Preliminary findings using subtalar arthroereisis as adjunct treatment for correction of flexible flatfoot: short-term radiographic results

Estudo preliminar da artrosise subtalar como adjuvante no tratamento do pé plano flexível: resultados radiográficos de curto prazo

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Abstract

Objective: Recent reports suggest that subtalar arthroereisis may be effective as one component of surgical reconstruction for adult acquired flexible flatfoot. This study assessed short-term radiographic outcomes with standard reconstruction with adjuvant arthroereisis and determined whether arthroereisis introduced any undesirable effect. **Methods**: Twenty-seven patients with adult acquired flatfoot were treated with a subtalar implant with other corrective procedures, including tendon transfer, calcaneal osteotomy, and/or heel cord lengthening by one surgeon. Pre and postoperative weight bearing radiographs at six months and one year were compared for angular measurements, subtalar arthritis and peri-implant lucency. Sinus tarsi space was measured. Statistical analysis was done with one-way of analysis of variance (ANOVA) with *post hoc* analysis and chi-square analysis. **Results**: The difference in talonavicular uncoverage angle and sinus tarsi space was significant between preoperative and 6-month and preoperative and 12-month values (p=0.03 and p=0.05, respectively). Of the 27 implants, ten were removed, at an average of 7.7 months (range, four to 12). **Conclusions**: This retrospective evaluation showed that radiographic correction of flatfoot deformity was achieved at one year follow-up with a standard surgical protocol that incorporates the adjuvant use of subtalar arthroereisis. The removal rate was relatively high, but subtalar arthroereisis did not appear to be associated with adverse consequences. The long-term effect of implant removal on correction cannot be established in this preliminary study and will be reported after longer follow-up.

Keywords: Subtalar joint/surgery; Flatfoot/surgery; Flatfoot/radiography; Arthrodesis/methods

Resumo

Objetivo: Relatos recentes sugerem que a artrorise pode ser efetiva como um componente da reconstrução cirúrgica para o pé plano flexível adquirido do adulto. Este estudo se refere aos resultados radiográficos de curto prazo com um protocolo de reconstrução pela técnica de artrorise e teve como objetivo avaliar se o emprego deste método produziu algum efeito indesejável. **Métodos**: Vinte e sete pacientes

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adultos com pés planos adquiridos foram tratados com implantes na articulação subtalar associados a outros procedimentos corretivos que incluíam, transferências tendíneas, osteotomia de calcânco e/ou alongamento de tendão calcâneo realizados por somente um cirurgião. Radiografias pré e pós-operatório, com seis meses e um ano, foram comparadas; os parâmetros eram a medida dos ângulos, a artrite subtalar e a radiolusância periimplante. O espaço do seio do tarço foi mensurado. Análise estatística foi feita ultilizando ANOVA post hoc analysis e o teste do qui-quadrado. **Resultados**: A diferença no ângulo talonavicular não coberto e o espaço do tarso foram significantes entre as faces pré-operatória e seis meses e o pré-operatório e 12 meses (com valores p=0,03 e p=0,05 respectivamente). Dos 27 implantes, dez foram numa medida de tempo de 77 meses (variação de 4 a 12). **Conclusões:** Esta avaliação retrospectiva mostrou que a correção radiográfica da deformidade em pé plano foi conseguida em um ano de seguimento com um protocolo consagrado, que incorporou o uso da artrorise subtalar em associação. A taxa de remoção foi relativamente alta, mas a artrorise subtalar não foi comprometida. O efeito tardio da remoção do implante não pode ser estabelecida neste estudo preliminar e será realizado posteriormente.

Descritores: Articulação sub-talar/cirurgia; Pé chato/cirurgia; Pé chato/radiografia; Artrodeses/métodos

INTRODUCTION

Stage II posterior tibial tendon deficiency (PTTD) is characterized by weakness of the posterior tibial tendon with associated increase in flexible flatfoot deformity[1]. Stage II PTTD represents a continuum of disease entities with varying degrees of tendon weakness, ligament and capsule attenuation, bony deformity and flexibility. No standard validated treatment protocol exists, although most surgeons use some combination of bony and soft tissue procedure to treat this condition[2]. Multiple recent reports suggest that subtalar arthroereisis may be an effective component of a more global surgical reconstruction for acquired adult[3,4] and pediatric flatfoot[5-7] to achieve alignment of the hindfoot and potentially allow healing of soft tissues after surgical intervention.

Subtalar arthroereisis involves limiting pathologic eversion of the hindfoot by placing an implant in the sinus tarsi. The use of sinus tarsi implants to correct flatfoot deformity has evolved over the last 50 years from Grice's extra-articular subtalar arthrodesis[8] to current techniques, using titanium and polyethylene devices placed in the sinus tarsi to prevent excessive pronation[9]. Subtalar arthroereisis has not gained wide acceptance in the orthopedic community, possibly based on a documented high removal rate, although no studies document complications from removal. Because of possible benefits that could result from adjuvant use of this device, it would be helpful to determine possible risks to adjuvant use of a subtalar implant for correction of acquired flexible flatfoot in a clinical scenario.

The purpose of this study was to evaluate the short-term radiographic outcome of adult patients who underwent various operative treatments for stage II posterior tibial tendon dysfunction and to determine whether the adjuvant use of the subtalar implant introduced any undesirable effects or complications.

METHODS

A retrospective radiographic review was done of 27 adult patients with flexible flatfoot due to stage II posterior tibial tendon dysfunction who received operative treatment with adjuvant arthroereisis. Average patient age was 53.1 years (range, 19 to 76 years). There were 21 women and six men. Eligibility criteria for the study were age greater than 18 years and acquired flexible flatfoot deformity resulting from stage II posterior tibial tendon dysfunction that was recalcitrant to conservative care. Patients with neuropathy, active or prior history of infection, previous hindfoot surgery, pre-existing symptomatic arthritis of the foot and the ankle, or previous traumatic or surgical wound overlying the sinus tarsi were excluded.

All patients underwent surgical reconstruction that included a subtalar arthroereisis implant with a Maxwell-Brancheau titanium arthroereisis sinus tarsi implant (KMI, Carlsbad, CA) or a Nexa conical subtalar implant (Nexa Orthopedics, San Diego, CA), in addition to other corrective procedures that included flexor digitorum longus (FDL) tendon transfer to the navicular, spring ligament repair, medializing calcaneal osteotomy (MCO), dorsal opening wedge medial cuneiform osteotomy and/or heel cord lengthening by a single surgeon. An isolated FDL transfer augmented by subtalar arthroereisis was performed on patients able to invert past the midline, with minimal heel valgus (<5° of clinical valgus), minimal abduction deformity (20-30% talonavicular uncoverage and talo-first metatarsal angle of <20° on anteroposterior radiographs) and minimal arch collapse (talo-first metatarsal angle of <10° on lateral radiographs). FDL transfer and MCO with subtalar arthroereisis was performed on patients unable to invert past the midline with moderate heel valgus (<15° of clinical valgus), moderate abduction deformity (30-40% talonavicular uncoverage and talo-first metatarsal angle of 21 to 40° on anteroposterior ra-

diographs) and moderate arch collapse (talo-first metatarsal angle of 11 to 20° on lateral radiographs).

The use of additional procedures was determined primarily preoperatively. With talonavicular uncoverage of over 30%, the spring ligament was closely evaluated intraoperatively and imbricated as needed. Patients with talonavicular uncoverage of 40% or more were presumed to have attenuation or tearing of the spring ligament and received this repair. Heel cord lengthening was considered if it was not possible preoperatively to reduce the ankle to neutral dorsiflexion with the hindfoot in neutral. Heel cord tightness was assessed again intraoperatively, after calcaneal osteotomy, but before medial soft tissue procedures. Those patients who did not reach neutral ankle dorsiflexion with the heel reduced underwent heel cord lengthening. The dorsal opening wedge medial cuneiform osteotomy was considered primarily with patients with congenital flatfoot who had fixed forefoot varus over 7° preoperatively. If forefoot varus was over 4° with the hindfoot held in 5 to 7° of valgus, a dorsal opening wedge medial cuneiform osteotomy was done. If forefoot varus occurred with use of the subtalar implant, a smaller implant was used that did not cause forefoot varus.

A standard postoperative protocol was followed. Patients returned to the office ten to 14 days after surgery, for wound inspection and suture removal. Patients were then placed in a removable boot brace in 20° of equinus non-weight bearing on the operative extremity for the first six weeks postoperatively. Protected weight bearing with the walking boot fixed in neutral occurred from six weeks to three months. At three months, patients were transitioned to a lace-up or stirrup ankle brace and allowed full weight bearing. When necessary, subtalar implant removal was performed electively, as an outpatient procedure.

Preoperative and postoperative anteroposterior (AP) and lateral weight bearing radiographs obtained at six months and one year were compared. Talo-first metatarsal angle and talonavicular uncoverage angle were obtained on the AP view, as previously described[10]. Talo-first metatarsal angle, medial column height, and calcaneal pitch were obtained on the lateral view[9]. A novel radiographic measurement of sinus tarsi space was obtained on lateral radiographs preoperatively and at six months and one year postoperatively. Sinus tarsi space was measured from a point on the anterior process of the calcaneus 1 cm distal to the angle of Gissane to the apex of the lateral talar process. Presence and severity (mild, moderate or severe) of subtalar arthritis was noted on the lateral radiograph preoperatively and at six months and one year postoperatively. Presence and severity (mild, moderate or severe) of lucency surrounding the subtalar implant was noted at six months and one year postoperatively. When subtalar implants required removal, the clinical reason for removal and time from implantation to removal were recorded.

One-way repeated measures of analysis of variance (ANOVA) with least squares differences *post hoc* comparisons were used to compare differences in mean talar-first metatarsal angle, talonavicular uncoverage angle, medial column height, calcaneal pitch, and sinus tarsi volume preoperatively and at six and 12 months postoperatively. Chi-square analyses were done to compare differences in severity and lucency at these three time points. Two-way repeated measures ANOVA was performed to compare radiographic correction of deformity preoperatively and at six and 12 months between those patients with implants and those with implants removed. Significance was set at $p \leq 0.05$.

RESULTS

The difference in talonavicular uncoverage angle and sinus tarsi space was significant between preoperative and 6-month and preoperative and 12-month values ($p=0.03$ and $p=0.05$, respectively), as shown in Table 1. The differences in AP talar-first metatarsal angle ($p=0.17$), lateral talar-first metatarsal angle ($p=0.14$) (Figure 1) and medial column height ($p=0.07$) (Figure 2) over time approached but did not attain significance. No significant change was noted in calcaneal pitch ($p=0.87$). With the number of subjects available, we were not able to draw conclusions about differences in deformity correction and maintenance of correction between patients with implants and those with implants removed for any of the parameters measured.

Of the 27 implants, ten were removed at an average of 7.7 months (range, four to 12). Of these, nine were removed secondary to sinus tarsi pain and one for residual forefoot supination. Two of the nine patients who had implant removal for pain also developed radiographic evidence of mild subtalar arthritis. One patient developed moderate radiographic subtalar arthritis, but had no pain and retained the implant. Of the 17 patients who retained the implant at one year, mild and marked radiographic lucency surrounding the implant was found in eight patients and one patient, respectively. After one year, only seven of the 17 patients with retained implants had no radiographic evidence of peri-implant lucency or subtalar arthritis.

Table 1 - Radiographic data*.

Parameter	Time	N†	Mean	Standard error	Range
TUA (degrees)	Preoperative	25	28.5	2.86	6-66
	Six months	27	20.0†	2.04	-5-35
	One year	23	20.2†	2.50	6-50
AP T1MTA (degrees)	Preoperative	25	21.8	2.35	0-45
	Six months	27	16.0	2.59	-6-62
	One year	23	17.1	1.79	1-33
Lateral T1MTA (degrees)	Preoperative	26	-15.6	2.01	-40-0
	Six months	27	-10.1	2.18	-35-11
	One year	23	-11.0	2.14	-41-8
MCH (millimeters)	Preoperative	26	12.6	0.80	4-20
	Six months	27	15.3	0.79	4-24
	One year	22	14.4	0.98	5-22
Calcaneal pitch (degrees)	Preoperative	26	6.8	0.86	-5-18
	Six months	27	7.3	0.90	-5-19
	One year	23	6.7	0.77	-5-15
Sinus tarsi space (millimeters)	Preoperative	26	4.5	0.54	0-9
	Six months	27	8.3†	0.51	0-12
	One year	23	6.7†	0.70	0-12

*TUA=talonavicular uncoverage angle; T1MTA=talo-first metatarsal angle; MCH=medial cuneiform height.
N varies as a result of unavailable or non-weight bearing radiographs at given assessment points.
†Significantly different from preoperative value (0≤0.05).

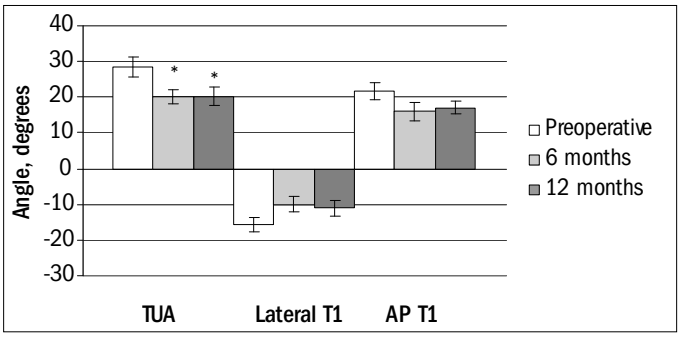

Figure 1 - Radiographic results in degrees for talonavicular uncoverage angle (TUA) and lateral (Lateral T1) and anteroposterior (AP T1) talo-first metatarsal angle. Calcaneal pitch did not approach significance. Error bars show standard error of the mean. *Significantly different from preoperative value (p≤0.05).

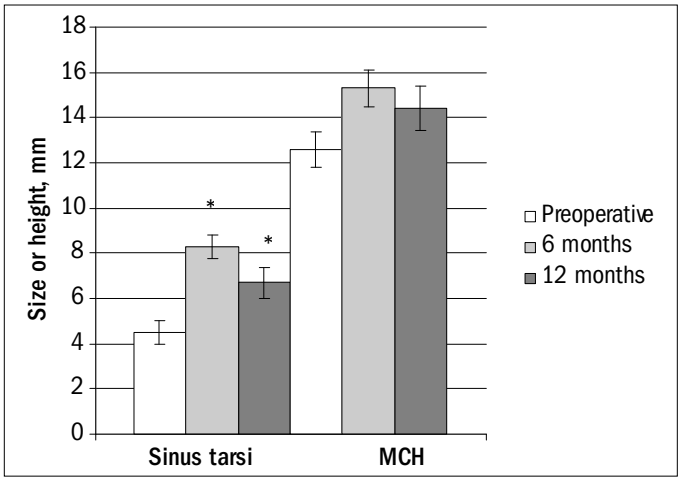

Figure 2 - Radiographic results in millimeters. MCH=medial cuneiform height. Error bars show standard error of the mean. *Significantly different from preoperative value (p≤0.05).

DISCUSSION

This preliminary retrospective evaluation of a small group of patients showed that good correction was achieved with standard surgical procedures administered based on radiographic parameters and that the adjuvant use of subtalar arthroereisis did not have adverse consequences. The removal rate was relatively high as has been reported previously[3] and the effect of removal on correction is not yet known at this early follow-up stage.

As noted in Table 1, there was a wide range in preoperative radiographic parameters that likely contributed to the findings of significant change in only two parameters measured. Several additional parameters showed change that approached significance and may have achieved significance with a larger sample size. These radiographic findings are similar to those found by other investigators in a previous clinical study of radiographic correction achieved with tendon transfer and calcaneal osteotomy[11]. The diseased foot could be compared to the contralateral foot, but the wide variability in radiographic angles of asymptomatic feet would likely lead to similar problems in statistical analysis. Substantial change in the right direction for parameters measured may be the most practical method to assess success in these widely varied patients.

The best radiographic representation of flatfoot deformity correction seemed to be talonavicular uncoverage angle as this two-dimensional projection seems to accurately depict the three dimensional change that occurs in the foot with correction. Sinus tarsi space would by necessity be improved any time an implant is used to distract the sinus tarsi.

Our removal rate of 10 of 27 implants (37%) in the first year is consistent with the rate reported by Needleman[9] (11 of 28,39%), but higher than that reported by Viladot et al.[4] (two of 19,11%). Viladot et al.[4] reported that all removals were based on overcorrection secondary to an oversized implant. Our finding of pain as the reason for implant removal in nine of ten patients is similar to that of Needleman, who attributed all implant removals to sinus tarsi pain[3]. Association with pain is likely related to the rich innervation of the sinus tarsi[12] and by motion between the implant and surrounding bone, as exhibited by high rate of peri-implant lucency observed on radiographs at one year postoperatively in the current study.

The clinical implications of lucency surrounding the implant and subtalar arthritis are unclear. With the numbers available, we were unable to correlate implant removal with peri-implant lucency. The patient with the most severe x-ray findings, graded as moderate, never experienced any sinus tarsi pain and retained the implant. With the small number of subjects available, no causal relationship between arthroereisis and subtalar arthritis could be determined.

There are several limitations to our study. We were not able to find statistical difference in several areas tested because of the relatively small number of subjects and wide variability in preoperative deformity. The short follow-up interval cannot be seen as representing the durability of this surgical repair with time. Although retrospective studies yield useful preliminary information, there is some bias inherent in this study design. Clinical parameters other than implant removal were not evaluated, which does not provide a complete picture of patient satisfaction and functional outcome. Finally, it is not possible to assess what portion of deformity correction is attributable to arthroereisis because of the adjuvant role of the implant among many other reconstructive procedures and the lack of a control group in the study.

Future reports on this group of patients as part of the larger study patient group with longer follow-up should help to establish the efficacy of subtalar arthroereisis as an adjuvant procedure in surgical correction of adult acquired flexible flatfoot. Subtalar arthroereisis may serve as a buttress to unload the medial soft tissue repair during the critical initial phase of healing. It will be critical to investigate whether deformity correction is maintained after implant removal. If the implant were the sole corrective force with no further bony or soft tissue rebalancing, one would expect recurrence of deformity when the implant is removed.

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