

Percutaneous heel cord release for clubfoot: a retrospective, multicentre cost analysis

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Abstract

Purpose The Ponseti method of treatment is the standard of care for idiopathic clubfoot. Following serial casting, percutaneous tendo-Achilles tenotomy (TAT) is performed to correct residual equinus. This procedure can be performed in either the outpatient clinic or the operating room. The purpose of this study was to evaluate the expense of this procedure by examining hospital charges in both settings.

Methods We retrospectively reviewed charts of 382 idiopathic clubfoot patients with a mean age of 2.4 months (0.6 to 26.6) treated with the Ponseti method at three institutions. Patients were divided into three groups depending on the setting for the TAT procedure: 140 patients in the outpatient clinic (CL), 219 in the operating room with discharge following the procedure (OR) and 23 in the operating room with admission to hospital for observation (OR+). Medical records were reviewed to analyze age, deformity, perioperative complications and specific time spent in each setting. Hospital charges for all three groups were standardized to one institution's charge structure.

Results Charges among the three groups undergoing TAT (CL, OR, OR+) were found to be significantly different (\$3840.60 versus \$7962.30 versus \$9110.00, respectively; $p \leq 0.001$), and remained significant when separating

unilateral and bilateral deformities ($p < 0.001$). There were nine total perioperative complications (six returns to the ER and three unexpected admissions to the hospital): five (2.3%) in the OR group, four (17.4%) in the OR+ group and none in the CL group. The OR+ group statistically had a higher rate of complications compared with the other two groups ($p = 0.006$). The total event time of the CL group was significantly shorter compared with the OR and OR+ groups (129.1, 171.7 and 1571.6 minutes respectively; $p < 0.001$).

Conclusion Hospital charges and total event time were significantly less when percutaneous TAT was performed in the outpatient clinic compared with the operating room. In addition, performing the procedure in clinic was associated with the lowest rate of complications.

Level of Evidence Therapeutic, Level III

Cite this article: Hedrick B, Gettys FK, Richards S, Muchow RD, Jo C-H, Abbott MD. Percutaneous heel cord release for clubfoot: a retrospective, multicentre cost analysis. *J Child Orthop* 2018;12:273-278. DOI 10.1302/1863-2548.12.170216

Keywords: clubfoot; Ponseti; heel cord; tenotomy

Introduction

Congenital clubfoot, also known as congenital talipes equinovarus, is a complex deformity of the foot involving cavus, adductus, varus and equinus deformities.¹ Incidence among Caucasians has been estimated at approximately one to two per 1000 births with a 2:1 male-to-female predominance.²⁻⁴ Approximately 50% occurs bilaterally and 80% is determined to be idiopathic in nature.⁵ Various theories exist as to the underlying aetiology, but there is no consensus in the literature as to the cause.

Treatment in the past was mainly surgical, requiring extensive soft-tissue releases leading to limited ankle and foot movement.^{1,6} In 1948, Ignacio Ponseti pioneered his methodology now commonly known as the Ponseti casting technique, which has become the most widely used method for treating clubfoot.^{4,7-9} Goals of treatment according to Ponseti were to obtain a 'functional, pain free, plantigrade foot, with good mobility and without calluses, and does not need to wear modified shoes'.¹ The Ponseti technique involves weekly casting of the foot in an attempt to correct the underlying deformities in a sequential manner. As part of the Ponseti technique, a

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percutaneous tendo-Achilles tenotomy (TAT) is performed on feet that are unable to obtain 15° of dorsiflexion once the forefoot adduction and hindfoot varus have been corrected. It has been reported that TAT is required in approximately 80% of cases.¹⁰

Debate exists regarding the optimal setting in which to perform the TAT. Multiple studies have demonstrated the safety and efficacy of performing the TAT in both the clinical setting and the operating room.^{6,9,11-14} Parada et al¹³ showed no surgical complications, post-anaesthesia apnea or bradycardia in 137 patients who underwent TAT under general anaesthesia in the operating room. Lebel et al¹² published that all 56 infants who underwent TAT in a clinical setting were safely discharged home without complication. Arguments have been made that performing the TAT in the operating room allows for more controlled conditions and better pain control, while performing in the clinic avoids anaesthetic concerns and additional costs associated with an event in the operating suite.¹¹⁻¹³ A few studies have evaluated costs and utilization of overall clubfoot treatment, however none have directly compared the financial costs of performing a TAT in clinic *versus* the operating room.^{15,16}

In a retrospective, multicentre study, we sought to investigate the cost of performing the TAT in an outpatient clinical setting *versus* the operating room by examining hospital charges associated with each setting. We hypothesized that performing the TAT in a clinical setting would result in significantly lower charges than performing it in the operating room without an increased complication rate.

Patients and methods

A retrospective, multicentre chart review was performed at three high-volume, tertiary referral paediatric hospitals. Each of the three institutions received study approval from their respective institutional review boards. We reviewed the medical records of 382 paediatric patients who underwent serial casting for idiopathic clubfoot via the Ponseti casting method and who required percutaneous TAT using the CPT codes 27605 and 27606 (percutaneous tenotomy of the Achilles tendon under local and general anaesthesia, respectively). Patients with neuromuscular conditions were excluded from the study. Each hospital system evaluated different time frames ending 31 December 2014, with a goal of achieving at least 100 consecutive idiopathic clubfoot patients. Each time frame was determined using an estimation of clubfoot patients treated per year at each institution.

The patients were grouped on the basis of the setting in which their TAT was performed: 140 patients in the outpatient clinic (CL); 219 patients in the operating room (OR)

with discharge following the procedure; and 23 patients in the OR with admission to the hospital for observation (OR+), with admission for 20 of these 23 patients planned for monitoring following anaesthesia due to either prematurity or medical comorbidity per hospital policy. The decision of setting of the TAT was largely due to standard practice at each institution with one institution routinely performing TATs in the clinic and the other two routinely in the OR. Therefore, a large majority of the TATs performed in the CL setting were performed at one institution, while the TATs performed in the OR and OR+ settings were performed at two other hospital systems.

Each TAT encounter was evaluated for time spent (per minute) in each specific setting (pre-operative, operating room, clinic room, post-anaesthesia care unit (PACU), etc). The time spent in the CL group was measured using the time from check-in to check-out. These time periods were used to calculate the hospital charges of each TAT encounter after being standardized to the University of Michigan 2015 fiscal-year data to allow direct comparison of charges among the three groups.

A centralized database was created utilizing REDCap software (Vanderbilt University, Nashville, Tennessee), and data were input into the database in a de-identified manner. Variables collected included demographic data (date of birth and gender), age at initial cast, age at TAT, unilateral/bilateral, Dimeglio scoring system for clubfoot¹⁷ (if known), aetiology of clubfoot, number of casts leading up to TAT, comorbidities, specific time periods in each setting, perioperative complications and whether admission to hospital following procedure was required.

Procedure

TAT in clinic required a staff orthopaedic surgeon, resident/fellow and often a medical assistant. The procedures were all performed in a clinic setting within the hospital. The prior cast was removed by the resident/fellow and topical anaesthetic cream (lidocaine 2.5% and prilocaine 2.5%) was placed or local anaesthetic injected in the region of the TAT. Sufficient time was allowed for full anaesthetic effect (usually 30 minutes for topical and ten minutes for injection). The parents were generally asked to remain in the waiting room during the procedure, which was performed in standard fashion using a small surgical blade entering just medial to the Achilles tendon. The cast was placed on the patient upon the parents' return, and the clinic visit was completed once the cast fully hardened and standard cast care instructions were discussed.

The OR procedure involved a standard operating room procedure (including preoperative holding and PACU stay). The procedure was commonly performed using a monitored anaesthesia care or a general anaesthesia, and in a fashion similar to the clinic procedure. The patient

was discharged from PACU once the standard American Society of Peri-Anesthesia Nurses (ASPN) discharge criteria¹⁸ were met.

Charge algorithm

Procedures performed in clinic at the University of Michigan incur a hospital charge and a provider charge for CPT 25605, which are both flat fees (Table 1). The hospital and provider charges for a unilateral TAT are \$2085 and \$790, respectively. The bilateral TAT hospital charge is \$3753, and the provider charge is \$1580.

Charges for TAT procedures performed in the operating room are calculated by adding the provider charge for the TAT with CPT 25606 (unilateral \$1089 flat fee, bilateral \$2178 flat fee), provider charge for anaesthesia (anaesthesia units × \$111), hospital charge for the OR (\$2700 for first 30 minutes + \$53 each additional minute), hospital charge for anaesthesia (\$1197 for 30 minutes + \$3 for each additional minute), hospital charge for PACU (\$463 for first 30 minutes + \$7 for each additional minute) and hospital charge for OR supplies (\$478 based on average OR supply usage for procedure in 2015). Anaesthesia units for both unilateral and bilateral TATs are calculated by adding the base units (3.0 units for TAT) + 1.0 unit for every 15 minutes while under the care of the anaesthesia provider.

Charges in the OR+ group were calculated as per the OR group with the addition of \$1.18 per minute once out of the PACU.

Statistical analysis

Demographic data, including age at initial cast, age at TAT, Dimeglio scoring, number of casts, as well as total event

time and charges among the three groups, were analyzed and statistical significance determined based on one-way analysis of variance followed by Tukey's method for multiple comparisons. These data were further stratified into bilateral or unilateral disease, and Fisher's exact test was utilized to determine statistical significance between the groups. The chi-squared test was used for bivariate categories, including unilateral/bilateral disease, whether complication occurred and gender in each of the three settings.

Results

A total of 563 clubfeet in 382 patients were included in the study. There were 140 patients in the CL group consisting of 93 male and 47 female patients with a mean age at TAT of 1.56 months (0.6 to 4.1) (Table 2). A mean of 4.24 casts (2 to 7) were placed prior to undergoing TAT. In all, 85 (60.7%) patients underwent unilateral TAT and 55 individuals underwent bilateral TAT.

The OR group consisted of 219 patients, 156 male and 63 female, with a mean age of 2.88 months (0.96 to 21.5) at time of TAT. On average this group received 5.1 casts (3 to 12) prior to TAT and 98 (44.7%) underwent unilateral TAT.

The OR+ group consisted of 19 male and four female patients with a mean age of 3.24 months (1.08 to 26.3) at time of procedure, with a mean of 5.2 casts (3 to 9) prior to undergoing TAT. In all, 18 (78.3%) patients underwent unilateral TAT and five underwent bilateral TAT.

Among the three groups, the CL group was significantly younger at the time of TAT compared with the OR and OR+ groups ($p \leq 0.006$). Additionally, the CL group had received fewer casts prior to undergoing TAT compared with the OR and OR+ groups ($p \leq 0.003$). There were no complications in the CL group, whereas the OR group had five complications (2.3%), all of which were unexpected returns to the emergency department within one postoperative day (three tight casts, one for diagnosis of croup and one for blood on the cast from an IV). The OR+ group had four perioperative complications, including one unexpected return to the emergency department

Table 1 Basic charge algorithm

Clinic	Operating room	Operating room + admission
PC _{procedure}	PC _{procedure}	PC _{procedure}
HC _{procedure}	PC _{anaesthesia}	PC _{anaesthesia}
	HC _{OR}	HC _{OR}
	HC _{anaesthesia}	HC _{anaesthesia}
	HC _{PACU}	HC _{PACU}
	HC _{OR supplies}	HC _{OR supplies}
		HC _{observation}

PC, provider charge; HC, hospital charge; OR, operating room; PACU, post-anaesthesia care unit

Table 2 Demographics

	CL		OR		OR +		p-value	CL vs OR	CL vs OR+	OR vs OR+
	n	%	n	%	n	%				
Total patients	140		219		23					
Male	93	66.4	156	71.2	19	82.6	0.252			
Mean age at TAT (mths)	1.6 (SD 0.6)		2.88 (SD 2.6)		3.2 (SD 5.2)		< 0.001	< 0.001	0.006	0.745
Mean age at initial cast (days)	18 (SD 14.6)		32.4 (SD 80.3)		21.6 (SD 25.6)		0.132	0.117	0.965	0.751
Unilateral	85	60.7	98	44.7	18	78.3	0.001	0.003	0.106	0.002
Casts (n)	4.24		5.1		5.2		< 0.001	< 0.001	0.003	0.958
Complications	0	0.0	5	2.3	4	17.4	< 0.001	0.161	< 0.001	0.006

CL, clinic; OR, operation room; OR+, OR + admission; TAL, tendo-Achilles tenotomy

and three unexpected admissions. The three unexpected admissions included one patient each for respiratory issues, parental request for pain control and premature ventricular contractions. The OR+ group had a significantly higher percentage of complications (17.4%) compared with both the CL and OR groups ($p = 0.006$).

Procedures performed in the clinic took a mean of 99 minutes (23 to 240), with the entire visit (check-in to discharge) taking 129.1 minutes (43 to 260) (Table 3). This was significantly less than the OR and OR+ event times of 171.7 minutes (110 to 284) and 1571.6 minutes (1349 to 1705), respectively ($p < 0.001$).

Charges among the three groups undergoing TAT (CL, OR, OR+) differed significantly (\$3840.60 versus \$7962.30 versus \$9110.00, respectively; $p < 0.001$) (Table 4). When stratified by laterality, it was shown that the mean cost of a unilateral TAT performed in clinic was significantly less, \$2875, compared with use of the operating room with or without postoperative admission (\$8703.30 [sd: \$1206.49] and \$7199.40 [sd: \$666.94], respectively) ($p < 0.0001$). A bilateral TAT performed in the clinic cost \$5333, which was also significantly less than the cost of this procedure performed in the operating room with or without admission ($p < 0.0001$). In addition, charges in the OR group were significantly less than those of the OR+ group when stratified by laterality ($p \leq 0.0006$).

Discussion

Clubfoot treatment was revolutionized by the work of Ponseti and his casting technique. Today, the vast majority of patients with clubfoot are treated with sequential casting followed by a percutaneous TAT. While the casting technique has very much been standardized, the clinical

setting for TAT is variable. Historically, Ponseti and others have performed the procedure in the CL under local anaesthetic. Proponents of this technique note the lack of anaesthetic risk and the possible cost savings. On the contrary, many have advocated for TAT in the operating room under anaesthetic with the noted advantages of a more controlled procedure and improved pain control. This study is the first to our knowledge to directly compare the expense and safety of both clinical settings.

Results from this study show that unilateral and bilateral TAT procedures performed in the clinic are less costly than these same procedures performed in the operating room. Overall, each patient was charged roughly \$4100 less for the same procedure performed in the outpatient clinic rather than the OR. In addition, 23 patients had an additional charge (roughly \$1100) for overnight hospital observation. This group of 23 patients required overnight observation following their TAT for a multitude of reasons, including 19 expected admissions due to anaesthetic protocol involving their age/prematurity, one expected admission for apnea monitoring and three unexpected admissions. The three unexpected admissions included one patient each for respiratory issues, parental request for pain control and premature ventricular contractions. Theoretically, all 23 of these hospitalizations and their related charges could have been avoided by performing these procedures in the outpatient clinic. In addition to the three unexpected admissions, six other complications affected patients treated in the operating room. These complications included three patients who returned to the emergency department over parental concern about a tight cast, one patient with blood on the cast from a peripheral IV, one patient with croup experienced on postoperative day 1 and one patient for nausea/fussiness after discharge from an observation period. Other than

Table 3 Average encounter times (minutes)

	CL	OR	OR +	p-value	CL vs OR	CL vs OR+	OR vs OR+
Total event time	129.1	171.7	1571.6	< 0.001	< 0.001	< 0.001	< 0.001
Clinic time	99.1						
Pre-operative time		70.1	77.0	0.559			
OR time		42.8	33.0	0.004			
Anaesthesia time		49.3	38.8	0.015			
Procedure time		20.0	14.1	0.009			
PACU time		63.0	59.1	0.748			
Hospital time			1540.6				

CL, clinic; OR, operation room; OR+, OR + admission; PACU, post-anaesthesia care unit

Table 4 Encounter charges (\$)

	CL		OR		OR +		p-value	CL vs OR	CL vs OR+	OR vs OR+
	N	Mean	n	Mean	n	Mean				
Unilateral	85	2875.0 (SD: 0)	98	7199.4 (SD: 1206.4)	18	8703.3 (SD: 666.9)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Bilateral	55	5333.0 (SD: 0)	121	8580.2 (SD: 1496.7)	5	10 574.3 (SD: 807.1)	< 0.0001	< 0.0001	< 0.0001	0.0006
All charges	140	3840.6 (SD: 1204.8)	219	7962.3 (SD: 1534.3)	23	9110.0 (SD: 1041.6)	< 0.0001	< 0.0001	< 0.0001	0.0001

CL, clinic; OR, operation room; OR+, OR + admission

the patient with blood on the cast, it is unclear whether any of these additional complications would have been avoided if performed in the outpatient setting. There were no complications within the CL group.

While the complication rate in this study was low overall, there are other concerns regarding the safety of percutaneous TAT, including recent concerns about anaesthetic exposure in infants and its effect on neurocognition. Animal studies have shown that exposure to anaesthetics commonly used in humans results in neuronal cell death, altered dendritic architecture and altered long-term neurocognition.¹⁹ A recent study by Backeljauw et al⁷ investigated the neurocognitive effects of early anaesthetic exposure (before four years of age) with a matched cohort of unexposed individuals. Individuals who were exposed to anaesthesia had significantly lower scores in performance IQ and listening comprehension compared with their matched cohort.⁷ Given the recent focus on anaesthetic risks during infancy, further research is needed to fully understand the risks of performing orthopaedic procedures under anaesthesia during the first year of life.

In addition to the possible anaesthetic risks, anaesthesia has been shown to be a parental stressor during elective surgical procedures.²⁰ Our study did not evaluate the effects of procedure setting on parental concerns or satisfaction, however, it is possible that such differences exist between the operating room and outpatient clinic. The study does show, however, that the total event time of the TAT in outpatient clinic was 31 minutes shorter than the event from check-in to PACU. It is also logical to assume that separation time between parents and child is much less for the clinical procedure compared with the OR procedure, however, this could not be calculated in our study.

There are obvious limitations to our study. Given the multicentre nature of the study, comparing charges between the three hospital systems required standardization to the University of Michigan charge structure according to a single fiscal-year data charge structure. This lends to some bias, as not all procedures were performed at one location and all TATs were not performed in that fiscal year. The efficiencies of the hospital systems were likely not equivalent, which may affect both procedure times and overall charges. However, each of the three hospitals performed the majority of the percutaneous TAT procedures in one setting, which should lead to an efficient overall event at each hospital. While patient charges are an important financial aspect of the TAT procedure, overall cost of the procedure to the hospital system is likely just as important. Unfortunately, we were unable to evaluate hospital procedural cost due to the complexity of the calculation and the fact that the procedures were not all performed at the same location. The study does not evaluate hospital reimbursement of the procedures given the large discrepancies among states and insurance providers.

Additionally, given the retrospective nature of the study, our ability to identify complications associated with the TAT was limited to those complications identified in the patient's chart.

Conclusion

With the ever-increasing costs of healthcare in the United States, understanding associated charges for procedures is becoming more important. The goal of all providers is to offer the most cost-effective, safe and efficient care possible. This study demonstrated that percutaneous TAT performed in an outpatient clinic setting is faster and has fewer hospital charges compared with the same procedure performed in an operating room suite. In addition, the clinical procedure was associated with a lower rate of complications. This study shows that performing percutaneous TAT for idiopathic clubfoot in a clinical setting is a safe, cost-effective and quicker alternative to the operating room for individuals less than three months of age.

Received 21 December 2017; accepted after revision 10 May 2018.

COMPLIANCE WITH ETHICAL STANDARDS

FUNDING STATEMENT

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

OA LICENCE TEXT

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ETHICAL STATEMENT

Ethical approval: The study was approved by the Institutional Review Board (IRB) at all three sites.

Informed consent: No informed consent was necessary for this study.

ICMJE CONFLICT OF INTEREST STATEMENT

None declared.

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