CLINICAL ARTICLE

Triple Hemisection Percutaneous Achilles Tendon Lengthening for Severe Ankle Joint Deformity

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Objective: To investigate the efficacy of modified percutaneous Achilles tendon lengthening for severe ankle joint deformity.

Methods: This retrospective case series study included 33 patients with an average age of 25.2 years who underwent surgery in our hospital from April 1, 2010 to March 1, 2018. Triple hemisection percutaneous Achilles tendon lengthening was performed. One stage surgery, other soft tissue surgery or bone correction surgery could be performed. After surgery, a plaster cast was used to fix the functional position, and rehabilitation training was carried out as planned. Complications during the perioperative period were recorded. Statistical analysis of the patients' visual analogue scale (VAS) and American Orthopedic Foot and Ankle Society (AOFAS) score before and at the last follow-up was performed. The recurrence rate of Achilles tendon contracture at the last follow-up and the patients' satisfaction rate were investigated.

Results: All patients were followed up, with an average follow-up period of 56.31 months (8–104 months). All achieved good ankle joint function and appearance improvement And there were no infection or skin necrosis complications. In two cases, the incision was poorly healed at non-Achilles tendon site and was cured by change of dressing. The average VAS score at the last follow-up was reduced from (2 ± 1.48) points before surgery to (0.26 ± 0.51) points ($P = 0.001$), and the average AOFAS score was increased from (64.97 ± 13.56) points before surgery to (90.06 ± 10.06) points ($P = 0.001$). During the follow-up period, there was no chronic rupture of Achilles tendon. There were two cases of recurrence of foot drop (5.7%), and the patients' satisfaction rate was 93.9%.

Conclusion: In the surgical treatment of severe ankle joint deformity, the application of triple hemisection percutaneous Achilles tendon lengthening for Achilles tendon contracture has the advantages of less trauma, beautiful incision, and reliable efficacy. The satisfaction rate of patients with this treatment is high, and it is worth promoting in the clinic.

Key words: Achilles tendon contracture; Ankle joint; Deformity; Percutaneous lengthening; Surgery

Introduction

Severe ankle joint deformities can be caused by abnormalities of the nervous system, trauma, and dysplasia, which have a great impact on lower limb motor function[1]. Severe ankle joint deformity is usually a combination of multiple deformities; its conservative treatment is often unreliable, and surgical treatment is more challenging and prone to complications. Many complex cases need to use different surgical techniques to correct the corresponding deformities, such as tendon transposition to balance soft tissue strength, osteotomy to adjust the alignment, etc[2,3]. In these cases, the presence of Achilles tendon contracture is very common, and the clinical manifestation is foot drop. In order to restore plantigrade foot, the Achilles tendon must be

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lengthened. The traditional technique is to cut the skin open and fully expose the Achilles tendon to perform Z-lengthening, then suture the lengthened Achilles tendon. Severe ankle joint deformity is often carried out by several surgical methods at the same time. Blood supply disorder between skin incisions would cause poor healing of the incision, and even complications of skin necrosis. In addition, increased trauma to the Achilles tendon is also prone to infection. The traditional open Z-lengthening can effectively solve the Achilles tendon contracture but has a high recurrence rate of contracture and many other complications, such as soft tissue adhesion, incision pain, and Achilles tendon rupture. Meanwhile, in some complicated ankle deformities, Achilles tendon contracture is only a part of the deformity. Open surgery often uses the prone position, which is not convenient for the simultaneous osteotomy and tendon transposition in the one-stage operation. To avoid these surgical defects, we need to explore new techniques.

The Achilles tendon is the largest tendon in the human body. It is formed by the confluence of gastrocnemius and soleus muscle tendons and inserts into the calcaneal tuberosity[4]. Percutaneous Achilles tendon lengthening for simple Achilles tendon contractures is currently recognized as an effective method[5–7]. Hatt and Lamphier then modified this technique in 1947[8]. Percutaneous Achilles tendon lengthening made hemisection on the Achilles tendon through small incisions at 2.5 cm intervals to reduce the complications of open surgery[5]. The advantages of this technique are less trauma, shorter hospital stay, less incision complications and scarring[9]. The purpose of Achilles tendon lengthening is to improve the dorsiflexion of the ankle joint and correct the deformity. The study of Lin *et al.*[10,11] showed that modified percutaneous Achilles tendon lengthening by triple hemisection was better compared with the traditional open Z-lengthening in terms of operation time, tendon healing and incidence of complications. This is because percutaneous lengthening significantly improved. Also, the triple hemisection percutaneous Achilles tendon lengthening could reduce the damage to the blood supply to the deep fascia and sheath, lower the possibility of delayed healing of the Achilles tendon and other complications, such as adhesions and pain.

In recent years, triple hemisection percutaneous Achilles tendon lengthening has achieved ideal results in the treatment of simple Achilles tendon contracture[10,11]. This technique bases on the percutaneous sliding technique with three hemi-cuts in the tendon to achieve the effect of lengthening the Achilles tendon. Obviously, compared with traditional open surgery, this triple hemisection technique has the advantages of beautiful incision and less trauma. Whether this minimally invasive technique can be applied to the surgical treatment of severe ankle joint deformity is worthy of in-depth discussion. At present, there are relatively few reports on this field.

Based on the previous research, this study reported a minimally invasive triple hemisection percutaneous lengthening that was applied to complex cases and achieved good short-term results. The core surgical details of this technique are different from the widely used percutaneous lengthening by triple hemisection that was first employed by Hoke *et al.* The authors have described it in detail in the discussion section of the article. The new technique can reduce surgical complications without reducing the surgical efficacy.

This study has conducted a retrospective analysis on the surgical treatments of severe ankle joint deformities with Achilles tendon contractures carried out in recent years, to: (i) explore the effectiveness of the triple hemisection percutaneous Achilles tendon lengthening; (ii) to clarify the safety of this triple hemisection surgical technique; and (iii) to provide reference for the promotion and further application of this technique.

Methods and Materials

Inclusion and Exclusion Criteria

The inclusion criteria were: (i) the patient was more than or equal to 5 years old; (ii) ankle joint deformity with Achilles tendon contracture, and there was manifestation of foot drop; (iii) the course of the disease was more than 6 months; and (iv) triple hemisection percutaneous Achilles tendon lengthening was performed during the operation as well as other orthopedic operations.

The exclusion criteria were: (i) the patient was younger than 5 years old, because they were not suitable for one-stage tendon transposition and osteotomy, etc.; (ii) the course of Achilles tendon contracture was within 6 months, because conservative treatment could be tried first; (iii) simple triple hemisection percutaneous Achilles tendon lengthening, because this follow-up study has been completed and a paper has been published; (iv) the patient received Achilles tendon lengthening before, because the local tissue adhesions or even the presence of sutures in the Achilles tendon would affect the effect of Achilles tendon sliding; (v) infection of soft tissues of the lower limbs; and (vi) coagulation disorder.

Patients

A total of 33 cases who received percutaneous Achilles tendon lengthening for severe ankle joint deformity with Achilles tendon contracture were included. Their surgeries were conducted by the same senior surgeon of this study. All cases were followed.

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Preoperative Examination

This group of patients all had severe ankle joint deformity, so it was particularly important to perform detailed

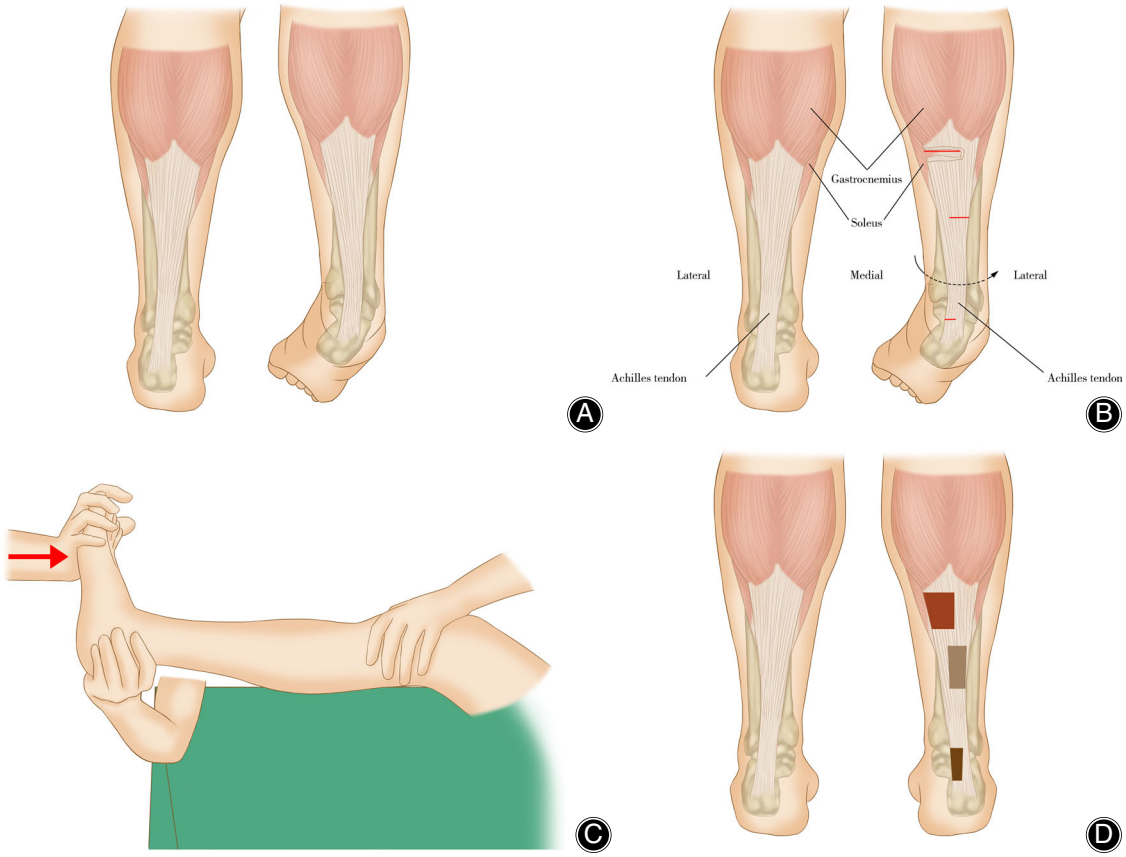

Fig. 1 (A) Achilles tendon contracture and inversion of the right ankle; (B) schematic diagram of the surgical incision design of the modified percutaneous Achilles tendon lengthening for the right ankle joint: the distal incision was marked at 0.5 cm of the calcaneal insertion of Achilles tendon; the middle incision was marked at 5–6 cm away from the distal incision, the most proximal incision was located on the surface of the soleus muscle, and should only cut part or all of the gastrocnemius aponeurosis and weaken part of the plantarflexion strength. The red short horizontal line represents the incision; (C) diagram of the surgical procedure: the patient took a supine position, and the surgeon's assistant fixed the knee joint in continuous extension. The surgeon dragged the ankle joint with his left hand and held the forefoot with his right hand to apply a dorsiflexion stress. Under this stress, the Achilles tendon glided, which could be conducive to realizing the percutaneous Achilles Tendon lengthening; (D) the deformity was corrected postoperatively.

physical examination before surgery to fully understand the motor function, sensation and blood supply of the lower limbs. A Silfverskiold test was performed to determine that it was Achilles tendon contracture and not gastrocnemius contracture[12–14]. Weight-bearing radiographs of the ankle joint and foot were taken to understand the changes in bone structure. Magnetic resonance imaging (MRI) examination was conducted to understand whether the Achilles tendon was continuous, with or without degeneration and Achilles tendon enthesopathy. Neural electromyography should be performed when necessary. These comprehensive examinations were done to analyze the cause of the disease and the severity of the deformity, assess the impact of different treatment measures on the patient. After communicating with the patient or the family, the surgical plan was finalized.

Operative Techniques

Anesthesia and Position

Nerve block, epidural anesthesia, or general anesthesia were chosen. The thigh tourniquet was routinely used. The patient was placed at supine position, with feet a little away from the edge of the operation table, which was convenient for the dorsiflexion movement of ankle joint during the operation, thereby facilitating the effect of Achilles tendon sliding.

Approach and Exposure

After disinfecting and draping, the border of the Achilles tendon and the surgical incision were marked with a marker. There were a variety of surgical procedures for this group of cases. When designing the incision, it was necessary to avoid the distance between the multiple incisions being too close,

Fig. 2 The main steps of the surgery: (A) the preoperative manifestation of varus right ankle joint and Achilles tendon contracture; (B) an incision mark was made on the Achilles tendon before the surgery; (C) after performing the minimally invasive modified percutaneous Achilles tendon lengthening and transposition of tibialis anterior tendon, the deformity of the ankle joint was significantly improved; (D) the ankle joint was fixed at the functional position with a plaster cast.

TABLE 1 Characteristics of included patients at baseline

Variable	Values
Age, years, mean ± SD	25.2 ± 11.7
Sex, male/female	16/17
BMI, kg/m^2, mean ± SD	22.94 ± 2.32
Side of lesion (foots)	
Left	11
Right	30
Double	2
The cause of classification Metatarsal	
Congenital horseshoe varus foot	8
Nerve damage causes foot prolapse	4
Ankle joint deformity caused by infection	1
Malformation after polio	6
Anklebone deformity due to secondary causes	14
Duration of follow-up (M)	56.3 ± 26.8

BMI, body mass index; M, month; SD, standard deviation.

which would affect the blood supply between each other. The design strategy of incision for percutaneous Achilles tendon lengthening is shown in Fig. 1: the distal incision was marked at 0.5 cm of the calcaneal insertion of Achilles tendon; the middle incision was marked at 5–6 cm away from the distal incision, and the interval could be expanded to 8–9 cm according to the degree of Achilles tendon contracture (the starting point of the soleus tendon was slightly farther); the most proximal incision was located on the surface of the soleus muscle, and part or all of the gastrocnemius aponeurosis and weakenedweakenedweakened part of the plantarflexion strength should be cut. should be cut. should be cut. Three longitudinal incisions were made, each about 0.5 cm, and the soft tissue was dissected subcutaneously with hemostatic forceps.

TABLE 2 Comparison of indexes between preoperative and the last follow-up

Indexes	Preoperative	Last follow-up	*t* value	*P* value
VAS	2 ± 1.48	0.26 ± 0.51	7.718	0.001
AOFAS	64.97 ± 13.56	90.06 ± 10.06	−14.279	0.001

Resection

A sharp blade was used to cut the Achilles tendon longitudinally, then blunt dissection was carried out with a detacher. While maintaining mild tension of the Achilles tendon, precisely controlled the depth of the blade to cut more than 1/2 of the Achilles tendon tissue. Then the knee joint was kept at the extension position and gradually the dorsiflexion strength of the ankle joint was increased. When the Achilles tendon was sliding, the surgeon may feel a sudden loss of strength, and even hear a "boom" sound. The purpose of the operation was achieved when the dorsiflexion angle of the ankle joint reached more than 20°. Studies have shown that percutaneous Achilles tendon lengthening by triple hemisection could improve the ankle dorsiflexion angle by more than 20°[18]. During the operation, if the Achilles tendon failed to be lengthened to a satisfying result, the surgeon needed to use a vascular forceps to detect whether the range of Achilles tendon release was sufficient through the incision, and the range of Achilles tendon cut should be increased when necessary. While performing Achilles tendon lengthening, other operations could also be conducted, such as transposition of tibialis anterior tendon, transposition of tibialis posterior tendon, calcaneus osteotomy, or subtalar joint arthrodesis, etc. Finally, the incision was sutured, and the ankle joint was fixed at the functional position with a plaster cast (Fig. 2).

Postoperative Management

Regular follow-ups were conducted after surgery. The stitches were removed 2 weeks after surgery; a plaster cast was used to fix the ankle joint at the functional position for 4–6 weeks, then changed to walking boots for another 4–6 weeks. During this period, the weight-bearing strength of the affected limb was gradually increased on the premise of no pain, and intermittent practice of non-weight-bearing ankle flexion and extension exercises could be conducted. At

12 weeks after surgery, patients could gradually participate in swimming and bicycle riding.

Outcome Measures

Complications, Visual Analogue Scale and American Orthopedic Foot and Ankle Society Scores

The perioperative complications were recorded. Statistical analysis of the Visual Analogue Scale (VAS) scores and American Orthopedic Foot and Ankle Society (AOFAS) scores of patients preoperatively and at the last follow-up was conducted.

Recurrence Rate of Achilles Tendon Contracture and Patient's Satisfaction Rate

The recurrence rate of Achilles tendon contracture at the last follow-up (recurrence rate = number of postoperative foot drop cases/total number of surgical cases × 100%), and the patient's satisfaction rate with treatment (satisfaction rate = number of satisfied patients/total number of patients × 100%) were investigated. Patient self-assessment satisfaction ranged from 0–10 points, and more than 8 points was counted as satisfied.

Statistical Analysis

Statistical analyses were performed by use of PASW 18.0 statistical software (SPSS Inc., Chicago, IL, USA). Quantitative data are presented as mean ± SD. We used a *t* test to compare the difference in means between groups. Categorical data are expressed in percentages, and chi-square tests were used to compare differences between groups. A *P* value less than 0.05 was considered statistically significant.

Results

General Results

All 33 patients were followed (Table 1). Among them, two had bilateral surgery, and the average follow-up period was 56.31 months (24–104 months). Besides Achilles tendon lengthening, nine cases received transposition of tibialis anterior tendon, 10 cases of transposition of tibialis posterior tendon, one case of calcaneus osteotomy, seven cases of subtalar joint arthrodesis, one case of transposition of anterior tibial tendon + subtalar joint arthrodesis, two cases of transposition of tibialis posterior tendon + subtalar joint arthrodesis,

Fig. 3 Typical Case 1: (A) general observation before surgery; (B, C) preoperative anteroposterior and lateral radiographs of the left ankle joint; (D, E) preoperative MRI examination of the left ankle joint; (F) postoperative radiograph of the left foot (the arrow indicated that the transposition tendon was inserted into the lateral cuneiform bone; (G) the incision of the transposition tendon at 3 days postoperatively; (H, I) general observation of the left ankle joint at 3 months postoperatively, which was significantly improved compared with before surgery, and the plantigrade foot was restored.

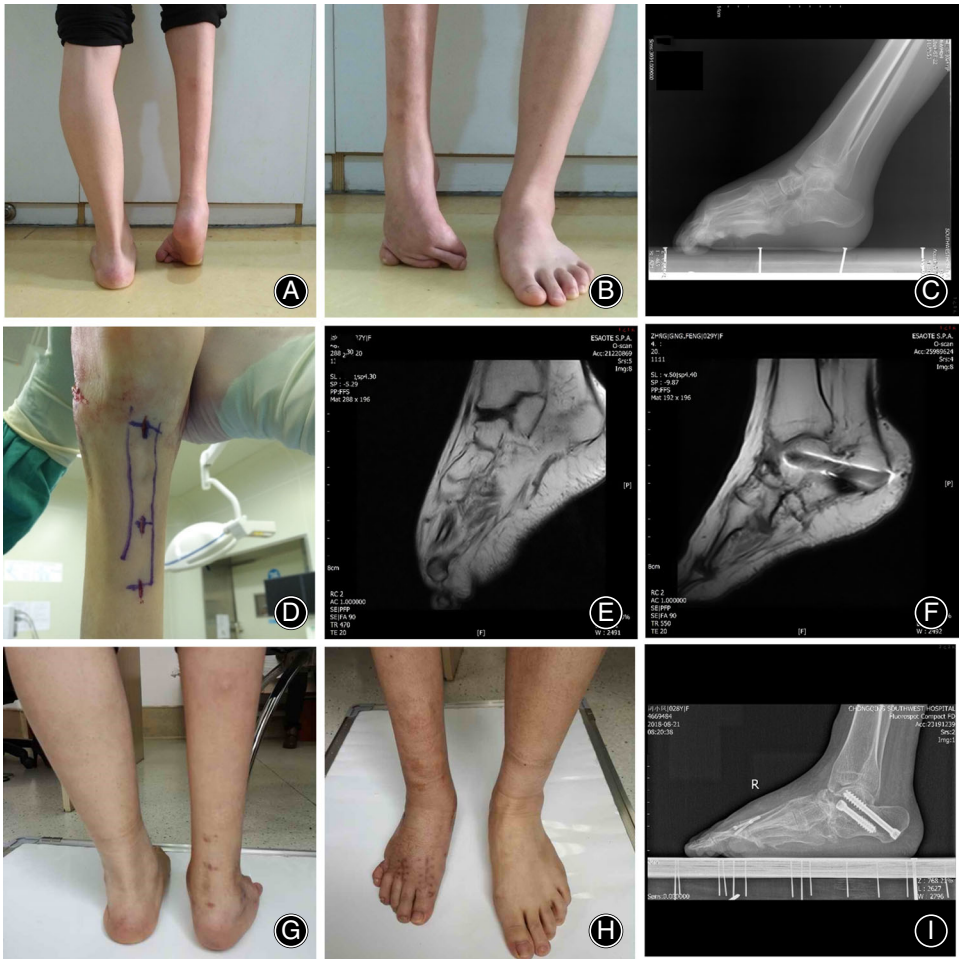

Fig. 4 Typical Case 2: (A, B) general observation of the congenital deformity of the right ankle joint before surgery; (C) lateral radiograph of right ankle joint before surgery; (D) incision of the percutaneous Achilles tendon lengthening; (E) ankle joint MRI examination showed that the Achilles tendon was continuous; (F) at 1 year postoperatively, the re-examination of ankle joint MRI showed that the Achilles tendon was continuous, and the diameter was thicker than before surgery; (G, H) general observation of the right ankle joint at 6 months postoperatively, showing obvious improvement compared with before surgery and the plantigrade foot being restored; (I) lateral radiograph of right ankle joint at 6 months postoperatively.

two cases of transposition of anterior tibial tendon + calcaneus osteotomy, and three cases of other surgical procedures.

Complications, Visual Analogue Scale and American Orthopedic Foot and Ankle Society Scores

There were no complications of infection, skin necrosis, and venous thrombosis of the lower limbs. For the other simultaneously performed surgical procedures, two cases had poor incision healing and were cured by dressing change. The average VAS score decreased from (2 ± 1.48) points before surgery to (0.26 ± 0.51) points ($P = 0.001$), and the average AOFAS score increased from (64.97 ± 13.56) points before surgery to (90.06 ± 10.06) points ($P = 0.001$), all of which were statistically significant.

Recurrence Rate of Achilles Tendon Contracture and Patient's Satisfaction Rate

During the follow-up period, there were no patients with chronic rupture of Achilles tendon, two cases had recurrence of foot drop (5.7%), one case had mild valgus ankle joint, and the patients' satisfaction rate was 93.9% (Table 2).

Typical Case 1

Female, 8 years old, the preoperative diagnoses were: (i) traumatic left talipes equinovarus; and (ii) postoperative skin graft of left foot dorsal skin and extensor tendon defect. The surgical method was minimally invasive percutaneous lengthening of left Achilles tendon + transposition of left tibialis anterior tendon. At 4 years postoperatively, the ankle function improved significantly, and the Achilles tendon contracture did not recur. The AOFAS score at the last follow-up was increased from 78 points before surgery to 94 points. See details in Fig. 3.

Typical Case 2

Female, 27 years old, the preoperative diagnoses were (i) congenital right talipes equinovarus (severe); (ii) right foot 1–4 metatarsophalangeal joints deformity; and (iii) secondary right foot fifth metatarsophalangeal joint dislocation after surgery for fifth metatarsal chronic osteomyelitis. The treatment

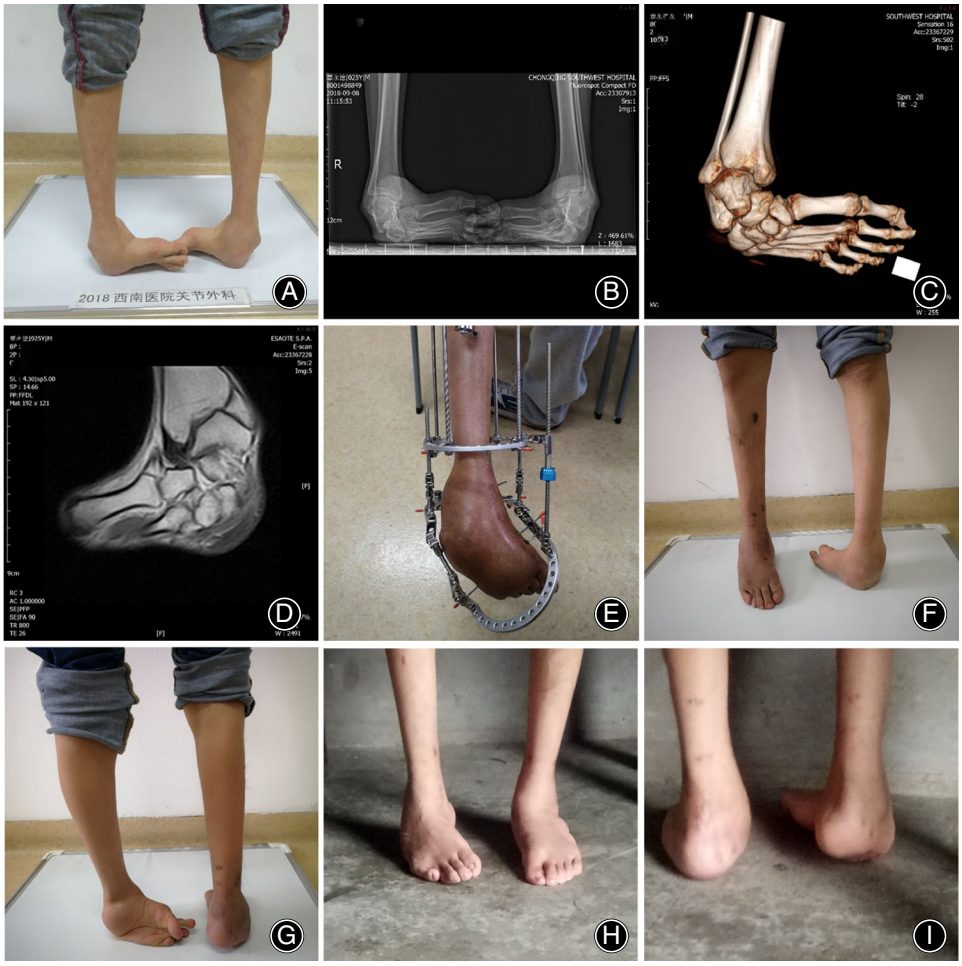

Fig. 5 Typical Case 3: (A) general observation of the congenital deformity of the bilateral ankle joints before surgery; (B) preoperative anteroposterior radiograph of the bilateral ankle joints; (C) preoperative three-dimensional CT reconstruction of the right ankle joint; (D) preoperative MRI examination of the right ankle joint showed continuous Achilles tendon (the arrow indicated the Achilles tendon); (E) the external fixation; (F, G) follow-up examination of the right ankle joint after 4 months postoperatively, the correction of right ankle deformity was satisfactory, and the plantigrade foot was restored; (H, I) follow-up examination of the left ankle joint after 2 years postoperatively, the correction of left ankle deformity was satisfactory, and the plantigrade foot was restored; meanwhile, the right ankle deformity partially recurred.

was divided into two stages. The first operation was: (i) right triple hemisection percutaneous Achilles tendon lengthening; (ii) right foot arthrodesis of three joints; and (iii) right tibialis posterior tendon release. The second operation was (i) right foot first metatarsophalangeal joint arthrodesis; and (ii) right foot 2–4th metatarsophalangeal joint arthroplasty. The ankle function improved significantly at 3 years postoperatively, and the Achilles tendon contracture did not recur. The AOFAS score of the last follow-up was increased from 34 points before surgery to 72 points. See details in Fig. 4.

Typical Case 3

Male, 25 years old, male, the preoperative diagnosis was congenital bilateral talipes equinovarus (severe). The treatment was divided into two stages. First, the right side surgery was performed: (i) percutaneous lengthening of the right Achilles tendon; (ii) soft tissue release of the right medial malleolus; and (iii) slow orthosis of the right foot deformity with external fixation. The plantigrade foot was restored after the right side operation. Then the left side was treated similarly. After 2 years of follow-up, the recovery of the left side was satisfactory; the right side deformity recurred and the three joints arthrodesis was planned. The AOFAS score of the last follow-up was increased from 50 points before surgery to 93 points. See details in Fig. 5.

Discussion

Surgical Strategy for Severe Ankle Joint Deformity

The cause of the ankle joint deformity needs to be analyzed and then treated accordingly along with rehabilitation training. Some of the patients may have remission of symptoms, but for patients with severe ankle joint deformities whose symptoms are not completely relieved after 6 months of conservative treatment, surgery could be considered to avoid aggravating the deformity. When determining the surgical plan, it is necessary to distinguish whether the deformity is flexible. If the deformity can be reduced by soft tissue balancing, then this method is often preferred; if the deformity is rigid, bone surgery may be required, including osteotomy or joint arthrodesis. The patient's age and occupation are also important references for deciding the surgical plan. In short, the treatment of severe ankle joint deformity is

challenging. Sometimes, it is necessary to resolve all deformities in two stages to reduce surgical complications.

Advantages and Disadvantages of Triple Hemisection Percutaneous Achilles Tendon Lengthening

In the first surgical treatment of simple Achilles tendon contracture, satisfactory results have been achieved with the application of triple hemisection percutaneous Achilles tendon lengthening[10,11]. As a new technique, it has the following four characteristics. (i) Better avoid the complications of complete rupture of the Achilles tendon; since the Achilles tendon is a combination of the gastrocnemius and soleus muscle tendons, the tendon lengthening area must be located at the site composed of these two parts of the tendon fiber. When using the traditional triple hemisection technique, the distance between the two distal incisions is less than 5 cm. For patient with significant Achilles tendon contracture, there is a greater risk of complete rupture of the Achilles tendon when sliding the tendon in dorsiflexion. Increasing the distance between the two distal incisions to cut the Achilles tendon and then conduct lengthening by sliding will maximize the lengthening of the Achilles tendon theoretically. That is why the triple hemisection technique can better avoid complete rupture of the Achilles tendon. (ii) There is often an imbalance of soft tissue strength in Achilles tendon contracture, with the plantarflexion strength stronger than the dorsiflexion strength, and the appropriate weakening of the plantarflexion strength is conducive to avoiding the recurrence of the Achilles tendon contracture. To this end, the most proximal incision of this technique is in the tendon area formed by the gastrocnemius muscle, whose deeper part is the soleus muscle tissue. Through the proximal incision, part or all the gastrocnemius tendon tissue is cut to appropriately weaken the strength of the Achilles tendon[15,16]. From our clinical observations, even if this part of the tendon tissue is completely cut, it is found that there is no significant effect on the patient's ankle function, just like the complete cutting of the gastrocnemius fascia for treating flat foot complicated with gastrocnemius contracture would not seriously affect the postoperative function of ankle joint. (iii) The blood supply of the Achilles tendon is mainly supplied by the posterior tibial artery and the peroneal artery. The percutaneous surgery would have little effect on the blood supply of the Achilles tendon, making the lengthened Achilles tendon easy to heal. (iv) Although Hoh *et al.*[17] reported that there was still a risk of infection by percutaneous Achilles tendon lengthening in diabetic patients, the incisions in this study were easy to heal, and no such complications were found[18,19].

Key Points of Triple Hemisection Percutaneous Achilles Tendon Lengthening

There is rotation phenomenon of Achilles tendon fibers in the three-dimensional spatial structure, and the rotational angle varies scientifically in different patients. Some have reported that this rotation had less effect on Achilles tendon lengthening[20,21]. This fiber rotation has a protective effect on stress dispersion and avoiding Achilles tendon damage, but it will increase the difficulty of percutaneous Achilles tendon lengthening. Thus, we usually control the distance between the distal and middle incisions to 5 cm; only when the Achilles tendon contracture exceeds 5 cm, that is, when the Achilles tendon contracture is very severe, should we consider increasing the distance between the two incisions. Due to fiber rotation, it is often difficult to determine the ratio of the transverse cut of the Achilles tendon and the degree of rotation control. Accurate cutting of the Achilles tendon and the control of the longitudinal sliding are still quite challenging[22,23]. Therefore, the safe method is to first cut more than half of the Achilles tendon transection, then try to lengthen it. If unsuccessful, gradually increase the proportion of fiber cut until the ankle dorsiflexion angle exceeds 20°. For the first operation of Achilles tendon contracture, almost all can be treated by percutaneous lengthening; but severe Achilles tendon contracture requires more experience before it can be implemented, otherwise the risk of failure is high. For relapsed patients who have undergone Achilles tendon lengthening before, the direction of the Achilles tendon fibers may be very chaotic, and there would be adhesions in the soft tissue and even sutures in the Achilles tendon to prevent the fibers from sliding. These adverse factors will seriously affect the efficacy of surgery. Thus, we do not recommend using percutaneous lengthening for these patients. In the plantigrade foot position, that is, the functional position, the fixation of transposition tendon and joint arthrodesis is also the basic principle of the surgery. If multiple deformities exist at the same time, first lengthen the Achilles tendon, then perform the rest procedures to avoid interfering with other fixation measures when applying dorsiflexion stress to the Achilles tendon. Meanwhile, after releasing the lengthened Achilles tendon, it is also helpful to restore the plantigrade foot. For postoperative rehabilitation, the ankle joint needs to be fixed with a plaster cast for 4–6 weeks to facilitate the healing of the Achilles tendon, thereby reducing the risk of complete Achilles tendon rupture[9,24]. When it comes to related operations such as Achilles tendon lengthening and Achilles tendon rupture repair, we need to emphasize early postoperative ankle movement to prevent ankle stiffness[25].

Limitations

This study mainly focuses on the minimally invasive percutaneous Achilles tendon lengthening. The surgeon must be very familiar with the local anatomy and have experience in open surgery in order to successfully complete the surgery. The learning curve is relatively long and thus limits the promotion of this technique. We recommend that the surgeon start with traditional surgery and be familiar with local anatomy. On the other hand, this is a single-center retrospective study. In the future, we will conduct multi-center research to include more cases to further explore the reliability of this study.

Conclusion

The application of triple hemisection percutaneous Achilles tendon lengthening for Achilles tendon contracture in severe ankle joint deformity has the advantages of less trauma, beautiful incision, and reliable efficacy. The patient's satisfaction rate with this treatment is high, and it is worth promoting in the clinic.

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