Original Article

Cock Up Great Toe Deformity Following Tibialis Anterior Tendon Transfer in Idiopathic Talipes Equinovarus: Measure of Deformity, Functional Test and the Newcastle Sign

Robert Cooper, Varun Gupta, Damian Mansour, Eric Ho, Sandeep Tewari, David Nicholson
Department of Orthopaedics, John Hunter Hospital, New Lambton Heights, New South Wales, Australia

Abstract

Background: Idiopathic talipes equinovarus (clubfoot) is a congenital deformity treated initially by the Ponseti method, but in cases of relapse, tibialis anterior tendon transfer (TATT) is commonly used. A complication of TATT is the development of 'Hallux extensus' deformity, characterised by hyperextension of the great toe at the metatarsophalangeal joint (MTPJ). This deformity's functional impact has not been systematically assessed. **Objective:** To measure and evaluate the occurrence of cock up great toe deformity following TATT surgery in recurrent talipes equinovarus patients. The study also aims to introduce a functional test, the 'Newcastle test', to identify this deformity reliably. **Methods:** This study involved four patients who had undergone TATT for relapsed clubfoot. Patients were assessed for active ankle dorsiflexion and MTPJ angles using goniometry. Measurements were taken with knees in extension and flexion to evaluate the impact of tendoachilles involvement. A functional 'Newcastle test' was also introduced to assess the deformity under weight-bearing conditions. The Newcastle sign was deemed positive if hyperextension at the MTPJ and a dorsal crease were observed during ankle dorsiflexion. **Results:** All patients with TATT demonstrated a positive Newcastle sign on the operated side. The average dorsiflexion in knee extension was lower on the TATT side (−0.75°) compared to the non-TATT side (9°). The average MTPJ dorsiflexion angle was significantly greater on the TATT side (91.25°) compared to the non-TATT side (45°). The Newcastle test consistently demonstrated the presence of the cock up deformity in the TATT-operated foot. **Conclusion:** The Newcastle test is a simple, reproducible functional test for identifying cock up great toe deformity following TATT in clubfoot patients. The study suggests that dorsiflexion weakness in the medial foot and posterior structural tightness may contribute to the deformity. Further biomechanical studies are recommended to refine tendon transfer techniques to prevent this complication and reduce the risk of long-term osteoarthritis in the MTPJ.

Keywords: Clubfoot, cock up great toe, Newcastle sign, tibialis anterior tendon transfer

Introduction

Idiopathic talipes equinovarus, commonly known as clubfoot, is a congenital deformity that causes the foot to turn inward and downward, making it difficult for affected individuals to walk normally. The deformity is marked by midfoot cavus, forefoot adductus and hindfoot varus and equinus and occurs in approximately 1–2 out of every 1000 live births globally.[1] This condition is typically present at birth and is one of the most common musculoskeletal abnormalities in newborns.[2] The Ponseti method, which involves serial manipulation and casting of the foot, is widely regarded as the gold standard for early treatment.[3] While this method is highly effective in correcting the initial deformity, some patients experience relapse or persistent deformities that require surgical intervention.[4]

One of the most common surgical procedures for recurrent clubfoot is tibialis anterior tendon transfer (TATT).[5] It is a standard procedure utilised in the treatment of recalcitrant talipes equinovarus.[6-10] The literature suggests a 12% use of the surgical procedure in the total presenting cases of talipes equinovarus.

Address for correspondence: Dr. Varun Gupta, Department of Orthopaedics, John Hunter Hospital, New Lambton Heights, New South Wales, Australia.
E-mail: Varun.gupta@health.nsw.gov.au

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This procedure involves transferring the tibialis anterior tendon from its original insertion on the medial side of the foot to the lateral cuneiform.[11] The goal of this surgery is to correct dynamic supination of the foot, which occurs during walking, by altering the direction of the pull of the tibialis anterior muscle.

Despite the effectiveness of TATT in addressing dynamic deformities, a notable complication that has been observed post-surgery is the development of a 'cock up great toe' deformity. This phenomenon is characterised by hyperextension of the great toe at the metatarsophalangeal joint (MTPJ), which can affect both the function and appearance of the foot.[12] While the occurrence of this deformity has been documented in the literature, there is little quantifiable data on its prevalence or functional impact. Moreover, no functional tests have been developed to systematically assess this deformity. This phenomenon has little reported on it in the literature regarding its impact on function, but also on the esthetic impact on the population of children in whom it occurs. It has a reported incidence of 21%–67% in post-TATT.[7,8] Long term there is report of 12% first MTPJ osteoarthritis occurring in TATT subjects.[10] Thus, the cock up toe phenomenon may have significant long-term functional and quality of life effects on these patients. Thus, the aim of the study is to review and measure the phenomenon of 'cock up great toe' following TATT surgery in patients with recurrent talipes equinovarus. It also aims to identify a new test and sign that will demonstrate the phenomenon in a functional manner.

Methods

A study was conducted to address the lack of a physical sign. In this single-center study, children who were known to have had TATT following relapse during standard Ponseti protocol for recalcitrant talipes equinovarus were identified as having cock up toes and recruited to the study during routing follow-up. They were examined in a clinical setting with parents present after consent was attained. Subjects were examined by a physiotherapist specialising in talipes equinovarus treatment, by supervising medical specialist and the chief investigator. Formal measures were taken of angles produced at the MTPJ of the great toe as well as at the ankle joint. The measures were conducted using a standard goniometer. The ankle dorsiflexion measures were done in extension of the knee and in knee flexion at 90° to assess for tendo Achilles involvement. In addition to this, patients were assessed for the occurrence of the cock up toe phenomenon in a functional position to produce a reproducible 'Newcastle sign'.

The TATT surgery was identified in the patient's journal and noted as being a complete tendon transfer using a dorsal incision and complete resection of the tibialis anterior tendon from its distal insertion with a subcutaneous transfer to the lateral cuneiform. The tendon was transfixed using a tenodesis screw. The tendoachilles was also released during the procedure and cast was applied to maintain position.

A total of four patients were assessed formally in this pilot study. The 'Newcastle test' was derived by the supervising investigator working with talipes equinovarus patients. Its aim is to demonstrate a reproducible 'sign' in a position of function. The



Figure 1:(a) Newcastle test on the right with positive Newcastle sign. (b) Newcastle test on left foot - negative test. Subject 1: Cock up toe (positive 'Newcastle sign' demonstrated on the right but not the left using the 'Newcastle test'. TATT: Tibialis anterior tendon transfer



Figure 2: Subject 2: Bilateral 'Newcastle Test' demonstrating positive 'Newcastle Sign' on the right, whilst demonstrating a negative test on the disease-free left foot. TATT: Tibialis anterior tendon transfer

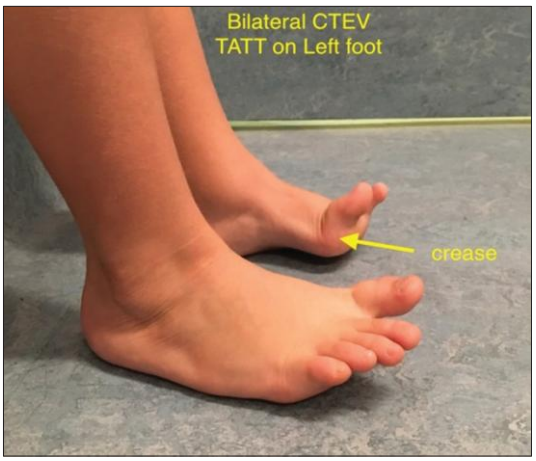


Figure 3:. Subject 3: Bilateral 'Newcastle Test' demonstrating positive 'Newcastle Sign' on the left with a negative test on the right – no definite crease demonstrated. TATT: Tibialis anterior tendon transfer

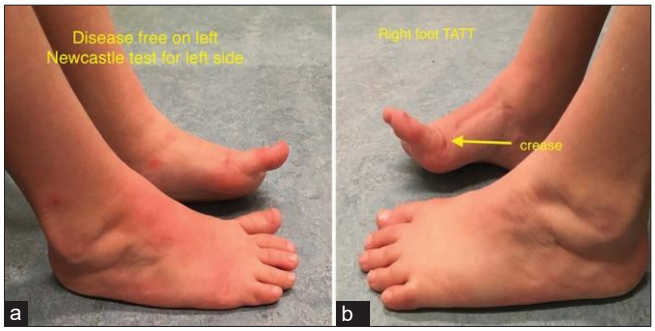


Figure 4: (a) Subject 4: Left foot 'Newcastle test' negative. (b) Subject 4: Right foot tibialis anterior tendon transfer operated; Positive 'Newcastle Test'. TATT: Tibialis anterior tendon transfer



Figure 6: (a) Subject 2: Left foot non-operative ankle dorsiflexion. (b) Subject 2: Right foot tibialis anterior tendon transfer operated side: active dorsiflexion

subject is asked to stand with heels 5–10 cm from the wall, back resting on the wall. With slight flexion of the knees, the subject dorsiflexes the ankle and foot, first on the non-operative side, then on the operative side. The cock up deformity is visible during this weight-bearing position, characterised by hyperextension at the MTPJ and a dorsal crease [Figure 1a]. The cock up deformity is defined as hyperextension of the MTPJ, producing a dorsal crease at this level, with flexion of the interphalangeal joint (IPJ) of the great toe.[13,14] Excessive dorsiflexion at the MTPJ is a known complication following TATT surgery, contributing to the development of the cock up deformity. When a cock up deformity is identified, it is said to be a positive 'Newcastle sign'

Results

A total of four patients were assessed formally.

On the TATT-operated side, the average ankle dorsiflexion in knee extension was −0.75°, whereas the average ankle dorsiflexion in 90° knee flexion was 8°. On the non operative side, mean ankle dorsiflexion measured with the knee extension was 9degrees increasing to 16.25 degrees when assessed with the knee flexed.

The average 1st MTPJ dorsiflexion angle with active ankle dorsiflexion in knee extension on the TATT operated side was 91.25°, whereas the non-operative side average was 45°.



Figure 5: (a) Subject 1: Left foot non-operative side active dorsiflexion. (b) Subject 1: Right foot tibialis anterior tendon transfer operated: active dorsiflexion

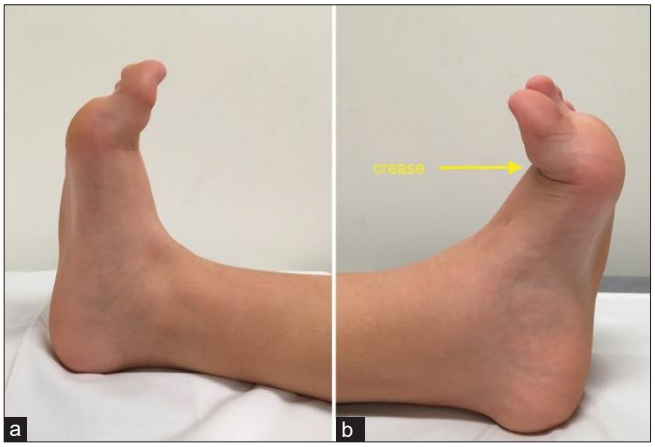


Figure 7:. (a) Subject 3: Right foot non-operative side: active dorsiflexion. (b) Subject 3: Left foot tibialis anterior tendon transfer operated side: active dorsiflexion

A cock up deformity was visible only on the feet that had been operated on with a TATT. All subjects who demonstrated a positive cock up deformity demonstrated a pronounced crease at the level of the 1st MTPJ.

The results for each patient are set out in the tables below.

Images of the weight-bearing 'Newcastle test' in subject [Figures 1-4].

Images of subjects during non weight-bearing active dorsiflexion in supine with knee extended [Figures 5-8].

Ankle dorsiflexion and first metatarsophalangeal joint extension findings are summarized in Tables 1 and 2.

Discussion

The cock up great toe phenomenon is a known consequence of TATT in recurrent talipes equnovarus patients. This study has demonstrated a method of measuring and producing an easy-to-perform and reproducible functional sign, the 'Newcastle sign'.

Table 1: Ankle Dorsiflexion passive

	Active ankle dorsiflexion knee in extension	Active ankle dorsiflexion knee in 90° Flexion
Subject 1		
Left – disease-free	14	20
Right - TATT	10	14
Subject 2		
Left	15	20
Right - TATT	−8	13
Subject 3		
Left - TATT	0	10
Right	12	30
Subject 4*		
Left - CTEV	−5	−5
Right – TATT	−5	−5

*Subject 4 has bilateral disease with right side treated with TATT. TATT: Tibialis anterior tendon transfer, CTEV: Congenital talipes equinovarus

Table 2: First metatarsophalangeal joint extension with active ankle dorsiflexion

	MTPJ angle
Subject 1	
Left	25
Right - TATT	90
Subject 2	
Left	30
Right - TATT	90
Subject 3 JB	
Left - TATT	95
Right	50
Subject 4	
Left	75
Right -TATT	90

TATT: Tibialis anterior tendon transfer, MTPJ: Metatarsophalangeal joint



Figure 8:. (a) Subject 4; Left ankle dorsiflexion non-operated side. (b) Subject 4: Right ankle dorsiflexion tibialis anterior tendon transfer operated

This tendon transfer surgery offers good success in reducing the recurrence of inversion in recurrent talipes equinovarus. However, with the transfer of the tibialis anterior tendon laterally, there is a secondary weakness in dorsiflexion production of the medial foot. This thus leads to a cock up of the great toe by extensor hallucis longus (EHL) to produce medial foot dorsiflexion. There appears to be increased activity of the extensor halluces brevis in recruiting the medial dosiflexors, given the flexion of the IPJ. The literature also notes often dropping of the first metatarsal and cavus foot production secondary to the defunctioning of tibialis anterior at its' natural insertion.

This study identifies a discrepancy in the first MTPJ extension of the TATT operative side as compared to the non-affected side. Having a TATT appears to produce a lot more extension of the first MTPJ in active ankle dorsiflexion. This demonstrates the extensor halluces longus contribution to active ankle dorsiflexion in a foot with medial ankle dorsiflexor weakness secondary to the TATT. This may be in conjunction with tightness in the plantar and posterior ankle structures. It certainly appears that Achilles tendon tightness is associated with the phenomenon. This is demonstrated by the difference in active ankle dorsiflexion range achieved in the TATT side in knee extension compared with knee flexion. There is a clear difference between TATT operative side ranges and the non-TATT side ranges in dorsiflexion, in which the TATT side had diminished dorsiflexion values in all positions compared with the non-TATT side.

It has not previously been clearly identified whether the cock up toe creates a functional deformity. This study has identified this and produced a functional weight-bearing 'Newcastle test' that allows one to demonstrate if the deformity is present. This test may be instituted quickly and simply during routine examination. It requires the correct positioning of the patient and that the subjects' feet are in the weight-bearing position.

This study demonstrates a pattern of difference in ankle dorsiflexion with the operative side versus the non-operative side. A tendoachilles length discrepancy may contribute quite significantly to the cock up deformity. In combination with weakness of dorsiflexion on the medial aspect of the foot, this may produce the overall pattern of movement. To address this, a trial assessing if calf lengthening correlates with improvement of the cock up deformity would be useful to determine the contribution of length of posterior structures such as tendo-achilles as compared with the lack strength of the ankle dorsiflexors in producing a cock up toe deformity.

Long term, it may be noted that cock up toe deformity may produce aesthetic challenges for these young and impressionable patient group. It does not appear to affect their basic function when mobilising at this young age. The extreme range of movement may contribute in the long term to osteoarthritic changes at the first MTPJ, and its incidence in the TATT cohort is up to 12%.[5] It would be ideal to aim to prevent this from occurring through an ongoing program of stretching of the Achilles tendon. The findings of this study prompt the thought to investigate what the incidence of cock up great toe is in patients who have had a split TATT and thus its potential use in recurrent talipes equinovarus.

Complete TATTs have been shown biomechanically to be the most balanced and effective when inserted on the 3rd ray into the lateral cuneiform.[6] However, given the overactivity of the EHL noted in this study, perhaps the tendon transfer is not producing enough dorsiflexion power, and the EHL is compensating with overactivity, thus producing the hyperextension of the first MTPJ. This may be because the insertion of the tibialis anterior is brought more proximal to the tibia in the sagittal plane so that it can be inserted on the lateral cuneiform. This reduces the effective dorsiflexion force acting on the 3rd ray. If the insertional distance from the tibia is increased in the sagittal plane to mimic that of the original insertion, this may increase the dorsiflexion force production and reduce the recruitment of EHL in ankle dorsiflexion production. Thus, we suggest a further biomechanical study to address this. Ultimately, this may reduce, if not create a solution to this great toe cock up deformity and reduce the burden of first MTPJ osteoarthritis in this patient group.

Conclusion

This article presents a novel method of functionally demonstrating the cock up great toe deformity in patients who have undergone the Ponseti protocol and have had TATT. In this small number of subjects, it demonstrates a measured difference in range of movement – particularly at the first MTPJ in operated versus non-operated limbs in the same subject. There is a need to increase the numbers studied to assess for statistical significance of these findings. This study ultimately prompts the idea that the biomechanics of the TATT for recalcitrant talipes equinovarus be studied formally to note if the reduction of the occurrence of this phenomenon can be achieved, given its potentially debilitating long-term effects.

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Conflicts of interest

There are no conflicts of interest.

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