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Pathologic external tibial torsion as one of the causes of knee joint dysfunction and formation of pronation deformity in children with cerebral palsy

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Introduction. One of the complications of the clinical course of cerebral palsy in children is external torsion of the tibia. The issue of localization and the mechanism of its formation, as well as effective methods of its elimination, is debatable.

Purpose – to study the mechanisms of the formation of pathological external torsion of the tibia in children with cerebral palsy, its effect on knee joint contracture and foot deformity, and effective methods of their correction.

Materials and methods. The data obtained during the observation of 45 patients (90 cases) aged from 6 to 16 years with spastic diplegia, spastic tetraparesis and foot pronation were analyzed. To study the mechanisms of formation of external torsion of the lower leg and its correction, 2 groups of patients were selected. The Group I – 24 patients with internal rotation contractures of the hip joint (10 patients with internal rotation contractures of the hip joint; 10 patients – in combination with pathological antetorsion of the femoral neck; 4 patients – in combination with flexion contractures of the knee joints). The relationship between internal rotation contracture of the hip joint and external torsion of the tibia. The Group II consisted of 21 patients who were diagnosed with flexion contracture of the knee joints in combination with external torsion of the tibia. In order to study the effectiveness of operative treatment of knee flexion contracture and external torsion of the tibia in the Group II, 2 subgroups were distinguished: the subgroup IIA – 9 patients who underwent osteotomy of the tibial bone; the subgroup IIB – 12 patients who only underwent biceps femoris transposition.

Results. Based on the study of clinical and radiological indicators, it was established that pathological torsion of the tibial bone is combined with flexion contracture of the knee joints. Proximal derotational osteotomy of the tibia has a positive effect on the results of correction of knee flexion contracture and foot position.

Conclusions. The main reason for the formation of external torsion of the tibia is the imbalance of the flexor muscles of the knee joint and the supinator and pronator muscles of the foot. Proximal tibial derotation osteotomy eliminates not only pathological torsion, but also flexion contracture of the knee joints and excessive pronation of the foot.

The study was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol was approved by the local ethics committees of all institutions participating in the study. Informed consent of the patients was obtained for the research.

No conflict of interests was declared by the authors.

Keywords: tibial torsion, cerebral palsy, pronation deformities of the feet.

Патологічна зовнішня торсія великогомілкової кістки як одна з причин дисфункції колінного суглоба та формування пронаційної деформації стоп у дітей з церебральним паралічем

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Вступ. Одним з ускладнень клінічного перебігу церебрального паралічу в дітей є зовнішня торсія великогомілкової кістки. Дискусійним залишається питання щодо локалізації та механізму її формування, а також стосовно ефективних методів її усунення.

Мета – вивчити механізми формування патологічної зовнішньої торсії великогомілкової кістки в дітей із церебральним паралічем; виявити вплив на контрактуру колінного суглоба та деформацію стопи; визначити ефективні методи їхньої корекції.

Матеріали та методи. Проаналізовано дані, отримані під час спостереження за 45 пацієнтами (90 випадків) віком від 6 до 16 років зі спастичною диплегією, спастичним тетрапарезом і пронацією стопи. Для вивчення механізмів формування зовнішньої торсії гомілки та її корекції виділено дві групи пацієнтів. I група – 24 пацієнти з внутрішніми ротаційними контрактурами кульшового суглоба (10 пацієнтів із внутрішніми ротаційними контрактурами кульшового суглоба; 10 пацієнтів із поєднанням із патологічною антеторсією шийки стегнової кістки; 4 пацієнти з поєднанням зі згинальними контрактурами колінних суглобів). У пацієнтів I групи досліджено зв'язок між внутрішньою ротаційною контрактурою кульшового суглоба та зовнішньою торсією гомілки. II група – 21 пацієнт, у якого діагностовано згинальну контрактуру колінних суглобів у поєднанні із зовнішньою торсією гомілки. З метою вивчення ефективності оперативного лікування згинальної контрактури колінного суглоба та зовнішньої торсії гомілки в II групі виділено дві підгрупи: підгрупа IIА – 9 пацієнтів, яким проведено остеотомію великогомілкової кістки; підгрупа IIБ – 12 пацієнтів, яким проведено тільки транспозицію двоголового м'яза стегна.

Результати. На підставі вивчення клініко-рентгенологічних показників встановлено, що патологічна торсія великогомілкової кістки поєднується зі згинальною контрактурою колінних суглобів. Проксимальна деротаційна остеотомія великогомілкової кістки позитивно впливає на результати корекції згинальної контрактури в колінному суглобі та позицію стопи.

Висновки. Основною причиною формування зовнішньої торсії великогомілкової кістки є дисбаланс м'язів-згиначів колінного суглоба та м'язів-супінаторів і пронаторів стопи. Проксимальна деротаційна остеотомія великогомілкової кістки усуває не тільки патологічну торсію, але й згинальну контрактуру колінних суглобів і надмірну пронацію стопи.

Дослідження проведено відповідно до принципів Гельсінської декларації. Протокол дослідження ухвалено Локальною етичною комісією зазначеної в роботі установи. На проведення досліджень отримано інформовану згоду пацієнтів.

Автори заявляють про відсутність конфлікту інтересів.

Ключові слова: торсія великогомілкової кістки, дитячий церебральний параліч, пронаційні деформації стоп.

Introduction

One of the complications of the clinical course of cerebral palsy is pathological external torsion of the tibia [3,6,7]. The deformation causes a violation of the axis of movement in the knee joint, relative to the line of progression, with an abnormal knee moment in the frontal plane, which leads to impaired locomotion and a decrease in power moments in the ankle joint [1,20]. The above-mentioned changes cause instability of the knee joint, dystrophy of the ligamentous apparatus, and the formation of flexion contractures [8,24]. Shifting the support points to the medial side of the foot changes statics with the formation of its pronation deformation [12,26]. Until now, there is no single point of view on the mechanism of formation of external torsion of the tibial bone. Thus, some authors, considering the deformation as one of the options for the formation of the bone skeleton in the growth process, allow the possibility of its occurrence in children in the absence of visible pathological changes in the musculoskeletal system. At the same time, the need to correct the torsion at its high values is noted [10,18]. At the same time, there are indications of the occurrence of pathological external torsion during deformation and pathology of the knee joint as well as a compensatory reaction of the bones of the lower leg to the internal rotation of the femur or in response to pathological antetorsion of the neck of the femur [5,16,23,27,29]. In patients with cerebral palsy, the main factor causing pathological external torsion of the leg is muscle imbalance, which is confirmed by experimental biomechanical research [13,17]. However, this point of view is contradicted by the observation of patients with lethargic paralysis of the lower limbs, in whom, in the absence of muscle strength, excessive external torsion of the leg is formed [2]. Considering this deformation from the position of the angle change between the transverse axes of the proximal and distal articular surfaces of the tibia, the authors do not indicate from which area the deformation begins and the localization of its epicenter [4,28]. In connection with this position, there are recommendations to perform an osteotomy of the lower third of the bones of the lower leg, although this technique does not eliminate the deformation of the bone in its proximal parts, but only makes it possible to restore the correct position of the foot in relation to the longitudinal axis of the lower limb [22].

There is an ongoing debate about the optimal methods and accuracy of measuring the tibial torsion angle. Computed tomography with high reliability allows you to determine the displacement of the transverse axes of the proximal and distal articular surfaces. However, the technique is faced with the need to perform a large number of sections and calculations to study different areas of deformation. Positive results were obtained when using a laser scanner with bone curvature mapping. The use of clinical methods for determining the torsion angle of the tibial bone based on the measurement of the thigh-foot angle (TFA) and transmalleolar axis (TMA), as well as using the «two fingers» test [14,19], is quite accurate. The disadvantages of the methods are the impossibility of determining the change in the curvature of

Fig. 1. Torsion angle calculation method: A – the line between the proximal and distal metaphysis of the tibia (continuous line); B – a dashed line that runs along the projection of the bone crest, N is the distance between the marking lines A and B

the bone along its length. Thus, the data of foreign and domestic authors testify to the importance of the problem and the difference in views on localization, causes, mechanism of formation of clinical manifestations of pathological external torsion of the tibial bone.

The purpose of the work is to study the mechanisms of the formation of pathological external torsion of the tibia in children with cerebral palsy, its effect on knee joint contracture, foot deformity and effective methods of their correction.

Materials and methods of the research

The data obtained during the observation of 45 patients (90 cases) aged from 6 to 16 years with spastic diplegia and spastic tetraparesis were analyzed. To study the mechanisms of formation of external torsion of the lower leg and its correction, 2 groups of patients were selected. The Group I consisted of 24 patients with internal rotation contractures of the hip joint (10 patients with internal rotation contractures of the hip joint; 10 patients – in combination with pathological antetorsion of the femoral neck; 4 patients – in combination with flexion contractures of the knee joints). The relationship between internal rotation contracture of the hip joint and external torsion of the tibia were observed. The Group II consisted of 21 patients who were diagnosed with flexion contracture of the knee joints in combination with external torsion of the tibia and pronation of the foot.

In both groups, pronation deformities of the feet of varying severity were observed.

In order to study the effectiveness of operative correction of knee flexion contracture and external torsion of the tibia in the Group II, 2 subgroups were distinguished: the subgroup IIA – 9 patients who underwent osteotomy of the tibial bone; the subgroup IIB – 12 patients who only underwent biceps femoris transposition.

Inclusion criteria: patients with internal rotation contractures of the hip joint, pathological antetorsion of the femoral neck, pathological external torsion of the tibia, flexion contractures of the knee joints and pronation deformities of the feet due to cerebral palsy.

Exclusion criteria: deformations of the bones of the lower leg, knee joint and foot, which were formed as a result of injuries, congenital and acquired diseases of the musculoskeletal system.

The following clinical and radiological methods were used: determination of active and passive movements in the hip, knee and ankle joints with gradation of contractures by degree. The longitudinal axis of the lower limb was examined using a slope lowered from the front upper iliac spine. Normally, the projection of the temple should pass through the center of the projection of the ankle joint. The angle of torsion of the tibial bone was determined by drawing with a marker, in the position of the patient on his back, the line of the longitudinal axis of the thigh, the longitudinal axis of the foot, the line connecting the parts of the medial and lateral bones that protrude. At the point of intersection of the longitudinal axes of the thigh and the TFA foot, torsion of the tibia was determined in degrees. The angle between the longitudinal axis of the thigh and the perpendicular to the joint line of the TMA ankle joint also makes it possible to determine the amount of bone torsion with high accuracy. Recently, the «second toe» test has become popular for measuring the torsion angle of the tibia: in a supine position, with the knee joint fully extended, the limb is rotated inward or outward until a position is reached in which the second toe becomes perpendicular to the horizontal plane Then, without changing the position of the limb, the lower leg is bent to 90 degrees. Torsion is determined by the point of intersection of the horizontal line and the longitudinal axis of the lower leg. The antetorsion angle of the femoral neck was measured on radiographs of the hip joints (the norm is 15^0-30^0). In the frontal projection of the foot, the Kite angle was assessed (norm <30^0). In order to study the torsional deformation of the tibia along the projection of the crest of the bone, metal markers with a length of about 0.5–1 cm were fixed using adhesive tape, starting from the tuberositas tibia to the projection of the ankle joint. On the anterior-posterior radiograph, the displacement of the markers was measured and the torsion angle was calcu-

Table 1

Relationship of external tibial torsion and foot pronation from concomitant deformities

Associated deformities	Indicators of tibial torsion	Valgus deviation of the heel bone
Hip contracture in the position of internal rotation	16.4°±1.7°	11.2°±2.4°
Flexion contractures of the knee joint	24.2°±3.1°	15.2°±1.5°
Antetorsion of the femoral neck	9.1°±2.1°	10.8°±1.6°

lated according to the formula 2πR/360×N (where R is the radius of the bone circumference, N – distance between A and B proximal and distal markers; A is the line between the proximal and distal metaphysis of the tibia; B is the line that runs along the projection of the bone crest). Torsion angle norm $<15^0$ (Fig. 1).

To determine the muscle mass, the transverse diameter of the biceps femoris muscle (m.) was measured, *m. semimembranosus*, *m. semitendinosus*, *m. tibialis anterior et posterior*, *m. peroneus brevis et longus*, *m. flexor digitorum longus*, *m. flexor hallucis longus* using ultrasound and measured their length, noting the points of their fixation to bones and fascia.

Statistical analysis. Numerical data were compared between groups and processed statistically with the determination of M±m and the reliability coefficient according to the Student's t-test. The probability level is set at $P<0.05$.

The study was approved by the Ethics Committee of the Shupyk National Healthcare University of Ukraine.

Results of the research

The patients of the Group I had a limitation of the external rotation of the hip in the supine position. The average values of rotational passive movements were 25.4±4.1°, active – 14.7±3.5°. The position of internal rotation of the hip in the vertical position is 20.2°±5.3°. Retraction of the anterior part of the gluteus medius muscle was the main reason for limiting the external rotation of the hip. During the clinical examination, the antetorsion angle of the femoral neck was 22.3°±2.5°, and the radiological one was 27.4°±5.2°. Thus, in patients of the Group I, the antetorsion angle corresponded to age. The evaluation of the external torsion of the tibial bone showed that its value was 16.4^0±5.7°. No direct correlation was found between the degree of rotational contracture of the hip joint and the magnitude of the external torsion angle. No correlation was found between the femoral neck antetorsion angle and the tibial external torsion angle. In one (4.2%) patient with internal rotational contracture of the femur up to an angle of 30°, internal torsion of the tibia by 25° was noted. At the same time, in 4 (16.7%) patients with a combination of internal rotation position of the hip and flexion contractures of the knee joints of the 1st degree [7], the angle of external torsion of the tibia was 24.2°±3.1°. Thus, the obtained data showed that there was no correlation between the internal rotational position of the femur and the external torsion of the tibial bone in the examined patients. Also, no direct relationship between the femoral neck antetorsion angle and tibial torsion was found. 4 (16.7%) patients with a combination of internal rotation contractures of the hip joints and flexion contractures of the knee joints of the 1st degree had increased external torsion of the lower leg. The analysis between the pronation position of the feet and the internal rotational contractures of the hip joints, without pathological external torsion of the leg, showed the absence of their dependence. Therefore, taking into account the fact that external torsion in the Group I was observed only in 4 (16.7%) children, it can be said that the pronation deformation of the feet was not always combined with the internal rotation of the hip. However, in 22 patients who were diagnosed with external torsion of the lower leg, pronation of the feet was observed (Table 1).

The study of clinical and radiological data obtained before surgical treatment in patients of the Group II showed that external torsion of the leg was present in 18 (85.7%) patients, and all patients of the Group II were diagnosed with flexion contracture of the knee joints. A direct relationship between the degree of flexion contractures and the torsion angle of the lower leg was observed (Fig. 2).

The greatest value of external rotation of the leg was in patients with II-III degree contractures. Thus, in patients of the Group II, there was a direct relationship between the degree of external torsion of the tibia and the flexion contracture of the knee joints: the greater the contracture of the knee joints, the greater the torsion of the tibia. The obtained data showed that the magnitude of the amplitude of active and passive movements in the knee joints, which indicates the degree of muscle dysfunction, also affected the level of external rotation of the lower leg. The smaller the difference between these indicators, the higher the values of tibial torsion in patients of the Group II (Fig. 3).

So, if the muscles of the semigroup are attached in the area of the upper third of the metaphysis of the tibia, then most of the biceps is attached more distally, performing external rotation of the lower leg. Analysis of the decomposition of forces on the upper third of the

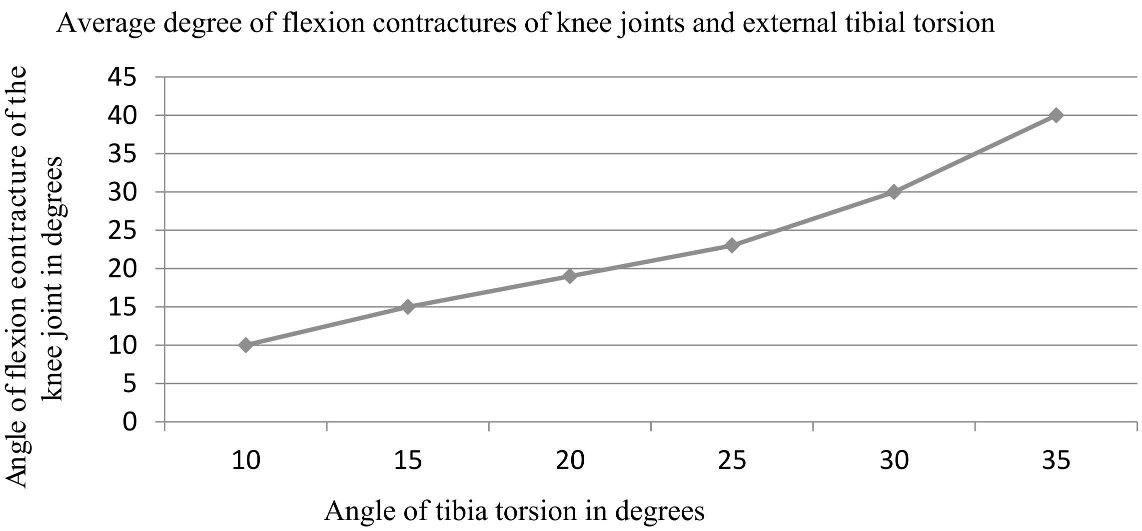


Fig. 2. Dependence of knee joint flexion contractures and external tibial torsion in patients of the Group II

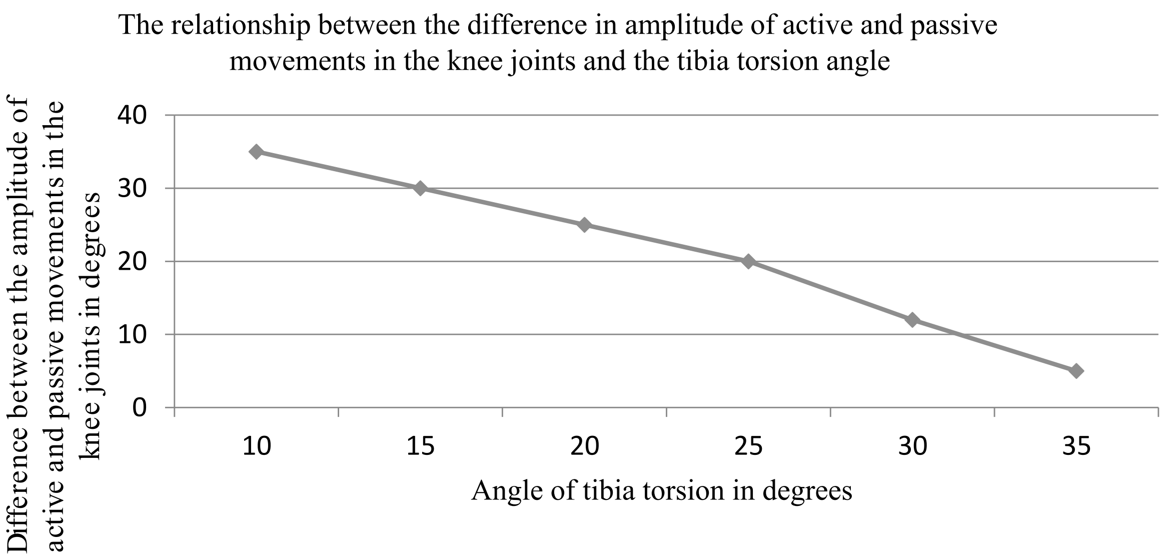


Fig. 3. Correlation between the difference in the amplitude of active and passive movements in the knee joints and the angle of tibial torsion in patients of the Group II

tibia indicates that the main points of attachment of the muscles of the Semi group, which rotate the tibia to the middle, are located proximal to the fixation point *m. biceps femoris*, which rotates the lower leg outward and intertwines with the fascia of the lower leg to its middle third. This action causes the tibia to twist outward. This mechanism can explain the positive effect of tendon transplantation *m. biceps femoris* on the tubercle of the tibia with simultaneous elimination of its external torsion by proximal isolated metaphyseal osteotomy. At the same time, along with the change in the function *m. biceps femoris*, which becomes an extensor of the lower leg, the points of attachment of the muscles of the Semi group converge, the duration of their force contraction phase decreases, thereby preventing the recurrence of flexion contracture of the knee joint. Decomposition of forces shows that the distance between the points of fixation of the muscles that rotate the lower leg inward (muscles of the semigroup) and outward (*m. biceps femoris*) is the zone of formation of deformation, the beginning of which falls on the area of the tibial tuberosity, and the end – on the level of its middle third. In this area of the lower leg, there is an arc-shaped curvature of the front edge of the tibia with the base facing the medial side. The main reason is, in our opinion, the compensatory reaction of the bone to its pathological twisting. That is, the deformation has a combined character. There is a direct relationship between the amount of arcuate curvature of the tibia and its external torsion. It should be noted that in 20 patients of the Group I without torsional deformation of the tibia, there was no curvature of its front edge in the frontal plane. The data of clinical observations are confirmed by X-ray indicators. On radiographs of the bones of the lower leg in a direct projection with the designation of the front edge of the tibia, it can be seen that the deviation of the line of projection of the front ridge of the tibia outward began distal to the projection of the lower pole of the tubercle of the tibia and ended in its middle third (Fig. 1).

In the lower third of the tibia, starting from its upper edge, an increase in torsion was not observed.

In order to practically confirm this position, a comparative analysis of the results of surgical correction of flexion contracture of the knee joints after 24 months of observation in patients of the Group II was carried out. In the subgroup IIA, the angle of external torsion of the tibial bone before the operation was $40.3^0 \pm 3.4^0$. The correction angle was noted within $17.6^0 \pm 4.1^0$. To study the effect of derotational osteotomy on the position of the foot, the Kyte angle was analyzed on the frontal radiographs of the foot with load before and after the operation, as well as the angle of valgus deviation of the calcaneus during the clinical examination. Indicators of the Kite angle before the operation were $42.3^0 \pm 3.2^0$, and after correction – $28.2^0 \pm 2.1^0$. The values of calcaneus valgus deviation were $11.3^0 \pm 2.3^0$ before surgery and $5.1^0 \pm 1.5^0$ after surgery. Therefore, the elimination of external torsion of the tibia had a positive effect on the position of the foot (Fig. 4).

In the IIB subgroup, after 24 months of follow-up, the results were less significant. The angle of correction of the external torsion of the tibial bone was $34.6^0 \pm 4.1^0$, the Kite angle was $41.2^0 \pm 0.8^0$ The angle of valgus deviation of the calcaneus before the operation was $10.2^0 \pm 2.7^0$, after the operation – $9.3^0 \pm 1.2^0$. Taking into account the measurement error, we can say that the indicators have not changed (Table 2).

Recurrences of flexion contractures of the knee joints were noted in 5 patients of the IIB group, which amounted to 41.7%. 14 months after the operation in these patients, the limitation of active leg extension was 15^0–25^0,

A *B*

Fig. 4. Photographs of the lower limbs of *patient V.*, 14 years old. Diagnosis: cerebral palsy, flexion contracture of the knee joints. Subgroup IIA. A – violation of the co-axis of the hip, lower leg and foot before surgical treatment (green – axis of the hip; blue – axis of the lower leg; yellow – axis of the foot); B – achievement of hip, lower leg and foot alignment after surgical treatment (green – lower extremity axis)

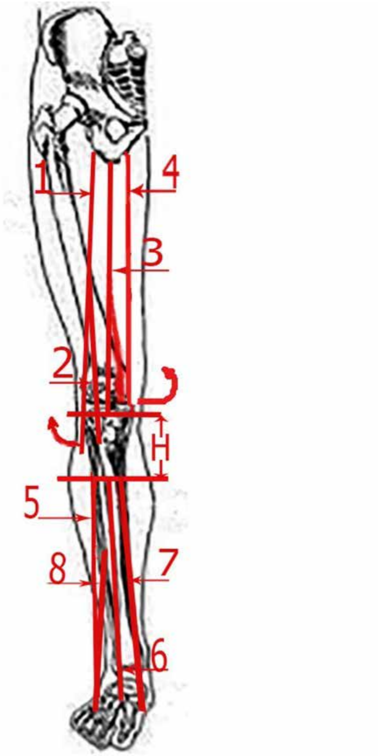
passive – 7–14^0. A direct relationship was observed between the degree of contracture before surgery and the degree of limitation of movements in the joint as a result of recurrence.

In 1 (8.3%) patient of the IIB subgroup during 18 months of observation, a deformation of the right tibial bone with the convex side to the back was formed. The deformation was accompanied by recurvation of the lower leg and hyperextension of the knee joint. Before the operation, the external torsion of the tibia was 43^0 on the right and 34^0 on the left. The angle of correction of the right tibia is 37^0, the left tibia is 16^0. Taking into account the instability of the right knee joint, a corrective tibial osteotomy was performed in the area of the epicenter of the deformation, with the elimination of bone bending and internal torsion of the distal fragment by 10^0. 4 months after the repeated operation, the lower ex-

Table 2

Results of correction of flexion contracture of the knee joint

Ro readings in degrees	**Subgroup A n=18 M±m**		**Subgroup B n=24 M±m**		**P**
	Before the operation	**After the operation (24 months)**	**Before the operation**	**After the operation (24 months)**	
Tibial torsion of the tibia bones	40.3±3.4	17.6±4.1	40.3±3.4	34.6±4.1	p<0.05
Angle Kite	42.3±3.2	28.2±2.1	46.3±1.7	41.2±0.8	p<0.05
Angle of knee joint contracture	45.1±1.2	20.5±16.7	44.2±3.2	35.6±2.5	p<0.05



Notes: 1 – *caput longus m. biceps femoris*; 2 – *caput brevis m. biceps femoris*; 3 – *m. semimembranosus*; 4 – *m. semitendinosus*; 5 – *mm. peroneus longus* and *brevis*; 6 – *m. tibialis anterior*; 7 – *m. tibialis posterior*; 8 – *mm. extensor digitorum longus fnd extensor Hallucis longus*; H – distance between fixacion points *m. biceps femoris* and *m. semi* of group.

Fig. 5. Influence of the lower leg muscles on the formation of the external torsion of the tibia

tremity was able to flexion, active extension of the knee up to 180^0, the patient fully loads the extremity, walks independently. The achieved result was maintained throughout the observation period.

Therefore, when analyzing the results of the study of the external torsion of the tibia and the influence of the muscles of the lower leg on its formation, the points of fixation of the muscles, their function, and the decomposition of the forces acting on the bone were taken into account. Moreover, the last factor was considered from the standpoint of their influence on the position of the foot. The points of attachment of the muscles and the direction of the force acting on the foot made it possible to distinguish two groups of muscles that affect the external torsion of the tibial bone. One – with a zone of attachment to the posterior or posterolateral surface of the tibia, as well as the posterior-medial surface of the fibula. It includes the flexor muscles of the foot and fingers, as well as its supinator (*m. tibialis posterior*). The direction of the forces of action of these muscles is located strictly to the center of the foot or its medial edge, that is, no twisting moment on the bone is observed. The second group of muscles is attached to the front and anterolateral surface of the tibia. Their force vector is directed both to the center of the foot and to the medial edge (*m. tibialis anterior*) and to the center and lateral edge (*m. et tensor digitorum longus*), while balancing the force of action of these muscle groups. At the same time, the vector of action of the fibula muscles is directed back and to the side, thereby causing pronation of the foot and torsion of the tibia outward through the interosseous membrane. Therefore, the pronation effect of the fibular muscles and partially the extensors of the toes has a direct torsional effect on the tibia, as well as indirectly through the tibiotarsal joint during pronation deformation of the foot (Fig. 5).

Discussion

It is known that the main factor affecting the formation of flexion contractures of the knee joint is a functional imbalance between the flexor muscles and the extensor muscles of the lower leg [8]. We noted the influence of muscle retraction on the amount of torsion of the tibial bone. According to the classification of the degree of violation of muscle tone, in severe stages of deformation, their rigidity was present, characterized by a sharp loss of both elasticity and contractility. The existence of a correlation between the degree of flexion contractures of the knee joints and the external torsion of the tibia raises the question of the mechanism of the formation of the latter. A comparative assessment of muscle mass, including the determination of the cross-sectional dimensions of the muscles and their length, showed that the main dominant force that causes contracture of the knee joint is the biceps femoris muscle, which is attached to the head of the fibula by one part of the tendon and others more distally – to the lower leg fascia. Another group of flexors of the tibia (Semi group) is fixed to the medial condyle of the tibial bone (internal bundle of the semimembranous muscle), the tuberosity of the tibial bone, as well as to the capsule of the knee joint, forming the popliteal ligament and the fascia of the popliteal muscle.

I.M. Engel et al. note the role of excessive antetorsion of the neck of the femur on the formation of external torsion of the tibia [10]. The author analyzed observations mainly in children without pathology of the nervous system. H.Y. Kim et al., N.A. Flack et al. in the study of biomechanical factors affecting the torsion of the femur and tibia, the leading role of the muscle component is noted. It has been proven that in cerebral palsy, the main factor influencing the torsion of the femur is the moment of force developed by the gluteal muscles, *m. tensor fascia lata* [11,16]. Our observations confirmed the opinion about the leading role of a minor static effect on tibial torsion of excessive antetorsion of the femoral neck and internal rotational contracture of the hip joint. D.A. Dolgin et al., B. Lofterod et al. showed the effectiveness of eliminating torsional deformations of the femur and tibia to improve static walking locomotion in patients with cerebral palsy [9,21]. D.D. Ryan et al., W. Michael propose to eliminate pathological external torsion of the tibia with the help of distal osteotomy of the tibia and fibula bones [5,25]. E. Andrisevie conducted a study of the effect of isolated detorsion distal tibial osteotomy on the anatomical relationship of the lower leg bones in 25 patients with cerebral palsy using computed tomography. The average values of the angle of detorsion were 21.6 degrees. In 9 cases, immediately after the operation, a subluxation was observed in the proximal tibiofibular syndesmosis, which was remodeled after 12 months [3]. W.F. Krengel et al. conducted a comparative analysis of proximal and distal derotational osteotomies of the tibia. Complications after proximal osteotomies were noted in 13% of patients [18]. Our own observations showed the presence of complications in the form of the formation of anterior-concave tibial deformity in the area of the osteotomy and instability in the knee joint in only one patient. Torsional correction in this case was 37^0. The main cause of the complication, in our opinion, was a large angle of correction, which led to a sharp change in the ratio of the bones of the lower leg in the proximal tibiofibular syndesmosis, compression in the anterior epiphyseal cartilage of the tibia and its deformation during growth. In favor of using a proximal osteotomy of the tibia, there are strong arguments such as a shorter period of bone consolidation in the area of the osteotomy and correction directly in the deformation zone.

Conclusions

A direct relationship between the degree and duration of the clinical course of knee flexion contracture and the amount of external torsion of the tibial bone was noted. The main reason for the formation of external torsion of the lower leg is the imbalance of the flexor muscles of the knee joint. The thesis of compensatory torsion of the tibia in response to internal rotation contracture of the hip joint or pathological antetorsion of the femoral neck is not confirmed. In most cases, external torsion of the lower leg is accompanied by a pronation position of the feet. An imbalance between the foot supinator and pronator muscles is an additional factor affecting the formation of external torsion of the tibial bone and pronation deformations of the feet.

The problem of pathological torsion of the tibial bone requires further study. Research into the causes of external torsion of the tibia and pronation of the foot will contribute to the improvement of methods of operative treatment of knee contractures and the reduction of the number of recurrences.

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