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Clinical Research

Treatment of Painful Pediatric Flatfoot With Maxwell-Brancheau Subtalar Arthroereisis Implant

A Retrospective Radiographic Review

Brandon M. Scharer, DPM,
Brian E. Black, MD,
and Nathan Sockrider, DPM

Abstract: *The purposes of this study were to evaluate the outcome of pediatric patients who have undergone Maxwell-Brancheau arthroereisis (MBA) subtalar implants for the treatment of painful pediatric flatfoot deformities. In a retrospective study, 39 patients (68 feet) were evaluated clinically and radiographically. The mean age of the patients was 12 years (range, 6-16 years). The mean period of follow-up was 24 months (range, 6-61 months). Statistical evaluation was performed on all radiographic measurements. Additional surgical procedures (gastrocnemius recession, Achilles tendon lengthening, Kidner posterior tibial tendon advancement) were performed in 22 of 68 feet. There were 10 (15%) complications, which consisted of 10 reoperations in 10 feet. Implants were exchanged in 9 feet because of implant migration, undercorrection, and overcorrection. There was 1 reoperation (in 1 foot) for implant removal because of persistent sinus tarsi pain. Radiographic evaluation demonstrated an improvement of all parameters determined. The parameters that were evaluated include talonavicular joint coverage, as well as lateral and anterior-posterior talocalcaneal angles. There were significant changes noted in pre- and postoperative measurements (P < .001). The MBA implant is effective for the correction of painful, flexible flatfoot deformity in children in short-term follow-up. However, this is a multiplanar deformity, and additional procedures may be needed in addition to the MBA.*

Keywords: painful flatfeet; pediatric; MBA

Flexible flatfoot is a common condition with a reported incidence of 5% in children and adults.[1] Most children with flexible flatfoot will remain asymptomatic; however, those who are symptomatic require treatment, either conservative or surgical. Conservative treatment includes shoe and orthotics modifications, bracing, physical therapy, and activity modifications.[2] Surgical treatment options include tendon transfers, osteotomy, arthrodesis, and arthroereisis.[3]

The concept of implanting a device into the sinus tarsi to limit abnormal motion has been around since 1946, when Grice's and Chambers's techniques of extra-articular arthrodesis with autogenous bone were introduced.[4-6] Since this time, bone grafts have been replaced by other materials, including silasitic plugs, the STA-peg, and polyethylene-threaded screws. Maxwell and Brancheau developed the Maxwell-Brancheau arthroereisis (MBA) implant as a self-locking titanium implant.[6,7] There have been many variations of the implant since its introduction.

DOI: 10.1177/1938640010362262. From Wheaton Franciscan Healthcare, Milwaukee, Wisconsin (BMS); Sports Medicine and Orthopedic Center, Milwaukee, Wisconsin (BEB); and Foot Specialists, Racine, Wisconsin (NS). Address correspondence to Brandon M. Scharer, DPM, Wheaton Franciscan Healthcare, 2956 North 90th Street, Milwaukee, WI 53222; e-mail: Brando_Scharer@yahoo.com.

Figure 1.

Lateral radiograph, preoperative view. Angular measurement depicted: lateral talocalcaneal angle.

Figure 2.

Anterior-posterior radiograph, preoperative view. Angular measurements depicted: anteroposterior talocalcaneal angle and talonavicular coverage.

Flexible flatfoot deformity is characterized by plantarflexion and medial rotation of the talus, calcaneal eversion, medial arch collapse, and abduction of the forefoot.[8] Commonly, the foot functions maximally pronated throughout the gait cycle, with little or no supination.[6,7] Correction of the flexible flatfoot must involve neutralizing the abnormal pronation. Arthroereisis accomplishes this by placement of the implant into the sinus tarsi. This limits anterior and medial displacement of the talus.[2-17] The purpose of this study is to evaluate the radiographic outcome of pediatric patients who have undergone MBA subtalar implants for the treatment of painful pediatric flatfoot deformities.

Patients and Methods

Between July 2000 and November 2006, 39 patients (68 feet) who underwent an MBA implant for a flexible flatfoot deformity were retrospectively studied. All surgical procedures were performed by the senior author (BEB) in his private orthopedic practice. In all patients, painful flexible pediatric flatfoot deformity was diagnosed by the surgeon. All patients who underwent surgical treatment did not respond to nonsurgical care such as functional foot orthoses, bracing, and, in some cases, immobilization. Patients also underwent surgical treatment for complications, including implant migration, undercorrection, and overcorrection. There was no financial interest or bias of the authors with regard to the implant used in this study.

> "Many treatment options have been advocated for pediatric flexible flatfoot, but there is no universally accepted treatment protocol, as this is a highly debated topic."

Radiographic Assessment

Charts were reviewed by the 2 junior authors (BMS and NS), which consisted of all preoperative and postoperative clinic records. Complications were defined as postoperative infection, delayed wound healing, persistent sinus tarsi pain, and migration of implant. The preoperative radiographs consisted of standardized weight-bearing anteroposterior (AP) and lateral views taken at the surgical consultation (Figures 1 and 2). The same radiographic views were taken at all postoperative visits and the patients' final follow-up visit (Figures 3 and 4). The following radiographic angles were manually measured: AP and lateral talocalcaneal angles and AP talonavicular coverage. All measurements were performed on both pre- and postoperative radiographs by the junior authors (BMS and NS) as follows:

- Lateral talocalcaneal angle (LTC): the intersection of the long axis of the talus and along the plantar surface of the calcaneus (Figures 1-4).[18] The normal range is 25 to 55 degrees.[18]
- AP talocalcaneal angle (APTC): the intersection of the long axis of both these bones (Figures 1-4).[18] The normal range for this measurement is 25 to 56 degrees.[18]
- AP talonavicular (TN) coverage was defined as the angle formed by a line drawn through the midpoint of the talus and a line drawn through the midpoint of the navicular. A percent talar head coverage was then determined based on the midpoint lines of the 2 bones (Figures 1-4).[19] The normal range is 50% to 70%.[18]

Figure 3.

Lateral radiograph, postoperative view. Angular measurement depicted: lateral talocalcaneal angle.

Figure 4.

Anterior-posterior radiograph, postoperative view. Angular measurements depicted: anteroposterior talocalcaneal angle and talonavicular coverage.

Statistical Plan

Two biostatisticians performed statistical analyses with de-identified data. SAS 9.1.3 for UNIX was used to obtain the results. A significance level of 5% was employed throughout the analyses. Student *t* test was conducted to compare preoperative and postoperative values for 3 measures of foot angle, stratified by foot. A linear mixed model was used to analyze whether the overall difference in foot angle was significant because the measures were no longer independent when a patient had implants on both feet. Univariate and multivariate logistic models were performed with outcome being defined as "excellent." When a patient had surgery on both feet, the average of the 2 foot angles was used in logistic models because of the dependency of both measurements. Note that generalized estimating equations (GEE) were not used to deal with dependency of both measurements because physician grades for both feet were always the same.

Surgical Technique

The procedure was performed with the patient in the supine position. The sinus tarsi was entered through a 1- to 2-cm incision made along the relaxed skin tension lines. The deep fascia was bluntly dissected to allow access into the sinus tarsi, taking care to avoid the intermediate dorsal cutaneous and sural nerves. A blunt probe was used to determine the proper angle for insertion of the guide pin. The guide pin was inserted from lateral to medial along the floor of the sinus tarsi, anterior to the posterior facet, and exited through a percutaneous incision on the medial aspect of the foot (see Figure 5). The guide pin was directed just superior to the posterior tibial tendon, inferomedial to the anterior tibial tendon and inferior to the medial malleolus. The sizing guides and trial implants were inserted while the foot was maintained in 1 to 2 degrees of valgus, and the proper position of the trial implant was verified with fluoroscopy. The AP radiographic image should show the implant 1 cm medial to the lateral edge of the calcaneus, with the leading edge of the implant less than half the width on the talus. On the lateral view, the implant should be seated directly on the floor of the sinus tarsi. If the position of the foot was determined to be clinically and radiographically acceptable, the appropriate-sized permanent implant was inserted. The position was again checked with fluoroscopy, and the incision was closed in layers.

Results

The charts and radiographs of 39 patients (68 feet) were retrospectively reviewed. All 39 patients had a minimum of 6 months follow-up, at a mean of 24 months (range, 6-61 months) follow-up. Of the 39 patients, 24 (62%) were male and 15 (38%) were female. The average age of the patients at the time of surgery was 12 years (range, 6-16 years). The total number of feet evaluated was 68, with 34 right and 34 left. The surgical procedures consisted of 68 (100%) MBA implants (Integra, Plainsboro, New Jersey), 12 (18%) gastrocnemius recessions, 6 (9%) Achilles tendon lengthening, and 4 (6%) Kidner procedures. There were 10 (15%) complications, which consisted of 10 reoperations in 10 feet. Implants were exchanged in 9 feet because of implant migration, undercorrection, and overcorrection. There was 1 reoperation (in 1 foot) for implant removal because of persistent sinus tarsi pain. No complications defined as postoperative infection and delayed wound healing were observed.

Radiographic evaluation demonstrated a significant improvement in 3 of 3 variables measured on the lateral and AP

Figure 5.

Intraoperative photograph depicting the incision and guide wire for insertion of the Maxwell-Brancheau subtalar arthroereisis implant.

Table 1.

Descriptive Statistics of Variables

Variables	Mean	Median	Standard Deviation
Age, y	11.6	11	2.7
Follow-up, mo	24	22	16.6
Pre-APTC, degrees	29.3	30	4.8
Pre-LTC, degrees	39	40	6.9
Pre-TN, %	51.7	50	10.6
Post-APTC, degrees	21.6	22	4.4
Post-LTC, degrees	31.6	30	7.2
Post-TN, %	70.8	70	10.9

TN, talonavicular coverage; APTC, anterior-posterior talocalcaneal angle; LTC, lateral talocalcaneal angle.

radiographs (Tables 1 and 2). Statistically significant improvements were also seen between preoperative and postoperative values for each measure, stratified by foot (Table 2). Statistically significant increases in the talonavicular percentage of joint coverage were seen, with an average preoperative TN coverage of 51.7% and 70.8% when the MBA device was implanted in the foot (with a paired *t* test $P < .001$; Tables 1 and 2). Lateral talocalcaneal angles were measured in degrees before and after placement of the MBA subtalar implant. The preoperative average of the lateral talocalcaneal angle was 39 degrees, and the postoperative average was 31.6 degrees (average change of –8 degrees, with paired *t* test $P < .001$; Tables 1 and 2). Anterior-posterior talocalcaneal angles were also statistically significant, with a preoperative average value of 29.3 degrees and a postoperative value of 21.6 degrees (average change of –8 degrees, with a paired *t* test $P < .001$; Tables 1 and 2). There were no significant covariates in either the univariate or multivariate analysis with the outcome being defined as "excellent" (Tables 3 and 4).

Discussion

At short-term follow-up (mean of 24.1 months) of 39 patients with painful pediatric flexible flatfoot deformity who had a subtalar arthroereisis implant, complications were noted in 10 (15%) feet, in which there were 9 reoperations for exchange of implants. The implants were exchanged for either a larger or smaller implant depending on the specific situation. In some instances, the implant was too large, which limited subtalar motion to the extent of causing pain to the patient. In other instances, the implant was too small, resulting in inadequate correction and radiographic migration of the implant. There was 1 reoperation (in 1 foot) for implant removal because of persistent sinus tarsi pain. The ideal size of the implant is based solely on the trial implant that is clinically evaluated intraoperatively. From our experience and complication rate in this study, choosing the correct size of implant can be challenging.

Many treatment options have been advocated for pediatric flexible flatfoot, but there is no universally accepted treatment protocol, as this is a highly debated topic. Many clinical studies involving arthroereisis have shown acceptable results in short- and mid-term follow-up.[6,7,16-18,20] A variety of procedures are also advocated in combination with arthroereisis, which are indicated for other associated pathological conditions that can include gastrocnemius or gastrosoleus equinus, metatarsus adductus, forefoot varus, and naviculocuneiform faults.[18,21-23] In our study, 14 (36%)

Table 2.

Statistical Comparison Between Preoperative and Postoperative Radiographic Variables

Variables	Pre-Post (SE)	95% CI	*P* Value
Right foot			
APTC	–7.743 (1.12)	(–9.996, –5.49)	<.0001
LTC	–6.8 (1.58)	(–9.958, –3.642)	<.0001
TN	18 (2.57)	(12.873, 23.127)	<.0001
Left foot			
APTC	–7.722 (1.09)	(–9.895, –5.55)	<.0001
LTC	–8 (1.80)	(–11.6, –4.4)	<.0001
TN	20.139 (2.57)	(15.006, 25.272)	<.0001
Both feet			
APTC	–7.7324 (0.46)	(–8.6552, –6.8096)	<.0001
LTC	–7.4085 (0.64)	(–8.6941, –6.1228)	<.0001
TN	19.0845 (1.23)	(16.6319, 21.5371)	<.0001

CI, confidence interval; TN, talonavicular coverage; APTC, anterior-posterior talocalcaneal angle; LTC, lateral talocalcaneal angle.

Table 3.

Univariate Analysis (Logistic Regression) of the Association of Independent Variables With the Outcome

Covariate	OR (95% CI)	*P* Value
Follow-up time	0.985 (0.946, 1.025)	.46
Sex (F vs M)	0.618 (0.159, 2.400)	.48
Age	0.881 (0.682, 1.139)	.93
LTC pre–LTC post	1.110 (0.945, 1.304)	.20
TN pre–TN post	1.049 (0.973, 1.132)	.21
AP pre–AP post	1.072 (0.883, 1.303)	.48

OR, odds ratio; CI, confidence interval; TN, talonavicular coverage; APTC, anterior-posterior talocalcaneal angle; LTC, lateral talocalcaneal angle.

Table 4.

Multivariate Analysis (Logistic Regression) of the Association of Independent Variables With the Outcome

Covariate	OR (95% CI)	*P* Value
Follow-up time	0.970 (0.920, 1.022)	.25
Sex (F vs M)	0.613 (0.127, 2.957)	.54
Age	0.842 (0.600, 1.182)	.32
LTC pre–LTC post	1.198 (0.962, 1.493)	.11
TN pre–TN post	1.041 (0.943, 1.149)	.42
AP pre–AP post	1.150 (0.920, 1.437)	.22

OR, odds ratio; CI, confidence interval; TN, talonavicular coverage; APTC, anterior-posterior talocalcaneal angle; LTC, lateral talocalcaneal angle.

of the patients had other associated procedures performed in conjunction with the arthroereisis.

Previous studies have shown that the MBA subtalar arthroereisis corrects the calcaneal valgus deformity.[6,7] Husain and Fallat,[15] in a previous biomechanical cadaveric analysis, showed a restriction of postoperative subtalar joint motion of 32.0%, 44.8%, 59%, 65.5%, and 76.8% for the 6-, 8-, 9-, 10-, and 12-mm implants. Other cadaveric studies have shown a statistical improvement in the tarsal relationship after an arthroereisis procedure, measuring the 3 cardinal planes of motion of the navicular, cuboid, talus, and calcaneus.[24] Our study showed similar results with statistical radiographic improvement in the talocalcaneal and talonavicular relationships.

Radiographic evaluation, although probably overestimated in its value, remains an important objective criterion at follow-up.[7,20] Radiographic findings revealed improvement of all radiographic parameters in our study. Lateral talo-first metatarsal angle was not included in our study, but Nelson et al[17] showed significant improvement in the talo-first metatarsal angle, as well as the AP talocalcaneal angle and lateral talar declination angle.

Significantly more study, both prospective and retrospective, is needed on subtalar arthroereisis. Our results were limited because there was no preoperative or postoperative pain and functional health measurement used. Additional studies should be performed in the future to evaluate long-term follow-up in pediatric patients to access the longevity of correction and need for future treatment if needed. The high implant exchange/removal rate is of some concern in this study, which suggests there is a fairly steep learning curve in its application. Despite these limitations, our results indicate a significant radiographic improvement of all variables measured and a complication rate that can be decreased by using the ideal size of implant to prevent reoperation and exchange of implants in the future. FAS

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