complications was lower in group 1.

Regarding the functional indicators of treatment, we did not find any obvious differences depending on the EFD type, which presumably indicates the influence of the pathology itself and not of the EFD used. For prophylactic purposes, the use of epiphysiodesis of the intact part of the distal growth zone of the femur with partial closure is justified; nevertheless, it is also appropriate to perform hypercorrection within the extreme normal values of the RLA, which, while maintaining the mechanical axis of the segment within the permissible deviation, will further increase the effectiveness of preventive measures in case of a lack of epiphysiodesis effectiveness.

Conclusion

A higher accuracy of correction of femoral deformity was registered with the use of the Ortho-SUV reposition unit, the advantages of which are most pronounced in the correction of deformities of medium and complex degrees. During correction of a femoral deformity using the Ortho-SUV module, the formation of a more complete distraction regenerate with a smaller number of complications was noted. In the case of partial damage to the distal femoral growth zone, its epiphysiodesis, in isolation or in combination with hypercorrection of deformity within the extreme normal values of RLA is indicated.

In summary, the use of the universal reposition unit Ortho-SUV at the stages of correction of the femoral deformity can increase significantly the effectiveness of the transosseous osteosynthesis technique.

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Patients (their representatives) gave their consent to processing and publication of personal data.

Contribution of authors

B.Kh. Dolgiev developed the study methodology, wrote all sections of the article, collected the literature data and performed their processing; operated 40 patients.

Yu.E. Garkavenko performed leadership and participation in the development of the study methodology; operated 36 patients.

A.P. Pozdeev performed leadership and participation in the development of the study methodology; edited the article text.

All authors made a significant contribution to the research and preparation of the article, read and approved the final version before its publication.

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