Original Article

Temporary Transphyseal Medial Malleolar Screw Hemiepiphysiodesis for Acquired Ankle Valgus following Fibular Graft Harvest in Children: A Series of 15 Patients

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Abstract

Purpose: The study is to assess the role of temporary transphyseal medial malleolar screw hemiepiphysiodesis in cases of acquired ankle valgus following non-vascularized fibular harvest.

Methods: This retrospective chart review included 15 children (18 ankles). Exclusion criteria were inadequate records or additional procedures besides screw hemiepiphysiodesis. Radiological evaluations included lateral distal tibial angle (LDTA) and fibular station (Malhotra grade).

Results: The average patient age was 8.6 years at surgery. The overall duration of treatment was 18.2 months and post removal follow-up (5 ankles) was 16.6 months. The average correction rate was 0.48°/month. LDTA changed significantly following hemiepiphysiodesis (Pre-op 077.3°/in situ follow-up 85.9°). The Malhotra grade did not change significantly during the same period. The average recurrence rate (noted in 4/5 patients) was 0.52°/month. However, LDTA and Malhotra grade did not change significantly post removal.

Conclusions: We report the results of temporary transphyseal medial malleolar screw hemiepiphysiodesis for post fibular harvest acquired ankle valgus in children. Temporary hemiepiphysiodesis is a viable option for the correction of acquired ankle valgus in children. The fibular station is however not restored following the procedure. Recurrence of deformity following screw removal remains a worrying complication in some patients.

Keywords: Hemiepiphysiodesis, Ankle valgus, Growth modulation, Fibula, harvest.

Introduction

Ankle valgus in children is commonly associated with bone dysplasia, congenital conditions, neurological disorders or following trauma [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13]. Fibula remains one of the most preferred autogenous bone graft sites because of ease of access and its shape, strength, and vascular pedicle. It aids in regeneration if the periosteum is preserved at the time of harvest [14]. Despite careful technique during graft removal, fibular regeneration is delayed or incomplete in some patients leading to ankle valgus [15, 16, 17].

Many methods have been tried to prevent or manage ankle valgus in this situation. These include modifications of harvest technique, preservation of periosteum, insertion of screw or wires above the syndesmosis, supramalleolar osteotomy, tibiofibular synostosis and reconstruction of fibular defect [18, 19, 20, 21, 22, 23,

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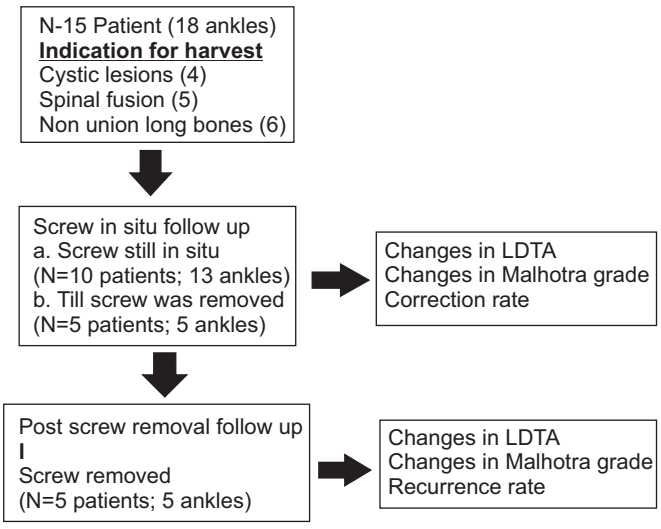

Figure 1: Study design.

24, 25, 26]. Growth modulation of lower tibial epiphysis either by screw only or plate and screw construct ("8" plate) is a relatively recent addition to the options available for managing this problem [25, 26]. We present our experience of managing 15 children (18 ankles) with post-harvest ankle valgus where transphyseal medial malleolar screw hemiepiphysiodesis was used for deformity correction.

Methods

This retrospective chart review (2015–2020) was carried out at our tertiary care pediatric center. The inclusion criteria were children younger than 13 years of age who were treated with a single transphyseal medial malleolar screw hemiepiphysiodesis for acquired ankle valgus (lateral distal tibial angle [LDTA] <84°) secondary to fibular harvest [3]. Patients who completed treatment (screw removed) and those still continuing treatment (with minimum 1 year follow-up) were included. Exclusion criteria were inadequate records or if other procedures were performed (use of multiple distal tibial screws, tibial osteotomy, fibular epiphysiodesis, or other interfering procedure). Patients with any associated condition affecting ankle mortise anatomy in the harvested limb were also excluded. We practice a periosteum-preserving technique for graft harvest and conserve at least 10% of total length at either end to maintain ankle stability at the distal end and for safety of the deep peroneal nerve proximally [15]. Percutaneous hemiepiphysiodesis technique was performed using a 4 mm cannulated partially threaded screw inserted perpendicular to the growth plate. Patient consent was obtained for publication of results and radiographs.

A total of 18 ankles in 15 subjects (8 males, 7 females) were included in the study (Fig. 1). The review analyzed radiographs at the time of surgery and at final follow-up (if correction was still incomplete) or the time of implant removal. In 5 patients, further follow-up after screw removal was available and these were screened for recurrence.

Radiological Evaluation

The radiological evaluation was based on standardized anteroposterior standing donor lower limbs radiographs with the patella facing forward. Ankle valgus was quantified using (LDTA, the angle between the tibial mechanical axis and the

Patients	Age in years	Sex	Side	Pre surgery		Screw in situ follow up			Post screw removal follow up		
				LDTA	Fibular station	LDTA	Fibular station	Follow up (months)	LDTA	Fibular station	Follow up (months)
				(in degrees)	(Malhotra grade)	(in degrees)	(Malhotra grade)		(in degrees)	(Malhotra grade)	
1.	4.5*	M	RIGHT	79.7	2	98.6	2	24	97.3	2	3
2.	10	M	LEFT	76.1	2	82.3	2	27	-	-	-
3.	4	M	LEFT	81.7	3	87.4	3	19	-	-	-
4.	11	M	LEFT	71.1	2	87.3	2	36	-	-	-
5.	10*	F	LEFT	68.5	1	86.9	1	6	73.7	1	18
6.	8	M	RIGHT	75.1	3	80.3	2	27	-	-	-
7.	8*	F	RIGHT	83.8	1	89.4	1	7	89.4	0	23
8.	10	F	RIGHT	81.2	2	81.5	1	13	-	-	-
			LEFT	77.8	2	83.1	1	13	-	-	-
9.	13	M	LEFT	77.4	1	88.1	0	23	-	-	-
10.	12*	M	RIGHT	77.6	2	90.7	1	12	89.4	1	21
11.	9	M	LEFT	80.3	3	83.9	3	12	-	-	-
12.	11	F	LEFT	78.5	3	86	2	12	-	-	-
13.	4	F	RIGHT	81	2	85.1	1	12	-	-	-
			LEFT	78.3	2	81.1	1	12	-	-	-
14.	10	F	RIGHT	77.3	2	89.5	1	21	-	-	-
			LEFT	69.1	2	84.1	1	21	-	-	-
15.	4*	F	LEFT	76	3	81	3	30	53.3	3	18

@ both screw and screw and plate construct; *screw group; #anatomical LDTA; MHE: hereditary multiple exostoses

Table 2: Various large series of screw hemiepiphysiodesis for ankle valgus

distal tibial joint surface; normal range, 84–92°) and fibular station (Malhotra grade 0: fibular growth plate at the level of the talar plateau, Grade 1: fibular growth plate between the top of the talus and the distal tibial growth plate, Grade 2: fibular growth plate in line with the distal tibial growth plate, and Grade 3: severe migration with fibular growth plate proximal to the distal tibial growth plate) [3, 27]. Ankle valgus was therefore quantified as LDTA <84° for the purpose of this study.

The LDTA measurements were made using an online app (Angulus). Measurements were independently obtained by two investigators and averages used. Statistical evaluation was done using an online tool at www.socscistatistics.com. Student t-test was used for LDTA. Mann- Whitney U Test was used for Malhotra grades. A $P < 0.05$ was considered significant. Rate of deformity correction/recurrence was also calculated.

Results

The average patient age was 8.6 ± 3.1 years at the time of surgery. The screw was in situ in 13 ankles (10 patients) at latest follow-up. In the remaining 5 ankles, the screw was removed at an average of 15.8 months and a further post removal follow-up of average 16.6 months was available (Table 1).

Screw in situ follow-up

The screw in situ follow-up was 18.2 ± 8.4 months. The LDTA changed significantly following the procedure (Pre-op LDTA 77.3 ± 4.2°/follow-up LDTA 85.9 ± 4.5°, $P = 0.0001$) (Fig. 2). The Malhotra grade did not change significantly during the same period (Pre-op and follow-up Malhotra grade 2.1 ± 0.7 and 1.6 ± 0.9). The average correction rate was 0.48°/month. There was a weak positive correlation between time elapsed and correction achieved (Pearson correlation 0.229).

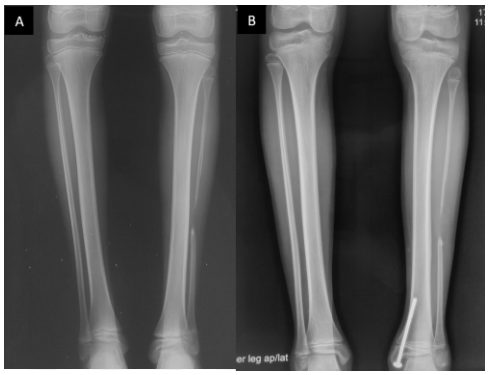

Figure 2: Screw in situ follow-up. The 11 year child was operated for postharvest ankle valgus on left side. A. The presurgery LDTA was 78.5° and Malhotra grade was 3. B. At a follow-up period of 12 months, LDTA corrected to 86°. Malhotra grade improved to 2. LDTA: Lateral distal tibial angle

Post screw removal follow-up

A recurrence was noted in 4/5 (80%) patients. The changes in LDTA post screw removal for 5 patients in the follow-up available were 1.3, 13.2, 0, 1.3 and 27.7°, respectively (Table 1). A significant change in LDTA (Post screw removal LDTA 85.9 ± 4.5°/follow-up LDTA 80.6 ± 17.5°, $P = 0.2404$) after screw removal was not observed during the available follow-up period. The average recurrence rate was 0.52°/month. The Malhotra grade did not change further in this period. We did not encounter any complications at screw removal. These children were advised repeat hemiepiphysiodesis to address the recurrence.

Discussion

The ankle valgus following non-vascularized fibular harvest differs from those associated with other pathologies. Before harvest, the ankle anatomy is practically normal. Following graft harvest, the lateral column shortens and there is proximal migration of the lower fibula. With uneven load distribution, secondary changes occur in distal tibial epiphysis [18, 28]. The combined effect manifests as ankle valgus. Unlike other conditions such as multiple hereditary exostosis, the changes often occur over a short duration. The phenomenon is more frequent in those with incomplete fibular regeneration and may manifest as early as 6 months post-harvest [16].

Growth modulation has been described for ankle valgus associated with generalized/local bone disorders [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13]. Almost all series using screw hemiepiphysiodesis, demonstrate significant effect of the technique with average correction rates being in range of

Series	Number of ankles	Main associated diagnosis for which used	Average age at surgery (in years)	Average correction rate (degrees per month)	Fibular station evaluation	Average recurrence rate (degrees per month)
Davids, et al 1997 [1]	29	Clubfoot	11.2	0.59	Yes	0.6
Stevens and Belle, 1997 [2]	50	Neuromuscular	11.8	0.19	Yes	-
Stevens et al, 2011 [3]	57	Clubfoot	10.4	0.6	Yes	-
Aurégan et al, 2011 [4]	10	MHE	12	-	-	-
Driscoll et al, 2013 [5]	58@	MHE, Non MHE	10.3	MHE 0.37	-	0.16
				Non MHE 0.51		
Driscoll et al, 2014 [6]	35*	MHE	9.8	0.55	-	0.2
		NON MHE				
Bayhan et al, 2014 [7]	18	Neuromuscular	10.05	0.87	-	-
Chang et al, 2015 [8]	63	Idiopathic	11	0.37	-	0.28
Rupprecht et al, 2011 [9]	15	MHE	11.8	0.58	Yes	-
Rupprecht et al, 2015 [10]	125	Clubfoot, MHE	11.7	0.65	-	-
Rupprecht et al, 2015 [11]	21	MHE	11.6	0.63	-	0.37
Westberry et al, 2020 [12]	189	Clubfoot	11.7	-	-	-
Gaukel et al, 2020 [13]	23	Multiple diagnosis	12	1.19#	Yes	2.4
Our series	18	Acquired post fibular	8.2	0.48	Yes	0.52

@ both screw and screw and plate construct; *screw group; #anatomical LDTA; MHE: hereditary multiple exostoses

Table 2: Various large series of screw hemiepiphysiodesis for ankle valgus

0.2–1.2°/month (Table 2).

Despite the contribution of the fibula being considered important in the pathogenesis of ankle valgus, the fibular station did not significantly change following screw hemiepiphysiodesis in our patients. There are many possible explanations for this: Malhotra grade is an ordinal scale rather than an absolute measurement, the mobile proximal end of fibula and the changes in fibular station are somewhat delayed compared to LDTA [15, 17]. Due to variability of fibular station, some series using screw hemiepiphysiodesis have refrained from commenting on fibular station in their results [4, 5, 6, 8, 10, 11, 12]. Others have expressed diverse comments on this grade [1, 2, 3, 13]. Gaukel et al. commented that fibular station distribution was comparable pre-op and after screw removal [13]. Davids et al. similarly reported no significant change in fibular station in their series of 29 ankles [1]. Stevens and Belle reported that following screw intervention, only 24 of 50 ankles demonstrating a change in the fibular station [2]. In another study, Stevens et al. 2011 demonstrated an improvement of fibular station in 15 out of 57 ankles [3].

Most studies describe recurrence in a significant number of subjects following screw removal (Table 2) [5, 8, 10, 11]. One study compared recurrence rate for plates and screw construct versus screws alone following distal tibial hemiepiphysiodesis [6]. The average rate of progression of recurrence deformity was 0.11 ± 0.22°/month with removal of plate and screw construct while it was 0.20 ± 0.21°/month in ankles treated with screw only. The same however did not reach a statistical significance in the study (P = 0.30).

Screw-only growth modulation is simple, easy to execute, economical and can be used in very young patients. There are minimal hardware prominences with screw alone compared to plate and screw construct. Although there is a theoretical risk of violating the physis with a transphyseal screw, the recurrence seen in our series and other results reported in literature refutes this belief [11].

High recurrence rates following screw removal of 43–82% have been reported for ankle valgus correction [5, 8, 11]. We had a relatively younger population undergoing the procedure (average age 8.2 years). Recurrence occurred in 4 patients (80%). In one patient, recurrence occurred despite a previously restored fibular station (Patient 5, Fig. 3).

There are two commonly practiced methods of managing established ankle valgus. Both involve major surgical undertaking: reconstruction of fibula or binding of lower tibia and fibula either temporarily with screws or wires or achieving a bony synostosis (Langenskiöld procedure) [22, 23, 24, 25, 26]. A concomitant supramalleolar tibia osteotomy may also be required. The experience with these above two procedures has been mixed in described series. Lesiak and Esposito demonstrated successful results following acute reconstitution of fibular length using grafting with tricalcium sulfate and fibular plating [23]. Fragnière et al. reported that this procedure failed to control ankle valgus [25]. In another series, the efficacy of the operation was rated as approximately 67% [28]. Tibiofibular synostosis can be responsible for persistent ankle pain, secondary knee and ankle deformities, and reversal of the normal growth pattern of the fibula relative to the tibia when carried out in young children [29].

Figure 3: Post screw removal follow-up. The child was treated with screw hemiepiphysiodesis at age 10 years. (a) Pre surgery LDTA was 68.5° and Malhotra grade was 1. (b) The correction was achieved at 6 months (LDTA 86.9°) and screw was removed at this time. Malhotra grade remained 1 at the time of correction. (c) At follow-up 18 months post screw removal, recurrence was noted with LDTA 73.7° and Malhotra grade being 1. LDTA: Lateral distal tibial angle

On the other hand, temporary screw hemiepiphysiodesis is a simple, minimally invasive procedure and can be performed on outpatient basis. Screw modulation can be a useful primary procedure as it can break the vicious cycle of altered ankle mechanics causing further instability. A repeat hemiepiphysiodesis procedure can be undertaken if the deformity recurs [9, 10, 11]. Many authors have simply recommended overcorrecting the deformity to slight varus till skeletal maturity to prevent a recurrence [1, 13]. Children treated with this technique do require close follow-up.

The retrospective study design, the different ages at which procedure was performed and limited follow-up were limitations of the study. The correction was still incomplete in many patients at the time of recording of data, but with the minimum follow-up of 1 year post surgery, the rate of correction with the technique could be judged with sufficient accuracy. Our study, being short term, did not follow all the patients for a recurrence post removal of screw. All of our patients were skeletally immature at the time of final review and require further follow-up.

This is an exclusive series of acquired post-fibular harvest ankle valgus in children managed with a uniform hemiepiphysiodesis technique. Other consistent parameters in our study were: only healthy legs were included; the technique of harvest left an intact periosteum and adequate residual distal fibular remnant. A sample size of 15 patients therefore appears justified.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of interest: Nil; **Source of support:** None

References

1. Davids JR, Valadie AL, Ferguson RL, Bray EW 3rd, Allen BL Jr. Surgical management of ankle valgus in children: Use of a transphyseal medial malleolar screw. J Pediatr Orthop 1997;17:3-8.

2. Stevens PM, Belle RM. Screw epiphysiodesis for ankle valgus. J Pediatr Orthop 1997;17:9-12.

3. Stevens PM, Kennedy JM, Hung M. Guided growth for ankle valgus. J Pediatr Orthop 2011;31:878-83.

4. Aurégan JC, Finidori G, Cadilhac C, Pannier S, Padovani JP, Glorion C. Children ankle valgus deformity treatment using a transphyseal medial malleolar screw. Orthop Traumatol Surg Res 2011;97:406-9.

5. Driscoll M, Linton J, Sullivan E, Scott A. Correction and recurrence of ankle valgus in skeletally immature patients with multiple hereditary exostoses. Foot Ankle Int 2013;34:1267-73.

6. Driscoll MD, Linton J, Sullivan E, Scott A. Medial malleolar screw versus tension-band plate hemiepiphysiodesis for ankle valgus in the skeletally immature. J Pediatr Orthop 2014;34:441-6.

7. Bayhan IA, Yildirim T, Beng K, Ozcan C, Bursali A. Medial malleolar screw hemiepiphysiodesis for ankle valgus in children with spina bifida. Acta Orthop Belg 2014;80:414-8.

8. Chang FM, Ma J, Pan Z, Hoversten L, Novais EN. Rate of correction and recurrence of ankle valgus in children using a transphyseal medial malleolar screw. J Pediatr Orthop 2015;35:589-92.

9. Rupprecht M, Spiro AS, Rueger JM, Stücker R. Temporary screw epiphyseodesis of the distal tibia: A therapeutic option for ankle valgus in patients with hereditary multiple exostosis. J Pediatr Orthop 2011;31:89-94.

10. Rupprecht M, Spiro AS, Breyer S, Vettorazzi E, Ridderbusch K, Stücker R. Growth modulation with a medial malleolar screw for ankle valgus deformity. 79 children with 125 affected ankles followed until correction or physeal closure. Acta Orthop 2015;86:611-5.

11. Rupprecht M, Spiro AS, Schlickewei C, Breyer S, Ridderbusch K, Stücker R. Rebound of ankle valgus deformity in patients with hereditary multiple exostosis. J Pediatr Orthop 2015;35:94-9.

12. Westberry DE, Carpenter AM, Thomas JT, Graham GD, Pichiotino E, Hyer LC. Guided growth for ankle valgus deformity: The challenges of hardware removal. J Pediatr Orthop 2020;40:e883-8.

13. Gaukel S, Leu S, Skovguard SR, Aufdenblatten C, Ramseier LE, Vuille-Dit-Bille RN. Temporary screw epiphysiodesis for ankle valgus in children. Acta Orthop Belg 2020;86:e37-43.

14. Steinlechner CW, Mkandawire NC. Non-vascularised fibular transfer in the management of defects of long bones after sequestrectomy in children. J Bone Joint Surg Br 2005;87:1259-63.

15. Agarwal A, Kumar D, Agrawal N, Gupta N. Ankle valgus following non-vascularized fibular grafts in children-an outcome evaluation minimum two years after fibular harvest. Int Orthop 2017;41:949-55.

16. Agarwal A. The regeneration at non vascularized fibular harvest site and development of ankle valgus in donor leg-investigations done over two time points. J Clin Orthop Trauma 2019;10:999-1003.

17. Agarwal A. Fibular donor site following non vascularized harvest: Clinico-radiological outcome at minimal five year follow-up. Int Orthop 2019;43:1927-31.

18. Goh JC, Mech AM, Lee EH, Ang EJ, Bayon P, Pho RW. Biomechanical study on the load-bearing characteristics of the fibula and the effects of the fibular resection. Clin Orthop 1992;279:223-8.

19. González-Herranz P, del Río A, Burgos J, López-Mondejar JA, Rapariz JM. Valgus deformity after fibular resection in children. J Pediatr Orthop 2003;23:55-9.

20. Babhulkar SS, Pande KC, Babhulkar S. Ankle instability after fibular resection. J Bone Joint Surg Br 1995;77:258-61.

21. Kang SH, Rhee SK, Song SW, Chung JW, Kim YC, Suhl KH. Ankle deformity secondary to acquired fibular segmental defect in children. Clin Orthop Surg 2010;2:179-85.

22. van der Veen FJ, Strackee SD, Besselaar PP. Progressive valgus deformity of the donor-site ankle after extraperiosteal harvesting the fibular shaft in children. Treatment with osteotomy and synostosis at one session. J Orthop 2014;12 Suppl 1:S94-100.

23. Lesiak AC, Esposito PW. Progressive valgus angulation of the ankle secondary to loss of fibular congruity treated with medial tibial hemiepiphysiodesis and fibular reconstruction. Am J Orthop (Belle Mead NJ) 2014;43:280-3.

24. Iamaguchi RB, Fucs PM, da Costa AC, Chakkour I. Vascularised fibular graft for the treatment of congenital pseudarthrosis of the tibia: Long-term complications in the donor leg. Int Orthop 2011;35:1065-70.

25. Fragnière B, Wicart P, Mascard E, Dudousset J. Prevention of ankle valgus after vascularized fibular grafts in children. Clin Orthop Relat Res

2003;408:245-51.

26. Sulaiman AR, Wan Z, Awang S, Che Ahmad A, Halim AS, Zain RA. Long-term effect on foot and ankle donor site following vascularized fibular graft resection in children. J Pediatr Orthop B 2015;24:450-5.

27. Malhotra D, Puri R, Owen R. Valgus deformity of the ankle in children with spina bifida aperta. J Bone Joint Surg Br 1984;66:381-5.

28. Gilbert A, Brockman R. Congenital pseudarthrosis of the tibia. Long-term follow-up of 29 cases treated by microvascular bone transfer. Clin Orthop Relat Res 1995;314:37-44.

29. Frick SL, Shoemaker S, Mubarak SJ. Altered fibular growth patterns after tibiofibular synostosis in children. J Bone Joint Surg Am 2001;83:247-54.

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