

Use of Allograft in Skeletally Immature Patients for Calcaneal Neck Lengthening Osteotomy

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Purpose: To date, there have been no studies evaluating the usefulness of allograft as a substitute for autograft in calcaneal neck lengthening osteotomy. This retrospective study examined the results of calcaneal neck lengthening osteotomy using allograft for pathologic flatfoot deformity in children and adolescents with various neuromuscular diseases. **Materials and Methods:** 118 feet in 79 children treated surgically between Mar 2000 and July 2005 were reviewed. The mean age at the time of the operation was 9 + 3 years (range, 3 - 17 years) and follow-up averaged 15.4 months (range, 13 - 21 months) postoperatively. Talo-1st metatarsal angle, talo-calcaneal angle, calcaneal pitch were measured before and after operation and bony union was estimated. **Results:** Bony union was noted at the latest follow-up and there were no postoperative complications such as reduction loss, infection, nonunion, delayed union or graft loss during the follow-up period in all but one foot. All radiographic indices were improved postoperatively in all cases. **Conclusion:** Our results indicate that use of allograft in calcaneal neck lengthening osteotomy is a useful option for correction of the planovalgus deformity in skeletally immature patients whose enough autobone can not be obtained.

Key Words: Calcaneal neck lengthening osteotomy, pathologic flatfoot, allograft

INTRODUCTION

Pes planovalgus or flatfoot is a common physiologic condition in normal children. The longitudinal arch of the foot shrinks or disappears

when a child stands, and foot position shows hindfoot valgus, forefoot supination and relatively shorter lateral column than the medial column. However, in various neuromuscular diseases, this deformity frequently leads to pain, callus formation or ulcerative lesion in weight bearing and gait disturbances due to non-reducible talonavicular joint subluxation.¹⁻³ Many surgical treatments have been suggested,²⁻⁶ and the most commonly used in these days would be calcaneal neck lengthening osteotomy (CNLO). The osteotomy is performed between anterior and middle facets of the subtalar joint and tri-cortical bone wedge is inserted into osteotomy site in order to "indirectly" reduce the talonavicular joint. However, in pediatric and adolescent populations, obtaining a sufficient amount of autobone from the iliac crest frequently is impossible. Incision in the apophysis of iliac crest may bring about growth arrest, and excessive length of bone graft extracted can make iliac wing deformities.^{3,7} The purpose of this retrospective study was to evaluate the usefulness of allograft as a substitute for autograft in CNLO for pathologic planovalgus deformity complicated by various neuromuscular diseases.

MATERIALS AND METHODS

Consecutive patients from March 2000 to July 2005 treated with CNLO in authors' institution were reviewed. Inclusion criteria for this study were as follows; the patient should be an independent community-ambulator preoperatively and the complete radiographic files were available before and after operation, and the minimum

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follow-up period was 12 months. 118 feet in seventy-nine patients met the inclusion criteria. 39 patients were affected bilaterally and 40 were affected unilaterally.

54 patients (80 feet) were cerebral palsied and 12 patients (19 feet) were affected with myelodysplasia. Of cerebral palsy patients, 47 patients (69 feet) were diplegics, 3 patients (4 feet) hemiplegics, and 4 patients (7 feet) triplegics. Other conditions included static encephalopathy (11 feet in 7 patients), hypermobile flatfoot with tight tendo-Achilles (2 feet in 2 patients), familial spastic paraplegia (1 feet in 1 patient), Seckel syndrome (2 feet in 1 patient), neurofibromatosis (1 feet in 1 patient), and congenital vertical talus (2 feet in 1 patient). There were 44 males and 35 females, and the average age at the time of the operation was 9^{+3} years (range, 3 - 17 years) and the follow-up averaged 15.4 months (range, 13 - 21 months) postoperatively.

All operations were done by the last author, and the procedures performed were based on Mosca's technique.³ Briefly, the middle facet was identified with a freer elevator and calcaneal osteotomy was done at the exact site between anterior and middle facets of the subtalar joint. Under the image intensifier, a transverse saw cut was made through both cortices, and a laminar spreader was used to open the osteotomy and simultaneously to ensure correct coverage of the talonavicular joint. After determining appropriate length and size of the graft to be inserted into osteotomy site, autograft from the iliac crest was obtained or commercially used human iliac crest bone wedge (Tutoplast Iliac Wedge®, Alachua, FL, USA) was trimmed in a trapezoidal shape by matched in size to fit the calcaneal osteotomy site. This allograft is solvent-dehydrated and gamma-irradiated preserved, and was re-hydrated prior to use by soaking in 0.9% saline solution for a minimum of 15 minutes. 9 patients (10 feet) used autograft and 70 patients (108 feet) used allograft. Graft was fixed with Kirschner wires, and shortened tendo-Achilles (75 feet) or gastrocnemius (27 feet) was lengthened accordingly. Long leg cast was applied for 3 weeks, and then short leg cast for additional 3 weeks after the operation.

Bony union was defined as the evidence of obliteration of the osteotomy lines based on

radiographic findings (Fig. 1). All patients followed radiological evaluation with standard anteroposterior and lateral views of the foot in standing position.⁸ The talo-1st metatarsal angle, talo-calcaneal angle, and calcaneal pitch were measured, and the bony union was evaluated. Windows SPSS 12.0 and paired t-tests were used for the statistical analysis and significance was set at $p < 0.05$.



Fig. 1. Anteroposterior and lateral radiographs of both feet of 9-year-old boy (A) Preoperative radiographs (B) Immediate postoperative radiographs (C) Bony union was confirmed at the postoperative 1 year, and corrected talonavicular subluxation was noted in standing position.

RESULTS

At the latest follow-up, bony union was confirmed and a recurrence in which the graft slipped out of the osteotomy site was not noted in all but one foot. In addition, there was no exacerbation compared with the preoperative status in terms of talonavicular coverage. None of the cases developed other types of foot deformity, and the restriction of ankle or subtalar joint motion or pain was not observed in all patients. One patient had persistent pain and recurrence of the deformity postoperatively, and plain radiograph showed subluxation of calcaneocuboidal joint and resorption of the allograft, which was treated eventually with curettage and arthrodesis of the calcaneocuboidal joint.

In comparisons of preoperative and postoperative anteroposterior radiograph, talo-1st metatarsal angle and talocalcaneal angle were decreased postoperatively ($p < 0.05$); talo-1st metatarsal angle from $25.6 \pm 10.9^\circ$ to $10.9 \pm 8.2^\circ$, and talo-calcaneal angle from $40.7 \pm 7.8^\circ$ to $27.3 \pm 7.7^\circ$, respectively. On the lateral radiograph, calcaneal pitch also was improved postoperatively ($p < 0.05$), from $-0.8 \pm 7.4^\circ$ to $11.3 \pm 7.8^\circ$ (Table 1).

In comparisons of the use of autograft and

allograft, there were no significant differences before and after operation in terms of radiographic measurements. In autograft group, there were significant differences between the preoperative and postoperative values ($p < 0.05$). Talo-1st metatarsal angle was improved from $20.2 \pm 4.8^\circ$ preoperatively to $8.7 \pm 4.4^\circ$ postoperatively, talo-calcaneal angle from $35.9 \pm 3.9^\circ$ to $24.1 \pm 3.3^\circ$, and calcaneal pitch from $1.8 \pm 6.1^\circ$ to $14.0 \pm 6.2^\circ$. In allograft group, there were significant differences between the preoperative and postoperative values ($p < 0.05$). Talo-1st metatarsal angle was improved from $26.5 \pm 11.4^\circ$ preoperatively to $11.2 \pm 8.6^\circ$ postoperatively, talo-calcaneal angle from $41.5 \pm 8.2^\circ$ to $27.9 \pm 8.1^\circ$, and calcaneal pitch from $-1.3 \pm 7.6^\circ$ to $10.9 \pm 8.0^\circ$ (Table 2).

DISCUSSION

In planovalgus deformity observed in many neuromuscular diseases, the length of lever arm acting on the triceps surae is short due to subluxated talonavicular joint and forefoot abduction. This results in inappropriate ankle plantarflexion-knee extension coupling. Hence, the surgical treatment should be directed to

Table 1. Preoperative and Postoperative Radiological Indices

	Preoperative	Postoperative	<i>p</i> value
Talo-1st metatarsal	25.6 ± 10.9	10.9 ± 8.2	< 0.05
Talo-calcaneal	40.7 ± 7.8	27.3 ± 7.7	< 0.05
Calcaneal pitch	-0.8 ± 7.4	11.3 ± 7.8	< 0.05

Table 2. Preoperative and Postoperative Radiological Indices According to Bone Graft Materials

		Autobone (n = 10)	Allobone (n = 108)	<i>p</i> value
preop	Talo-1st metatarsal	20.2 ± 4.8	26.5 ± 11.4	0.09
	Talo-calcaneal	35.9 ± 3.9	41.5 ± 8.2	0.06
	Calcaneal pitch	1.8 ± 6.1	-1.3 ± 7.6	0.18
postop	Talo-1st metatarsal	8.7 ± 4.4	11.2 ± 8.6	0.24
	Talo-calcaneal	24.1 ± 3.3	27.9 ± 8.1	0.13
	Calcaneal pitch	14.0 ± 6.2	10.9 ± 8.0	0.18
	<i>p</i> value*	< 0.05	< 0.05	

**p* value: preoperative versus postoperative.

correct foot malalignment, secure the stability of foot during stance, and for achieving sufficient ankle plantarflexion at push-off and foot clearance during swing. Although there have been many surgical methods for flatfoot deformity, the indication of each procedure is not clearly established yet. One of the most commonly used method, extra-articular subtalar arthrodesis,^{5,9} has the advantage of preventing secondary deformity and maintaining the growth of the foot. However, there might be a limitation of motion at the subtalar joint postoperatively and a possibility of subsequent arthritis.^{3,10,11}

In os calcis lengthening for correction of the planovalgus deformity, insertion of a structural graft is an essential part of the procedure.^{2,3} There are many kinds of graft materials such as autobone, allobone, xenobone and artificial bone which have different characteristics in terms of osteoinduction, osteoconduction and resorption of host bone. Considering all the characteristics, autograft is generally proposed in preference to allograft. However, harvesting bone with sufficient mass and size have been limited in the skeletally immature patients and apophyseal injury to the iliac crest can result in permanent defects and deformities.¹²⁻¹⁶

Mosca¹³ introduced the modified technique of calcaneal lengthening osteotomy with which hindfoot deformity could be corrected without hindering the motion of talocalcaneal joint. Many of his series were treated with autograft, probably due to the fact that most patients were older children and adolescents (mean age: 11⁺¹⁰ years) in whom the acquisition of autograft could be performed without much difficulty. However, he noted that maintaining the reduction of talonavicular joint was not feasible by inserting autograft only because the autograft was not strong enough to hold distracted osteotomy site. In order to achieve a complete reduction in the operation field, he should have added procedures on the medial column such as joint plication and tibialis posterior tendon advancement besides the os calcis lengthening. In our series, we observed maintaining reduction of a subluxated joint without adding the medial column procedures during the follow-up period.

The advantages of allograft are that bone mass

needed is prepared before operation and the choice of proper size and shape for grafting or replacement is possible.¹³ However, material characteristics of allograft should be considered in terms of source of derivation, storage, and sterilization that can change biomechanical stiffness of the graft.¹³⁻¹⁶ Major complications after allobone graft are infection, fracture, bony absorption and nonunion. The fracture rate has been reported ranged from 12 to 20%, and infection is one of the most serious complications resulting in graft failure.¹⁷ In this study, calcaneal neck lengthening osteotomy showed improved radiological indices and all the cases had bony union and satisfactory results at the final follow-up. However, further evaluation of calcaneal lengthening osteotomy with and without reconstruction of medial column of the foot is necessary. Although cases treated with autograft were small in number, there were significant improvement between preoperative and postoperative radiological indices in both autograft and allograft groups. This suggests that when skeletally immature patients are not able to extract sufficient bone mass of their own, allograft would be used appropriately without major complications. In conclusion, use of allograft in skeletally immature patients for calcaneal neck lengthening osteotomy is a useful alternative for cases where autograft is not a viable option, or allobone can be applied as an initial graft of choice.

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