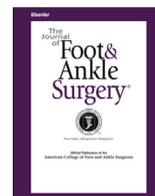




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Original Research

Flexible Juvenile Flat Foot Surgical Correction: A Comparison Between Two Techniques After Ten Years' Experience



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ABSTRACT

The aim of our study is a retrospective analysis of the 2 most common surgical treatments of symptomatic juvenile flat foot: different arthroereisis techniques. Exosinotarsal arthroereisis with metallic screw and endosinotarsal with bioabsorbable devices were compared. In total, 402 feet were examined for a median follow-up of 130 months. Only symptomatic (plantar or calcaneus pain), flexible, and idiopathic flat feet were included in our study. Congenital (fibrous/bone tarsal coalitions), neurologic, and posttraumatic flat feet were excluded. During clinical examination, the feet were categorized according to the Viladot classification, which took into consideration the plantar impression: only grades 3 and 4 were included (complete medial longitudinal arch collapse). Evaluation was determined by taking into consideration 3 parameters: clinical evaluation, pain, and variation of the radiologic angles. No statistical differences were found between the 2 techniques; the choice can be determined mostly by the surgeon's preference.

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Flexible juvenile flat foot is a common pathology characterized by an abnormal pronation of the subtalar joint and a valgus hindfoot, which can be associated with a shortened Achilles tendon and an abducted forefoot (1–3). The abnormal pronation is determined both by a lateral rotation of the heel on its longitudinal axis and by a medial deviation and plantar flexion of the talus; this movement stops when the lateral process of the talus meets the floor of the tarsal sinus. Therefore, a medial rotation of the lower limb and modifications on the axis of the joints between the talus and the navicular bone by one side and between the heel and the cuboid bone by the other are frequently associated. There are many different types of implants that can be used for the correction of flat feet (4–9). The aim is to reduce both the excessive pronation of the subtalar joint and the valgus of the heel, and to increase the height of the medial arch. The Vogler classification divides prostheses into 3 groups depending on their action: (i) implants that modify the axis of the subtalar joint (axis altering), such as STA Peg described by Lepow and Smith (9) and made of cemented polyethylene; (ii) exosinotarsal implants (implant-blocking devices), such as orthopedic association metallic screws implanted in the sinus tarsi floor (“calcaneus-stop”) or in the talus (“talar screw”) (7); and (iii) endosinotarsal implants

(self-locking wedges), such as metallic or expandable polyethylene screws invented by Giannini et al (5) and modified by Maxwell-Brancheau (10–12), which are located in the sinus tarsi. Over the past few years, with the improvement of biomaterials, endosinotarsal and exosinotarsal bioabsorbable implants (poly-L-lactic acid) have been developed (13,14).

The aim of our study is not to analyze the indications to perform surgery in patients affected by flat feet but to compare by performing a retrospective analysis of the patients who underwent operation in our division over the past 8 years with the 2 most-used techniques for the correction of juvenile flat foot: the exosinotarsal technique with metallic screws and the endosinotarsal technique with bioabsorbable expandable screws (15–18) (Figs. 1 and 2).

Patients and Methods

In total, 402 feet (58% male; 42% female) underwent surgical correction of symptomatic flat foot in our hospital from March 2003 to July 2011; they were divided into 2 groups depending on the type of procedure used: exosinotarsal arthroereisis with metallic AO screws (group A: C-STOP) and endosinotarsal correction with bioabsorbable device (group B: ENDO).

Only symptomatic (plantar or calcaneus pain), flexible, and idiopathic flat feet have been included in our study. Congenital (fibrous/bone tarsal coalitions), neurologic, or posttraumatic flat feet were excluded. During clinical examination, the feet were categorized according to the Viladot classification, which divides flat feet according to the percentage of plantar area that on static weightbearing touch the ground (17) (Fig. 3): only grades 3 and 4 were included (complete medial longitudinal arch collapse).

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Fig. 1. Metallic orthopedic association screw used for exosinotarsal arthroereisis.

Group A included 202 feet: 105 left feet and 97 right feet, 49% male and 51% female, mean age 13.6 years (range 8 to 16 years). Group B included 200 feet: 150 left feet and 50 right feet, 61% male and 39% female, mean age 12.8 years (range 8 to 16 years). It is well known that juvenile flat foot is a symmetrical condition, so the variance between the numbers of left and right feet in our study is owing to the date of inclusion considered (March 2003) for both groups, as well as the different type of screw used for group B. Median follow-up was 130 months (range 35 to 150 months) for both groups.

The choice of the technique was based exclusively on the surgeon's preference. Percutaneous lengthening of the Achilles tendon was performed on 92% of feet in group A and 71% of feet in group B; the Achilles tendon was lengthened at 2 levels (half distal and lateral plus half medial and proximal) only if the dorsiflexion was $<10^\circ$ when the subtalar joint was in the neutral position (measurement was executed both before and after implantation of the prosthesis in both groups).

The surgical incision was the same in both groups and was performed on the lateral side of the tarsal sinus for 2 cm; then a small dissection of soft tissues was performed, with care taken to avoid damaging the peroneal tendons on the distal/posterior side and to expose the floor of the sinus tarsi. Half plasters at 90° were positioned after surgery for 2 weeks or for 3 weeks if tendon lengthening was performed; after removal of the plaster, walking with crutches (partial weight-bearing) was recommended for a week. None of the patients were allowed to participate in sports activities for 90 days. Clinical evaluation was made before and after surgery (14 days, 60 days, 1 year), and it was based on the examination of the medial longitudinal arch collapse during a static stance on the podoscope, of the valgus of the hind foot, and on the research of correlated pathologic signs such as Achilles tendonitis, plantar fasciitis, and juvenile hallux valgus. These signs were used as inclusion criteria. Standing foot x-ray images were obtained both before and 1 year after surgery; 4 angles were measured to analyze their

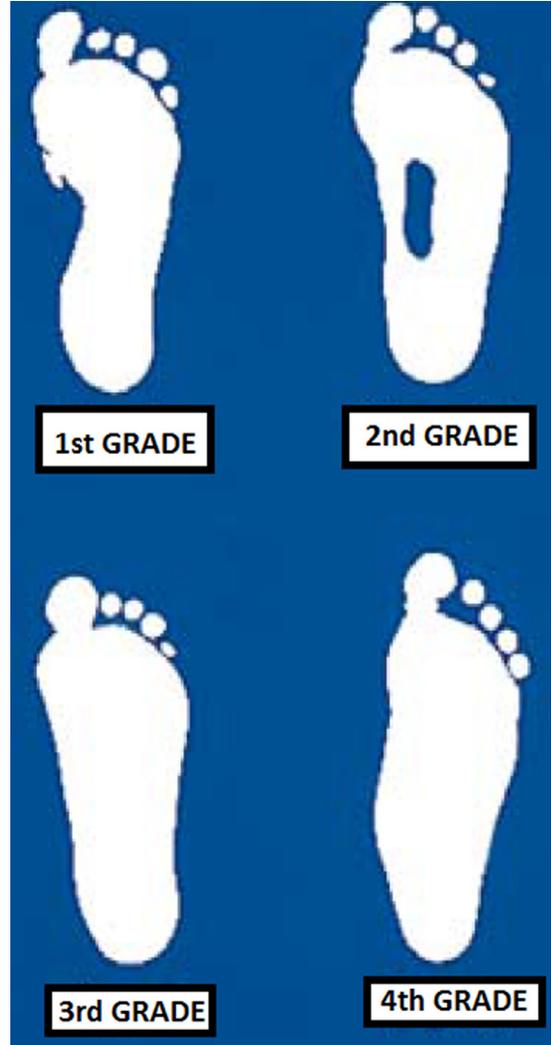


Fig. 3. Viladot classification.

variation after surgery (18–21): the Costa Bertani angle (120° to 125°), heel inclination angle (15° to 20°), talar declination angle (20° to 30°), and kite angle ($<25^\circ$).

Results

Results were analyzed by considering 3 parameters: clinical evaluation, pain, and variation of the angles measured on x-ray images. Clinical evaluation showed an improvement of all feet in both groups, with restoration of the medial arch and the hind foot valgus in orthostasis (Fig. 4).

Some patients experienced difficulty in walking at the beginning (some of them tended to put their weight on the external side of the foot and to adduct their forefeet); all patients returned to normal walking in 3 months. Pain before surgery was described by patients as a bother located in the midfoot after long periods of standing, walking, or playing sports. Of the patients who experienced rupture or intolerance of the screw, only 32 (15.8%) patients in group A and 11 (5.5%) patients in group B mentioned pain at 3 months after surgery; these patients expressed their pain through a numeric pain scale, in which values ranged from 0 (no pain) to 10 (tearing pain). The mean average was 7.8 (5.5 to 9) in group A and 7.4 (5 to 9) in group B.

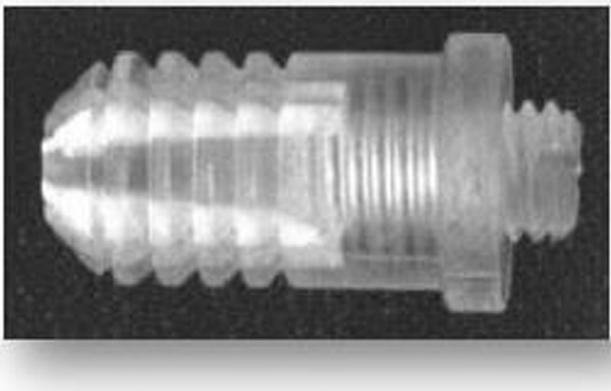


Fig. 2. Bioabsorbable endosinotarsal device (poly-L-lactic acid).



Fig. 4. Clinical preoperative and postoperative image of a patient undergoing the endosinotarsal technique.

Group A had 32 (15.8%) complications: 23 (11.4%) patients had an incomplete correction, and 9 (4.5%) others had to remove the screw because of breakage. Group B had 25 (12.5%) complications: 20 (10%) patients had an inflammatory process involving soft tissues around tarsal sinus and were treated with rest, local ice bag application, and nonsteroidal antiinflammatory drugs; 5 (2.5%) others had to remove and substitute the screw owing to a technical error (incorrect site of screw implantation). For both types of treatment, hospitalization time lasted 1 night to control postoperative pain.

Preoperative and postoperative radiographic parameters are shown in Table 1; the average and standard deviation for each angle in the patients of the 2 groups were calculated. After surgery all patients, except 32 (15.8%) in group A and 11 (5.5%) in group B, showed a standardization of the 4 angles considered (Figs. 5–7).

We used SPSS software (IBM, Armonk, NY) for statistical analysis of the data. Comparative analysis of preoperative and postoperative angular parameters according to type of surgical treatment showed no statistically significant difference (Table 2). Therefore, there is no evidence that would justify a preferential choice of 1 between the 2 different surgical methods but only consideration of the x-ray images.

Discussion

It is well defined that conservative treatment of high-grade symptomatic flat foot during growth, such as insoles or

Table 1

X-ray image parameters before and after surgery in group A (calcaneus-stop) (n = 202) and B (endosinotarsal correction) (n = 200)

Angle	INT	No.	Mean	SD	SEM
CB_PRE	C-STOP	200	136.7200	3.61621	0.25570
	ENDO	186	136.6183	3.57007	0.26177
CB_POST	C-STOP	200	122.1050	4.20385	0.29726
	ENDO	186	122.2903	4.55378	0.33390
CB_6M	C-STOP	181	123.1492	5.72663	0.42566
	ENDO	167	122.0898	5.96862	0.46187
CB_1Y	C-STOP	154	123.3701	6.28303	0.50630
	ENDO	130	124.0769	5.91623	0.51889
HI_PRE	C-STOP	200	13.0250	1.46462	0.10356
	ENDO	186	12.9086	1.42837	0.10473
HI_POST	C-STOP	200	16.6300	2.32381	0.16432
	ENDO	186	16.3602	2.34908	0.17224
HI_6M	C-STOP	181	17.7127	2.78594	0.20708
	ENDO	167	17.4850	2.86200	0.22147
HI_1Y	C-STOP	154	17.9610	3.09941	0.24976
	ENDO	130	17.5308	3.21862	0.28229
TDA_PRE	C-STOP	200	34.6400	4.18665	0.29604
	ENDO	186	34.8817	4.30675	0.31579
TDA_POST	C-STOP	200	27.5550	4.74971	0.33586
	ENDO	186	27.4570	4.46376	0.32730
TDA_6M	C-STOP	181	27.8343	5.49496	0.40844
	ENDO	167	29.0120	5.17523	0.40047
TDA_1Y	C-STOP	154	29.7857	4.97308	0.40074
	ENDO	130	29.9308	4.91665	0.43122
KI_PRE	C-STOP	200	28.2850	2.59953	0.18381
	ENDO	186	28.0538	2.54204	0.18639
KI_POST	C-STOP	200	17.2000	4.59517	0.32493
	ENDO	186	17.9409	4.69177	0.34402
KI_6M	C-STOP	181	18.4530	5.34834	0.39754
	ENDO	167	18.7904	5.23983	0.40547
KI_1Y	C-STOP	154	21.8571	5.20486	0.41942
	ENDO	130	21.6462	4.81899	0.42265

Abbreviations: CB_PRE, preoperative Costa Bertani angle; CB_POST, postoperative Costa Bertani angle; CB_6M, Costa Bertani angle after 6 months; CB_1Y, Costa Bertani angle after 1 year; C-STOP, calcaneus-stop; ENDO, endosinotarsal correction; HI_PRE, preoperative heel inclination angle; HI_POST, postoperative heel inclination angle; HI_6M, heel inclination angle after 6 months; HI_1Y, heel inclination angle after 1 year; KI_PRE, preoperative kite angle; KI_POST, postoperative kite angle; KI_6M, kite angle after 6 months; KI_1Y, kite angle after 1 year; SD, standard deviation; SEM, standard error of the mean; TDA_PRE, preoperative talar declination angle; TDA_POST, postoperative talar declination angle; TDA_6M, talar declination angle after 6 months; TDA_1Y, talar declination angle after 1 year.

physiotherapy, is not enough to lead to a resolution of this pathology (22). The incidence of flexible flat foot decreases spontaneously during growth, becoming around 10% to 15% at age 10 (22); in this percentage of cases, a surgical solution must be considered if the grade according to the Viladot classification is high (grades 3 to 4) and the patient has symptoms. High-grade flat feet in adulthood are correlated to a high risk for development of tarsal arthrosis. Insoles can be an effective option to prevent arthrosis; however, not all patients tolerate them, and the inserts need to be replaced at least every year with the remarkable problem of cost

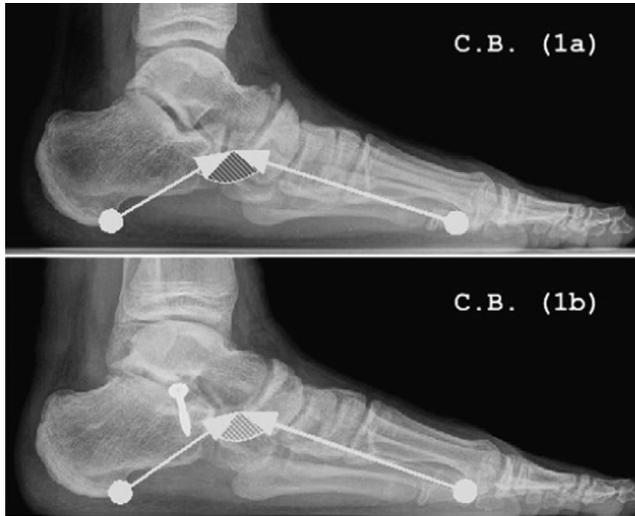


Fig. 5. Postoperative reduction of the Costa Bertani angle in a patient undergoing exosinotarsal arthroereisis (C-STOP).

(23,24). Therefore, it is necessary to assess which is the most appropriate surgical technique to use and the best time for surgery. Surgery must be performed during bone maturation, because it leads to the correct growth of the tarsal bones. After this period, the epiphyseal plates are replaced by bone, and the only possible correction is mechanical. In our experience, the older the patients, the less well they tolerate the devices and will need to remove them in adulthood.

Many authors have already considered and proved the accuracy between the parameters measured on radiography and the diagnosis of flat feet (25,26). The correlation between them and the symptoms is not yet well defined, even if studies have shown their difference in normal feet (27).

According to the literature, the retrospective evaluation of our patients points out the efficacy of each technique in removing pain, both at the plantar site (plantar fasciitis) and at the distal end of the Achilles tendon (enthesitis, tendinitis), as well as in recovering

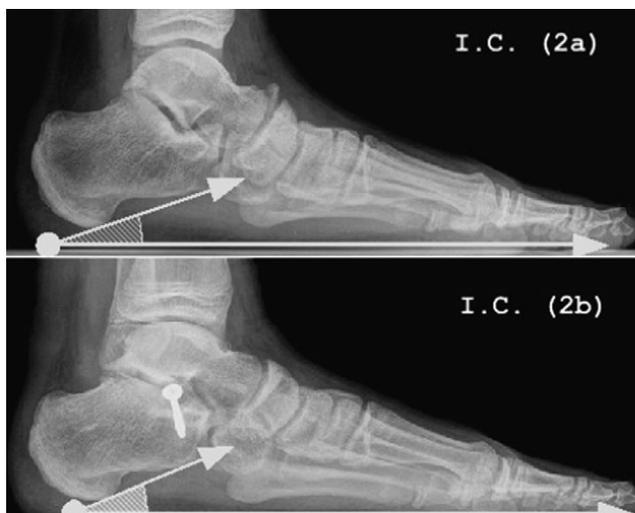


Fig. 6. Postoperative reduction of the heel inclination angle in a patient undergoing exosinotarsal arthroereisis (C-STOP).



Fig. 7. Anteroposterior. Postoperative reduction of the kite angle in a patient undergoing endosinotarsal correction with a bioabsorbable device.

normal walking, with a significant improvement of radiographic angle values (9,10,12,14,19–21). Relative indications, benefits, and complications of the 2 techniques are specified on the basis of the results.

In particular, some studies on endosinotarsal correction with a bioabsorbable device (8–10,13,14,19–21) underline recovery of the articular excursion range, especially in dorsiflexion and pronation-supination, a greater stability of the foot in single leg stance, a better response to the Jack test, a significant reduction of the ankle-foot pronation in gait analysis, an earlier normalization of the load absorption capacity, and propulsion just 1 year after surgery.

According to other authors (12,14,19–21,27), the advantages of the calcaneus-stop technique are easier execution, shorter hospitalization, and greater ability to correct because the endosinotarsal proprioceptive structures are saved; articulation is not damaged and the operation is reversible. However, further intervention to remove the screw, when correction occurs, may be necessary. Immediate postoperative pain, usually easily controlled, does not reappear even with the resumption of the load.

In conclusion, this study may help to define the indications concerning the 2 interventions considered. First, both provide excellent and stable correction of the deformity, which is clinically and radiographically evident and significant; therefore, the choice of method relies on the surgeon's preference. Second, the intrinsic characteristics of both surgical techniques, the operational protocol, and rehabilitation allow a rapid return to daily activities. Third, the rate of major complications, considered as a rupture or an intolerance of the devices (around 4.45% in group A and 2.5% in group B), observed in our study groups is low. All of the other minor complications, such as incomplete correction or inflammatory processes (around 11.38% in group A and 10% in group B), have been easily solved with conservative treatments and insoles. Our results for each operation are similar to those reported in the literature in analogue cases by age and indications, demonstrating the validity of the analysis. Both surgical methods can provide satisfactory clinical and morphologic correction in the short and medium term, with no significant differences considering radiographic and clinical parameters.

Table 2

Comparative analysis of preoperative and postoperative angular parameters plus controls at 6 months and 1 year according to type of surgical treatment

	t Test for Equality of Means						
	T	Df	Significance (2-tailed)	Mean Difference	SE Difference	95% Confidence Interval of the Difference	
						Lower	Upper
CB_PRE	0.278	384	0.781	0.10172	0.36611	-0.61810	0.82154
CB_POST	-0.416	384	.678	-0.18532	0.44575	-1.06174	0.69110
CB_6M	1.689	346	0.092	1.05935	0.62705	-0.17395	2.29266
CB_1Y	-0.970	282	0.333	-0.70679	0.72868	-20.14113	0.72754
HL_PRE	0.790	384	0.430	0.11640	0.14743	-0.17346	0.40626
HL_POST	1.134	384	0.258	0.26978	0.23796	-0.19808	0.73765
HL_6M	0.752	346	0.453	0.22768	0.30287	-0.36802	0.82337
HL_1Y	1.145	282	0.253	0.43027	0.37571	-0.30929	1.16983
TDA_PRE	-0.559	384	0.576	-0.24172	0.43241	-1.09190	0.60846
TDA_POST	0.209	384	0.835	0.09801	0.47002	-0.82612	1.02214
TDA_6M	-2.054	346	0.041	-1.17772	0.57340	-2.30550	-0.04994
TDA_1Y	-0.246	282	0.806	-0.14505	0.58925	-1.30494	1.01483
KL_PRE	0.883	384	0.378	0.23124	0.26199	-0.28389	0.74636
KL_POST	-1.567	384	0.118	-0.74086	0.47285	-1.67056	0.18884
KL_6M	-0.594	346	0.553	-0.33738	0.56831	-1.45516	0.78040
KL_1Y	0.352	282	0.725	0.21099	0.59933	-0.96875	1.39073

Abbreviations: CB_PRE, preoperative Costa Bertani angle; CB_POST, postoperative Costa Bertani angle; CB_6M, Costa Bertani angle after 6 months; CB_1Y, Costa Bertani angle after 1 year; Df, degree of freedom; HL_PRE, preoperative heel inclination angle; HL_POST, postoperative heel inclination angle; HL_6M, heel inclination angle after 6 months; HL_1Y, heel inclination angle after 1 year; KL_PRE, preoperative kite angle; KL_POST, postoperative kite angle; KL_6M, kite angle after 6 months; KL_1Y, kite angle after 1 year; SE, standard error; T, distribution; TDA_PRE, preoperative talar declination angle; TDA_POST, postoperative talar declination angle; TDA_6M, talar declination angle after 6 months; TDA_1Y, talar declination angle after 1 year.

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