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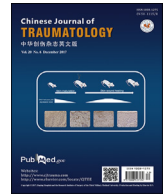
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Original Article

Should proximal ruptures of the anterior rectus femoris muscle be treated surgically?

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ABSTRACT

Purpose: No therapeutic consensus has been established about proximal ruptures of the rectus femoris muscle. The objective of this literature review is to determine a therapeutic course of action.

Methods: We conducted a literature review on the PubMed database using the following keywords (in French and English, respectively): "quadriceps/quadriceps", "droit antérieur/rectus femoris", "proximal/proximal", "chirurgie/surgical", "avulsion/avulsion". We collected 266 articles, 36 of them were selected, which were related to our topic: proximal rupture of the anterior rectus femoris. Patients with a proximal rupture of the rectus femoris, minor or major patient of traumatic origin were included in this study. Patients injured at another lesion level, or non-traumatic lesions of the proximal rectus femoris (tendinitis without ruptures, tumor or others) were excluded. For each patient, the indications, the type of treatment and the functional result were analyzed, with the time to recovery and the level of recovery from sports and professional activities (same sport/profession or not, same level or not) as the main criterion of judgment. Fisher exact test was used for statistical comparison.

Results: The aims of conservative treatment are to be pain free for the patient, to fight hematoma and to rehabilitate the injury as quickly as possible. The surgical techniques are varied, with most consisting of either a reinsertion of the musculo-tendon stump or a resection of the scar tissue with myo-tendino-aponeurotic suture in place. The functional results are good for the majority of the treatments proposed, but the conservative treatment has a shorter recovery time (3 months vs. 4 months for the best surgical results). Highly displaced bone avulsion is the only indication for first-line surgical treatment.

Conclusion: The main disadvantage of conservative treatment is the risk of residual pain beyond 3 months (10%), justifying an MRI to guide secondary surgical treatment. We propose a treatment plan for proximal rupture of the proximal rectus femoris rupture.

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1. Introduction

Damage to the musculotendinous junction of the quadriceps is frequent, but injuries to the proximal seat in the rectus femoris remain rare, accounting for approximately 1.5% of hip injuries occurring during sports activity.¹ They generally affect top-level athletes as a result of sudden eccentric contraction in the position

of muscle elongation (hip extension, knee flexion). It is too often initially misdiagnosed,^{2,3} leading to a delay in treatment.

No therapeutic consensus has yet been clearly established for proximal rupture of the anterior rectus tendon. The aim of our work was to analyze the outcomes of the different treatments proposed in the literature for proximal anterior rectus tendon rupture in order to define the surgical indications. Our hypothesis was that surgical treatment allowed a better and earlier functional recovery with resumption of the same sports and professional activities at the pre-injury level.

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2. Methods

We conducted a literature review on the PubMed database using the following keywords (in French and English, respectively): "quadriceps/quadriceps", "droit antérieur/rectus femoris", "proximal/proximal", "chirurgie/surgical", "avulsion/avulsion".

From these words we were able to collect 266 articles. Among these articles, 36 were selected. There were 15 case series (at least 2 cases each), 18 clinical cases reports, and 3 expert opinion articles that related to our topic: proximal rupture of the anterior rectus femoris. We checked for each of them that the inclusion criteria were respected: patients with a proximal rupture of the rectus femoris, minor or major patient of traumatic origin. We excluded patients injured at another lesion level, or non-traumatic lesions of the proximal rectus femoris (tendinitis without ruptures, tumor or others).

For each patient, the indications and the type of treatment (conservative or surgical) were analyzed according to the type of lesion (myo-tendinous rupture, bone avulsion) and the functional result, with the time to recovery and the level of recovery from sports and professional activities (same sport/profession or not, same level or not) as the main criterion of judgment.

We analyzed the time taken to complete recovery. We compared conservative treatment against 1st line surgical treatment with *p* values defined as significant if less than 0.5. To do this comparison, we used a minimum and a maximum time for each situation. The statistical comparison was done with an exact test of Fisher. The secondary objectives were to identify the modalities of the different treatments, as well as the risks and disadvantages of each.

3. Results

3.1. Results of different treatment options

Some authors proposed different treatments in the same series of patients.

3.1.1. Conservative treatment

Thirteen articles (describing a total of 51 patients) reported conservative treatment.^{4–16} The aim of conservative treatment was in all cases to combat hematoma (icing, compression, discharge, cessation of activity, puncture-evacuation) and to optimize musculo-tendinous healing (rehabilitation, ultrasound, etc). The general principles of the rehabilitation protocols (when they were detailed in the articles) were:

- (1) Limit fibroblastic production with ultrasound and by administering no non-steroidal anti-inflammatory drugs during the first 48 h.
- (2) Orient the healing process by gentle early rehabilitation, stretching, and isometric, then isotonic, and concentric, then eccentric, contractions, in discharge, then in charge.
- (3) Optimize the function of the muscle fibers with isokinetic muscle strengthening, proprioceptive work, starting/accelerating work, and the progressive resumption of sport (cycling and swimming, then jogging and jumping).

Of these 51 patients, 12 had bone avulsion (11 adolescents and 1 adult).^{6,14–16}

3.1.2. Surgical treatment

Twenty-five articles reported surgical treatment in a total of 67 patients.^{2,5,7,14,17–35} Numerous surgical techniques were utilized without any comparative study between them.

Common elements were the anterior approach, which, according to Hueter (48 cases), was the most common, Smith-Petersen approach was less common (4 cases). In the majority of cases, a regional release of the rectus femoris was necessary because it was often retracted with adhesions to facilitate mobilization.

The differences were in the type of repair. In acute cases (10 articles reporting a total of 26 patients), repair was performed by reinsertion on anchors in 14 cases^{18–22}; the fibrous stump was resected with local musculo-tendino-aponeurotic suture in 1 case; 26 the stumps were directly sutured in 8 cases^{20,24,25}; and the stumps were reinserted through *trans*-osseous tunnels in 1 case.²³ In 2012, Garcia et al.²⁰ proposed optimizing healing of the surgical repair by a local injection of platelet-rich plasma for 4 of his 10 patients. In acute cases of bone avulsion (2 cases), either screw fixation (1 adult case)¹⁷ or anchor fixation (1 adolescent case)¹⁸ was proposed.

When surgical treatment was proposed as second-line treatment after failure of conservative treatment (15 articles with 41 patients),^{2,9,14,17,19,27–35} it was carried out as proximal tendon reconstruction (1 case of synthetic graft, no cases of autologous graft),^{2,9,14,17,19,27–35} resection of scar tissue alone (23 cases, including 16 by arthroscopy),^{5,35} or resection of the fibrous stump with a local myo-tendinous suture (6 cases).²⁶ For cases of bone avulsion treated secondarily by surgery (9 cases), either bone resection alone (7 cases, including 1 by arthroscopy)^{14,27–30} or reduction and fixation by screwing (2 cases)^{17,31} was performed. In 2 cases, second-line surgery was resection of a symptomatic labral lesion.^{17,31} The delay between trauma and second-line surgical treatment was a minimum of 6 months^{17,31} and a maximum of 2 years.^{17,31}

Post-operative care consisted of a limb discharge and the wearing of an extended knee splint for 6 weeks in order to limit post-operative stress on the repair.^{19,26,35,36} A protocol of early passive rehabilitation was always put in place to limit adhesions, then the rehabilitation was gradually intensified, with a complete resumption of activities at a minimum of 4 months and a maximum of 2 years post-operatively. Sonnery-Cottet^{19,26,35,36} proposed a faster post-operative rehabilitation protocol after resection of the fibrosis and local suture, with 2 weeks or more of discharge (depending on the pain), progressive rehabilitation of the extensor apparatus between 2 and 6 weeks, then muscle strengthening up to the 10th week (depending on tolerance). Sports-specific training could be resumed from the second month. This approach was similar to that proposed for pediatric patients who had a shorter discharge length of 1 week on average (3 days minimum, 2 weeks maximum).^{9,17,27,28}

3.2. Functional outcomes of the different treatments

The functional outcomes of the different treatments show in Table 1. In study of Gamradt⁴ on non-operated professional athletes (11 cases), the complete return to the same sport at the same level took between 6 and 12 weeks. These results were corroborated by others.^{8,10,11} Hsu et al.⁷ treated 2 high-performance athletes without surgery who returned to the same sport at the same level at 3 months.

Studies presenting surgical treatments^{8,9,14,17–35} reported good results, even for high-performance sports patients (6 articles representing 18 patients in total).^{2,5,19–21,25,26} Recovery time was longer for patients undergoing surgery, with a minimum of 4 months²⁶ and a maximum of 1 year.^{2,5,19–21,25,26}

For second-line surgery, consisting of direct suture performed at 12 months after failure of conservative treatment (failure to return to sport at the same level), there was a favorable evolution (complete return to activity at the same level) at 6 months post-

Table 1
Summary table of functional results.

Treatment methods	Complete recovery time (return to the same activities at the same level) for a proximal lesion of the rectus femoris found in the literature (months)			
	(Myo-) tendon rupture		Bone avulsion	
	Minimum	Maximum	Minimum	Maximum
Conservative treatment	1.5	3	3	48
First line surgical treatment	4	12	12	48
Second line surgical treatment	6	24	6	54
Conservative treatment against 1st line surgery (p value)	0.06		1	

operatively at best.^{2,5,19–21,25,26} This return to activity was observed at most 2 years after resection of the fibrous scar tissue following 6 months of insufficient conservative treatment.^{2,5,19–21,25,26}

For lesions of the bone avulsion type, with conservative treatment, Uzun et al.⁶ found a completely favorable evolution for 9 young athletes, with an average total follow-up of 26 months (12 months minimum, 48 months maximum). For the same treatment, Deehan et al.¹⁶ reported a complete recovery at 3 months for his patient. Other authors reported 1 year¹⁷ or even 2 years^{18,29} for a complete recovery with an acute surgical treatment. Patients with avulsions treated with second-line surgery had full recovery at 6 months at best,^{2,5,19–21,25,26} and this could be up to 54 months at most.^{2,5,19–21,25,26}

We found no statistical difference of conservative treatment against first-line surgical treatment concerning time taken to complete recovery.

3.3. Complications

3.3.1. Conservative treatment

The complications of conservative treatment can be determined by analyzing the indications for surgeries performed in a second stage (41 patients).^{2,5,7,9,14,17,26,28,30,35} These are as follows:

- (1) Sequelae pain alone (10% according to Gamradt⁴): 22 patients. The 2 main elements that could cause long-term pain were the fibrotic or ossified stump of the rupture (20 patients)^{5,34,35} and the associated coxo-femoral labral lesions (2 patients).^{5,34,35}
- (2) Recurrence (rupture of the scarring area or a partial rupture that is complete): 6 patients.^{26,34}
- (3) Sequelae pain associated with loss of function (quadriceps extension strength): 4 patients.^{2,33,34}
- (4) Complications related to hematoma are regularly mentioned in the literature, but never in cases reports or cases series.

MRI made it possible to search for a pathological scarring area and/or associated labral lesions in situations in which a conservative treatment was unfavorably progressing.^{9,12}

For cases of bone avulsion (9 patients out of 41) treated by surgery in a second stage after failure of a conservative treatment, we found 6 painful pseudoarthrosis,^{17,28,29,31} and 3 painful heterotopic ossifications around the avulsion.^{14,27}

3.3.2. Surgical treatment

No recurrence of the rupture was reported in the studies. Mild sequelae pain was found in 2 of 26 patients treated with first-line surgery.^{18,25} The main complications were related to the surgical approach, with lesions of the lateral cutaneous nerve of the thigh (2 cases out of 5 for Irmola²²) causing painful paresthesia and/or hypoesthesia on the anterolateral side of the thigh. The general risks associated with any surgery should be taken into account (for

example, Sonnery-Cottet reported that 1 in 5 patients was complicated by a hematoma.^{3,13}).

4. Discussion

Our review of the literature confirms the rarity of these lesions and the lack of consensus in terms of treatment. The rarity can also be explained by the difficulty of clinical diagnosis, which often remains unknown and is responsible for diagnostic wandering and a delay in treatment.^{3,13} Imaging is useful for confirming the diagnosis (radiography showing bone avulsion, ultrasound, and MRI) and analyzing the rupture (level of rupture, level of retraction, hematoma, involvement of 1 or 2 heads of rectus femoris muscle).^{3,37,38} Ultrasonography allows static and dynamic evaluation at a lower cost and is therefore indicated for first-line examinations, especially in acute cases. MRI is of interest in cases of sequelae pain and allows a more precise analysis, especially in a second stage when conservative treatment has failed, as it can highlight pathological scarring areas.^{3,26,34,39} In particular, it allows the search for symptomatic associated coxo-femoral labral lesions¹² called HAL-TAR (hip antero-superior labral tear with avulsion of rectus femoris lesion)⁴⁰ for which a surgical procedure may be necessary.^{9,12} This is the first exhaustive review on the treatment of proximal tears of the rectus femoris tendon.

From an epidemiological point of view, the rectus femoris muscle is the quadriceps muscle portion most often affected in cases of proximal involvement.^{5,41,42} This can be explained by the biarticular anatomy of this muscle and its hyper-solicitation during resistance work (sudden eccentric contraction in elongated position of the muscle – hip extension with knee flexion during sprinting and football, for example).^{41–45} The 2 most frequent bone avulsion sites (with or without bone fragment) are at its proximal origin (anterior superior iliac spine) and the distal tendinous portion.⁴⁶

Pure muscle damage appears to be an indication for conservative treatment only.^{4,5,7,8} The therapeutic approach was highly variable and dependent on the type of proximal lesion (tendinous, musculoaponeurotic, bone avulsion); no consensus exists. In cases of bone avulsion (predominant in adolescents,⁴⁷ with 14 of the 23 patients found being adolescents) or pure musculo-tendinous or tendon damage in the body, treatment is discussed (conservative or surgical, which type of surgery).^{5,13}

The therapeutic results (return to sport, functional result) seemed good regardless of the treatment (conservative or surgical). The main difference was the recovery time, which was shorter for conservative treatment (maximum 3 months)^{4,7} than for surgical treatment (minimum 4 months).^{20,21,26} Whether a patient was a high-level athlete and the type of lesion (tendon, musculoaponeurotic, bone avulsions) did not influence whether acute surgical treatment was applied. In the case of full-body musculo-tendinous or pure tendon damage, conservative treatment seemed preferable because of the shorter recovery time. In professional and

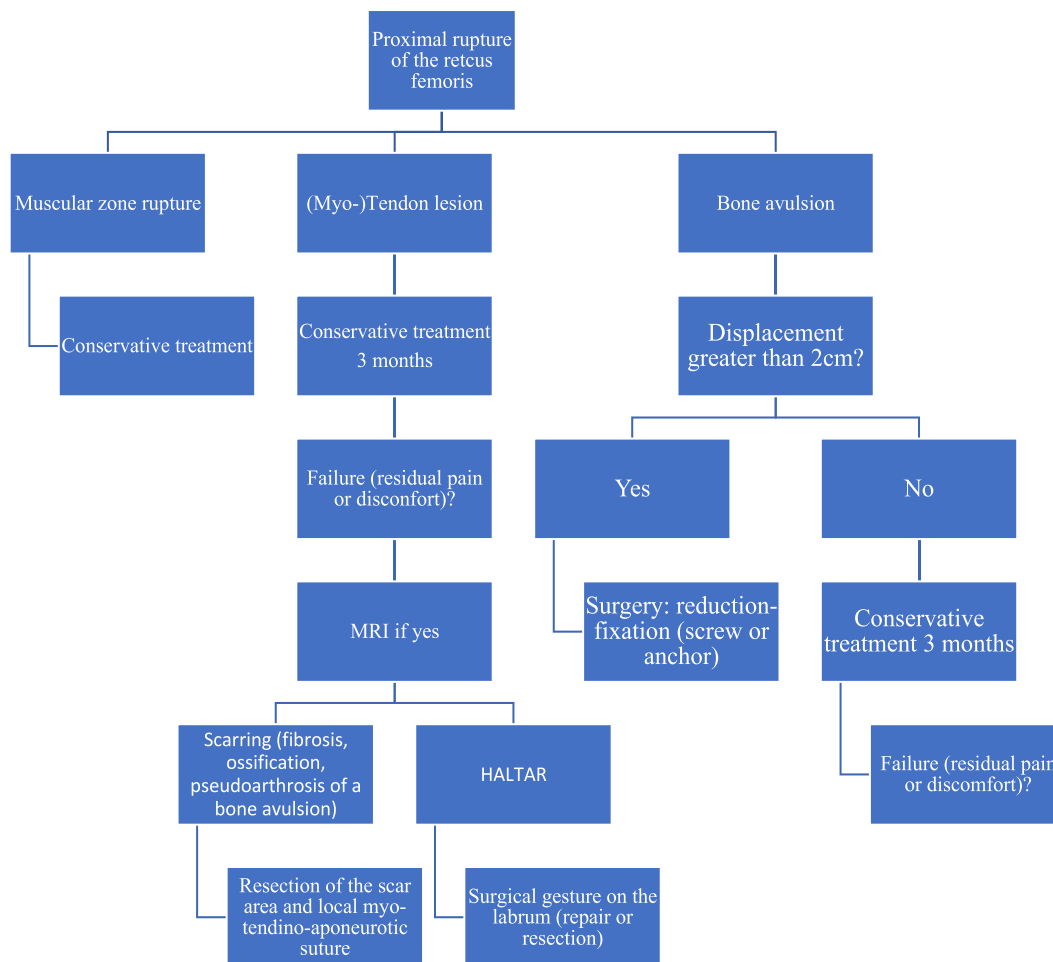


Fig. 1. Decision tree in front of a proximal rupture of the rectus femoris.

very high-level athletes, it has not been shown that surgical treatment allows an earlier return to the same sport at the same level, especially for those with a high functional demand on explosive hip flexion movements.^{4,7} On the contrary, conservative treatment allowed a faster recovery.^{4,19,22,25}

The same findings were made⁶ with conservative treatment for bone avulsions with little or no displacement of the proximal rectus femoris. No precise data on the extent of displacement were provided. The consensus that emerged was that provided in Rajasekhar's article¹⁷: surgery should be proposed for bone avulsions in cases in which displacement is greater than 2 cm or symptomatic pseudarthrosis or heterotopic ossification around the avulsion is observed.

The main prognostic factor mentioned was the time to management, with a benefit to early management (diagnosis and treatment). Early conservative treatment would make it possible to limit residual pain and complications in the medium term, to promote a quick complete recovery, and accordingly prevent the development of scarring fibrosis.

The main risk of surgical treatment was related to the approach, as the lateral cutaneous nerve of the thigh could be affected. In contrast, conservative treatment was associated with sequelar pain beyond 3 months in 10% of patients,^{4,34} justifying surgical intervention in a second stage. There are many second-line surgical techniques, but simple resection of the tendinous fibrosis with local

musculoaponeurotic suture seems sufficient to allow complete and quick recovery.^{4,7}

Concerning the surgical technique, it is not possible to define a reference technique because there are no comparative or comparable studies. In the case of tendon avulsion, a two-row reinsertion with 2 anchors versus a single-row anchor has been discussed in the literature to provide a better hold, but at a higher cost and without an influence on the final result.^{4,7} Garcia²⁰ is the only author to have proposed a complementary local infiltration of platelet-rich plasma intraoperatively, with better results in his series.

In the event of failure of the conservative treatment after 3 months of appropriate treatment,^{4,19} a surgical procedure could be proposed and would be predicted to provide good functional results^{4,19} after excision of the fibrous tissue and suturing of the stump at the level of retraction. This technique makes it possible to resect the fibrosis that is often responsible for residual pain,^{4,19} and suturing instead of retraction in the myo-tendinous zone would allow more solid local integration without reinsertion tension with a reduced risk of recurrence, particularly in high-level athletes.^{4,19}

In conclusion, after review of the literature, we propose the following treatment plan (Fig. 1) for the proximal rectus femoris rupture:

- (1) Myotendinous rupture: do a conservative treatment for 3 months (analgesic treatment, measures to reduce

hematoma, and early adapted rehabilitation). If conservative treatment fails (persistent pain): you should an MRI. The 2nd line surgery is so: resection of the fibrosis/ossification, and suturing in place of the musculo-tendino-aponeurotic stumps, as well as treatment of the associated lesions (HALTAR).

- (2) Bone avulsion: conservative treatment unless the displacement is greater than 2 cm. In such cases, reinsertion by screw or anchor is recommended.

The analysis was based on a review of very heterogeneous articles of low to medium scientific quality (case series and clinical cases). Thus, the conclusions of our analysis can only be of low scientific value and need to be validated by future studies of higher level of evidence. However, this remains the only exhaustive analysis to date on the subject.

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Declaration of competing interests

The authors declare that they have no competing interests (financial or nonfinancial).

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