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Patient Factors in the Selection of Operative Versus Nonoperative Treatment for Posterior Tibial Tendon Dysfunction

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ABSTRACT

Background: **The influence of demographic, medical history, and treatment variables on the maintenance of nonoperative care or progression to operative intervention in Posterior Tibial Tendon Dysfuction (PTTD) was explored. This retrospective study compared demographic, medical history and treatment variables between operative and nonoperative care in subjects with PTTD.** ***Materials and Methods:*** **Charts with the ICD-9 codes (726.72, 726.90) and brace distribution records for 2005 and 2006 were used to identify subjects. From these, 166 of 606 charts included documentation of PTTD. Variables were grouped into three categories including demographics (Age, body mass index, gender and working status), medical (stage, symptom duration, pain at initial evaluation, and past treatments) and treatment (initial brace, length of care episode, and brace change). Statistical comparisons between subjects treated nonoperatively and operatively were made. Significant variables were entered into a logistic regression analysis. Accuracy (sensitivity/specificity) was assessed by examining the success of predicting which subjects were treated operatively or nonoperatively.** ***Results:*** **Of the 166 subjects, 125 (75.4%) received nonoperative care and 41 (24.6%) operative care. Nine variables distinguished the operative from the nonoperative group ($p < 0.05$): including BMI, work status, stage, symptom duration, prior orthotic use, prior injection, custom brace, brace changes, and length of care episode. The logistic regression model identified BMI, symptom duration, prior cortisone injections, and prior orthotic use as significant and resulted in a specificity of 95.4% and sensitivity of 38.2%.** ***Conclusion:*** **This retrospective analysis provides a patient profile of factors in the success of nonoperative care in PTTD.**

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INTRODUCTION

Posterior tibial tendon dysfunction (PTTD) is most commonly a degenerative process that leads to tendinosis and elongation of the primary dynamic stabilizer of the arch, the posterior tibial tendon (PTT).[12,15] While many factors have been suggested as causes of this condition[7,10] few natural history studies have been done to confirm factors predictive of clinical management.[9] Failure of clinical management may lead to progression of tendinosis, and ultimately rupture.[8,13] With or without rupture, tendinosis and the resultant dysfunction of PTT result in abnormal foot mechanics and contribute to acquired flatfoot deformity.[8,13] In the presence of PTTD, daily activities are limited due to pain and fatigue with walking and standing.[8,13]

Historically, the literature documenting PTTD management centers on operative techniques.[11] In the past several years a limited number of publications have explored nonoperative management.[2–5,9] In 1996, Myerson described both operative and nonoperative interventions for various stages of PTTD.[11] Since then, few studies have examined the role of orthotics, braces, and physical therapy in treatment.[2–5,9] In a prospective single cohort study, the Arizona brace (Arizona AFO, Mesa, AZ) was found to be successful in 90% of patients with all three stages of PTTD at 12 months.[3] Chao et al. reported that 33 out of 49 subjects showed improvement in pain, limp, ambulation, and the use of assistive devices following intervention with either a medial posted shoe insert or molded ankle foot orthotic.[5] More recently Lin et al. reported a 60% satisfaction rate for subjects with PTTD at 7- to 10-year followup.[9] Notably in this study, after 15 months of initial brace wear, 36% of the subjects reported at least one episode during which they used their brace a second time over the 7- to 10-year followup. Bracing in conjunction with physical therapy has also been found to be effective in 83% of patients with Stages 1 and 2 PTT.[2]

Although these nonrandomized studies suggest short- and long-term effects, there were small subject numbers ($n = 32$)[9] and no studies explore which factors influenced patient choice of operative or nonoperative care. Many patients present to the orthopedist after having already tried a variety of braces and orthotics. Preliminary studies that include larger subject pools are needed to plan more costly prospective studies. Retrospective studies that collect information from the medical record are one method of increasing the subject numbers. We evaluated individual factors or combination of factors like subject demographics, medical history, stage of disease, and prior treatment that could be gleaned from the medical record and billing records that might be influential in determining the choice of operative or nonoperative treatment. Even though there was always an alternative brace or nonoperative option, the question arises "What is the chance that a subsequent brace or orthotic will be successful?" and alternatively, "When is surgery the best option?" Although limited by the retrospective design, some insights were made possible using medical and billing records. As nonoperative treatments continue to develop, it is important to know which patients will most likely require this option for pain relief and functional improvement. This will allow both patients and clinicians to make better decisions with long-term treatment plans. The aim of this study was to determine if there were factors in the medical and billing records at initial evaluation, prior medical history, and course of care (treatment) that could predict which patients could be adequately managed by nonoperative methods and which would need operative intervention.

MATERIALS & METHODS

Subjects

Institutional research subjects review board approval was obtained. Subjects were identified through an ICD-9 code search. Codes 726.72 (tibialis tendonitis) and 726.90 (enthesopathy of unspecified site) filed over the time period from January 2000 to June 2006 were used to identify patients. All subjects identified were previously seen by a fellowship-trained foot and ankle orthopedist at a large university medical center. In addition, brace distribution records from an isolated brace supply facility were used to identify subjects from January 2005 to June 2006. The charts of those identified were reviewed to determine a diagnosis of PTTD. Subjects under the age of 18 were excluded from this study.

Chart review

The charts of eligible subjects were reviewed for data in three categories: demographics, medical history, and treatment. The demographic data included subject age at initial evaluation (IE) and was stratified by decade (less than 30, 30 to 39, 40 to 49, 50 to 59, 60 to 69, more than 70). Gender (male/female) and working status (working/not working) were recorded. Height and weight were assessed using body mass index (BMI) and stratified as less than 25, 25 to 30, or greater than 30. This categorization fits with Center for Disease Control classification of less than 25 being normal weight, 25 to 30 overweight and over 30 obese.[1]

Medical history data included stage of the disease, symptom duration and pain at initial evaluation (IE) and prior treatments. The staging criteria was published by Johnson and Strom.[8] Stage I included subjects with signs of tendinopathy (swelling and pain) without foot deformity, stage II included subjects with signs of tendinopathy and flexible flatfoot deformity and Stage III included subjects with signs of tendinopathy and fixed flatfoot deformity. The duration of symptoms prior to IE was recorded in months and then further categorized as less than 6 months, 6 months to 1 year, 1 year to 2 years, 2 years to 3 years, and more than 3 years. Pain level at IE was reported on a visual analogue scale from 0 to 10 which was used to represent pain intensity. Treatments prior to IE evaluated included prior physical therapy (yes/no), prior cortisone injection (yes/no), prior orthotic use (yes/no). Other medical diagnoses that were noted included hypertension, diabetes, rheumatoid arthritis and thyroid disease.

Treatment data included the treatments administered after the IE including bracing and surgery. The brace or orthotic prescribed at IE was graded as over the counter (OTC) or custom molded. Custom braces have shown some success in case series studies.[3,9] Other studies used less restrictive and less expensive over the counter braces.[4,5] The ability of subjects to transfer from a "more aggressive" to a "less aggressive" brace has been associated with surgery in some studies.[2,9] Therefore, the variable brace change was defined by noting whether subjects were "stepped down" to a less aggressive brace, if there was "no change," or if they were "stepped up" to a more aggressive brace. The term bracing was used in this study to include all durable medical goods (braces, orthotics/inserts). Definitions of these categories were based on the types of braces prescribed. For example if a patient was changed from an OTC ankle brace to a custom Arizona brace it was considered to be a change to a "more aggressive brace". Conversely, if during the course of treatment a patient was changed from an OTC ankle brace to a medial heel and sole wedge orthotic it was considered a change to a "less aggressive" brace. Time frames relating to the episode of care (defined as time from IE to final visit, or from IE to surgery) and duration of initial brace use (defined as date from initial prescription to date of subsequent change) were used to document the course of treatment.

Statistical methods

Patients were divided into two groups: those who underwent surgery and those who were managed nonoperatively. To assess which demographic, medical variables, and treatment data variables were associated with subjects in the

Table 1: Demographic Data

	Nonoperative	Operative	
Age	***n* = 125**	***n* = 41**	***p* = 0.81****
Less than 30	4%	5%	
30–39	11.2%	7%	
40–49	12.8%	17%	
50–59	24.8%	29%	
60–69	28%	17%	
More than 70	19.2%	22%	
Gender	***n* = 125**	***n* = 41**	***p* = 0.37***
Females	77.6%	71%	
Males	22.4%	29%	
Working	***n* = 121**	***n* = 37**	***p* = 0.03***
Employed	46.3%	67%	
BMI	***n* = 109**	***n* = 34**	***p* < 0.01****
Less than 25	15.5%	34%	
25–30	29.3%	40%	
More than 30	55.0%	23%	

*, Fisher Exact Test; **, Mann Whitney-U.

operative or nonoperative groups, Mann-Whitney U test and Fisher Exact test, respectively, were used to test for ranks and proportions, while a t-test was used for continuous variables. All analyses were performed using SPSS 13.0 (SPSS, Inc., Chicago, IL). To assess whether demographic, medical history, and treatment data variables could predict who would ultimately undergo surgery, a step wise logistic regression analysis was used. Variables that were found significant ($p < 0.05$) between the operative and nonoperative groups were entered into a stepwise logistic regression analysis. Subjects with missing data for any of the variables were excluded from the analysis. A K-fold cross validation procedure was used to evaluate the logistic regression model and determine accuracy.[6,14] The K-fold cross validation approach iteratively utilizes subsets of the data to "train" the logistic regression model.[6,14] Once the model is determined, the predictions of group assignment (operative versus nonoperative) based on the model were made and compared to the actual data for accuracy. The sensitivity and specificity of the model were then evaluated using a 2×2 table.

RESULTS

Six hundred twenty-six subjects were identified by the initial search. Of these, 166 had a documented diagnosis of PTTD at their IE. Among the 166 patients identified, 125 patients (75.4%) were in the nonoperative group, while 41 (24.6%) were in the operative group. When comparing demographic variables between groups (Table 1), patients in the operative group had a lower BMI ($p < 0.01$), and were more likely to be working ($p = 0.03$) than patients in the nonoperative group.

For medical history variables (Table 2) statistical differences between the operative and nonoperative groups were found. Patients in the operative group had a higher stage ($p = 0.015$) at IE (greater severity), had a longer duration of symptoms (symptom duration, $p = 0.04$), were more likely to have had a cortisone injection ($p = 0.05$), and were more likely to have used an orthoses (prior orthotic use, $p < 0.01$). In contrast, pain at IE ($p = 0.57$) and other medical diagnosis were not significant ($p > 0.05$) between groups.

For the treatment variables (Table 3), variations were also found in the progression of treatment between the two groups. Those who were in the operative group were more likely to have a custom brace prescribed at IE (initial brace, $p < 0.01$), to have been treated for more than 300 days (care episode, $p = 0.04$), and were more likely to fall into the "no change" category (operative = 60% versus nonoperative 46.4%) from their initially prescribed brace (brace change, $p < 0.01$).

A total of nine variables were found significant between the operative and nonoperative groups at IE: BMI, working status, stage, prior orthotic use, symptom duration, previous cortisone injection, initial brace, brace changes and episode of care. Those variables that are present at the IE: BMI, working status, stage, prior orthotic use, symptom duration, previous cortisone injection, and initial brace, were entered into the logistic regression analysis. Of the 166 subjects, 96 (24 surgery and 72 no surgery cases) had complete data for all seven variables. However, there were 49 missing data points for stage. When stage was excluded, the sample size changed to 142 subjects (34 operative cases and 108 nonoperative cases) with complete data sets for the six remaining variables. The results of the stepwise logistic regression analysis suggested four of these six variables were predictive of whether they were managed with or without surgery including, BMI, symptom duration, prior cortisone injections, and prior orthotic use. The K-fold cross validation procedure showed that the accuracy of the model when all four variables were present was 38.2% sensitivity for predicting the subjects that were in the operative group, and a 95.4% specificity in identifying subjects in the nonoperative group (Table 4).

DISCUSSION

The aim of this study was to determine if there are factors from the medical record present at the IE or during the course of care that can be used to differentiate those patients subsequently being treated operatively or nonoperatively for PTTD. The hope was to identify the failed nonoperative patients in order to recommend surgery sooner. However, factors from the medical record present at IE were not

Table 2: Medical Data

	Nonoperative	Operative	
Stage	$n = 85$	$n = 32$	$p = 0.02$**
I	21%	3%	
II	67%	75%	
III	12%	22%	
Symptom Duration	$n = 114$	$n = 36$	$p = 0.04$*
Less than 6 mo	54.3%	25%	
6 mo to 1 yr	18.4%	25%	
1 to 2 yr	10.5%	19%	
2 to 3 yr	3.5%	8%	
More than 3 yrs	13.2%	23%	
Pain at IE	$n = 88$	$n = 20$	$p = 0.58$***
Average out of 10	6	6	
Prior Physical Therapy	$n = 123$	$n = 38$	$p = 0.07$*
No PT	88.6%	76%	
PT	11.4%	24%	
Prior Cortisone Injections	$n = 117$	$n = 37$	$p = 0.05$*
No	85.5%	70%	
Yes	14.5%	30%	
Prior Orthotic Use	$n = 124$	$n = 38$	$p < 0.01$*
No	58.9%	29%	
Yes	41.4%	71%	
Hypertension	$n = 122$	$n = 38$	$p = 0.57$*
No	62.3%	68%	
Yes	37.7%	32%	
Diabetes	$n = 122$	$n = 38$	$p = 0.57$*
No	87.7%	92%	
Yes	12.3%	8%	
Rheumatoid Arthritis	$n = 122$	$n = 38$	$p = 0.48$*
No	93.4%	89%	
Yes	6.6%	11%	
Thyroid Disease	$n = 121$	$n = 38$	$p = 0.07$*
No	82.6%	95%	
Yes	17.4%	5%	

*, Fisher Exact Test; **, Mann Whitney-U; ***, t-test.

successful in identifying subjects likely to have surgery. It is notable that items believed to be relevant to clinical decision making like BMI and pain were not predictive of surgery. We believe this supports the view that the decision to have surgery is complex, motivated by patient beliefs and practitioner preferences. Exploring patient motivations and beliefs may be more appropriately evaluated using qualitative research methods rather than the quantitative research methods used in this study. In contrast to surgery, these same factors were successful in identifying those likely to continue with nonoperative care. The six variables present at the IE selected in the regression analysis suggest an initial model for both the surgeon and patient to prepare a possible course of care. When considered together, four of the six variables contributed to classifying subjects into groups. This model was successful at predicting subjects with successful nonoperative treatment, however, was inadequate when predicting subjects who would progress to surgery during the study timeframe.

This study found that lower BMI (less than 30), initial prescription of a custom brace, prior injection, and a longer duration of symptoms before seeing an orthopedic foot and ankle specialist were all more likely to undergo surgery with a sensitivity of 38.2% and specificity of 95.4%. The lower sensitivity suggests that these factors are poor at predicting the need for surgical intervention at initial evaluation. However, patients without these factors had a high specificity, suggesting nonoperative management may be

Table 3: Treatment Data

	Nonoperative	Operative	
Initial Brace	$n = 125$	$n = 39$	$p < 0.01$*
OTC	86.4%	67%	
Custom	13.6%	33%	
Care Episode	$n = 123$	$n = 41$	$p = 0.04$*
Less than 300 Days	79.5%	61%	
More than 300 Days	20.5%	39%	
Brace Change	$n = 125$	$n = 40$	$p < 0.01$**
Less Aggressive	33.6%	20%	
No Change	46.4%	60%	
More Aggressive	20.0%	20%	

*, Fisher Exact Test; **, Mann Whitney-U.

successful for these patients. Given that the majority of subjects will choose nonoperative treatment (75% in this study) factors that suggest success are clinically relevant to predict prognosis. While other patient factors like beliefs (i.e., qualitative data) and progressive deformity (i.e., radiographs) also may influence these decisions, this study isolated the value of factors selected from the medical record. Future prospective studies that combine various sources of data (e.g. beliefs, medical record, clinical exam, and imaging) are needed to evaluate multiple factors that may predict outcomes in subjects with PTTD.

A strength of the current analysis is the focus on durable medical goods which remain the mainstay of nonoperative intervention for subjects with PTTD. Durable medical goods like ankle braces and orthotics are expensive and often not fully covered by insurance. Although other factors may also influence clinical decision making, using the factors identified in this study as a guide, we believe that additional brace cost may be worthwhile and adequate for management of patients without these four factors. This conclusion is also supported by other recent studies.[2–5,9]

This is the first study to examine which factors may result in eventual success of nonoperative treatment as an aid to the physician in recommending additional nonoperative care for PTTI. Two factors assessed during the course of nonoperative care were also found to be significant: brace change and episode of care. Those patients undergoing operative management tended to have a longer episode of care, and tended remain in their initially prescribed brace, unable to step down in their brace needs or go brace free. This suggests that many patients are unwilling to wear custom braces indefinitely. Again, other factors (ie. clinical exam variables and imaging) not consistently available from the medical record might have also been relevant.

Another interesting finding in this study was the rate of operative care. It was higher in this study than other reports. Augustin et al. reported a 90% success rate with the Arizona brace, with only one of 20 subjects requiring operative care.[3] However, this study was limited to followup of only 5 years. It is unknown if any patients became dissatisfied with brace wear and went on to have surgery after this period of time. Alvarez et al. reported five of 47 (11%) patients required operative care after failing to improve with a combination of bracing and physical therapy.[2] In our study, the rate of operative care was much higher at 24%, with 60% of these subjects undergoing operative care within 300 days of treatment (median number of days treatment). One factor may be differences in choices of braces and exercise prescription across studies. This may also be reflective of the tertiary care referral center from which subjects were identified, larger sample size, retrospective design, or recruitment methods.

The major limitations of this study include the retrospective study design and reliance on medical records. While the reliability of the coding system used was carefully developed, the precision of the use of dichotomous or ranked variables is low (e.g., more aggressive bracing). However, from this retrospective data it is clear that additional prospective studies, that are able to control evaluation procedures and treatment choices, are needed that compare different brace designs, and explore more definitive criteria for changing between braces during the course of treatment. The logistic regression model developed from this data may be specific to this subject group. Only when the same factors are applied to a separate set of subjects in a prospective manner (validity study) will it be known that the model is likely to replicate clinical practice. Sampling biases were introduced in several

Table 4: Regression Analysis

		Actual Outcomes	
		Operative	**Nonoperative**
Model Outcomes	Predicted Operative	13	5
	Predicted Nonoperative	21	103
	Total	$n = 34$	$n = 108$
		Sensitivity = 38.2%	Specificity = 95.4%

ways. In addition to eliminating subjects because of missing data, subjects were only included if they were prescribed a brace through the orthopedist's office, and/or were assigned one of the identified ICD-9 codes. In this study specifically, removing stage from the regression model may have affected which variables were found to be significant. It is possible that longer duration of symptoms and initial custom bracing are related to being at a higher stage at IE.

In conclusion, this retrospective study suggests common characteristics of patients, obtainable from a medical record, at initial examination (IE) that predict success for continued nonoperative management. Of the variables identified at the initial examination (IE), four were predictive of subjects successfully treated (pain relief and functional improvement) with continued nonoperative care while those patients needing operative management were not able to be predicted by this modeling. Future studies may consider prospective studies of clinical variables and changes in status that occur over time to predict prognosis.

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