

ORIGINAL PAPERS

Adv Clin Exp Med 2006, 15, 3, 471–480
ISSN 1230-025X

© Copyright by Silesian Piasts
University of Medicine in Wrocław

KRZYSZTOF SKIBA¹, ROMAN RUTOWSKI¹, ROMAN WIĄCEK¹, PAWEŁ REICHERT¹,
KRZYSZTOF DUDEK²

Treatment of Subcutaneous Ruptures of the Achilles Tendon in Own Material

Leczenie podskórnych przerwania ścięgna Achillesa w materiale własnym

¹ Department of Traumatology and Hand Surgery in Wrocław, Poland

² Institute of Machines Design and Operation, Wrocław University of Technology, Poland

Abstract

Background. Traumatic subcutaneous Achilles tendon ruptures are a serious problem in traumatic and orthopedic surgery. They constitute a considerable percentage of injuries not only in persons practicing sports professionally, but also in those who do it for pleasure. The choice of the treatment method, i.e. the use of traditional conventional surgery, conservative treatment, or microsurgical reconstruction of the tendon, largely depends on the level of destruction in tendon continuity as assessed by ultrasound as well as CT and magnetic resonance results.

Objectives. The assessment of surgical results in the treatment of traumatic subcutaneous ruptures of Achilles tendons.

Material and Methods. In 1992–2004, 115 patients underwent treatment, including 83 surgical interventions, at the Department of Traumatology and Hand Surgery. They were 67 males (80.7%) and 16 females (19.3%) and their age range was 20–90 years. The average post-injury time was five days. The patients were operated under supra-rural anesthesia and limb ischemia both in emergency and scheduled procedures. The majority were patients brought from other centers. The procedures were carried out using classical methods (Bunnel's, Strell's, Kessler's methods, Christensen's and Gebhardt's reconstruction methods) as well as with the microsurgical reconstruction introduced in the Department of Traumatology and Hand Surgery.

Results. Surgical treatment brings the best results in early ruptures of Achilles tendon. Selection of treatment depends on the level and the degree of rupture. At the typical site of rupture, microsurgical reconstruction is the method of choice in the majority of cases. The assessment of mobility of the operated limb showed very good results of this method. In none of the cases were early or late complications observed in the form of repeated ruptures, which often occur in patients treated with traditional surgical methods. Tendon inveterate ruptures which require plastic surgery incorporating the plantar muscle, especially the more difficult plastic surgical procedure involving the aponeurosis of the calf muscle, are quite a different group of cases.

Conclusions. The microsurgical reconstruction method deserves the highest recognition. Patients operated on with this method showed no complications and their work-disability period was much shorter than that of patients in whom other methods were applied. Microsurgical reconstruction constituted 50.6% of the total procedures (**Adv Clin Exp Med 2006, 15, 3, 471–480**).

Key words: Achilles tendon, treatment, microsurgical reconstruction, diagnostic examination, ultrasound, thermovision.

Streszczenie

Wprowadzenie. Urazowe podskórne przerwania ścięgna Achillesa są poważnym problemem w chirurgii urazowo-ortopedycznej. Stanowią znaczny odsetek urazów nie tylko u osób profesjonalnie uprawiających sport, ale również rekreacyjnie. Wybór metody leczenia – zastosowania tradycyjnych konwencjonalnych form leczenia operacyjnego, leczenia zachowawczego czy też mikrochirurgicznej rekonstrukcji ścięgna – jest uwarunkowany poziomem i stopniem zniszczenia ścięgna, wykorzystując ultrasonograficzną ocenę jego ciągłości, badanie tomograficzne i rezonans magnetyczny.

Cel pracy. Ocena wyników leczenia operacyjnego chorych z urazowymi podskórnymi przerwaniem ścięgna Achillesa.

Materiał i metody. W Klinice Chirurgii Urazowej i Chirurgii Ręki AM we Wrocławiu leczono w latach 1992–2004 łącznie 115 pacjentów, w tym operacyjnie 83 chorych: 67 mężczyzn (80,7%) i 16 kobiet (19,3%) w przedziale wiekowym 20 ± 90 lat. Średni czas od urazu do operacji wynosił 5 dni. Pacjentów operowano w znie-

czuleni nadoponowym i niedokrwieniu kończyny w trybie ostrodyżurkowym oraz planowym; większość stanowi-li chorzy przekazani do leczenia z innych ośrodków. Operacje wykonywano klasycznymi metodami (sposobem Bunnela, Strelliego, Kesslera, plastyką według Christensena i Gebhardta oraz wprowadzoną w Klinice Chirurgii Urazowej i Chirurgii Ręki AM we Wrocławiu, metodą mikrochirurgicznej rekonstrukcji.

Wyniki. We wczesnych, tzw. świeżych, zerwaniach ścięgna Achillesa leczenie operacyjne daje najlepsze wyniki. Dobór metody leczenia jest uwarunkowany poziomem i stopniem zerwania ścięgna Achillesa. W przypadku zerwań ścięgna w miejscu typowym postępowaniem z wyboru w większości przypadków jest metoda mikrochirurgicznej rekonstrukcji. Obserwacje pacjentów leczonych tą metodą z oceną funkcji ruchowej operowanej kończyny dały bardzo dobre rezultaty. W żadnym przypadku nie obserwowano wczesnych czy też późnych powikłań pod postacią supuracji czy też powtórnych zerwań, które są częstym obrazem u pacjentów leczonych tradycyjnymi metodami operacyjnymi. Inaczej sprawa przedstawia się w przypadku zastarzałych zerwań ścięgna, które wymagają zastosowania plastyki z użyciem ścięgna mięśnia podeszwowego, a zwłaszcza znacznie trudniejszej technicznie plastyki m.in. z odwróconym rozciągnięciem mięśnia brzuchatego łydki.

Wnioski. Zasługująca na największe uznanie okazała się metoda mikrochirurgicznej rekonstrukcji. U pacjentów operowanych tą nową metodą nie obserwowano powikłań, a powrót do pracy następował znacznie szybciej niż u operowanych pozostałymi metodami. Metoda ta stanowiła 50,6% wszystkich operacji (*Adv Clin Exp Med* 2006, 15, 3, 471–480).

Słowa kluczowe: ścięgno Achillesa, leczenie operacyjne, mikrochirurgiczna rekonstrukcja ścięgna, badania diagnostyczne, ultrasonografia, termowizja.

Traumatic subcutaneous ruptures of the Achilles tendon have been a serious problem in traumatic and orthopedic surgery for years. Their prevalence has increased considerably in persons participating in sports both professionally or for pleasure, especially in such disciplines as skiing, volleyball, basketball, tennis, football (i.e. soccer) and hand ball. According to some authors [17], tendon rupture occurs in 400–500 persons every year, and in 80% it is the result of practicing sports. Achilles tendon ruptures are most often observed in persons aged 30–50. They involve men more than women and, according to German authors, they prevail (56%) in the dominant left lower limb in right-handed persons [12, 17].

Achilles tendon rupture usually takes place at the so-called typical site located 2–5 cm above the tuber attachment of the calcaneal bone (96%). Proximal segment breaks (2%) as well as breaks in the tuber attachment of the calcaneal bone (2%) constitute much smaller percentages [16].

Mechanics explains the pathomechanism of the tendon's rupture. In accordance with this theory, a sudden uncoordinated contraction of the triceps muscle of the calf with a plantar flexed foot and the limb straightened at the knee joint very often results in tendon rupture. Sportsmen also show muscular hypertrophy as an effect of continuous practice as well as muscles tension, which favor tendon breaks [12]. The degenerative theory also attributes the effect of tendon rupture to some degenerative changes such as collagen fibers fragmentation or homogenization and mucopolysaccharide basis decay, which appears in people over 35 and is manifested as loss of tendon resilience and distension resistance.

Numerous diseases, such as contagious diseases, infections or long corticosteroid therapy in diabetic patients, pyelonephritis, and local admini-

stration of steroids predispose patients to tendon rupture.

On the basis of investigations of tensile strength performed on the tendons of corpses, the authors followed the pathomechanism and assessed the degree of tendon strength in relation to age as it definitely decreases after the age of 35. They also estimated the most common level of rupture which, in the experimental studies, is the same as the clinical status [19, 20].

At present, the diagnostics of Achilles tendon injuries is not a problem due to ultrasound examination (USG), computed tomography (CT), magnetic resonance (MR), and thermography, the latest diagnostic achievement [1–4, 14, 15, 18].

Ultrasound examination plays the most important role in both the pre- and post-operative diagnostics of Achilles tendon ruptures as it enables an exact differentiation of partial and total break. It shows the degree of end separation of the ruptured tendon, helps to assess the size of hematoma, as well as the space between the two ends of the tendon, which greatly influences the decision of the treatment method and enables the evaluation of surgical treatment results (Figs. 1, 2).

If both ends of the tendon approach at the plantar flexure, only conservative treatment (plaster cast immobilization) should be considered. Surgical treatment can be performed if the distance between the two tendon ends exceeds 6 mm, which can be seen on ultrasound examination. Ultrasound scan and thermovision examination (Fig. 3) enable the assessment of the healing process of the Achilles tendon as well as the evaluation of surgical and conservative treatment results. They allow a suitable rehabilitation schedule and the patient's return to professional activity.

There are numerous methods of surgical treatment depending on the time which has passed since

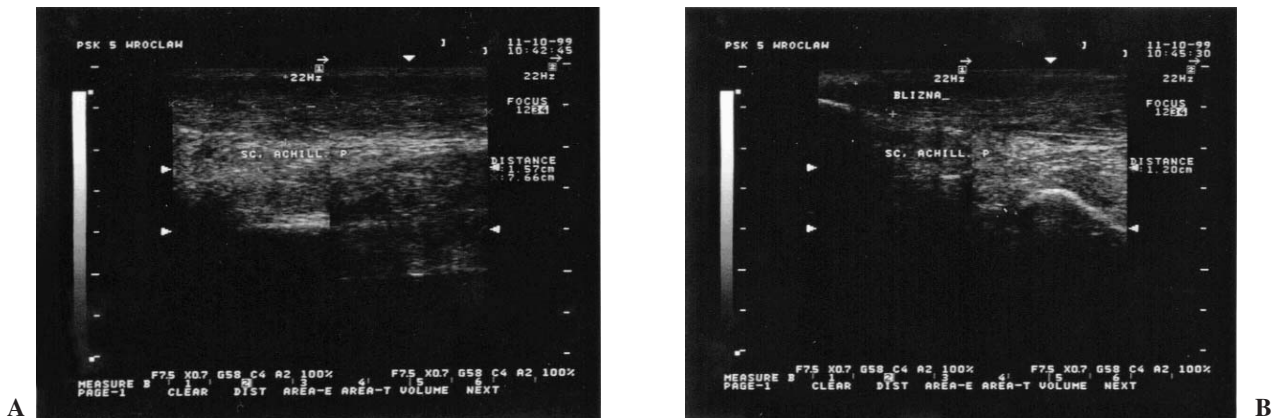


Fig. 1. a) Post microsurgical reconstruction, condition of the right lower limb Achilles tendon, distance of 1.7 cm from the tuber of the calcaneal bone in a 28-year-old male 9 months after the surgery. Poorly evident post-operative scar. The tendon characteristic for the regular course of bundles, slightly thickened (1.18 cm); correct course of normal linear bundles. **B.** Left lower limb Achilles tendon of the same individual, the tendon thickness at the same level: 1.14 cm

Ryc. 1. **A.** Stan po rekonstrukcji mikrochirurgicznej ścięgna Achillesa kończyny dolnej prawej w odległości 1,7 cm od przyczepu do guza kości piętowej u 28-letniego mężczyzny – 9 miesięcy od operacji. Blizna pooperacyjna mało widoczna. Ścięgno o regularnym przebiegu wiązek, nieznacznie pogrubiałe – 1,18 cm; przebieg wiązek prawidłowy, linearny. **B.** Ścięgno Achillesa kończyny dolnej tego samego pacjenta, grubość ścięgna na tym samym poziomie – 1,14 cm

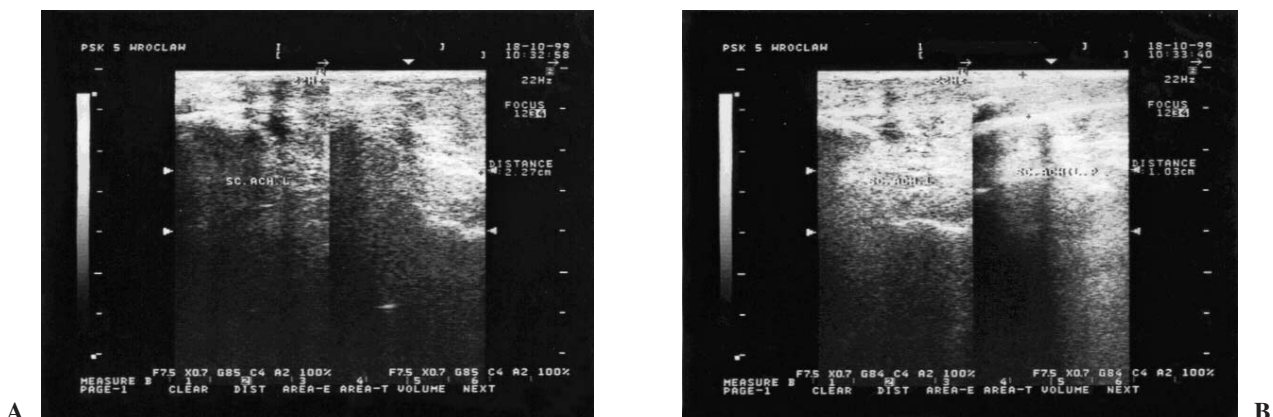
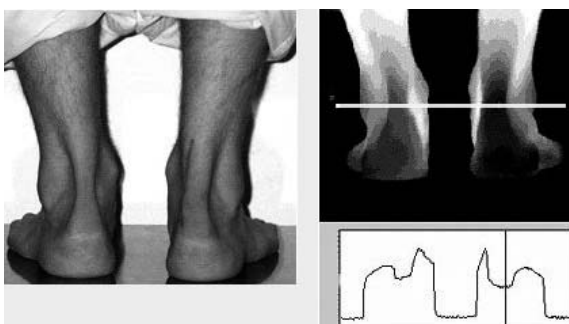


Fig. 2. **A.** Bunuel's method, post-suturing condition of the left lower limb Achilles tendon in a 54-year-old female at a distance of 1.8 cm from the tuber of the calcaneal bone. At the suture site the tendon is clearly thickened up to 2.3 cm and the course of bundles remains irregular. **B.** The right lower limb Achilles tendon is 1.0 cm wide with correct and regular course of bundles

Ryc. 2. **A.** Stan po zeszytciu ścięgna Achillesa kończyny dolnej lewej u 54-letniej kobiety sposobem Bunuela w odległości 1,8 cm od przyczepu do guza kości piętowej. Ścięgno Achillesa w miejscu zeszytcia wyraźnie pogrubiałe do 2,3 cm. Przebieg wiązek nieregularny. **B.** Ścięgno Achillesa kończyny dolnej prawej szerokości 1,0 cm o prawidłowym, regularnym przebiegu wiązek

the injury. Thus there are so-called recent and inveterate tendon ruptures (three weeks after the injury) [5, 6, 8–10]. Traditional surgical methods are pre-



ferred in countries of central Europe, while in Scandinavian countries, North America, and Great Britain, conservative treatment forms are used.

In 1993, a new method of tendon reconstruction was elaborated and introduced in the Depart-

Fig. 3. Demonstration thermograph of the Achilles tendon area in a 34-year-old patient operated with the microsurgical reconstruction method, 5 months after the injury

Ryc. 3. Przykładowy termogram okolicy ścięgna Achillesa kończyny 34-letniego pacjenta operowanego metodą mikrochirurgicznej rekonstrukcji – 5 miesięcy od urazu

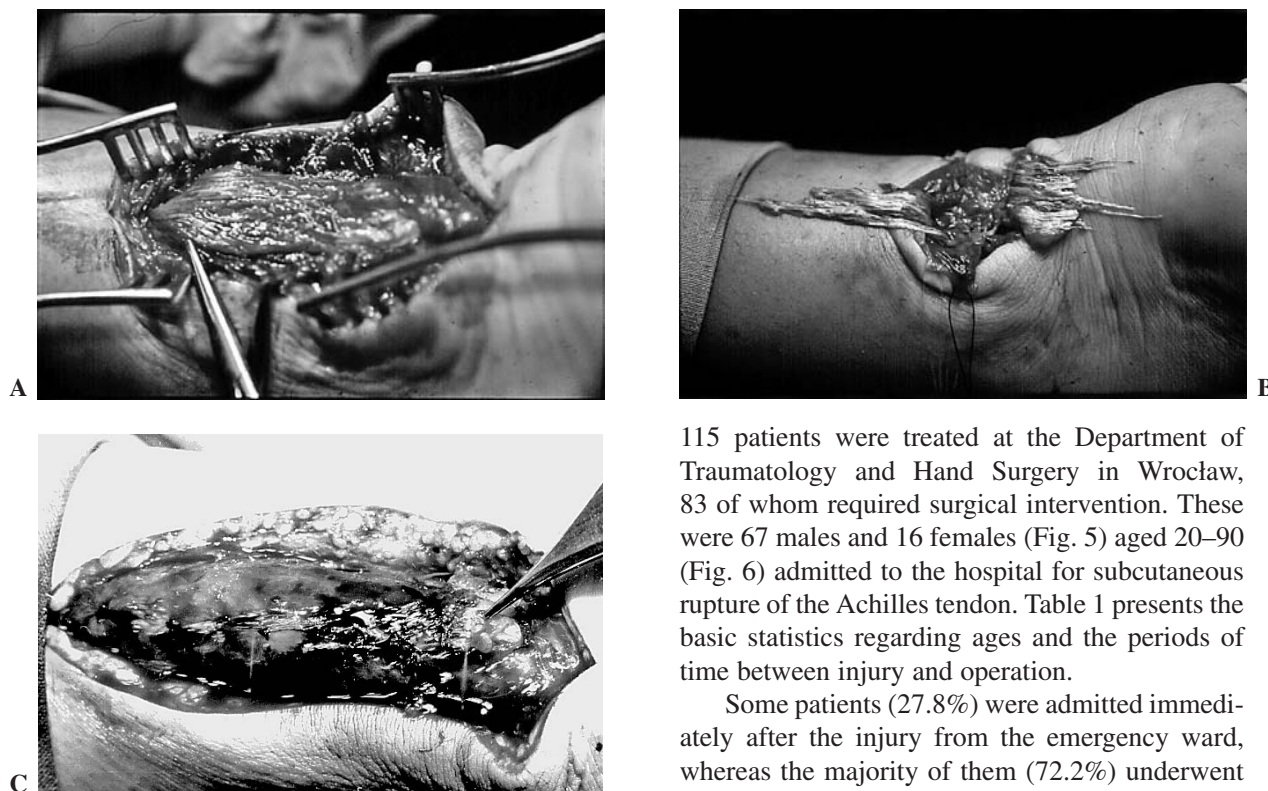


Fig. 4. **A.** Intra-operative photograph of ruptured Achilles tendon five days after the injury. Hematoma is visible after revealing both ends of the ruptured tendon. In the first operation stage, the tendon is 'tufty' delaminated, with the bunches of different length. **B.** Groups of tendon bunches adopted with absorbable microsurgical sutures. **C.** The condition after suturing the tendon sheath with resorbable sutures. The tendon sheath covers the reconstructed Achilles tendon

Ryc. 4. **A.** Zdjęcie śródoperacyjne przerwanego ścięgna Achillesa 5 dni po urazie. Po odślonięciu obu końców przerwanego ścięgna widoczny krwiak. Widoczne rozwarstwione „pęczelkowato” ścięgno o różnej długości pęczkach (1. etap operacji). **B.** Zaadaptowane wchłanianymi nićmi mikrochirurgicznymi grupy pęczków ścięgna. **C.** Stan po zeszytciu pochewki ścięgna pojedynczymi resorbowanymi nićmi. Pochewka ścięgna pokrywa zrekonstruowane ścięgno Achillesa

ment of Traumatology and Hand Surgery. This method uses microsurgical techniques and has already been described in the journal “Ortopedia Polska” [7, 8]. It combines the advantages of operative methods and, due to the application of microsurgical techniques, it prevents tendon traumatization and allows successful convalescence and restoration of sport activity (Fig. 4).

Material and Methods

This article presents a retrospective assessment of the results of treatment of traumatic injury to the Achilles tendon. In the years 1992–2004,

115 patients were treated at the Department of Traumatology and Hand Surgery in Wrocław, 83 of whom required surgical intervention. These were 67 males and 16 females (Fig. 5) aged 20–90 (Fig. 6) admitted to the hospital for subcutaneous rupture of the Achilles tendon. Table 1 presents the basic statistics regarding ages and the periods of time between injury and operation.

Some patients (27.8%) were admitted immediately after the injury from the emergency ward, whereas the majority of them (72.2%) underwent scheduled surgical procedures, having been transported from other centers, usually 4 days after the injury. Besides routine biochemical tests, ultrasound examination was performed in all patients to assess the rupture level and the degree of Achilles tendon damage and to provide a basis for the choice of treatment method.

The patients were operated with supradural anesthesia and were placed on the abdomen with plantar flexure of the foot and with the posterior-medial or sinuous incision of Torklus and Nicol (Fig. 11). After revealing the ruptured tendon, the sheath was always incised and the existing hematoma removed. The appropriate method was selected in relation with the intra-operative condition.

Figures 7–10 present the circumstances of the injuries, tendon rupture levels, as well as the methods of treatment.

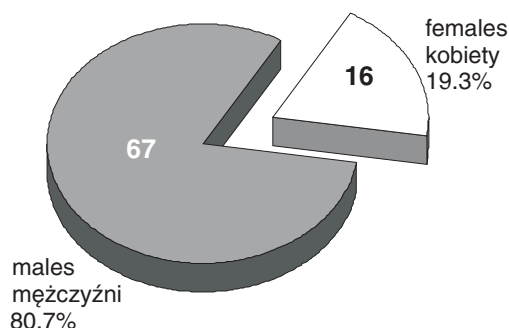


Fig. 5. The structure of the operated patients according to sex

Ryc. 5. Struktura operowanych pacjentów pod względem płci

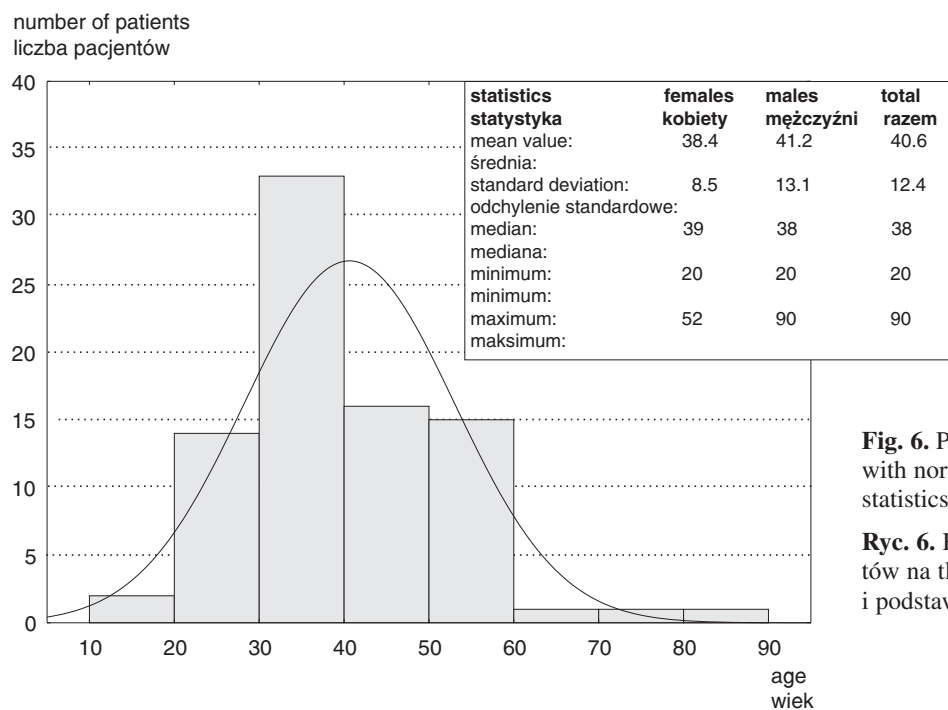


Fig. 6. Patients age histogram with normal distribution and basic statistics

Ryc. 6. Histogram wieku pacjentów na tle rozkładu normalnego i podstawowe statystyki

Table 1. Statistical values characterizing the patients

Tabela 1. Wartości statystyczne charakteryzujące pacjentów

	Females (Kobiety)	Males (Mężczyźni)	Total (Suma)
Age – years; mean value (Wiek – lata; wartość średnia)	38.4	41.2	40.6
Standard deviation (Odchylenie standardowe)	8.5	13.1	12.4
Median (Mediana)	39	38	38
Minimum (Minimum)	20	20	20
Maximum (Maksimum)	52	90	90
Number of days between injury and surgery; mean value (Liczba dni dzielących uraz od operacji; wartość średnia)	11.4	18.0	16.7
Standard deviation (Odchylenie standardowe)	28.7	45.2	42.3
Median (Mediana)	3	4	4
Minimum (Minimum)	0	0	0
Maximum (Maksimum)	108	224	224

The 83 patients (87%) treated operatively included 25 emergency cases (30.1%), 47 (56.6%) scheduled procedures, and 11 patients (13.3%) who underwent conservative treatment with foot-crus plaster cast immobilization for about 6 weeks.

Sport injuries (67.5%) were the most common cause of Achilles tendon rupture (Fig. 7). They usually took place during basketball (23 persons, 27.7%), volleyball (12 persons, 14.5%), football (soccer, 12 persons, 14.5%), jogging (6 persons, 7.2%), jumping (1 person, 1.2%), skiing (1 person, 1.2%), and dancing (1 person, 1.2%). These mostly involved young persons aged 20–50 (mean: 38.7 years). Other causes were accidents such as collapse in the street (10, 12%), open wound with glass (6, 7.2%), stumbling (5, 6.0%), blunt object injury (1, 1.2%), pushing a car (3, 3.6%), and other circumstances (2, 2.4%) (Fig. 7).

In 10 cases, patients with inveterate injuries (6 months after) were operated on. They had been treated in other medical centers with conservative methods such as Christensen's and Gebhardt's method (Fig. 12) and the plastic surgery technique of Strelli (Fig. 13).

In each case, after surgery the limb was immobilized in a foot-femur plaster cast with foot plantar flexure for a period of 2–3 weeks, correcting the foot to the intermediary position and reducing the foot plantar flexure. In the early postoperative period as well as after 6 and 12 months after surgery, ultrasound and thermovision follow-up examination were performed. This helped to monitor both the tendon healing process and the restoration of limb function.

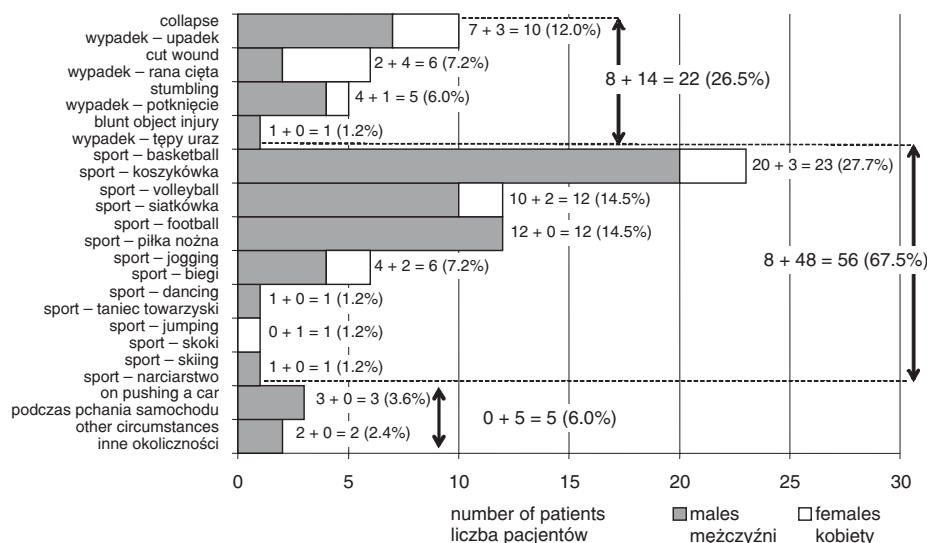


Fig. 7. Number of patients in relation to trauma circumstances

Ryc. 7. Liczba pacjentów w zależności od okoliczności powstania urazu

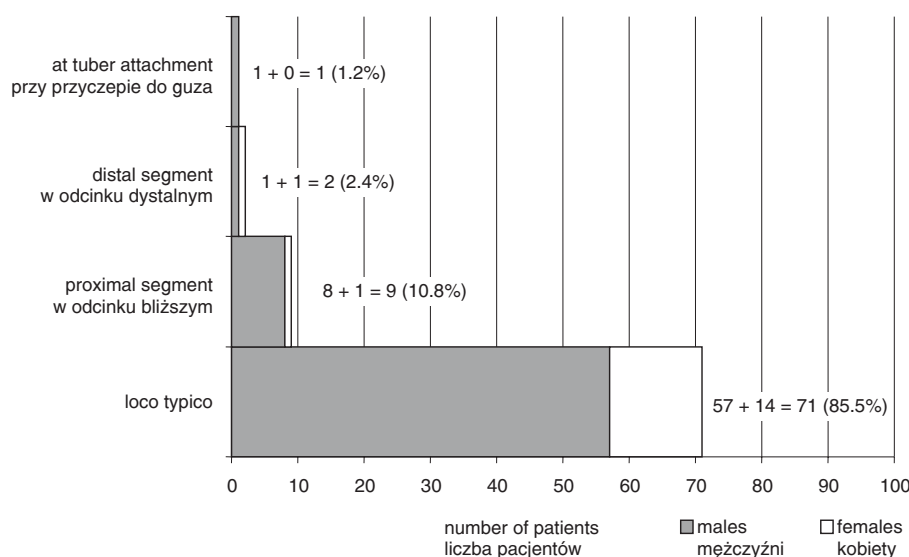


Fig. 8. Tendon rupture degree

Ryc. 8. Poziom uszkodzenia ścięgna

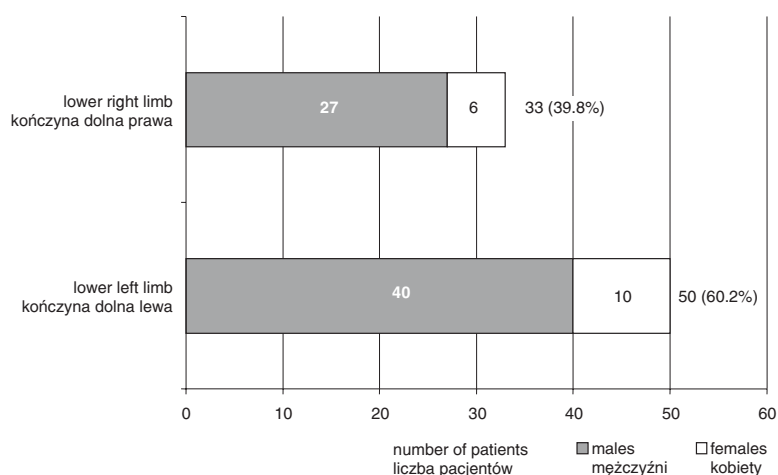


Fig. 9. Achilles tendon damage localization

Ryc. 9. Umiejscowienie urazu ścięgna Achillesa

Results

The selection of the surgical method was done individually depending on the results of ultrasound examination and intra-operative condition. In majority of cases (71 patients, 85.5%), traumatic

subcutaneous rupture of the Achilles tendon referred to a break in the continuity at the typical site which is 2–5 cm distant from the tuber attachment of the calcaneal bone. In 9 cases (10.8%) it was located in the proximal segment, in one case (1.2%) by the tuber attachment of the calcaneal bone, and in 2 cases (2.4%) in the distal segment. However, rupture of a tendon with avulsion of its fragments in a distal segment at the site of the tuber attachment of the calcaneal bone was not observed. According to other reports, this occurs very rarely.

Achilles tendon rupture is very characteristic.

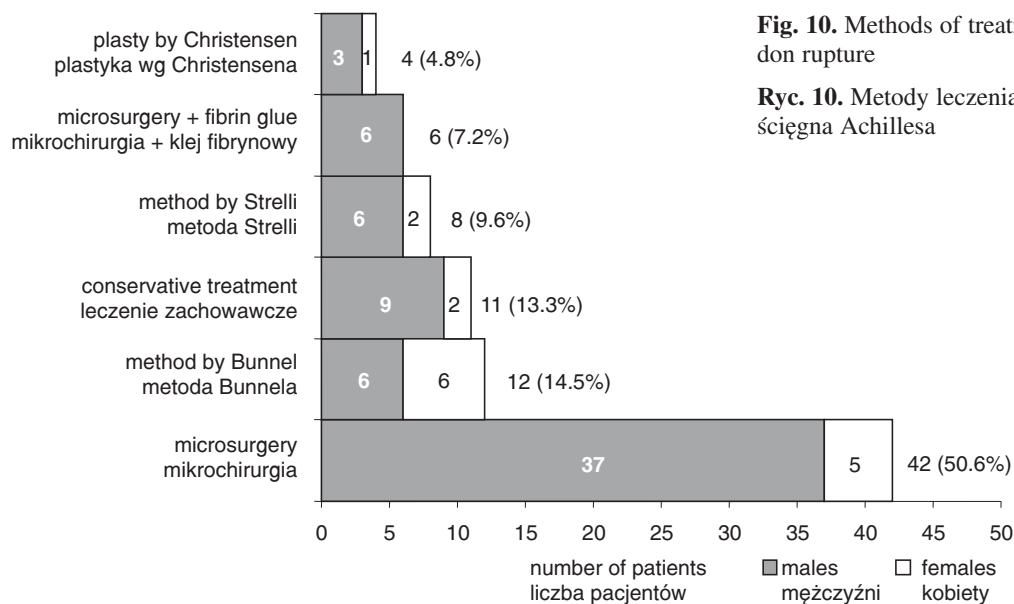


Fig. 10. Methods of treating Achilles tendon rupture

Ryc. 10. Metody leczenia zerwanego ścięgna Achillesa

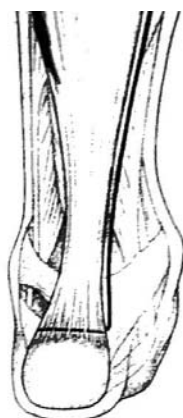


Fig. 11. Posterior-medial access of Torklus

Ryc. 11. Dostęp tylno-przyśrodkowy wg Torklusa

The tendon fiber bunches usually get torn at various levels and become tufty. The tendon sheath is damaged and suturing seems indispensable to avoid dermal and tendinous adhesions.

In the majority of cases (56%), tendon reconstruction was done microsurgically, excising

abnormal bunches of fiber and binding them together under a surgical microscope. The surgical microscope was used in adopting single or grouped bunches by applying up to 20 single resorbable sutures. Tendon sheath continuity was always restored, thus preventing the formation of the dermal and tendinous adhesions which appear in more traditional, conventional methods of treatment.

In 6 cases (7.2%) of microsurgical reconstruction of the Achilles tendon, tissue glue was successfully applied (Fig. 15) [11, 13]. The results of microsurgery proved very good. No early or late complications were observed in the group of patients operated with the microsurgical reconstruction method, including those in whom tissue glue was applied. Six-week limb immobilization provided proper healing of the tendon, and subsequent rehabilitation and bio-stimulating laser allowed uneventful recovery and further sport practice (Fig. 16).

So-called inveterate tendon ruptures presented



Fig. 12. Intra-operative image, plastic surgery technique of Christensen and Gebhardt with inverted flap of the gastrocnemius muscle aponeurosis: **A.** calf lateral image, **B.** calf posterior image

Ryc. 12. Zdjęcie śródoperacyjne – plastyka według Christensena i Gebhardta z odwróconym płatem z rozciągnięta mięśnia brzuchatego łydki: **A.** widok z boku, **B.** widok z tyłu łydki



Fig. 13. Achilles tendon suture with the use of the plantar muscle tendon by the Strelli method

Ryc. 13. Szew ścięgna Achillesa z użyciem ścięgna mięśnia podeszwowego sposobem Stelli



Fig. 14. Operated limb immobilization method

Ryc. 14. Sposób unieruchomienia operowanej kończyny

a greater problem due to the considerable defect in tendon continuity and the inability to mobilize its ends (10 cases). In these cases, the plastic surgical method of Strelli with use of the plantar muscle tendon had to be performed (8 cases), or even the more complicated procedure with the use of the inverted aponeurosis of the gastrocnemius muscle in the Christensen and Gebhardt technique (3 cases). The plastic surgery method of Strelli using the plantar muscle tendon, which remained undamaged in all rupture cases, proved efficient both in recent



Fig. 16. Lower right limb efficacy after surgery

Ryc. 16. Ilustracja sprawności kończyny dolnej prawej po zabiegu

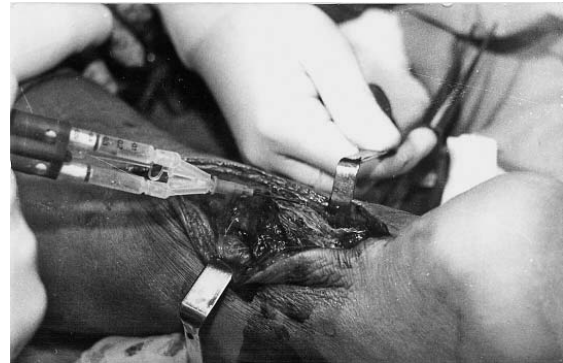


Fig. 15. The use of fibrin glue in microsurgical nerve reconstruction

Ryc. 15. Zastosowanie kleju fibrynowego w mikrochirurgicznej rekonstrukcji nerwów

and inveterate tendon ruptures. Neither early nor late complications were observed.

In one patient operated on with the method of Christensen six months after the injury, early complications appeared in the form of abscess and fistula. Interstitial tissue staining was performed with disulphine blue dye and necrotic tissues were excised intra-operatively (Fig. 17). A healing effect was achieved; however, the functional quality of the foot was not satisfactory.

Discussion

In traumatic subcutaneous ruptures of the Achilles tendon, the choice between an operative treatment method or the introduction of conservative treatment depends on the degree of tendon rupture, its degree of destruction, as well as the dehiscence of the tendon ends. Ultrasound examination and magnetic resonance prove very useful in such cases. Ultrasound examination also helps to monitor the tendon healing process. Based on their clinical observations, the authors have found thermovision examinations very useful in the



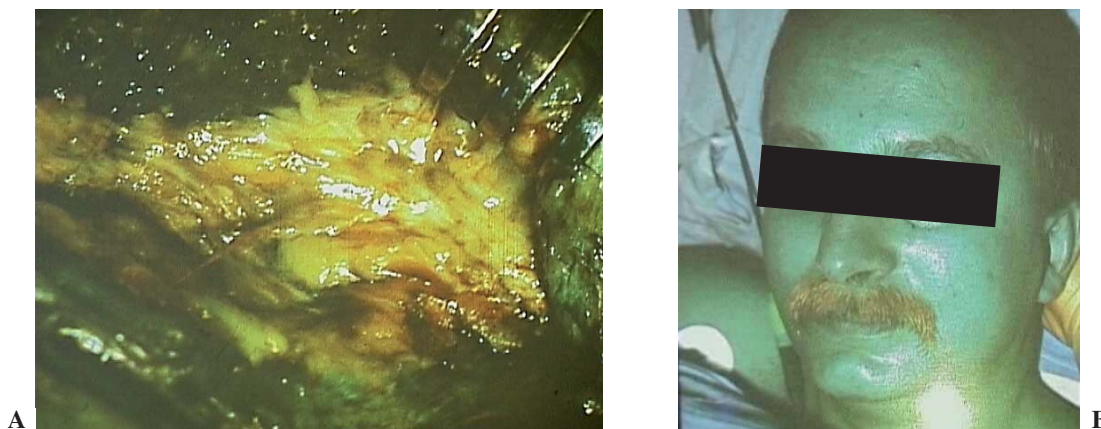


Fig. 17. A. Achilles tendon necrotic tissues made visible by use of disulphine blue dye. **B.** Patient's appearance after disulphine blue dye injection

Ryc. 17. A. Widoczne wybarwione barwnikiem *disulphine blue* tkanki martwicze ścięgna Achillesa. **B.** Wygląd chorego po wstrzyknięciu barwnika *disulphine blue*

assessment of both the tendon reparative processes and post-treatment limb aptitude.

In the majority of cases of traumatic subcutaneous ruptures of the Achilles tendon, the effects of surgical treatment depend on the time passed since the injury. An emergency procedure as well as treatment administered a few days after the injury, described as recent ruptures, bring the best results. In the majority of inveterate ruptures requiring various plastic procedures, the effects are usually unsatisfactory and the percentage of early and late complications is significant. The new method of Achilles tendon microsurgical reconstruction brings the best effects, as previously proved by survey results. It allows full reconstruction of the tendon with the sheath cover to provide healing without the formation of hypertro-

phied scarring of the connective tissue or dermal and tendinous adhesions. Such conditions allow convalescence and the patients' return to practicing sport.

The authors concluded, that: 1) males prevailed (82.8%) among the treated patients, 2) most often (85.5% of cases), the tendon rupture was found at the typical location: 2–5 cm distant from the tuber attachment of the calcaneal bone, 3) the majority of patients (51%) were operated on with the use microsurgical reconstruction, which brings excellent effects in the treatment of recent tendon ruptures, 4) advanced methods allowed the treatment of tendon rupture patients and recovery of function of the operated limb, 5) the choice of method largely depends on ultrasound assessment and the intra-operative condition.

References

- [1] **Burhardt H, Krebs U, Fuchs M, Stankovic P:** Die sonographische Beurteilung von Gleitverhalten und Gleitlager operierter Achillessehnen. *Unfallchirurg* 1991, 94, 589–593.
- [2] **Dudek K:** Thermography as diagnosis system. *System Journal of Transdisciplinary System Science* 1998, 3, 2, 68–79.
- [3] **Grechening W, Clement HG, Fellingner M, Seggl W:** Wertigkeit der Sonographie der Achillessehne in der Traumatologie. *Radiologe* 1997, 37, 322–329.
- [4] **Khan KM, Forster BB, Robinson J, Cheong Y, Louis I, Maclean L, Taunton JE:** 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, 2, 149–153.
- [5] **Kroepfl A, Obrist J:** Zur plastische versorgung der verzogert operierten subcutanen Achillessehnenruptur. *Unfallchirurg* 1987, 90, 386–390.
- [6] **Kuś WM, Zawadziński S:** Pierwotny szew ścięgna achillesa zmodyfikowany sposobem Blautha. *Chir Narz Ruchu Ortop Pol* 1980, XLV, 2, 133–135.
- [7] **Kuś H, Maciejewska M, Rutowski R, Skiba K, Żynda L:** Mikrochirurgiczna rekonstrukcja przerwanego ścięgna Achillesa. *Chir Narz Ruchu Ortop Pol* 1994, LIX, Supl. 3, 515–519.
- [8] **Kuś H, Rutowski R, Skiba K:** Mikrochirurgiczna rekonstrukcja przerwanego ścięgna Achillesa. In: *Wybrane zagadnienia z mikrochirurgii*. Red. Mackiewicz Z, Szymczyński GA. Eds.: Wydawnictwo Andromed, Bydgoszcz 1998, pp. 99–104.
- [9] **Lindholm A:** A new method of operation in subcutaneous rupture of the Achilles tendon. *Acta Chir Scand* 1959, 117, 261–270.
- [10] **Majewski M, Rickert M, Steinbruck K:** Die frische Achillessehnenruptur. Eine prospective Untersuchung zur Beurteilung verschiedener Therapiemöglichkeiten. *Orthopaede* 2000, 29, 670–676.

- [11] **Paar von O, Bernett P:** Therapie der Achillessehnen-ruptur beim Sportler. Vorteile der Fibrinklebung. *Fortschr Med* 1984, 43, 1106–1108.
- [12] **Riede von D:** Subkutane Achillessehnenrupturen als typische Sportverletzung. *Beitr Orthop* 1965, 12, 11/12, 739–741.
- [13] **Rupp G, Stemberger A:** Versorgung frischer Achillessehnenrupturen mit resorbierbaren Nahtmaterial Fibrinkleber. *Med Welt* 1978; 29, 796–798.
- [14] **Skiba K, Dudek K, Wiczowski E, Gabryszewski Z, Rutowski R, Szumańska M:** Zastosowanie termografii do oceny sprawności kończyny po leczeniu chirurgicznym ścięgna Achillesa. *Acta Bioeng Biomech* 2000, 2, Supl. 1, 483–488.
- [15] **Skiba K:** Diagnostics and treatment of traumatic damages to Achilles tendon. *Engineering Transactions* 2003, 51, 2–3, 325–337 Polish Academy of Sciences, Institute of Fundamental Technological Research.
- [16] **Thermann H, Hufner T, Tschene H:** Achillessehnenruptur. *Orthopaede* 2000, 29, 235–250.
- [17] **Thermann H, Zwipp H:** Achillessehnenruptur. *Orthopaede* 1989, 18, 321–335.
- [18] **Thermann H, Zwipp H, Milbradt H, Reimer P:** Die Ultraschallsonographie in der Diagnostik und Verlaufskontrolle der Achillessehnenruptur. *Unfallchirurg* 1989, 92, 266–273.
- [19] **Wiczowski E, Gabryszewski Z, Skiba K:** Wyniki rozciągania ścięgna Achillesa w I obszarze fizjologicznym. *Acta Bioeng Biomech* 2000, 2, Supl. 1, 591–598.
- [20] **Wiczowski E, Skiba K, Gabryszewski Z:** Wyznaczanie sił zrywających ścięgno Achillesa w czasie statycznej próby rozciągania. *Acta Bioeng Biomech* 1999, 1, Supl. 1.

Address for correspondence:

Krzysztof Skiba
Department of Traumatology and Hand Surgery
Silesian Piasts University of Medicine
Traugutta 57/59
50-417 Wrocław
Poland
E-mail: cristoferr@o2.pl

Conflict of interest: None declared.

Received: 3.01.2006
Revised: 10.02.2006
Accepted: 10.02.2006

Praca wpłynęła do Redakcji: 3.01.2006 r.
Po recenzji: 10.02.2006 r.
Zaakceptowano do druku: 10.02.2006 r.