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Primary surgical repair of acute Achilles tendon rupture: comparative results of three surgical techniques

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Summary
Purpose To determine which of the three surgical techniques for acute unilateral complete rupture of Achilles tendons in use at the University Clinical Centre Maribor gives the best short-term functional results.
Methods In the retrospective analysis of the results of 3 surgical techniques, 262 patients of which 244 (93.1%) were men (mean age 41.6 ± 10.0 years, range 21.5—83.0 years) operated on during the period from 2000 to 2008 were included. Group A (open technique with fascial augmentation) included 42 (16%) patients, group B (original modification of percutaneous suturing according to Čretnik and Kosanović) included 159 (60.7%) patients, and group C (original percutaneous fixation with two embracing and crossed loops according to Kruščić) included 61 (23.3%) patients. The rehabilitation protocol for group C included use of individually manufactured closed ankle functional orthosis, which replaced the plaster cast after 2 weeks of immobilization and permits early ankle range-of-motion exercising and full weight bearing. The functional outcome and incidence of postsurgical complications were analysed from medical records covering the period of 6 months.
Results Patients from group C achieved the best functional results in the shortest time. The duration of immobilization (5.3 ± 0.1 weeks) and use of crutches (5.3 ± 0.5 weeks) were the shortest. The ability to rise up on toes on the affected leg, to walk on toes and heels, and duration of restriction of physical activities including sports were shorter than in the other two groups ($p < 0.001$ for all variables). Two reruptures were experienced in group B, one in group C, and none in group A.
Conclusions Good functional results and a relatively small number of postsurgical complications advocate the use of percutaneous suturing techniques. The best and fastest functional recovery was attained in the group treated with the original technique of percutaneous fixation with two embracing and crossed thread loops according to Kruščić.

Keywords Open repair · Percutaneous suturing · Postoperative complications · Orthosis · Rehabilitation

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Introduction

The incidence of Achilles tendon (AT) rupture is between 9 and 18 cases per 100,000 inhabitants per year [1], and this number is constantly growing [2, 3]. The consequences of this injury have considerable impact on the patients' quality of life [4, 5].

Acute AT complete ruptures can be conservatively or surgically treated. Despite a large amount of research and meta-analyses, there is still no consensus on the best treatment [1, 6]. Many surgeons advocate open repair techniques, especially in young patients and athletes, because of the possibility of early

functional treatment, achievement of greater muscular strength, and a low frequency of reruptures [1, 7, 8]. The frequency of postoperative complications is relatively high, and some of them demand additional and long-lasting hospitalization [9, 10].

Ma and Griffith introduced percutaneous suturing of AT ruptures under local anesthesia, which is a technically relatively simple procedure [11]. It contributes to the diminution of perisurgical and postsurgical complications, in comparison to open repair techniques [7, 11, 12]. This technique represents the bridge between the advocates of nonoperative treatment, which results in less tendon strength and more frequent reruptures, and the advocates of open repair techniques, which results in higher tendon strength and less frequent reruptures [11, 12].

At the University Clinical Centre Maribor (UCCM), the conservative therapy of AT ruptures dominated until 1960, when open surgery with autologous transplants was introduced in cases of unhealed ruptures. Percutaneous repair techniques became more frequent in the last two decades. In the period from 2000 to 2008, three techniques of primary surgical treatment were used: open technique with fascial augmentation from the triceps surae muscle and two original modifications of percutaneous techniques (older one described by Čretnik and Kosanović [7, 12], and a newer one according to Kruščić, which is based on percutaneous insertion of two embracing and crossed thread loops). These techniques and their key rehabilitation issues are described in details in the patients and methods section.

Classical postoperative rehabilitation protocols incorporate ankle immobilization and no weight bearing or partial weight bearing for 6 weeks. Modern rehabilitation protocols promote faster tendon healing by encouraging an early range of motion (ROM) exercising and permitting immediate partial or full weight bearing with the use of walking orthoses and crutches [13–15].

Despite the fact that surgical treatment of acute AT ruptures is scientifically supported by results of numerous comparative studies and meta-analyses, there is still no definitive consensus regarding which surgical technique is the most appropriate one [7, 9, 10]. The optimal postoperative rehabilitation protocol is still unknown [13–15].

Patients and methods

In the 9-year period (from January 2000 to November 2008), a total of 290 patients with acute unilateral complete closed rupture of AT were operated on at the UCCM by 21 surgeons using 3 different techniques, open repair with triceps surae muscle fascial augmentation (group A), original modification of percutaneous suturing according to Čretnik and Kosanović (group B) and original percutaneous fixation with 2 embracing and crossed loops according to Kruščić (group C).

Patients more than 18 years old with unilateral acute total closed AT rupture surgically treated at UCCM during the first 72 h after injury were included in this retrospective study. Diagnosis was based on clearly present clinical signs (palpable AT defect, positive Thompson test, and inability to rise up on toes [2]). In clinically unclear cases an ultrasound examination was indicated. The exclusion criteria were: (1) inflammatory rheumatic disease, (2) corticosteroid therapy, (3) rupture of the other AT within 1 year, (4) fractures of lower limbs or more prominent posttraumatic osteoarthritis of a large lower limb joint, (5) preceding local infiltration of steroids and anesthetics, and (6) immunosuppression therapy.

We retrospectively analyzed patient medical records with special attention to the evaluation measurements used and clinical and rehabilitation outcomes. Medical records were not standardized, and their quality was not uniformly assured. Some clinical and rehabilitation outcomes were used inconsistently. We collected and analyzed the following data: patient age and gender, causal activity (e.g. sport and recreation, activities of daily living, work and unknown), number of physiotherapy sessions and surgeon's controls, duration of immobilization (in weeks), use of crutches (in weeks), time of the final medical examination (in the first 3 months, 6 months, 8 months or more). The following data was collected during the final medical examination: passive and active ankle ROM as good (half or more than half of normal ROM), fair (between one third and half of normal ROM), poor (less than one third of normal ROM), limping (no limp, slight, prominent), ability to rise on toes synchronously and unilaterally (on affected leg) (yes, no), toe and heel walking (yes, no), duration of physical activity restrictions (in months), duration of sports activity restrictions (in months), and postsurgical complications as swelling (no swelling, minor, moderate, major), sensation impairment – sural nerve lesion, wound inflammation, skin defects, and rerupture (the last three items expressed as the number of positive cases).

Of the participants 42 (16%) were surgically treated with the open repair method with triceps surae muscle fascial augmentation (group A). Group B (the original modification of percutaneous suturing according to Čretnik and Kosanović) contained 159 (60.7%) participants, and group C (the original percutaneous fixation with two embracing and crossed threads loops according to Kruščić) contained 61 (23.3%) participants.

Surgical techniques

A. Open surgical technique

A patient is operated on while in a prone position and under general or spinal anesthesia. A tourniquet assures bloodless surgery. The incision, approximately

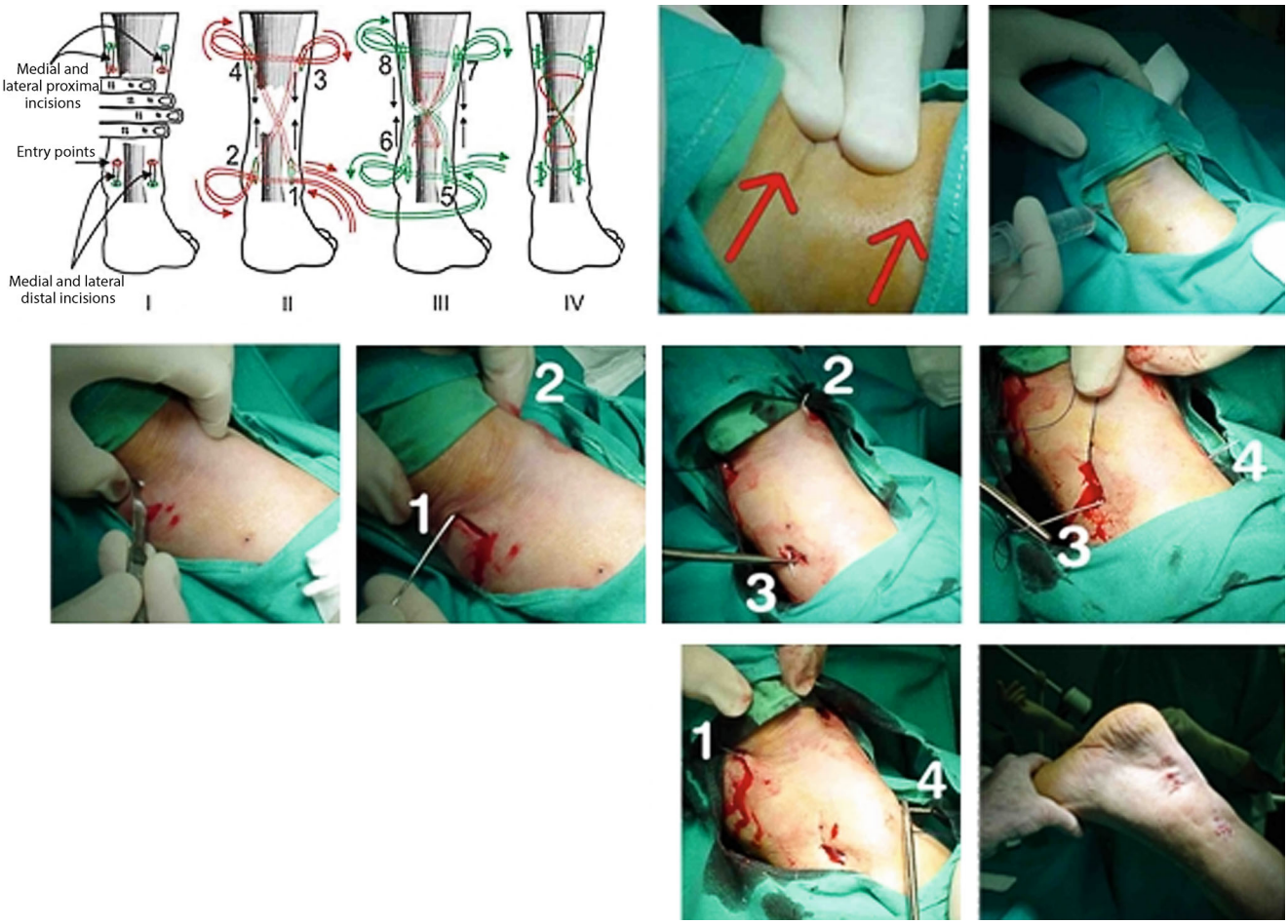

Fig. 1 Percutaneous fixation technique with two embracing and crossed loops (according to Kruščić, schema and photographs)

40 cm long, is made on the inner side of the tendon. Saphenous vein and sural nerve are spared. After the incision of the fascia and paratenon, the torn part of AT is revealed. A 7–9 cm section of the central part of triceps surae muscle fascia is then prepared as a slice. The ends of torn AT can be adjusted end to end when the ankle is in plantar flexion of approximately 20°, and then sutured with Kessler's sutures. The fascia slice is turned down and fixated on the ends of the sutured tendon. The suction drainage is placed, and the wound is closed in levels and then sterile wrapped. A ventral plaster cast is applied. The patient stays in hospital for 1 week. After 2 days, the wound is redressed and suction is removed. A non-walking Sarmiento boot with dorsal opening on sutured wound and in ankle gravity plantar flexion is given to the patient, who is taught to walk with crutches without weight bearing. After 12–14 days, the sutures are removed, the foot is placed in neutral position, and a non-walking Sarmiento boot is given. After 3 weeks, a walking heel is attached, so that the patient can walk with partial weight bearing. After 6 weeks, the cast is removed and rehabilitation, supervised by physiatrist, begins. Following completion of the rehabilitation program, the surgeon carries out a final medical examination.

B. Original modification of percutaneous suturing according to Čretnik and Kosanović

The operation is carried out with the patient under local anesthesia and without a tourniquet in a prone position with the ankle in 25° plantar flexion. The diastasis in the AT is palpated and the sites for cutaneous incisions are marked. In the region of the tendon defect, a volume of 15–20 ml of 1% lidocaine is infiltrated: 8 short cutaneous and subcutaneous incisions are made with special care for the sural nerve at the outer edge of the AT. Doubled resorbable thread is crossed in the lower and upper tendon ends, passing the lateral side at the level of rupture and ending transversally in the upper part of the distal tendon end, where it is knotted. Incisions are sutured or glued, the region is wrapped, and a ventral below the knee cast is applied. Walking with crutches without weight bearing is prescribed. The first check-up by the surgeon is usually done after 2 days. After 3 weeks of cast using, ankle plantar flexion is corrected, and a heel is attached to enable walking with partial

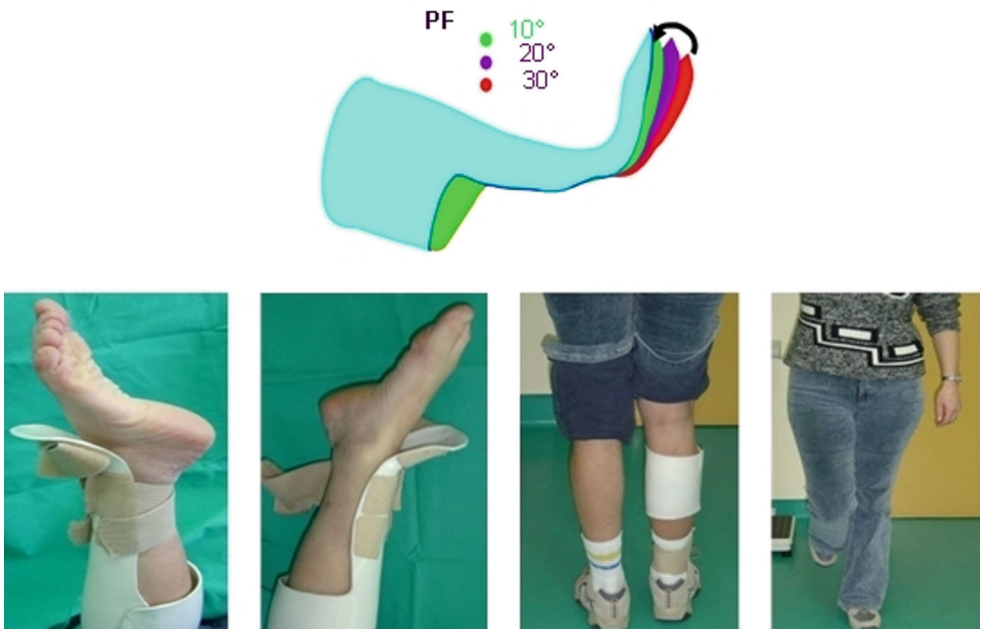

Fig. 2 Closed ankle functional orthosis (CAFO) enables early range of motion exercising and walking without crutches in normal sport shoes: *PF* plantar flexion

weight bearing. At the end of 6 weeks, the cast is removed and rehabilitation program begins.

C. Original percutaneous fixation with two embracing and crossed loops according to Kruščić

The author (A. K.) uses two embracing and crossed loops of different length in percutaneous suturing and fixation of Achilles tendon. He developed this idea when practicing the usage of tension band wiring in a figure of eight in osteosynthesis [16–18]. Although the author first used this modification of percutaneous tendon suturing in 1969, more frequent use began after the introduction of atraumatic resorbable threads. It is believed that this kind of percutaneous fixation could provide correct approximation of the ends of the tendon and enough fixation when used with appropriate plaster immobilization and dorsal ankle and foot orthosis.

The patient is placed in a prone position with the ankle in 25° of plantar flexion. Local anesthesia is used without a tourniquet. The surgeon palpates the area between the tendon ends, and makes four incisions: two of them are situated approximately 5 cm above and two others 4 cm below the rupture (Fig. 1). An infiltration with approximately 15–20 ml of 2% lidocaine is used, covering palpable defect, skin, subdermal layers and paratenon. Atraumatic resorbable threads are placed with a long plane needle, first transversally through outer and inner distal incisions (Fig. 1 numbers 1 and 2), then diagonally from inner inferior incision to outer superior incisions (Fig. 1 numbers 2 and 3), then transversally from superior outer incision to superior inner incision (Fig. 1numbers 3 and 4), and finally diagonally from inner superior incision to outer inferior incisions (Fig. 1 numbers 1 and4). The sutures are tightened up to approximate the ends of the AT and then knotted at the outer inferior incision. The application of the second loop follows the same procedure. Two suture loops of different length are used, and both cross the middle part of the AT tendon (at the level of the rupture). The incisions are sutured or glued. A ventral below the knee plaster cast and crutches are given to the patient, and walking without bearing is recommended for 2 weeks. After 2 weeks, the plaster cast is removed and an individually modelled thermoplastic orthosis (closed ankle functional orthosis, CAFO) is applied, which enables the use of normal footwear and ankle plantar flexion exercises. If tolerated, walking with full weight bearing (without crutches) is allowed (Fig. 2). After 3 weeks, the orthosis is removed, and the patient continues with the rehabilitation program, which is controlled by a physiatrist and the surgeon.

We emphasize that our study is a retrospective one covering a 9-year period. The rehabilitation program was not uniform and previously agreed on. Programs were designed and supervised by many physicians and physiotherapists. Usually a galvanic bath, ultrasound therapy and kinesiotherapy program were incorporated and individually adjusted. Table 2 shows some interesting rehabilitation parameters in favor of group C. In the discussion section we appropriately stress the differences in the rehabilitation approach for the group C, in which early weight bearing and early ROM exercises were used.

The history of our CAFO can be briefly summarized as follows; in 1996, we started to use a 3M Scotchcast below the knee cast boot, which has a dorsal cutting under the distal third of the shank and heel. Ankle dorsal flexion was controlled with a narrow band over the dorsal foot and the distal part of the shank. The cast permitted the use of normal shoes and walking

Table 1 Demographic characteristics (age, gender and causal activity) of three groups of patients with AT ruptures (group A = open surgical technique with fascial augmentation, group B = percutaneous suturing Čretnik and Kosanović, group C = percutaneous fixation Kruščić)

	Group A	Group B	Group C	*p*
N = 262 (100%)	42 (16.0%)	159 (60.7%)	61 (23.3%)	/
Age (years)	44.5 ± 12.3	41.1 ± 10.2	42.1 ± 9.3	0.174*
Gender				
Men *N* = 244 (93.1%)	37 (88.1%)	150 (94.3%)	57 (93.4%)	/
Women *N* = 18 (6.9%)	5 (11.9%)	9 (5.7%)	4 (6.6%)	
Causal activity				
Sport and recreation *N* = 162 (61.8%)	20 (47.6%)	107 (67.3%)	35 (57.4%)	0.154**
Activity of daily living *N* = 55 (21.0%)	11 (26.2%)	26 (16.4%)	18 (29.5%)	
Work *N* = 34 (13.0%)	11 (26.2%)	15 (9.4%)	8 (13.1%)	
Unknown *N* = 11 (4.2%)	0 (0%)	11 (6.9%)	0 (0%)	

N Number of patients
p Statistical significance ($p < 0.05$) for Kruskal-Wallis* and χ^2-test**

Table 2 Comparison of some rehabilitation parameters between three groups of patients (group A = open surgical technique with fascial augmentation, group B = percutaneous suturing Čretnik and Kosanović, group C = percutaneous fixation Kruščić)

Variables	Group A *N* Mean ± SD	Group B *N* Mean ± SD	Group C *N* Mean ± SD	*p**
Number of physiotherapy sessions	21 19.8 ± 9.8	55 19.3 ± 9.7	44 26.8 ± 13.9	0.007
Duration of immobilization (in weeks)	40 6.5 ± 2.2	157 6.0 ± 0.6	61 5.3 ± 0.1	<0.001
Use of crutches (in weeks)	40 6.5 ± 2.2	157 6.0 ± 0.6	61 5.3 ± 0.5	0.003
Number of surgeon's controls	42 5.24 ± 3.0	156 5.3 ± 2.2	59 4.7 ± 2.4	0.010

N number of patients (total number of patients in each group and variable varies because of missing data), *SD* standard deviation
p statistical significance ($p < 0.05$) for Kruskal-Wallis test
*group C differs in the sample (post hoc analysis)

with full weight bearing. Content with good functional results using this cast, we decided in 2002 to start manufacturing CAFO from thermoplastic material (Orfit Industries, Wijnegem, Belgium) at the ergotherapeutic unit of the Institute of Physical and Rehabilitation Medicine UCCM. The upper part of the orthosis is closed (glued) and embraces the shank, the lower part is designed in the form of a flap placed on the dorsum of the foot in order to inhibit dorsal flexion. The flap is fastened to the foot with adhesive bands (Fig. 2). The CAFO permits positioning of the foot in progressive ankle dorsal flexion until reaching a painless plantigrade position. Heel height of 1–2.5 cm can be used. Flap angle and heel height are gradually reduced every 3–5 days, according to pain and swelling regression, ankle ROM progression, and the patient's tolerance.

Statistical analysis was carried out with the software program SPSS v. 17. For comparisons between the three groups, Kruskal-Wallis and χ^2-tests were used, and appropriate post hoc analysis. Statistical significance was defined as $p < 0.05$.

Results

Our retrospective study included 290 patients with unilateral acute closed complete rupture of AT that were surgically treated during the 9-year period from 2000 to 2008. Of the injured persons 28 were excluded based on the exclusion criteria listed in the patient and methods section, thus the final number of participants was 262. Of the participants 42 (16%) were surgically treated with the open repair method with triceps surae muscle fascial augmentation (group A). Group B (the original modification of percutaneous suturing according to Čretnik and Kosanović) contained 159 (60.7%) participants, and group C (the original percutaneous fixation with 2 embracing and crossed threads loops according to Kruščić) contained 61 (23.3%) participants.

Table 3 Comparison of some variables between three groups of patients at the time of the final medical examination (group A = open surgical technique with fascial augmentation, group B = percutaneous suturing Čretnik and Kosanović, group C = percutaneous fixation Kruščić)

Variables	Group A *N* (%)	Group B *N* (%)	Group C *N* (%)	p
Time of the final medical examination (by surgeon)				<0.001*
In the first 3 months	3 (16.7)	10 (7.6)	39 (67.2)	
In 6 months	15 (83.3)	119 (90.1)	17 (29.3)	
In 8 months or more	0 (0.0)	3 (2.3)	2 (3.5)	
Passive ankle ROM				<0.001*
Good	9 (47.4)	113 (77.4)	56 (91.8)	
Fair	10 (52.6)	32 (21.9)	5 (8.2)	
Poor	0 (0)	1 (0.7)	0 (0)	
Active ankle ROM				<0.001
Good	7 (36.8)	20 (14.5)	50 (82.0)	
Fair	5 (26.3)	31 (22.5)	5 (8.2)	
Poor	7 (36.8)	87 (63.0)	6 (9.8)	
Possibility to rise on toes synchronously				<0.001*
Yes	14 (73.7)	76 (54.3)	54 (93.1)	
No	5 (26.3)	64 (45.7)	4 (6.9)	
Possibility of one leg rise on toes (on affected leg)				<0.001*
Yes	0 (0)	33 (24.4)	45 (75)	
No	19 (100)	102 (75.6)	15 (25)	
Limping				<0.001*
No limp	8 (42.1)	106 (76.3)	52 (91.2)	
Slight	10 (52.6)	33 (23.7)	4 (7.0)	
Prominent	1 (5.3)	0 (0.0)	1 (1.8)	
Toe walking				<0.001*
Yes	5 (29.4)	40 (34.5)	54 (93.1)	
No	12 (70.6)	76 (65.5)	4 (6.9)	
Heel walking				<0.001*
Yes	5 (29.4)	40 (35.7)	56 (94.9)	
No	12 (70.6)	72 (64.3)	3 (5.1)	
Duration of physical activity restrictions (in months)				<0.001*
1–2	7 (38.9)	87 (75.0)	47 (83.9)	
3–4	10 (55.5)	28 (24.1)	8 (14.3)	
5–6	1 (5.6)	1 (0.9)	1 (1.8)	
Duration of sports activity restrictions (in months)				<0.001*
Up to 3	1 (5.9)	69 (66.3)	33 (75.0)	
Up to 6	13 (76.5)	30 (28.9)	8 (18.2)	
More than 6	3 (17.6)	5 (4.8)	3 (6.8)	

N number of patients (total number of patients in each group and variable varies because of missing data)
p statistical significance ($p < 0.05$) for χ^2-test
*group C differs in the sample (post hoc analysis)

The mean age of 262 patients at the time of injury was 41.9 ± 10.4 years (range, 21.5–83 years). There were 244 (93.1%) men (mean age 41.6 ± 10 years, range, 21.5–83 years) and only 18 (6.9%) women (mean age 45.6 ± 14.8 years, range, 22.9–75 years). The ratio between men and women was 13.5:1. The AT ruptures occurred mostly during sport and recreational activities (162 (61.8%) patients), 55 (21%) patients were injured in different activities of daily life and only 34 (13%) patients at work. For 11 (4.2%) patients we could not define the activity that had caused the injury. Clinical tests for rupture were sufficient for diagnosis in 224 (85.5%) cases. In a minority of cases (38, i. e. 14.5% patients), the diagnosis was confirmed with an ultrasound examination. The differences in age and causal activity between groups were not statistically significant (data are shown in Table 1).

The comparability of three groups was weakened due to a lack of standardization in the medical records.

Table 4 Comparison of the complication rates between three groups of patients (group A = open surgical technique with fascial augmentation, group B = percutaneous suturing Čretnik and Kosanović, group C = percutaneous fixation Kruščić)

Complications	Group A	Group B	Group C	Total	*p*
Swelling					<0.001
No swelling	0/16 (0.0%)	4/147 (2.7%)	32/51 (62.8%)	36	
Minor	15/16 (93.7%)	104/147 (70.8%)	17/51 (33.3%)	136	
Moderate	1/16 (6.3%)	35/147 (23.8%)	2/51 (3.9%)	38	
Major	0/16 (0%)	4/147 (2.7%)	0/51(0%)	4	
Sensation impairment (sural nerve lesion)					0.157
Yes	0/19	24/143 (16.8%)	9/59 (15.3%)	33	
No	19/19 (100%)	119/143 (83.2%)	50/59 (84.7%)	188	
Minor wound inflammation	1/42 (2.4%)	0/159 (0%)	2/61 (3.3%)	3	<0.001
Skin defect	1/19 (5.3%)	1/141 (0.7%)	0/60 (0%)	2	0.098
Rerupture	0/42 (0%)	2/159 (1.3%)	1/61 (1.6%)	3	0.331

N number of patients (total number of patients in each group and variable varies because of missing data), *p* statistical significance ($p < 0.05$)

In order to include as many participants as possible for each variable, we also included those participants for whom the data on some variables were missing. If the information in the medical record was not contained or unclear, we considered it as missing data and not as negative data. Where the data were missing the participants were excluded from the total number, resulting in a different number for each group and variable listed in the tables.

In group B, the surgeon's final evaluation was provided for 119 out of 132 (90.2%) patients within 6 months after the surgery. In group C the evaluation was provided for 39 out of 58 (67.2%) patients within the first 3 months and for 17 out of 58 (29.3%) patients within the first 6 months after the surgery. The surgeon's final opinion stated during the final surgeon's evaluation upon completion of the rehabilitation program was provided statistically significantly faster in group C in comparison with group B ($p < 0.01$).

A statistically significant difference was found between the three groups in two outcomes: the number of the surgeon's ambulatory controls (the least in group C, $p = 0.01$), and the number of physiotherapy sessions (the least in group A and the most in group C, $p = 0.007$).

The mean values of some variables for all three groups are shown in Table 2 and 3. The differences that were statistically significant and advantageous for group C were: the ability to rise on toes synchronously and unilaterally (on affected leg), the ability to walk on toes ($p < 0.001$), duration of physical activities restriction, and duration of sports activities restrictions ($p < 0.001$ for all variables). Patients younger than 45 years did not have statistically significantly better results in any variable in comparison with older patients. The rate of complications was higher in patients older than 45 years ($p = 0.014$). A comparison of the complication rates between three groups is shown in Table 4. In group A, there was only 1 (2.4%) patient with major complications (wound infection with skin and tendon defect as sequel), in group B, there were 24 (16.8%) patients with minor complications (sural nerve injury), and 3 (1.9%) patients with major complications (2 reruptures and 1 skin breakdown), in group C, there were 9 patients (15.3%) with minor complications (sural nerve injury) and 1 (1.7%) patient with major complications (rerupture). In group A, there were no reruptures. There were no statistically significant differences between groups B and C with regard to major and minor complications.

Discussion

Acute complete AT ruptures typically occur in men between the ages of 30 and 50 years. In our study there were 93% men, and their mean age was 42 years. The predominance of men has been confirmed in numerous studies and meta-analyses [1–3]. A definitive reason why men are more frequently injured is not known, it might, however, be the result of men's higher levels of physical activity.

There is no generally accepted evaluation score for this pathology [19]. Clinical and functional evaluations in medical records were somewhat inconsistent. We decided to use a 3-grade scale for the evaluation of some clinical outcomes (i. e. active and passive range of motion: poor, moderate, good) and a dichotomic definition of some functional tests (i. e. able or not able to walk on toes). We also included some outcomes specifically used in early rehabilitation, such as early partial weight bearing (use of crutches) and the time when ambulatory rehabilitation was begun.

More then 40 different open surgery techniques have been described [19]. All of them cause considerable iatrogenic traumatization of the region tissue. In augmentation with a fascial flap, the flap thickness increases the volume of the tendon and the shank and impedes suturing of different tissues. The time needed for flap remodelling can last from some months to 1 year or even more. The time of immobilization in the group A corresponds to the results from meta-analyses, from 4 [2] to 8 weeks [13], mostly

6 weeks [2, 7]. It is questionable if tendon strength is a result of the augmentation technique or a "decelerated" rehabilitation [7], which is incompatible with a fast return to sports activities.

It has been proven that open surgery results in the highest level of AT strength and the lowest rerupture rates [3, 19], but the number of postoperative complications is the highest (the percentage of overall complications is up to 24% [2], of wound complications from 5.4 to 14.6% [19] and of reruptures up to 4.3% [20]). Patients from group A achieved good functional results and showed only a small number of complications. Skin defects were the most frequent complication (5.3%) in this group, but it was the only group without any reruptures.

Modern operative techniques aim at assuring minimum iatrogenic trauma with the lowest possible complication rate, and they promote accelerated rehabilitation protocols. It has been proven that early exercising and weight bearing stimulates healing and strengthening of soft tissues [13–15]. Accelerated rehabilitation must prevent unwanted trophic changes, preserve muscular strength and result in an early return to independence in performing daily activities. It could be especially useful for two categories of patients, for athletes, because of a faster return to sports, and for older people, because of the reduction of comorbidity and postoperative complications. In the case of percutaneous suturing, cast immobilization usually lasts from 4 [21] to 6 [7] or even 8 weeks [19]. Full weight bearing and physical therapy usually starts after 6 weeks [7].

Percutaneous suturing of AT guarantees approximately 50% of the strength that can be achieved with open surgery, but this was confirmed only in the comparison of open technique with Bunnell sutures and the original version of percutaneous suturing according to Ma and Griffith [22]. The majority of studies confirmed that the frequency of reruptures is higher in percutaneous suturing then when using the open repair techniques. The frequency ranges from 2.1% [20] to 12% [7] and even 17% [23], although some authors have not been able to detect statistically significant differences [24] or have even found an advantage of percutaneous suturing [20].

The percentage of general complications in percutaneous suturing is 15.6%, and the overall percentage of complications is between 8.5 and 24.1% [19]. Our results are much better. It is believed that shorter surgery times, smaller incisions and the absence of bandages can considerably reduce the frequency of complications [7].

Twaddle and Poon stated that a rehabilitation protocol that includes early ROM exercises and early bearing is more essential than the surgery itself [25]. Early mobilization has been advocated because of numerous beneficial effects (it prevents muscle atrophy, stiffness, adhesions, and deep venous thrombosis and has been associated with faster healing and stronger tendons due to improved vascularization and an improved immunological response) [26]. Early functional bearing is definitively the fastest way to recuperate some important motoric parameters (speed of movement, reaction time, and coordination) [13]. The results of Jomha et al. have proven that improvement of functional results and quality of life in patients treated with early postoperative weight bearing as tolerated at the beginning of the second postoperative week can be achieved without an increase in complication rates [27]. No differences have been found in the occurrence of minor or major complications including reruptures after early weight bearing (within 4 weeks) in the surgically and non-surgically treated patients [26]. The meta-analysis by Suchak et al. showed that postoperative protocols stressing early function ameliorate subjective patient satisfaction without increasing the frequency of rerupture [14]. A meta-analysis by Khan et al. confirmed that patients treated with percutaneous suturing and supplied with functional postoperative orthoses, which permitted early ROM exercising, suffered fewer complications in comparison with those treated with immobilization [20].

As practiced in our hospital, the variation of percutaneous technique used in patients from group B was not compatible with the accelerated and more aggressive rehabilitation protocol. Kruščić's modified percutaneous suturing in a way by fixing the tendon ends with two embracing and crossed thread loops is compatible with the accelerated rehabilitation protocol.

Patients from group C achieved the best functional results in the shortest amount of time. The time period spent with immobilization and crutches in comparison with other two groups was the shortest one. Early range of motion exercises and weight bearing using closed functional orthosis did not compromise the healing of the tendon. An AT rerupture was registered in only 1 (1.7%) patient from the group C, and in 2 (1.3%) patients from the group B.

Patients from group C had statistically significant number of physiotherapy sessions and the longest rehabilitation follow-up. This was necessary because of the need to carefully follow-up the appropriateness of the relatively aggressive rehabilitation protocol. Special concern was directed versus manufacturing, application and eventual adaptation of CAFO. In only two cases, we applied heel height in the first 2–3 weeks because of pain on full weight bearing.

Most authors agree that injuries of the sural nerve are more frequent in percutaneous techniques (from 0% [27] to 16.7% [19]) than in open techniques, but nevertheless this injury is not restricted to operative techniques. In conservatively treated patients, the frequency of sural nerve lesion is 1.8% [9]. In most cases, it is only a temporary problem and there is a good chance of spontaneous resolution of symptoms, es-

pecially when resorbable suturing material has been used [7].

After the omission of conservative treatment of acute complete rupture of AT, senior surgeons in our hospital proclaimed an open repair surgery to be the most appropriate one. Younger generations of surgeons advocated percutaneous techniques because of some important advantages. Percutaneous suturing is done in the outpatient department with local anesthesia and without hospitalization. It permits an earlier start of physical therapy and rehabilitation program. It shows a relatively small number of postoperative complications, although the rerupture rate is higher than in open surgery. Only partial AT ruptures are nowadays treated conservatively. Complete AT ruptures are primarily treated with percutaneous suturing and open repair surgery is indicated only in the case of rerupture. Based on our results, we state that percutaneous suturing with two embracing and crossed loops according to Kruščić represents the treatment of choice in all patients with acute complete rupture no matter the patient's age.

Conclusion

The ideal treatment for patients with acute complete AT rupture has not yet been discovered. Open technique has relatively high risk of postoperative complications, but results in less reruptures. Percutaneous technique has an acceptable frequency of minor complications. In UCC Maribor the treatment of choice is percutaneous technique, no matter of patient's age and level of physical activity. The usage of different modifications depends on the surgeon's knowledge and experience. With a retrospective analysis of short-term results, we proved the advantages of the original modification of percutaneous suturing with two embracing and crossed loops according to Kruščić. This technique makes it possible to carry out an accelerated rehabilitation protocol, which includes usage of a special orthosis named CAFO. It permits early weight bearing and ROM exercising and therefore allows faster functional recovery, without increasing postoperative complication rates.

Conflict of interest D. Lonzarić, A. Kruščić, D. Dinevski, P. Povalej Bržan and B. Jesenšek Papež declare that they have no competing interests.

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