Introduction

Although quadriceps tendon rupture is extremely rare, it is a very serious injury which requires prompt diagnosis and early surgical treatment [1,2]. Not recognizing it on time with the consequent late surgical repair may result in disability and weakened function of the knee joint [3,4]. Early surgery of the ruptured tendon is the basic prerequisite of positive treatment outcome [5].
are numerous dilemmas concerning surgical techniques [2,6-10]. In case of acute trauma, an end-to-end suture can be performed provided that there is enough tendon tissue left after tear [6]. When the rupture occurs at the osseous tendon junction, which is the most frequent spot, three longitudinal interosseous holes are made through the patella, and sutures are to be passed through them later on [6].

Scuderi technique can serve as one of the alternatives in treating acute tendon ruptures [7]. This surgical technique makes use of a distally based inverted triangle flap that originates from the proximal part of the ruptured tendon [3].

In case of chronic and neglected ruptures with retraction of the tendon and a large gap, Codivilla technique is highly recommended (Figure 1) [7], which results in lengthening and repair of the tendon [7]. Post-operative results of old and neglected ruptures are significantly worse when compared to promptly treated ones [11,12].

Recent literature data mention positive outcomes of repairing quadriceps tendon rupture using anchors (Figure 2), claiming that it is a more advanced technique in comparison to others [9,10].

The aim of our research was to evaluate the results and complications of surgical treatment of quadriceps tendon rupture as well as the great importance of fast and accurate diagnosis and surgical treatment.

Material and Methods

A retrospective multicentric study including 29 patients who had suffered from quadriceps tendon rupture was conducted. The results of surgical repair of quadriceps tendon rupture were analyzed. The study sample consisted of patients who were operated between 2002 and 2011 at the Department of Orthopedic Surgery and Traumatology, Clinical Center of Vojvodina, at the General Hospital in Subotica, as well as at the General Hospital Đorđe Joanović in Zrenjanin. The data about patients were collected from medical records and by interviewing patients on phone.

Most of the patients included in the study sample were men (n=28). The oldest patient was 73, the youngest 18; the average age was 54. A comorbid risk factor was found in 65% of the subjects. The most common risk factors were chronic renal insufficiency (7 subjects), diabetes mellitus (7 subjects) and obesity (4 subjects).

Four patients had bilateral injury, the right sided tear happened in 8 cases, while 17 patients hurt their left knee.

One patient suffered from the partial tendon rupture, while all the others had their quadriceps tendon torn completely. Regardless of the extent of rupture, all the injured were treated surgically.

Concerning the time that elapsed from getting injured until the operation, we deducted what the time required to make the diagnosis was. Injuries surgically treated within a week’s time were defined as acute ones; all the other cases, operated after a week’s time, were defined as chronic ones. Out of 29 subjects, 22 were operated within seven days from getting injured, which leads us to the conclusion that the diagnosis was set in an optimum term for the most of our patients.

Given the fact that the operation was mostly performed in the acute phase, the most frequent surgical technique used in our sample was tendon suture (n=11); in two cases the suture was reinforced with wire loop [13]. Transpatellar sutures were done in nine cases. One case of acute injury was treated by Scuderi technique and yet in another one, anchors with sutures and Bunell sutures were applied [9].

Codivilla surgical technique [7] was performed in six chronic tendon ruptures, as well as in two cases of an acute trauma.

After the operation, all patients wore immobilization with the knee fully extended for six weeks and only a partial leaning against the leg was allowed. Rehabilitation program was performed afterwards during next three months in order to recover previous motion range of the knee.
After approximately 3.5 years (0.5-9 years), the check-up examination was performed, when the range of motion in the knee joint as well as the muscle volume of the quadriceps muscle 10 centimeters above the patella were measured. Quadriceps muscle hypotrophy was reported when the difference between the thighs measured 1.2 cm and atrophy was reported when this difference was more than 2 cm.

Surgical treatment results were evaluated by Lysholm subjective knee scoring scale [14] which refers to the presence and intensity of limping, locking sensation in the knee, giving way sensation from the knee or pain, need for using cane or crutches, signs of swelling, as well as the ability to climb the stairs or to squat [14]. The results were defined as excellent, satisfactory and poor or unsatisfactory when the Lysholm score was from 90 to 100, 80 to 89 and below 79, respectively.

The exclusion criteria were death of the patient or their failure to come to the check-up (four cases).

**Results**

Lysholm knee scale values ranged from 63 to 100 in the study sample, the average value being 87.6. The excellent result was achieved in the majority of patients (n=12), a satisfactory result was present in nine and a poor or unsatisfactory result in four cases.

The comparison of Lysholm knee scale average values between the patients at risk and those without a risk factor showed that the latter had somewhat better results (Table 1). Three (out of four) cases of unsatisfactory Lysholm results were achieved in the patients with comorbid risk factor (Table 2).

Somewhat better results were recorded in the group of patients with promptly made diagnosis followed by an early surgical intervention (Table 1) compared to the chronic cases when the injury was not recognized and consequently not operated after a month’s period or even longer (in one case even after one year).

Four patients with bilateral tendon rupture showed better surgical treatment results comparing to the group with unilateral injury (Table 2).

There was a slight difference between various surgical techniques. The best results were achieved by using tendon suture followed by fixation with anchors to the patella (Table 2). A somewhat worse Lysholm score (81) was recorded in the group of patients who had undergone Codivilla tendon repair technique.

Complications of surgical treatment were present in nine patients, the most frequent being hypotrophy or atrophy of quadriceps muscle (n=4). Other observed complications were tear of the wires during physical therapy, phlebothrombosis, rerupture, avulsion of patella bipartite, contracture, infection

<table>
<thead>
<tr>
<th>Type of injury</th>
<th>Average Lysholm knee scale score</th>
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<tbody>
<tr>
<td>Acute/Akutna</td>
<td>89.15</td>
</tr>
<tr>
<td>Chronic/Hronična</td>
<td>81.4</td>
</tr>
<tr>
<td>Unilateral/Jednostrana</td>
<td>87</td>
</tr>
<tr>
<td>Bilateral/Obostrana</td>
<td>92</td>
</tr>
<tr>
<td>Without risk factors/Bez faktora rizika</td>
<td>90.13</td>
</tr>
<tr>
<td>With comorbid risk factor/Sa komorbidnim faktorom rizika</td>
<td>86.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Surgical techniques/Operativne tehnike</th>
<th>Average Lysholm score/Prosečni Lysholm skor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tendon suture/Sav tetive</td>
<td>86.3</td>
</tr>
<tr>
<td>Transpatellar sutures/Šavovi kroz čašicu</td>
<td>91.2</td>
</tr>
<tr>
<td>Op.sec. Codivilla/Codivilla tehnika</td>
<td>81</td>
</tr>
<tr>
<td>Op.sec. Scuderi/Scuderi tehnika</td>
<td>86</td>
</tr>
<tr>
<td>Bunnels sutures/Bunelovi šavovi</td>
<td>82</td>
</tr>
<tr>
<td>Anchors with sutures/Ankeri sa šavovima</td>
<td>95</td>
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and separating of one anchor, each occurring in one case only.

Several patients claimed that their ability to perform everyday physical activity was fully recovered (three among them even go in for recreational sports now). Six subjects showed worse knee function in comparison to the pre-injury period.

Discussion

Since a quadriceps tendon rupture is a very rare injury, only solitary case reports [15-17] or small case series from 5 to 42 patients [18-23] can be found in literature. Our study sample, which included 29 patients operated in a ten-year-period in three clinical centers, may be considered a larger series.

This injury mostly occurs in males older than forty [1,24,25], as confirmed by the results of our study. Our study sample consisted of mostly elderly men, with the exception of an eighteen-year-old-boy. This exception from a much older age is explained by the mechanism of the trauma, which occurred under immense force during the car accident.

The quadriceps tendon is an extremely strong structure which can take extreme loads without a consequent tearing [2]. Degenerative and fibrous changes of a tendon contribute to its rupture [3]. According to Neubaur et al [26], the most frequent risk factors for quadriceps tendon rupture are obesity, diabetes, elderly age, chronic renal insufficiency and long-term hemodialysis, secondary hyperparathyroidism, rheumatic diseases, systemic corticosteroid therapy, which all lead to insufficient blood supply of the muscle and tendon [3,26]. When there is a comorbid risk factor present, there are more chances for quadriceps tendon rupturing even without any significant trauma [27], which is in accordance with the frequency of risk factors of 65.5% observed in our sample.

The results of surgical treatment were evaluated according to the Lysholm knee scoring scale [14]. The average Lysholm score in our sample (87.6) is the most similar to the result of the research made by Konrath et al [32].

The most frequently used method for managing an acute case of tendon rupturing are transpatellar sutures pulled through the drilled holes in the patella [6,7,13]. However, the most frequently performed operation technique in our sample, is an end-to-end suture (n=11). Vainionpaa et al came to a similar conclusion in their research and they claim that an end-to-end suture is an efficient method provided that there is enough tendon tissue left after the trauma [8]. Some authors state that there is no particular difference between various surgical techniques with respect to final results of surgical treatment [9,28-30]. Unlike the results obtained by Lighthart et al [9], Brandon claims in his study [10] that the reconstruction using anchors has many advantages such as simplicity, minimal invasiveness, shorter duration of operation and reduced possibility of rerupture. On the other hand, this method is one of the most financially demanding [9]. It was performed in one case our study sample and it gave excellent post-operative result.

Early diagnosis is of the greatest importance, given the fact that the delay of surgical intervention results in prolonged physiotherapy, incapacity to extend the knee, inadequate flexion and difficulties in walking [31]. Early surgical intervention is an absolute imperative in treating quadriceps tendon rupture [3,6,7,13,18,30,32]. There are different re-com-mendations with respect to the optimal period for performing a surgery: Scuderi claimed that an early intervention is the one performed within three days after injury, while Rougraff et al define the optimal time for surgical intervention as the period of one to two weeks at most [11,31]. We have defined an injury as a fresh or acute one if it is surgically managed within a week from injuring. The fact that our patients whose injury had been managed early showed better post-operative results than ones with chronic one confirms the above statements. Wenzl et al [28] have also come to the conclusion that the final post-operative result mostly depends on the time of performing the surgery. Out of 24 patients operated within the fourteen days after injury, 20 showed excellent results and 4 of them had good post-operative results. On the other hand, out of five patients operated after two weeks’ period, two had satisfactory results and even three showed unsatisfactory post-operative results [28]. Contrary to that, Shah et al [5] have failed to confirm that an early intervention improves final result, but they underline the importance of further dealing with this issue. The same researchers [5] believe that the age and the presence of risk factor affects the treatment results, claiming that much better post-operative results can be seen in younger patients who do not suffer from any disease falling into the risk factor category. Unlike this research [5], our study comes up with the result of just slightly lower Lysholm score in the patients who have comorbid risk factor, which is nevertheless consi-dered satisfactory on average (86.4%). On the other hand, even three of four cases with poor results were recorded in those patients who had had a risk factor condition or disease.

Bilateral quadriceps tendon ruptures are very rare [5]. By comparing the results of 55 bilateral tendon ruptures, Shah et al [5] have concluded that bilateral tears show worse post-operative results than the unilateral ones. By comparing unilateral and bilateral injuries, we have come to somewhat different results since a better result was obtained in the patients with bilateral injuries in our study sample. This fact could be explained by a small number of subjects in our sample.

Only a few studies have dealt with the problem of post-operative complications in cases of the quadriceps tendon rupture [28,30]. Serious complications such as deep venous thrombosis and pulmonary embolism are rather rare [28,30], and they
are most probably due to long-term immobilization. Deep venous thrombosis developed in one of our patients. Frequent post-operative complications include difficulties in performing motions in the knee joint and also difficulties in walking, low patella, limited flexion, pain and muscle weakness [33]. The most common complication in our sample was hypotrophy, which could be explained by insufficiently aggressive physical therapy [33]. This issue should be examined more thoroughly in some future research. On the other hand, an aggressive physical therapy could cause rerupture [34], which also occurred as a complication in our sample. Konrath et al [32] noticed high frequency [34], which also occurred as a complication in our sample. Konrath et al [32] noticed high frequency.

One of the drawbacks of our study is the inability to measure the isokinetic strength of the quadriceps muscle, which would certainly make the results more objective. Most of our patients did not undergo additional diagnostic procedures, such as check-up radiography, magnetic resonance imaging or ultrasound imaging. A pathohistological analysis of the ruptured tendon might give an answer to some unresolved questions about the origin and pathogenesis of this complex injury. Some further studies should take into consideration other factors that could affect the treatment outcome, such as type, length, and aggressiveness of physiotherapy.

**Conclusion**

Early diagnosis and surgical intervention are the imperative in management of quadriceps tendon rupture. We have failed to confirm that one surgical technique has any advantages over the others. Comorbid risk factors contribute to a lower Lysholm score. Most subjects from our study sample have resumed their physical abilities to the extent they had prior to the injury. Generally speaking, surgical intervention seems to be the best solution for treating quadriceps tendon rupture since it gives rather satisfactory results in spite of reported cases with post-operative complications.

**References**


