Combined Lateral and Transcuneiform without Medial Osteotomy for Residual Clubfoot for Children

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Abstract Residual deformity in resistant clubfoot is not uncommon. The “bean-shaped foot” exhibits forefoot adduction and midfoot supination and may interfere with function due to poor foot placement. For children less than 5 years of age we describe a corrective procedure combining a closing wedge cuboidal osteotomy and trans-midfoot rotation procedure without a medial opening wedge osteotomy. We retrospectively reviewed twelve patients (14 feet), mean age 4.7 years (range, 4–5 years), who had undergone the procedure to correct forefoot adduction and midfoot supination deformities. We obtained minimal access via a small lateral skin incision. Cuboid lateral wedge osteotomy was followed by transcuneiform osteotomy using a Kirschner wire as a guide under an image intensifier. The minimum followup was 2 years (mean, 2.6 years; range, 2–3.2 years). All patients had qualitative improvement in correction of adduction and supination deformities. Radiographically there was an

improvement in adduction deformity, the mean antero-posterior talo-first metatarsal and calcaneo-fifth metatarsal angles improved by 28° (from 40° to 12°) and by 11° (from 21° to 10°). The supination improved by 11° (from 19° to 8°) and the cavus improved by 17° (from 30° to 13°). The short-term outcome was reliable and this combination is useful for children younger than 5 years old where the medial cuneiform ossification center remained poorly defined.

Level of Evidence: Level IV, therapeutic study (case series). See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Residual deformity in resistant clubfeet is not uncommon. The “bean-shaped foot” combines forefoot adduction and midfoot supination and may interfere with full plantigrade placement of the foot on the ground and proper shoe fitting, thus limiting gait and daily activities [10, 14]. Although Ponseti serial casting techniques, soft tissue releases, and tendon transfers have met with success in most cases [13], there remains a group of resistant clubfoot patients that require a bony procedure to correct the residual deformity.

Various osteotomies have been described to correct this deformity, including those at the levels of the transmetatarsal region, midfoot, and Lisfranc joint [3, 4, 6, 7, 18]. The combined procedure of shortening the lateral column and lengthening the medial column is the most logical approach to address the pathology of forefoot adduction. [2, 5, 10, 12, 14, 15, 17]. However, children younger than 5 years old generally do not have a well-developed medial cuneiform ossific nucleus resulting in a high risk of graft extrusion [5, 12]. Several authors have advocated

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transcuneiform osteotomy which would address the rotational/supination deformity of the midfoot [10, 15].

We describe a new surgical procedure for younger children less than 5 years old using a combination of a closing wedge cuboidal osteotomy and trans-midfoot osteotomy with rotation procedure without a medial opening wedge osteotomy. We present the short-term clinical (presence of adduction, supination and hindfoot varus) and radiographic findings (talo-first metatarsal angle, calcaneo-fifth metatarsal angle, talo-first metatarsal angle, and calcaneo-first metatarsal angle).

Material and Methods

We retrospectively reviewed 12 patients (14 feet) with residual clubfoot, mean age 4.7 years (range, 4–5 years), who had undergone cuboid closing wedge osteotomy and trans-midfoot osteotomy for adduction and supination deformities from 2005 to 2006. There were seven boys and five girls in the study. Our indications for surgery were as follows: children with clubfoot who still had residual forefoot adduction and supination despite previous treatment (serial casting and soft tissue release), and had no previous osteotomy. Two patients had bilateral deformities and had surgery on both feet. Preoperatively, eight patients had mild hindfoot varus and three feet had calluses on the lateral plantar surface of the foot. Seven patients had previous serial casting and five had prior soft tissue release procedures. The minimum followup was 2 years (mean, 2.6 years; range, 2–3.2 years). No patients were lost to followup.

Assessment of patients was performed by two junior authors (IM, AM) preoperatively from the clinic. In addition, history was taken from the parents and this included: difficulty in footwear, pain associated with activities, foot deformity, presence of calluses on the lateral plantar surface of the foot, and abnormal gait by visual observation. Forefoot adduction, supination, and hindfoot varus in relation to resistant clubfoot were also clinically documented qualitatively by visual inspection. Hindfoot varus was tested using the Coleman block test for assessment of flexibility.

The patient was positioned supine on the surgical table. All patients underwent surgery under general anesthesia and a tourniquet was used. We prepared and draped the foot in a sterile fashion. A longitudinal lateral incision was made to expose the cuboid. We identified and reflected the extensor digitorum brevis. A closing dorsolaterally based wedge was performed on the cuboid measuring approximately 2 to 4 mm at the base and this was removed. A smooth k-wire was inserted under image intensifier from the cuboid to the estimated center of medial cuneiform to

act as a guide for osteotomy. Hoffman retractors were used to protect the soft tissues above and below the bones. An osteotome was used to make a transverse osteotomy guided by the k-wire across from the cuboid to medial cuneiform without making a medial incision. We achieved correction of the foot supination by rotating the forefoot at the midfoot transverse osteotomy (Fig. 1A–B). The lateral cuboid wedge was closed and held with one or two wires. The medial column was not opened and no bone graft placed on the medial cuneiform. The closure of the lateral cuboid wedge was accompanied by the rotation of the forefoot, corrected adduction and supination. The wound was closed without drain. The wires were left outside the skin.

An above-knee cast was applied and the wires were removed after 4 weeks. A below-knee cast was reapplied for another 2 weeks. Postoperatively we advised patients remain nonweightbearing with walking assists during the 6 weeks in the cast. Once the cast was removed at 6 weeks, physiotherapy was started for progressive weight bearing as tolerated. No walking assist was used but the

Fig. 1A–B (A) Line drawings show correction of the bean-shaped foot. (B) A three dimensional illustration of a left foot shows the laterally based closing wedge and the transverse osteotomies from the cuboid crossing to the medial cuneiform. The closure of the lateral cuboid wedge is accompanied by rotation of the forefoot at the midfoot transverse osteotomy, correcting the adduction and supination. The medial column is not opened and no bone graft placed on the medial cuneiform.

physiotherapist taught the parents to aid the children in ambulating.

Postoperatively, patients were followed up at 1 week for cast inspection, at 4 weeks for removal of k-wires, at 6 weeks for removal of cast, and at 12 weeks for clinical and radiological assessments. The clinical outcome was measured qualitatively by visual assessments, comparing the preoperative and postoperative adduction, supination and hindfoot varus during followup. The followup routine occurred at 3, 6, 12, 18 and 24 months.

Anteroposterior (AP) and lateral weight-bearing radiographs of the foot were taken pre- and postoperatively to assess the severity of the deformity and to document any radiographic improvement with surgery. On the AP radiograph, we (IM, AM) measured the calcaneo-fifth metatarsal angle and the talo-first metatarsal angle as indicators of forefoot adduction [15]. On the lateral radiograph, the talo-first metatarsal angle and the calcaneo-first metatarsal angles were measured to give an indication of supination and cavus deformity respectively [15].

Results

All patients had improvement of forefoot adduction and midfoot supination deformities (Fig. 2A–B). No hindfoot

varus was noted postoperatively in all eight patients. Parents of 11 of 12 patients reported better appearance of the foot, less difficulty in footwear, and reduced foot pain. The lateral calluses disappeared in the three patients having them preoperatively. Qualitatively the gait improved due to plantigrade placement of the foot. We observed no recurrences of deformity at the last followup.

At the last followup, radiographically, there was an improvement in adduction deformity (Fig. 3A–B), the mean anteroposterior talo-first metatarsal and calcaneo-fifth metatarsal angles improved by 28° (from 40° to 12°) and by 11° (from 21° to 10°). The supination improved by 11° (from 19° to 8°) and cavus improved by 17° (from 30° to 13°) (Tables 1, 2).

Two patients had wound infection postoperatively, both of which resolved with removal of wires and oral antibiotics.

Discussion

Treatment of residual deformities in resistant clubfoot remains challenging. Many patients have undergone prior surgical procedures, leading to scarring of the skin and soft tissues. Complications such as skin necrosis, difficulty in manipulating the medial side due to scarring, cartilage, or

Fig. 2A–B (A) This picture shows the preoperative right foot appearance in a 4-year old boy with residual clubfoot. (B) This postoperative photo shows the same patient after the cuboid closing wedge osteotomy and transmidfoot osteotomy at 2 years followup.

Fig. 3A–B (A) The preoperative anteroposterior radiographic view of the patient's left foot is shown. (B) The postoperative anteroposterior radiograph of the left foot is shown following this procedure which demonstrated correction of adduction on AP view.

Table 1. Radiographic angles measured in degrees

Case	Talo-1st metatarsal		Calcaneo-5th metatarsal		Lateral talo-1st metatarsal		Lateral calcaneo-1st metatarsal	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	22	10	16	2	8	4	32	14
2	41	12	6	11	2	–	26	13
3	33	12	5	–	27	5	6	13
4	48	11	31	12	34	10	62	21
5	–	7	–	20	19	11	29	13
6	39	6	22	8	–	7	–	11
7	41	17	21	4	19	4	31	10
8	39	18	32	13	14	3	20	12
9	40	15	20	8	19	11	30	6
10	56	14	38	11	28	15	32	18
11	37	–	23	–	–	6	–	15
12	41	13	20	9	20	10	33	10
13	39	12	19	10	19	9	27	14
14	43	11	22	12	18	7	30	12

Table 2. Means and ranges of the radiographic parameters

Angle in degrees	Talo 1st metatarsal		Calcaneo 5th metatarsal		Lateral talo 1st metatarsal		Lateral calcaneo 1st metatarsal	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	40 (22–56)	12 (6–18)	21 (5–38)	10 (2–20)	19 (2–34)	8 (3–15)	30 (6–62)	13 (6–21)

physal damage to the growing bone can occur following reoperations [10]. We describe how correction of forefoot adduction and midfoot supination can be achieved without medial osteotomy for children younger than 5 years when the cuneiform ossific nucleus is not well-developed and provide short-term clinical and radiographic findings.

The limitations observed in this study include the small number of patients and the short duration of followup with mean follow up of 2.6 years (range, 2–3.2 years). The long-term outcome of this procedure therefore remains unknown. Pohl and Nicol reported one case of recurrence at 2 years, attributed to the collapse of the medial graft [15], however, Schaefer and Hefti observed a tendency to adduction deformity with longer followup [17]. Another limitation arises from the qualitative clinical outcome measures based on parents' perceptions and visual assessments. These qualitative assessments were, however, supplemented by the more objective radiographic measures.

The essential deformity in residual clubfoot is the length disproportion between medial and lateral columns of the

Table 3. Data comparison with other series

Study	Type of study	Number of patients (number of feet)	Mean age (range)	Mean followup (range)	Methods	Skin approach	Parameters: clinical radiography	Complications
Arjandas et al. (current study)	Retrospective	12 (14 feet) 7 serial casting 5 soft tissue release	4.7 y (4 to 5 years)	2.6 y (2.0 to 3.2 years)	1 Stage: a. Closing cuboidal wedge osteotomy b. Transmidtfoot rotation procedure. c. No medial wedge osteotomy	Single longitudinal lateral incision	a. Clinical: Shoe-wear problems Pain Deformity Callouses Gait b. Radiographic: Anteroposterior: (forefoot adduction) i. Talo-first MTA ii. Calcaneo-fifth MTA Lateral weight-bearing: (supination and cavus) i. Talo-first MTA ii. Calcaneo-first MTA	2 wound infections resolved with removal of wire and antibiotics
Gordon et al. [5]	Retrospective	33 (50 feet)	5 y 6 m (3 y 1 m to 17 y 10 m)	At least 2 y	1 Stage: a. Closing cuboidal wedge osteotomy b. Opening wedge of medial cuneiform osteotomy	2 incisions: i. Oblique medial, over medial cuneiform ii. Separate lateral longitudinal incision	a. Clinical: Appearance Gait Shoe-wear problems Pain b. Radiographic: (forefoot adduction) i. AP Calcaneo-second MTA ii. AP Talo-first MTA iii. Mean length of medial column iv. Mean cuboid/ lateral column length v. Ratio of medial to lateral column length	5 of 50 feet: 2 wounds: Infection, breakdown 2 lost corrections: Graft displacement 1 developed valgus forefoot

Table 3. continued

Study	Type of study	Number of patients (number of feet)	Mean age (range)	Mean followup (range)	Methods	Skin approach	Parameters: clinical radiography	Complications
Pohl and Nicol [15]	Retrospective	10 (13 feet) 11 feet serial casting 9 feet soft tissue release	6 y (4 to 11 y)	48 m (6–123 m)	1 Stage: a. Closing cuboidal wedge osteotomy b. Opening wedge of medial cuneiform osteotomy c. Transcuneiform osteotomy for rotational correction	2 incisions: i. Medial approach + modified Steinler for plantar fascial release ii. Lateral incision	a. Clinical: Shoe-fitting Abnormal shoe-wear Pain Deformity Callous/ skin breakdown b. Radiographic: Anteroposterior: (forefoot adduction) i. Talo-first MTA ii. Calcaneo-fifth MTA lateral weight-bearing: (supination and cavus) i. Talo-first MTA (Meary angle) ii. Calcaneo-first MTA	1 recurrence of deformity due to graft collapse; 1 subtalar pain requiring triple arthrodesis; 1 wound infection

foot [1]. Although the Ponseti serial casting technique has been effective in correcting even neglected clubfeet [13], surgical procedures may be needed to correct more rigid and structural deformities. We chose not to perform the medial opening wedge osteotomy since all of the children were younger than 5 years old with a less than well-developed medial cuneiform ossific nucleus. In addition, we believe that it would be difficult to locate the exact site for the medial osteotomy and would possibly disturb the medial column growth plate as well as increase the risk of medial graft extrusion in a cartilaginous area. Nonetheless, correction of adduction deformity in our series was comparable to others radiographically [5, 11, 15] (Table 3).

We believe the medial cuneiform opening wedge osteotomy should still be performed in older children once the ossific nucleus is well-defined, for a better correction of forefoot adduction deformities. Addressing the medial side for older children may have the benefit of handling the following issues: (1) the abductor hallucis longus, which can be a deforming force; (2) cavus component of the deformity is often present, thus the ability to perform a plantar fascia release from the medial side; (3) a Z-plasty can be performed at the medial scar if the previous scar is contributing to the deformity; (4) performing a medial cuneiform—1st metatarsal capsulotomy which may help correct the forefoot adduction deformity; (5) lengthening the medial column with an opening wedge medial cuneiform osteotomy may improve long-term results in the older child (> 4 years of age); and (6) as noted by Ponseti [16], the anterior tibial tendon can often be a supination deforming force, therefore, the anterotibial tendon transfer to the mid-foot (Garceau procedure) at the time of the double-tarsal osteotomy can be performed [16].

The minimal access was an added advantage to our procedure whereby only a small lateral incision was made for cuboidal wedge osteotomy. Using the same approach, the trans-midfoot osteotomy was subsequently performed under an image intensifier using a Kirschner wire and osteotome. This ensured minimal disruption to the soft tissue on the medial side of the foot.

Numerous types of osteotomies and their combinations have previously been described for correction of forefoot adduction and midfoot supination. Johanning in 1958 described wedge resection and enucleation of the cuboid to shorten the lateral column, followed by manipulation and casting as treatment of resistant clubfoot [9]. Lengthening of the short medial column had also been described by Hofmann et al. where medial wedge cuneiform osteotomy corrected the forefoot adduction but did not easily address the supination [8].

In 1991, McHale and Lenhart [14] first described the combination of a shortening osteotomy of cuboid and elongation of cuneiform. Supported by cadaveric study,

they suggested the cuboid closing wedge corrected the midfoot, whereas the cuboid and cuneiform osteotomies both contributed to the correction in the forefoot [14]. Kose et al., using cadaveric and clinical studies, reported a combination of three procedures namely transmidtarsal, closing cuboidal, and opening cuneiform wedge osteotomy [10]. The added advantage of the trans-midfoot procedure was to allow correction of the rotational component as it was centered at the apex of the deformity. Therefore, these combinations allowed corrections of three planes to be made simultaneously. However, this method did not address the residual hindfoot varus. Pohl and Nicol adapted the technique by exiting the osteotome at the apex of cuboid osteotomy and reported similar results with a reliable correction of adduction and supination [15] (Table 3).

Lourenco et al. subsequently reported their series of treatment of residual adduction deformity in clubfoot by double osteotomy and advocated that surgery should be reserved for children older than 4 years of age when the medial cuneiform ossific nucleus is well-developed [12]. Using similar techniques, Gordon et al. [5] stated a success rate of 90% improvement in both clinical and radiographic evaluation. They, too, recommended that the procedure should be reserved for patients age 5 years or older.

We found the combined closing wedge cuboid and trans-midfoot rotation osteotomy had a low rate of complications and reasonably corrected residual forefoot adduction and midfoot supination. We believe this combination is useful for children younger than 5 years of age in whom a medial cuneiform ossification center is not well-developed.

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