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Long-Term Results of the “Horseman” Procedure for Severe Idiopathic Flatfoot in Children: A Retrospective Analysis of 41 Consecutive Cases With Mean 8.9 Year Duration of Follow-Up

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ABSTRACT

The “horseman” procedure is a surgical technique used to correct the talocalcaneal joint displacement of severe idiopathic flatfoot in children while maintaining the reduction with a temporary talocalcaneal screw. While this technique has been used since the early 1960s, very little has been reported on its results. Our objectives were to estimate the correction, functional results, and postoperative complications of the “horseman” procedure. We conducted a retrospective study on 23 consecutive patients (41 cases) who underwent the “horseman” procedure for a talocalcaneal joint displacement. Mean follow-up was 8.9 (range 1 to 28) years, and 8 patients (12 feet) had reached bone maturity at last follow-up. Mean age at surgery was 6.6 (range 4 to 9.5) years. At last follow-up, all the patients were asymptomatic except 2 [8.7%] (4 [9.8%] cases). The talocalcaneal divergence on anteroposterior and lateral radiographic views was reduced by 8.9° and 11.4°, respectively, after the surgery, and the correction was maintained with loss of 0.7° and 2.9°, respectively, at final follow-up. The talonavicular coverage angle was reduced by 25° without loss of correction at last follow-up. The calcaneal pitch angle did not change after the surgery. Mean American Orthopedic Foot and Ankle Society score increased from 88.7 of 100 (63 of 100 to 93 of 100) preoperatively to 99 of 100 (97 to 100 of 100) at last follow-up. No major complication occurred. The “horseman” procedure allows an immediate and lasting correction of severe idiopathic flatfoot in children.

Idiopathic flatfoot in children combines hind foot valgus, decrease of the longitudinal medial arch, abduction, and supination of the forefoot. This deformation can be reducible in the pediatric patient. Also, it is frequently associated with a contraction of the triceps (1). Plantar insoles or foot orthotics have no effect on the realignment and/or stabilization of the talotarsal joint, but they may enhance the footwear (2–5). Also, physical therapy could improve the triceps contraction but has not been proven to have a positive effect on the realignment or stabilization of the talotarsal joint (2,6). In severe cases, orthotics and rehabilitation can be ineffective, and the occurrence of pain or worsening of the deformation may lead to surgical treatment.

Several surgical techniques have been developed for young children. The partial arthrodesis such as the cuneonavicular or subtalar arthrodesis aim to improve the shape of the foot but can lead to stiffness with mixed long-term results because of an impact on the tibiotalar joint (7,8). Subtalar arthroereisis techniques, such as sinus tarsi implants or calcaneus stop-procedure, were introduced to avoid sacrificing a joint and its complications. Both techniques share the same theoretic principles of mechanical alteration, proprioceptive effects and potential modulation of growth (9–11). In fact, these subtalar arthroereisis techniques showed a real efficacy with very limited complications (12–15).

The “horseman” procedure shares the same principles as the subtalar arthroereisis techniques. It was first reported by Judet et al (16) in 1963. Because it aimed to correct the talocalcaneal divergence by exaggerating the relocation of the talus on the calcaneus—like putting back the talus on the saddle—it was called the “horseman” procedure (16). A temporary talocalcaneal screw was inserted through the sinus tarsi to maintain the correction (16–18). Initial enthusiasm led to extend the use of this technique for flat feet caused by hyperlaxity or neurologic conditions. However, authors recommended its use for idiopathic flat feet only (16,18).

Despite its simplicity, promising immediate results, and low rate of complications, long-term results of the “horseman” procedure have not

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yet been reported. In this study, we aimed to estimate 1) the architectural correction obtained after surgery and at last follow-up, 2) the functional results at last follow-up, and 3) the postoperative complications.

Patients and Methods

General Settings

We designed a retrospective study about all the patients treated with the "horseman" procedure for talotarsal displacement from idiopathic flatfoot in a pediatric orthopedic department between 1985 and 2015.

Patients

Our inclusion criteria were patients treated with the "horseman" procedure for idiopathic flatfoot with a follow-up longer than 1 year after the initial surgery. Our exclusion criteria were flat feet caused by hyperlaxity or neurologic conditions, an incomplete medical chart, or an inconsistent follow-up.

Ethical Approval

This study has been performed in accordance with the ethical standards in the 1964 Declaration of Helsinki and has been approved by the local ethical committee before completion. Informed consent was obtained from all individual participants included in the study.

The "Horseman" Procedure

Indications

This procedure was used on children younger than 9 years of age, with severe idiopathic flatfoot, who underwent a consistent medical and orthotic treatment for at least 6 months, and who continued to have pain.

Contraindications

The "horseman" procedure is contraindicated for flat feet caused by hyperlaxity or neurologic conditions (16,18).

Surgical Technique

The surgery is performed with the patient under general anesthesia. The patient is placed supine on a radiolucent operating table. A dorsal approach is made distal to the lateral malleolus and lateral to the extensor digitorum longus tendons. The extensor digitorum brevis muscle is elevated, and the talocalcaneal lateral ligament is incised to expose the dorsal surface of the calcaneus. Usually, the head of the talus is difficult to access because it is tilted medially. Hence, the talar head is released by incising the capsular ligament between the talus and the cuboid. A curved spatula is inserted above the talar neck and in the direction of the medial aspect of the calcaneus. Then, a lever movement using the posterior part of the calcaneus as a base helps transferring the talus laterally. Simultaneously, an inversion of the heel is performed to bring the talar head above the anterior process of the calcaneus. A temporary pinning of the talus and the calcaneus is performed, under fluoroscopy. If the talocalcaneal divergence is in accordance with the preoperative planning, a 3.5-mm screw is inserted from the talar neck to the plantar cortex of the calcaneus through the sinus tarsi. It is of tremendous importance that the screw remain away from the subtalar joints to avoid any cartilage damage. Then, dorsiflexion is assessed and a lengthening of the Achilles tendon is performed if the dorsiflexion of the ankle is not possible.

Postoperative Follow-Up

After the surgery, the patient is immobilized in a walking cast for 6 weeks. After removal of the postoperative cast, a first clinical evaluation was made. The foot was considered as undercorrected if the clinical aspect of the foot was still flat or overcorrected if its clinical aspect was a pes cavus. The screw can be removed after 6 months.

Postoperative Analysis

Two authors (C.D. and J.C.A.) reviewed the medical charts of all the included patients. For each patient, the clinical, functional, and radiologic analysis was retrieved at 3 time points: before surgery, 3 months after surgery, and at last follow-up. Clinical analysis comprised the functional signs (pain and activity limitation), clinical examination (foot morphology, reducibility, stiffness, gastrocnemius retraction), and foot morphology according to the Lelièvre classification (19). Function was assessed by the American Orthopedic Foot and Ankle Society (AOFAS) hindfoot score (20,21). Radiographic analysis was conducted on anteroposterior (AP) and lateral weight-bearing radiographs:

- On the AP view, the reported data were the talocalcaneal divergence, corresponding to the angle between the axis of the talus (bisector between its medial and lateral edges) and the axis of the calcaneus (axis tangent to the lateral edge of the calcaneus), and the talonavicular coverage angle, corresponding to the angle between the articular surfaces of the talus and the navicular, which is a good estimation of the abduction of the calcaneopedal unit (Fig. 1*A*, *B*).

- On the lateral view, the reported data were the talocalcaneal divergence, corresponding to the angle between the longitudinal axis of the talus (bisecting the top and bottom edges) and the longitudinal axis of the calcaneus (tangent to the lower edge of the calcaneus), and the calcaneal pitch angle, corresponding to the angle between the tangent to the plantar aspect of the calcaneus and the horizontal ground (Fig. 1*C*).

Results

Our results are shown in Tables 1 and 2, and described below.

Patients

Over the 30-year period, 23 patients (41 feet) were eligible. None of them met the exclusion criteria. Hence, we included 23 consecutive patients (41 feet). The male:female ratio was 2.3:1. Mean age at diagnosis was 5.3 (range 1.5 to 9, ±2.06) years and mean age at surgery was 6.6 (range 4 to 9.5, ±1.39) years. The mean time between diagnosis and surgery was 1.3 (range 0 to 4.5, ±1.12) years. Mean follow-up was 8.9 (range 1 to 28, ±7.32) years. Eight (34.8%) patients (12 [29.3%] feet) had reached bone maturity at last follow-up.

Of the 23 patients, 5 had unilateral deformity, and 18 had bilateral involvement. There were 21 (51.2%) right feet and 20 (48.8%) left feet in the case series. In regard to flexibility, 27 (65.9%) feet were fully reducible and 13 (31.7%) were partially reducible, and 1 (2.4%) was nonreducible. Moreover, 19 (46.3%) extremities displayed Achilles contracture (ankle equinus), and 22 (53.7%) did not; and an Achilles tendon lengthening procedure was performed in 10 (%) of the involved extremities.

Preoperative Analysis

The initial morphology of the foot was Lelièvre stage 2 for 2 (4.9%) feet, Lelièvre stage 3 for 14 (34.2%) feet, and Lelièvre stage 4 for 25 (61%) feet. Reducibility of the deformity was deemed incomplete in 14 (34.2%) feet. Ankle equinus was associated with 19 (46.3%) feet.

Surgery

The position of the screw was vertical and went through the opposite cortex in 29 (70%) feet and yet was too horizontal without going through the opposite cortex in 12 (30%) feet. An Achilles lengthening was performed in 10 (24%) feet. Two (5%) feet were insufficiently corrected by the surgery. No overcorrection occurred. The screw was removed at a mean average of 9 months (range 6 to 18, ±2.95).

Clinical Analysis

At last follow-up, all the patients were asymptomatic except 2 [8.7%] (4 feet, 9.8%) who had mild pain after long walks (>1 hour). No major

Table 1
Preoperative and post-operative comparisons (N=41 feet in 23 patients)

Outcome	Preoperative	Immediate postoperative	*p*-value	Late postoperative	*p*-value
Calcaneal pitch angle (°)	10 .7 ± 4.9	13.6 ± 4.8	0.007	13.3 ± 5.2	0.025
AP talocalcaneal divergence (°)	31.8 ± 7.4	22.9 ± 5.9	0.001	23.6 ± 4.4	0.001
Lateral talocalcaneal divergence (°)	54.1 ± 7.5	42.7 ± 6.7	0.001	39.9 ± 7.7	0.001
AOFAS Score	88.7 ± 8.9	NA	NA	99 ± 1.1	0.01

Abbreviation: AP, anteroposterior.

Table 2
Patient characteristics

Patient	Foot	Sex	Side	Age at Onset (y)	Lelièvre Stage	Reducible	Achilles Contraction	Preoperative Talocalcaneal Pitch	Preoperative AP Talocalcaneal Divergence	Preoperative L Talocalcaneal Divergence L	Age at Surgery (y)	Postoperative Talocalcaneal Pitch	Postoperative AP Talocalcaneal Divergence	Postoperative L Talocalcaneal Divergence	Achilles Lengthening	Screw Removal (months)	Follow-Up (y)	Final Talocalcaneal Pitch	Talocalcaneal divergence AP Final	Talocalcaneal divergence L Final
1	1	M	R	1.5	4	Yes	Yes	6	50	55	4	20	20	55	1	8	4	20	20	50
1	2	M	L	1.5	4	Yes	Yes	6	45	55	4	20	28	45	1	8	4	26	24	50
2	3	M	R	8.75	4	Partial	Yes	10	30	52	9	12	20	40	0	10	2	12	20	40
2	4	M	L	8.75	4	Partial	Yes	10	30	52	9	8	20	40	0	10	2	8	20	40
3	5	M	R	6	2	Partial	Yes	10	32	50	7	10	20	36	1	7	10	14	28	30
3	6	M	L	6	2	Partial	Yes	10	40	48	7	15	25	30	1	7	10	15	30	35
4	7	M	R	4	4	Partial	Yes	12	30	65	6	12	20	50	1	10	21	14	20	30
4	8	M	L	4	3	Partial	Yes	18	40	70	6	20	20	50	1	10	21	18	30	35
5	9	M	R	3	3	Partial	Yes	10	22	50	5,5	15	18	42	1	7	2	15	26	40
5	10	M	L	3	3	Yes	Yes	10	22	52	5.5	12	22	32	0	7	2	12	26	36
6	11	M	L	3	3	Partial	Yes	12	35	60	5.5	20	28	50	1	7	21	20	28	40
7	12	M	R	2	4	Yes	No	4	34	55	6.5	4	26	34	0	7	6	6	22	34
7	13	M	L	2	4	Yes	No	6	32	55	6.5	8	26	36	0	7	6	6	18	32
8	14	F	R	5.5	3	No	No	12	20	60	6.5	14	26	52	0	8	22	14	30	40
9	15	M	R	6.5	3	Yes	No	20	30	65	6.5	22	20	50	0	9	7.5	20	22	40
9	16	M	L	6.5	3	Yes	No	20	35	70	6.5	28	28	50	0	9	7.5	20	28	45
10	17	F	R	4	3	Yes	No	10	26	50	5.5	14	22	40	0	6	3.5	14	24	42
10	18	F	L	4	3	Yes	No	12	32	48	5.5	14	26	40	0	6	3.5	18	26	40
11	19	F	R	8.5	4	Partial	Yes	8	30	50	9	10	20	30	0	7	4.5	10	18	35
11	20	F	R	8.5	4	Partial	Yes	10	20	46	9	10	22	32	1	7	4.5	10	22	34
12	21	M	R	9	4	Partial	No	5	25	45	9.5	16	26	40	0	8	15	16	20	38
13	22	M	R	6	3	Yes	Yes	5	42	55	7	8	28	36	0	18	10	8	19	30
13	23	M	L	6	3	Yes	Yes	5	40	56	7	10	30	38	0	18	11	10	24	32
14	24	M	R	6.5	4	Yes	No	11	32	46	8	20	15	45	0	11	1	7	20	35
14	25	M	L	6.5	4	Yes	No	4	26	55	7.5	8	14	50	0	18	1.5	4	25	40
15	26	F	R	8	4	Yes	No	10	32	65	8	10	15	40	0	10	9	8	17	37
15	27	F	L	8	4	Yes	No	10	35	64	8	10	20	42	0	10	9	8	20	35
16	28	M	L	7	3	Partial	Yes	0	30	45	7.5	15	20	40	1	12	4	8	25	35
17	29	F	R	5	4	Yes	Yes	11	28	54	5	12	18	40	0	8	7	14	22	38
17	30	F	L	5	4	Partial	Yes	12	30	50	5	13	20	38	0	8	7	14	24	36
18	31	M	R	4	3	Yes	No	18	35	38	7	14	30	42	0	12	28	14	25	42
18	32	M	L	4	3	Yes	No	20	38	42	7	12	20	40	0	12	28	20	25	40
19	33	M	R	3.5	4	Yes	No	16	14	56	5	16	26	47	0	9	5	16	20	45
19	34	M	L	3.5	4	Yes	No	16	25	53	5	20	20	45	0	9	5	17	16	46
20	35	F	R	6	4	Yes	No	10	31	66	7	8	48	60	0	11	7	5	30	75
20	36	F	L	6	4	Yes	No	8	48	60	7	8	12	50	0	9	7	8	38	50
21	37	M	L	4	4	Yes	No	22	25	42	5	12	23	42	0	9	11	23	20	47
22	38	F	R	4.5	4	Yes	No	11	34	52	5.5	14	21	41	0	7	8.5	12	22	38
22	39	F	L	4.5	4	Yes	Yes	10	31	53	5.5	15	21	43	0	7	8.5	14	22	37
23	40	M	R	5.5	4	Yes	No	10	33	56	7	14	23	42	0	9	9.5	14	24	40
23	41	M	L	5.5	4	Yes	No	11	33	55	7	14	24	43	0	9	9.5	13	24	41

Abbreviations: AP, anteroposterior; F, female; L, left; M, male; R, right.

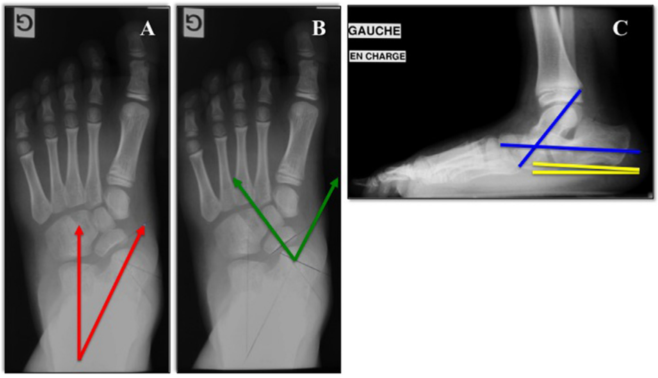

Fig. 1. Radiographic analysis conducted on anteroposterior (AP) and lateral weight-bearing radiographs: (*A*) talocalcaneal, (*B*) talonavicular coverage angle, and (*C*) talocalcaneal divergence and calcaneal pitch.

complication occurred. The clinical analysis revealed 25 (61%) normal feet, 14 (34.2%) Lelièvre stage 1 flat feet, and 2 (4.9%) Lelièvre stage 2 flat feet. Finally, 1 (4.4%) patient (2 feet, 4.9%)—who kept the screws 18 months despite our indication of removal after 6 months—had stiffness of the subtalar joint without pain, functional impairment, or arthritic changes noted on the ankle radiographs.

Radiologic Analysis

The talocalcaneal divergence on AP and lateral views were reduced by 8.9° (±9) and 11.4° (±6.8), respectively, after the surgery, and the correction was maintained with no significant loss of either 0.7° (±6) and 2.8° (±6.2), respectively, at final follow-up. The talonavicular coverage angle was reduced by an average of 25° (±12.3) with no significant loss of either 2.5° (±10.7) at final follow-up. The calcaneal pitch angle did not change significantly after the surgery (Fig. 2).

Functional Analysis

The mean preoperative AOFAS ankle-hindfoot score was 88.7 of 100 (range 63 of 100 to 93 of 100, ±8.9), and the mean postoperative AOFAS ankle-hindfoot score at last follow-up was 99 of 100 (range 97 of 100 to 100 of 100, ±1.1).

Postoperative complications

No patient required additional surgery except for screw removal. No major complication occurred. Four (9.8%) minor complications occurred: 3 (7.3%) screws moved back partially without any symptoms (Fig. 3*A*) and 1 (2.4%) broke (Fig. 3*B*). The broken screw occurred in a case where the screw removal was delayed until 18 months because a parental decision despite medical indication (Fig. 3*B*).

Discussion

In this study, we aimed to present the long-term results of the “horseman” procedure for idiopathic flatfoot in children. Our hypotheses were that the initial correction would be maintained until bone maturity, that this correction would allow satisfying functional outcomes, and that few complications would occur. We found that this procedure allowed satisfying immediate and long lasting correction. This correction was associated with good clinical results and excellent functional scores. Finally, we

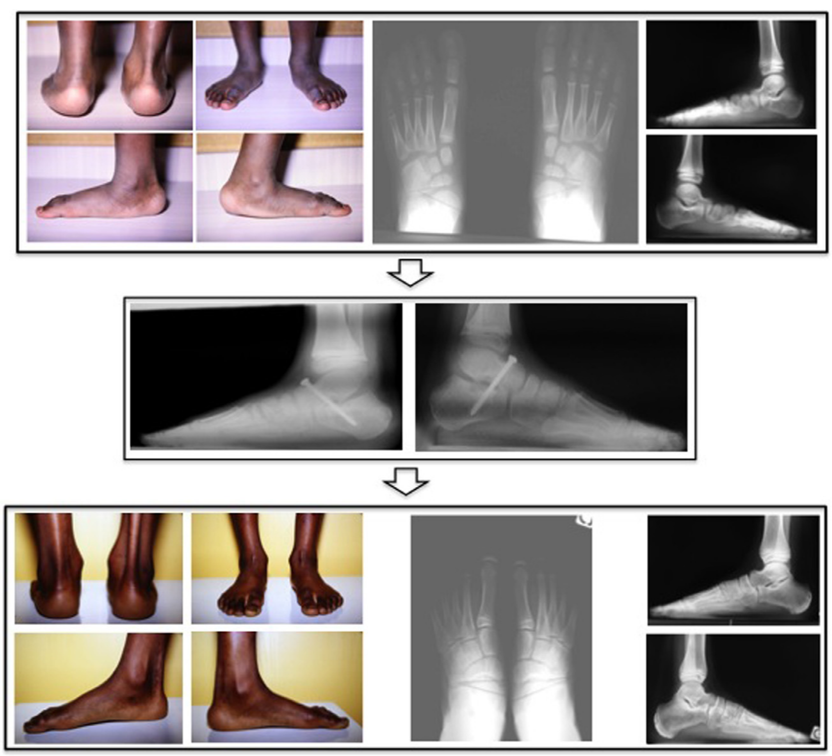

Fig. 2. Example of stage 3 idiopathic flat feet. The “horseman” procedure and Achilles tendon lengthening were performed at the age of 4.5 years. Screws were removed 8 months after surgery. Clinical and radiologic aspects displayed at last follow-up of 7 years.

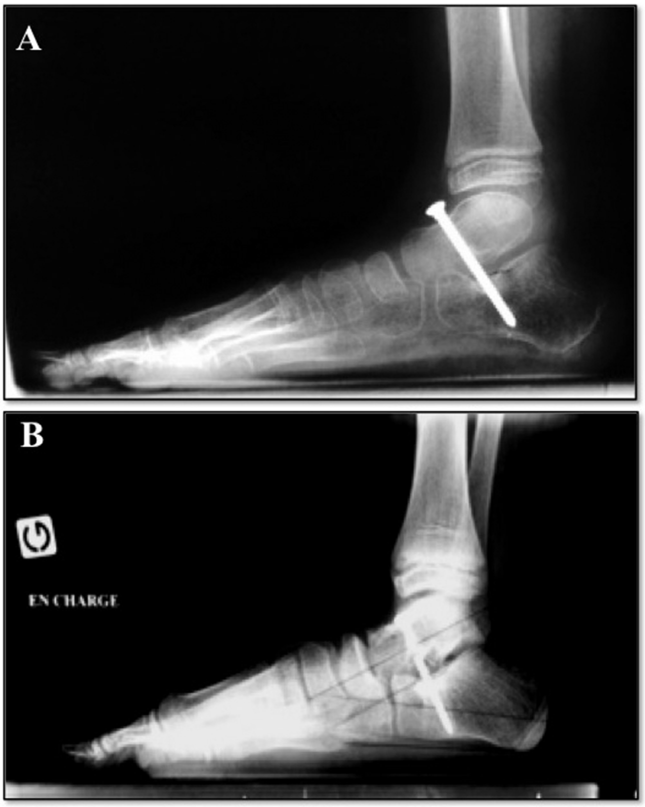

Fig. 3. (*A*) Screw that does not bite the lower cortical. Subsequently, the screw moved back partially without any symptoms. (*B*) Screw that bites the lower cortical with a vertical position. The screw broke 18 months after surgery (the parents refused the removal after 6 months).

reported only minor complications, all related to the screw, especially when it was kept longer that indicated.

In our experience, idiopathic flatfoot is rarely symptomatic in children <9 years old. Hence, indication of a surgical treatment in a child is based on the conjunction of symptoms, morphological criteria and failure of a well-conducted orthotic treatment for 6 months at least. Several authors attempted to clarify the indications for surgery in children: clinical symptoms of fatigue, cramps, or limitation of activities; age between 8 and 12 years; follow-up >2 years without spontaneous improvement; hind foot valgus >10°; and Meary angle <170°. For others, treating children younger than 8 years of age is not recommended because part or all the deformity could be spontaneously corrected with time (10,22). In our study, the mean age was 6.6 (range 4 to 9.5) years. Despite a limited functional impairment—reflected by the preoperative AOFAS score reported—morphologic parameters let us anticipate a worsening with age. That explains why we reported a short period between the first consultation and the surgery.

Several surgical techniques have been described to address idiopathic flatfoot in children. However, none are without drawbacks. In 1946, Chambers (22) aimed to correct the deformity and prevent its recurrence by blocking the subtalar joint with a bone graft. In 1952, Grice (7) described a surgical technique aiming to correct the deformity and prevent its recurrence by an extraarticular subtalar bone graft. This technique was originally developed for nonwalking children with a paralytic flatfoot. If this procedure proved to be effective in term of morphological correction, some do not recommend its use for idiopathic flatfoot because of its negative impact on the ankle due to residual subtalar stiffness.

Recently, other authors described the use of devices implanted to maintain the correction as a sinus tarsi arthroereisis (9,11–13). In 1995, Alvarez (10) described the calcaneus-stop procedure aiming to create a subtalar arthroereisis but distant from the sinus tarsi. The principle is to place an external and vertical implant in the calcaneus just in front the subtalar joint to create a stop maintaining the correction of the calcaneopedal unit. Studies reported sustainable corrections (23–26). The complications were dominated by postoperative pain due to conflicts with the implant and/or implant mobilizations (27–29).

In our opinion, the "horseman" procedure could be considered as an arthroereisis technique as well. As the other arthroereisis techniques, the main complications of the "horseman" procedure are related to the implant. In this study, the screw moved back partially in 3 feet but the patients expressed no symptom. In 1 case, the patient's parents refused to remove the temporary screw, and it broke eventually. It was discovered from a routine radiograph because the patient had no complaint at the time (Fig. 4). These mechanical complications reflect how strong the constraints are on the screw that temporarily immobilizes the calcaneopedal unit in the reduced position. Finally, we did not report other postoperative complications such as pain, difficulty walking, or intolerance of the implant, as it has been reported in the use of other arthroereisis techniques such as subtalar implant or the calcaneo-stop procedure.

In this study, we found that the temporary blocking of the calcaneopedal unit by a temporary screw in idiopathic flat feet in children under 10 years of age allows a sustainable correction of the shape of the foot even after removal of the screw. The radiologic study confirmed the clinical correction with a decrease of the talonavicular coverage angle and a decrease of the AP talocalcaneal divergence. These findings reflect the reduction of the navicular and a correct adduction of the calcaneopedal unit. The decrease of lateral talocalcaneal divergence reflects the horizontalization and the eversion of the talus. Unfortunately, we were not able to assess radiologically the hind foot valgus correction. Indeed, the hind foot valgus correction is not assessed by the AP talocalcaneus angle but by the Meary incidence, which was not performed systematically in our series (30).

The exact mechanism by which this temporary fixation allows a stable correction is unknown. It involves probable bone remodeling but also a change of muscle balance and proprioceptive mechanisms. We suggest that the reduction of the talus gives proper support to the navicular head, which leads to relaxation of both the spring ligament and tibialis posterior tendon. In addition, the peroneal tendons may be stretched by the diminution of the hindfoot valgus, which may result in a slight traction on the lateral aspect of the foot helping to maintain the correction during time. Finally, lengthening of the Achilles tendon avoids the calcaneal valgus, which contributes to the abduction of the calcaneopedal unit. However, a quantitative gait analysis before and after the procedure would be necessary for a better understanding of these adaptive phenomena in the child. One limitation of the approach may be a weakening of the blood flow or the talar neck by the screw. This risk seems to be only empiric because none of the patients included displayed such complication.

This study has several limitations. First, it was retrospectively designed and so, we did not avoid selection biases. Second, we used a wide period of inclusion to involve a sufficient number of patients. This could have led to surgical biases because several surgeons were involved. For instance, a lengthening procedure was carried out in only 10 (24%) of the extremities despite the fact that an ankle equinus was observed in 19 (46.3%) of the extremities. However, the simplicity of the technique must have limited the impact of this potential bias. Finally, only 8 patients (12 cases) had reached bone maturity at last follow-up. Even if the possibility of sudden degradation after a satisfying postoperative result could not be strictly eliminated, this could hide some secondary unsatisfying results of the surgery.

In conclusion, the "horseman" procedure allows an immediate and lasting correction of severe idiopathic flatfoot in children without sacrificing a joint. It may be considered as an alternative to other arthroereisis technique such as subtalar implants or the calcaneo-stop

Fig. 4. Example of stage 4 idiopathic flatfoot. The “horseman” procedure was performed at the age of 7.5 years. The parents refused to remove the screw 6 months later. At last follow-up, the patient was 10.5 years old with a persistent stiff hind foot with no functional impairment at the time.

procedure. The “horseman” procedure has probably suffered from a lack of promotion and an initial enthusiasm that led some to use it for incorrect indications (adolescent and/or nonidiopathic flat feet). However, when the indication is correct, it is a simple and reliable technique useful for both early and long-term correction of severe idiopathic flat feet in children.

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