

Specific Features in Treatment of Children with Fractures of the Distal Metaphyseal Cartilage of Lower-Leg Bones: Clinical Cases

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Abstract

This case study discusses the treatment of distal metaphyseal fractures of lower-leg bones in children. The choice of this problem based on wide expansion of fractures and poor treatment results. Age of children ranges from 10 to 16 years. Examination was done with X-rays, computed tomography (CT), and ultrasound, especially in cases where damaged ligamentous apparatus was suspicious. The main method of treatment was surgical-osteosynthesis by wires, plates, and screws. In the rehabilitation period, the legs were immobilized in plaster cast up to the knee joint for 4 - 6 weeks. The first case demonstrated the probability of damage of the distal tibiofibularis ligaments and necessity of their reconstruction. In the management of the second case, the efficacy of CT scans in validation of the fracture is presented. The treatment of the teenager presented in the third case was based on biomechanical principles. In majority of cases, outcomes in the period of 6 - 8 weeks after trauma were good and satisfactory. In our opinion, diagnosis and treatment of distal methapyphiseal cartilage fractures of the shin in children must be different that was proved in the examination of bones and ligaments injuries. Creation of the special structure classification for understanding and effective treatment of these kinds of metaphyseal fractures in children is believed to be necessary.

Keywords: Trauma; Children; Distal Tibial Metaphysis; Distal Tibiofibular Syndesmosis; Structure Classification

Introduction

Fractures of the distal epiphyseal cartilage of the lower-leg bones pose a complex problem from the perspective of treatment and rehabilitation in both children and adults due to anatomical localization, proximity of the joint and involvement of the ligamentous apparatus in the process. According to the American and Canadian registers, such fractures are observed in more than 2 mln. children annually [1]. The official statistics of the RF shows that factures of the lower-leg bones in children and adolescents account for 10.4% of fractures of various locations without breakdown by the fracture location [2]. According to our data based on the statistical report of the Traumatology Department of the Children's Municipal Clinical Hospital (CMCH) named after Z. A. Bashlyaeva (Moscow) for 2019, factures of the

lower-leg bones in children account for 8.6% of fractures of various locations, while 53.7% of them account for the damage of the distal epiphyseal cartilage of the lower-leg bones.

This area has some specific anatomical and physiological features. This is, first of all, a growth plate. It is known that the epiphyseal plate of the distal tibia is responsible for 45% of the lower limb growth [3]. As a result of fracture, the growth plate is often damaged and, depending on the fracture nature, it determines its early closure. Normally, the growth plate is physiologically closed gradually from 12 to 14 and fractures that occur during the growth plate closure have specific morphological and biomechanical characteristics [3,4].

Blood supply of this area also has specific features due to the absence of a muscle mass around the malleolar. In case of fracture, the microcirculatory activity is sharply reduced, which leads to pronounced hypoxia of the local tissues. As a result, this growth plate is temporarily deprived of nutrients and oxygen [5]. Nevertheless, there is a study, which finds positive features in the hypoxia development. Hypoxia leads to generation of the induced signal molecule in cells, which stimulates angiogenesis in the fracture area, proliferation and migration of osteoblasts, promoting the healing of the fracture and increased bone density [6]. But it is still unknown, how such a shift from hypoxia to hyperemia impacts the development of pathological epiphysiodesis.

A specific feature of the distal metaphyseal crural region is the ligamentous-capsular apparatus stabilizing the ankle joint. It incorporates a deltoid ligament, bundles of the talofibular and peroneal-calcaneal ligaments, tibiofibular ligaments that form the distal tibiofibular syndesmosis. Injury often leads to a partial or complete rupture of these structures. Underestimation of such a type of injury may cause disturbed regeneration, instability of the ligamentous apparatus and instability of the ankle joint at an older age [3]. Due to the foregoing, incorrect treatment tactics that does not take into account the damage to the ligamentous apparatus and underestimates the degree of damage to the growth plate may lead to the development of deformation and post-injury arthrosis of the ankle joint [7]. Unlike in other major joints of the lower limb, arthrosis of the ankle joint occurs in 78% of cases after fractures and the damage to the ligamentous apparatus leads to arthrosis in 16% of cases, while clinical manifestations of changes in the cartilage tissue can be seen in 10 - 20 years after the injury [3,8,9].

Objective of the Study

The objective of this study is to demonstrate the clinical cases based on our interpretation of various fractures of the distal epiphyseal cartilage of the lower-leg bones in children. All patients underwent GE Al01F radiology (Germany) to verify the fracture. The degree of fragments displacement and the fracture nature were specified using multispiral computer tomography (Toshiba cxi tomograph, Japan). In case of suspected damage to the ligamentous apparatus of the ankle joint, ultrasound examination was performed using Toshiba Aplio 500 scanner (Japan).

Clinical Cases

Clinical case No. 1

Boy, 10 y. o., with the diagnosis: "Closed epiphyseal fracture of the distal part of the left tibia, type I according to Salter-Harris [10], communicated fracture of the fibula diaphysis". The injury occurred while playing football. According to the mechanism, the fracture was pronation-eversion. The ultrasound diagnostics showed the rupture of tibiofibular syndesmosis. The tibiofibular distance was 6.5 mm compared to the healthy limb, where the tibiofibular diastasis did not exceed 3 mm. Considering the patient's age, osteosynthesis was performed by a closed method, and the distal tibiofibular syndesmosis was fixed with two crossing wires. Additional immobilization was implemented in the posterior plaster cast up to the knee joint. Control radiographs were performed 4 and 6 weeks after reduction. The

wires were removed after 6 weeks, the joint configuration was restored completely, there were no signs of diastasis in the tibiofibular syndesmosis (Figure 1-4).



Figure 1: X-ray of the patient: epiphyseal fracture of the distal part of the left tibia, type I according to Salter-Harris, communicated fracture of the fibula diaphysis.

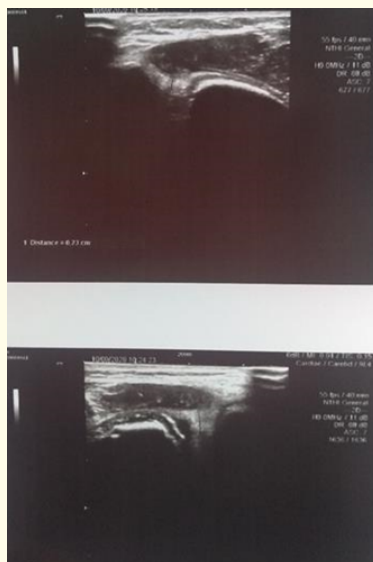


Figure 2: Ultrasound examination of distal tibiofibularis ligaments. Signs of anterior ligament rupture.

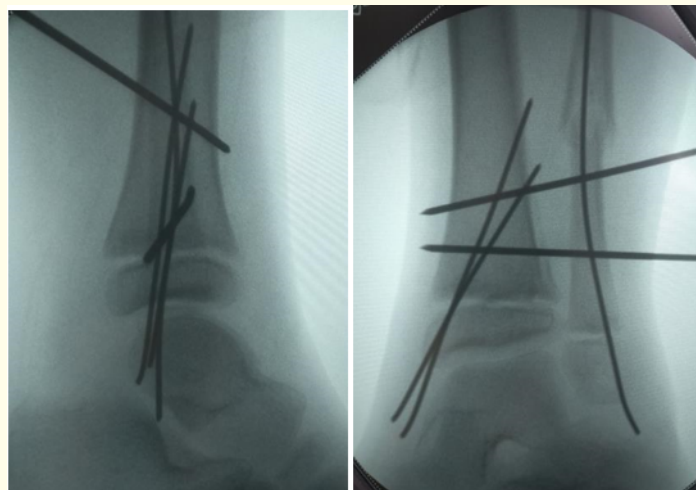


Figure 3: Polyfocal osteosynthesis by wires.

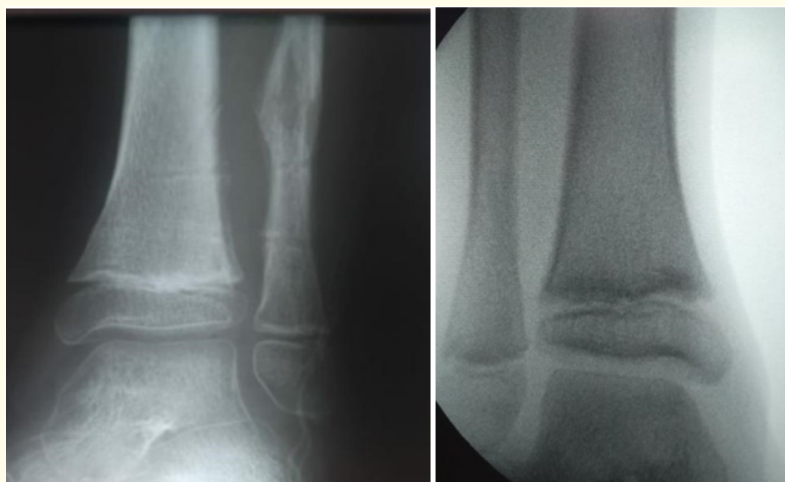


Figure 4: Healing of the fracture and tibiofibularis ligament with healthy joints.

Clinical case No. 2

Boy, 14 y. o., with the diagnosis: “Closed distal osteoepiphysiolyis of the left tibia, type IV according to Salter-Harris”. The injury occurred at a wrestling training. The injury mechanism is indirect, supination-eversion. At this age, the epiphyseal growth plate begins to gradually close, which leads to a change in its biomechanical properties, such as rigidity, elasticity and resilience. This structure becomes uneven in morphology, and as a result of partial closure, the posteromedial zone of the epiphyseal plate becomes denser, which causes

additional fracture planes. In addition to the frontal and sagittal plane, the fracture can also be found in the transverse plane, such fractures are called Triplane Fractures [11]. Taking into account the severity of fracture and its intra-articular nature, the child underwent computed tomography of the right ankle. The epiphyseal part of the fracture was displaced by 5.53 mm. Polyfocal osteosynthesis with wires was performed in the patient. Additional immobilization was carried out in a plaster cast up to the knee joint. Control radiographs were performed 4 and 6 weeks after reduction. The wires were removed after 6 weeks. The joint configuration and the limb function were fully restored (Figure 5-9).

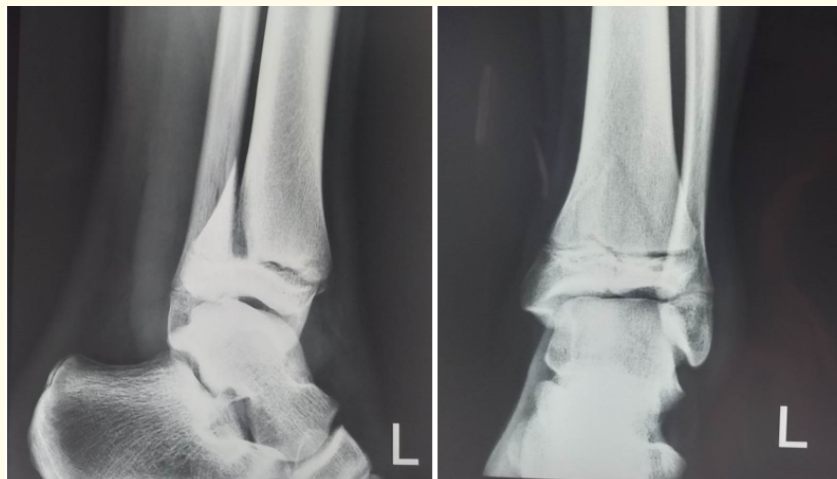


Figure 5: X-ray of the patient: distal osteoepiphysiolsis of the left tibia, type IV according to Salter-Harris.



Figure 6: 3Dimential tomography of the distal part of the left tibia.



Figure 7: Computer tomography of the left tibia epiphyseal.



Figure 8: Polyfocal osteosynthesis by wires.



Figure 9: X-rays after 6 weeks. Healing of the fracture.

Clinical case No. 3

Girl, 16 y. o., with the diagnosis: “Closed fracture of the lateral malleolus at the level of syndesmosis, fracture of the posterior edge of the tibia on the right, fracture of the inner malleolus.” The injury mechanism is supination-eversion. Type B according to Denis-Weber, unstable. In children of this age, morphological changes in the fracture area become similar to those in adults, and the Salter-Harris classification becomes irrelevant. Denis-Weber and Lauge-Hansen classification shall be used to diagnose patients with closed growth plate [12]. Due to the fact that the fracture line of the fibula passes through the distal tibiofibular syndesmosis, according to the classification data, there is no complete rupture, but a damage to the anterior portion. The child underwent open osteosynthesis with a plate, screws and wires. The wires were removed in 2 months after the fracture. The plate and screws were removed in 6 months after the fracture. The joint configuration and the limb function were fully restored (Figure 10-13).



Figure 10: X-ray of the patient: fracture of the lateral malleolus at the level of syndesmosis, fracture of the posterior edge of the tibia on the right, fracture of the inner malleolus. The injury mechanism is supination-eversion. Type B according to Denis-Weber, unstable.



Figure 11: Osteosynthesis of the fibula, screw fixation of the posterior part of the tibia, and wires fixation of the internal malleoli.

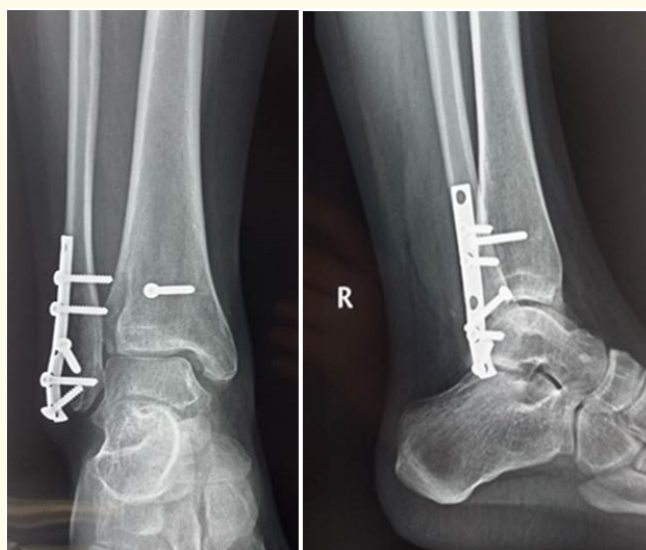


Figure 12: X-rays since 6 months . Healing of the fractures.



Figure 13: X-rays after removing of fixators in internal rotation of the foot. Healing of the fractures in right position of syndesmosis.

Discussion

In the first clinical case, the fracture was fixed with crossed wires. In our opinion, when the growth zone is open, fixation with wires in combination with plaster immobilization is the safest and most effective method, and in the setting of an emergency hospital with a large flow of patients it can be the method of choice. The Weber's method of dynamic compression osteosynthesis is considered one of the most reliable and widespread in adult practice. In pediatric practice, the method is used for fractures without damage to the growth plate. It should be avoided in case of the epiphyseal plate damage since additional compression can cause its ischemia and induce premature closure. There is an opinion that the ligamentous apparatus in children is elastic and is rarely subject to serious damage [5,13]. However, these works did not measure the tibiofibular distance using ultrasound diagnostic methods. In addition, attention should be paid to the complexity of differential diagnosis between damage to the ligamentous apparatus and damage to the growth plate, which otherwise may lead to an incorrect diagnosis. In the work by K. Boutis, *et al.* (2010) of 18 patients with malleolus fracture of type I according to Salter-Harris external, none of the patients showed damage to the growth plate according to magnetic resonance imaging, 14 children showed a sprain of the ligamentous apparatus, and 1 had an avulsion fracture of the peroneal bones with a portion of the anterior talofibular ligament [14,15].

Conclusion

Thus, our studies confirm the need to develop a structural and functional classification of these fractures and create an algorithm for treatment and rehabilitation of such patients, taking into account the degree of damage to the ligamentous apparatus and age-related features of bone tissue regeneration. A differential approach is mandatory in the treatment of children with complex fractures of the distal epiphyseal cartilage of the lower leg bones with the choice of optimal osteosynthesis methods depending on the patient's age and morphological features of the fracture.

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