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Original Article

Sonographic Appearance of Surgically Repaired Achilles Tendons

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Background and purpose: Ultrasonography is an accurate and non-invasive imaging tool for assessing a ruptured Achilles tendon. This study attempts to correlate the sonographic appearances of surgically repaired Achilles tendons with their clinical outcomes.
Methods: Ten patients (3 men and 7 women) with surgically repaired Achilles tendons were enrolled in this study. All patients had unilateral Achilles tendon ruptures related to sports injuries. All were treated by the same orthopedic surgeon at a University Hospital, from January 1990 to September 2000. Patients had a mean age of 47.2 years (range: 22-66). Mean post-surgical duration was 6.0 years (range: 2.1-12.1). All patients had good Achilles functioning at their examinations. Ultrasonographic examination was carried out with a 10 MHz linear-array ultrasound transducer. Continuity, thickness, echogenicity, vascularity and mobility of the repaired tendons were assessed. The subjects' normal tendons were also examined as controls.
Results: All repaired Achilles tendons showed good sonographic continuity. Most had reduced echogenicity, and focal hypoechogenic areas were noted in 4 cases. None had increased vascularity. However, the diameters of the repaired tendons were significant thicker than controls (8.48±1.96mm vs. 4.90±0.54mm, $p < 0.01$). Only one subject had ultrasonographic morphology similar to her uninjured side, and she also had excellent mobility in her repaired tendon. All 10 patients had good clinical Achilles tendon performance.
Conclusions: Morphological changes in repaired Achilles tendons persist for many years. There was no correlation between sonographic appearance and clinical outcome. (Tw J Phys Med Rehabil 2008; 36(1): 23 - 30)

Key Words: ultrasonography, Achilles tendon, surgery

INTRODUCTION

The Achilles tendon is the largest and strongest tendon in the human body, and most of its injuries are sports related.[1] Clinical Achilles examination is confounded by plantar flexion compensation from the posterior tibial, peroneal, and plantar muscles.[2] Both ultra-

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sonography and magnetic resonance imaging can diagnose and monitor Achilles injuries accurately.[3-7] Ultrasonography is a non-ionizing imaging tool that has proven itself ideal for assessment of pathological muscle and tendon conditions, such as Achilles rupture.[8-10] It has many advantages, including real-time imaging, convenience, cost-effectiveness and dynamic viewing, making it the most popular assessment tool for Achilles injuries.[9,11]

Ultrasonography has been used to evaluate Achilles tendons after surgical repair.[12] Sonographic findings have been shown to be in line with histological evaluations.[9] The authors of that study suggested that ultrasound would prove importance in Achilles assessment. Some studies have shown that decreased tendon gliding and echogenic changes correlate with clinical outcomes. However, Rupp et al., examined 60 patients that underwent Achilles surgery and found poor correlation between sonography and clinical outcome.[4] This study attempts to define the sonographic images of surgically repaired Achilles tendons and clarify their relationships with clinical outcomes.

MATERIALS AND METHODS

Ten patients (3 men and 7 women) with complete Achilles tendon ruptures (all sports related) that had been surgically repaired were retrospectively enrolled in this study. All were treated by the same orthopedic surgeon at a University Hospital (from Jan. 1990 to Sep. 2000). Subjects had a mean age of 47.2 years (range: 22-66). Injuries were seven lefts and three rights. All patients underwent medial paratenon tendon repair. End-to-end running sutures with number one Dexons were performed. Short leg casts in 20 degree equinus positions of the ankle joints were applied immediately after surgery and remained on for two weeks. They were then changed to casts that positioned the ankles neutrally that remained for four weeks. Patients with bilateral injuries, open wounds or infections were excluded. No subjects suffered from further Achilles trauma.

Sonography was performed using a 10 MHz real-time linear-array transducer (HDI 5000; Advanced Technology Laboratories, Bothell, WA, USA). All examinations were performed by the same experienced sonographer. Patients were examined in the prone position with the feet hanging over the edge of the scanning table. All sonographic examinations and measurements were performed with ankles in the neutral position (Figure 1). Continuity, anterior-posterior diameter and echogenicity were recorded. Achilles vascularity was quantitatively evaluated by power Doppler. Repaired tendon mobility was assessed by dynamic study. Opposite Achilles tendons were examined as controls.

Examination began with a longitudinal scan for the control and then the repaired tendons. Achilles tendon continuity was also checked. If there was a focal hypoechoic area within the tendon, its area was measured. Echogenicity was then determined, with focus on local hypoechoic areas. Anterior-posterior diameter was measured at 1, 2, 3 and 4 cm proximity to the tendon's calcaneal insertion. Vascularity was determined at 85% gain in the power Doppler mode. The transverse view was scanned at the calcaneal insertion level. Dynamic longitudinal study was performed to assess motion and gliding conditions for the repaired tendons with passive movement of the ankle joint and isometric contraction of the calf muscle. Gliding characteristics between the Achilles tendon and the surrounding tissue were rated good when the tendon moved alone during passive ankle motion and rated limited when the surrounding tissue moved with the tendon. Simple finding scores (Table 1) were used to evaluate the clinical outcome. Any pain sensations reported when patients tiptoed (repeated five times) with one standing leg, stretched the ankle, compressed the Achilles tendon, did daily activities, or returned to sports, were noted. Each item of pain counted as one point. A 0-5 scale indicated excellent, very good, good, fair, poor, and very poor clinical outcome. According to simple finding scores of clinical outcome, the subjects were divided into asymptomatic group (0 scale) and symptomatic group (1-5 scale).

Wilcoxon rank sum test was used to evaluate diameter differences between the repaired and control tendons. Fisher's exact test was used to correlate clinical outcome with static sonographic morphology of diameter and echogenicity ($p < .05$). Fisher's exact test was also used to determine correlation between clinical outcome and dynamic sonographic gliding characteristics ($p < .05$).

RESULTS

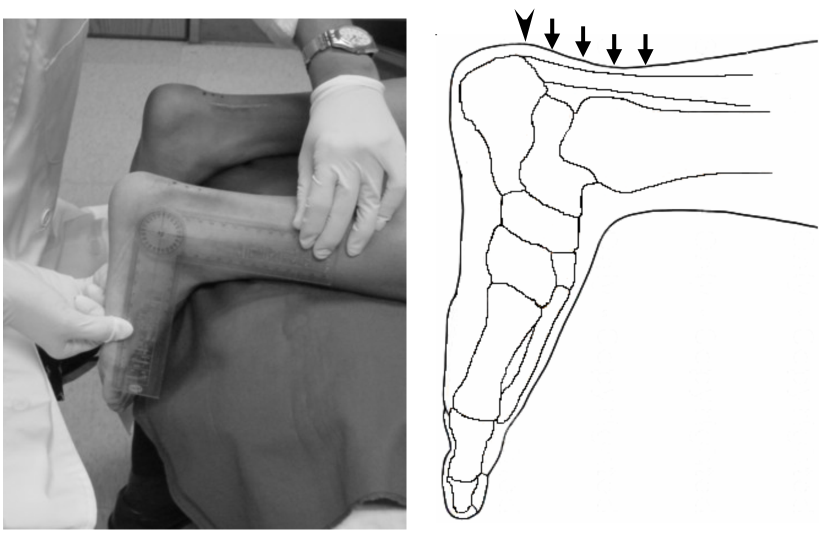
The average post-surgical duration was 6.0 years (range: 2.1-12.1). All repaired tendons had good continuity. However, focal hypoechogenic areas were detected in 4 subjects (Figure 2), but neither calcification spots nor focal hyperechogenic areas were found. Anterior-posterior diameters of the repaired tendons at 1, 2, 3 and 4 cm, proximal to the calcaneus bone, were 7.93 ± 1.75, 8.60 ± 2.21, 8.69 ± 2.09, 8.69 ± 2.08mm, respectively. Control diameters were 4.92 ± 0.88, 4.85 ± 0.56, 4.96 ± 0.50 and 4.86 ± 0.67mm, and all were significantly thinner than the repaired tendons ($p<0.01$, Table 2). Nine subjects had decreased general echogenicity (Figure 3), and none had increased vascularity. One female had almost the same sonography on both sides (Figure 4). She also had good gliding characteristics, while the others nine had limited gliding.

Clinical outcomes were excellent for 4 patients, very good for 4, and good in 2. There was no correlation between clinical outcome and ultrasound morphology ($p=0.4$). Moreover, there was still no correlation between clinical outcome and gilding characteristics ($p=0.4$).

Table 1. Simple finding score of subjects

	Induce pain	Not induced pain
Tiptoe with one leg standing for five times	1	0
Stretch the ankle	1	0
Compress the Achilles tendon	1	0
Do daily activity	1	0
Return to sport	1	0

Score: excellent - 0 point, very good -1 point, good - 2 points, fair - 3 points, poor - 4 points, very poor -5 points



(A) (B)

Figure 1. (A) Examination of the Achilles tendon: patients were placed in prone position with a goniometer to keep the ankle in a neutral position. (B) Illustration of Achilles tendon: the anterior-posterior diameter was measured at 1, 2, 3 and 4 cm (arrows) proximal to the tendon insertion of calcaneus (arrowhead).

Figure 2. Repaired Achilles tendon (between calipers) had good continuity of Achilles tendon with focal hypoechoic area (arrows).

Table 2. The anterior-posterior diameter of the repaired Achilles tendon at 1cm, 2cm, 3cm, and 4cm proximally to the calcaneus bone

Proximal to calcaneous bone	Control group	Operative group	*p* value by Wilcoxon test
1cm	4.92±0.88	7.93±1.75	0.007
2cm	4.85±0.56	8.60±2.21	0.005
3cm	4.96±0.50	8.69±2.09	0.005
4cm	4.86±0.67	8.69±2.08	0.005
Average	4.90±0.54	8.48±1.96	0.005

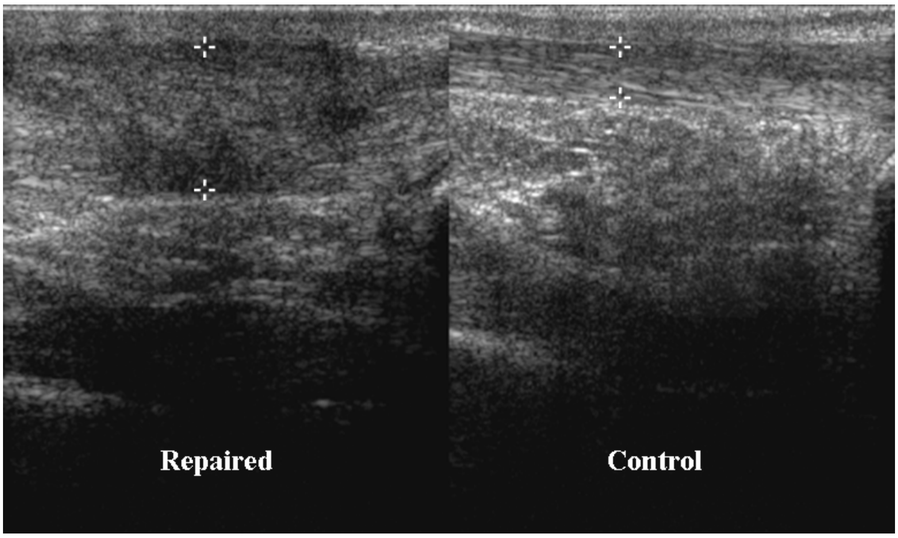


Figure 3. Repaired Achilles tendon: increased thickness of anterior-posterior diameter and generally reduced echogenicity. Calipers indicate the measurement of the tendon thickness.

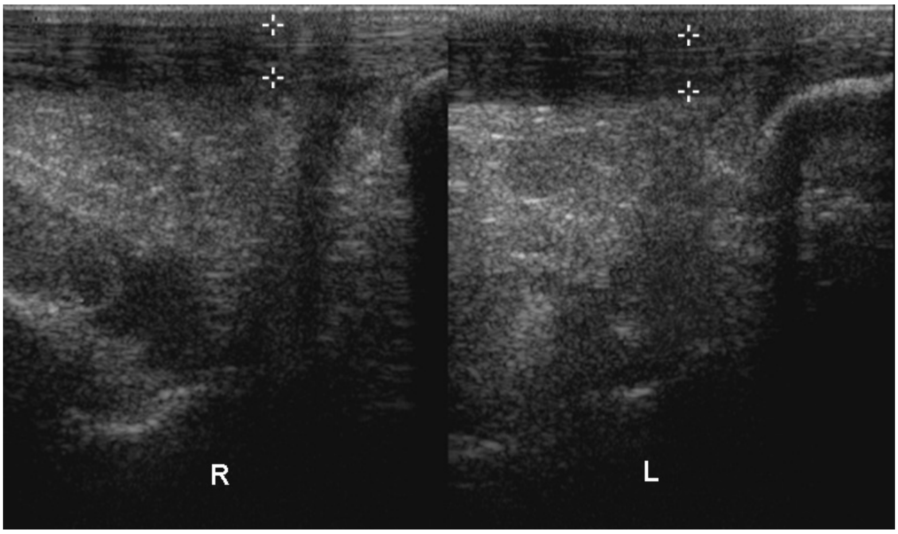


Figure 4. Left repaired Achilles tendon (between calipers) of the patient who started physical therapy two weeks after repair, with almost normal pictures when compared to sound side.

DISCUSSION

Results show that decreased echogenicity and increased thickness remain for at least two years for repaired Achilles tendons, which is in line with most previous reports.[4,5,13] Mean anterior-posterior diameters for normal Achilles tendons have been reported no greater than 6mm, with echogenic texture, while repaired Achilles tendon are greater than 6.5mm, with intervening hypoechogenic areas.[14-16] One biopsy specimen report demonstrated that repaired Achilles tendon have abnormal fiber structure, decreased collagen staining, increased non-collagenous extracellular matrix and focal variations in cellularity.[17] Martinoli et al., also found that repaired Achilles tendons showed a disorganized pattern of soft tissue and loss of fibrillar tendon structure pattern at 18 months after surgery.[13] This would explain the long-lasting echogenic alterations seen in this study. Furthermore, the increased thickness and ill-defined demarcation of the paratenon implies that scar tissue modification is not complete, even after many years.

The study showed no increased vascularity in the repaired Achilles tendons. Normally, the tendon injury healing process has three phases, with the first being angiogenesis with acute inflammation (1 to 7 days after injury), followed by proliferation with scar formation (7 to 21 days) and maturation and remodeling (three weeks to 1+years).[18] Each stage requires adequate blood supply for delivery and removal of cells and metabolic substrates at the injury site.[19] Vascular regression continues as the scar matures, and a fibrous, avascular scar will eventually form.[20]

Power Doppler ultrasound is an accurate microvasularity assessment tool.[15,16] Normal tendon blood flow cannot be visualized by Doppler due to the relatively low flow rate. However, newer vessels with higher flow rates can be visualized during the healing process.[21,22] Stephen et al., reported that an initial high flow state may exist within and around repaired tendons, and the total blood flow amount consistently and predictably decreases with time. That study concluded that vascular response may implicate the process of tendon healing.[23] The increased vascularity showed by power Doppler indicated a possible healing progress of repaired tendon, and persisted until avascular scar formation. However, patients in our study had no increased vascularity at 2 years after surgery. Healing may have been complete. Increased vascularity might indicate re-injury.

Nine of our ten subjects had poor gliding. Peritendinous adhesion has already been shown to be the major postoperative complication associated with tendon healing.[24] Scar formation provides initial physical continuity at the repair site, but scar proliferation attachment to surrounding tissue is not expected. Adhesion, formed by accumulated scar tissue around the repair site, interferes with tendon gliding.[25] Thus, scar formation control is essential to restoring tendon integrity. The only case in this study with nearly normal sonographic findings and good mobility of the Achilles tendon is a sprinter at the international level. She received early intensive rehabilitation two weeks after surgery and a well-tailored physical therapy program afterwards. After repair, she returned to her sport and performed well. Previous studies have shown that early functional rehabilitation has minor postoperative complications without increasing re-rupture or infection rates while increasing tendon density values, tensile strength, adhesion absence and patient satisfaction.[26,27] In addition, Weigl et al., found that early mobilization of the repaired tendon can enhance healing.[11] They used sonography to define the Achilles healing stages after tendomuscular lengthening in children with cerebral palsy and concluded that the healing process lasted for months, even years, and that early mobilization could improve tendon healing and shorten its duration. Nevertheless, other prognostic factors interfered with functional outcome, and further study may be done.

This study shows good functional recovery for all the repaired Achilles tendons although most of them had abnormal sonographic pictures. Many studies reported sonograms of repaired Achilles tendons showed changes of echogenicity and thickness. However, there are arguments for the values of ultrasonographic findings to predict the clinical outcomes. One study has indicated that ultrasonography effectively predicts clinical outcome for repaired Achilles tendons.[9] Our results are to the contrary, which is in line with most studies.[3,4,6,28,29] This supported that sonographic findings of repaired tendon were poorly correlated with clinical outcomes.

CONCLUSION

Ultrasonography can reveal long lasting morphological changes to repaired Achilles tendons. However, ultrasonographic features do not correlate with clinical outcome.

REFERENCES

1. Waterston SW, Maffulli N, Ewen SW. Subcutaneous rupture of the Achilles tendon: basic science and some aspects of clinical practice. Br J Sports Med 1997;31: 285-98.
2. Mann RA. Foot and ankle: biomechanics of the foot and ankle linkage. In: DeLee JC, Drez D, Miller MD, editors. DeLee and Drez's orthopaedic sports medicine: principles and practice. 2nd ed. Philadelphia: Saunders; 2003. p.2184-6.
3. Mathieson JR, Connell DG, Cooperberg PL, et al. Sonography of the Achilles tendon and adjacent bursae. Am J Roentgenol 1988;151:127-31.
4. Rupp S, Tempelhof S, Fritsch E. Ultrasound of the Achilles tendon after surgical repair: morphology and function. Br J Radiol 1995;68:454-8.
5. Bleakney RR, Tallon C, Wong JK, et al. Long-term ultrasonographic features of the Achilles tendon after rupture. Clin J Sport Med 2002;12:273-8.
6. Möller M, Kälebo P, Tidebrant G, et al. The ultrasonographic appearance of the ruptured Achilles tendon during healing: a longitudinal evaluation of surgical and nonsurgical treatment, with comparisons to MRI appearance. Knee Surg Sports Traumatol Arthrosc 2002; 10:49-56.
7. Bergin D, Morrison WB. Postoperative imaging of the ankle and foot. Radiol Clin North Am 2006;44:391-406.
8. Wang CL, Shieh JY, Wang TG, et al. Ultrasonographic assessment of posterior heel pain. J Formos Med Assoc 1999;98:56-61.
9. Aström M, Gentz CF, Nilsson P, et al. Imaging in chronic Achilles tendinopathy: a comparison of ultrasonography, magnetic resonance imaging and surgical findings in 27 histologically verified cases. Skeletal Radiol 1996;25:615-20.
10. Hartgerink P, Fessell DP, Jacobson JA, et al. Full-versus partial-thickness Achilles tendon tears: songraphic accuracy and characterization in 26 cases with surgical correlation. Radiology 2001;220:406-12.
11. Kainberger FM, Engel A, Barton P, et al. Injury of the Achilles tendon: diagnosis with sonography. Am J Roentgenol. 1990;155:1031-6.
12. Weigl D, Copeliovitch L, Itzchak Y, et al. Sonographic healing stages of Achilles tendon after tenomuscular lengthening in children with cerebral palsy. J Pediatr Orthop 2001;21:778-83.
13. Martinoli C, Derchi LE, Pastorino C, et al. Analysis of echotexture of tendons with US. Radiology 1993;186: 839-43.
14. Fornage BD. Achilles tendon: US examination. Radiology 1986;159:759-64.
15. Richards PJ, Dheer AK, McCall IM. Achilles tendon size and power Doppler ultrasound changes compared to MRI: a preliminary observational study. Clin Radiol 2001;56:843-50.
16. Richards PJ, Win T, Jones PW. The distribution of microvascular response in Achilles tendonopathy assessed by colour and power Doppler. Skeletal Radiol 2005;34:336-42.
17. Movin T, Gad A, Reinholt FP, et al. Tendon pathology in long-standing achillodynia: biopsy findings in 40 patients. Acta Orthop Scand 1997;68:170-5.
18. Kader D, Saxena A, Movin T, et al. Achilles tendinopathy: some aspects of basic science and clinical management. Br J Sports Med 2002;36:239-49.
19. Woo SL, Hildebrand K, Watanabe N, et al. Tissue engineering of ligament and tendon healing. Clin Orthop Relat Res 1999;367:S312-23.
20. Kumar V, Abbas AK, Fausto N. Tissue renewal and repair: regeneration, healing, and fibrosis. In: Robbins and Cotran pathologic basis of disease. 7th ed. Philadelphia: Elsevier-Saunders; 2005. p.87-118.
21. Ohberg L, Lorentzon R, Alfredson H. Neovascularisation in Achilles tendons with painful tendinosis but not in normal tendons: an ultrasonographic investigation. Knee Surg Sports Traumatol Arthrosc 2001;9:233-8.
22. Alfredson H. Ohberg L. Increased intratendinous vascularity in the early period after sclerosing injection treatment in Achilles tendinosis: a healing response? Knee Surg Sports Traumatol Arthrosc 2006;14:399-401.
23. Fealy S, Adler RS, Drakos MC, et al. Patterns of vascular and anatomical response after rotator cuff repair. Am J Sports Med 2006;34:120-7.
24. Wright PE II. Flexor and extensor tendon injuries. In:

Canale ST, editor. Campbell's operative orthopaedics. 10th ed. Philadelphia: Mosby; 2003. p.3423-4.

25. Siddiqi NA, Hamada Y, Ide T, et al. Effects of hdroxyapatite and alumina sheaths on postoperative peritendinous adhesions in chickens. J Appl Biomater 1995; 6:43-53.
26. Armbrecht A, Zenker W, Egbers HJ, et al. Plaster-free, early functional after-care of surgically managed Achilles tendon rupture. Chirurg 1993;64:926-30. (Fulltest in German, abstract in English)
27. Suchak AA, Spooner C, Reid DC, et al. Postoperative rehabilitation protocols for Achilles tendon ruptures: a meta-analysis. Clin Orthop Relat Res 2006;445:216-21.
28. Kotnis R, David S, Handley R, et al. Dynamic ultrasound as a selection tool for reducing achilles tendon reruptures. Am J Sports Med 2006;34:1395-400.
29. Khan KM, Forster BB, Robinson J, et al. Are ultrasound and magnetic resonance imaging of value in assessment of Achilles tendon disorders? A two year prospective study. Br J Sports Med 2003;37:149-53.

手術修復後阿基里氏腱超音波影像之臨床應用

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目的：高頻超音波在診斷阿基里氏腱斷裂具有相當高的準確度，理論上應該可用以評估手術修補後阿基里氏腱癒合的情形。本研究欲探討手術修補後阿基里氏腱的超音波表現與臨床表現的相關性。

材料與方法：本研究共收集民國 79 年 1 月至 89 年 9 月因運動傷害導致單側阿基里氏腱斷裂，而於台大醫院接受手術修補的患者 10 人（3 位男性，7 位女性；平均年齡：47.2 歲，年齡範圍：22-66 歲），以超音波作爲追蹤工具（平均追蹤時間：6.0 年，追蹤時間範圍： 2.1-12.1 年），所有患者於接受超音波檢查追蹤時的阿基里氏腱功能良好。使用的超音波檢查儀器為 HDI 5000 (Advanced Technology Laboratories, Bothell, WA, USA)，並利用 10MHz 線性排列探頭(linear array transducer)來量測術後阿基里氏腱的連續性、厚度、回音度、血液灌流、及肌腱活動度。所有患者以手術對側的阿基里氏腱作爲對照組。

結果：10 位患者修補後阿基里氏腱於超音波圖像顯示具有良好的連續性，且皆無血液灌流增加的情形；其中有 4 位患者存在局部低回音的間隙。共有 9 位患者術後阿基里氏腱的厚度均較健側來的厚（平均值±標準差，實驗組：8.48±1.96mm，對照組：4.90±0.54mm，P< 0.001），且回音度均較健側低；僅有一位患者的超音波表現幾乎與健側完全相同。所有患者阿基里氏腱都具有極佳的臨床性能。

結論：手術修補後阿基里氏腱的型態變化可持續數年，但其超音波的表現與臨床表現並無明顯相關性。（台灣復健醫誌 2008；36(1)：23 - 30）

關鍵字：超音波(ultrasonography)，阿基里氏腱(Achilles tendon)，手術(surgery)

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