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Flexor hallucis longus transfer versus turndown flaps augmented with flexor hallucis longus transfer in the repair of chronic Achilles tendon rupture

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ABSTRACT

Background: Repairs of chronic Achilles tendon ruptures are technically challenging due to large defects after scar excision. Multiple techniques for repair have been proposed but little consensus on best practice established. This study aims to compare flexor hallucis longus (FHL) transfers versus turndown flaps augmented by FHL transfers.

Methods: Between 2005 and 2015, 49 unilateral repairs of chronic Achilles tendon ruptures were performed. We retrospectively compared the outcomes of 20 patients who underwent FHL transfer with 19 patients who underwent turndown flaps augmented with FHL transfer before surgery and at three time points after surgery (three, six and twelve months). Visual Analogue Scale (VAS), American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale and the 36-Item Short Form Health Survey (SF-36) were used to evaluate outcome.

Results: Both techniques demonstrated significant improvement in their outcome scores and were comparable to one another. At one year, the mean VAS score was 0 for both groups. The mean AOFAS Ankle-Hindfoot score was 90 ± 11 (FHL) and 95 ± 10 (FHL with turndown flaps); and SF-36 scores showed significant improvements in physical, role and social function scores. Turndown flaps augmented with FHL transfer however required significantly longer operative time (100 ± 21 min) compared to FHL transfer alone (73 ± 23 min).

Conclusions: FHL transfer required significantly less operative time compared to turndown flaps augmented with FHL transfer, with comparable outcomes. FHL transfer is a reliable and effective technique in the repair of chronic Achilles tendon ruptures.

1. Introduction

The Achilles tendon is the biggest tendon in the human body. However, it is also one of the most frequently ruptured tendons. Complete rupture commonly occurs at around one-and-a-half to two inches from the tendon's insertion to the calcaneus [1–3], corresponding to the "watershed" region of the tendon [4,5]. Achilles tendon ruptures are considered to be chronic after 4–6 weeks delay from the time of injury [1,6–8] and it is often due to misdiagnosis or a delay in seeking medical attention. Whilst there is a role for non-operative management through bracing and rehabilitation, these non-surgical management options of chronic Achilles tendon have less favourable outcomes [9,10]. Therefore, non-operative management tends to be reserved for poor surgical candidates with extensive peripheral vascular disease or poor overlying skin [11,12].

Surgical techniques used in the repair of chronic Achilles tendon ruptures are namely: direct repairs, advancement flaps (e.g. turndown flaps), tendon transfers (e.g. flexor hallucis tendon (FHL)), augmentation with synthetic materials or a combination of techniques. Flexor hallucis longus (FHL) transfer is a widely used technique that produces reliable and excellent results with minimal morbidity [13–16]. Anatomically, the FHL is the most posterior of the deep plantaflexors and is in close proximity to the common Achilles tendon rupture site. The FHL also works in phase with the gastrocnemius soleus complex, with an mechanical axis that resembles the Achilles tendon [17]. The FHL muscle is the second strongest plantar flexor to the gastrocnemius–soleus complex and is stronger than the peroneous brevis and flexor digitorum longus [18]. There is also potential for the FHL to hypertrophy up to 52% after transfer [19,20]. The FHL muscle belly provides an alternative source of blood supply to the hypovascular

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rupture site. In addition, the loss of hallux push-off strength, an expected complication, is often well tolerated in most patients [17,21,22].

Another surgical technique employs the use of turndown flaps. There are various adaptations and modifications of applying the turndown flap technique; it can applied as a stand-alone repair or augmented with tendon transfers. One version of this technique employs the use of two turndown flaps coupled with FHL augmentation to achieve consistent and reliable results [11,22].

The abovementioned techniques produce good results [11,13–16,22–27] but there is limited literature to guide best practice and the choice of surgical technique. Majority of the literature regarding the repair of chronic Achilles tendon repair stems from expert opinion and general sentiment points towards the use of different techniques to suit different tendinous separation gaps after the intervening scar has been excised [21]. We aim to compare the clinical outcomes of standalone FHL transfer versus turndown flaps augmented by FHL transfer in the surgical management of chronic Achilles tendon ruptures. We hypothesize is that FHL transfer alone has comparable outcomes for the treatment of chronic Achilles tendon ruptures.

2. Materials and methods

This study was approved by the hospital's ethics committee (CIRB: 2015/2007) and carried out in accordance to the ethical standards laid down in the 1964 Declaration of Helsinki. Written inform consent was obtained from all the patients.

2.1. Patient demographics

We conducted a retrospective cohort study in Singapore General Hospital from January 2005 to December 2015. A total of 49 patients with unilateral chronic Achilles tendon rupture were surgically treated using FHL transfers or turndown flaps augmented by FHL transfer at least four weeks after their date of injury. All surgeries were performed at the Foot and Ankle division of a tertiary hospital. Patients were divided into two groups based on the surgery performed — namely FHL transfers only and FHL transfers with turndown flaps.

2.2. Operative technique

FHL transfer. The patient was positioned prone with tourniquet applied to the thigh. A longitudinal midline incision just medial to the Achilles tendon was made and the rupture exposed. The sural nerve identified away from the incision and protected. Tenolysis and subsequent debridement of the fibrosed ruptured Achilles tendon was performed. The proximal tendon and muscle were freed from the surrounding scar through blunt finger dissection, enabling greater mobility of the proximal tendon. The muscle belly of the FHL was then identified deep to the Achilles tendon, and subsequently followed to the level of medial malleolus, where it was excised. It was then passed into a calcaneal tunnel created just anterior to the tendoachilles insertion and secured with an absorbable screw (Bio-Tenodesis Screw™, Arthrex, Naples, Florida).

Turndown Flaps augmented with FHL transfer. After preparing the ruptured Achilles tendon (above), the tendon gap was measured with the ankle plantar-flexed. Turndown flaps were fashioned, both with widths at least one centimetre wide. The required flap length is the sum of the rupture gap after debridement and at least four centimeters (allowing for a minimum crossover length of two centimeters when the proximal flap is turned down onto itself). The turndown flaps were then dissected from the muscle belly before being secured side-to side with the distal Achilles stump. The FHL augmentation was then performed with the muscle belly of the FHL transfer sutured over the rupture site.

2.3. After operation care

Patients from both groups received similar after-operative care. Backslab was applied with ankle in slight plantar-flexion after surgery. This was converted to a full cast at an outpatient setting at two weeks and all patients were kept on non-weight bear crutch mobilisation for six weeks. After six weeks, patients underwent physical therapy, focused on stretching and strengthening and was allowed to weight-bear as tolerated.

2.4. Outcome measures

Functional outcome scores were collected pre-operatively and at 3, 6 and 12 months after surgery. At these intervals, patients were assessed and completed questionnaires for the Visual Analogue Scale (VAS), American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Scale [28], and the 36-Item Short Form Health Survey (SF-36) — scoring systems used to evaluate surgical repair outcomes in Achilles tendon injuries [29]. The Physical Component Summary (PCS) and Mental Component Summary (MCS) scores [30] derived from the SF-36 components were used to summarise individual component scores.

The primary outcome measures of this study were the functional outcomes scores. Secondary outcome measures included duration of procedure, length of stay after operation and complications after surgery (e.g. Wound dehiscence, re-rupture).

2.5. Statistical analysis

Statistical analysis was performed using statistical software (SPSS version 21.0, IBM Corporation, Armonk, New York). Student's unpaired t-test was used for continuous variables with normal distribution (age, body mass index (BMI), size of defect, duration of injury before surgery, length of hospital stay, duration of procedure, length of stay, AOFAS Hindfoot scores and SF-36 scores). Fisher's exact test was used to compare categorical data (gender, side of injury, co-morbidities, complications after surgery and VAS). Significance was set at the $p < 0.05$.

3. Results

3.1. Demographics

Both groups were similar in age, BMI and gender. Potential confounders of outcomes such as co-morbidities [31], time between injury to surgical intervention as well the size of defect did not show significant differences (Table 1). Both study groups were comparable and demographically similar.

3.2. Outcomes

Patients in both groups showed significant improvements in the VAS pain score, AOFAS Ankle Hindfoot score and components of the SF-36 (Table 2). At 12 months after surgery, the median VAS pain score was 0 for both groups. AOFAS Ankle-Hindfoot scores at 12 months with FHL transfer was 90 ± 11 and turndown flaps augmented with FHL transfer was 95 ± 10, demonstrated excellent outcomes in both groups. Overall improvements in the SF-36 questionnaire were also noted. Some components, in particular Physical Function, Physical Limitation and Social Function showed significant improvement after operation.

Table 1
Comparison of patient demographics, presentation between injury and surgery as well as the mean defect size of the chronic Achilles tendon rupture between Group 1 and Group 2.

		FHL only	FHL with turndown flap	P≤
Total participants (n =)		29	20	–
Age, mean ± SD[a]		56 ± 13	60 ± 9	NS[b]
BMI, mean ± SD		27 ± 4	29 ± 4	
Gender, n (%)	Male	16 (55%)	10 (50%)	
	Female	13 (45%)	10 (50%)	
Side of injury, n (%)	Right	13 (45%)	10 (50%)	
	Left	16 (55%)	10 (50%)	
Co-morbidities, n (%)	Diabetes mellitus	6 (20%)	2 (10%)	
	Thyroid disease	1 (3%)	2 (10%)	
	Gout	3 (10%)	2 (10%)	
Time between injury and surgery, weeks ± SD		17 ± 13	18 ± 15	
Mean size of defect, mm, ± SD		50 ± 16	55 ± 24	

[a] SD — standard deviation.
[b] NS — not significant ($p < 0.05$). All comparisons on Table 1 between FHL only and FHL with turndown flap were not significant.

Table 2
Procedure outcomes comparing VAS pain, AOFAS ankle hindfoot and SF-36 scores pre-operatively and at 3, 6 and 12 months after surgery for FHL only and FHL with Turndown Flaps respectively.

Timeline	FHL only					FHL with turndown flaps				
	Pre-operative	After surgery				Pre-operative	After surgery			
		3 months	6 months	12 months	*p* (12 months)		3 months	6 months	12 months	*p* (12 months)
VAS pain score	3	0	0	0	0.005*	5	0	0	0	0.004*
AOFAS Ankle-Hindfoot Score	62 ± 22	79 ± 19	88 ± 13	90 ± 11	0.001*	52 ± 19	76 ± 22	83 ± 18	95 ± 10	0.001*
Physical function[a]	58 ± 24	59 ± 29	79 ± 19	78 ± 21	0.001*	40 ± 25	53 ± 29	77 ± 15	82 ± 14	0.001*
Role limitation physical[a]	30 ± 40	43 ± 46	71 ± 37	63 ± 40	0.005*	11 ± 22	31 ± 41	61 ± 40	75 ± 35	0.001*
Bodily pain[a]	60 ± 28	73 ± 25	77 ± 21	70 ± 25	NS	51 ± 30	63 ± 30	74 ± 27	79 ± 24	0.03*
General health[a]	75 ± 18	75 ± 20	78 ± 17	77 ± 18	NS	68 ± 23	69 ± 21	68 ± 16	75 ± 13	NS
Vitality[a]	74 ± 20	79 ± 19	79 ± 15	75 ± 21	NS	73 ± 29	77 ± 28	75 ± 20	72 ± 23	NS
Social function[a]	72 ± 31	63 ± 39	90 ± 33	96 ± 11	0.002*	46 ± 39	60 ± 32	80 ± 29	93 ± 16	0.001*
Role limitation emotional[a]	92 ± 25	100 ± 0	93 ± 26	100 ± 0	NS	87 ± 33	100 ± 0	98 ± 8	97 ± 10	NS
Mental health[a]	79 ± 15	85 ± 11	82 ± 16	86 ± 19	NS	76 ± 24	79 ± 17	85 ± 17	84 ± 13	NS
SF-36 – PCS[b]	39 ± 10	41 ± 11	49 ± 10	49 ± 9	0.001*	33 ± 10	40 ± 11	48 ± 8	50 ± 9	0.001*
SF-36 – MCS[c]	55 ± 9	57 ± 8	58 ± 8	57 ± 12	NS	51 ±14	53 ± 11	54 ±9	53 ± 17	NS

[a] All components of SF-36.
[b] PCS – Physical Component Score.
[c] MCS – Mental Component Score.
* Statistical significance $p < 0.05$.

Patients in FHL with turndown flaps also noted a significant improvement in Bodily Pain. This improvement was also noted in FHL transfer alone although not statistically significant. PCS scores improved significantly for both groups at 12 months. MCS scores however remained relatively unchanged.

3.3. Comparing Group 1 and Group 2

There were no differences between FHL transfer without vs with turndown flaps in VAS score, AOFAS score, SF-36-PCS, or SF-36-MCS before surgery and at 3, 6, and 12 months after surgery.

3.4. Alternative outcomes measures

The mean operative duration for turndown flaps augmented with FHL transfer was 100 ± 21 min compared to 73 ± 23 min in the group with FHL transfer alone. The addition of turndown flaps required almost a third more operative time and this difference was significant. Despite the longer and more complex procedure, there was no significant difference between the length of stay after surgery in both groups (FHL transfer — 2 ± 3 days and FHL with turndown flaps — 2 ± 2 days).

We noted more complications with turndown flaps augmented with FHL. Two cases soft tissue complications were documented — one stitch abscess and one wound dehiscence. FHL transfer alone had no complications. No re-ruptures occurred in both groups.

4. Discussion

Our study demonstrated that in patients with similar demographics and presentation, the use of FHL transfers alone versus the use of turndown flaps augmented with FHL transfer yielded comparable outcomes 12 months after surgery. Our results in both groups mirrored findings within literature, demonstrating comparable mean AOFAS score improvements and achieving good to excellent mean AOFAS hindfoot scores after surgery [22,26,32]. The VAS pain score after operation was 0 for both groups — commonly seen in patients after repair of chronic Achilles tendon rupture [22,26,27].

The SF-36 questionnaire surveys overall wellbeing through eight overarching concepts, namely physical function, role limitation due to injury, bodily pain, social functioning, general mental health, role limitations due to emotional problems incurred due to this injury, vitality and general health perception. The SF-36 is therefore well poised to demonstrate the impact surgical repair of chronic Achilles tendon ruptures on the general health of the patient [29]. Our findings demonstrate significant improvements in physical function, reduction in physical limitation, pain and improvements in social function — contributing to significant

Table 3
Comparing both intra-operative and after surgery factors between both study groups.

		FHL only	FHL with turndown flaps	P≤
Intra-operative factors				
Duration of procedure, min		73 ± 23	100 ± 21	0.001*
Factors after surgery				
Length of stay, days		2 ± 3	2 ± 2	NS
Complications	Soft tissue, n	0 (0%)	2 (10%)	
	Re-rupture, n	0 (0%)	0 (0%)	

* Statistically significant.

improvement in the overall PCS score (Table 2). Most studies to date show similar findings with most patients returning to pre-injury activities [22,27].

Rates of re-rupture in open repair of acute Achilles tendon rupture is quoted to be as low as 1.7–3.6% [9,33–35]. In the repair of chronic ruptures, rates remain low. A retrospective review in 2006 achieved zero re-ruptures in their cohort of chronic Achilles tendon repair (n = 10) over a mean follow up duration of 4.5 years [36]. Our study yielded similar findings with both cohorts not experiencing any re-ruptures over a follow up of 12 months (Table 3).

In addition, complications associated with the incision site is a common complication of Achilles tendon repair. Incisional site complications have been noted to occur between 2.2–16% of cases [33–35]. At one year, FHL transfers alone had no complications. However, turndown flaps augmented by FHL transfer had two reported complications. The need for additional procedures in an already technically challenging procedure could account for the higher rate of complications seen.

It is imperative that we address the major significant difference between both study groups — the significantly longer operative duration in turndown flaps augmented with FHL transfer. Patients in Group 2 were subjected to almost a third more operative time compared to subjects in Group 1 with yet comparable outcomes (Table 3). Almost all studies to date on the management of chronic Achilles tendon ruptures are focused surgical outcomes and there is a lack of data regarding operative time for each procedure. Despite this, it can be appreciated that turndown flaps augmented with FHL would require more time due to the additional procedures. It has long been documented that prolonged anaesthetic time increases complication rates [37–40]. In view of comparable functional outcomes, this study suggests that FHL transfer is an acceptable and efficient technique for the repair of chronic Achilles tendon ruptures.

While our findings support the use of FHL transfer, there may be some merits in performing turndown flaps. Within literature, turndown flaps have been employed to bridge large defects [17,21]. The use of turndown flaps was first described in 1953 through the use of a central turndown flap [10]. The use of peripheral turndown flaps like the technique described in this study was subsequently introduced in 1959 [41]. Turndown flaps are popular as it advances local tissue to cover the rupture gap and has been widely applied in the treatment of acute injuries. Local advancement flaps are often augmented with tendon transfers, especially in the setting of chronic tendon rupture as turndown flaps are associated with altered contractility and fatty infiltration of the gastrocnemius–soleus complex [42,43]. The addition of tendon transfer contributes to the strength and integrity of the repair [27,44]. Therefore, turndown flaps may potentially be better suited for massive ruptures [11].

This strengths of this study is that it is the first to compare between techniques currently applied in practice. In a field with a wide array of techniques demonstrating comparable outcomes, futures studies should strive to compare outcomes of each technique — thereby guiding best practice. We also encourage our colleagues to comment on intra-operative factors, in particularly operative times required for their respective techniques to help set operative-standards and support the use of expeditious surgical techniques in a technically-challenging procedure.

The limitations of our study include the small cohort size and short duration of follow up. Re-rupture may only be apparent after many years [33,34]. Long-term follow-up may be needed to better compare outcomes of both techniques. A potential source of selection bias stems from the study design. As a retrospective cohort study, patients were not randomly divided to two study groups. A prospective randomised controlled study would provide greater evidence in determining best practice. Finally, we acknowledge that there is limited evidence validating the AOFAS Ankle-Hindfoot score in complex ankle and hindfoot injury [28,45] — this may be an area for further evaluation and validation.

5. Conclusion

The stand-alone FHL transfer technique should be considered when repairing chronic Achilles tendon ruptures in view of its significantly shorter operating time with comparable outcomes. FHL transfer has proven to be an efficient and reliable technique with low rates of complications. More studies should strive to compare repair techniques and thereby define best practice for this technically challenging repair.

Conflicts of interest

The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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