

Case Report

Return to play after Achilles tendon rupture in elite athletes by Uchiyama surgical repair technique

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ARTICLE INFO

Keywords:

Achilles tendon
Heel raise
Heel raise height
Return to play
Toe height distance

ABSTRACT

Background: Modification of the Achilles tendon repair technique accomplish a high return-to-play rate at the early period.

Case presentation: This study involved sixteen elite athletes with Achilles tendon rupture were treated using the Uchiyama method, which adjusted the total tendon length via Tsuge and half-Bunnell sutures. Postoperative clinical outcomes, return-to-play time, accomplishment time of heel raise abilities were measured. The tendon functions were also evaluated: heel raise height difference (HRH) in single-leg heel raise and toe height distance (THD) between bilateral feet in the prone and knee-bended positions. The mean return-to-play time was 22.4 weeks. All athletes returned to their original activities, with 94 % (15/16) returning within seven months. The average achievement time of single-leg heel raise was 10.8 weeks. The average THD and HRH were 0.4 and 0.5 cm.

Conclusions: Elite athletes were able to accomplish a return-to-sports in the early period, with a reliable recovery of the heel-raise function by Uchiyama Achilles tendon repair technique.

Level of Clinical Evidence: Level 4, Case series.

1. Introduction

According to a systematic review, approximately 25 % of professional athletes have not returned to their respective sport after an Achilles tendon (AT) rupture [1]. Among those who were able to return to compete professionally, the average time of return-to-play (RTP) was 11 months. To accomplish early return-to-sports, Uchiyama et al. introduced a tendon repair technique [2]. This original modification enables to endure early weight bearing, range of motion exercise, and achievement recovery in approximately five months. The purpose of this study was to evaluate postsurgical outcomes of the Uchiyama AT repair technique applying for elite athletes who required for an early return-to-sports, while maintaining high performance levels.

2. Materials and methods

Between January 2011 and July 2020, a retrospective review of 16 elite athletes who underwent surgical repair for unilateral AT rupture in our institution was performed. The elite athletes are defined as Japan league players from the correspond sport categories or professional

dancers in this series. All patients underwent open AT repair using the Uchiyama method [2]. The cases consisted of six women and 10 men with a mean age of 24.1 (range, 18–37) years. The involved sports or physical activities of the patients included soccer (n = 3), classical ballet (n = 3), basketball (n = 2), badminton (n = 2), gymnastics (n = 2), and one case each for track and field, American football, handball, and judo (Table 1). All study procedures involving human participants were in accordance with the ethical standards set by the research committee and with the 1964 Helsinki Declaration. Informed consent was obtained by the investigators from all participants after the purpose of the study was thoroughly explained. We investigated clinical outcome from toe height distance (THD) and heel raise height difference (HRH), which were measured five and six months after surgery (Fig. 1A and B), and the time of RTP. Return time was defined as the time elapsed in weeks before returning to baseline functional activity or competition. This was determined solely by patients' declaration. The average postoperative follow-up period was 4.6 (range, 2–10) years, which were likewise based on individual patient accounts.

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<https://doi.org/10.1016/j.joscr.2023.09.015>

Received 20 June 2023; Received in revised form 31 August 2023; Accepted 19 September 2023

Available online 3 November 2023

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Table 1
Patients' demographic characteristics, return time after surgery, and status after returning.

case	age	sex	event	level	RT	results after returning
1	23	M	football	JL	21	winning member
2	23	M	soccer	JL	21	winning member
3	26	M	soccer	JL	21	retired in 3 years
4	18	F	gymnastics	JL	21	victory by event
5	24	F	gymnastics	JL	23	6th in all japan
6	22	F	basketball	JL	34	Japan national team player
7	19	F	basketball	JL	29	Japan national team player
8	28	F	badminton	JL	21	champion of all Japan senior competition
9	28	F	badminton	JL	23	3rd prize in all-japan game.
10	29	M	classical ballet	professional dancer	21	retired in 4 years
11	37	M	classical ballet	professional dancer	17	principal dancer
12	27	M	classical ballet	professional dancer	21	principal dancer
13	28	M	beach soccer	JL	17	2nd prize in the world cup
14	24	M	judo	JL	21	2nd prize in all-japan game
15	18	M	athletics	JL	27	continued for 2 years
16	26	M	handball	JL	27	continued for 3 years

JL:Japan League RT:Return time(week).

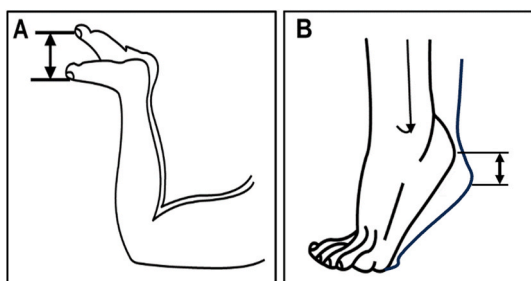


Fig. 1. (A) Toe height distance difference (THD) was defined as the distance difference between at the height of bilateral thumb nail tips in the prone and knee bending position; (B). Heel raise height difference (HRH) was defines as the distance difference between floor and heel tips.

2.1. Surgical technique

Intraoperative tendon length control was achieved using Tsuge core suture [3] at approximately 5° plantar flexion angle (PFA) in the gravity equinus ankle position relative to the opposite limb (Fig. 2A). Each patient was laid prone on the operating table under general anesthesia. Surgical exposure was initiated with a 5 cm longitudinal incision along the medial margin of the affected tendon. First, the tendon length was controlled by adjusting the optimal PFA with a Tsuge suture (Fig. 2B). Second, prior to tendon repair preparation, both ruptured tendon ends were divided into three bundles at the proximal end and two bundles at the distal end via half-Bunnell-like suturing (Fig. 2C) [4]. Third, each bundle was pulled into the gutter of opposite sutured bundles (Fig. 2D). The paratenon was carefully repaired, followed by closure of the gastrocnemius aponeurosis.

2.2. Postoperative rehabilitation protocol

The rehabilitation protocol consisted of approximately two weeks of below-knee cast immobilization. Postoperative cast applied at the same plantarflexion angle with the intra-operative equinus position when the tendon was repaired.

On the fourth or fifth postoperative day, the initial non-weightbearing cast was changed into a walking cast that permitted full weightbearing. The walking cast with a rubber heel was applied at the slightly turning-back plantarflexion position.

Two weeks after surgery, the walking cast was changed to a hinged ankle-foot orthosis, which permits full active planter flexion but limits dorsiflexion. Active range of motion exercise was subsequently initiated. Double-leg heel raise exercises in the sitting position were initiated on the third week of recovery, and on standing position on the sixth week. After the orthosis was removed, jogging was permitted after single-leg heel raise was achieved. Multidirectional exercise was started after achieving 20 consecutive single-leg heel raises (20-HR). The decision to RTP was made by the team leader.

2.3. Postoperative evaluation

We researched the time of RTP, single-leg heel raise (S-HR), and 20-HR. THD and HRH, which are related to the side-to-side differences in the length of the AT, were measured as an index of muscle strength recovery (Fig. 1A and B).

3. Results

The average RTP time was 22.4 (range, 17–29) weeks. All athletes returned to their original activities, with 94 % (15/16) returning within seven months. One athlete with delayed RTP due to pain required 10 months to return to competition. The mean PFA at the end of surgery was +3.6° (range, 0–6) compared with the normal limb. No dorsiflexion ROM deficit was detected in the series at the time of recovery. The mean THD was 0.4 (range, 0–2) cm less than the non-affected limb. HRH deficit relative to the non-affected limb was 0.5 (range, 0–2) cm at the time of recovery. The average time of achieving S-HR and 20-HR activities were 10.8 (range, 8.5–14) and 13 (range, 10–18) weeks, respectively. There was a positive correlation between the time to acquire 20-HR and return time/RTP (Fig. 3).

4. Discussion

The main purpose of AT rupture repair is to recover plantar flexor strength. Weakness of planter flexion performance and decline heel-raise activity were evident after Achilles tendon repair [5], therefore clinical outcome in the AT rupture can be evaluated by the planter flexion strength recovery. Bäcker et al. stated that the treatment goals of AT rupture repair are to restore appropriate tension to the tendon, achieve normal baseline strength, and maintain functional soft-tissue length [6]. Our surgical repair method for AT rupture has been modified to enable early weight bearing and ROM training, and achieve recovery in approximately five months [2]. Sanada et al. reported that the average RTP with this method was 24.3 weeks, Toyooka et al. reported RTP after 22 (range, 13–29) weeks [7,8], and in our current study, it was 23.5 weeks. The recovery rate of the 16 elite athletes who underwent the Uchiyama method was 100 %. This technique likewise produced better RTP outcomes compared with results from a recent systematic review [1]. In our series, 15 cases (94 %) achieved RTP within seven months (average of 22.3 weeks), and only one case experienced delay. We assumed that functional rehabilitation using early ROM training and full weightbearing could be accomplished by adjusting tendon length and using multistranded suture repair.

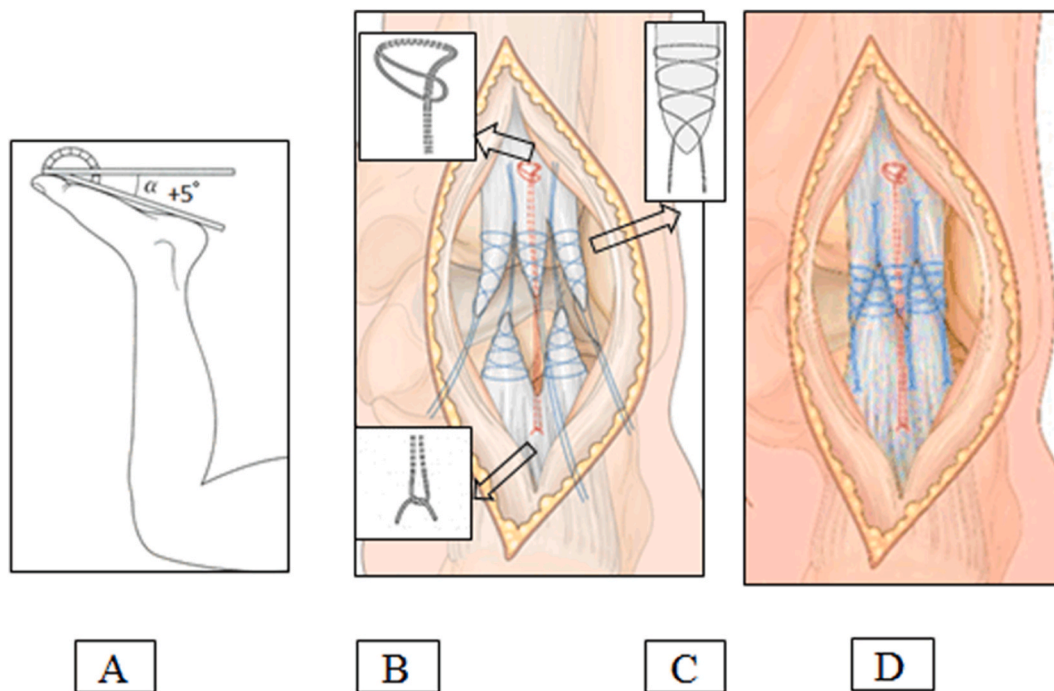


Fig. 2. (A) 5° more plantar flexion angle (PFA) in the gravity equinus ankle position to the opposite limb ($\alpha + 5^\circ$). (B) Tendon adjusted to an adequate length with a Tsuge suture using a 1-0 non-absorbable braided polyester Tevdek suture thread (Deknatel, Fall River, Mass, USA). Subsequently, a loop suture was used proximally and a single knot suture distally. (C) Each tendon end was divided into three proximal bundles and two distal bundles by half-Bunnell-like suturing using 2-0 Tevdek suture thread (D). Each bundle was pulled lightly and fixed to the other end of the tendon secured in a linear configuration fashion (“Half-mini-Bunnell” sutures: proximal bundles to the distal end and vice versa).

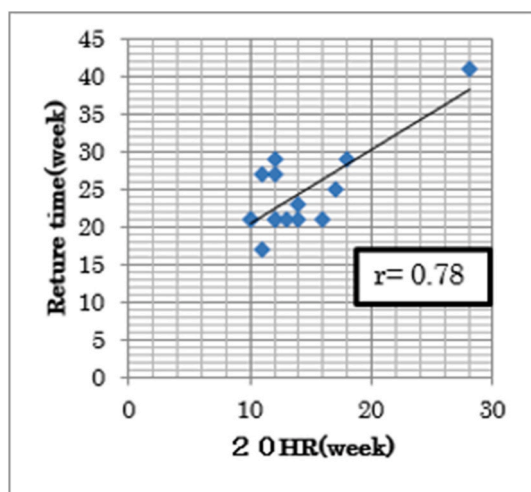


Fig. 3. Correlation between the time to acquire 20-HR and the RTP. 20-HR, 20 consecutive single-leg heel raise; RTP, return to play.

4.1. Muscle strength evaluation

A uniform measuring system may lead to better understanding of AT function and muscle strength evaluation after AT rupture repair [9]. According to Hislop et al., the triceps surae muscle strength is considered normal if 20-HR is achieved [10]. 20-HR evaluation can be a simple method to evaluate tendon endurance for stepping up activity level and muscle strength recovery. The average acquisition time of S-HR in this series is 10.8 (range, 8.5–14) weeks and the time to achieve 20-HR was 13 (range, 10–18) weeks. There was a positive correlation between the time to acquire 20-HR and the return time. Therefore, HR acquisition time is useful for postoperative evaluation after AT rupture repair

(Fig. 3). We used single-leg HR as an indicator to initiate running. 20-HR was used as an indicator of adequate endurance for comprehensive activities, and once achieved, agility and endurance exercise was started.

4.2. Tendon length adjustment

If the tendon is longer than normal, sufficient recovery of muscle strength cannot be achieved. There has been a consensus that adjusting the length of the AT is important for muscle recovery [11–13]. A systematic review by Diniz et al. reported on the influence of tendon elongation in biomechanical parameters [11]. According to Carmont et al., AT rupture may result in reduced plantar flexion strength. These changes may arise from AT elongation which can result to an increased plantar flexion angle at rest. Additionally, AT length correlates with HRH, which is considered as a simple and effective method to evaluate AT function one year after repair [12]. According to Silbernagel et al., side-to-side difference in maximum HRH can be explained by AT length differences in patients recovering from AT rupture. Additionally, minimizing tendon elongation is an important treatment goal when aiming for full return of function [13]. In other words, the major principle of muscle strength recovery in surgical treatment is tendon length adjustment. We use the plantar flexion angle (PFA) to estimate the length of the tendon intraoperatively (Fig. 2A). Since there is a positive correlation between HRH and THD (Fig. 4), HRH was used as an index to compare tendon length after surgery. In our series, PFA difference was set at $+3.6^\circ$ (range, $0-6^\circ$). According to the results, THD and HRH differences were minor when the PFA difference was set to $\geq 4^\circ$. We recognized that a PFA difference of $\geq 5^\circ$ should be the ideal adjustment angle.

5. Conclusion

With the Uchiyama tendon repair technique, elite athletes were able to accomplish a return-to-sports in the early period, with a reliable

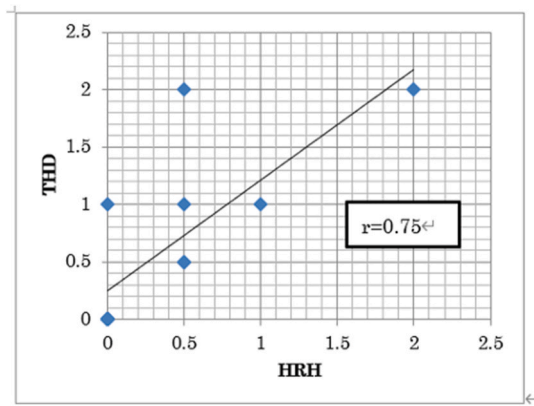


Fig. 4. Correlation between THD and HRH. THD, toe height distance; HRH, heel raise height.

recovery of the heel-raise function.

Disclosure of funding

There is no conflict of interest.

Ethical approval

All study procedures involving human participants were in accordance with the ethical standards set by the research committee of Iwai Medical Foundation (No. 20210510-2, May 10, 2021) and with the 1964 Helsinki Declaration. Informed consent was obtained by the

investigators from all participants after the purpose of the study was thoroughly explained.

References

- [1] Johns W, Walley KC, Seedat R, Thordarson DB, Jackson B, Gonzalez T. Career outlook and performance of professional athletes after achilles tendon rupture: a systematic review. *Foot Ankle Int* 2021;42(4):495–509.
- [2] Uchiyama E, Nomura A, Takeda Y, Hiranuma K, Iwaso H. A modified operation for Achilles tendon ruptures. *Am J Sports Med* 2007;35(10):1739–43.
- [3] Tsuge K, Ikuta Y, Matsuishi Y. Intra-tendinous tendon suture in the hand -a new technique. *Hand* 1975;7(3):250–5.
- [4] Bunnell S. The injured hand; principles of treatment. *Ind Med Surg* 1953;22(6):251–4.
- [5] Mullaney MJ, McHugh MP, Tyler TF, Nicholas SJ, Lee SJ. Weakness in end-range plantar flexion after Achilles tendon repair. *Am J Sports Med* 2006;34(7):1120–5.
- [6] Bäcker HC, Yenckel AJ, Trofa DP, Vosseller JT. Strength measurement after Achilles tendon repair. *Foot Ankle Spec* 2019;12(5):471–9.
- [7] Sanada T, Iwaso H, Fukai A, Honda E, Yoshitomi H. Comparison study of mini-incision versus original open technique of the half-mini-bunnell achilles tendon repair. *J Foot Ankle Surg* 2021;61(2):355–62.
- [8] Toyooka S, Takeda H, Nakajima K. Correlation between recovery of triceps surae muscle strength and level of activity after open repair of acute achilles tendon rupture. *Foot Ankle Int* 2017;38(12):1324–30.
- [9] Maquirriain J. Achilles tendon rupture: avoiding tendon lengthening during surgical repair and rehabilitation. *Yale J Biol Med* 2011;84(3):289–300.
- [10] Hislop HJ, Montgomery J, Connelly B. Daniels and worthingham's muscle testing: techniques of manual examination. sixth ed. Philadelphia, PA: WB Saunders; 1995.
- [11] Diniz P, Pacheco J, Guerra-Pinto F, Pereira H, Ferreira FC, Kerkhoffs G. Achilles tendon elongation after acute rupture: is it a problem? A systematic review. *Knee Surg Sports Traumatol Arthrosc* 2020;28(12):4011–30.
- [12] Carmont MR, Grävare Silbernagel K, Brorsson A, Olsson N, Maffulli N, Karlsson J. The Achilles tendon resting angle as an indirect measure of Achilles tendon length following rupture, repair, and rehabilitation. *Asia Pac J Sports Med Arthrosc Rehabil Technol* 2015;2(2):49–55.
- [13] Silbernagel KG, Steele R, Manal K. Deficits in heel-rise height and achilles tendon elongation occur in patients recovering from an Achilles tendon rupture. *Am J Sports Med* 2012;40(7):1564–71.