FOOT & ANKLE INTERNATIONAL

Percutaneous vs. Open Repair of the Ruptured Achilles Tendon—A Prospective Randomized Controlled Study

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ABSTRACT

A prospective randomized controlled trial comparing open and percutaneous repair of closed ruptured Achilles tendons was performed over a period of 30 months. Sixty-six patients from seven district general hospitals were entered into the study with 33 patients randomized into each group. A modification of the technique described by Ma and Griffith was used in the percutaneous group and a Kessler suture supplemented with interrupted sutures was used in the open group. Patients were followed up for a minimum of six months. The mean age was 38.5 years (26 to 53 years). Forty patients were male and 26 female. After the rupturing event but prior to surgery, it was noted that seven patients had paresthesia in the territory of the sural nerve. The mean duration of immobilization was 12.4 weeks (10 to 14). The complications in the open group included seven wound infections (21%), two adhesions (6%) and two cases of re-rupture (6%). In the percutaneous group there were three cases of wound puckering (9%), one re-rupture (3%) and one case with persistent paresthesia in the sural nerve territory (3%). The difference in infective wound complications between the two groups was statistically significant (Fisher's exact test P = 0.01). Percutaneous repair is advocated on the basis of the low rate of complications and improved cosmetic appearance.

The study was undertaken in hospitals in the North East Thames and Oxford regions of the UK.

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INTRODUCTION

Closed rupture of the Achilles tendon is an infrequent but disabling injury. There is still considerable debate regarding the best method of treatment. The two most common treatments are open surgical repair or plaster immobilization. The treatment chosen is usually based on the delay to presentation, the patient's athleticism, age, medical fitness and the preferences of both surgeon and patient. Recently, there has been a trend towards percutaneous methods of surgical repair.

Percutaneous repair was described in 1977 by Ma and Griffith with no re-ruptures and only two minor complications.[18] Since then, there have been mixed results in studies where some have shown higher re-rupture rates and sural nerve complications. These have led some authors to develop alternative methods of percutaneous repair.[5,7,10,25] There is, however, a paucity of studies comparing percutaneous versus open repairs in the English literature and none of these were randomized controlled trials. The purpose of this study was to prospectively compare percutaneous versus open repair of Achilles tendon ruptures.

MATERIALS AND METHODS

A prospective, randomized study was carried out over a period of 30 months. The 66 patients recruited were from seven district general hospitals. Patients who had non-operative treatment, open ruptures, previous ipsilateral ruptures, presented later than seven days from the injury or refused to take part in the study were excluded. Randomization to percutaneous or open surgical groups was done using the last digit of the patient's hospital number. If the digit was odd then percutaneous repair was chosen and if even, open repair. The patients were blinded to the randomization process.

Of the 66 patients entered into the study, 40 were male and 26 female. The mean age was 38.5 years, with a range of 27 (26 to 53 years).

Fifty of the patients had a sedentary occupation. For the purposes of this study this was defined as an occupation where the majority of the working week did not involve physical activity in any significant measure. Sixteen patients in this series were manual workers. There were no professional or high level amateur athletes in the series, reflecting the District General Hospital setting from which these patients originated.

Twenty of the patients described themselves as active participants of sports or outdoor activities. Forty-three patients participated in sports/outdoors on an occasional basis and three patients had no sporting/outdoor activities.

The mechanism of injury was playing squash in 15, running/jogging in 15, football in eight, tennis in five, netball in five, basketball in two, bowling in two, standing on tip-toes in two, missing a step in two, miscellaneous in nine and unspecified in one case.

Only four of the 66 had any previous history of pain or discomfort in the Achilles tendon prior to the rupture.

A standard pro-forma was used to collect data. This was filled in at the initial examination, end of the operation and at successive outpatient visits. Appendix 1 is a sample copy. Patients were followed up for six months and discharged then with instructions to return if any problems occurred.

A statistician was consulted and a statistical package, S.P.S.S. (Statistical Product and Service Solutions) version 9.0 for Windows was used. The Mann-Whitney U test was used on the duration ofimmobilization and return to final functional activity. Fisher's exact test was used on the complication rates. A p-value of less than 0.05 was considered significant.

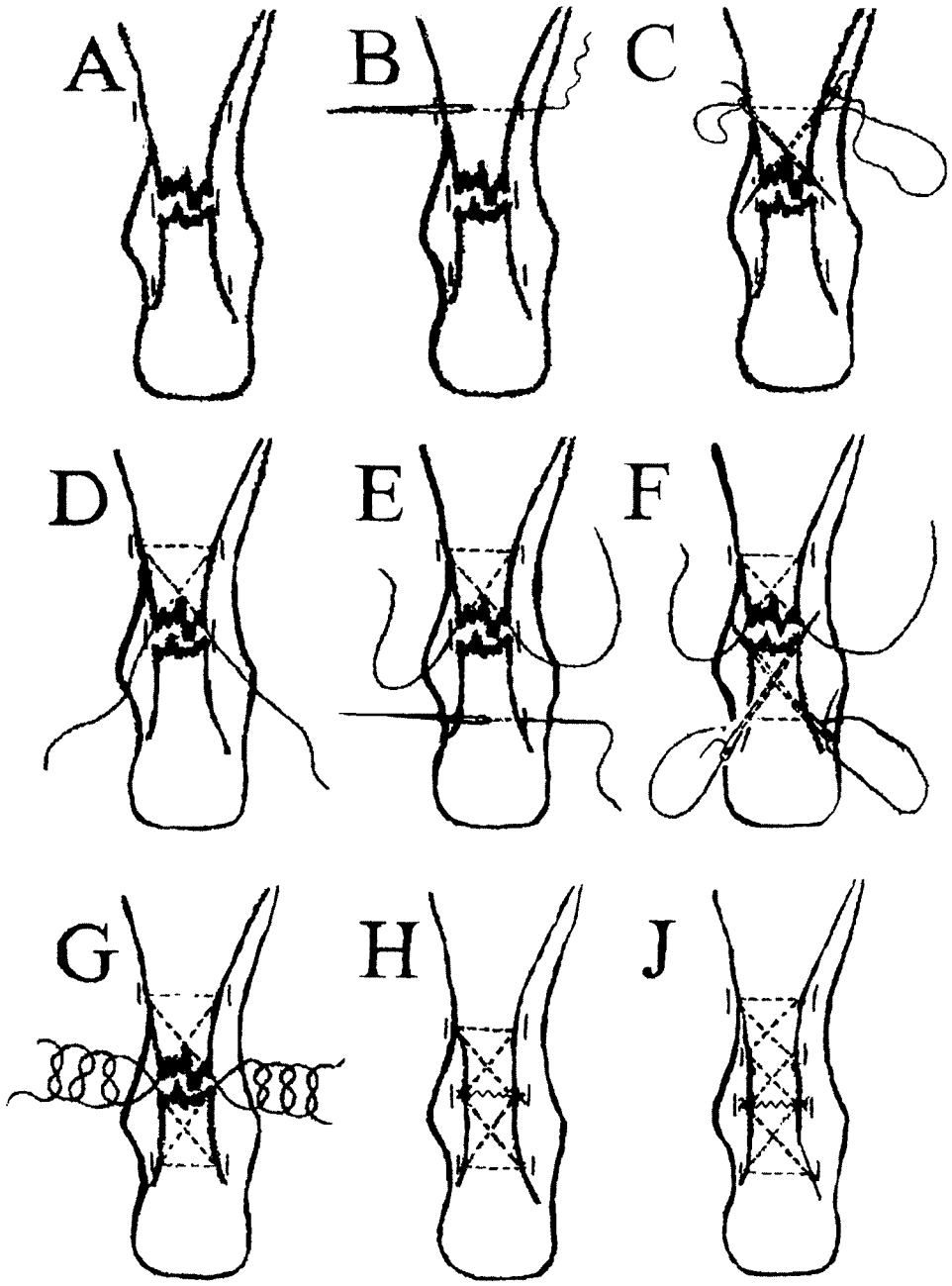

Fig 1: Overall scheme outlining the method of percutaneous repair as elaborated in the text. The lateral malleolus is represented as the lower protuberance on the side of the ankle. Figure 1h shows the repair using six incisions and figure 1J shows the repair using eight incisions.

SURGICAL TECHNIQUE

Open Repair

The operation was performed under general or spinal anaesthesia. The patient was positioned prone or lateral and a tourniquet was used. Prophylactic

antibiotics were not used. A posteromedial or posterolateral incision was used depending on the surgeons' preference. The sural nerve was identified and protected if a posterolateral incision was used. The frayed ends of the tendon were exposed with gentle handling of the soft tissues. A modified Kessler suture, supplemented with interrupted sutures was used. The suture material used was a number one monofilament Polydioxanone. The wound was closed in two layers with Polyglactin 910.

Percutaneous Repair

The operation was performed under general, spinal or local anaesthesia. The patient was prone and a tourniquet was not used. Prophylactic antibiotics were not used. A kidney dish padded with a draping towel was placed under the ankle and the location of the tear was identified by palpation. A modification of the technique described by Ma and Griffith[18] was used. A number one monofilament Polydioxanone with two straight needles on both ends was used.

1) With a No.15 blade, stab incisions were made through the skin and subcutaneous tissue on the medial and lateral aspect of the tendon at the following locations: at the level of the rupture, 2.5 cm distal to the rupture, 2.5 cm proximal to the rupture (Fig. 1a). If eight stab incisions were used, medial and lateral stab incisions were also made 5 cm proximal to the rupture.
2) Each incision was opened up with a curved hemostat to free the skin/subcutaneous tissue from the tendon sheath underneath and to minimize puckering.
3) At the most proximal pair of incisions the needle and suture is passed transversely from lateral to medial and adjusted so that an equal length of suture lay of each side (Fig. 1b).
4) The needles are then reintroduced through the ipsilateral proximal incisions and angulated distally, approximately 45° to the long axis of the tendon, to emerge at the pair of incisions at the level of the rupture if six stab incisions were used (Figs. 1c and 1d). In the eight-incision operation step two is then repeated at this level so that the needles emerge at the incisions at the level of the rupture.
5) The suture ends are pulled to tighten the proximal suture.
6) Step one is repeated at the level of the most distal pair of incisions (Fig.1e).
7) Step two is repeated but this time angulating proximally so that the needles emerge through the incisions at the level of rupture next to the proximal suture ends (Fig. 1f). The sutures are pulled to tighten both proximal and distal sutures.
8) The tendon ends are apposed by plantarflexion and pulling the sutures, which are then tied, burying the knots subcutaneously (Fig. 1g).
9) Later addition: to minimize puckering, a curved hemostat is used again to free the skin from the underlying tendon at all incision sites.
10) Steristrips are used to close the wound.

After the repair was completed, the ankle was taken through an arc of motion from 20° of plantarflexion to neutral noting the tension on the repaired rupture. This gave the operating surgeon an indication of the position in which to immobilize the limb.

Immobilization

A below knee plaster was used apart from cases where the surgeon had a personal preference for an above knee plaster. The position of immobilization was in plantarflexion for four to six weeks followed by neutral for six to eight weeks. The mean duration of immobilization was 12.4 weeks (10 to 14 weeks).

RESULTS

The level of the rupture was at the musculotendinous junction in 10 cases, middle third in 17 cases and in the lower to middle third in 39 cases.

Thirty-three cases were randomized into the open surgical group (13 female, 20 male, mean age 36.9 years) and 33 into the percutaneous group (14 female, 19 male, mean age 40.1). The mean operating time was 45 minutes in the open group with a range of 45 minutes (30 to 75), and 30 minutes in the percutaneous group with a range of 25 minutes (20 to 45).

Table 1 shows the method and duration of immobilization, the time taken before the patients return to activities of daily living, final functional activity, return to active sports/outdoor activities, the patient's subjective assessment of the treatment received and the complications. We defined final functional activity as when the patient was unhindered in all his or her activities apart from active sports (Fig. 2).

At discharge six months post-operatively, all 66 patients had returned to a level where their daily activities, other than sports, were unhindered. However, a total of 25 patients were not actively participating in active sports or outdoor activities. Of these, seven had described themselves as active, 15 as occasional exercisers and three had no sporting/outdoor activities. Of the 20 patients that described themselves as active before their injury, four out of the nine in the open group, and nine out of the 11 in the percutaneous group, had returned to active sports by discharge.

In the open surgery group, there was one case of wound breakdown with deep infection and six cases of

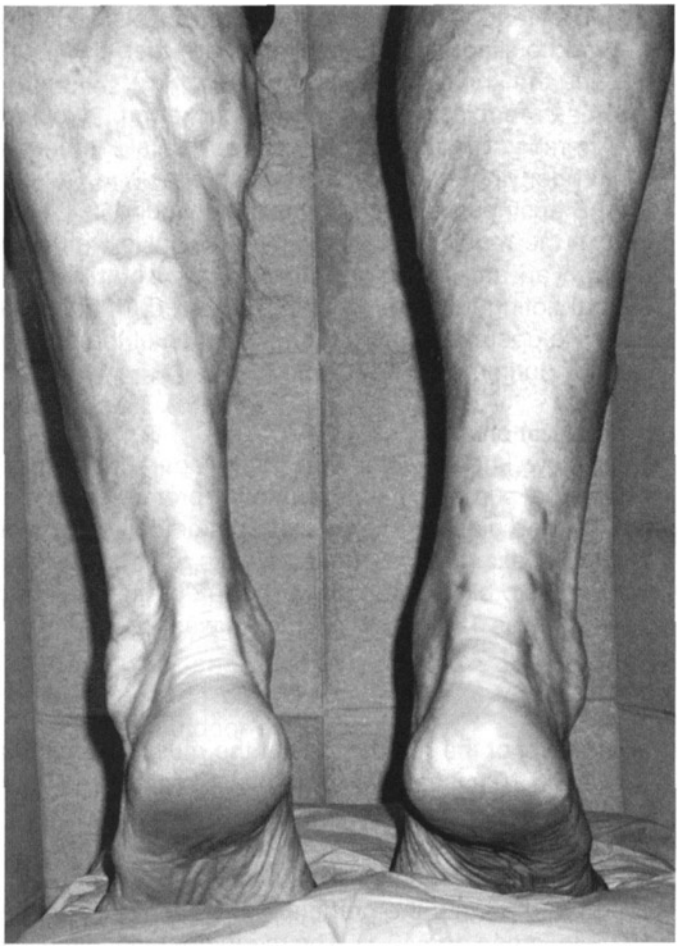

Fig. 2. Appearance of the ankle six months post-operatively. The patient is standing on tip-toe to demonstrate the appearance of the repaired right side compared to the uninjured left side.

superficial infection. A Staphalococcus Aureus was cultured from the wound of the case of deep infection and one of the cases of superficial infection. In the remaining five cases of superficial infection the diagnosis was made clinically but there were no positive microbiological cultures. The cases of superficial infection were treated successfully with oral antibiotics but the wound breakdown required plastic surgical intervention with a fasciocutaneous flap.

The two re-ruptures in the open group occurred at 12 and 16 weeks after the repair. The first patient slipped off a curb and the second stumbled while walking. The only re-rupture in the percutaneous group occurred 16 weeks post-operatively and occurred when the patient missed a step while walking downstairs. All three were treated by open reinforced repair using plantaris tendon and gastrocsoleus fascia.

One scar in the open group developed a keloid. This did not cause any functional disability and no active intervention was taken. There were three cases of puckering of the stab incisions in the percutaneous group. All three occurred early on in the series.

Two patients in the open group developed adhesions of the repair to the wound. This was minor in one case and did not alter management but the other patient required prolonged physiotherapy and still had persistent discomfort after one year.

Seven patients had paresthesia along the lateral border of the foot after the rupturing event but prior to surgery. The mechanism of injury to these patients was jogging in three cases and the others by missing a step, football, tennis and trying to stop a dog from running. In the two patients treated by open repair, the sural nerve was found to be intact macroscopically. They persisted with decreased sensation along the sural nerve distribution until 14 weeks post-op. Amongst the five treated percutaneously, three had a similar recovery time span and one recovered after six weeks. One patient who had ruptured his tendon playing tennis and was treated percutaneously, however, continued to have paresthesia at six months. He had returned to his pre-injury activity level by then and no active intervention was necessary.

The difference in infective wound complications between the open and percutaneous groups was statistically significant (Fisher's exact test $P = 0.01$). With the numbers available, no statistically significant difference could be detected between the two groups with respect to the duration of immobilization, return to functional activity and other complications.

DISCUSSION

The best method of treatment of closed ruptures of the Achilles tendon has long been debated. Non-operative treatment has its advocates[2,9,16,21] but increasingly, operative repair is the treatment of choice for athletes, cases of delayed diagnosis and young patients, particularly active ones.[6,11,14,17,23,26] The vexing choice between open surgical repair and non-operative management is well illustrated by a quantitative review, by Lo et al., of all the English language articles published between 1959 and 1997, where an overall re-rupture rate of 2.8% for operatively treated patients and 11.7% for non-operatively patients was calculated.[17] Operatively treated patients, however, had twenty times more moderate and minor complications than patients not operated on.[17]

Percutaneous repair was described in 1977 by Ma and Griffith[18] as a solution to the difficult choice of the higher complication rate associated with open repair or the higher repeat rupture rate associated with non-operative treatment. They successfully treated 18 patients this way with no re-ruptures and only two minor wound complications.

Rowley and Scotland[22] retrospectively compared 10 patients treated using the Ma and Griffith technique with 14 patients treated non-operatively over the same period. They reaffirmed that the repair could be performed under local anaesthesia and advocated this method of repair to prevent lengthening of the tendon with few complications.

Hynes[13] reviewed 48 patients percutaneously treated in Hawaii and was able to test strength using Cybex II dynamometry in 32 of them. The mean follow-up period was seven years and he reported five cases of re-rupture following significant trauma and one case of sural nerve entrapment. He concluded that this technique resulted in strength comparable to those of open surgical procedures and greater than with casting alone.

Bradley and Tibone[4] compared 12 patients treated percutaneously with 15 treated with open surgical repair using a gastrocsoleus fascial graft. No significant differences in range of motion, strength and endurance using Cybex II testing were found. Cosmetically, the percutaneous repairs were better but there were two re-ruptures produced by violent ankle dorsiflexion in this group. The authors advocated percutaneous repair in recreational athletes and those concerned with cosmesis but open repair in high-caliber athletes who cannot afford any chance of re-rupture.

In an *in vitro* study, Hockenbury and Johns[12] performed percutaneous tenotomies on 10 fresh frozen below knee specimens and used five open repairs and five percutaneous repairs. These were stressed to failure using progressive ankle dorsiflexion. The percutaneous repairs all failed by suture breakage (No.1 Ethibond) and of the five open repairs, which used No.1 Ethibond Bunnell suture with supplementary interrupted mattress sutures, three failed by suture pull-out and two by suture breakage. The percutaneous repairs failed at approximately half the dorsiflexion angle as that required for failure of the open repairs. Sural nerve transfixation was found in three of the five cadavers with percutaneous repair. The authors cautioned that in inexperienced hands the percutaneous repair puts the sural nerve at risk and is not as strong as an open Bunnell repair.

Table 1. Method and duration of immobilization; time taken before the patients return to activities of daily living and final functional activity; patient's subjective assessment of the treatment received and the complications

	Open N=33		Percutaneous N=33	
Method of Immobilization				
Above Knee Cast	4		1	
Below Knee Cast	29		32	
Duration of immobilization				
10 weeks	6		3	
12 weeks	17		18	
14 weeks	10		12	
Returned to Activities of Daily Living by:				
8 weeks	2		2	
13 weeks	28		25	
26 weeks	3		6	
Returned to Final Functional Activity by:				
13 weeks	12		9	
26 weeks	21		24	
Participating in Active Sporting/Outdoor Activities by:				
13 weeks	3		0	
26 weeks	16		22	
unknown	14		11	
Complications				
Infections	7	(21%)	0	
Re-ruptures	2	(6%)	1	(3%)
Keloid formation	1	(3%)	0	
Wound puckering	0		3	(9%)
Adhesions	2	(6%)	0	
Sural nerve problems	0		1	(3%)
Patients Subjective Assessment at six months				
Excellent	14		17	
Good	13		16	
Fair	6		0	

Sural nerve injuries continued to be reported in studies that followed.[1,8,15] Klein et al.[15] used the Ma-Griffith technique in 43 patients of which 38 were available for follow-up. Sural nerve injuries were noted in five patients early in this series, and the authors modified the operative technique by extending the midlateral skin incision to 2 cm, so that sural nerve could be seen and retracted. There were three cases of re-rupture where a resorbable suture was used. The authors recommended their modified technique for repairs of fresh ruptures but emphasized the need for non-resorbable sutures.

Fitzgibbons et al.[8] reported one case of sural nerve injury and no cases of re-rupture in 14 patients who

were treated by the closed method. Using a Cybex II dynamometer, they were able to demonstrate only a 3% loss of strength and a 7% loss of power which they cited as comparable to that of open repair and superior to closed treatment. The authors argued that the percutaneous repair was suitable for professional athletes as well as recreational ones if appropriate precautions were taken after cast removal.

Steele et al.[24] evaluated 30 patients retrospectively. Among those treated by open repair there were two re-ruptures and two wound infections. Among the patients treated percutaneously the only complication was one case of sural nerve entrapment. Ten patients from each group were assessed for plantar flexion isokinetic strength, mid-calf girth, ankle joint position sense and range of movement. No significant difference was found between the two methods of repair. The authors felt that the percutaneous repair was a viable alternative to open repair and indeed, had fewer complications.

To minimize the risk of sural nerve injury Webb and Bannister[25] described a technique of percutaneous repair using posterior incisions. In a series of 27 cases, there were no re-ruptures or nerve injuries but one patient developed a stitch abscess and one developed complex regional pain syndrome type II. Other methods of percutaneous repair have also been described.[3,5,7,10] The largest of these, by Buchgraber and Pässler[5] involved 48 patients and used a Polydiaxonone suture in a box configuration. Five stab incisions were used of which one was located centrally, directly posterior to the tear. They retrospectively compared and evaluated the 30 cases where functional post-operative treatment was used and 18 cases where immobilization was used post-operatively. There was one case of repeat rupture and eight cases of sensory impairment in the territory of the sural nerve. The authors favored functional postoperative treatment after percutaneous repair.

Maffulli[19] suggested, in a recent review, that operative management should be used in athletes and in patients who have a high level of physical activity. Regarding percutaneous repair, his main concerns were that the rate of re-rupture was reported to be higher than after open repair and that high rates of sural nerve transfixation had been reported. In the clinical literature, however, a re-rupture rate using percutaneous repair higher than 2.8% has been reported only in three series with greater than 10 patients. Hynes[13] reported five cases in 48 patients. Klein[15] reported three cases in 38 patients, and Bradley and Tibone[4] reported two cases in 12 patients. Delponte,[7] Ma and Griffith,[18] Rowley,[22] Fitzgibbons[8] and Webb[25] reported no re-ruptures; Buchgraber[5] and Gorschewsky[10] reported one case each. In our randomized study the repeat rupture rate was 3% in the percutaneous group and 6% in the open group. The re-rupture rate in the percutaneous group is comparable to the overall rate of 2.8% in open repairs found by Lo et al.[17] The 6% re-rupture rate in the open group is higher but still similar to re-rupture rates reported in some series of open repair of 4% and 5% in Nistor[21] and Cetti et al.'s[6] prospective randomized studies.

The location of entrapment of the sural nerve was 2.5 cms proximal to the repaired Achilles tenotomy in all three cadaveric cases in Hockenbury and John's study.[12] Other authors also believe the nerve is most at risk at the proximal and middle lateral stab incision sites.[1,8,12,15] Sural nerve injury, however, is not restricted only to cases of percutaneous repair; Nistor[21] described a rate of sural nerve injury of 20% in open repair. Interestingly, in our series, seven of the 66 patients (11%) patients had pre-operative, post-injury sural nerve signs. They did not have any medical illnesses that could account for this and this association has not previously been reported in the literature. The most likely explanation is that some complete ruptures must result in a stretching injury to the sural nerve. In our series, there were no cases who developed signs of sural nerve injury that were not present pre-operatively in the open group or the percutaneous group. One patient treated percutaneously had decreased sensation in the territory of the sural nerve pre-operatively which persisted post-operatively. No active intervention was taken as he had returned to his pre-injury activity levels. We therefore believe that the rate of nerve injury is low but nonetheless present, and that retrospective studies which have reported a high rate of sural nerve injury may have included cases where the nerve was damaged at the time of tendon rupture.

Adhesions to the skin are common after open repair with rates ranging from 10.7% to 44% reported by Cetti et al. and Nistor respectively.[6,21] It is rarely seen after percutaneous repair. In our study, however, there were two cases of adhesions in the open group but three of the patients treated percutaneously developed puckering at some incision sites. All three occurred early on in the series and this problem was overcome by using a curved hemostat to free the subcutaneous tissue from the tendon after making the incisions and again at the end of the repair (step 7).

CONCLUSION

Percutaneous repair of Achilles tendons is a simple operation that can be performed under local anaesthetic and without a tourniquet. There is little doubt that the rate of wound complications and the cosmetic results of

percutaneous repair of the ruptured Achilles tendon are superior to those of open techniques. The functional results after percutaneous repair are believed to be equal to that of open repair but there were fears about the possibility of a greater rate of recurrent rupture. This prospective randomized controlled trial has shown no difference in the numbers of re-ruptures between the open and percutaneous groups and that the rate of injury to the sural nerve occurring during the repair is low, but nevertheless present.

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APPENDIX 1: Sample of the three page pro-forma used to collect data.

Name: Consultant

Age: D.o.b.:

Sex: Occupation: manual/sedentary

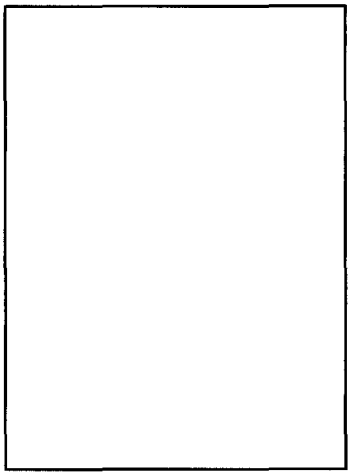
Hospital No. Sports/outdoors:

Hospital Active/occasional/none

1. Mechanism of Injury

2. Pre-existing symptoms of
   - pain
   - weakness
   - previous history of rupture
   - TA tightness

3. Clinical findings:



- Closed/open
- Level of rupture
- Simmond's test
- Gastrosoleus bulk compared with opposite side
- Sural nerve symptoms/signs

4. Pre-existing medical condition/drug history:

   i) steroids
   ii) diabetes
   iii) Renal disease/CRP
   iv) others

Operative technique:

Open	Percutaneous
Incision:	
Posteromedial	no. of stabs
Posterolateral	- suture material

Findings:

- level
- fraying

Procedure:

suture technique:

suture used:

Peri-op

apposition	+	-	
strength of repair:		good	poor

Post-op

AKPOP		BKPOP in equinus
Duration:	4 - 6 weeks	
BKPOP in neutral	6-8/52	

Post-op:	YES	NO
- physiotherapy		
- scars		
- power		
- infection		
- paraesthesiae along sural nerve distribution		

	8 weeks	3mm	6mm
Physio R			
i) gastrosoleus bulk			
ii) power (MRC grade)			
iii) return to final activity			
iv) return to ADL			
v) return to active sports			

Subjective Assessment at 6mm

Excellent

Good

Fair

Poor

Complications: