

Comparison of Gastrocnemius Turn Flap and Hamstring Graft for the Treatment of Kuwada Type 3 Chronic Ruptures of the Achilles Tendon

A Retrospective Study

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Background: Chronic Achilles tendon rupture is challenging to repair, and many procedures have been suggested to fill the gap that separates the distal and proximal ends of the ruptured tendon.

Purpose: To compare clinical outcomes between the free hamstring graft (HG) and gastrocnemius turn flap (GTF) procedures in the treatment of chronic Achilles tendon rupture.

Study Design: Cohort study; Level of evidence, 3.

Methods: This retrospective study included 26 patients (25 males, 1 female; mean age, 36.7 years; range, 22-53 years) with Kuwada type 3 chronic rupture of the Achilles tendon. A total of 11 patients underwent GTF surgery, whereas 15 patients underwent HG surgery. Follow-up assessments were conducted at 3, 6, and 12 months postoperatively.

Results: The complication rate was significantly higher in the GTF group compared with the HG group (27.2% vs 6.6%, respectively; $\chi^2 = 12.462$; $P = .001$). At the 3-month follow-up, the degree of ankle dorsiflexion was significantly higher in the HG group than in the GTF group ($t = 3.144$; $P = .004$). At 6-month and 1-year follow-up, no significant differences in ankle function were seen between the 2 groups.

Conclusion: Hamstring tendon graft is associated with better early recovery of dorsiflexion compared with GTF. The long-term clinical outcomes of these 2 procedures are similar.

Keywords: chronic Achilles tendon rupture; gastrocnemius turn flap; hamstring graft; functional outcome

Achilles tendon rupture is a common sport injury, and its incidence has increased in recent years.¹⁴ In chronic cases (>6 weeks), tissue fibrosis and necrosis occur at the ruptured site of the Achilles tendon, thereby increasing the difficulty of surgery. Chronic rupture of the Achilles tendon can be divided into 4 types, according to the criteria by Kuwada¹³: type 1, partial rupture; type 2, complete rupture with a gap (ie, separation between the distal and proximal ends of the ruptured tendon) less than 3 cm; type 3, complete rupture with a gap of 3 to 6 cm; and type 4, complete rupture with a gap larger than 6 cm. Defects in types 1 and 2 Achilles tendon ruptures can be reattached through V-Y advancement. However, for types 3 and 4 Achilles tendon ruptures, it is

difficult for V-Y advancement to provide enough tendon length to fill the gap. Even if the gap is filled through V-Y advancement flaps, the tension of the Achilles tendon does not usually meet the patient's functional requirements after surgery.⁷ Therefore, tendon graft and flap surgery are ideal choices for the repair of Achilles tendon ruptures.⁴ This study compared the effects of the free hamstring graft (HG) and gastrocnemius turn flap (GTF) procedures in patients with Kuwada type 3 chronic rupture of the Achilles tendon.

METHODS

Patients

This was a retrospective study, so patients were not selected by random methods. We had used the GTF

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technique until November 2013. At that point, the surgery group reviewed the previous cases and found that flap surgery might entail a higher rate of complications, so we changed our procedure to use the tendon graft technique. This retrospective study included 36 patients with Kuwada type 3 chronic Achilles tendon rupture who were treated with either GTF surgery or HG surgery in our hospital from September 2012 to December 2014. Inclusion criteria were as follows: (1) the time between the onset of the injury and diagnosis was more than 6 weeks; (2) no nonoperative treatment was used, such as splint or walking brace; (3) no surgical treatment that involved the Achilles tendon was performed; and (4) the patient had no history of Achilles tendinitis calcification or steroid treatment. We included only type 3 cases because type 4 ruptures may be too long to repair with GTF surgery and may need a graft to enhance the flap. Exclusion criteria were (1) non-union Achilles tendon rupture with nonoperative treatment; (2) nonhealed or healed rupture with elongated Achilles; and (3) re-rupture cases.

Using these criteria, we excluded 5 patients, and thus a total of 31 patients were selected for the research. The study meets the *International Journal of Sports Medicine* ethical standards document.⁹ All participants in the study signed the informed consent forms. This study was approved by the ethics committee of the local hospital.

Surgical Procedure

Under spinal anesthesia, patients underwent surgery with a tourniquet in the prone position. For patients undergoing GTF surgery, a posteromedial incision (approximately 10 cm long) was performed. After debridement of the fibrosis tissue, the length of the separation was measured with the ankle in neutral position. A long-segment flap of gastrocnemius aponeurosis was made with the pedicle, as described by Bosworth.² The length of the flap depended on the size of the Achilles defect. The pedicle of the flap was no larger than half of the entire proximal end of the tendon. The aponeurosis flap was sutured to the distal end of the Achilles tendon by use of the Bonell technique (No. 2 FiberWire suture; Arthrex). After suturing, No. 2-0 Ethibond (Ethicon) was used for reinforcement (Figure 1).

For patients who underwent HG surgery, an incision was performed in the anteromedial pes anserinus. After the sartorius aponeurosis was excised, the semitendinosus and gracilis were exposed and harvested. The surgeon made 2 small incisions to expose the proximal and distal ends of the Achilles tendon. Then, the graft was sutured to the proximal end of the Achilles tendon and passed through the subcutaneous tunnel to the distal end. The distal end of the

Achilles tendon was dissected until the calcaneal tuberosity was exposed. A bone tunnel was made for the graft. The tendon graft was passed through the bone tunnel, tension was adjusted, and the tendon was fixed with a BioScrew (Arthrex). Simple sutures were used to reinforce the graft and the distal end of the Achilles tendon (Figure 2).

In both HG and GTF groups, we used the same method to determine the tension of the Achilles tendon during surgery, by positioning the patient's leg 90° perpendicular to the ground with the foot positioned at 30° plantarflexion. Postoperative management was the same for both groups.

Postoperative Management

Antibiotics were administered to prevent infection. A splint positioned at slight plantarflexion (10°) was used to fix the ankle for 2 weeks, and weightbearing boots with adjustable wedges were used for another 2 weeks (patients used crutches to off-load their body weight). After wedges were removed, the weightbearing boots were used for walking training for 2 weeks. After the boots were removed, the patients wore sports shoes to walk normally. Generally, patients started jogging at 3 months after the operation. At 6 months after the operation, the patients were allowed to participate in competitive sports.

Postoperative Follow-up

Patients were followed up at 3 months, 6 months, and 1 year postoperatively, after which they underwent follow-up once a year. The average final follow-up time was 29.5 months (range, 24-42 months). During the follow-up, physical examination was performed, and the Leppilahti score¹¹ and American Orthopaedic Foot & Ankle Society (AOFAS) hindfoot score were recorded. For measurement of ankle motion, the patient was in the supine position with the knee in full extension, and an electronic angle ruler was used to measure the dorsiflexion and plantarflexion angles of the ankle. In our research, we do not use measurements of the uninjured side in the functional comparison, because in these chronic cases, the time between surgical treatment and injury varies. As well, the muscle strength of the injured and uninjured sides may differ greatly ($t = 2.412$; $P = .039$), and a confounding bias may be present in case comparison. So we compared only the pre- and postoperative function.

Statistical Analysis

Statistical analyses were performed by use of PASW 18.0 statistical software (SPSS Inc, IBM). Quantitative data

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Ethical approval for this study was obtained from Peking University Shenzhen Hospital, Shenzhen, Guangdong, China.

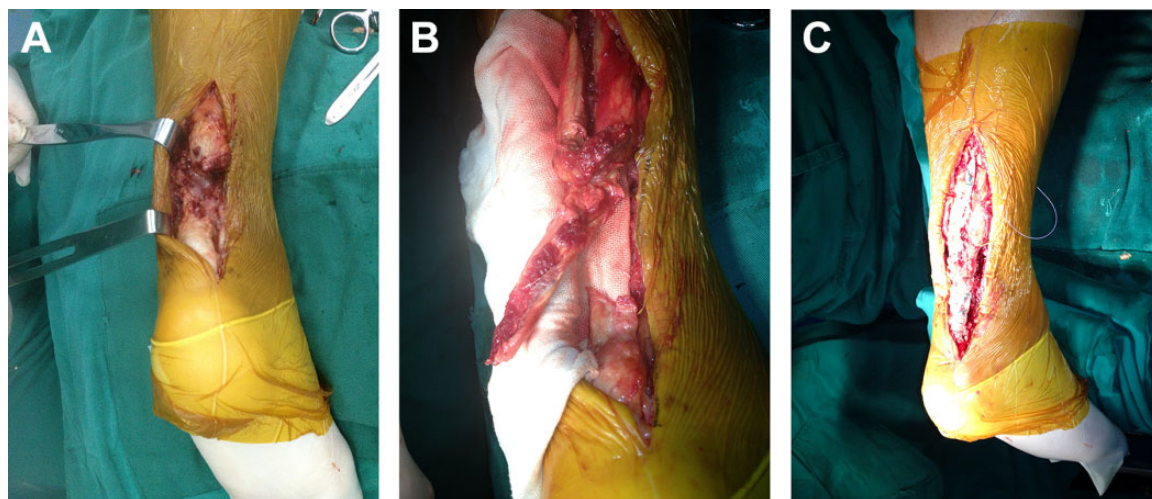


Figure 1. Illustration of the gastrocnemius turn flap procedure. (A) An incision is made to reveal the gap between the distal and proximal ends of the Achilles tendon. (B) After debridement of the scar tissue, the gastrocnemius flap is turned down. (C) The gastrocnemius flap is sutured to fill the gap.

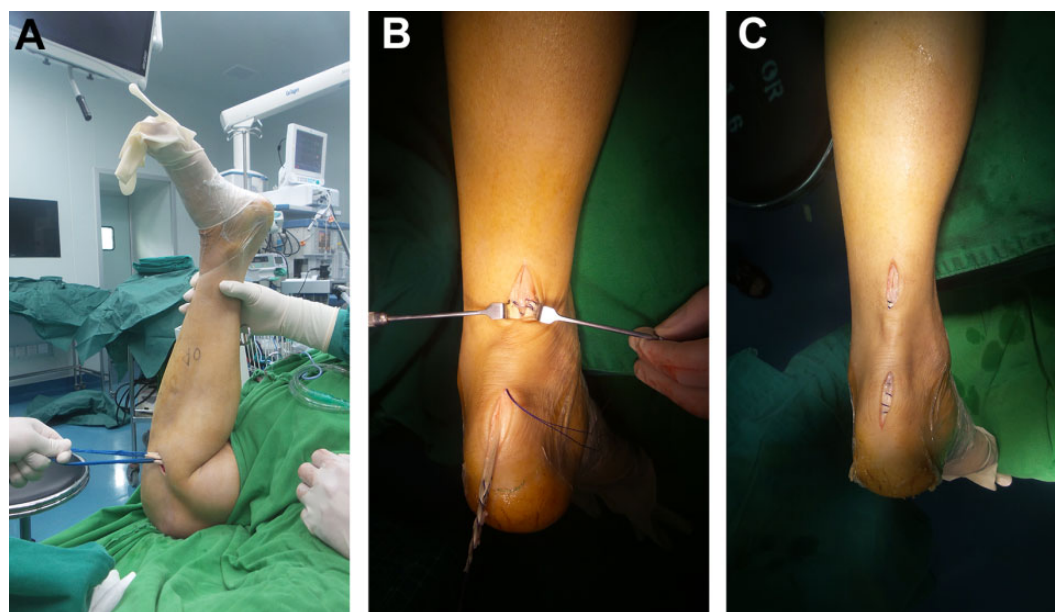


Figure 2. Illustration of hamstring graft procedure. (A) The hamstring autograft is removed with the patient in the prone position. (B) The defect is not incised, and the tendon is percutaneously passed through the gap. (C) After fixation of the graft, the continuity of the Achilles tendon is restored.

are presented as mean \pm SD. We used a *t* test to compare the difference in means between groups. Categorical data are expressed in percentages, and chi-square tests were used to compare differences between groups. A *P* value less than .05 was considered statistically significant.

RESULTS

Among the 31 patients, 5 moved to another city and were lost to follow-up. Ultimately, a total of 26 patients

were included in the present study. Of these patients, 25 were male and 1 was female, and the mean age (\pm SD) was 36.7 ± 5.9 years (range, 22-53 years). Among the patients, 11 underwent GTF surgery and 15 underwent HG surgery (Table 1). In comparing the 2 surgical procedures, we did not compare the involved ankle with the uninjured side.

The mean surgical time was not significantly different between the 2 groups (GTF, 63.1 ± 7.8 minutes; HG, 57.6 ± 9.2 minutes; $t = 1.678$; $P = .183$). We defined post-operation complication according to Paavola et al.²¹

TABLE 1
Clinical Information of Patients Who Underwent GTF and HG Surgery^a

	GTF	HG	P
Sex, male/female, n	11/0	14/1	
Age, y	33 ± 5.7	36 ± 4.1	.373
Separation, cm ^b	4.9 ± 0.7	5.0 ± 0.9	.906
BMI	24.3 ± 2.7	25.7 ± 2.2	.163
Time of therapy after injury, mo	7.6 ± 2.1	11.5 ± 4.9	.041
Follow-up time, mo	29.0 ± 4.8	29.9 ± 5.8	.545
Strength of uninjured side, N	431.4 ± 40.1 (378-499)	439.8 ± 26.1 (389-453)	.530
Strength of injured side, N	321.9 ± 36.5 (265-372)	317.4 ± 41.0 (239-401)	.778

^aValues except for sex are expressed as mean ± SD with ranges in parentheses. BMI, body mass index; GTF, gastrocnemius turn flap; HG, hamstring graft.

^bGap separating the distal and proximal ends of the ruptured tendon.

All patients recovered, and no rerupture cases occurred during the follow-up period. Saphenous nerve injury occurred in 1 patient in the HG group during hamstring harvesting. Impaired wound healing occurred in 2 patients in the GTF group, and the wounds healed after dressing change. Deep vein thrombosis occurred in 1 patient in the GTF group and was relieved by the administration of low-molecular weight heparin. The complication rate was significantly higher in the GTF group than in the HG group (27.2% [3/11] vs 6.6% [1/15], respectively; $\chi^2 = 12.462$; $P = .001$).

At the 3-month follow-up, the degree of dorsiflexion was significantly higher in patients in the HG group than in the GTF group ($t = 3.144$; $P = .004$). No significant differences between groups were noted in plantarflexion ($t = 1.301$; $P = .206$), AOFAS hindfoot score ($t = 1.415$; $P = .170$), or Leppilahti score ($t = 0.600$; $P = .554$) at 3 months. At the 6-month follow-up, no significant differences were seen in ankle dorsiflexion ($t = -0.621$; $P = .540$), ankle plantarflexion ($t = 0.865$; $P = .365$), AOFAS hindfoot score ($t = 1.442$; $P = .165$), or Leppilahti score between these 2 groups. At 1 year after the operation, 9 patients in the GTF group and 12 patients in the HG group had returned to their original level of sport. No significant difference was found between these groups at 1 year ($\chi^2 = 0.794$; $P = .373$). Furthermore, at 1 year, no significant differences were noted in ankle dorsiflexion ($t = -0.326$; $P = .747$), ankle plantarflexion ($t = 1.335$; $P = .317$), AOFAS hindfoot score ($t = -0.897$; $P = .379$), or Leppilahti score ($t = -0.326$; $P = .747$) between these 2 groups (Table 2).

DISCUSSION

For chronic Achilles tendon rupture, current surgical methods mainly concentrate on retaining the length and elasticity of the tendon. For patients with Kuwada type

TABLE 2
Functional Outcomes at the Different Follow-up Points in the GTF and HG Groups^a

	3 Months	6 Months	1 Year
Dorsiflexion, deg			
GTF	11.6 ± 1.1	21.1 ± 2.5	24.8 ± 1.9
HG	15.1 ± 1.2	21.9 ± 2.3	25.8 ± 2.5
<i>t</i>	3.144	-0.621	-0.632
<i>P</i>	.004	.540	.477
Plantarflexion, deg			
GTF	31.5 ± 3.1	39.2 ± 3.7	41.1 ± 1.7
HG	32.1 ± 2.8	40.7 ± 3.3	41.4 ± 2.0
<i>t</i>	1.762	1.335	2.312
<i>P</i>	.739	.317	.806
AOFAS score			
GTF	81.2 ± 4.9	94.5 ± 3.1	92.6 ± 3.0
HG	78.6 ± 4.4	92.9 ± 2.7	93.5 ± 2.1
<i>t</i>	1.415	1.442	-0.897
<i>P</i>	.170	.165	.379
Leppilahti score			
GTF	80.8 ± 4.5	92.9 ± 2.7	94.7 ± 3.1
HG	79.7 ± 5.2	93.5 ± 2.3	95.1 ± 3.1
<i>t</i>	0.600	-0.628	-0.326
<i>P</i>	.554	.536	.747

^aValues are expressed as mean ± SD. AOFAS, American Orthopaedic Foot & Ankle Society; GTF, gastrocnemius turn flap; HG, hamstring graft.

1 or 2 injury, soft tissue release and V-Y advancement can repair the defect. However, if the defect is longer than 6 cm (Kuwada type 3), these methods may not be sufficient to achieve the ideal length and tension. Thus, a graft is required to fill the gap. Free tendon grafting, flexor hallucis longus transfer, and GTF are generally used. As a pedicle graft, the gastrocnemius muscle flap has a good blood supply, and the width and length of the flap can be adjusted during the operation after assessment of the defect.¹⁹ Among types of open surgery, GTF is widely used and has provided good results. At long-term follow-up (>5 years), patients have satisfactory AOFAS scores (average, 98.5),²³ and most return to their previous level of activity.⁵

However, because it is an open surgery, the GTF procedure may increase the risk of impaired wound healing. In this study, the complication rate was significantly lower in patients in the HG group than in the GTF group. Thus, as reported by Highlander and Greenhagen¹⁰ and Saxena et al,²² the risk of impaired wound healing was higher with GTF surgery. We found that wound complications occurred in 2 patients in the GTF group, which may be related to the long incision needed for the gastrocnemius flap. A meta-analysis that included 10 comprehensive randomized controlled clinical studies revealed no significant difference in rerupture rates between closed Achilles tendon surgery and open Achilles tendon surgery, although open surgery was associated with a slightly higher risk of wound complication (relative ratio, 9.32; 95% CI, 1.77-49.16).¹² In the HG procedure, the graft passes through the subcutaneous tunnel to the defect instead of through a

long incision, thereby reducing the risk of wound complication.

The degree of dorsiflexion motion at 3 months postoperatively was significantly higher in the HG group than in the GTF group, however at 6 months and 1 year after surgery, no significant differences were seen in ankle joint function between these 2 groups. In our series, the mean \pm SD length of defects (ie, gap) was 4.9 ± 0.7 cm in the GTF group and 5.0 ± 0.9 cm in the HG group. No statistically significant differences were seen ($P = .906$). No matter what kind of reconstruction surgery is performed, early postoperative ankle motion is important to functional recovery.¹ In our study, we noticed that in the early postoperative stage, tendon grafting held an advantage regarding ankle range of motion under the same rehabilitation protocol. This may be because the free tendon graft tension had better elasticity compared with the gastrocnemius aponeurosis flap.²⁴ Alternatively, it is possible that the tendon graft experienced creep and was elongated during postoperative exercise.²⁶ We assume that 2 reasons may contribute to the difference between the 2 groups. First, with a free tendon graft, tendon adjustment is easy during surgery: We can adjust the tension and length of the graft before fixation of the interference screw, whereas the GTF procedure offers less potential for tension and length adjustment. Second, free tendon graft may experience biological processes such as creep, host cell repopulation, reshaping, and collagen formation.²⁵ These biological processes may contribute to tendon adaptation to the new environment, especially biomechanical tension. This may be the potential benefit of the tendon graft.

Another option for tendon graft is the flexor hallucis longus (FHL). The FHL tendon can be obtained by minimally invasive endoscopic surgery¹⁶ and can provide good function.^{8,15} However, FHL transfer has been associated with increased risk of vascular nerve injury,²⁰ decreased hallux function,³ decreased strength of the FHL tendon, and a decline in toe grip strength.⁶ Thus, we did not choose FHL transfer as our goal of comparison. Compared with the FHL, the free hamstring is relatively easy to access and would less likely damage the foot muscle motor unit. If the gracilis muscle is not sufficient because of serious defects or the small diameter of the tendon, the semitendinosus can be obtained as a supplement in the same incision.

Maffulli and Leadbetter¹⁷ reported in 2005 that free gracilis graft resulted in good clinical outcomes in 21 patients with chronic rupture of the Achilles tendon who had a defect larger than 6 cm. In 2012, Maffulli et al¹⁸ improved this technique by using minimally invasive percutaneous surgery. In this procedure, 2 minimal incisions were made at the proximal and distal ends, and the free tendon was passed through a subcutaneous tunnel to the position between the gap, thereby avoiding the middle incision and contracture of the skin and reducing wound complications. This method resulted in satisfactory outcomes in 14 of 15 cases after a follow-up period of 10.9 years, suggesting that percutaneous free hamstring transplant is associated with good long-term clinical outcomes and lower risk of wound

complications. In the current study, results showed a lower risk of complications and better early ankle motion.

CONCLUSION

In our study, the HG procedure had a lower risk of complications and provided better ankle dorsiflexion motion at an early stage after surgery when compared with the GTF procedure. After rehabilitation, the clinical outcomes of the 2 procedures were similar.

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