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Comprehensive Management of Ankle Sprains: Structure, Diagnosis, Treatment, Prevention Strategies, and High-Risk Groups

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Abstract: Ankle sprain is one of the most common injuries in ankle sports. Due to the special characteristics of human body structure, lateral ankle ligament sprain is a common injury during exercise. The severity of ankle sprain is closely related to the degree of ligament damage and. This type of sprain can be classified as mild, moderate, and severe. Most of the ankle sprains are mild, but some severe patients need to fix their ankle joints for a long time to complete basic movements such as walking smoothly. Currently, surgery is needed to help them recover. However, the risk of surgery is still high today, so it is crucial for patients to take some conservative management strategies first, which include physical therapy and rehabilitation and show a promising outcome during previous experiments. This review elaborates on the structure of ankle joints, as well as diagnosis, treatment, and prevention methods of ankle sprains, aiming to discuss effective treatment plans, reduce the possibility of severe ankle joint injuries, and help people with corresponding problems recover.

Keywords: Structure of ankle, Diagnosis, Treatment, Prevention strategies, High risk groups

1. Introduction

An ankle sprain is a general concern in sports injury, especially for those engaged in ball games and gymnastics. The human ankle's complex bone, joint, and ligament network makes it a vulnerable part. The lateral ankle ligament is more vulnerable to injury due to the common varus injury of the foot and ankle in sports, such as basketball, volleyball, football, rock climbing, skating, skiing, and other activities, which require people to jump and change direction frequently, thus increasing the risk of ankle sprain [1]. In addition, people of different ages will have different injury probabilities. As they grow older, ankle flexibility decreases, and they are more prone to sprains. For example, the frequency of ankle sprains caused by uneven terrain, inappropriate shoes, and other reasons will further increase with the natural aging process of ligament weakening and muscle strength decline.

Given the high incidence and potential severity of ankle sprain, it is essential to understand its basic anatomy. The ankle joint is composed of the talus, tibia, calcaneus, fibula, and supporting ligaments [2]. It is a complex system that can flexibly move and maintain stability, supporting people in daily activities. The interosseous ligaments, lateral ligaments, and medial ligaments play a key role in stability, and their integrity is essential to protect the ankle joint [3,4].

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Diagnosing ankle sprain is a key step because improper diagnosis will lead to inappropriate treatment, thus causing chronic ankle instability. Various clinical trials can be used to evaluate the integrity of specific ligaments and the overall stability of the ankle joint, such as the front drawer test, the rear drawer test, and the eversion stress test, which can help improve the accuracy of the diagnostic results [5]. These examinations and a detailed patient history can help clinicians determine the severity of the sprain and give a treatment plan.

There are many treatment options for ankle sprain, which can be roughly divided into conservative measures and surgical intervention. The RICE principle (rest, ice, compression, and elevation) is the basic measure of conservative treatment at the initial stage, and drug treatment, physical therapy, and external fixation can also be adopted when necessary [6,7]. For more serious cases, surgical repair and ligament reconstruction may be required, and the individualized rehabilitation plan formulated by doctors for different patients may be supplemented after surgery to restore the basic function of the ankle joint and maintain its stability. At the same time, it is equally important to prevent ankle sprains.

This review aims to provide a comprehensive overview from the theoretical basis to clinical treatment and prevention measures of ankle sprain. By integrating existing research and clinical practice, this review aims to emphasize effective treatment options, reduce the incidence of severe ankle injury, and help patients with ankle sprain recover. The review also emphasized the necessity of personalized treatment methods and the collaborative role of medical staff and patients in preventing and rehabilitating ankle sprains and pointed out the direction of future research.

2. Description and Anatomy

The foot and ankle are composed of 26 independent foot bones and long bones of the lower limbs, forming a total of 33 joints. Many of these joints can promote foot movement [3].

The ankle joint is composed of talus, tibia, calcaneus, and fibula joints [2]. The talus is connected to the calcaneus joint below, providing cushioning and shock absorption [2]. The joint surface between the talus and calcaneus and the surrounding soft tissues can disperse the ground reaction force during walking or running, protecting the ankle joint from injury. The tibia bears most of the body's weight and works together with Talus and Fibula to enable flexible flexion and extension movements of the ankle. Calcaneus is one of the main load-bearing parts of the human body when standing upright or ambulating. The fibula and tibia fix the talus together to prevent excessive displacement of the talus within the ankle joint and improve ankle stability. The medial malleolus is located on the inner side of the lower end of the tibia, while the lateral malleolus is located on the lower end of the fibula [2]. In most cases, ankle sprains are caused by inversion of the ankle joint, which puts more pressure on the outer ankle and makes it more susceptible to injury.

The ligament structure of the ankle joint includes the interosseous ligament, lateral ligament, and medial ligament. The interosseous ligaments are thick ligaments that extend from the articular surface of the lower talus to the upper surface of the calcaneus bone [3]. These ligaments are important in maintaining the relationship between the talus and the calcaneus. The lateral ligament complex is composed of anterior talofibular ligaments (ATFL), calcaneofibular ligaments (CFL), and posterior talofibular ligaments (PTFL). The anterior flexor ligaments are relatively thin and weak, ranging from the anterior part of the lateral malleolus (or the end of the fibula) to the neck of the talus. Its main function is to prevent excessive anterior displacement and the varus of talus. The calcaneofibular ligament connects the lateral malleolus and the lateral calcaneus, providing stability and preventing excessive joint rotation. The posterior talofibular ligament is located at the posterior part of the lateral ankle. It extends from the lateral ankle's posterior part to the talus's posterior part. Its main function is to prevent the posterior displacement of the talus. The medial ligament, also known as the deltoid

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ligament, is in the medial aspect of the ankle joint and is a thick ligament complex. Its main function is to provide stability and prevent excessive ankle joint eversion [4].

3. Symptoms and High-Risk Groups/Activities

Ankle sprain is a common sports injury, which can be divided into acute symptoms and chronic symptoms according to the severity and time of injury. Acute symptoms are those that occur immediately after an ankle sprain. Acute ankle sprain symptoms include severe pain, rapid swelling of the injured site, congestion, restricted movement, and elevated temperature at the injured site. After an acute ankle sprain, you can immediately use the "RICE" method to deal with it, that is, rest, ice, compression, and elevation. In addition, patients can also take ibuprofen and other analgesics for appropriate pain relief and seek medical help. Chronic symptoms are those that persist or recur for some time after ankle sprain and are not resolved. Chronic symptoms of ankle sprain include persistent pain and swelling, reduced ankle flexibility, reduced ankle and leg strength, and repeated sprains, and these symptoms cannot fully recover until at least 12 months after the injury [8].

Some sports that need to change the speed and direction frequently are more likely to cause ankle sprain than slow-paced sports and have higher requirements for ankle flexibility. In basketball, volleyball, and football, the risk of ankle sprain is high due to frequent jumping and changing direction. The probability of sprain will increase, especially when stepping on uneven ground or colliding with others when landingse. Secondly, when climbing, athletes mostly use the protruding stones on the mountain to force. Because of the uneven movement surface, the probability of ankle sprain increases. In addition, in skating and skiing, athletes need to change direction quickly during sliding, so the risk of ankle sprain is high. Cailbhe Doherty et al.'s study demonstrated a higher incidence of ankle sprain in females compared with males (13.6 vs 6.94 per 1,000 exposures), in children compared with adolescents (2.85 vs 1.94 per 1,000 exposures) and adolescents compared with adults (1.94 vs 0.72 per 1,000 exposures) [9]. Athletes and sports enthusiasts have a higher risk of injury as they often experience sudden stops or bounces during exercise, leading to ankle sprains. Older people may also be more susceptible to injuries, as with age, the ligaments around the ankle joint will become loose and fragile, and the muscles will also atrophy, resulting in insufficient strength and inability to support and protect the ankle joint. In addition, older people's joint flexibility decreases, and the range of motion of the ankle joint becomes smaller, which leads to the inability of the ankle joint to move significantly to maintain balance, increasing the risk of ankle sprain [10,11]. In short, basketball, football, and some extreme sports like skiing or skating are all high-risk sports. For some people who are prone to sprain, uneven ground, or inappropriate shoes, strenuous exercise, running, and even walking will increase the probability of ankle sprain.

4. Diagnosis and Examination

The main methods for detecting ankle sprains include the Prior Drawer Test, the Posterior Drawer Test, and the Eversion Stress Test [5]. The Prior Drawer Test is mainly used to evaluate the integrity of the anterior talofibular ligament (ATFL). When this method is used for detection, the patient is usually supine or sitting, and the knee joint is bent about 90 degrees. During the examination, the patient usually lies supine with a knee joint bent at approximately 90 degrees. The examiner fixes the distal end of the patient's calf with one hand and holds the heel with the other hand, applying a gentle pulling force forward and observing the movement of the ankle joint. If the ankle is excessively displaced, the test result is positive. That is, the patient's anterior talofibular ligament is damaged [2]. The posterior drawer test is usually used to examine the posterior talofibular ligament and stability of the ankle joint. When using this method, patients are usually in a supine or sitting position, with feet in a relaxed position. The examiner stabilized the distal leg with one hand and placed the other hand

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on the patient's heel, slowly pulling down the calcaneus to separate the calcaneus from the tibiofibula. The test result is positive if the ligament feels relaxation or pain, or the talus is excessively displaced backward. That is, the patient's ankle joint has been injured in the posterior talofibular ligament. The Eversion Stress Test is mainly used to evaluate the injury of the triangular ligament, especially the injury of the tibia and calcaneus. During the examination, the patients are usually supine or sitting. The examiner holds the distal end of the calf with one hand and holds the foot's inner side with the other hand, applying an outward turning force. The test result is positive if the patient has ligament relaxation or pain symptoms when exerting force outward. That is, the triangular ligament is damaged.

5. Treatment and Prevention

If ankle sprains are not diagnosed and treated correctly, they are likely to develop into chronic ankle instability (CAI) [8]. Patients with CAI can be treated with progressive weight-bearing exercises, balance training, and ankle range of motion training. This type of conservative treatment needs to last for at least 6 months. For some patients whose conservative treatment is ineffective, surgery is a treatment method. This type of surgery usually focuses on repair and reconstruction, and patients usually need 6-12 months to recover. In the early postoperative period, the patient must fix the ankle joint with a plaster or other medical device with fixation and support to protect the injured and operated parts, such as ligaments. In the middle postoperative period, patients need some rehabilitation training under the guidance of doctors, such as weight-bearing training and walking and balance training. This training usually goes from shallow too deep to protect patients from secondary injury after surgery. In the late postoperative period, patients should continue to strengthen their ankle flexibility training to improve the flexibility of the injured part. If they want to return to a professional level after surgery, some professional athletes need to train longer [10]. The first and most important step is to confirm whether the patient has a history of ankle sprains during the diagnosis process. If the patient has suffered multiple sprains and has not fully recovered, CAI can be the focus of diagnosis.

The treatment of ankle sprain is mainly divided into conservative treatment and surgical treatment. First, conservative treatment methods include the RICE principle, drug therapy, physical therapy, and external fixation. When the symptoms of ankle sprain in patients are mild, rest, ice, compression, and elevation methods can be used, that is the RICE rule. Rest is to stop activities immediately after a sprain to avoid aggravating injury. Ice is to be applied every 1-2 hours for 15-20 minutes within 1-3 days after injury. Ice compress can deal with some emergency sprains, reduce bleeding and swelling, and relieve pain. Compression is the use of bandages to appropriately bandage the injured part to relieve swelling symptoms. When bandaging, pay attention to moderate strength, not too tight, so as not to affect blood circulation, nor too loose, so as not to reduce swelling. Elevation elevates the injured foot of the patient to promote blood reflux and reduce swelling. For example, you can use a pillow or stool to pad your feet to a level higher than your heart [6]. The main content of drug treatment is to use some drugs with analgesic and anti-inflammatory effects to relieve pain symptoms, such as ibuprofen. The contents of physical therapy include massage, which is helpful in relieving muscle spasms and promoting the rehabilitation of patients. External fixation refers to the use of plaster to fix the ankle joint, limit the range of motion of the injured part, and prevent secondary sprains. Secondly, surgical treatment mainly refers to ligament repair and reconstruction. Ligament repair is to suture the torn ligament ends together through surgery under local anesthesia or general anesthesia. Ligament reconstruction is the use of autologous or allogeneic tendons as grafts and fixing them in the appropriate position through surgery when the ligament injury is serious and cannot be directly sutured. Through surgical treatment, the situation of severe joint sprain can be improved more rapidly. Postoperative rehabilitation training, according to the doctor's recommendations, can help restore the stability of the patient's ankle and reduce pain [7].

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Proprioceptive training is an effective preventive measure that includes a series of exercises that can help improve an individual's ability to perceive body position and motion. These exercises include balance exercises, coordination exercises, and strength exercises, such as single leg standing, balance board training, and jumping exercises. Through proprioceptive training, the strength and coordination of the muscles around the ankle joint will be enhanced, and the stability of the ankle joint will be improved, thus reducing the risk of ankle sprain [1]. Proprioceptive training can effectively reduce the incidence of ankle sprain, especially for people with a history of ankle sprain. Specifically, proprioceptive training reduced the risk of ankle sprain by 41%, and the preventive effect was more significant in participants with a history of ankle sprain. This indicates that proprioceptive training can not only effectively prevent primary ankle sprains but also significantly reduce the occurrence of recurrent ankle sprains [6].

6. Conclusion

This review discusses the structure and function of the ankle joint, the methods of diagnosis, treatment, and prevention, and the symptoms of sprain and high-risk groups. This study summarizes previous studies on ankle sprains and emphasizes the importance of accurate diagnosis, early investigation of treatment methods, and the adaptability of different populations. By referring to other reviews, it is found that there are still some problems that cannot be solved in the research process of ankle sprain. It acknowledges ongoing challenges in chronic ankle instability, including the optimal timing and methods of treatment, necessitating further research for effective solutions. At the same time, the current treatment strategies cannot provide personalized services for each patient. Some patients may reject a particular treatment method and need to develop individualized plans. Therefore, future research can be devoted to finding out the best treatment timing and scheme for chronic ankle sprain and how to provide individualized treatment schemes for patients according to the actual situation. In addition, collaborative efforts among medical professionals and patients are crucial. Patients should adjust their diet and exercise according to the doctor's advice and be more cautious in life. They should actively take measures to cooperate with the treatment to prevent ankle sprain or reduce the possibility of sprain recurrence.

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