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Tibial lengthening with ankle arthrodesis in poliomyelitic patients with unilateral dysfunction of both knee extension and ankle dorsiflexion

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Objective: The aim of this study was to assess the results of tibial lengthening with ankle arthrodesis in poliomyelitic patients with unilateral dysfunction of both knee extension and ankle dorsiflexion.

Methods: Twenty-five consecutive adult patients with poliomyelitic sequelae of unilateral dysfunction of both knee extension and ankle dorsiflexion were treated. Patients had an average shorthening of 5.4 cm (range: 4.5–6.5 cm) on the affected side. The tibia was osteotomized and lengthened with external fixators, which were then replaced with plates supplemented with bone grafting. Ankle arthrodesis was performed concomitantly. Protected weight bearing was advised until bony union was achieved. Gait function was evaluated with Functional Mobility Scale and modified Mazur Scoring System.

Results: Twenty-one patients were followed up for an average of 4.3 years (range: 2.0–8.2 years). External fixation was applied for an average of 6.2 weeks (range: 5–8 weeks). Complete bone healing was achieved in all patients and the average union time was 4 months (range: 3.5-4.5 months) after plating. At final follow-up, gait function significantly improved according to Functional Mobility Scale and modified Mazur Scoring System scores ($p < 0.001$ for both).

Conclusion: The tibial lengthening with ankle arthrodesis appears to be an efficient alternative for treating poliomyelitic patients with unilateral dysfunction of both knee extension and ankle dorsiflexion.

Keywords: Ankle arthrodesis; poliomyelitis; tibial lengthening.

Level of Evidence: Level IV, Therapeutic Study.

Following advancements in modern medicine, the incidence of poliomyelitis has gradually decreased.[1] Currently, poliomyelitis has been almost completely eradicated in developed countries and has been significantly decreased in developing countries.[2] A developed country possesses advanced treatment technology, though few patients are in need of treatment. Conversely, a developing country may have a large number of poliomyelitis patients but no advanced treatment available. Following advancements in modern orthopedic technology, musculoskeletal sequelae of poliomyelitis may be significantly mitigated.

According to the author's clinical observations, patients with musculoskeletal sequelae of poliomyelitis in the lower extremity–appropriate for treatment by the described combined technique (tibial lengthening

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with ankle arthrodesis)–may be divided into 3 groups depending on loss of motor action in the knee or ankle joint (according to the author's own series). A group 1 disorder indicates complete loss of knee extension ability with preserved ankle dorsiflexion ability. A group 2 disorder indicates complete loss of ankle dorsiflexion ability with preserved knee extension ability. A group 3 disorder indicates complete loss of both knee extension and ankle dorsiflexion ability. These patients not only experience motor dysfunction but are also associated with shortened limbs after growth maturity. Long-term outcomes include limping and chronic low back pain (LBP), which deteriorate further with ageing.[3] Previously, no attempt to correct such disorders has been endeavored, as the majority of patients live in developing countries. Lengthening the shortened lower extremity and treating motor dysfunction of the knee and ankle to improve gait are highly technically demanding. However, recent lower limb lengthening and ankle arthrodesis techniques have advanced significantly, and effective treatment for such disorders is now theoretically possible.[4,5] The purpose of this retrospective study was to report outcomes of using this combined technique to treat indicated musculoskeletal sequelae of poliomyelitis in a shortened lower extremity.

Patients and methods

From March 2004 to December 2011, 25 consecutive adult patients (age >18 years) who had unilateral sequelae of poliomyelitis (complete loss of both knee extension and ankle dorsiflexion ability) were treated by the author using combined technique at the author's institution. Patients were aged from 23 to 55 years (average: 36 years) with a male to female ratio of 1:1.3 (Table 1). All patients sustained poliomyelitis since childhood and walked with a limp, but no aids were necessary. Although a heel lift had been used by some patients, LBP occurred intermittently in all patients. All patients attended the author's clinic after being informed by public service announcements that gait function might improve following treatment.

Table 1. Clinical data for patients with sequelae of poliomyelitis treated using combined technique (n= 25).

Case no.	Gender	Age (yr)	Shortening (cm)		EF Duration (wk)	Union after plating (m)	LLD (cm)	
			Femur	Tibia			Initial	Latest
1	Female	42	2.0	3.5	5	4.0	5.5	2.0
2	Male	52	2.0	3.0	5	4.0	5.0	2.2
3	Female	28	2.5	4.0	6	4.0	6.5	1.8
4	Female	38	1.5	3.0	5	4.5	4.5	1.8
5	Male	24	2.0	3.0	6	4.0	5.0	2.0
6	Male	31	1.5	3.0	6	3.5	4.5	2.2
7	Female	42	1.5	3.5	7	3.5	5.0	–
8	Male	55	2.0	3.5	6	4.0	5.5	2.2
9	Male	33	2.5	2.5	5	4.5	5.0	2.0
10	Female	36	2.0	3.0	7	3.5	5.0	1.8
11	Female	28	1.5	3.5	6	4.0	5.0	2.0
12	Female	42	2.0	3.5	8	4.0	5.5	2.2
13	Female	29	2.0	3.5	6	3.5	5.5	–
14	Female	45	2.0	4.0	7	4.0	6.0	2.5
15	Male	52	1.5	3.5	8	4.5	5.0	2.5
16	Male	23	2.5	3.5	6	4.0	6.0	2.2
17	Male	36	1.5	3.5	5	3.5	5.0	1.8
18	Female	45	2.0	4.0	8	4.0	6.0	2.0
19	Male	32	1.5	4.0	6	3.5	5.5	–
20	Female	28	2.0	4.0	6	4.5	6.0	2.0
21	Female	38	2.5	3.5	6	4.0	6.0	2.5
22	Male	36	1.5	4.0	5	3.5	5.5	---
23	Female	29	2.5	3.5	6	4.0	6.0	2.0
24	Male	24	2.5	3.0	7	4.5	5.5	2.1
25	Female	37	2.0	3.5	6	4.0	5.5	2.2

EF: External fixation; LLD: Leg length discrepancy; –: Unavailable.

At the outpatient department (OPD), course of the disease was carefully monitored. Muscle power and range of motion (ROM) of the hip, knee, and ankle were evaluated manually and by goniometry. A full-length standing scanogram was routinely taken. The treatment plan was explained thoroughly to patients. Inclusion criteria were sequelae of poliomyelitis with unilateral lesion, complete loss of both knee extension and ankle dorsiflexion action, and leg length discrepancy (LLD) ≥4 cm. Exclusion criteria were bilateral lower extremity lesions (no need of correction), groups 1 and 2 sequelae of poliomyelitis, and main shortening located in the femur. Patients with main shortening in the femur were treated with femur lengthening and were excluded from the study. Patients with completely flaccid knee and ankle (complete loss of flexion and extension action) were excluded because the effectiveness of treatment was considered minimal. In the 25 included patients, the shortened lower extremity was an average of 5.4 cm (range: 4.5–6.5 cm) on the lesion side (Table 1). The tibia was shortened an average of 3.4 cm (range: 2.5–4.0 cm) and the femur an average of 2.0 cm (range: 1.5–2.5 cm).

Under general anesthesia with endotracheal intubation or spinal anesthesia, the patient was placed on the operating table in the supine position. A pneumatic tourniquet was used routinely.

A mid-third fibulotomy was performed first. After a mid-third tibial shaft transverse osteotomy was performed with a power saw, a lengthening external fixator (Ilizarov or TraumaFix external fixator, Paonan Biotech Co., Taipei, Taiwan) was applied. The wound was closed with non-absorbable sutures.

The patient was advised to use crutches and followed up at the OPD. Lengthening of the tibia was implemented by the patient at home at a rate of 1.0–1.5 mm per day. Passive ankle dorsiflexion was encouraged as tolerated. The pin tract site was cared for with 70% alcohol solution once per day. After the desired length (1 cm shorter than the contralateral lower extremity) was achieved, the patient was re-admitted.

Under general anesthesia with endotracheal intubation, the patient was placed on the operating table in the lateral decubitus position. Corticocancellous bone graft was procured from the ipsilateral posterior iliac crest, as much as possible. The patient was moved to a supine position, and the external fixator was removed. A pneumatic tourniquet was applied.

The lengthened site in the tibia was opened directly. In most patients, the tissues in this area were unhealthy and fragile. The local area was completely debrided. With the assistance of a spinal spreader, the gap was distracted to the desired length (1 cm shorter than the contralateral lower extremity). A dynamic compression plate (Synthes, Bettalach, Switzerland) was inserted on the lateral aspect of the tibia with 4 cortical screws on each fragment. Corticocancellous bone graft with or without bone graft substitute (Wiltrom, Hsinchu, Taiwan) was packed in the gap. Four vials of vancomycin powder were placed in the local area to prevent infection. The wound was closed with non-absorbable sutures.

Ankle fusion was performed with direct anterior approach on the ankle joint concomitantly. The articular surfaces of the tibial plafond and talus were resected with a power saw. Ankle alignment was adjusted. Right angle, mild external rotation, and mild valgus of the foot were preferred. The gap was filled with cancellous bone graft, and the ankle was stabilized with 2 staples (Richards, Memphis, TN, USA). A short leg splint was applied. Eight patients required Achilles tendon lengthening concomitantly, which was performed with an oblique incision of the Achilles tendon and sutured after ankle fusion was achieved.

Postoperatively, early ambulation with protected weight bearing was permitted. Knee ROM exercises were encouraged. Patients were followed up at the OPD at 4–6 week intervals. Clinical and radiological bony healing processes were recorded. Crutches were discontinued after bony healing was achieved. After the bone healed, the patient was advised to attend follow up each year and whenever necessary.

Bony union was clinically defined as no pain or tenderness, and connection of both fragments via radiographically solid callus.[6] Nonunion was defined as when the local area remained unhealed after 1 year of treatment or when a second operation was required to achieve bony union.[7]

Gait function was evaluated with the Functional Mobility Scale (FMS) and modified Mazur Scoring System (mMSS).[8,9] The 2 scoring systems were used individually because of varied requirements for poliomyelitis patients. The FMS focuses on walking distance ability (5, 50, and 500 meters). Results of the test are strongly influenced by severity of the disease. The mMSS (excluding pain, ROM, and parts of functional items; 24 points total in 5 items) was used to evaluate the function of concomitant ankle fusion. It included limp (6 points), down stairs (3 points), distance (6 points), up stairs (3 points), and support (6 points). More than 90% of total scores were considered excellent (≥22 points),

80%–89% of total scores good (≥20 points), 70%–79% of total scores fair (≥17 points), and less than 70% of total scores poor (<17 points). A satisfactory result was not defined because treatment techniques still require continuous development and improvement.

Statistical comparison was performed using Fisher's exact test or paired Student's t-test. A p value <0.05 was considered statistically significant.

Results

Twenty-one patients were followed up for an average of 4.3 years (range: 2.0–8.2 years). Four patients were lost during follow-up despite efforts to contact them (Table 2).

External fixation in 21 patients was applied for an average of 6.2 weeks (range: 5–8 weeks). All lengthened sites healed with a union rate of 100% and an average union time of 4 months (range: 3.5–4.5 months) after plating (Figures 1, 2; Table 1).

Ankle arthrodesis healed in all 21 patients at an average of 3.9 months (range: 3–5 months) (Table 2).

There was no nonunion or malunion of the tibia (angular or rotational deformity >5°). Final LLD of the 21 cases was an average of 2.1 cm (range: 1.8–2.5 cm), as measured by full length standing scanograms (Table 1).

Gait function improved at final follow-up, as evaluated by FMS (comparison of walking ability at 500 meters) and mMSS ($p<0.001$ for both) (Table 2). Before treatment, no patients could walk more than 500 meters without aids. After treatment, all patients could walk more than 500 meters without aids. Before treatment, all patients had a marked limp. At final follow-up, all patients had improved to a slight or moderate limp in level walking (evaluated by limp item in mMSS).

Table 2. Clinical data for patients with sequelae of poliomyelitis treated using combined technique (n= 25).

Case no.	Time to ankle fusion (m)	Functional outcome								Follow-up (yr)
		FMS						mMSS		
		5 m	50 m	500 m	5 m	50 m	500 m	Initial	Latest	
		(Initial)			(Latest)					
1	4.0	5	5	3	5	5	5	12	18	8.2
2	3.5	5	5	3	5	5	5	12	18	6.8
3	3.5	5	4	3	5	5	5	11	17	6.6
4	3.0	5	5	3	5	5	5	12	17	5.6
5	3.0	5	5	4	5	5	5	11	18	5.5
6	4.5	5	5	3	5	5	5	13	17	5.2
7	3.5	5	5	4	–	–	–	12	–	–
8	3.0	5	5	3	5	5	5	11	18	4.8
9	4.5	5	4	3	5	5	5	12	18	4.5
10	3.5	5	5	3	5	5	5	12	18	4.5
11	3.5	5	5	4	5	5	5	13	18	4.2
12	4.5	5	5	4	5	5	5	11	17	4.2
13	3.5	5	4	3	–	–	–	12	–	–
14	4.5	5	5	3	5	5	5	11	18	3.9
15	3.5	5	5	3	5	5	5	12	18	3.8
16	5.0	5	4	4	5	5	5	12	18	3.6
17	3.5	5	5	4	5	5	5	11	18	3.6
18	5.0	5	4	4	5	5	5	12	18	3.2
19	5.5	5	5	4	–	–	–	12	–	–
20	4.5	5	5	3	5	5	5	11	17	2.7
21	3.5	5	5	4	5	5	5	12	18	2.6
22	3.0	5	5	4	–	–	–	12	–	–
23	4.5	5	5	4	5	5	5	11	18	2.4
24	3.5	5	5	4	5	5	5	12	18	2.1
25	4.5	5	5	4	5	5	5	12	18	2.0

FMS: Functional Mobility Scale (total: 6 points); mMSS: modified Mazur Scoring System (total: 24 points); m: Meters; –: Unavailable.

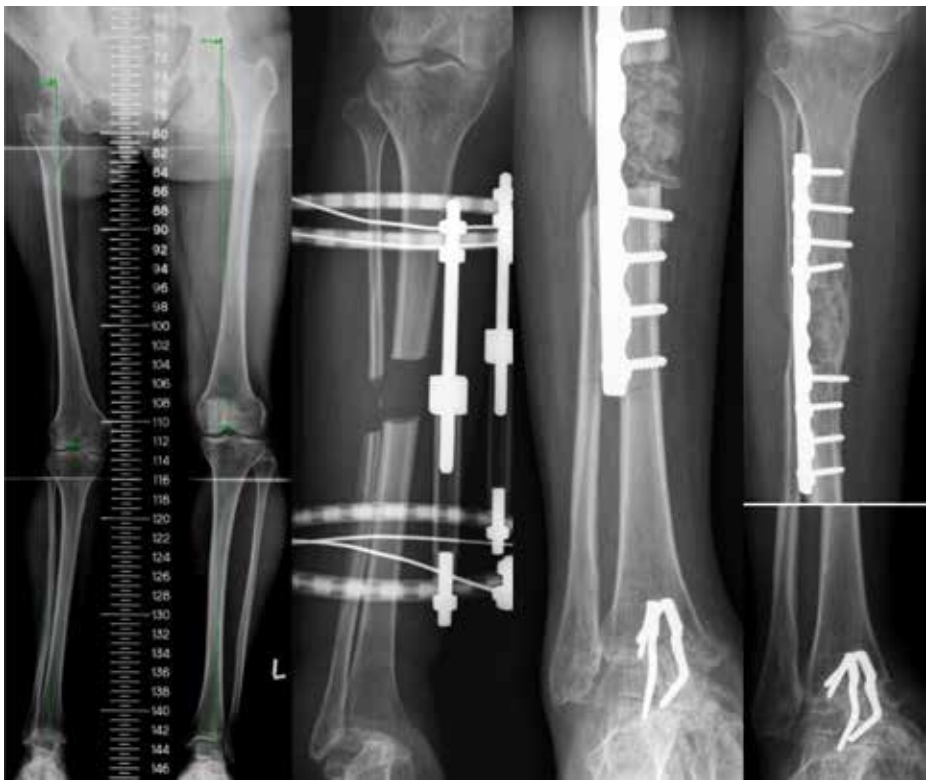

Fig. 1. Case 1: A 42-year-old woman sustained poliomyelitis with shortening of the right lower extremity of 5.5 cm (femur: 2.0 cm; tibia: 3.5 cm). The tibia was lengthened 4.5 cm, and ankle arthrodesis was performed. Gait function improved from poor to fair grade, and gait improved from a marked to slight limp over 8.2-year follow-up. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

Discussion

In the literature, only 0.5% patients with poliovirus infection develop permanent sequelae of nerve dysfunction.[3,10] The boundary of local destruction by polioviruses decides the severity of the sequelae of poliomyelitis. Motor dysfunction is localized at the unilateral L1-L5 level in most patients. Therefore, extension of the knee and dorsiflexion of the ankle are impaired, while flexion function of the knee and ankle is preserved.[11,12] Bilateral involvement or unilateral extension to the sacral level is rare.

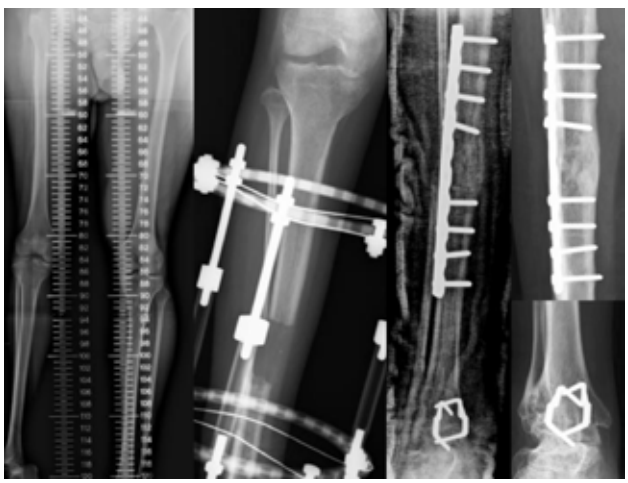

Fig. 2. Case 2: A 52-year-old man sustained poliomyelitis with shortening of the right lower extremity of 5 cm (femur: 2 cm; tibia: 3 cm). The tibia was lengthened 4 cm, and ankle arthrodesis was performed. Gait function improved from poor to fair grade, and gait improved from a marked to slight limp over 6.8-year follow-up.

Motor function impairment manifests variously in patients with poliomyelitis.[3,13] Nearly all patients exhibit significant LLD (>2 cm).[13] The combined disorders may introduce progressive pelvic torsion and intractable LBP.[3] Comprehensive treatment of these disorders is difficult. However, for patients with significant LLD, treatment of ankle disorders in addition to LLD may achieve maximal efficiency.

In normal individuals, more than 2 cm of LLD will cause a limp.[14,15] A heel lift is suggested for 2–4 cm of LLD. In cases of LLD greater than 4 cm, surgical correction is advised because of the inconsistent level of the knee joint. However, in poliomyelitic patients with drop foot, a heel lift on the orthosis may be too clumsy to wear.

To improve gait, lengthening of the limb may be more practical. However, because the hip is often associated with flexion dysfunction (L1-L2 lesion), the lower extremity swings in the gait.[3,13] Therefore, the limb should be slightly shortened to avoid the foot impaction on the ground.[16,17] In this study, all patients had a final LLD of approximately 2 cm (average: 2.1 cm; range: 1.8–2.5 cm), and no heel lift was needed.

LLD in patients with poliomyelitis is usually due to combined shortening of the femur and tibia. However, it is unnecessary to lengthen both bones concomitantly. In most cases, one bone is more severe, and lengthening of this bone is sufficient. In this study of 25 patients, the shortened lower extremity was of an average of 5.4 cm (range: 4.5–6.5 cm). The tibia was shortened an average of 3.4 cm (range: 2.5–4.0 cm) and the femur an average of 2 cm (range: 1.5–2.5 cm). Therefore, over-lengthening of the tibia to compensate for femur shortening was performed, with successful results.

Techniques for ankle arthrodesis have been continuously developed, and a high success rate has been reported.[4,18] The orientation of ankle fusion is recommended, and cancellous bone grafting to improve fusion rate is suggested. In the current study, the ideal principle was followed, and successful fusion was achieved in all patients. Drop foot in poliomyelitic patients generally cannot be treated with anterior transfer of the posterior tibial tendon. For poliomyelitic patients, flexors in the ankle and foot are also weak, rendering the tendon useless after transfer. When a tendon is rerouted to a new pathway, its muscle power will decrease at least one grade.[19]

Currently, techniques using tendon transfer to resume knee extension action have not been proven effective.[20] In groups 1 and 3, extension of the knee normally depends on body position control.[3,13] Patients require a period of practice after treatment. A slightly shortened limb (2 cm in this study) is generally more favorable in this situation.[16,17]

Huang treated 35 patients using single Ilizarov technique for tibial lengthening. The complication rate was 68.6%, and satisfaction rate was 82.9%. Using the Ilizarov over intramedullary nailing technique in 12 patients, while a 33.3% complication rate occurred, a 100% satisfaction rate was achieved.[21] Song et al. reported 14 patients treated with the Ilizarov over intramedullary nailing technique. Foot deformity was corrected concomitantly using Ilizarov frame with or without local fusion. Satisfaction rate was 57.1%.[22] Emara and Khames treated 32 patients (21 without and 11 with associated knee or foot deformity) using the simple Ilizarov technique. No significant improvement of gait function was found.[23] However, in the present study, all 21 patients achieved improved gait function in level walking.

In the present study, all external fixators were converted to plates instead of locked intramedullary nails, as the tibial diameters were too narrow for the use of intramedullary nails. Using plates to immobilize bony fragments after lengthening by external fixation has been reported in the literature.[14,24–26] A success rate of 100% may be achieved. Deep infection and fixation failure are potential complications. However, in the author's experience, infection may be prevented by pin tract care and local antibiotic use, and implant failure may be avoided with protected weight bearing.[14,24] Neither of these complications occurred in the current study.

There are certain limitations in the current study. Firstly, as a result of the modern rarity of poliomyelitis, the sample size was small (21 patients). Additionally, the follow-up period was short (average: 4.3 years), so future studies should investigate longer-term follow-up. Secondly, gait function needs evaluation with a modified scoring system. In previous reports, the severity of patients was not delineated, making comparison with the current study impossible. Finally, no patients in the current study had ankle pain before or after treatment. Therefore, pain score in gait functional evaluation was removed. The total scores decrease, and it may become necessary to redefine satisfactory outcome.

In conclusion, the described combined technique (tibial lengthening with ankle arthrodesis), an efficient and non-complex procedure, may be an excellent alternative for treating poliomyelitic patients with unilateral dysfunction of both knee extension and ankle dorsiflexion.

Conflics of Interest: No conflicts declared.

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