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A Retrospective Study on the Complications of Ilizarov Technique in the Treatment of Neurogenic Talipes Equinovarus

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A Retrospective Study on the Complications of Ilizarov Technique in the Treatment of Neurogenic Talipes Equinovarus

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Abstract- In order to discuss the postoperative complications of Ilizarov technique in the treatment of neurogenic talipes equinovarus, we conducted a retrospective study on the postoperative complications of neurogenic talipes equinovarus patients treated with Ilizarov technique from January 2013 to December 2020. 182 patients (228 feet), 134 males (171 feet) and 48 females (57 feet). The age ranged from 4 to 70 ($\bar{x}$23.6 ± 13.9) years old. There were 44 cases of sequelae of cerebral palsy (24.2%), 112 cases of sequelae of poliomyelitis (61.5%), 18 cases of congenital horseshoe foot (9.9%), and 8 cases of traumatic horseshoe foot (4.4%). The postoperative curative effect was evaluated, and the types of complications and their correlation with age were statistically analyzed. According to ICFSG score, the excellent and good rate of this group was 89.04%. The complication rate was 33.77%. A total of 16 kinds of complications occurred. In the early stage, pain, swelling, numbness and other "tissue displacement reactions" were dominant (78.07%). In the later stage, "tissue displacement syndrome" occurred in 21.49%, but the prognosis was good. 88.37% of the patients in the follow-up data had basically recovered within two years; The looseness of connecting rod accounts for 7.5%; Toe flexion deformity and needle infection accounted for 5.7% respectively; The main complications were positively correlated with age ($P<0.05$). The application of Ilizarov technology has created a good technical advantage for the treatment of neurogenic talipes equinovarus. However, in the process of applying Ilizarov technology to correct neurogenic talipes equinovarus, it is the key to reduce complications and successfully treat neurogenic talipes equinovarus by fully communicating with patients before surgery, strictly controlling the surgical indications, installing and debugging the external frame individually, strengthening long-term and regular rehabilitation training after surgery, and improving patients' compliance with treatment.

Keywords: Ilizarov technology; Horseshoe varus foot; complications; tissue displacement syndrome; Retrospective study.

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I. Introduction

Neurogenic talipes equinovarus is a disease with the highest prevalence and the greatest harm among the modern disabled people. It is one of the common orthopedic malformations, and also a disease with the longest treatment cycle, greater difficulty and poor patient satisfaction. The main pathological change is due to the dislocation of calcaneus, talus and scaphoid, which leads to imbalance of muscle force and local tendon contracture. It is a three-dimensional deformity caused by complex pathological changes of soft tissue and bone and joint, mainly manifested as foot drop, high arch, varus, adduction and other foot and ankle deformities. Due to the relative lack of subcutaneous soft tissue and poor blood supply in the ankle, traditional surgery is easy to cause skin ischemic necrosis, postoperative secondary infection, soft tissue scar contracture and other complications, and the recurrence rate is as high as about 20% [1]. In order to reduce the complications of correction of neurogenic talipes equinovarus and reduce the recurrence rate after operation, we applied Ilizarov technology for treatment. Lizarov technology is to install a special external fixator in the ankle, and gradually correct the deformity of horseshoe foot through slow tissue drafting. The clinical application of many scholars has proved that [2~3], not only the deformity correction is satisfactory, but also the shape and function of the foot can be preserved to the maximum extent, and at the same time, serious complications can be avoided and reduced. It is a safe and reliable method for the correction of neurogenic clubfoot. Due to the different treatment methods and various methods, it is necessary to carry out personalized force line analysis, osteotomy plane and angle design, neuromyoelectric test and analysis, determine tendon transposition, repair of nerve, blood vessel and skin tissues, and long-term, systematic and comprehensive rehabilitation training after surgery according to the patient's different age, sex, occupation, deformity, etc. Therefore, orthopedic physicians need to have comprehensive knowledge of basic medicine and clinical medicine. However, at present, there are not many orthopedic doctors who have received standardized training in China, and the amount of orthopedic operations is large, with many

therapeutic effects and postoperative complications. Therefore, this paper conducts a retrospective clinical study on the treatment effect and postoperative complications of 182 patients with complete data from 262 patients with neurogenic talipes equinovarus treated with Ilizarov technology in our hospital from January 2013 to December 2020.

II. Proposed Method

a) Inclusion criteria

1) Foot deformity secondary to nervous system diseases, such as cerebral palsyPoliomyelitis sequela, congenital horseshoe foot, etc;
2) Type III (severe) or above according to Dimeglio classification method;
3) No severe osteoporosis;
4) Patients with complete clinical data and follow-up ≥ 3 times.

b) Exclusion criteria

1) Soft clubfoot;
2) Plantar flexion deformity is less than 400and there is no complaint of discomfort;
3) Patients with incomplete clinical data and follow-up less than 3 times.

c) General data

182 patients (228 feet) in this group. Among them, 136 were unilateral and 46 bilateral. 134 males (171 feet) and 48 females (57 feet). The age ranged from 4 to 70 ($\bar{x}$ 23.64 ± 13.96) years, 12 cases were ≤ 7 years old (6.6%), 52 cases were 8-17 years old (28.6%), 72 cases were 18-30 years old (39.6%), 44 cases were 31-59 years old (24.2%), and 2 cases were ≥ 60 years old (1.1%). Figure 1. Classification of diseases: 44 cases (24.2%) of sequelae of cerebral palsy, 112 cases (61.5%) of sequelae of poliomyelitis, 18 cases (9.9%) of congenital clubfoot, and 8 cases (4.4%) of traumatic clubfoot. Figure 2. Hospitalization time: 7~271 days ($\bar{x}$ 83.19 ± 43.8 days), return visits after discharge: 3~6 times (¯x3.4 ± 0.63 times)

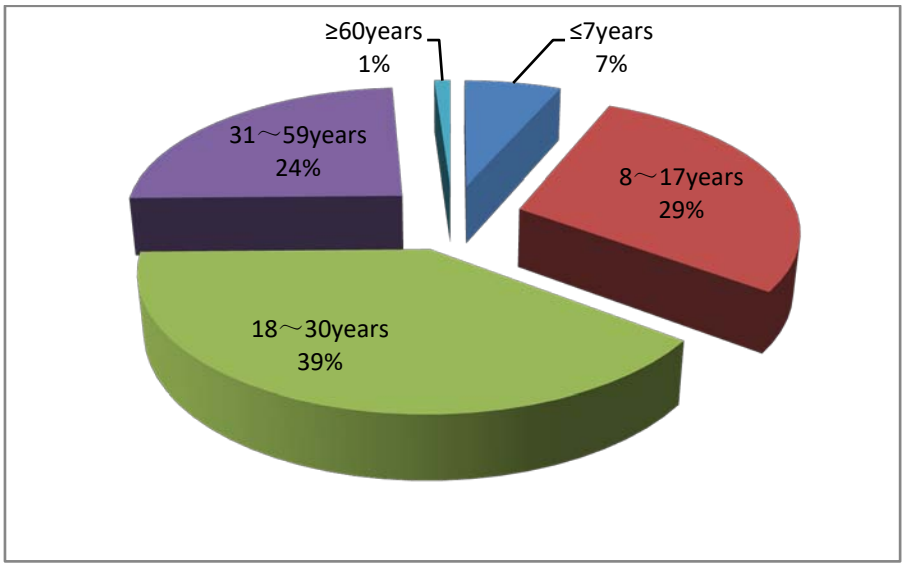

Figure 1: Age group (%)

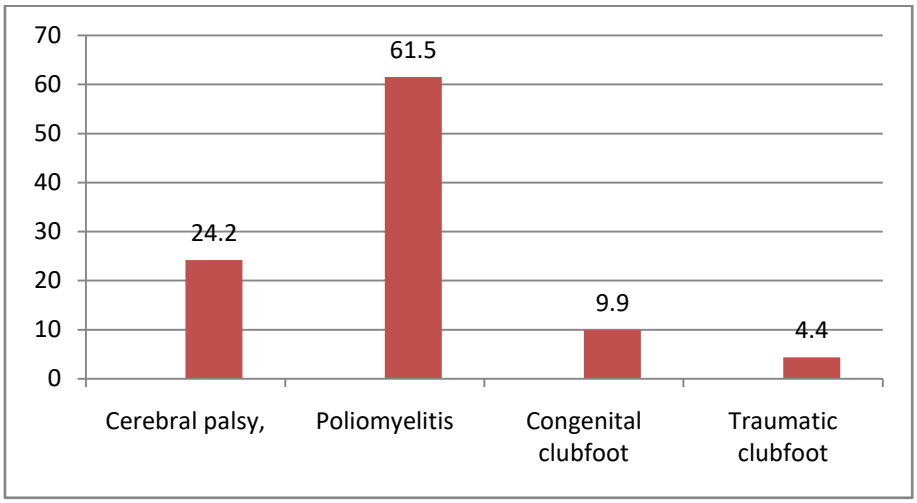

Figure 2: Disease classification (%)

d) Treatment method

According to the degree of bone deformity of the patient's foot, muscle strength, age, the degree of cooperation of the patient and his family, the ability of the doctor to master this technology and other factors, a personalized surgical plan is formulated. First, according to the degree of deformity of the patient's foot, the posterior medial soft tissue release, Achilles tendon lengthening, external transfer of tibial anterior muscle, osteotomy of the three joints of the foot, internal rotation osteotomy under the tibial tubercle and other soft tissue release, muscle force balance, osteotomy correction and joint fusion were selected, and then the Ilizarov external fixator was used for correction.

e) Data collection and sorting

During the hospitalization, the responsible physician (with 5-10 years of clinical experience) is responsible for tabulating, statistical analysis and sorting out the clinical symptoms, signs and relevant examinations of patients after using the Ilizarov external fixator. After the patient leaves the hospital, the responsible physician and the customer service department personnel will conduct telephone or on-site follow-up to the patient and his family members 1 month, 3 months, 6 months, 1 year or 2 years after the patient leaves the hospital. The responsible physician focuses on understanding the patient's disease, guiding the later rehabilitation, prevention and treatment of complications, frame adjustment, frame removal, reexamination, etc. The customer service department staff mainly understand the patient's recent situation, physical recovery, and the evaluation and suggestions on the hospital's work.

f) Statistical methods

All data were analyzed by SPSS 20.0 software. The measurement data are expressed as mean ± standard deviation ($\overline{x} \pm S$). Take the percentage of 5 groups of data of the same variable, calculate the 99% confidence interval and the correlation between the variables. The P value of the detection level is less than 0.05 on both sides, which is considered to be statistically significant.

III. Results and Analysis

a) Evaluation method and efficacy

According to the ICFSG scoring standard, the patients were scored according to the 2-year follow-up after surgery. 228 feet, ICFSG score: excellent 136 feet, good 67 feet, fair 11 feet, poor 8 feet, the excellent and good rate is 89.04%.

b) Postoperative complications and analysis

The time of using Ilizarov external frame for this group of cases was 36~381 days (¯x86.3 ± 56.5). The patients were followed up for 1 month, 3 months, 6 months, 1 year or 2 years after discharge. The follow-up time ranged from 1 to 24 months, with an average of 16.2 months. Among them, 65 people (77 feet) had 16 kinds of complications, the incidence was 33.77%. It is significantly higher than 22.5% reported in the data [4]. We think it is related to different statistical caliber. English literature records the frequency of various complications during limb lengthening of Ilizarov, which may reach 100% [5,6].

i. *Early complications*

In this group, 147 patients (178 feet) had pain, swelling, numbness and other symptoms after operation, accounting for 78.07%. It lasted for 2~12 ($\bar{x}$ 5.85 ± 2.41) weeks, 13 feet had needle infection, 17 feet had loose connecting rods, 5 feet had broken needles, 3 feet had nerve injury and 2 feet had skin necrosis. Needle infection is a common complication in the process of Ilizarov external fixation device orthopedics, with an incidence of 21%~42% [7,8,9,10]. The incidence of cases in this group is low (5.7%). The main causes are thermal burns to tissues during operation, skin and muscle injuries caused by long-term traction, exposed

needle mouth pollution, and skin diseases of a few patients themselves. The causes of this group of cases were prevented in advance, such as using a protective sleeve when threading the needle during the operation, paying attention to the direction and strength of the steel needle and the condition of skin displacement, ensuring the skin is clean, and timely dealing with early infection. Therefore, the needle infection rate is far lower than that reported in the literature. In this group, one patient suffered from allergic dermatitis with infection and finally osteomyelitis due to untimely treatment of early needle infection. The loose connecting rod is mainly due to the loose screw fixation or more patient activities, especially in the rehabilitation training of patients with spastic cerebral palsy. In order to relieve local tension pain, individual patients adjust the screw by themselves. Two cases of common peroneal nerve injury and one case of posterior tibial nerve injury were caused by intraoperative traction. After the application of neurotrophic drugs, rehabilitation physiotherapy and other treatments, they all recovered completely. Two patients suffered from skin necrosis within 1 cm around the anterior medial tibial needle path due to skin heat injury, and recovered after dressing change. 5. The needle breaks at the edge of the fixed screw. Pull out the broken end and fix the broken pin again with the connecting piece, which does not affect the fixing effect.

ii. *Late complications*

The application of Ilizarov technology has created unique technical advantages for limb orthopedics, but there may be a variety of complications in the application of Ilizarov technology, including needle infection, osteomyelitis, footswelling, toe flexion deformity, metatarsophalangeal joint subluxation, foot stiffness and even recurrence [11,12,13]. It is difficult to treat adult neurogenic talipesequinovarus, especially in patients with long course and severe deformity. Although there are many methods of surgical treatment, it is difficult to correct all malformations in one operation [14]. Repeated soft tissue release and osteotomy orthopaedic surgery are more likely to cause stiffness, small and pain of the foot and ankle [15,16]. Beaty JH. Freedman JA et al. [12,13,] believed that ankle and subtalar joint stiffness, arthritis, pain and residual deformity existed for a long time. In this group, 1.8% of the patients had limited knee movement, 2.6% had ankle arthritis and 1.3% had subtalar joint stiffness, which was lower than that reported in the literature. The deformity of toe flexion contracture was 5.7%. After orthopedic surgery, a kind of instinctive anti fall reflex causes the toe to flex and contract for a long time when the foot touches the ground, resulting in toe flexion contracture deformity. Parmanand Gupta et al. [17] believed that toe flexion contracture deformity is a complication that is difficult to treat, and once it occurs, it will not be able to participate in sports competitions as a professional athlete. In this group, 43 patients (49 feet) had limb pain, swelling, numbness and other symptoms more than 3 months after surgery, which we call "tissue displacement syndrome", accounting for 21.49%. The incidence of complications in different age groups is shown in Table 1.

Table 1: Postoperative complications at different ages

complication	≤7 year	8～17 year	18～30 year	31～59 year	≥60 yesr	Total（%）
Pain (>3 months)	1	2	12	9	1	25（10.96）
Swelling (> 3 months)	1	2	10	9	1	23（10.09%）
Numbness (> March)	1	5	16	12	1	35（15.35%）
Needle infection	1	1	5	6	0	13（5.7%）
Broken needle	0	0	2	3	0	5（2.2%）
Loose connecting rod	1	2	6	8	0	17（7.5%）
osteomyelitis	0	0	1	0	0	1（0.4%）
Restricted knee movement	0	0	2	2	0	4（1.8%）
Nonunion of bone	0	0	1	1	0	2（0.9%）
Skin necrosis	0	1	0	1	0	2（0.9%）
Nerve injury	0	0	1	1	0	3（1.3%）
Ankle dislocation	0	0	2	1	0	3（1.3%）
Toe flexion deformity	1	3	5	4	0	13（5.7%）
recrudescence	0	1	1	1	0	3（1.3%）
Ankle arthritis	0	0	3	3	0	6（2.6%）
Subtalar joint stiffness	0	0	2	1	0	3（1.3%）

iii. *Tissue displacement syndrome*

The clinical characteristics of equinovarus foot are mainly ankle plantar flexion, heel varus and forefoot adduction [18]. During the surgical correction, tendon transposition, such as Achilles tendon extension and tibial anterior tendon insertion, should be done. A few patients need to do rectangular shortening osteotomy of the lateral column of the calcaneus, then use a steel needle to cross the calcaneus and metatarsal, connect the half ring and fix it on the calcaneus and foot back, and then slowly pull it for 2 to 3 months, so that the forefoot and midfoot gradually rotate outward and turn

outward, so as to restore the normal appearance of the foot. During the whole operation and slow tissue traction process, the tissue has been displaced, local microvessels have been damaged, and circulation obstacles have occurred, leading to local swelling; Pain caused by tissue injury, hemorrhage, edema, and inflammatory stimulation; Tissue compression, nerve damage, numbness. This series of pathophysiological reactions is called "tissue displacement syndrome". The similar reaction in the earlier stage is "tissue displacement reaction". If the angle of the external frame is adjusted properly or the speed of frame adjustment is slowed down, drug treatment, physical therapy and other comprehensive treatments are carried out, and the symptoms still have no significant change and affect the normal walking function after more than 3 months, it is called "tissue displacement syndrome". The severity of the syndrome is related to surgical trauma, displacement angle, traction time, speed, patient age, and body regeneration and repair ability. In this group, most of the patients with "tissue displacement syndrome" occurred in adults over 18 years old, and there was a significant positive correlation with age (P<0.05-0.01). Among the 43 patients with "tissue displacement syndrome" in this group, 26 (60.47%) were followed up 1 year after discharge, and 12 (27.91%) were followed up 2 years after discharge. The symptoms such as swelling and pain of the patients' limbs basically disappeared, and some patients felt a little numbness locally, but the walking function of the limbs was not affected. Five patients were not followed up. The symptoms of patients with "tissue displacement syndrome" persist, but the prognosis is good.

c) Correlation between complications and age

The correlation test was conducted between the first 6 complications with high incidence rate and different age variables. Among them, pain, swelling and numbness (tissue displacement syndrome) were positively correlated with age (P<0.05-0.01). There was no correlation between needle infection, loose connecting rod and toe flexion deformity and age (P>0.05). Table 2.

Table 2: Correlation between major complications and different age variables

age (year)	pain	swelling	numbness	needle infection	Loose connecting rod	toe flexion deformity
≤7	0.83	0.83	0.83	8.3	8.3	8.3
8～17	3.85	3.85	9.62	1.9	3.8	5.8
18～30	16.67	13.89	22.22	6.9	8.7	6.9
31～59	20.45	20.45	27.27	13.6	18.2	9.1
≥60岁	50.00	50.00	50.00	0	0	0
r	0.93	0.926	0.976	−0.144	0.51	−0.585
p	<0.05	<0.05	<0.01	>0.05	>0.05	>0.05

d) Prevention measures

The distraction osteogenesis theory of Ilizarov technology has proved that the external fixator is beneficial to the shape recovery of various bone tissues, the adjustment and maintenance of limb length during the slow traction process, so that the correction of talipes equinovarus deformity can obtain satisfactory results for clinicians and patients [18, 19]. However, due to the wide variety of configurations of external fixation devices, wide surgical indications, and long learning curve of postoperative management process and doctors, errors are inevitable in the treatment process, and problems in any link, such as needle threading and installation of external fixators, needle bag, postoperative management and guidance of patients' functional training, and the time to remove external fixators, may occur large and small complications [4]. However, through our efforts, most of these complications can be avoided. Paley [20] divided the problems arising from the application of Ilizarov technology into three categories: one is called problems, which can be solved without surgery; The second type is called obstacle, which needs to be solved by reoperation, but will not leave sequela; The three types are called complications, which will still leave morphological abnormalities or dysfunction after treatment. According to the Paley classification, there are 6 kinds of "problems" in this group, of which 3 are "tissue displacement syndrome"; 6 "obstacles"; There were 4 kinds of "complications", 25 feet, accounting for 10.96%.

Orthopedic surgery (including peripheral nerve surgery) is recommended by the bone and joint professional committee of the Chinese Rehabilitation Medical Association, the China Brain Palsy Multidisciplinary Cooperation Alliance, and the surgical treatment experts of spastic cerebral palsy by consensus as the second stage surgery of spastic cerebral palsy, an important supplement to SPR surgery, and is not recommended to take corrective surgery first. It is suggested that rehabilitation training is an important guarantee for postoperative functional improvement. Advocate the concept of "three points operation, seven points training" [21]. Therefore, the key to the successful treatment of neurogenic clubfoot is to objectively predict the surgical effect, fully communicate with patients, reduce patients' expectations, improve patients' compliance, strengthen the sense of

responsibility of medical personnel, scientifically, rigorously and strictly control the surgical indications, reduce complications, strengthen long-term and standardized rehabilitation training for patients after surgery, and cooperate with doctors and patients.

IV. Conclusion

In this group, 182 patients (228 feet) with neurogenic clubfoot were treated with Ilizarov external fixator, and the excellent and good rate was 89.04%. There were 16 kinds of complications, accounting for 33.77%. In the early stage, pain, swelling, numbness and other "tissue displacement reactions" were the main symptoms (78.07%). In the later stage, "tissue displacement syndrome" occurred (21.49%), but the prognosis was good. Among them, 88.37% of the patients had basically recovered from follow-up data within two years. The loose connecting rod accounted for 7.5%, toe flexion deformity and needle infection accounted for 5.7% respectively. The main complications increased with age, and there was a significant positive correlation between complications and age ($P<0.05$). However, through our efforts, most of these complications can be avoided. Therefore, in the process of applying Ilizarov technology to correct neurogenic talipes equinovarus, we should strengthen the sense of responsibility of medical personnel and improve their professional skills. Scientific, rigorous and strict control of surgical indications. Do a good job of communication between doctors and patients before surgery to improve patients' compliance with treatment. Personalized installation and adjustment of the external frame, strengthening long-term postoperative rehabilitation training, and other factors are the key to reduce complications and successfully treat neurogenic clubfoot.

Data Availability

The data used to support the study are included in the paper.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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