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Original Research

Comparison of mini-open repair system versus percutaneous repair for Ruptured Achilles tendon – A Prospective Study

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ABSTRACT:
A prospective study comparing open and percutaneous repair of closed Achilles tendon ruptures was conducted over a period of 24 months. 13 patients with acute complete rupture of the Achilles tendon who were operated upon exclusively by modified percutaneous repair were compared with the results of 15 consecutive patients who were operated exclusively by open repair under general or spinal anesthesia during the same period. The described modification of the technique by Ma and Griffith was used in the percutaneous group and the Krackow suture supplemented with interrupted sutures was used in the open group. The study aimed to compare the results of percutaneous and open repair of the Achilles tendon. Patients were followed for a minimum of six months. There were significantly fewer serious complications in the percutaneous repair group compared with the open repair group (7.7% vs. 13.33%; P = 0.03), especially necrosis (0% vs. 6.6%; P = .019) and a lower overall complication rate (23.1% vs 26.6%; P = 0.013). There were slightly more re-ruptures (7.7% vs 0%; P = 0.51) and sural nerve disorders (15.4% vs 0%; P = 0.36) in the percutaneous repair group, with no statistically significant difference. Functional assessment using the Holz score showed no statistically significant difference. The results of the study support the choice of a modified percutaneous suture under local anesthesia as a method that brings functional results comparable to open repair, with a significantly lower rate of complications.
Keywords: Achilles tendon; Ma and Griffith; open repair; percutaneous repairs; comparative study

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INTRODUCTION

The appropriate management of acute complete rupture of the Achilles tendon remains controversial. Most authors[5,10,21,32] prefer open surgical repair. It contributes to a low incidence of re-rupture, which ranges from 1.4%[5] to 2.8%,[19] and offers the possibility of early functional treatment.[4] Because open repair is associated with a significant number of complications (11.8%[5]–21.6% [14]) as well as high costs, some authors advocate non-operative treatment.[5,16,22,23] High incidence of re-rupture (12%[14,19]-17%[31]) and loss of strength are the main arguments for opponents of this method.[5,9,10,21]

Open surgical repair is considered the standard technique for acute TA ruptures, [32,33] but the minimally invasive technique results in lower rates of infection and wound breakdown with functional results equivalent to those of open repair.[27] The percutaneous suture technique is widely used by many surgeons in the Repair of Achilles tendon, but the sural nerve injury remains a problem. Pinching of the sural nerve is one of the most common complications after percutaneous surgery [6–9]. Careful placement of stab incisions to expose the nerve is recommended to prevent this. In addition, to reduce the risk of injury to the sural nerve, some surgeons use curved ring forceps [10, 11], or Kirschner wire [12] as an aid, but it

remains a problem to prevent the sural nerve from being punctured or pinched. . In 2019, Carmont and Maffulli reported results on percutaneous Bunnel repairs for the treatment of acute Achilles tendon ruptures [13]. The rate of sural nerve damage remains up to 6.8%.

Percutaneous suturing,[2,7] first described by Ma and Griffith,[22] especially under local anesthesia[15] and with functional postoperative care,[3] appears to bridge the gap and combine the advantages of both methods. However, percutaneous suturing is criticized because it provides approximately 50% of the original strength of the open repair,[8] exposes the sural nerve to a high risk of injury (up to 60%),[8,13] and has a higher re-rupture rate (6.4%) than open surgical repair. [8,13,21,31] However, there is a lack of long-term, prospective, controlled studies with a large number of patients operated percutaneously.[18,21]

The purpose of this study was to compare the results of this newly modified technique of percutaneous suturing of Achilles tendon ruptures under local anesthesia with the results of open repair under spinal or general anesthesia.

MATERIALS AND METHODS

This prospective study was conducted between October 2020 to September 2022 in patients with an Achilles tendon rupture who visited Govt. Hospital for Bone and Joint Surgery, associated hospital of Government Medical College, Srinagar. The inclusion criteria were: (1) patients 18 years of age or older, (2) closed Achilles tendon rupture, (3) a rupture that occurred no more than 7 days before the operating procedure, (4) complete rupture, (5) rupture that occurred in the tendinous portion (2-8 cm proximal to the insertion), (6) no previous operating procedures or history of partial or complete rupture of the involved tendon, and (7) no previous local, oral, or parenteral therapy that might have weakened the tendon (eg, local infiltration of anesthetics or steroids in the Achilles tendon region, oral or parenteral immunosuppressive therapy in patients with transplanted organs or immune diseases, etc).

The diagnosis was based on the presented clinical criteria: (1) palpable gap in the tendon, (2) positive Thompson's test result,[29], and (3) clinical signs of the rupture (patients were unable to raise their toes or heels. In any case, in which there was some doubt, ultrasonography was performed to confirm the diagnosis.

Table 1: Patient Data

	No.[P]	%	No.[O]	%
Patients	13		15	
No. of Patients in the final follow up	13	100	15	100
Gender				
Male	12	92.3	14	93.3
Female	1	7.7	1	6.7
Laterality Left	8	61.5	11	73.3
Right	5	38.4	4	26.6
Injury manner				
Missed steps on stairs	7	53.8	9	60
Soccer	2	15.3	3	20
Other	4	30.7	3	20

13 patients met the above-mentioned inclusion criteria called the percutaneous [P] group and 15 patients in the second group known as the open repair [O] group. The final results of 13 patients in the first group and 15 patients in the second group were evaluated. The most frequent activity in which injury occurred was missed step on the stairs (7 patients [53.8%] in the P group and 9[60%] in the O group). Details are listed in *Table 1.*

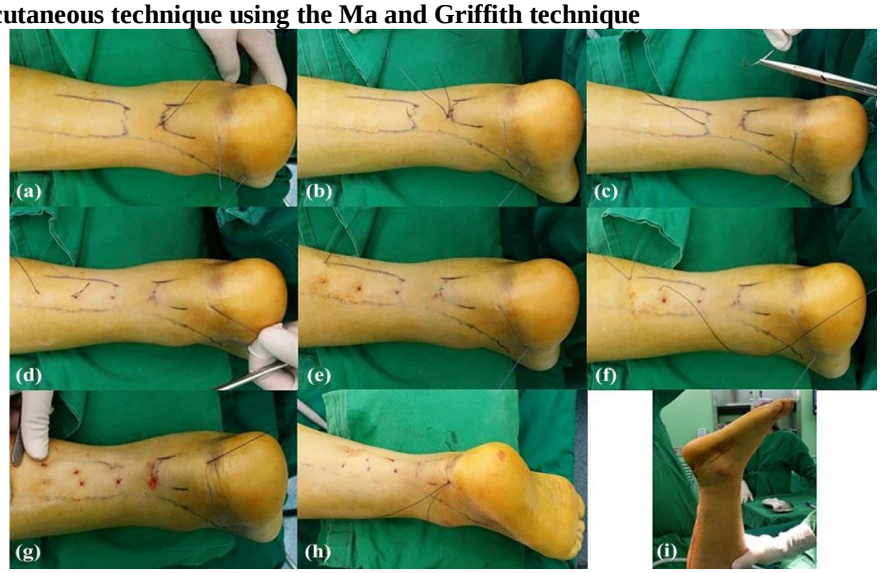
SURGICAL TECHNIQUE

PERCUTANEOUS REPAIR

The operation was performed with the patient in the prone position and with the injured leg in approximately 25° plantar flexion, under local anesthesia without a tourniquet. Antibiotic prophylaxis was administered. The rupture and gap location was localised before the procedure began. Next, proximally (about 5 cm) and distally (about 4 cm) around the palpated gap, the skin, subcutaneous tissue, and peritendon were infiltrated with approximately 15 to 20 mL of 1% lidocaine (without norepinephrine) through 8 puncture holes that were later used for needle entry and subsequently enlarged (Figure 1). Special attention was paid to the lateral side, especially the proximal one, where the sural nerve lies nearby and crosses the Achilles tendon. The patient was instructed to report any changes or tenderness in the sural nerve area during the puncture or infiltration. In this case, the injection site was changed approximately 0.5 to 1 cm towards the center (inner side). The tendon was then repaired with ethibond. The procedure was started and finished medially and distally. First, a long semi-curved needle suture was passed transversely through the tendon, and then a (diagonal) cross suture. At each point of needle entry or exit, the incision was extended longitudinally with a #11 blade over the inserted

needle to allow the surgeon to bury the suture subcutaneously (on the paratenon) while threading the suture through the same hole. A small hemostat can also be used to widen the opening and facilitate the insertion of the suture. The thread was then passed longitudinally, subcutaneously, and outside the tendon, and another crossing of the tendon was performed proximally. Next, both ends of the sutures were guided extra-tendinously back through the second and third holes distally and pulled back symmetrically until both ends of the ruptured Achilles tendon were fully approximated and the defect was no longer palpable. After approximating the ruptured ends of the Achilles tendon, the lateral end of the suture was passed medially, and after the final simultaneous tightening of both ends of the suture, the suture was ligated. The nodes were buried subcutaneously in the previously widened second medial stab incision. This procedure left only 8 small stab incisions visible (and folds of skin that later disappear completely). These incisions could be closed with fine sutures, although this procedure was not routinely performed**. [Figure 1(a)-(i)]**

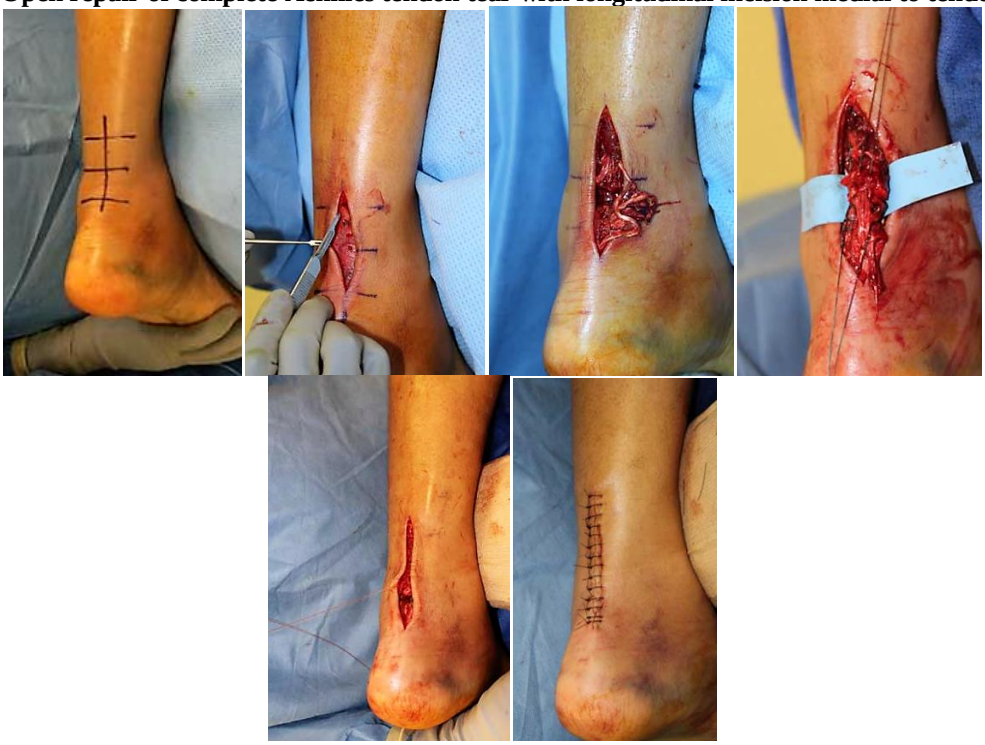
Figure 1: Percutaneous technique using the Ma and Griffith technique



OPEN REPAIR

The procedure was performed with the patient in the prone position, under general or spinal anesthesia with a tourniquet. Patients received antibiotic prophylaxis. A direct skin incision was made from the medial aspect of the heel to the calf as needed, preserving the lesser saphenous vein and sural nerve. The paratenon was carefully dissected. The rupture occurred and necessary (minimal) debridement was performed. The tendon was repaired with Ethibond using a Krackow suture and fine interrupted sutures. The paratenon was carefully reconstructed at the pin harvest site. The procedure was completed with subcutaneous and skin sutures [Figure 2]. For both methods, a sterile dressing and cast were applied after suturing with the foot in approximately 20° plantar flexion to be worn for 3 weeks. Patients used crutches for assistance and were kept non-weight bearing. For open repair, sutures were removed after 2 weeks. After 3 weeks, a new immobilization was applied with the leg in a neutral position. Patients were allowed to bear weight as tolerated. After 6 weeks, the immobilization was removed and the patients were allowed to walk and begin (careful) rehabilitation with range of motion, progressive resistance exercises, weight-bearing with an elastic band, and so on (until the pain was felt). Special attention was paid to the correct walking pattern (no limping). Stretching exercises were allowed after 8 weeks with a careful increase in load. Lifting on toes or heels was allowed 12 weeks after surgery. Limited sports activities were individually allowed after 3 months with full weight bearing recommended 6 months after surgery. No special lifting shoes or boots were used.

Figure 1: Open repair of complete Achilles tendon tear with longitudinal incision medial to tendon



Patients were followed up regularly at 3 and 6 weeks postoperatively and then at 2 and 3 months. After that, they were individually scheduled according to their rehabilitation progress or complication. Final assessments and analyses were made. Clinical outcome was assessed using the rating scale according to Holz.[33]

Table 2: Scoring Post Repair of Tendo-Achilles Rupture[a]

Percutaneous Repair Group		Open Repair Group			
Rating Points		**No.**	**%**	**No.**	**%**
Gait					
Normal	3	13	100	14	93.3
Mild limp	2	0	0	1	6.6
Limp	1	0	0		
Motion at ankle (loss of plantar flexion)					
Symmetrical	3	12	92.3	13	86.6
Decreased ≥ 5°	2	1	7.6	2	13.3
Decreased ≥ 10°	1	0	0	0	0
Standing strength on tiptoe (on the injury leg)					
Normal strength	3	10	76.9	12	80
Weakness	2	2	15.4	3	20
Not possible	1	1	7.7	0	0
Disturbances (pain, weakness, tender scar)					
None	3	11	84.6	12	82
Minor	2	2	15.4	2	13.3
Considerable	1	0	0	1	6.66

[a]Ratings according to Holz. No values were statistically significant.

Table 3: Scoring Post Repair of Tendo-Achilles Rupture[a]

PercutaneousRepairGroup		Open Repair Group				
Result	**Points**	**No.**	**%**	**No.**	**%**	***P***

Good	12-15	12	92.3	13	86.6	.305
Fair	8-11	1	7.69	2	13.4	.595
Poor	7 or less	0	0	0	0	.440

[a]Ratings according to Holz.

A description of the Holz scale is reproduced in Tables 2 and 3. The neutral zero method,[27] with maximum dorsiflexion considered to be 20° and plantar flexion to be 50°, was used for the assessment of ankle motion. The patient's final neurological status and ability to perform repeated toe raises were also evaluated. Patients were asked first to raise 20 times (in 30 seconds) on the toes with both legs simultaneously (test 1) and then 5 times (in 15 seconds), first with the non-injured leg followed by the injured leg (test 2). They were allowed to balance with a hand at the edge of the table but were not allowed to bear weight on the hand. We also evaluated patients' return to their previous activities and the presence of any associated complaints. Patients' subjective assessments of the treatment were scored as good, fair, or poor. Complications were divided into 2 groups: major complications and minor complications (Table 4).[5,19,23]

STATISTICAL ANALYSIS

The results were analyzed statistically with a 1-tailed t-test for numerical parameters and with a $\chi 2$ test for attributive parameters using the editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). A P value of less than .05 was considered significant.

RESULTS

The procedures were well tolerated, with no pain or complications during the procedures in all patients regardless of the method used. There were no allergic reactions to lidocaine or problems with suture disintegration. The results of the functional evaluation according to the Holz score are presented in Tables 2 and 3. One patient (7.7%) in the P group was unable to stand on tiptoes with the operated leg. Patients treated percutaneously were operated on an average of 2.1 days after the injury and spent 3.3 days in the hospital due to surgery and treatment complications. In 8 cases, the procedure was performed on an outpatient basis. Patients treated with open repair underwent surgery an average of 1.4 days after injury and spent 3 days in the hospital for surgery and treatment complications. Complications are listed in Table 4.

In group P, one patient (7.7%) experienced a partial re-rupture 6 weeks after the procedure. The mechanism in the patient was an uncontrolled full load during a fall (on the stairs during rehabilitation). The diagnosis was confirmed by ultrasonography. Clinical examination and ultrasound demonstrated preservation of tendon continuity in a patient with a partial rupture. The patient with the partial rupture was treated with a knee cast for 1 to 6 weeks. There were no further complications, with a full return to the previous activity. Two patients (15.4%) reported disturbances in the distribution area of the sural nerve.

Table 4: Complications in Achilles Tendon Repair[a]

	Percutaneous Repair Group		Open Repair Group		
Complication	**No.**	**%**	**No.**	**%**	**P**
Major					
Rerupture, partial	1	7.7	0	0	NS
Deep infection	0	0	1	6.66	NS
Necrosis of the skin	0	0	1	6.66	.019
Total	1	7.7	2	13.33	.030
Minor					
Superficial infection	0	0	2	13.3	NS
Delayed wound healing	0	0	0	0	NS
Adhesion of the scar	0	0	0	0	NS
Disturbances of sensibility	2	15.4	0	0	NS
Total	2	15.4	2	13.33	NS
Total Complications	3	23.1	4	26.66	.013

[a]NS, not significant.

Patients were encouraged to undergo early and careful rehabilitation with non-steroidal anti-inflammatory drugs and B-complex vitamins. In group O, one patient (6.66%) had a deep infection and necrosis was found. The final result was good, 5° limitation of dorsiflexion and plantarflexion and return to all activities (including sports) with some difficulty, mostly due to the thickness of the operated area and problems with putting on shoes.

In the patient with skin necrosis (6.66%), the defect healed with granulations after non-operative treatment in 1 to 7 months. Problems in the area of distribution of the sural nerve in patients treated with percutaneous repair disappeared after 3 weeks to 6 months without surgery. In patients with superficial infection in group O, symptoms completely disappeared only after 14 days of oral antibiotic therapy.

DISCUSSION

Although rupture of the Achilles tendon is not a very common injury, it has always attracted a lot of attention. Despite many different studies and meta-analyses, there is no universal agreement on the optimal treatment strategy for acute total Achilles tendon rupture. Percutaneous repair is supposed to be a weaker repair compared to open sutures, with a higher number of reruptures, and is therefore not recommended for patients with high demands.[2,8,13,21] Klein et al[13] reported 3 reruptures out of 38 patients (7.9%) using the Ma and Griffith technique, and Webb and Bannister[31] found 6.4% re-rupture (in 5 of 78 patients) with the percutaneous repair. Biomechanical studies demonstrated significantly greater and thus comparable strength of the proposed percutaneous technique with open repair.[6] In our clinical results, only 1 (7.7%) partial re-rupture (confirmed by ultrasonography) was found when using this technique, with no statistically significant difference compared to open repair with augmentation. The rupture occurred as a result of full uncontrolled loading of the operated tendon early in the postoperative period. The protocols of the original percutaneous techniques by Ma and Griffith[22] and Buchgraber and Pässler[3] recommend an 8-week immobilization period after surgery, which may have prevented re-rupture, which in our study occurred 6 weeks after surgery (immediately after removal of immobilization). However, based on the results of other patients, we retain with the same immobilization time (6 weeks) with strict instructions for patients at the beginning of rehabilitation. Rerupture occurred within 10 weeks after surgery. For the first 10 weeks after surgery, we do not recommend weight-bearing or sports activities.

Adequacy of application and fixation of torn ends appears to be essential for all methods and techniques. Complete rupture leads to retraction of the triceps surae muscle and diastasis of the torn ends. As with nonoperative treatment, the torn ends of the tendon usually remain separated; this gap leads to the tendon healing in an extended position and loss of normal muscle tone and weakness. [9,30] The gap is filled with fibrous tissue that is never as strong as the original tendon, contributing to a high rate of re-rupture. Open repair allows the best visualization and approximation of the torn ends and the possibility of augmentation with different types of strips and parts of the tendon, thereby reducing the number of reruptures to a minimum.

Reapproximation of the torn ends with a single suture may only approximate one side and result in an asymmetric repair. Using the proposed new modified technique, the plucked ends are drawn symmetrically and simultaneously with 2 thread ends and the double pulley technique. This technique minimizes pullout forces at the suture-tendon interface and provides almost double the repair strength compared to the Ma and Griffith repair configuration.[6] The percutaneous method is criticized as being closed (blind). The exact position of the torn ends and their approach cannot be visualized.[21] However, once the torn ends are separated from each other, the gap between them can be felt and thus the position of the ends can be located.

The proposed modified technique is probably more challenging but can be performed if the guidelines are followed carefully. It is very important to bring the torn ends close enough so that the defect is no longer clinically palpable. Plantar flexion of the foot during reapproximation assists in this maneuver. Considering that the healing process begins immediately after the rupture and the hematoma begins to be replaced by fibrous tissue, it is clear that with the closed method after a certain time, the fibrous tissue cannot be removed and the torn ends cannot be completely approximated. Therefore, if a good repair is to be achieved, we do not recommend the percutaneous method for ruptures that are older than 7 to 10 days.

Sensory disturbances in the sural region that occur with open repair are upto 12% and between 0% to 60% using Ma and Griffith's technique.[8,13,22] In one of the largest series of percutaneously treated patients, Buchgraber and Pässler reported sural nerve disorders in 8 of 48 patients (17%) using their technique.[3] Assal et al proposed a specially designed instrument and reported no sensory impairment with this technique.[1] It requires brief instructions, special instruments, and limited open repair with all the risks and drawbacks mentioned above. Traversing the lateral side of the needle, making small incisions, and looping the threads puts the neural nerve at risk in the proposed percutaneous method. In the proposed percutaneous method, the use of local anesthesia while closely monitoring any neural changes during the procedure, as well as placing the proximal lateral incision as medially as possible on the edge of the tendon, could help reduce the incidence of sural nerve damage. The incision must be extended with the blade longitudinally above the inserted needle only if the injection has not caused any nerve disturbances. The return passage of the thread must always be made through the same hole.

The prognosis of sural disorders in our study was good; however, it took a long time (up to 10 months) to fully resolve the issues. Another reason for the skepticism associated with the percutaneous method may be the lack of long-term studies with a large

number of patients. The original study by Ma and Griffith included 18 patients.[20] We found only one prospective randomized trial comparing percutaneous versus open Achilles tendon repair, with 33 patients randomized to each group from 7 district general hospitals and followed for 6 months.[18] In a review article of percutaneous reports, Riedl et al found that a study with 62 patients represented the largest number of patients treated percutaneously.[26] These findings do not support the use of the percutaneous method and do not facilitate any statistical analysis. The non-randomized design of the study may raise some questions. Since only one type of treatment was used for all patients in one center, there was no (sometimes questionable) randomization or large heterogeneity in the groups (by sex, age, etc.). Questions regarding the potential for treatment bias may be related to institutional differences in organization, the skill level of staff (including surgeons), hygiene, risk of infection, and so on.

The clinical outcome of Achilles tendon rupture treatment has been assessed by many different scoring systems, but none has been universally accepted.[5,12,17,21,22,33]Different subjective parameters in some scales and high technical demands and costs in others may contribute to difficulties in comparing ***Limitation:*** Small number of patients in the study served as a big drawback to drawing conclusions on a broader scale.

CONCLUSION

The results of this study showed no statistically significant difference in functional outcome between open surgical repair of the ruptured Achilles tendon with augmentation under general or spinal anesthesia and proposed percutaneous suturing under local anesthesia. The re-rupture rate and the number of sural nerve disturbances were slightly higher with percutaneous repair, but the difference was not statistically significant.

There were statistically significantly more major complications as well as overall complications together with open repair. Patients were subjectively more satisfied with the proposed percutaneous suturing under local anesthesia in comparison to open repair.

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