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Analysis of Bone Nonunion in a Child with Lower Fibula Fracture

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Abstract: ***This paper reported a case of a child with old fracture of the lower fibula. After complete examination, the patient underwent "open reduction and elastic intramedullary nail internal fixation + allograft bone grafting of the lower fibula". Reexamination 5 months after operation revealed allograft bone resorption, bone defect and bone nonunion at the fracture end. After that, a second operation was performed in the external hospital, with the method of "bone nonunion incision elastic intramedullary nail extraction after the fracture of the left fibula + plate screw internal fixation + autologous bone grafting". The review four months after the operation showed that autologous bone absorption at the broken end of the fracture resulted in obvious bone defect, loosening of internal fixation, and bone non-union again, and internal fixation was finally removed, and the family gave up further treatment.***

Keywords: Bone nonunion, Elastic intramedullary nail, Locking bone plate**.**

1. Clinical Data

The patient, male, 4 years old, was admitted to hospital with "repeated left calf pain for 2+ years, aggravated with limited activity for 3 days". According to the patient's family, the patient was accidentally injured 2 years ago, and felt pain and swelling of the left calf after the injury, and the child could barely move after the injury, but it was not paid attention to; Pain in the left calf was felt afterwards, especially after activity, which could be relieved after rest without special treatment; Three days ago, the child experienced pain in his left calf after exercise and his gait was hobbled, but no significant relief was found after rest, so he was admitted to our hospital. DR Of the left tibia and fibula in our hospital: old fracture of the lower part of the left fibula, and old fracture of the upper part of the tibia was possible (Figure 1). Later, for further treatment, he was hospitalized in our department for treatment. After admission, relevant examinations were completed, and the ESR and CRP were normal. After the infection was ruled out, "open reduction elastic intramedullary nail-internal fixation + allograft bone grafting" was performed in mid-April 2022. Intraoperative findings: "The broken end of the fracture was separated and displaced about 0.5cm, and a large amount of proliferative synovioid soft tissue was seen at the fracture end. Soft tissue entrapage was seen at the fracture end. The tissue at the fracture end was removed, and the broken end was exposed. During the operation, the soft tissue was routinely cleaned, the hardened bone was cleaned until the blood permeated, and then the pulp cavity was opened, and then the reduction was performed. 1.5mm elastic intramedullary nail was implanted at the upper end of the external ankle, and then allogeneic bone was implanted at the broken end, and the incision was sutured. The operative time was about 60 minutes without tourniquet. About one week after surgery, the incision of the affected limb was immobilized by plaster on long leg. Light bloody fluid exudated from the patient's incision and contained a few fat drops. Fat liquefaction was considered at that time, but infection could not be ruled out. Enhanced dressing changes and treatment with antibiotics to prevent infection; Allogeneic bone spilt from the incision during dressing change, so the possibility of allogeneic bone rejection was considered. After active dressing change and treatment, the incision was completely healed and discharged 26 days after surgery. The patient was instructed to continue to immobilize the affected limb with plaster, and the outpatient review was conducted monthly in the first 3 months.

图片 1↵ 2022-04（术前）↵

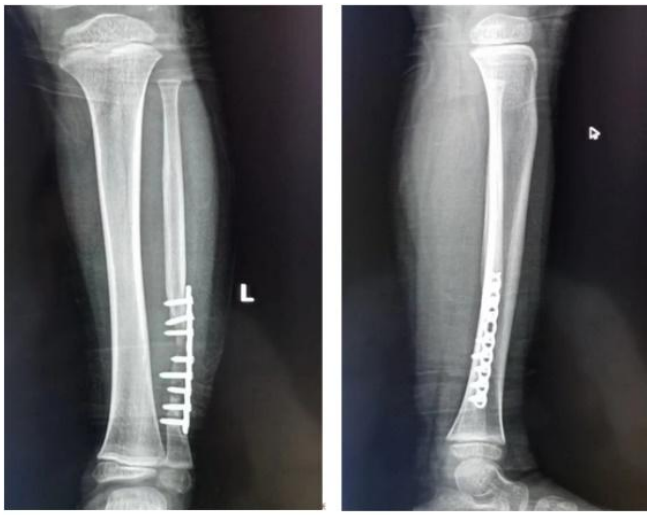
图片 2↵ 2022 年 04 月（术后第二天）↵

图片 3 2022-06-01

图片 4 2022-07-18

图片 5 2022-08-23

Reexamination 2 months (Figure 3) and 3 months (Figure 4) after surgery showed no callus growth, atrophy or allograft bone absorption at the broken end of the fracture. 4+ months after surgery (Figure 5), the fracture did not show signs of healing, and the family requested treatment in another hospital (Grade III hospital). After a complete examination in our hospital, the "bone nonunion incision elastic intramedullary nail extraction after fracture of the left fibula (+) plate screw internal fixation (+) autogenous bone grafting" was performed in September 2022. After three consecutive months of review, no callus growth was observed, the autogenous bone implanted at the fracture end was completely absorbed, and the broken end of the fracture was atrophied with separation of about 0.8cm. The patient was then returned to our hospital (Figure 6). Removal of the internal fixation was requested in January 2023 (Figure 7- Reexamination 1 month after removal of internal fixation), and reoperation was abandoned.



图片 6 2023-01

图片 7 2023-02

Children are in a critical period of growth and development, with abundant and active osteoblasts, osteoclasts, osteoblasts and osteoblasts, abundant blood supply, fast fracture healing, early callus formation than adults, and rare occurrence of bone nonunion. However, with the increase of high-energy injuries, bone nonunion is still one of the common complications in pediatric fractures. In 1988, the US Food and Drug Administration (FDA) defined bone nonunion as those who have suffered fractures for at least 9 months and have no signs of healing in X-ray examinations for 3 consecutive months [1]. Chinese scholars such as Xu Shao ting and Ge Bao feng defined it as: the fracture did not heal for at least 6 months after treatment, and the X-ray examination even 3 months showed no further healing [2]; There are many reasons for bone nonunion in children. Currently, it is believed that it mainly includes two aspects: systemic factors and local factors. Systemic factors include metabolic and nutritional status of patients, age, systemic diseases and lack of related growth factors. Local factors were the primary causes of bone nonunion, which mainly included: (1) open fracture

comminuted fracture caused by high energy injury; (2) Infection of fracture site; (4) The blood supply of the fracture site; (4) Iatrogenic factors include: unstable internal fixation of the fracture (there is fretting at the fracture end), insufficient fixation time, improper selection of surgical methods, and insufficient contact surface of the fracture end. In contrast, iatrogenic factors and the lack of multiple bone growth factors at the broken end of fractures are an important reason for the formation of bone nonunion [3].

For the classification of bone nonunion, Weber-Cech classification is currently the most commonly used clinical classification method of bone nonunion, which can be divided into: dystrophic nonunion, infectious nonunion, hypertrophic nonunion, atrophic nonunion and synovial pseudojoint according to tissue reactivity. Combined with preoperative DR Film, relevant examination and intraoperative findings, the patient was considered to be atrophic bone nonunion with synovial pseudojoint formation.

The two basic conditions for fracture healing are good blood supply and stability of the fracture end (strong internal fixation), in which stability is the key, stability is greater than everything, and the recovery and reconstruction of blood flow also depends on a stable mechanical environment. The treatment of nonunion includes surgical treatment and nonsurgical treatment. Surgery is still the most important method for the treatment of bone nonunion, the treatment of fracture end is particularly important, first of all, to remove sclerotic bone and dead bone, so that the fracture end of extensive bleeding, red pepper sign; The second is to re-open the pulp cavity. At present, the surgical treatment of bone nonunion mainly includes intramedullary techniques and extramedullary techniques, including intramedullary nails and elastic intramedullary nails. Extramedullary techniques include internal fixation with plate screw, external fixation with stent, bone transplantation, bone transport, etc. All these techniques have been maturely applied in clinical practice. First of all, we should determine the type of bone nonunion according to the relevant examination; Then, according to the type of bone nonunion, the most appropriate surgical method is selected. For hypertrophic nonunion: At present, it is mainly believed that it is caused by the instability of the fracture end. Due to the abundant blood supply at the broken end of the fracture, a large amount of callus is formed at the fracture end. However, due to the instability of the fracture end, no bone bridge is formed, so the fracture end cannot be brided and healed. Or on the basis of intramedullary nails to block screws, or even on the basis of intramedullary nails can be fixed with auxiliary steel plate to further strengthen its stability; In this case, bone grafting is often not necessary, and the soft tissue at the interrupted end of the operation should be removed as far as possible to avoid damaging the surrounding soft tissue and affecting the blood supply. Infectious bone nonunion: At present, most scholars advocate staging treatment, complete debridement in one stage, removal of infected tissue, and the use of antibiotic bone cement if necessary. Secondary treatment of bone nonunion or bone defect. But there are also scholars put forward different opinions, which advocate a phase of debridement, bone grafting fixation. Atrophic bone nonunion: poor broken blood supply and no or little callus formation in bone forming biological activities, insufficient osteogenesis, hardening of the fracture end and absorption of necrotic bone lead to defect of the fracture end. During the operation, soft tissue, hardened bone or dead bone should be removed between the broken end of the fracture, and then the medullary cavity should be removed, and autogenous cancellous bone graft should be used to reconstruct the blood supply between the broken end. Synovial pseudarthrosis: the medullary cavity is completely closed by the proliferative synovial membrane, and the long-term micromotion eventually leads to the formation of a pseudarthrocapsule with synovial fluid inside the articular capsule. In surgical treatment, the synovial tissue and articular capsule at the fracture end need to be removed, and then the medullary cavity can be opened, and finally bone reconstruction can be obtained through autogenous bone transplantation [4].

Elastic intramedullary nail fixation was selected for the first operation of the patient, which is mainly applicable to a variety of fracture types such as short oblique shaft fracture, transverse fracture, and accompanied cuneiform bone mass, and is usually used in children aged 3-15 years [5-6]. Elastic intramedullary nail has great advantages in the fixation of long shaft fractures in children: First of all, this operation is minimally invasive, with small incision and small damage; Secondly, the fracture end is fretting, which can effectively promote the rapid formation of callus and promote fracture healing. Of course, the occurrence of bone nonunion is not caused by a single factor, but by many factors, such as: the stability is still relatively poor (often need to assist plaster or support to assist external fixation), the selection of elastic intramedullary nail diameter is not reasonable, the type of fracture is not appropriate, premature weight bearing, etc. [7-9]. Relative contraindications: comminuted fracture, proximal to the joint or/and spread to the joint. As the fracture in this case was an old fracture with a large amount of tissue growth at the fracture end accompanied by separation and displacement, closed reduction was not feasible, so "non-union open reduction elastic intramedullary nail internal fixation + allograft bone grafting" was chosen. Open reduction damaged the blood supply around the fracture, and increased the amount of bone defect during the removal of the hardened bone at the fracture end. Meanwhile, the patient was not aware of the rejection reaction of allograft bone before surgery, resulting in partial absorption of allograft bone and partial seepage from the incision, resulting in insufficient contact surface of the broken end and poor involution of the fracture end. In addition, the elastic intramedullary nail fixation itself was unstable. Although the affected limb was fixed in plaster for 1 month after surgery, the child was very young and active, and could not fully follow the doctor's advice. The plaster broke midway and was replaced once, resulting in bone nonunion.

Locking plate internal fixation was selected for the second surgery. The locking plate is currently a commonly used bone plate in clinical practice. Its advantage is that the fracture end can be pressurized through the dynamic compression hole to achieve the compression fixation of the fracture end and achieve the purpose of primary healing. By locking the thread hole, the screw and the steel plate anchor can be joined as a whole, so as to achieve bridge fixation and provide good angular stability for the fracture. The steel plate does not contact with the bone surface, does not need to peel the

periosteum, and does not exert pressure on the periosteum after being placed in place, thus avoiding the destruction of the periosteum blood supply source and achieving the purpose of protecting the periosteum blood supply [10]. Autologous bone has the advantages of bone regeneration, bone conductivity, bone induction, immunocompatibility and rapid fusion [11], which can promote bone healing. For the second time, "nonunion incision elastic intramedullary nail extraction + plate screw internal fixation + autogenous bone graft after fracture of the left fibula" was performed. The incision length of the patient was about 13cm, and the intraoperative stripping range was wide, which caused great damage to the blood supply around the fracture. Postoperative reexamination of the patients for 3 consecutive months showed no callus growth, complete absorption of autologous bone, and increased defects. Finally, screws became loose and internal fixation failed.

2. Thinking

At present, the patient has undergone two surgical treatments, which all ended in failure. Combined with the current situation of the patient and relevant data, low-intensity pulsed ultrasound or extracorporeal shock wave therapy can be considered as non-invasive conservative treatment for this child, which has been proved to be effective in promoting bone. At the same time, acoustic wave is used as a treatment method, which has the advantages of simple operation, non-trauma and high precision. In terms of surgical treatment, Ilizarov technology is a traction tissue regeneration technology invented by Ilizarov, a former Soviet orthopedic surgeon. Although its operation is complex, it is a very effective method. It stimulates the proliferation of bone cells by controlling and maintaining the appropriate tensile tension and stress, so as to gradually realize the synchronous regeneration of bone and soft tissue, and its growth mode is consistent with fetal tissue, which is the same cell division, professionally referred to as the traction osteogenesis technology. This technique uses annular, unilateral and bilateral scaffolds to stretch bone segments at a safe speed (usually 0.75 ~ 1.00 mm/d, divided into four times) to achieve defect repair [12]. Another surgical method can be Masquelet technique, also known as induced membrane technique, which was reported publicly for the first time by French professor Masquelet. This technique is a bone defect repair technique with easy operation, low cost, wide indications and wide clinical application [13]. In addition, between non-invasive and surgical treatment, percutaneous autologous red bone marrow transplantation (local injection) can be selected. Studies have shown that red bone marrow has the ability to form functional cells, because it contains bone progenitor cells and bone marrow mesenchymal stem cells (BM-SCs), which have the functions of proliferation and bidirectional differentiation, and can differentiate into chondrocytes, tendon cells, bone cells and fat cells under certain induction conditions [14]. Finally, the healing possibility was missed because the parents of the child gave up the operation again, which is very regrettable. Finally, there is a hypothesis that the child may have a congenital fibular pseudojoint.

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