Surgery Can Reduce the Nonoperative Care Associated with an Equinovarus Foot Deformity

Sudheer Reddy MD, Sharat Kusuma MD, MBA,
Harish Hosalkar MD, MBMS, (Orth), FCPS (Orth), DNB (Orth),
Mary Ann Keenan MD

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Abstract Equinovarus is the most common lower extremity deformity seen after a stroke. Despite its frequency, there are no specific guidelines in determining when surgery should be considered and for which patients it is appropriate. We evaluated the charges of nonsurgical and surgical treatments for equinovarus foot in 29 consecutive patients who underwent surgery for a unilateral equinovarus deformity after stroke. Twenty-six patients (seven males, 19 females) were available for followup. Mean patient age at the time of stroke was 48.2 years (range, 3–66 years). The average age at surgery was 54.7 years (range, 23–72 years), with a mean duration of nonsurgical treatment of 74.7 months. The minimum followup was 6 months following surgery (mean, 18.2 months; range, 6–48 months). Physical therapy accounted for 88% of nonoperative charges, with chemodenervation and orthotics accounting for 10% and 2%, respectively. Postoperatively, 19 patients were able to discontinue physical therapy compared with none preoperatively, and 17 discontinued orthotic use. Surgical correction of the equinovarus foot, in the appropriate patient, can decrease the use of nonoperative care for a patient who has had a stroke. We recommend surgery be

considered earlier when an equinovarus deformity persists after the period of spontaneous neurologic recovery.

Level of Evidence: Level III, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Stroke is a common cause of long-term disability, with an estimated annual healthcare expense of \$15 billion in the United States alone. Stroke is currently the third leading cause of mortality [2]. Approximately 60% of patients survive and ½ of these patients may have residual hemiparesis [9]. The overall prevalence of stroke is approximately 1.7 million in the US population [8, 9]. The patient who survives the initial months after a stroke has a life expectancy of longer than 6 years [5, 8]. Physical limitations as a residuum of stroke are common and include a spectrum of motor dysfunction, limb spasticity, and resultant deformities [1, 7]. The most common deformity noted in the lower extremity is the equinovarus foot, which is a well-recognized cause of functional disability in patients after a stroke [3, 9].

Various treatment options have been described for an equinovarus foot deformity. These include nonsurgical and surgical treatments. Nonsurgical modalities include physical therapy with stretching, serial casting, orthoses, oral drug therapy for muscle relaxation and relief of spasms, phenol nerve blocks, and chemodenervation using botulinum toxin injections to reduce hypertonicity [9].

Surgery for an equinovarus deformity includes soft tissue releases, tendon transfers, and tendon lengthenings. Procedures commonly used to restore a plantigrade foot include Achilles and posterior tibial tendon lengthening

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S. Reddy, S. Kusuma, H. Hosalkar, M. A. Keenan (✉)
Department of Orthopaedic Surgery, Hospital of the University
of Pennsylvania, 3400 Spruce Street, Two Silverstein,
Philadelphia, PA 19104, USA
e-mail: maryann.keenan@uphs.upenn.edu

and split anterior tibial tendon transfer [10]. The success of surgical correction of the equinovarus foot has been documented [6, 12, 14]. However, little attention has been devoted to analyzing and potentially reducing the expenditures involved in caring for these patients. We believe additional investigation is warranted given the annual healthcare expense in caring for patients who have had a stroke.

We raised two questions: (1) Does surgery for this deformity potentially allow for a reduction in the use of nonoperative therapies in caring for patients who have had a stroke? (2) Can ambulatory ability be improved with surgery? We hypothesized surgical treatment of the equinovarus foot would aid in decreasing the use of nonoperative modalities in caring for patients who have had a stroke and potentially could improve ambulatory ability.

Materials and Methods

Using a longitudinal design for nonoperative and operative treatments, we retrospectively reviewed 29 consecutive patients referred for surgical correction of an equinovarus foot. All patients had hemiparesis secondary to a stroke. Data were collected using a standardized protocol in all cases and included details regarding any previous treatments or surgery. Detailed history and physical examinations were performed by the senior author (MAK) in all patients to ensure consistency of physical findings and prevent any interobserver variability. There were 21 female patients and eight male patients (Table 1). We excluded three of the 29 patients because we were unable to contact them for final followup. The average age of the patients at the time of their stroke was 48.2 years (range, 3–66 years); several patients were young owing to vascular malformations including the patient who was 3 years old. The average age at the time of surgery was 54.7 years (range, 23–72 years), with an average duration of nonoperative treatment of 6.2 years. The average age at latest followup was 56.4 years (range, 24–74 years). The minimum postsurgical followup was 6 months (mean, 18.2 months; range, 6–48 months). No

patient had died at the time of final followup. Twenty-six patients (seven males, 19 females) were included in the final review. We obtained prior Institutional Review Board approval.

All patients had been treated with nonoperative modalities for varying times in this series. We collected data regarding their prior nonoperative treatments as determined by patient and family interviews and review of their medical records. These treatments included physical therapy, orthoses, phenol nerve blocks, and chemodenervation using botulinum toxin. The total expenditures accumulated for each patient during this period were calculated. The data included the duration of the patient's nonsurgical treatment, number and expense of orthotic devices used, physical therapy sessions, and chemodenervation treatments (including botulinum toxin and phenol). To accurately determine the total expenditures of each patient's nonoperative treatment, we reviewed the patient's medical records to determine exactly where these treatment modalities were administered. We then contacted the billing department of each of these providers to determine the charges for these treatments. These data then were compiled and totaled for each patient to arrive at the sum total that represented the total charge of preoperative treatment. The dollar figures were not comparable because the times were different for preoperative (mean 74 months) and postoperative (mean 18 months) care and because of regional variations in charges. Rather, we determined each item as a percentage of the total expenditure.

Although the decision to recommend surgery was based on clinical grounds, the final decision to perform a particular surgical procedure was based on laboratory gait analysis, evaluation of dynamic polyelectromyography, and clinical evaluation. In particular, overactivity in the tibialis anterior on dynamic electromyography, with resultant varus positioning of the foot, was the indication for performing a split anterior tendon transfer. Spasticity in the gastrocnemius complex (resulting in equinus posturing of the foot) and in the toe flexors was the primary indication for performing an Achilles lengthening and release of the toe flexors, respectively. Flexor digitorum longus transfer (FDL) to the calcaneus was performed to augment the strength of the gastrocnemius complex, which is weakened from paresis and Achilles lengthening [8].

All patients had a split anterior tibialis tendon transfer, Achilles lengthening, release of the toe flexors, and transfer of the FDL to the calcaneus. The split anterior tibialis tendon transfer was accomplished by dividing the lateral half of the anterior tibialis tendon and transferring it subcutaneously to the lateral aspect of the foot. It then is secured through a bony tunnel into the cuboid using an interference screw [4]. The FDL transfer to the calcaneus was accomplished by harvesting the FDL tendon through a

Table 1. Demographics of the study patients

Demographic characteristic	Average time (years)
Age at the time of the cerebrovascular accident	48.2
Length of nonsurgical management	6.2
Age at the time of surgery	54.7
Postsurgical followup	1.5
Survival after the cerebrovascular accident	8.2
Age at latest followup	56.4

medial arch incision and then passing it subcutaneously posterior to the medial malleolus. The tendon then is passed subcutaneously into a bony tunnel from medial to lateral in the os calcis and secured with an interference screw. Release of the toe flexors was performed by making a longitudinal incision at the base of each of the five toes, identifying the flexor hallucis longus and FDL tendons and transecting them [4, 8]. All procedures were performed by the senior surgeon (MAK). Additionally, if the posterior tibialis muscle showed abnormal activity, it was lengthened, and when the extensor hallucis longus was overactive, it was transferred to the middle cuneiform. These surgical techniques have been described [3, 12].

We then determined the charges for each patient's entire perioperative episode. Expenses tabulated included the surgical fees for the corrective procedure, operating room charges, anesthesia charges, charges for the patient's hospital stay, charges for required postoperative orthoses, charges for postoperative outpatient treatment, physical therapy, and postoperative chemodenervation treatments. All surgeries were performed at the same institution and inpatient hospital stays were at this same institution. For each patient, the charges for surgical fees, anesthesia, and the operating room were determined from this institution's billing office. These figures were compiled to determine the total expense of surgery and perioperative treatment. Actual dollar figures, however, are not directly specified given the regional variation in charges, as for the preoperative charge analysis. Rather, relative charges have been provided to determine if surgery could allow for a reduction in the use of nonoperative modalities in caring for patients who have had a stroke.

We noted the preoperative and postoperative ambulatory abilities on a previously validated ambulation scale [13]. This scale categorizes patients in one of six classes: (1) unable to ambulate; (2) maximum assistance required (two assistants); (3) minimum assistance required (one assistant); (4) independent household; (5) limited community; and (6) unlimited community [13].

The average charges of nonsurgical and surgical treatments for all patients were computed. We did not compare nonoperative versus operative charges given the difference in preoperative and postoperative times and given we computed only relative charges. We compared preoperative and postoperative ambulatory abilities using a Student's *t* test.

Results

Surgery for equinovarus deformity allowed a reduction in the use of nonoperative therapies in caring for patients with this condition. Physical therapy was the greatest expense preoperatively (88% of total expenditure), with patients using an

Table 2. Charges for nonoperative treatment by percentage

Item	Percentage of total
Physical therapy	88%
Chemodenervation	10%
Orthotics	2%

Table 3. Charges for operative treatment by percentage

Item	Percentage of total
Surgical/anesthesia/hospital costs	49%
Physical therapy	47%
Orthotics	3%
Chemodenervation	1%

average of 84 ± 105.4 (SD) outpatient physical therapy sessions (Table 2). Although physical therapy was used during the initial postoperative period (47% of total expenditure), 19 patients were able to discontinue physical therapy, compared with none preoperatively (Table 3). Patients required an average of 1.8 ± 1.3 molded ankle-foot orthoses preoperatively to assist with gait dysfunction as a result of their spastic deformity. Seventeen of the 29 patients (61%) became brace-free after surgery compared with none preoperatively. Eighteen patients received an average of three botulinum toxin or phenol chemodenervation injection treatments preoperatively. Chemodenervation was used less frequently postoperatively, with three patients receiving additional botulinum toxin/phenol chemodenervation. There were no complications from anesthesia or from the surgical procedure.

The mean postoperative ambulatory score improved ($p = 0.012$) over the preoperative score (3.5 ± 1.17 versus 3.0 ± 1.1 , respectively). Ten of the 29 patients (34%) were able to improve ambulatory ability by one or more scale factors on the ambulation functional scale that was used preoperatively (Table 4). Sixteen of the 29 patients (55%) maintained the same ambulation status postoperatively as

Table 4. Comparison of preoperative and postoperative ambulatory ability [13]

Level	Ambulatory status	Preoperative	Postoperative
0	Unable	2	1
1	Maximum assistance	0	0
2	Minimum assistance	4	4
3	Independent household	10	5
4	Limited community	10	12
5	Unlimited community	0	4

Using classification of Viosca et al.

preoperatively, indicating surgery can improve ambulatory ability but does not guarantee it. Five of the 10 patients who improved were independent household ambulators who were able to improve to limited community ambulators or to unlimited community ambulators. Five of the 16 patients who did not improve one scale factor or more required assistance preoperatively. Of the patients who were unable to ambulate, one progressed to a limited independent community ambulator, whereas the other was still unable to ambulate postoperatively.

Discussion

The success of surgical correction of the equinovarus foot has been documented [6, 12, 14]; however, little attention has been devoted to analyzing and potentially reducing the expenditures involved in caring for these patients. We hypothesized surgical treatment of the equinovarus foot would allow for a reduction in the use of nonoperative modalities when caring for patients who have had a stroke and potentially could improve ambulatory ability.

We recognize limitations in our study. This analysis was performed on a relatively small sample size of 26 patients who were available for followup. The length of followup is short (18.2 months) given this study was conducted on a consecutive series of patients who were referred for surgery and many eventually were referred back to their original doctors or institutions. The length of followup is not equivalent to the length of the preoperative period given not all of the patients were followed for an indefinite time postoperatively. All patients and surgical corrections of the deformity were evaluated by the senior author and not by an independent observer, potentially introducing systematic bias. The study reflects the perspective of one institution regarding surgical treatment of this deformity (although one of the largest regional tertiary neuroorthopaedic referral centers). A multi-institutional trial would have allowed not only a greater number of patients to be analyzed but also variations in treatment regimens. Unfortunately, we have not been successful in eliciting interest in nonsurgical physicians to participate in a randomized, controlled trial comparing treatment regimens. Given all patients were treated at a tertiary care center and referred for surgical consideration, it is possible we examined a disproportionate number of patients who had more severe foot deformities and for whom nonoperative treatments (and perhaps more expensive treatments) failed resulting in selection bias. We think it is likely, however, these patients' deformities were unlikely to respond to additional nonoperative treatment given the longer period of unsuccessful treatment, and therefore they were referred to a tertiary referral center. In addition, the average age at

the time of stroke in our population was young (48.2 years) relative to the older patient who is more characteristic of stroke. Several of our patients experienced a stroke at a young age owing to structural abnormalities such as an arteriovenous malformation and a cerebral aneurysm. Furthermore, the patients in this series on average lived longer than the typical patient who has had a stroke. This is likely attributable to the fact that this population was younger than the typical patient who has had a stroke. This age discrepancy potentially limits application of our results to the typically older patient who has a stroke. Our study population, however, is similar to that of the older patient in the sense that each patient's nonsurgical course varied greatly in terms of duration and extent of care, with many having a notably prolonged nonsurgical course. This is partly attributable to the concern and limited experience among nonsurgical physicians (primary care physicians, physiatrists, and neurologists) with surgical treatments for this condition.

We believe it is likely the surgery ultimately will aid in reducing the use of nonoperative modalities in caring for these individuals given the fact that 19 of our patients were able to free themselves from physical therapy and 17 became brace-free. It also can allow patients the potential to improve their ambulatory ability. Given the average patient in our study was treated for more than 6 years nonoperatively before undergoing surgery, it is possible earlier surgical intervention can help reduce the expense related to caring for these patients, especially for those who have not had success with nonoperative therapy. We would need to follow the patients an equivalent length of time postoperatively to make this definitive assessment.

The success of surgical correction of the spastic equinovarus foot in patients who have had a hemiplegic stroke is well known [11, 12]. Postoperative gait analysis shows correction of an equinus deformity can improve the stance and double-support phases of gait and improve abnormal positioning of the hip, knee, and ankle on the hemiparetic side [11, 14]. However, little attention has been devoted to the timing of surgery (other than waiting 6 months to allow for neurologic recovery [8]), especially in relation to the overall cost of caring for patients with an equinovarus deformity. Although the data do not suggest a particular time after a stroke at which surgery should be considered, it does illustrate the need for the clinician to contemplate the possibility and timing of surgical intervention.

We believe earlier surgical intervention would aid patients with a cerebrosplastic equinovarus deformity in whom nonoperative therapy has been unsuccessful. Given the current prevalence of stroke in the United States, if surgery can be used to reduce expenditures by thousands of dollars individually for the care of the average survivor, the collective savings to our healthcare system would be

considerable. This is especially true when one considers the hidden costs associated with caring for these patients, such as transportation to and from various appointments and the emotional and financial burdens on family members. Additional studies could help better delineate patients who could benefit from surgery and the optimal timing of it.

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