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DIAGNOSTICS AND TREATMENT OF TRAUMATIC DAMAGES TO ACHILLES TENDON

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Traumatic damages of Achilles tendon constitute an important and serious problem in clinical practice. Many theories are applied in order to explain the pathomechanism of traumatic damages of Achilles tendon. Among them, there is a mechanical theory which claims that sudden and not co-ordinated contraction of the calf triceps muscle with plantarly bent foot and extended limb causes rupture of the tendon continuity. In clinical practice, Achilles tendon appeared more susceptible to rupture in persons over 35 when elasticity degree is reduced due to the tendon deformative lesions (fragmentation and collagen fibres homogenisation).

In the Department of Traumatic Surgery and Hand Surgery of the Wrocław University of Medicine, since 1993, clinical surveys have been carried on upgrading the surgical treatment methods of traumatic and subcutaneous ruptures of the Achilles tendon. In years 1995–1999, the examinations were carried on in co-operation with the Institute of Material Science and Applied Mechanics, Wrocław University of Technology in order to explain the pathomechanism of traumatic lesions of Achilles tendon. New examination methods such as: ultrasonography, tomography, magnetic resonance as well as recent thermovision method contribute largely towards evaluation of both early and long-term results of operative treatment.

Key words: Achilles tendon rupture, microsurgical reconstruction, biomechanics investigation, thermography, ultrasonography

1. Introduction

Traumatic damages of the Achilles tendon constitute an important problem in clinical practice. They occur not only in persons exercising sports professionally, but also in persons doing it for relax: football (40% of cases), basketball or tennis. These lesions happen to men 3–4 times more often than to women and the total number of cases amounts to 400–500 a year (Germany) [5, 6].

Achilles tendon is the strongest one in the human organism. It is 10–12 cm long, with 0.5–1 cm diameter and it is composed by the common attachment of the calf triceps muscle to calcaneal bone tuber.

In the damaged tendon, its structure collagen fibres as well as mucopolysaccharide base are of great importance but they undergo many lesions with age. The main component of the Achilles tendon is collagen-fibres protein which is poorly vascularised. Collagen is the most common protein in the human body. Collagen fibres are usually in the form of boundles 50–100 µm thick. They are characteristic for significant resistance to uniaxial tension [16]. Collagen fibres and mucopolisaccharide base largely influence the tendon mechanical resistance. The tendon characteristic feature is relatively small number of cells (fibroblasts) on the contrary to the mucopolisaccharide base. Fragmentarisation as well as collagen fibres homogenisation (degenerative theory) which appear in patients over the age of 35 cause loss of elasticity of the tendon [3, 10, 13, 14]. Achilles tendon traumatic ruptures pathomechanism is explained by many theories, such like the mechanical theory, in accordance to which sudden and not co-ordinated constriction of the calf triceps muscle with extended lower limb causes rupture of the tendon continuity.

In 97% of cases, the rupture leads to the tendon break in typical–classical site at the distance of 2.5 cm above the tendon attachment to calcaneal bone tuber. The surveys (Riede and Zwipp) proved that left lower limb is more susceptible to such damages (55%) than the right one (45%) [13, 14]. Tendon proximal lesions (1.3%) and the distal ones (1.6%) constitute smaller percentage of damages and they are usually accompanied by calcaneal bone fragment avulsion. The procedures applied in the case of traumatic damages of Achilles tendon vary significantly. In Central Europe, operative treatment is preferred and in Scandinavian countries, North America or Great Britain, conservative treatment forms are used if the span in the tendon discontinuity is not longer than 6 mm, as confirmed in ultrasonographic and clinical examination [1, 12].

2. Aim of studies

In co-operation with the Institute of Materials Science and Applied Mechanics, Wrocław University of Technology, Poland, in years 1995–1999, experimental strength tests were performed in order to explain traumatic damages patomechanisms of the Achilles tendon. Their aim was also to determine the 'locus minoris resistance' as well as to compare the tests results to the ruptures occurring in clinical practice. The obtained results were also referred to the new microsurgical method of Achilles tendon reconstruction introduced at the Department of Traumatology and Hand Surgery of the Wrocław University of Medicine. The studies concentrated also on ultrasonographic as well as thermographic evaluation of operative and conservative treatment effects.

3. Strength tests methods and results

Preparations of Achilles tendon were taken from human corpses on average 12 hours after death in Forensic Medicine Department and Pathological Anatomy Department of Medical University of Wrocław. Totally, 60 Achilles tendon samples underwent tensile static tests using Instron 1126 with initial force 5 kN and measurement base $L = 100$ mm and breaking velocity $V = 2$ cm/min.

Figure 1 presents force P depending on patient age t on the basis of statistical analysis. The graphs visualise dependences for the left lower limb – (a) and the right lower limb – (b). The results were approximated by the formula

$$P(t) = a_3t^3 + a_2t^2 + a_1t^1 + a_0.$$

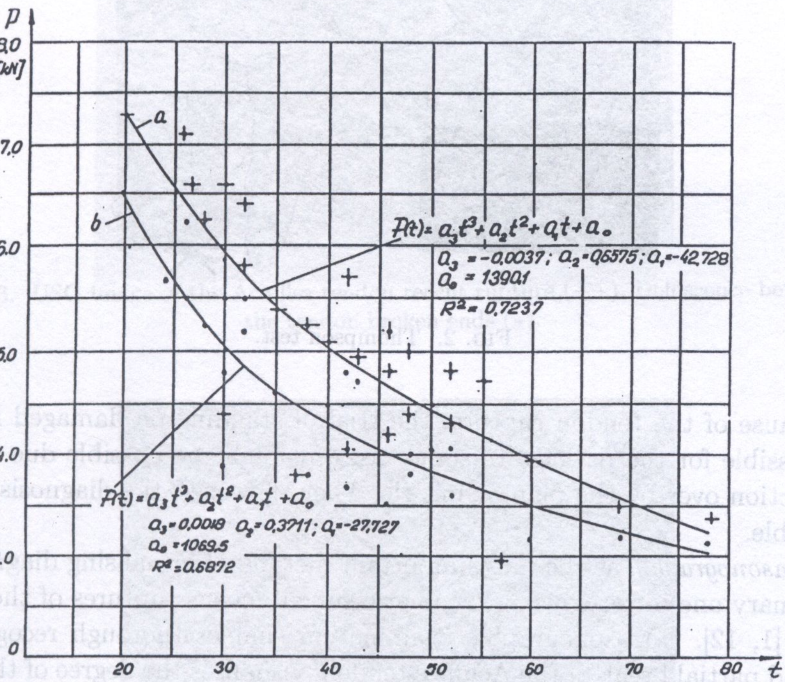

FIG. 1. Tensile test of Achilles tendon in relation to individual's age, a) left lower limb, b) right lower limb.

On the basis of the performed analysis, important difference between the tendon strength of the left and right lower limbs was found. The rupture strength of Achilles tendon in both lower limbs does not undergo significant changes between 25 and 45 years of age. With years, however, the strength of both tendons decreases significantly and the strength of the left limb reaches the level of the right one.

Experimental studies revealed that it is possible to stimulate the rupture of the tendon which would correspond to traumatic ruptures in the terms of its form and localisation.

4. Diagnostics

The first observable symptom of Achilles tendon rupture is a sudden cracking pain in the tendon area and its clinical image is the formation of characteristic void in the break site (usually typical site) as well as Thompson test performance, see Fig. 2.

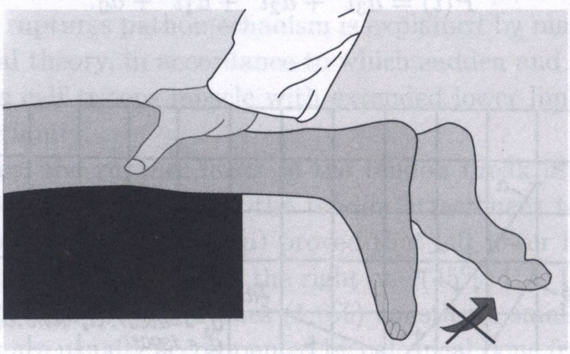

FIG. 2. Thompson test.

Because of the tendon rupture, the trial of standing on damaged limb toes is impossible for the patient. In some cases, it might be possible due to taking the function over by the plantar muscle. Then, however, the diagnosis may not be reliable.

Ultrasonography, as the most important method of visualising diagnostics, is the primary one in recognising traumatic subcutaneous ruptures of the Achilles tendon [1, 12]. Ultrasonographic examination enables thorough recognition of total and partial break of the Achilles tendon, visualises the degree of the tendon broken ends dehiscence and reveals haematoma size which largely influences the choicetreatment method. This examinnation helps to observe operative and conservative treatment results, shows the healing process, enables planning of adequate rehabilitation as well assessment of patients' return to full professional activity.

In ultrasonographic images, the tendon structure breaks of various size can be observed. At an early stage of the trauma, the tendon continuity break is filled with anechoic haematoma (Fig. 3) and with progression of the lesion, typical changes characteristic for haematoma organisation appear. A cicatrix in connective tissue is formed and it constitutes the area of non-homogenous repercussions with an irregular contour of the tendon (Fig. 4) or hyperechogenic lesion with a clear boundary along the tendon (Fig. 5). In the healing process, hypoechogenic or anechoic areas disappear (regions of inflammatory reaction to suture material). Operative treatment results in the tendon thickening with visible changes in the tendon internal fibrous structure (Fig. 6 a, b).

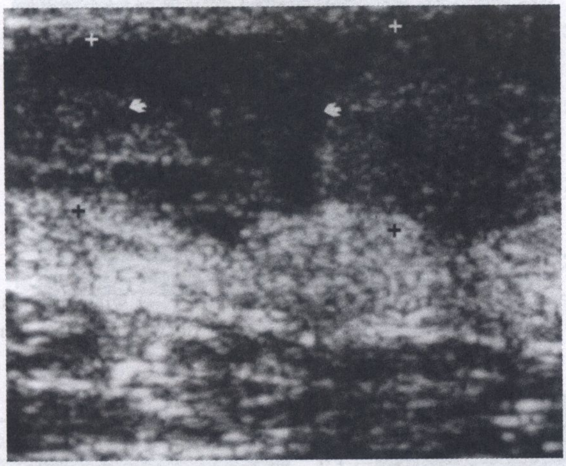

FIG. 3. USG image of the Achilles tendon recent rupture (++). Dehiscence between the tendon broken ends (»).

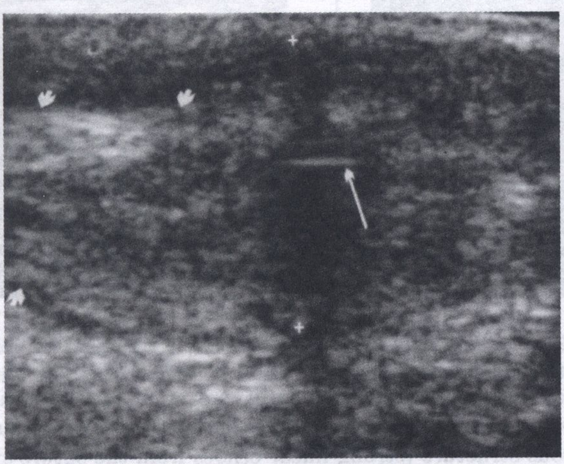

FIG 4. USG image of the Achilles tendon old rupture with a scar. There are thickening and the tendon irregular contour visible as well as the focus of non-homogenous repercussions (++) in the site of the total rupture corresponding to calcified cicatrix in the central area (→). Proximate end of the tendon broken fragment (><).

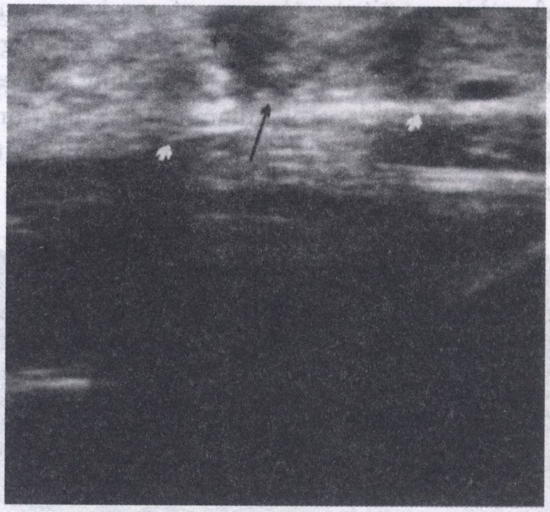

FIG. 5. USG image of the Achilles tendon old rupture (→) with fibrous cicatrix formed and connecting the tendon ends (><). Cicatrix area between the tendon stumps (++).

a) b)

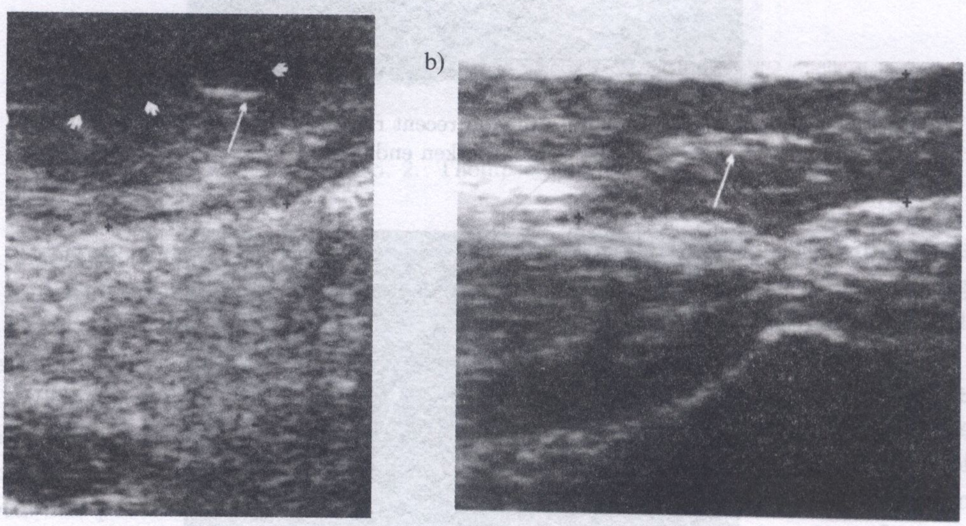

FIG. 6. USG image of Achilles tendon after rupture operative repair: a) considerably thickened hypoechogenic tendon (++) with fluid spaces (>) 10 weeks after operation, delayed healing process with possible inflammatory reaction by the suture; b) Achilles tendon 2 months after operation, clearly visible outline (++), irregular anterior contour, fibrous structure (strong linear echoes from the suture side).

Recently, besides the computer tomography and magnetic resonance, *termography* has been regarded as a very useful method in diagnosing traumatic ruptures of the Achilles tendon.

As a non-invasive and non-contact method of measuring the temperature, *termography* proves to be a perfect way to examine human body surface thermal processes on the surface of the human body and to observe pathologic changes [2, 4, 11].

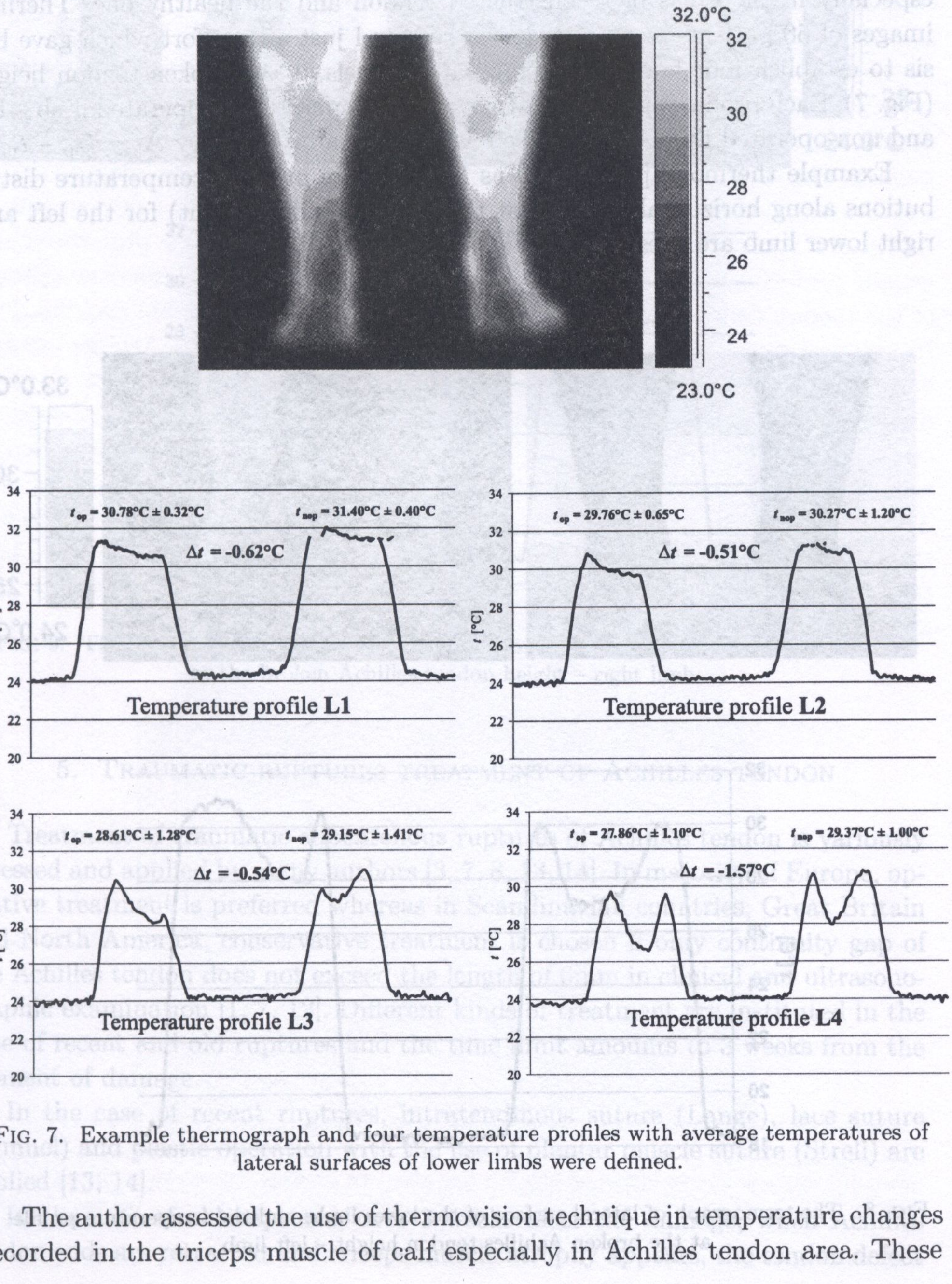

FIG. 7. Example thermograph and four temperature profiles with average temperatures of lateral surfaces of lower limbs were defined.

The author assessed the use of thermovision technique in temperature changes recorded in the triceps muscle of calf especially in Achilles tendon area. These observations referred both to patients with ruptured tendon and operated with the new microsurgical reconstruction method [5, 6, 9] as well as to the ones treated with traditional operative methods [8, 13, 14]. Thermovision 550 camera was used to measure the temperature distribution in the calf triceps muscle, especially in the areas of reconstructed tendon and the healthy one. Thermal images of 50 patients were recorded at rest and just after effort which gave basis to establish four horizontal temperature levels at the broken tendon height (Fig. 7). Each profile was ascribed to average temperature of operated limb – t_{op} and non-operated limb – t_{nop} as well as to thermal asymmetry $\Delta t = t_{op} - t_{nop}$.

Example thermographs as well as temperature profiles (temperature distributions along horizontal segment at the broken tendon height) for the left and right lower limb are presented in Figs. 8 and 9.

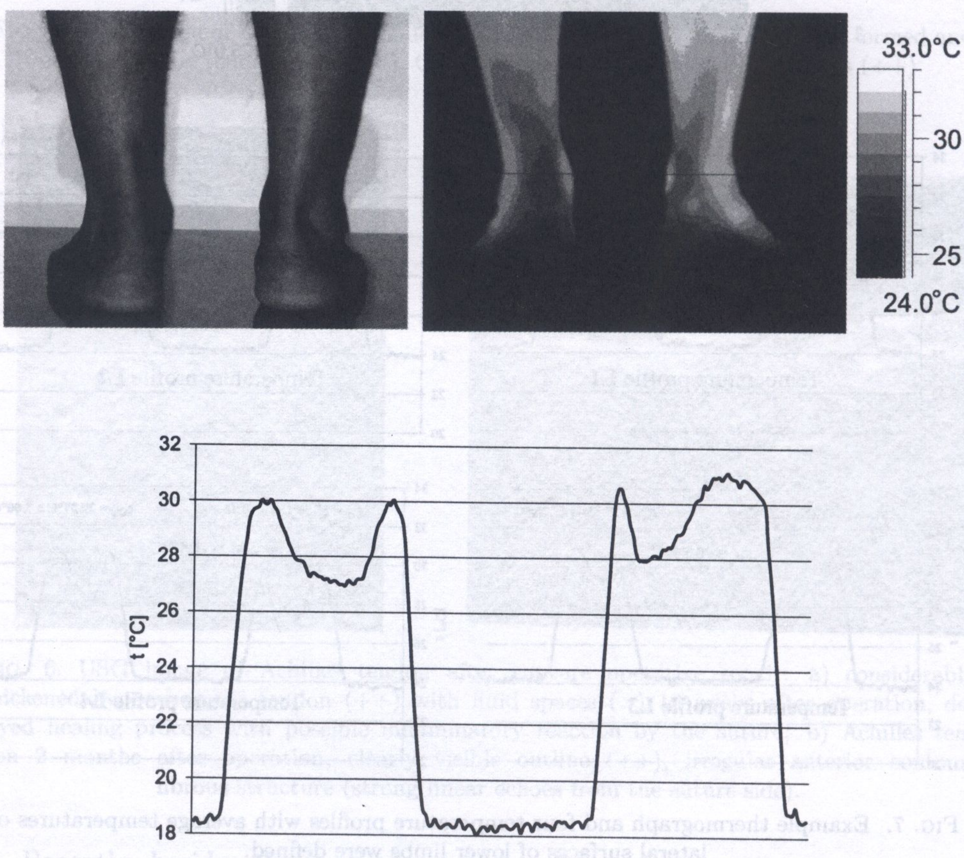

FIG. 8. The termograph of lateral surface of the lower limbs and the temperature profile at the broken Achilles tendon height – left limb.

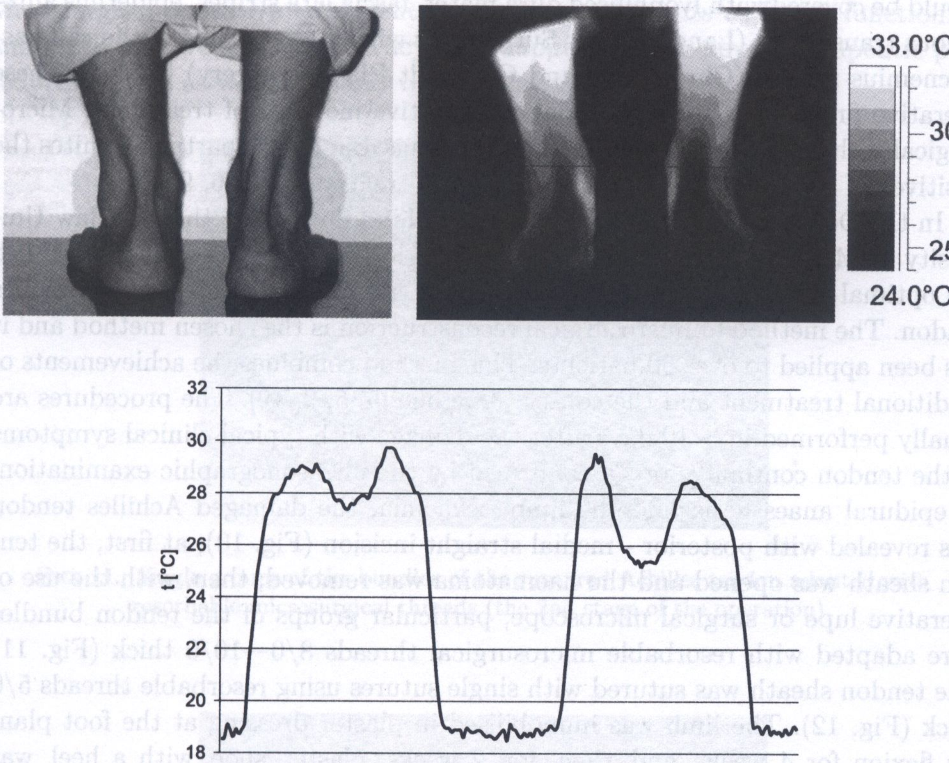

FIG. 9. The termograph of lateral surface of the lower limbs and temperature profile at the broken Achilles tendon height – right limb.

5. Traumatic ruptures treatment of Achilles tendon

Treatment of traumatic subcatenous ruptures of Achilles tendon is variously assessed and applied by many authors [3, 7, 8, 13, 14]. In majority of Europe, operative treatment is preferred whereas in Scandinavian countries, Great Britain and North America, conservative treatment is chosen if only continuity gap of the Achilles tendon does not exceed the length of 6mm in clinical and ultrasonographic examination [1, 7, 12]. Different kinds of treatment are instituted in the case of recent and old ruptures and the time limit amounts to 3 weeks from the moment of damage.

In the case of recent ruptures, intratendinous suture (Lange), lace suture (Bunnel) and plastic operation with the use of plantar muscle suture (Streli) are applied [13, 14].

In the case of old ruptures, over 3 weeks after the damage, when Achilles tendon ends are retracted and triceps muscle atrophy appears, the tendon defect should be covered with lyophilised dura mater, fascia lata stripes, epidermis autogenous transplants (Lange Plastic Surgery) or with inverted lobe of the calf gastrocnemius muscle (Christensen and Gebhardt Plastic Surgery) [13, 14]. These operative procedures are traditional conservative methods of treatment. Microsurgical technique being a new method introduced in our Department unites the positives of both traditional and conservative treatments [5, 6, 9].

In the Department of Traumatology and Hand Surgery at the Wrocław University of Medicine, since 1993, examinations have been carried on to establish the optimal and effective method of treating traumatic rupturesof the Achilles tendon. The method of microsurgical reconstruction is the chosen method and it has been applied to over 50 patients. This method combines the achievements of traditional treatment and the conservative one [5, 6, 9, 10]. The procedures are usually performed in 3–10 days after the damage with typical clinical symptoms of the tendon continuity break confirmed by the ultrasonographic examination. In epidural anaesthesia and the limb ischaemia, the damaged Achilles tendon was revealed with posterior - medial straight incision (Fig. 10); at first, the tendon sheath was opened and the haematoma was removed; then, with the use of operative lupe or surgical microscope, particular groups of the tendon bundles were adapted with resorbable microsurgical threads 8/0—10/0 thick (Fig. 11) The tendon sheath was sutured with single sutures using resorbable threads 5/0 thick (Fig. 12). The limb was immobilised in plaster dressing at the foot plantar flexion for 4 weeks and then, for 2 weeks, plaster shoe with a heel was applied.

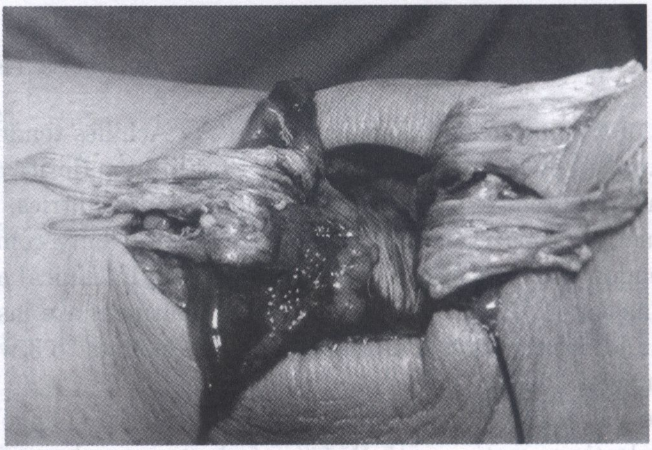

FIG. 10. Intraoperative image on the 5th day after the damage, ruptured Achilles tendon; tuftily delaminated tendon with various length bundles;visible haematoma between broken tendon stumps (the1st stage of the operation).

Microsurgical operative treatment gave very good results as far as functioning and aesthetics are concerned. They were supported with physiotherapeutic procedures as well as with the laser biostimulating the scar.

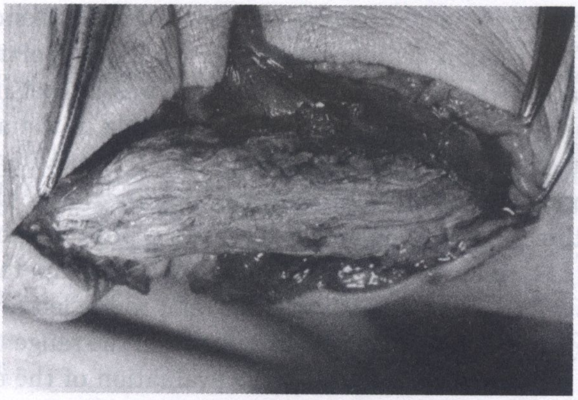

FIG. 11. Single groups of the bundles of the ruptured Achilles tendon adapted with resorbable microsurgical threads (the 2nd stage of the operation).

FIG. 12. The tendon sheath closed with single resorbable sutures covers the whole of the reconstructed tendon (the 3rd stage of the operation).

6. DISCUSSION AND CONCLUSIONS

Various operative methods are used in the treatment of traumatic damages of Achilles tendon [8, 13, 14]. In many centres, especially in the Scandinavian countries and North America, conservative treatment methods are preferred [7]. The new method of microsurgical reconstruction of ruptured Achilles tendon introduced in the Department of Traumatology and Hand Surgery at the Wrocław

University of Medicine can be placed between traditional aggressive operative methods and the conservative treatment [5, 6, 9]. Due to the tendon bundles microsurgical anastomosis and the tendon sheath reconstruction, the healing process proceeds uneventfully and no postoperative complications such as skin necrosis or wound infection have been registered. In ultrasonographic images, normal stages of the tendon healing were observed, the hypertrophy of the connective tissue cicatrix was not found and the scar was almost invisible.

Thermovision examinations play an important role in the assessment of operative treatment of the Achilles tendon rupture. Thermovision gives excellent results in the monitoring of the limb full convalescence after the tendon reconstruction.Evaluation of various operative methods is possible along with mobility efficiency tests [2, 11]. The examinations revealed that temperature distribution within the reconstructed tendon (99% of cases refer to the left lower limb) in relation to the healthy limb Achilles tendon varied within the range of 0.5 to 3 degrees Celsius, which is a minimal difference in the evaluation of the efficiency of both limbs. This confirms excellent results of microsurgical reconstruction method. Other traditional methods of operative treatment show wider unfavourable dispersion of temperature values in the reconstructed tendon area. These values were twice or three times greater than the ones in microsurgical method.

Strength tests revealed that it is possible to stimulate the rupture of the tendon continuity similar to traumatic ruptures in their form and localization [10, 15].

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