Repair of fresh patellar tendon rupture: tension regulation at the suture line

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Abstract The reported complications of the repaired patellar tendon have been attributed to the influence of the mechanical environment on the healing process. This study postulates that the healing complications can be minimised through tension regulation at the suture line using an absorbable reinforcement device. Twelve patients with fresh patellar tendon rupture were included in the study. They were prospectively followed up for an average period of 45 months. The patients resumed their pre-injury activities at an average of 6.1 months. The active knee movement averaged 0–154.6° compared to 0–156.7° in the contralateral knee. Radiologically no patella alta, patella baja or degenerative changes in the patellofemoral joints were noted. The results support use of the absorbable reinforcement device for tension regulation at the suture line.

Introduction

Surgical intervention is the rule for ruptures of the patellar tendon [19]. The techniques described can be categorised under two headings: techniques that do not reinforce the repair [15] and techniques that reinforce it [10, 11, 21]. The reinforcement devices were made of metals [21], nonabsorbable sutures [11] or autografts [10]. Previous techniques generally have reported complications, which were either immediate and necessitated a second operation for removal of the reinforcement devices [11, 21] or late [11, 15, 21]. Rupture, tendon lengthening or degenerative

changes in the patellofemoral joint are among the late complications that hinder the pre-injury activities.

Poor healing is the putative factor for the incidence of late complications. However, better healing is possible, but requires timely mechanical loading of the repaired tendon [1, 4, 6, 9, 16–18]. According to current knowledge the appropriate time point during the healing process for loading to start has been identified [1, 18], but there is a need to find a practical tool for initiation of the biomechanical loading. We suggest that an absorbable reinforcement device can regulate the tension at the suture line. The device offers the advantages of initial biomechanical protection and timely loading of the repaired tendon, and a reduced need for hardware removal.

We present the technique and its results in the repair of a fresh patellar tendon rupture.

Patients and methods

During the period from October 2001 to March 2007, 12 patients who agreed to participate in this prospective study were identified and managed for fresh rupture of the patellar tendon (Table 1). The local Ethics Committee approved the study.

All patients were men; their mean age at the time of operation was 32.08 (range: 18–42) years. They presented with a history of trauma and inability to bear weight.

Physical signs such as swelling, bruised skin or a deep wound traversing the tendon area were observed. Tenderness, lost tone of the patellar tendon, inability to elevate the straight leg and high patella were detected.

Radiographically, patella alta was detected in all patients using the Insall-Salvati ratio [8] (Fig. 1).

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Table 1 Preoperative and postoperative data for 12 male patients with repaired fresh patellar tendon rupture

No.	Preoperative data		Clinical outcome							Radiological outcome	
			Lysholm rating		Siwek and Rao criteria			Thigh atrophy		Patellar height	P-F joint (compared to preoperative)
	Age (years)	Side	Points	Rating	Knee motion		Qs power				
					Injured	Healthy					
1	40	Right	88	Good	0–140°	0–150°	Equal	Excellent	2 cm	I-S=1.12	Similar
2	30	Right	100	Excellent	0–160°	0–160°	Equal	Excellent	No	I-S=1.19	Similar
3	28	Right	100	Excellent	0–160°	0–160°	Equal	Excellent	1 cm	I-S=1.14	Similar
4	28	Left	100	Excellent	0–160°	0–160°	Equal	Excellent	No	I-S=1.19	Similar
5	40	Right	100	Excellent	0–150°	0–150°	Equal	Excellent	No	I-S=1.12	Similar
6	38	Right	92	Good	0–150°	0–155°	Equal	Excellent	3 cm	B-P=0.87	Similar
7	30	Right	100	Excellent	0–160°	0–160°	Equal	Excellent	No	I-S=1.15	Similar
8	42	Right	100	Excellent	0–150°	0–150°	Equal	Excellent	No	I-S=1.16	Similar
9	40	Right	97	Excellent	0–148°	0–158°	Equal	Excellent	2 cm	I-S=1.13	Similar
10	18	Right	100	Excellent	0–160°	0–160°	Equal	Excellent	2 cm	B-P=0.85	Similar
11	26	Left	100	Excellent	0–158°	0–158°	Equal	Excellent	No	B-P=0.84	Similar
12	25	Right	100	Excellent	0–160°	0–160°	Equal	Excellent	No	B-P=0.92	Similar

Qs quadriceps, P-F joint patellofemoral joint, I-S Insall-Salvati LT/LP ratio [8], B-P Blackburne-Peel A/B ratio [2]

Operative technique

Patients were operated upon within 48 hours of arrival. With a tourniquet applied, the tendon was exposed through a midline longitudinal incision extending from the upper patellar pole to the tibial tuberosity. Avulsion of the tendon

Fig. 1 Preoperative lateral radiograph of a knee shows patella alta in association with an avulsed patellar tendon

from the lower patellar pole was observed in all patients. A 3.2-mm drill bit was used to create two osseous longitudinal tunnels between the lower and upper patellar poles. Another two coronally directed tunnels were created, one in the lower patellar half and one posterior to the tibial tuberosity.

For reattachment of the tendon to its bed, a thread of #2 Vicryl was inserted as a modified Kessler stitch in the upper portion of the tendon (Fig. 2a). The threads that emerged from the corners of the tendon stump were passed through the longitudinal tunnels, one in each tunnel. To facilitate passage of the Vicryl threads, we used a pliable wire 1.0 mm thick to create “a custom-made needle” with cephalad eyelet to avoid penetration through the tunnel. The threads that emerged at the upper pole of the patella were left temporarily unknotted (Fig. 2b).

Afterwards, we made a reinforcement suture, which we called “suture line tension-regulating suture” by the way the following steps: using our needle a thread of at least #2 Vicryl was passed from lateral to medial through the transverse patellar tunnel, then from medial to lateral through the tibial tunnel. The knee was flexed to 45°, the patella was pushed downward so its lower pole rested nearly at the level of the roof of the intercondylar notch and then the threads were tied laterally. The threads of the Kessler suture were tied at the upper patellar pole (Fig. 2c). The knee was flexed to about 90° (2–3 times) to ensure integrity of the reinforcement device. The device was considered satisfactory when the patellar tendon remained

Fig. 2 Drawing illustrates steps of the tendon repair and making of the “suture line tension-regulating suture”. **a** The modified Kessler suture in the proximal portion of an avulsed patellar tendon. **b** The modified Kessler suture and the reinforcement device before tying the threads into a knot. **c** The final appearance after tying the threads into a knot

lax during knee flexion. The retinacular tears were repaired using #1 Vicryl and the wound was closed. A high above knee cast was applied with the knee flexed to about 15°.

Postoperative care

Based on perception of the healing progress, we simplified the rehabilitation programme into three stages.

The first stage starts from the day of the operation to the day of the cast removal (four weeks). During this period, the full tensile strength of the reinforcement suture protects the repair [3, 5, 20]. Thus, isometric quadriceps exercises are instituted and walking in plaster is allowed as tolerated.

The second stage starts from the day of the cast removal and ends when the patient is able to do straight leg raises (two weeks). During this period, the reinforcement suture has lost its tensile strength [5]; thereby, the recommended biomechanical loading [1, 4, 17, 18] is possible. A programme of straight leg rising and active flexion exercise is instituted. Protected partial weight-bearing with crutches is allowed.

The third stage starts from the end of the second stage and ends when the patient resumes his pre-injury activity. By six weeks after surgery, the sutured tendon-bone junction achieved mechanical strength [6]. Therefore, a vigorous programme of straight leg rising with weights and active flexion exercise is instituted. Patients were advised to progress to one cane for two weeks. Quadriceps strengthening continued until there was nearly no, or minimal, differences between the circumferences of both thighs.

Follow-up examinations were carried out every other week for 12 weeks and then at four, six and 12 months postoperatively. After the first year, patients were examined twice per year. The most recent examinations were performed at a median of 45 months (range: 24–84) postoperatively.

Outcome measures

Subjective assessment patients were asked about continuation of normal activities. Then they were asked to categorise their overall subjective opinion of the most recent status as satisfied or not satisfied. Patients were categorised according to the Lysholm knee scale [12].

Clinical assessment included observation regarding wound infection and swelling. The patella and patellar tendon were palpated and compared to the other side. Rerupture was defined as a palpable infrapatellar gap with the patella displaced proximally compared to the contralateral side. Tendon lengthening was defined as a palpably intact patellar tendon but the patella has clinical and/or radiographic proximal displacement. Reruptures or tendon lengthening were considered unsatisfactory results.

The ranges of active knee motion were measured with a goniometer, and thigh girth was measured using a tape and compared to the other side.

The functional results were graded according to the Siwek and Rao criteria [21].

Radiological assessment

Radiographs were examined for the patellar height and patellofemoral articular surfaces. For identification of the patellar height, the Insall-Salvati LT/LP ratio [8] was calculated. However, in some cases, the callus of the healed tendon-bone junction increased the length of the patella (Figs. 3c and 4); therefore, we used the Blackburne-Peel A/B ratio [2].

Patella alta was diagnosed when the LT/LP ratio was >1.2 or A/B ratio >1.06 . Patella baja was diagnosed when the LT/LP ratio was <0.8 or A/B ratio <0.54 . Patella alta, patella baja and degenerative changes in the patellofemoral joint were considered unsatisfactory results.

Fig. 3 **a** An immediate postoperative lateral view radiograph of a knee showing repaired patellar tendon complicated by “temporary” patella baja. **b** A radiograph was made at 6 weeks postoperatively; the lower pole of the patella shows callus formation and the patellar height is relatively higher than that in Fig. 3a. **c** A radiograph was made at 12 weeks postoperatively; the patella has resumed its normal height and the callus at the tendon-bone junction appears more evident

Results

Subjective results

All patients reported that they were satisfied with the results and that they resumed pre-injury activities at an average of 6.1 months (range: 4–7). According to the Lysholm knee-rating system [12], ten cases were classified as excellent and two as good. The scores averaged 98.08 points (range: 88–100) (Table 1).

Fig. 4 Lateral view radiograph made 2 years postoperatively shows that the large callus at the lower patellar pole has increased the diagonal length of the patella to provide a false impression of patella baja, but the A/B ratio=0.85

Clinical results

There were no cases of rerupture or lengthening of the patellar tendons and no infections.

All patients had active full knee extension; the range of knee movement averaged 0–154.6° compared to 0–156.7° in the contralateral knee. Flexion deficit averaged 2.1° (range: 0–10°) (Table 1). Thigh girth atrophy averaged 0.83 cm (range: 0–3).

All patients were rated according to the Siwek and Rao criteria [21] as excellent (Table 1).

Radiographic results

Using the Insall-Salvati ratio [8] in eight patients, patellar height averaged 1.15 (range: 1.12–1.19). The Blackburne-Peel ratio [2] that was used in four patients averaged 0.87 (range: 0.84–0.92) (Table 1). Patella alta, patella baja and degenerative changes in the patellofemoral joint were not reported.

Complications

In one case, we accidentally tied the reinforcement suture with the patella pressed more inferiorly than normal. A “temporary” patella baja was observed in the immediate postoperative radiograph. At the 12th postoperative week, the patella had resumed its normal height (Fig. 3a–c).

Discussion

Because of the great distraction forces that arise from the quadriceps muscles, the repaired patellar tendon has been reinforced by long-lasting devices [10, 11, 21]. However, prolonged reinforcement inhibits the healing progress [1, 4,

6, 16]. On the other hand, mechanical loading too early will only risk a failure of suture threads or permanently lengthen the tendon callus [1]. This study postulates that an absorbable reinforcement device can regulate the tension at the suture line.

The utility of absorbable devices in tension regulation has been mentioned in several studies [16, 17, 20], yet it is not attributed to anyone. The reinforcement device in this study is made of Vicryl (polyglactin 910) suture, which has initial tensile strength equal or superior to nonabsorbable sutures [3, 20]. Thereby, it serves initially as “a suture line tension-relieving suture”. By the fourth postoperative week, the suture loses about 75% of its tensile strength [5]; fortunately, this coincides with the beginning of the remodelling phase [4, 9]. Mechanical loading of the callus during the remodelling phase leads to elastic deformation, which allows mechanical signalling to start to influence the healing process [1, 4]. Production of type I collagen takes over, type III collagen is resorbed and cross-linking increases [1, 4, 9]. Finally, the reparative tissue acquires the mechanical properties of the normal tendon [1, 4].

Our patients have an avulsed patellar tendon, which is in continuity with the quadriceps tendon across the anterior patellar surface [14]. Therefore, healing of the avulsed tendon comprises healing of the tendinous tissue and tendon-bone junction. Lack of mechanical stimulation is detrimental to healing progress at both interfaces [1, 4, 6, 16–18].

It is remarkable that animal studies have suggested the fourth week for institution of biomechanical loading at the tendinous interface as well at the tendon-bone junction [4, 9, 18]. Hibino et al. recorded radiographically good callus formation at the loaded tendon-bone junction by six weeks [6]. In this study, the callus was observed radiographically at the lower patellar pole by six weeks postoperatively (Fig. 3b). Therefore, we believe that the periods that were given in reports on animal experiments can be transferred to humans.

Tendon lengthening occurs when the repaired tendon is exposed to distraction forces during the inflammatory phase [1] or when it is not loaded at a suitable time and therefore healed by scar tissues [1, 6, 9, 13, 16]. The scar tissues are less resistant to tensile forces [1, 6, 9, 16] and may therefore predispose the tendon to spontaneous rerupture [9, 13] followed by spontaneous healing by scar tissues and almost immediately by tendon elongation. The elongated patellar tendon renders the patella higher (patella alta) with increased liability for patellofemoral dysfunction [22]. Theoretically, collaboration of the distraction force with limited tendon-holding capacities of suture materials [23] offers a suitable mechanical environment for the tendon lengthening. Marder and Timmerman described a technique without augmentation. They reported five patients with patellofemoral complications, two of whom could not return to their pre-injury activity level [15].

Patella baja indicates shortening of the patellar tendon which may be a consequence of prolonged immobilisation of the extended knee [7, 19] or when a reinforcement device is fixed while the patella is lower than normal (Fig. 3a). Patella baja once established has a negative impact on the knee function [7, 19]. Considering the temporary effect of the reinforcement suture, “permanent” patella baja cannot be expected with this technique (Fig. 3b, c).

Besides this technique did not sacrifice any autologous tissue and did not necessitate removal of the reinforcement device; the group of patients that were immobilised in a cast in 15° of flexion for only four weeks resumed their pre-injury activities at an average of 6.1 months. Siwek and Rao [21] reinforced their repairs using hardware. Their patients then were placed in a cast in extension for six to 11 weeks. One of their patients reported rerupture, and four patients had some loss of flexion. Lindy et al. [11] protected the repair with nonabsorbable tape. Two of their patients had prominent knots; in one, the knots were painful and were removed surgically. Six patients developed patellofemoral chondrosis. Larson and Simonian [10] repaired four knees and protected the repair with semitendinosus autograft. One of their patients reported discrepancy with the contralateral knee.

Conclusion

The results support use of the absorbable reinforcement device for regulation of the mechanical environment at the suture line. The temporary effect of the absorbable reinforcement suture nullifies the requirement for intra-operative meticulous adjustment of the patellar height. This study may open the way for earlier institution of more vigorous rehabilitation programmes; thereby, the morbidity period can be reduced.

Conflict of interest The authors declare that they have no conflict of interest.

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