CORRECTION OF AXIAL DEFORMITIES OF THE KNEE JOINT IN CHILDREN BY CONTROLLED GROWTH METHOD

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ANNOTATION

Axial deformities of the knee joints in children are a common problem and a frequent reason for contacting an orthopedic doctor [1]. Most of them are physiological, although there are also pathological forms that require timely diagnosis and treatment. The causes of these deformities, indications, terms and methods of their treatment still remain topical issues that need to be addressed. The purpose of this publication is to analyze the literature and present current ideas about axial deformities of the knee joint in children and the possibilities of their correction using the controlled growth method. The formation of the lower limb axis in children goes through a number of stages, manifesting itself in the process of growth by its regular change. In most cases, these deformities are physiological in nature and do not require correction. Thus, a child at birth has a varus deviation of the mechanical axis at the level of the knee joints (the anatomical femoral-tibial angle is 10-15°). According to several authors, this is due to the intrauterine position of the fetus during pregnancy.

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As a result of this intrauterine position, contracture occurs not only in the medial capsule, but also in the posterior oblique ligament of the knee joint. This leads to rotation of the entire lower limb, the formation of varus deformity of the knee joints in newborns. During the first year of the child's life, this contracture gradually decreases, and the remaining value at the time of starting independent walking will determine the severity of varus deformity of the lower extremities. By 18-22 months, the contracture of the medial capsule finally disappears, hypercorrection occurs — varus deformity of the lower extremities is replaced by hallux valgus (8-10°) [2]. In the future, the mechanical axis is restored over several years [3]. However, axial deformities at the level of the knee joints are not always physiological in nature and can be corrected independently. Unlike physiological deformities, pathological deformities are manifested against the background of the underlying disease, which affects the growth and formation of the child's skeleton, which leads to a gradual deviation of the mechanical axis of the lower extremities. This provokes an uneven distribution of the load on different parts of the knee joint, which can lead to the appearance of osteoarthritis in the future [4, 5]. G. Brouwer et al. A study was conducted to identify the relationship between the presence of axial deformity of the lower extremities in patients and the development of osteoarthritis of the knee joint. The study involved 1501 people (2664 knee joints), of which 38 % of patients (1012 knee joints) did not have deviation of the mechanical axis of the lower extremities, 26 % (693 knee joints) patients had varus deformity. deviation, 36 % (959 knee joints) - had a valgus deviation of the mechanical axis. The follow-up period averaged 6.6 years. Based on the results obtained, it was found that the risk of osteoarthritis in patients with valgus axis deviation was 1.64 % higher than in patients who did not have a deviation of the mechanical axis of the lower extremities. At the same time, in the presence of varus deviation, the risk of osteoarthritis increases almost twice and amounts to 2.06 % [6]. These disorders can be formed due to deformity of the femur, lower leg bones, or a combination of them. Regardless of the etiology of axial

deformities, the main goal of their treatment is to restore the mechanical axis of the lower extremities. Various calculation methods are used to determine the amount of deformation, its vertex, and the degree of correction required. Currently, the most commonly used method for determining the center of Rotation of angulation — Center of Rotation of Angulation (CORA), proposed by D. Paley. At the same time, reference lines and angles are determined on radiographs and deviations of both the anatomical axis of the femur and tibia, and the general mechanical axis of the lower limb, are calculated. The most informative parameters that characterize varus and hallux valgus deformities of the knee joints are Mechanical Axis Deviation (MAD), mechanical lateral distal femoral angle femoral angle(mLDFA), and medial proximal tibial angle tibial angle(MPTA). According to the localization of the deformation vertex and the values of the reference angles, the level and magnitude of correction of the deviation of the mechanical axis are planned. Methods of correction of these deformities are currently diverse, and their effectiveness and safety are debatable.

According to some authors, conservative methods of treatment for this pathology are ineffective in most cases due to the degree of deformity severity [7]. Surgical methods mainly include simultaneous correction — corrective osteotomies followed by fixation of bone fragments in the correct position using various metal structures (spokes, external fixation devices, plates with screws), as well as gradual correction using compression-distraction devices [4, 7]. M. Azizov published the results of treatment of children with axial deformities of the knee joints that were treated with both conservative and surgical methods of treatment — installation of an external fixation device. The study included 55 patients. Conservative treatment was performed in 18 patients, operative treatment-in 37 patients. Distraction was performed from the 3rd-4th day after surgical treatment and up to 4-5°hypercorrection of the deformity. The distraction rate was 1 mm per day, and the fixation period was 4-6 weeks. According to the author, 16 patients had good results with the conservative method of treatment, two patients had a recurrence of deformity, which required further use of the surgical method of treatment. Using the operative method, the results of treatment were evaluated in 24 children, including: 21 patients showed good results with correction of the limb axis and with full range of motion in the joints of the lower extremities, 3 patients had complications during treatment — inflammation of the soft tissues around the spokes, which required the appointment of antibiotic therapy. Based on the results obtained, the author came to the conclusion that axial deformities of the lower extremities in children often require surgical methods of treatment, among which hardware-surgical treatment is less traumatic and most effective in children even at a young age [7]. At the same time, the author does not indicate the etiology of the origin of axial deformities of the lower extremities in children, the degree of its severity, which does not allow us to fully assess the effectiveness of these methods. Of course, surgical treatment methods can correct axial deformity and thereby restore the mechanical axis of the lower extremities, but as the child grows, relapses of deformities may occur, which will require repeated corrective osteotomy. In addition, osteotomy is a fairly large surgical intervention and has a certain percentage of complications associated both directly with the surgical intervention itself and with the violation of consolidations. For a long time, doctors have tried to use the natural growth potential of the child's bones to correct axial deformities of the lower extremities, without resorting to osteotomies. The possibility of purposeful impact on the growth zone was the basis of the concept of controlled growth. Due to the fact that the range of interests of modern orthopedics is shifting towards minimally invasive manipulations, recently the technique of controlled growth has become more popular [8-15]. In 1933, D. Phemister performed the first operations on the germ zone to correct axial deformations [16]. The

operation consisted of excision of a bone-cartilage fragment in the area of the metaepiphyseal cartilage with its subsequent reversal in such a way that the growth zone overlaps with a section of the bone fragment [17]. This created a permanent synostosis between the epiphysis andmetaphysis of the bone, but this manipulation was irreversible and was accompanied by the risk of excessive correction of deformity, which limited its use. In 1949, W. Blount proposed the use of metal brackets for epiphyseodesis to correct the mechanical axis of the lower extremities in order to have a reversible effect on the germ zone. A positive effect when using Blount braces in children with hallux valgus of the lower extremities was also obtained by other authors. I. Deqreef et al. The results of treatment of 44 patients with valgus deformity of the knee joints, who underwent temporary epiphysis of the medial parts of the distal femoral and proximal tibial bones, were reported. The correction period averaged 7 months (from 3 to 18 months). A satisfactory result was observed in forty patients, four of them had recurrent deformity. Based on the study, the authors concluded that Blount braces are a reliable method for treating hallux valgus deformities in children with a small percentage of complications [20]. A similar effect was obtained in R. Zueqe, which described the results of treatment of 56 patients with axial deformities at the level of the knee joints. Treatment was performed using Blount brackets. The efficiency of deformity correction was 87 % [11]. Despite the fact that there were positive results when using Blount brackets, this technique is still not widely used in practice. This is primarily due to the high risk of possible complications when using it. Metaepiphyseal cartilage is a dynamic structure, and under its action during growth, the brackets can deform, break or migrate, which can lead to damage to the growth zone and its premature closure [21]. In addition, this method also has age restrictions: Blount it is undesirable to use Blount brackets when creating epiphysis in girls under 9 years of age and in boys under 11 years of age due to an increased risk of possible complications (migration of brackets) [22]. In order to avoid undesirable effects of using Blount brackets, J. Metaizeau began to use transphyseal screws to correct deformations [23]. The author obtained positive results of deformity correction, but later doubts began to arise about the reversibility of this type of epiphysis [24]. In 2004, P. Stevens suggested using plates with two screws to temporarily block the bone growth zone. This method provides for extraperiostal installation of the plate at the level of a certain segment of the growth zone at the top or in the plane of deformation. This technique later became known as the controlled growth method using 8-shaped plates. According to the majority of authors who used this method, its advantages over brackets and transphyseal screws are minimallyinvasive, higher accuracy, ease of use, reliability and efficiency of use, as well as a low risk of possible complications [25-29]. As evidence of the effectiveness and reliability of his method, P. Stevens conducted a study aimed at comparing the rate of correction of hallux valgus and varus deformities of the knee joints in children using braces and 8-shaped plates. The study involved 34 patients aged 20 months to 17 years. The correction period was 11 months, and after the deformation was eliminated, the metal structures were removed. Based on the results obtained, the author concluded that when using 8-shaped plates, the rate of deformity correction was 30 % higher than when using Blount brackets, while premature closure of the growth zone in children was not observed [4]. At the same time, some authors note that the rate of correction of hallux valgus andvarus deformities of the knee joints in children is the same both when using Blount bracketsand when using 8-shaped plates. But even so, 8-shaped plates have a number of obvious advantages. In particular, their installation and removal takes less time than with similar interventions with Blount staples [28]. M. Niethard, after evaluating the results of his research, came to the conclusion that the use of 8-shaped plates for temporary epiphysis is the safest and most reliable method. The

technique of installing the specified metal structure is easy to learn, and the frequency of complications is minimal compared to using Blount brackets. This study included 13 patients with an average age of 9.5 years (from 2.3 to 13.7 years). Axial deformities of the lower extremities were observed in all patients. The correction period ranged from 6 to 34 months. No complications were observed [30]. A. Kanellopoulos et al. et al. conducted studies on pigs to compare the rate of correction of axial deformities when using 8-shaped plates and Blount brackets. To do this, each animal underwent temporary epiphysis under the control of EOP on the right shin using 8-shaped plates, on the left-using Blount brackets. As a control, radiographs were performed every 4 weeks. Animal studies have shown that the correction of axial deformities of the lower extremities is more effective when using 8-shaped plates compared to Blount brackets. In addition, when using 8-shaped plates, complications in the form of migrations and deformations of metal structures are less common than when using Blount brackets [31]. Initially, the controlled growth method was used only to correct deformities of the lower extremities in the frontal plane. Subsequently, the indications for its use have significantly expanded, and today the controlled growth method is actively used to correct deformities in both the frontal and sagittal planes, including post-traumatic deformities, various changes in epimetaphyseal cartilage as a result of systemic diseases, as well as deformities at the level of the ankle and hip joints [32]. Thus, the method of controlled bone growth has proven to be an effective method for correcting axial deformities of the lower extremities in children who have not reached the end of bone growth. However, despite the widespread use of this technique, at the moment there are a number of unresolved issues. Thus, the age range of patients for the use of 8-shaped plates is still debatable. In his studies, P. Stevens used this method in children aged 20 months to 17 years. M. Niethard used 8-shaped plates to correct axial deformities of the knee joints in children whose average age was 9.5 years (from 2.3 to 13.7 years). The age of patients in the R. Burghardt study ranged from 4.9 to 13.7 years [33]. No complications from the growth zone were observed in these studies. The question is also relevant regarding the need for epiphysis of the proximal fibula growth zone in the correction of varus deformities of the knee joints. In the literature, there is no data on the need to perform hypercorrection when eliminating axial deformities of the knee joints in children. In addition, the largest number of scientific publications is devoted to idiopathic hallux valgus and varus deformities of the knee joint, and the issues of deformity correction in primary pathology of the growth zones, in particular in children with systemic skeletal dysplasia, are insufficiently covered. Methods for predicting the deformation correction potential have also not been developed. Despite the simplicity and relative versatility of 8-shaped plates, it is still important to improve the tools andimplants for controlled growth. However, the method of controlled growth is a real alternative to osteotomies in the correction of knee deformities in children and can be more widely used in the daily practice of pediatric orthopedists.

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