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Advances in the Treatment of Bone Nonunion in Limb Fractures

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Abstract: Limb fractures are a common disease type in clinical practice caused by incidents such as traffic accidents and work-related injuries in daily life. Most patients gradually recover after receiving internal fixation treatment, and the treatment effect is relatively significant. According to relevant surveys and studies, the probability of bone nonunion in postoperative patients is 5–10%, which is a common complication. Nonunion is a condition where the fractured bone has not healed after an extended period of time, e.g. 9 months after treatment, and there is no sign of improvement for 3 consecutive months, necessitating timely treatment. This article reviews the research progress in the treatment of nonunion in limb fractures.

Keywords: Nonunion; Limb fractures; Treatment method; Research progress

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1. Introduction

From the analysis of clinical practice, bone nonunion is one of the main topics in clinical orthopedic research at this stage. With the improvement of medical and hygiene levels, the probability of bone nonunion has a marked downward trend compared with before. Clinical diagnosis of bone nonunion is based on X-ray and corresponding symptoms and also requires the assessment of the healing situation. In order to reduce the incidence of bone nonunion, it is of great significance to carry out corresponding treatment.

2. Etiological analysis of nonunion in limb fractures

2.1. Iatrogenic factors

Bone nonunion is commonly seen in fractures of the extremities, and iatrogenic factors refer to the medical procedures or treatments that result in bone nonunion. Some common causes and preventive measures for iatrogenic factors of bone nonunion in a limb fracture are described below.

(1) Surgical procedures: Incorrect surgical procedures can lead to bone nonunion. Improper bone

reduction or fixation during surgery can interfere with the healing process and increase the risk of nonunion [1]. Therefore, surgical procedures must be performed carefully to ensure that the bone is properly reduced and appropriate internal fixation devices are used to ensure the stability of the bone.

(2) Soft tissue injury: Soft tissue injury around the bone, such as breaking or contusion of muscles, blood vessels, nerves, etc., can also lead to the occurrence of bone nonunion. Damage to soft tissue can result in a blockage of blood circulation and a reduction in the nutrients and oxygen supply to the bones, which can affect bone healing [2]. Therefore, when dealing with limb fractures, the protection and repair of the surrounding soft tissues must be considered at the same time to avoid excessive injury.

(3) Infection: Postoperative infection is another iatrogenic factor that can lead to bone nonunion. Postoperative infections can cause an enhanced inflammatory response and produce pus and scar tissue, which can affect bone healing. Therefore, it is very important to prevent and manage infections promptly after surgery and administer antibiotics if necessary.

2.2. Systemic factors

Systemic factors may also lead to the occurrence of bone nonunion, mainly including the following aspects.

(1) Disease effects: Some systemic diseases can also lead to the occurrence of nonunion [3]. For example, chronic diseases such as diabetes and rheumatoid arthritis can affect the metabolism and repair ability of bones, increasing the risk of bone nonunion.

(2) Age factors: The ability of bone tissue to grow and repair gradually diminishes with age, resulting in longer healing times for fractures. Hence, older people have a higher probability of bone nonunion [4].

2.3. Drug factors

Certain drugs that have a negative effect on the skeletal system can cause fractures of the extremities and bone nonunion. The following are some medications that can cause bone nonunion.

(1) Anticoagulants: Anticoagulants are used to prevent the formation of blood clots, but excessive anticoagulation can result in inadequate blood supply to the fracture site, affecting the healing process of the fracture.

(2) Certain antitumor drugs: Some drugs used in chemotherapy, such as methotrexate, etoposide, etc., may cause damage to the skeletal system and interfere with the normal healing of the fracture [5].

(3) Certain antibiotics: Long-term or high-dose use of certain antibiotics, such as fluoroquinolones, may interfere with bone cell metabolism and affect the healing process at the fracture site.

3. Physical therapy for bone nonunion in limb fractures

3.1. Low-intensity pulsed ultrasound

Low-intensity pulsed ultrasound is a type of physical therapy often used to treat nonunion after a fracture of the extremities. This therapy promotes the repair process of bone by using low-frequency, low-intensity pulsed ultrasound to stimulate the regeneration and healing of bone tissue [6]. It takes a certain amount of time for bone tissue to heal after a fracture. However, there are cases where the fracture site may not heal properly due to a variety of reasons, leading to the appearance of bone nonunion. At this point, low-intensity pulsed ultrasound can provide a non-invasive treatment to help promote bone regeneration and healing [7]. The principle of low-intensity pulsed ultrasound is to transmit pulsed ultrasound waves to the fracture to promote bone regeneration by stimulating the metabolic activity of bone cells and increasing intracellular signaling and protein synthesis. The vibration effect of ultrasound can increase the fluidity of intracellular fluid, enhance the supply of nutrients and the

exclusion of metabolites, and promote the repair and regeneration of bone tissue. Low-intensity pulsed ultrasound has a very low power density and does not cause any damage or pain sensation to the surrounding tissue [8]. During treatment, the patient only needs to place the ultrasound probe over the fracture and follow the doctor's instructions. The whole procedure is safe, easy, and painless, and is suitable for patients of different ages.

3.2. Extracorporeal shock wave

Extracorporeal shock wave therapy is a method of treating bone disorders using pressure waves generated by high-intensity sound waves. These shock waves are delivered to the patient's bone area via an external device and promote healing and regeneration at the fracture site by stimulating and regulating the physiological processes of cells and tissues [9]. Extracorporeal shock wave therapy offers a number of advantages over traditional surgical therapies. Firstly, it is a non-invasive treatment that does not require cutting through the patient's skin, thus reducing the risk of surgery and the occurrence of complications. Secondly, extracorporeal shock wave therapy can be applied topically to precisely stimulate the fracture and avoid damage to the surrounding healthy tissue. In addition, extracorporeal shock wave therapy is simple to operate and patients can be treated in the outpatient department without the need for hospitalization, reducing the burden on patients and the pressure on medical resources.

4. Local treatment of bone nonunion in limb fractures

4.1. Percutaneous autologous bone marrow transplantation

Percutaneous autologous bone marrow transplantation is a currently widely used topical treatment for fractures of the extremities where the bones are not connected. This treatment promotes the regeneration and healing of the bone by extracting bone marrow from the patient's own body and injecting it into the injured site after processing [10]. The advantage of this treatment is that it is a non-invasive procedure that does not require surgery, and that autologous bone marrow can be delivered directly to the fracture site in need of healing during a local injection. During the injection, the doctor will usually inject the bone marrow between the fracture end and the surrounding soft tissue via a guide needle, thus stimulating and promoting the regeneration and healing of the bone. This treatment works by stimulating the regeneration of bone through stem cells and osteoblasts in the bone marrow [8]. Stem cells are pluripotent cells that have the ability to self-renew and differentiate into other cell types. Osteoblasts, on the other hand, are a special cell type whose primary function is to synthesize and secrete bone matrix, which helps in the regeneration and healing of bones. Percutaneous autologous bone marrow transplantation is a relatively simple procedure that can often be done under local anesthesia. The recovery period is relatively short, and patients can usually quickly return to their normal lives and work. In addition, during treatment, the patient's autologous bone marrow does not require an outside donor, reducing the risk of rejection.

4.2. Injectable bone growth factor

Injectable bone growth factor is a locally injected therapy used to treat fractures of the extremities with bone nonunion. In this therapy, bone growth factor is injected into the fracture site to promote healing of the fracture and regeneration of the bone. The principle of injectable bone growth factor is to use the properties of growth factors to stimulate the proliferation and differentiation of bone cells and promote the formation of new bone [11]. These growth factors can include, but are not limited to, bone morphogenetic protein, bone hematopoietic factor, and angiogenic factor, among others. In injectable therapy, the doctor will first identify the fracture site and administer local anesthesia [12]. An injection needle will then be inserted into the exact area of the fracture or bone nonunion to inject bone growth factor into the bone tissue. These factors will promote the formation and healing of new bone

by locally stimulating the proliferation and differentiation of bone cells as well as angiogenesis. Injectable bone growth factor therapy has many advantages. Firstly, it is a non-invasive treatment that does not require surgical procedures, reducing pain and recovery time for patients. Secondly, since the drug is injected directly into the bone tissue, the growth factor can work locally efficiently and improve the treatment effect. In addition, the therapy can also be used to treat some difficult-to-operate locations, such as the spine and joints [13].

4.3. Exosome

Exosome therapy is a method of using the body's own biogenic substances to promote fracture healing. It works by injecting substances rich in growth factors and extracellular matrix into the fracture site to stimulate bone cell proliferation and differentiation, thus speeding up the healing process. Exosomes can be derived from many types of cells, including bone marrow mesenchymal stem cells, fat stem cells, platelets, and others. After being cultured and treated, these cells release bioactive extracellular vesicles containing a large number of substances such as growth factors, extracellular matrix, and regulatory factors. Exosome therapy has certain advantages and characteristics [14]. Firstly, exosomes can promote the proliferation and differentiation of bone cells, thus accelerating the healing rate of fracture. Secondly, exosomes can provide rich biological substances, including growth factors and extracellular matrix, etc., to help improve the blood supply and repair process at the fracture site. In addition, exosome therapy is a local treatment with less impact on surrounding tissues and higher safety.

5. Surgical treatment

5.1. Bone graft treatment

Bone grafting is a common surgical treatment for bone nonunion in limb fractures. Fracture nonunion is a condition in which the fracture surface fails to heal, or a hole or defect is formed between the fracture and the nonunion. In response to this condition, bone grafting is widely used to repair and promote healing of fracture surface. The basic principle of bone grafting is to transplant the patient's own or external bone tissue to the bone nonunion to promote fracture healing and repair of bone defects. Specifically, bone grafting can be divided into two methods: autogenous bone grafting and allogeneic bone grafting. Autogenous bone grafting refers to the grafting of the patient's own bone tissue to the bone nonunion [15]. The advantage of this method is that there is no risk of graft rejection because the patient's own tissue is used. Common autogenous bone graft materials include bone marrow, bone slices, and bone. Allogeneic bone grafting involves the grafting of bone tissue from a person other than the patient into the bone nonunion. The advantages of this method are that it can provide a large amount of bone tissue for transplantation and the operation time is relatively short [16]. Common bone allogeneic grafts include bone from a donor of the same animal or human species. The basic procedure is roughly the same for both autogenous and allogeneic bone grafts. Firstly, the doctor will accurately locate and measure the bone nonunion to determine the exact location and size of the graft [17]. The bone graft is then fixed to the nonunion, usually with a metal plate, steel nail, or screw. Lastly, the patient goes through a period of rehabilitation and bone healing. Bone grafting has a wide range of applications in the repair of nonunion in limb fractures. It can effectively promote the healing of fractures and the repair of bone defects, and greatly shorten the recovery time. However, bone graft therapy also has certain risks and complications, such as infection, graft rejection, and graft fracture. Therefore, before performing bone graft surgery, doctors will comprehensively consider the specific situation of the patient and choose the most appropriate treatment.

5.2. Internal fixation treatment

Internal fixation treatment is a common surgical treatment for limb fractures and nonunion of the bone at the

site of the fracture. The main principle of internal fixation treatment is to fix and stabilize the broken end of the fracture through the use of metal internal fixation at the fracture end (including steel plates, steel nails, screws, etc.) to promote the healing of the bone pieces and the bony connection.

The operation of internal fixation surgery generally requires the following steps.

(1) Preoperative preparation: This includes general examination to ensure that the patient has no contraindications and general cleaning and disinfection.

(2) Anesthesia: According to the specific situation of the patient and the location of the fracture, the anesthesia methods of local anesthesia or general anesthesia is determined.

(3) Incision and exposure: According to the specific conditions of the fracture, the doctor makes one or more incisions on the skin, exposes the fracture site, and cleans up the broken end of the fracture and the surrounding soft tissue [18].

(4) Internal fixation device selection: According to the type of fracture, location, the age of the patient, and other factors, the appropriate internal fixation device is selected, such as plate, steel nail, or screw.

(5) Fixation of the broken end of the fracture: The doctor places the selected internal fixation device on the broken end of the fracture, and fixes the fracture end stably through screws or steel plates to maintain the correct position and alignment of the fracture end.

(6) Intraoperative examination: After the placement of the internal fixation device, the doctor performs an intraoperative X-ray to ensure that the fracture end is stable and properly aligned.

(7) Incision closure: The surgical incision is sutured layer by layer to avoid infection and bleeding [19].

After the internal fixation surgery, the patient needs to strictly follow the doctor's postoperative care instructions, including keeping the incision clean, avoiding weight bearing on the injured area, and appropriate activities to promote blood circulation and muscle function recovery. Routine postoperative review and rehabilitation training are also an important part to ensure fracture healing and function recovery.

6. Conclusion

To sum up, at this stage, there are various treatment methods for limb fracture nonunion. In clinical practice, doctors will take corresponding treatment methods according to the specific situation of patients with bone nonunion. The most important thing is choosing the right treatment method. Among many treatment approaches, surgical treatment is still the most important treatment method, through bone grafting and internal fixation treatment, the most ideal treatment outcomes can be obtained. For some patients with mild disease, physical therapy and local injection therapy can be applied. In the future, the treatment of the symptoms of bone nonunion in the limbs will be more diverse and the treatment effect will improve.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Chen G, Xue Z, Li X, et al., 2022, Effect of Interlocking Intramedullary Nail or Plate Fixation of Autogenous Bone and Artificial Bone in the Treatment of Bone Nonunion After Traumatic Fracture of Extremities. Journal of Clinical Medicine, 42(10): 5–7.

[2] Wang SC, 2022, Effect of Interlocking Intramedullary Nailing on Bone Nonunion After Traumatic Fracture of

Extremities. Health Renren, 2022(18): 63–65.

[3] He L, 2022, Effect of Interlocking Intramedullary Nailing Fixation on Bone Nonunion After Traumatic Fracture of Extremities on Postoperative Motor Function of Patients. Systematic Medicine, 7(16): 63–68.

[4] Li ZW, Liu HJ, 2022, Clinical Effect of Interlocking Intramedullary Nail Fixation in the Treatment of Nonunion After Traumatic Fracture of Extremities and Its Influence on Limb Mobility. Clinical Medical Research and Practice, 7(24): 62–64.

[5] Yu Y, 2022, Effect of Interlocking Intramedullary Nailing on Bone Nonunion After Traumatic Fracture of Extremities. Jilin Medical Science, 43(08): 2214–2216.

[6] Li Q, Cheng B, Li L, 2022, Effect of Interlocking Intramedullary Nail in Treatment of Bone Nonunion After Traumatic Fracture of Extremities. Chinese Health Standard Management, 13(12): 35–38.

[7] Cao X, 2022, The Effect of Multichannel Nonunion Prevention on Fracture Healing Factor and Healing Effect in Patients with Limb Fracture. Journal of Mathematical Medicine & Pharmacology, 35(04): 615–617.

[8] Zheng Y, 2022, Clinical Study of Bushenjigu Prescription Combined with Interlocking Intramedullary Nailing for Treatment of Bone Nonunion After Limb Fracture. New Chinese Medicine, 54(04): 90–93.

[9] Fan Y, Dong Q, Zhong C, 2022, Effect and Complication Observation of Interlocking Intramedullary Nailing in Treatment of Nonunion After Traumatic Fracture of Extremities. Heilongjiang Traditional Chinese Medicine, 51(01): 93–95.

[10] Wang T, 2022, Therapeutic Effect of Interlocking Intramedullary Nailing on Bone Nonunion After Traumatic Fracture of Extremities. Chinese Journal of Modern Materia Medica, 16(02): 56–58.

[11] Huang J, Wang Y, 2021, Clinical Effect of Different Implants in Traumatic Fracture of Extremities. China Continuing Medical Education, 13(13): 124–127.

[12] Xin X, Peng QZ, Dong H, et al., 2020, Effect of Tongluo Xugu Decoction on Fracture Healing in Patients with Limb Fracture Without Bone Union. Henan Traditional Chinese Medicine, 40(12): 1896–1898.

[13] Chen Q, 2020, Application Value of Locking Compression Plate in the Treatment of Bone Nonunion After Limb Fracture. Systematic Medicine, 5(06): 4–6.

[14] Wei J, Wang H, Guo W, 2019, Effect Difference Between Interlocking Intramedullary Nailing and Plate Screw Fixation in Treatment of Bone Nonunion After Limb Fracture. Journal of Practical Clinical Integration of Traditional Chinese and Western Medicine, 19(09): 70–72.

[15] Zhang H, 2019, Analysis of the Efficacy of Different Internal Fixations in the Treatment of Nonunions After Limb Fractures. Continuing Medical Education, 33(07): 61–62.

[16] Chen YQ, Wang S, Huang D, 2019, Causes and Prevention Measures of Malunion and Nonunion After Internal Fixation of Limbs Fracture. Chinese Journal of Contemporary Medicine, 26(16): 122–124.

[17] Chen B, Zeng G, Qian R, et al., 2019, Clinical Observation of Extracorporeal Shock Wave Combined with Platelet-Rich Plasma in Treatment of Bone Nonunion of Limbs Fracture. Guangdong Med, 40(10): 1480–1482 + 1486.

[18] Ben Y, 2019, Clinical Study of Interlocking Intramedullary Nailing in the Treatment of Postoperative Nonunion of Limbs. World Latest Medical Information Digest, 19(19): 56–57.

[19] Li X, 2019, Advances in the Treatment of Fracture Nonunion of Extremities. Journal of Clinical Medicine Literature Electronic, 6(19): 197–198.