Lateral column lengthening for adolescent idiopathic pes planovalgus deformity – Systematic review

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ABSTRACT

Pes planovalgus is the commonest foot deformity in children and presents with wide range of severity and symptoms. Surgery is mostly indicated for significant malalignment, resistant to non-surgical management. Lateral column lengthening is considered an appealing option as does not involve arthrodesis and allows for further growth and foot development.

Methods: We conducted a systematic review on lateral column lengthening for pes planovalgus deformity in line with PRISMA-P Checklist. We carried out detailed literature search on PubMed, Cochrane, EMBASE, CINAHL, Google Scholar and Bibliographies. We analysed selected studies for patient demographics, radiological, clinical outcome and complications.

Results: We identified seven studies with 103 patients involving 156 feet. The mean age was 13.3 years (Range 5.7–42) and mean follow up was 70.2 Months (Range 24.9–156). There was statistical significant improvement in Calcaneal pitch, Lateral Talo-metatarsal and AP Talo-navicular angles (p-value 0.001). The mean preoperative AOFAS Score (71 Feet) was 58.85 (Range 34–78) and mean postoperative AOFAS Score (91 Feet) was 92.25 (Range 73–100). Two studies (32 Feet) used author specified criteria has reported Good/Excellent result in 72% (23/32 feet) and Fair/Poor result in 18% (9/32) feet. Complications were reported in 17.5% (18/103) included nerve related, pseudo arthrosis, non-union and metal related complications.

Conclusion: Surgical intervention with lateral column lengthening has good radiological and clinical outcome with high patient satisfaction and acceptable complications. The literature is mostly retrospective and there is need for prospective, multi-centre studies using patient centred validated outcome measure.

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1. Introduction

Pes planovalgus is one of the commonest foot deformities seen in paediatric orthopaedic practice. The prevalence of flat feet was 2.7% in a study² on 1181 children between ages of 4–13 years. Pfeiffer et al.³ reported that the prevalence decreases with age. In a group of 3 year old children the prevalence was 54%, whereas 6 year old children only 24%. The prevalence of pathological flat foot was less than one percent.³ Most children presenting with flat foot have flexible arches and does not require any intervention. Rigid and pathological flat foot should be differentiated as

associated with other conditions such as congenital vertical talus, tarsal coalition, and skew foot.⁴

There is no consensus to the effectiveness of non-surgical or surgical management for flexible pes planus in children and young adults. Biomechanically, pes planovalgus is complex and involves three dimensional deformities. Surgical treatment is aimed at relieving patient's symptoms by realigning the foot.

Surgical treatment is rarely indicated and reserved for patients, who have persistent localised symptoms despite conservative treatment.⁵ There are several approaches to operative management and surgical reconstruction is usually individualised. The preservation of joint and open physis should be always considered in children and adolescent. Lateral column lengthening as described by Evans⁶ and modified by Mosca⁷ remains most appealing option in children as it allows further growth and does not involve arthrodesis. It corrects the hind foot as well as midfoot

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deformity; however this mechanism of correction remains unclear. This technique is based on the concept of three dimensional reorientations and localisation of sustentaculum tali to lift talonavicular joint. The lengthening osteotomy also tightens the peronei tendons and planter aponeurosis to facilitate planter flexion of first ray.

Evans⁶ felt that this technique was contraindicated in neurological disorders such as cerebral palsy (CP) and spina bifida, where the graft was predisposed to be sunk into the main fragment because of poor quality of bone. He also felt that there was tendency of over-correction in neurological cases. This technique has been used successfully in neurological disorders by other authors.^{7,8} Phillips⁹ reported results of patients operated by Evans 7–20 years after operation. Seventeen of the twenty three feet showed improvement when assessed on the criteria of relief of symptoms and clinical appearance, and stood the test of time.

We carried out a systematic review on lateral column lengthening to evaluate the clinical and radiological outcome, complication and re-operation rate in the literature. Our aim was to assess the results of surgery for pes planovalgus in children and young adults. To the best of our knowledge, there is no systematic review in the published literature on this topic.

2. Material and methods

This review was performed in line with PRISMA-P 2015 checklist¹ (Preferred reporting items for systematic review and meta-analysis protocols). The Pubmed, Cochrane, CINAHL, EMBASE, Google Scholar and bibliography of articles was searched for all relevant articles against search criteria. The keywords used for search are summarised in Table 1.

The author performed literature searches on electronic databases with above keywords and reviewed abstracts. The articles meeting the inclusion criteria were reviewed by authors. The inclusion criterion was Randomised Controlled Trials; Prospective or retrospective case studies on the surgery for pes planovalgus deformity. Patient data; radiological; clinical outcome and complications included in the studies. Patient followed for a minimum of 24 months. All studies that did not meet the above criteria were excluded from the review as well as studies not available in English language. Studies with predominant neurological (cerebral palsy) deformity and non-joint preserving procedures like arthrodesis were also excluded from the study.

We collected patient demographic data including number of patients and feet operated, age of patient, follow up duration. Clinical and radiological outcome was documented. For radiological parameters we used talo-metatarsal and calcaneal pitch angle as was most commonly used by most studies. We also recorded underlying pathology, additional procedures, post-operative

management, complications and re-operations. We also noted the number and nature of additional soft tissue procedures.

2.1. Statistical analysis

GraphPad prism 7 (GraphPad Software Inc, San Diego, California Software Version 7) and differences with p -value < 0.05 was considered statistically significant. An independent sample t -test was performed to analyse preoperative and postoperative radiological measurements of calcaneal pitch angle, lateral talo-1stmetatarsal angle and talonavicular coverage angle.

3. Observations and results

The initial search of the literature with the above keywords identified 391 articles. We excluded 286 articles with their titles including duplicates and identified 105 for further evaluation of abstract. Twenty one studies were assessed by reading full text against inclusion criteria and identified seven studies (Table 2).

There were 156 calcaneal lengthening osteotomies performed on 103 patients in these seven studies. The mean age at the time of surgery was 13.3 Yrs. (Range 5.7–42) and mean length of follow up was 70.2 Months (Range 24.9–156). There were 33 females and 29 males of the 62 patients in four studies where information available. The underlying aetiology was Idiopathic in 146 feet, congenital conditions (like uncorrected club foot, skew foot) in 5, polio in 4, tibialis posterior insufficiency in one foot and not specified in 9 feet. Table 3 has demographic information.

3.1. Radiological outcome

Pes planovalgus is complex deformity involving multiple joints and in three dimensions. There were numerous radiological parameters reported and available in four of the seven studies. Calcaneal pitch angle, lateral talo-1stmetatarsal angle, AP Talo-navicular coverage angle were most commonly used in the studies therefore were included in the review. Summary of these values is given in Table 4, with further details shown in Table 5.

From these publications as listed above, mean preoperative calcaneal pitch angle was 10.4 ($SD \pm 4.0$, Range 4.4–12.9) and the mean postoperative CP Angle was 21.9 ($SD \pm 6.2$, Range 17.3–31) (p Value = 0.001). The mean preoperative Lateral Talo-1stmetatarsal angle was 19.7 ($SD \pm 7.0$ Range 15.5–27.5) and improved to 5.2 ($SD \pm 6.4$ Range -0.3 –13.7) (p Value = 0.001). The mean preoperative AP Talo-navicular coverage angle also improved from 28.4 ($SD \pm 7.3$, Range 21.8–38.6) to 6.0 ($SD \pm 8.5$, Range -3.4 –13.7) (p value < 0.0001). We used GraphPad Software to calculate statistical significance using sample t -test.

Normal values are reported variably in the literature. According to Escobedo et al¹⁶, normal calcaneal pitch angle is 18 – 20° , however range from 17 to 32° is reported as normal in literature. The talo – 1st metatarsal angle greater than 4° and talo-navicular coverage angle greater than 7° are considered abnormal. Measurement is shown in Diagram 1.

3.2. Clinical outcome

Four publications (91 feet) used AOFAS Score¹⁷ for measuring clinical outcome and preoperative scoring was available in three studies. Two publications (32 feet) used author specified criteria and one used ACFAS Score for measuring clinical outcome.

The mean preoperative AOFAS Score¹⁷ was 58.84 (Range 34–78) and mean postoperative AOFAS Score was 92.25 (Range 73–100) as shown in Table 6. Two studies that used author specified criteria has reported Good/Excellent result in 72% (23/32 feet) and Fair/

Table 1
Keyword searches for identifying articles.

Planovalgus surgery	AND	Children
Planovalgus surgery	AND	Paediatric
Planovalgus surgery	AND	Adolescent
Planovalgus surgery	AND	Pediatric
Lateral column lengthening	AND	Children
Lateral column lengthening	AND	Paediatric
Lateral column lengthening	AND	Adolescent
Calcaneal lengthening osteotomy	AND	Children
Calcaneal lengthening osteotomy	AND	Paediatric
Calcaneal lengthening osteotomy	AND	Adolescent
Calcaneal osteotomy	AND	Juvenile
Pes Planovalgus surgery	AND	Paediatric
Flatfoot surgery	AND	Paediatric

Table 2

Identification of articles against inclusion criteria.

Table 3

Demographic information and postoperative management (NWB Non weight bearing, WB Weight bearing, SL Cast – Short Leg Cast).

References	No of patients	No of feet	Follow-up in months	Patient age (Range)	Post-op plan
Phillips et al. ⁹	20	23	156	15 (9–42)	Cast 16/52, WB 4/52
Akimau et al. ¹⁰	12	20	54	12.6 (5.7–16.3)	NWB 6/52, Insole 3/12
Anderson et al. ¹¹	5	9	80	10.4 (6–13)	Specified SL cast 2 cases
Oh et al. ¹²	10	16	62	15.6 (10–22)	Cast 8–10/52 NWB
Viegas et al. ¹³	17	34	24.9	12.1 (8–18)	SL Cast 6/52 NWB
Moraleda et al. ¹⁴	21	33	63	11.6 (9.1–15.1)	NS
Yontar et al. ¹⁵	18	21	51.2	15.6 (9–25)	SL Cast 6/52 NWB
Totals	103	156	70.2*	13.3*	*Mean
		Range	24.9–156	(5.7–42)	

Table 4

Analysis of radiological parameters.

Publication	Feet	Calcaneal Pitch		Lat TMT Angle		AP TN Angle	
		Preop	Postop	Preop	Postop	Preop	Postop
Oh et al. ¹²	16	12.3	17.3	15.5	−0.3	21.8	−3.4
Viegas et al. ¹³	34	4.47	31	27.5	1.06	28.2	1
Moraleda et al. ¹⁴	33	11.8	19.7	23.4	13.7	38.6	13.7
Yontar et al. ¹⁵	21	12.9	19.5	12.3	6.4	25	12.6
Mean	104	10.4	21.9	19.7	5.2	28.4	6.2
SD		4.0	6.2	7.0	6.4	7.3	8.5
Range		4.4–12.9	17.3–31	15.5–27.5	(−0.3 to 13.7)	21.8–38.6	−3.4 to 13.7

Table 5

Standard Deviation or Range of Calcaneal pitch, lateral talo-1stmetatarsal angle and talo-navicular coverage angles as available from publications.

Publications	Calcaneal Pitch				Lat TMT Angle				AP TN Angle			
	Pre	SD/R	Post	SD/R	Pre	SD/R	Post	SD/R	Pre	SD/R	Post	SD/R
Oh et al. ¹²	12.3	4–20	17.3	10–25	15.5	–1 to 30	–0.3	–14 to 11	21.8	5–37	–3.4	
Viegas ¹³	4.47	±3.4	31	±6.3	27.5	±6.6	1.06	±4.0	28.2	±3.6	1	±1.8
Moraleda ¹⁴	11.8	±5.2	19.7	±5.5	23.4	±9.9	13.7	±6.2	38.6	±9.9	13.7	±12
Yontar ¹⁵	12.9		19.5		12.3		6.4		25		12.6

Diagram 1. a: Radio graphical Angles. b: Pre and postoperative radiographs with angles.**Table 6**Mean Preoperative and Postoperative AOFAS Score.¹⁵

AOFAS Score	Preop	Range	Postop	Range
Akimau et al. ¹⁰			87	73–100
Oh et al. ¹²	49.1	34–73	93.4	80–100
Viegas et al. ¹³	68.59	58–78	96.35	94–100
Yontar et al. ¹⁵	56.76	48–73	95.29	90–100
	58.84	(34–78)	92.25	(73–100)

Poor result in 18% (9/32) feet. One used ACFAS Subjective and Objective Scoring but only postoperative scores were available.

3.3. Complications

Complications were reported in 18 (17.5%) of 103 patients. The common complications included sural neuropathy, pseudo-arthritis, non-union, calcaneocuboid subluxation, metal irritation and adhesion formation. Moraleda et al.¹⁴ reported calcaneocuboid

subluxation in 51.5% feet (17/33) following calcaneal lengthening osteotomy but did not change the outcome score. There were no comprehensive details on surgical technique or postoperative regimen available in this publication.

Further surgery/Recurrence was reported in 7 (12.3%) of 57 feet in three studies where it was reported. The commonest reported reason for revision was recurrence. Other indication for further surgery reported were lysis of adhesions and tarsal tunnel release. It was not possible to perform further analysis based on available information.

2.2. Surgical technique

Surgical technique for calcaneal lengthening osteotomy was described by Evans⁶ in 1975. Mosca⁷ popularised this procedure and described modifications with regards to incision, position and direction of osteotomy, shape of the graft, soft tissue management and internal fixation. Most studies in the review utilised surgical technique as described by Evans⁶ and modified by Mosca⁷ with only minor alterations. Osteotomy is performed 1.5 cm proximal to calcaneocuboid joint aiming for interval between anterior and middle facet of calcaneum. Trapezoid shaped tricortical iliac crest autograft or allograft may be used to achieve lengthening. Other modifications regarding site of osteotomy are published as case series with short term results.

In addition to calcaneal lengthening procedure as described above, a range of additional soft tissue and bony procedures were also performed to correct deformity. Soft tissue procedure included Achilles tendon or gastrocnemius aponeurosis recession, peroneus brevis lengthening, brevis to longus transfer, accessory navicular excision and tibialis posterior repositioning, talonavicular joint capsular plication including advancement of tibialis posterior tendon. Additional bony procedures included medial calcaneal shift and medial cuneiform osteotomy. All surgeries included in the review involved lateral column lengthening and additional procedures were decided per-operatively depending on the progress of deformity correction.

Postoperative management of patients in six studies is summarised in Table 3. Short leg cast was used in most studies for 6–16 weeks with variation in weight bearing status. Patients were initially treated non weight bearing for 3–8 weeks. Long leg cast was used in one study for 6/52.

3.4. Data analysis

All seven studies were retrospective case series; therefore there is high risk of selection and performance bias. There was no randomisation of patient selection or blinding in all studies involved in this review. Author's assessment of risk of bias is given in Graph 1 and Table 7.

4. Discussion

Pes planovalgus deformity is a common foot deformity seen in children. According to Rome et al.,¹⁹ there is no evidence from randomised controlled trials on the efficacy of foot orthosis or any other non-surgical intervention on asymptomatic patients. Optimal choice of orthosis and long term outcome for symptomatic patients also remains unclear. There is general opinion from these studies that operative intervention is indicated when prolonged non-surgical management fails to relieve pain and symptoms. Operative management of pes planovalgus with arthrodesis and joint preservation are published with short term results, but medium to long term results are unclear. Lateral column lengthening is considered an appealing option as it does not involve arthrodesis and allows for further growth and foot development. Our aim for undertaking this systematic review was to evaluate previously published literature on lateral column lengthening, with regards to clinical and radiological outcome of surgery in medium and long term.

This systematic review has limitations because of type of studies included in the review. All publications were retrospective case studies on small number of patients (5–21) from single unit. These studies do not have control group, any blinding and randomisation, and therefore as such are prone to allocation, selection and randomisation bias. The patients, surgeons and personnel collecting data were aware about the operative intervention, resulting in performance and detection bias. For this systematic review, we analysed studies for completeness of patient information on clinical, radiological outcome and complications. All studies that included complete information on radiological, clinical outcome and complications on all patients were classed as low risk of bias for the purpose of this publication.

The age group and aetiology differed across these studies, making it difficult to isolate results of surgical intervention for pes

Graph 1. Cochrane risk of bias graph¹⁸.

Table 7
Summary of author's assessment on risk of bias¹⁸.

	Random sequence generation	Allocation Concealment	Blinding of participants & outcome	Blinding of outcome	Incomplete outcome data	Selective reporting
Akimau et al (2013)	⊖	⊖	⊖	⊖	⊖	⊕
Anderson et al (1984)	⊖	⊖	⊖	⊖	⊖	⊖
Oh et al (2011)	⊖	⊖	⊖	⊖	⊕	⊕
Phillips et al (1983)	⊖	⊖	⊖	⊖	⊖	⊕
Viegas et al (2003)	⊖	⊖	⊖	⊖	⊕	⊕
Moraleda et al (2012)	⊖	⊖	⊖	⊖	⊕	⊕
Yontar et al (2016)	⊖	⊖	⊖	⊖	⊕	⊕

⊖ High risk of bias ⊕ Unclear risk of bias ⊕ Low risk of bias.

planovalgus on paediatric patients. It was also difficult to completely isolate results for a particular underlying diagnosis like idiopathic, congenital or neurogenic. Most studies utilised lateral column lengthening as described by Evans⁶ and modified by Mosca⁷ with only small alterations. There was variability of additional procedure, which was performed by surgeon as deemed appropriate at the time of surgery. It was not possible to draw firm conclusions with regards to additional procedures due to heterogeneity of aetiology and information across studies. There was also variability across studies with regards to postoperative course and details in reporting, making it difficult to draw conclusion on the evidence for the use of particular type of regimen.

A number of outcome measures and radiological parameters were utilised for the purpose of reporting results in these studies. Only four studies used validated outcome scoring (AOFAS) to report their outcome with preoperative score available in only three studies. There was significant improvement in AOFAS Score postoperatively. Other studies used different secondary outcome measures, making it impossible to combine the results. Patient satisfaction from surgery and author specified criteria on the basis of pain relief, functional improvement and clinical appearance were used in other studies. Radiological parameters were different across studies, but we evaluated three most commonly used in these studies. These radiological parameters showed significant improvement in postoperative patients. There were inconsistencies in reporting recurrence or further surgery and reported in three out of seven studies included in the review. There was variability in the level of data reporting in these studies with either range or standard deviation with radiological parameters, making it impossible to perform descriptive statistics.

5. Conclusion

Based on limited evidence, this systematic review suggests that surgical treatment for pes planovalgus deformity in children and young adults with lateral column lengthening has good clinical and radiological results in medium term, with high patient satisfaction and acceptable level of complications. The radiological outcome and postoperative AOFAS Scores were significantly improved.

Currently available evidence does not allow sufficient evidence base for developing guidelines for individual aetiology, additional procedures and postoperative regimen. The methodological quality of studies in the published literature was low and there is need for high quality multi-centre studies on large number of patients using patient centred validated outcome scores.

Conflict of interest

None.

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