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Bilateral, simultaneous rupture of the quadriceps tendon: a diagnostic pitfall?

Report of three cases and meta-analysis of the literature

T. Neubauer · M. Wagner · T. Potschka · M. Riedl

Abstract Bilateral, simultaneous quadriceps tendon rupture (QTR) represents a rare entity and delay in establishing the correct diagnosis is not uncommon. Another three cases are reported here and in all the correct diagnosis was missed initially. A review of the English and German literature retrieved 105 cases of bilateral, simultaneous QTR and in 32 patients (30.5%) the correct diagnosis was established with delay. In 28 cases—representing 25 men (89.3%) and 3 women (10.7%)—sufficient data was available for further analysis. In the majority of patients ($n = 19/28$; 67.9%) rupture was associated with trauma, while no trauma was reported in 9/28 cases (32.1%). No direct correlation between age and the kind of rupture form (traumatic/spontaneous) could be detected ($P = 0.35$). Most partients ($n = 18/28$; 64.3%) presented risk factors associated with QTR and obesity ($n = 6/28$; 21.4%) was most frequently encountered. A direct association between the rate of risk factors and the rupture form was not seen ($P = 0.5$). Overall diagnostic delay lasted 64.7 days on an average (traumatic ruptures 67.7 days/spontaneous ruptures 58.7 days) with this period being longer than 2 weeks in 51.9% and longer than 3 months in 33.3% of patients. Delay varied distinctly in different medical institutions as this period lasted in hospital departments 93.9 days, in ambulances 24 days and in General Practitioners 7.6 days on an average. Initially 25 incorrect diagnoses were established in 21/28 (75%) patients, while 7/28 cases (25%) were discharged initially without any diagnosis. Clinical examination revealed most often palpable suprapatellar gaps ($n = 17/24$) and effusions ($n = 13/24$), while the classic trias of painful swelling, suprapatellar gap and loss of knee extension was found in only 58.3% of reported patients ($n = 14/24$). The correct diagnosis of bilateral QTR was established in 60.7% ($n = 17/28$) by history and clinical examination alone. In 10.7% ($n = 3/28$) clinical suspect was supported by sonography and in 14.3% ($n = 4/28$) by MRT; in 14.3% ($n = 4/28$) the correct diagnosis represented a by chance finding during diagnostic or operative procedures of other indication. In 52 tendons detailed information about repair was provided and most often transosseous fixation ($n = 30/52$; 57.7%) and direct repair ($n = 14/52$; 26.9%) were used, while a tenoplasty was performed in only 15.4% ($n = 8/52$). Only 34.6% of patients ($n = 9/26$) with follow-up data ($n = 26/28$) reported a full recovery with a trend that early surgical repair (limit 2 weeks) improves the final outcome.

Keywords Quadriceps · Tendon · Rupture · Diagnostic difficulties · Repair

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Introduction

Quadriceps tendon rupture (QTR) is a well-known condition in orthopedic practice, requiring adequate surgical treatment to avoid residual deformity and loss of knee function [13, 29]. However, bilateral and simultaneous QTR is rarely observed and only 66 cases

have been reported in the English literature between the first description in 1949 [31] and 2002 [28]. Diagnostic difficulties are not unusual and rates of missed diagnoses up to 50% have been reported [11, 18, 24, 28, 29, 32]. Though modern imaging studies provide excellent visualization of the tendon's lesion, diagnostic evaluation is still based on history and physical examination. As the majority of patients with QTR are initially examined in medical institutions [18, 24, 29] an increasing awareness in respect to this entity and it's diagnostic problems may help to avoid delay in treatment with a prolonged disability of the individual patient.

Thus, we evaluated the existing English and German literature on simultaneous, bilateral QTR with regard to reports of initially missed or incorrect established diagnoses. Three additional cases of bilateral, simultaneous QTR are reported here.

Case reports

From I/1992 till XII/2004 55 patients with complete QTR have been treated surgically in our institution. Among these patients three (5.4%) presented with simultaneous, bilateral rupture and in all cases an incorrect diagnosis was established initially.

Case 1

W.F., an obese man (130 kg) of 55 years felt a sudden, burning ache in his left knee without trauma while walking downstairs. Seconds later, while trying to stabilize and to prevent a fall he felt a burning ache in his right knee too and fell down. He could not raise nor control his legs and was admitted to a department of internal medicine for diagnostic work-up. Clinical and laboratory findings revealed no systemic diseases except oral demanding diabetes mellitus. Initially a diagnosis of cerebral ischemia was established, but was denied by the consultant neurologist, who suspected a spinal process due to bilateral missing patellar reflexes. However, an MRI investigation of the spine revealed no pathologic findings and the patient was seen two days later in our department due to persisting pains and swelling of both knees. On examination he was not able to extent his knees actively nor to raise his legs in supine position, while passive motion was still possible. Additionally effusions and distinct suprapatellar gaps were found in both knees. Radiographic studies revealed bilateral a low riding and anterior tilting of the patellae (Fig. 1). Sonographic examination indicated hematoma forma-

Fig. 1 a Radiographs show low riding and anterior tilting of both patellae. **b** Sonography reveals bilateral hematoma formation and disruption of the tendons echoes near the patellar insertion

tion and disruption of both quadriceps tendons next to their patellar insertion (Fig. 1b), which was confirmed intraoperatively as both tendons were found completely avulsed from the cranial pole of the patella and the retinacula ruptured (Fig. 2). The tendons were refixed by transosseous sutures and the retinacula repaired. Histologic evaluation of the tendineous tissues revealed unspecific reactive changes. Postoperatively both legs were planned to be immobilized in plaster splints for 6 weeks with full weight bearing. Despite low-dose heparin prophylaxis deep venous thrombosis with subsequent pulmonary embolism occured in the 3rd postoperative week and required anticoagulant therapy. After early removal of the plaster splints physical therapy was started and full range of motion was reached in both knees within 4 months. At follow-up 54 months after repair the patient was free of complaints with unlimited occupational and recreational activities. Examination revealed no limitation in range of motion of both knees without marked atrophy of the quadriceps muscles (Fig. 3).

Case 2

B.B, m, 52 years, weighting 110 kg, fell on icy ground onto his flexed knees and felt a burning ache in his right knee. He presented to our out-patient department
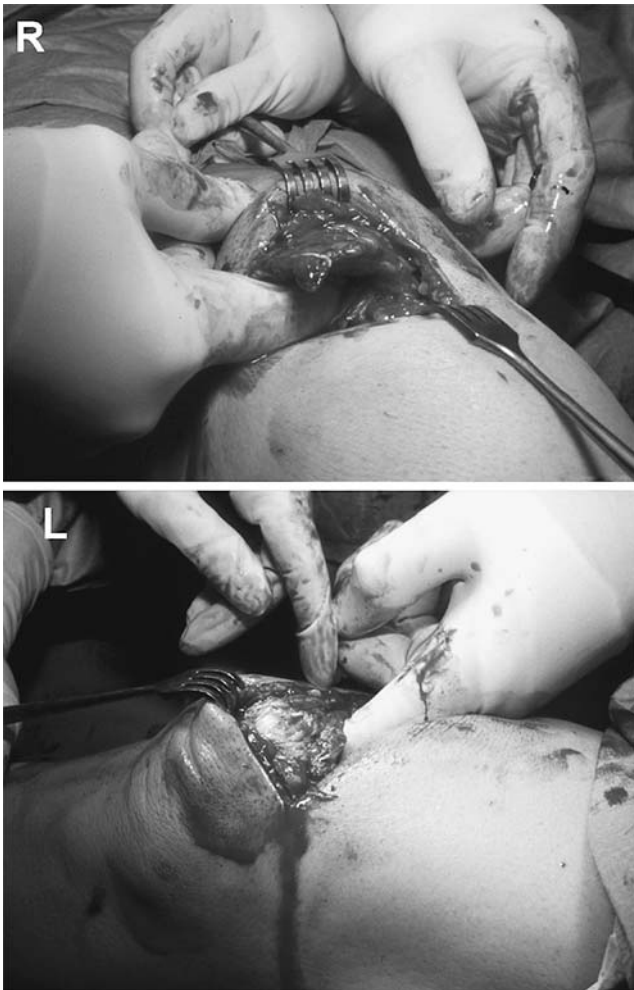
Fig. 2 Intraoperatively both quadriceps tendons are found ruptured at the osteotendineous junction with additional rupture of the retinacula on both sides

the same day due to persisting pains, but examination revealed only superficial hematoma on the lateral aspect of the right distal femur without limitation of function; so he was treated with tapes and local ice application. Due to persisting complaints he mobilized himself using a cane to continue his occupational duties as a General Practitioner. Three weeks later he stumbled once again on icy ground, feeling an intense pain in both knees accompanied by some kind of a poping sound. The patient was now unable to raise by himself or extend his knee joints actively. As loading of both legs was impossible he mobilized himself for another 4 weeks in a wheelchair and performed his daily routines. After that period he consulted a local orthopedic surgeon, who suspected degenerative changes in both knees and ordered an MRI investigation, which revealed bilateral tears of the quadriceps tendons. The patient was readmitted to our department for surgery

and presented as an obese man, who could not walk nor stand by himself. Local tenderness and palpable suprapatellar gaps were found in both knees which could not actively be extended. Clinical and laboratory investigation revealed arterial hypertension and obesity as underlying risk factors for QTR. Intraoperatively both quadriceps tendons were found to be avulsed from the cranial pole of the patella with their retinacula torn. The tendons were refixed using transosseous sutures and the retinacula repaired. Histologic evaluation revealed unspecific reactive changes according to a nonrecent traumatic tendon rupture. Postoperatively both legs were placed in plaster splints for 6 weeks with full weight bearing mobilization. At follow-up control 14 months after repair he complained about weakness in both knees causing bilateral gait disturbance and forcing him occasionally to use a wheelchair. Clinical investigation revealed a decreased range of motion of 0/0/90° of both knees in supine position. However, in contrast to the reported complaints he was able to walk independently without a supporting device and could extend both legs against resistance with a forceful contraction of both quadriceps muscles. Intense physical therapy was advised to increase range of motion but the patient died soon afterwards due to congestive heart failure.

Case 3

W. R, m, 30 years: a very obese patient (180 kg) fell downstairs onto his flexed knees doubling the legs beneath his body. He felt an immediate pain in both knees and could not raise or actively extend his knees. At presentation in our outpatient department a diagnosis of bilateral patellar contusion was established by a resident, though "weakness" of both quadriceps muscles, an inability to raise both legs and a lack of active knee extension were noticed by the examiner. The next day the patient was seen by an orthopedic consultant, who suspected bilateral QTR due to the patient's history and local findings. However, palpation of bilateral suprapatellar gaps was difficult due to articular effusions and the extreme obesity of the patient. Sonography revealed disruption of the tendons echoes and hematoma indicating complete bilateral rupture of the quadriceps tendons. Intraoperatively avulsion of both tendons at the basis of the patella was found and repaired by transosseous sutures. Clinical or laboratory evaluation indicated no underlying disease. Both legs were placed in plaster splints for 2 weeks with full weight bearing, followed by application of a motion limited orthesis. The patient made an uneventful recovery and 21 months after repair he was free of

Fig. 3 Clinical status
54 months after repair. The
patient is free of complaints,
performing all of his activities
without limitation

complaints performing all of his occupational and daily
routines without limitation of knee motion or decrease
of muscle strength.

Methods and review of the literature

A MEDLINE® search of the English and German
literature covering the years from 1949 to 2004 was
performed using the search terms: "tendon, quadri-
ceps, rupture, simultaneous and bilateral" in various
combinations. The retrieved articles were reviewed to
proof bilateral and simultaneous QTR in the reported
cases. Articles cited in references lists but not included
in the MEDLINE® results were reviewed too. If cases
with initially incorrect or missed diagnoses were found,
their data was analyzed in regard to the pathomecha-

nism of injury, underlying risk factors and diseases,
diagnostic delay and initially established wrong diag-
noses, kind of initially evaluating medical institution,
reported symptoms, method of establishing the defini-
tive diagnosis, location of tendon lesions, definitive
treatment as well as the reported out-come of the pa-
tients. Three own cases were included in this review.

Descriptive statistics were performed on all vari-
ables (mean and/or median, frequencies, SD). Statis-
tical analyses were performed using the Chi square test
on following associations: age of the patients and kind
of rupture (spontaneous/traumatic), risk factors and
kind of rupture (spontaneous/traumatic), age of the
patients and duration of diagnostic delay as well as the
association of diagnostic delay and reported functional
out-come; a value of $P = < 0.05$ was considered sta-
tistical significant.

Results

Cases (105) of bilateral and simultaneous QTR—including our 3 own cases—could be retrieved from the English and German literature since the first description in 1949 till December 2004. In 32/105 cases (30.5%) an incorrect or no diagnosis at all was established at initial examination. Four patients were excluded from further review as their reports lacked of details [15, 24, 26]. The remaining 28 patients (Table 1) represented 25 men (89.3%) and 3 women (10.7%) with a mean age of 54.5 years (min 30/max 84, SD 16.9). Eight out of 28 patients (28.6%) were younger and 20/28 patients (71.4%) older than 40 years of age; the latter group included 8/28 elderly patients (28.6%) with an age of more than 65 years.

Pathomechanism of rupture

Rupture without trauma occurred in 9/28 patients (32.1%), while some kind of injury was reported in 19/28 cases (67.9%). Patients sustained most often minimal trauma [stumbling ($n = 2$), simple falls ($n = 9$)] in 11/19 cases (57.9%), while a significant impact due to a fall over stairs ($n = 6$) or a fall from a height ($n = 2$) was recorded in 8/19 patients (42.1%). In 2/28 patients (7.1%) extensive strain of the quadriceps muscles in association with rupture was reported due to pushing an automobile and weight lifting, respectively. Extensive local loading of the tendons during the fall occurred in 3/28 patients (10.7%) when both legs were doubled behind the body. Direct trauma or open injuries of the suprapatellar region were not recorded. No correlation was found between the age of the patients (limit 40 years) and the incidence of spontaneous or traumatic rupture ($P = 0.33$) (Table 2).

Risk factors known to be associated with tendon ruptures (Table 3) were detected in the majority of patients ($n = 18/28$; 64.3%) with half of these patients ($n = 9/28$) presenting more than one risk factor. In 7/28 patients (25%) evaluation was negative and in 3/28 patients (10.7%) no details were provided. With regard to an individual risk factor (Table 3) obesity was most frequently ($n = 6$) observed, followed by diabetes mellitus ($n = 5$). Contribution of occupational or recreational activities to QTR was considered in 6/28 patients (21.4%). No direct correlation between the presence of risk factors and the occurrence of spontaneous ($n = 5/9$; 55.6%) or traumatic ruptures ($n = 13/19$; 68.4%) could be found ($P = 0.5$) (Table 4).

Tendon ruptures of other anatomic sites occurred in 4/28 patients (14.3%): two achilles tendon ruptures prior, one triceps tendon rupture simultaneously and one biceps tendon rupture after bilateral QTR. In one patient a successful repair of a left sided QTR 7 years prior to the actual trauma was reported [34].

Diagnostic delay

In 27/28 patients (96.4%) data about the time interval between injury and definitive surgical treatment was provided. It lasted 64.7 days on an average (min 2/max 300, SD 87.58; median 21) with half of the cases ($n = 14/27$; 51.9%) revealing a delay of more than 2 weeks and one-third ($n = 9/27$; 33.3%) more than 3 months. The time elapsing in patients with spontaneous ruptures was found to be 58.7 days on an average (min 30/max 78; SD 15.94; median 21 days) and in those with a traumatic rupture 67.7 days (min 2/max 300; SD 94.50; median 16 days). A significant influence of the patients age (limit 40 years) on the duration of diagnostic delay (limit 14 days) could not be found ($P = 0.47$) (Table 5).

Only 2/28 patients (7.14%) contributed to delay by not seeking medical aid and in another report ($n = 1/28$; 3.57%) this fact was not clearly defined by the authors. All other patients ($n = 25/28$; 89.3%) underwent medical evaluation initially in hospital departments ($n = 16$), emergency ambulances or casualties ($n = 6$) and General Practinioners or free orthopedics ($n = 3$). The interval of diagnostic delay varied considerably among these institutions as hospitals revealed a mean delay of 93.9 days (min 2/max 300/SD 99.9/median of 70 days), while in General Practioners and in ambulances this period was distinctively shorter with a mean of 24 days (min 14/max 30/SD 8.71/median 28) and 7.6 days (min 2/max 21/SD 6.86/median:6.5), respectively.

Initial diagnoses and treatment

In 21/28 patients (75%) a total of 25 incorrect diagnoses were established initially which covered exclusively orthopedic ($n = 12/25$; 48%) and neurologic ($n = 13/25$; 52%) conditions (Table 6). Multiple incorrect diagnoses were suspected in 3/21 patients (14.3%) during evaluation and 7/28 patients (25%) were discharged without any diagnosis after initial examination.

Plain radiographs of both knees had been obtained in 14/28 cases (50%) during work-up and six of these studies revealed indirect signs of QTR on retrospective re-evaluation.

Other diagnostic measures included CT-scans of the central nervous system ($n = 2$), of the knee joints ($n = 1$) and of the pelvis ($n = 1$) as well as MRI studies

Table 1 Patients ($n = 28$) with bilateral, simultaneous QTR and initially established incorrect diagnoses or no diagnosis at all

Author	Year	Age	Sex	Delay	Injury	Risk factors	Initial diagnosis	Evaluating institution	Imaging study	Definite diagnosis	Location	Op technique	Follow-up	
Wetzler [31]	1950	46	M	42	Spontaneous	–	Neurog. paralysis	Hospital	–	Clinic	Oss. tend.	Transoss. Refixation	4 mo	c
Preston FS [23]	1962	33	M	210	Spontaneous	Renal failure, sec. hyperparathyroidism	Rheumatoid arthritis	Hospital	Plain radiogr.	Clinic	Oss. tend.	Tendoplasty	12 mo	Decre
Mac Donald [17]	1966	49	M	150	Fall from a horse	–		Hospital	Plain radiogr.	Clinic	Oss. tend.	Repair	18 mo	
Preston ET [22]	1972	43	F	270	Fall over stairs	Prim. hyperpara-thyroidismfocal tend. atrophy			nm	Clinic	Oss. tend.	Tendoplasty	12 mo	Decrease
Lotem [16]	1978	38	F	120	Fall over stairs	Chronic renal failure, sec. hyperparathyroidism	–	nm	nm	Clinic	Intratend	Tendoplasty	3 mo	
Hohlbach [7]	1981	65	M	5	Fall over stairs	Obesity, gout., artherosclerosis, occupational	Bilat. tibial head fx	nm	nm	Clinic	Oss. tend.	Refixation	2 mo	
Geisl [5]	1983	65	M	65	Fall	Hyperlipidemia, gout, diabetes mell., occupational	Guillan–Barre Syndron	Hospital	Plain radiogr.	Clinic	Oss. tend.	Refixation	36 mo	
Mac Eachern [18]	1984	68	M	30	Stumbling	nm	Mild stroke	GP	nm	Clinic	Oss. tend.	Refixation	12 mo	
		84	M	7	Fall	nm	–	Ambulance	Plain radiogr.	Clinic	Intratend	Repair	2.5 mo	
		80	M	6	Fall	nm	Intraart. effusions	Ambulance	nm	Clinic	Intratend	Repair	8 mo	Decrease
*Keogh [11]	1987	70	M	98	Fall from a ladder	Gout, occupation	–	Hospital	nm	Clinic	nm	Repair (one side)	60 mo	Decrease
Dhar [4]	1988	75	M	7	Fall	Obesity	Osteoarthritis	Ambulance	Plain radiogr.	Clinic	Musculotned	Repair	4 mo	Decrease
Kleintz [12]	1989	59	M	14	Spontaneous	–	Knee sprain	GP	Plain radiogr.	Clinic	Oss. tend.	Refixation	Nm	
Ribbans [25]	1989	76	F	21	Fall over stairs	-	Osteoarthritis	Hospital	Plain radiogr.	Clinic	Oss. Tend.	Refixation	3 mo	Decrease
Sagiv [26]	1989	78	M	3	Spontaneous	–	"Neurologic condition"	Hospital	Plain radiogr.	Clinic	Oss. tend.	Refixation	36 mo	
Barasch [1]	1989	30	M	3	Spontaneous	Chronic renal failure	–	Ambulance	Plain radiogr.	Clinic	Oss. tend.	Repair	nm	
Immermann [31]	1993	64	M	3	Fall	Obesity	Stroke	Hospital	Plain radiogr.	Clinic	Oss. tend.	Refixation	30 mo	
Lombardi [15]	1995	30	M	2	Fall over stairs	Chronic renal failure	Knee sprain	Ambulance	nm	Clinic, MRT	Oss. tend.	Refixation	36 mo	
Calvo [3]	1997	39	M	21	Spontaneous	–	–	Ambulance	Plain radiogr., CT	Clinic, MRT	Oss. tend./intratend	Refixation/repair	nm	
Wick [35]	1997	38	M	120	Stumbling	Lupus erythematodus. occupation	Discus prolaps, psychiatric disease	Hospital	Plain radiogr.	Arthrotomy	Intratend.	Repair	36 mo	
Stein [30]	1999	58	M	8	Fall over stairs	M. Wilson	–	Hospital	Plain radiogr.	Clinic	Oss. tend.	Refixation	6 mo	
*Tedd [33]	2000	58	M	112	Spontaneous	"Pseudogout", diabetes mellitus	Neuropathia, septic arthritis	Hospital	nm	Arthrotomy	nm	Refixation (one side)	6 mo	Decrease

Table 1 continued

Author	Year	Age	Sex	Delay	Injury	Risk factors	Initial diagnosis	Evaluating institution	Imaging study	Definite diagnosis	Location	Op technique	Follow-up	
Mahlfeld [19]	2000	36	M	300	Fall	M. Werlhof, steroid use, diabetes mellitus	Intramedullary bleedin	Hospital	nm	Clinic	Oss. tend	Refixation	6 mo	Decrease
Yilmaz [36]	2001	68	M	150	Fall	Diabetes mellitus, recreational behaviour	"Neurologic condition,	Hospital	nm	Clinic, MRT	Intratend	Tendoplasty	60 mo	Decre
Bikkina [2]	2002	40	M	nm	Weight lifting	–	Fibular fracture	Hospital	Plain radiogr.	MRT	Oss. tend./tendomus	nm	nm	
Neubauer	2004	55	M	2	Fall over stairs	Diabetes mellitus, obesity	Spinal process, discus prolaps	Hospital	–	Clinic, sonography	Oss. tend.	Refixation	54 mo	Decrease
		52	M	28	Fall	Hypertension, obesity	Contusion	GP	Plain radiogr.	MRT	Oss. tend.	Refixation	14 mo	Decrease
		30	M	3	Fall over stairs	Obesity	Contusion	Hospital	Plain radiogr.	Clinic, sonography	Oss. tend.	Refixation	21 mo	

P of one side denied

Table 2 Correlation of the age of the patients ($n = 28$, limit 40 years) and rupture form (spontaneous/traumatic)

	Spontaneous	Traumatic	Sum
< 40 years	4	5	9
> 40 years	5	14	19
Sum	9	19	28

$P = 0.33$

Table 3 Associated risk factors in bilateral, simultaneous QTR with an initially missed or neglected diagnosis ($n = 28$)

Obesity	6
Diabetes mellitus	5
Chronic renal failure	3
Hyperparathyreoidism	3
Artherosclerosis/ hypertonus	3
Gout	3
Pseudo-gout	1
M. wilson	1
Hyperlipemia	1
Lupus erythematodus	1
M. werlhof	1
systemic use of steroids	1
occupational/ recreational factors	6

Multiple nominations possible

Table 4 Correlation of pre-existing risk factors and rupture form (spontaneous/traumatic) in 28 bilateral and simultaneous QTR

	Risk factor +	Risk factor –	Sum
Spontaneous	5	4	9
Traumatic	13	6	19
Sum	18	10	28

$P = 0.5$

Table 5 Correlation of the patient's ($n = 27$) age and duration of diagnostic delay (limit 14 days)

	<– 14 days	> 14 days	Sum
<–40 years	3	5	8
> 40 years	10	9	19
Sum	13	14	27[a]

$P = 0.47$

[a] Missing data in one patient

of the central nervous system ($n = 2$). Noninvasive investigations like psychiatric examination ($n = 1$), nerval conduction investigation ($n = 2$) as well as invasive diagnostic procedures like myelography ($n = 1$), lumbar puncture ($n = 1$), arthroscopy ($n = 2$) and arthrotomy ($n = 1$) of the knee joints and biopsy of the quadricpes tendons ($n = 1$) had been performed but did not contribute to establish the correct diagnosis.

Initial treatment attempts were started in 13/28 patients (46.4%) and consisted most often in physiotherapy and mobilization of the patients ($n = 8$), followed by (bed-) rest ($n = 5$), local therapy with tapes ($n = 2$) and evacuation of effusions ($n = 1$), administration of antirheumatic drugs ($n = 1$), "neurologic therapy"($n = 1$) and mobilization in a wheelchair ($n = 3$). No therapeutic measures at all had been initiated in 11/28 patients (39.3%) and no information was provided in another 4/28 (14.3%).

Local symptoms + definitive diagnosis

In 24/28 patients (85.7%) information about local symptoms was available. Most often pains were reported by 22/24 patients (91.6%), followed by an inability to walk and a loss of active knee extension in 17/24 patients (70.8%), respectively. Thirteen out of 24 patients (54.2%) were unable to stand alone and 6/24 (25%) required a supporting device for mobilization.

On clinical examination most often palpable suprapatellar gaps and effusions were found in 17/24 (70.8%) and 13/24 (54.2%) patients, respectively. Eleven out of 24 patients (45.8%) were unable to raise their straight legs in supine position though 6/24 (25%) had an unlimited passive range of motion. A classic trias of painful swelling, suprapatellar gap, loss of knee extension or inability to raise the legs was found in only 58.3% of the patients ($n = 14/24$).

The accurate and final diagnosis of bilateral QTR was established on the basis of clinical examination alone in 17/28 patients (60.7%) while it was supported preoperatively in 3/28 cases (10.7%) by sonography and in 4/28 cases (14.3%) by MRI studies. In another 4/28 patients (14.2%) the diagnosis represented a by chance finding in MRI studies ($n = 2$) and in arthrotomies ($n = 2$) of one knee joint performed for other indications than tendon rupture, respectively.

Site of lesion and therapy

Surgical repair of 54/56 ruptures (92.9%) was performed as 2/28 patients (7.1%) denied operative repair of one knee and no information about the operated side was provided by the authors. Thus, in 52 tendons detailed information about QTRs location was available, revealing 48/52 (92.3%) tendon ruptures bilateral at the same level (18 osteotendineous, 5 intratendineous, 1 musculotendineous) and only 4/52 tendons (7.7%) at different levels (1 osteotendineous/intratendineous; 1 osteotendineous/tendomuscular).

Operative repair consisted most often of transosseous tendon refixation to the patella ($n = 30/52$;

57.7%) including two fixations with additional enhancement by cerclage wiring. In 14/52 tendons (26.9%) a direct suture repair was performed, including additional cerclage wiring and enhancement by a strip of fascia in two tendons, respectively. Tendoplasty in Scuderi and Mc Laughlins technique [27] was required in 8/52 procedures (15.4%) due to scary retraction of the quadriceps muscle. Additional repair of ruptured retinaculae was reported in 9/28 cases (32.1%). Histologic examination of the ruptured tendons had been performed in only 10/28 patients (35.7%) revealing only unspecific degenerative changes and patterns of repair.

Postoperative course and out-come

Most patients ($n = 22/28$; 78.6%) were mobilized postoperatively in plaster splints with full weight bearing. Duration of plaster immobilization lasted 6.1 weeks on an average (min 4/max 8, SD 0.6837; median 6). In 3/28 patients (10.7%) early mobilization was started with the use of a motion limited knee orthesis and in another 3/28 patients (10.7%) no information was provided about postoperative immobilization of the limbs.

Postoperative course was uneventful in 21/28 patients (75%) and in 3/28 (10.7%) not mentioned by the authors. Four out of 28 patients (14.3%) sustained complications including deep vein thromboses with subsequent pulmonary embolism (2), superficial wound infection (1) and re-rupture of a quadriceps tendon (1) four months after repair.

Information about final outcome was available in 26/28 patients (92.8%) with a mean follow up of 22.7 months ($n = 24/28$; min 2/max 78, SD 22.17; median 12). Full recovery with unlimited range of motion, full muscle strength and no pains was reported in 9/26 (34,6%) patients, while 17/26 patients (65.4%) showed at least in one of these parameters a deficit. Twenty-one out of 26 patients (80.8%) denied pains at follow-up, while 1/26 patient (3.8%) complained of pains and in 4/26 (15.4%) patients the status was not reported. Loss in range of motion was seen in 14/26 cases (53.8%) and impairment of muscle strength in 10/26 cases (39.5%). Duration of diagnostic delay showed no statistical significant influence ($P = 0.12$) on the final out-come due to the small number of proofs (Table 6). However, there was a clear trend indicating that patients with a delayed repair of maximal two weeks ($n = 12$) had a full recovery rate of 50% ($n = 6/12$), while in patients with a longer delay full recovery was seen in only 21.4% ($n = 3/14$).

Table 6 Correlation of diagnostic delay (limit 14 days) and final functional out-come in patients with follow-up data ($n = 26$)

	Full recovery	Decreased recovery	Sum
Delay <–14 days	6	6	12
Delay > 14 days	3	11	14
Sum	9	17	26

$P = 0.1$

Discussion

QTR represents a well-documented injury to the extensor mechanism of the knee joint, affecting predominantly men over 40 years of age [13, 25, 29, 36]. However, bilateral and simultaneous ruptures are very rarely reported and since the initial description by Steiner and Plamer in 1949 [31] only 105 cases of this entity could be found in our review.

Closed QTR is considered to be caused most often by a forced contraction of the quadriceps muscle with the knee in a flexed position and a fixed foot [18, 30]. On the other hand quadriceps tendon can resist considerable loads. Mc Master [21] demonstrated in experimental work that approximately 50% of a healthy tendon's tissues have to be severed to achieve rupture. So it is commonly accepted that impairment of the tendon's ultrastructure by a risk factor (Table 3) represents an important contribution to closed QTR [4, 7, 13, 18, 35]. Ilan et al. [8] reported a frequency of associated risk factors in 20% of unilateral and in 30% of bilateral QTR with a significantly higher rate in simultaneous than in asynchronous, bilateral ruptures [13]. Chronic renal failure is considered to be the most frequently encountered risk factor in simultaneous QTR with a reported rate of more than 40% [28]. In renal patients incidence of QTR seems to be correlated to the duration of the disease, which contributes to the weakening of the tendon's ultrastructure by connective tissue elastosis and disturbance of the ground substance; primary or secondary hyperparathyroidism additionally may yield in weakening at the osteotendineous junction [16, 22, 23]. The fact that in our review obesity was found most frequently among risk factors (21.4%), might be explained by the selected group of patients. However, apart from diagnostic difficulties extreme obesity itself may lead to fatty degeneration of the tendon's microstructure and increases the loading of the tendon during a fall [24, 25]. Occupational or recreational activities straining the quadriceps tendon are not considered as true risk factors; however their contribution in the developement of tendon lesions due to repeated microtraumas is

discussed [5, 7, 11, 23, 35, 36]. Keogh et al. [11] pointed out that a prolonged knee-flexion over 90° renders an extensive area of contact between the tendon and the distal femur and thus may create a circumscript ischemia of the tendon. However, simultaneous bilateral QTR in patients without any underlying risk factors and without histologic evidence of degenerative changes are reported very infrequently [2, 12]. In some of these cases additional immunohistologic evaluation of intraoperative specimens revealed amyloidosis as the underlying disorder [20].

Diagnostic difficulties in bilateral, simultaneous QTR are not uncommon with high rates of initially missed diagnosis [4, 25, 32]. Ribbans et al. [25] reported in his review of the literature a diagnostic delay in 38.7% patients with QTR ($n = 12/31$) of which 50% had been examined initially by a doctor. Stephens et al. [32] mentioned that in 50% of bilateral ruptures the correct diagnosis was not established at initial examination. In our review initially missed diagnoses in QTR represented 30.4% ($n = 32/105$). Extensive delay in hospital departments (median 70) compared to ambulances and GPs (median 6.5/28 days) may be influenced by preceeding and frustrane treatment attempts prior to hospital admission or admission into departments not common with orthopedic entities.

Diagnosis of QTR is still based on history and clinical examination [12, 26, 37] though imaging studies can be helpful in problematic cases. However, it seems that frequently bilateral QTR is not included into diagnostic considerations due to it's rarity and due to the difficulties on physical examination. In contrast to unilateral rupture comparison with an uninjured contralateral side is not possible [37]. The classic trias of symptoms [1,3, 4, 11, 15, 18, 26] with painful swelling of the knee, a palpable suprapatellar gap and the inability to extend the knee actively or to raise the straight legs in supine position is an inconstant finding in the reviewed patients (58.3%). Pain may not necessarily be present and a suprapatellar defect may be obscured by articular effusions or obesity [5, 8] as well as scar-tissue formation in neglected cases [29]. Li [14] emphasized that a suprapatellar gap masked by hemarthrosis can be well demonstrated by active flexion of the hip in supine position, thus widening the defect by contraction of the rectus muscle and pull back of the whole quadriceps muscle. Intact retinacula may additionally contribute to diagnostic confusion as some ability of active knee extension is preserved [7, 29, 37] though weak and with a considerable extensor lag [8]. Thus, in neglecting an accurate evaluation of the extensor apparatus minor trauma or arthritis of the knee joint may be suspected, when a limited ability to walk

without extensive tenderness is found in a stable knee-joint [15, 24, 32], while loss of function and missing patellar reflexes without reported trauma may suggest neurologic conditions [18, 26, 34]. Elderly people are considered at special risk for misdiagnosis of bilateral, simultaneous QTR as a neurologic disorder due to an underlying organic brain syndrome [9]. However, elderly people with an age of over 65 years represented in our review only 28.6% of the patients.

Plain radiographs are of limited diagnostic value in QTR as they reveal only indirect signs of the lesion. A poorly defined shadow in the tendon line, suprapatellar mass, patellar spurs at the tendons insertion, joint effusion, low riding and forward tilting of the patella as well as suprapatellar calcifications due to systemic diseases or due to bony transformation of scar tissues are well described [3, 10]. Kaneko et al. [10] found evidence that in almost all cases multiple findings comparable to QTR are detectable and that poor comprehension of radiographic findings is responsible for failing rather than overlooking diagnostic hints. Sonography [6, 19, 35] represents a cheap and almost universal available method which provides reliable results even in neglected cases [6, 19] though it requires an experienced investigator as it's echoes may be obscured by soft tissues and hematoma formation [3, 8]. MRI is considered today to be the most reliable tool providing an excellent visualization of the lesion and the retraction of tendon edges [1–3, 15, 26]. However, in 71.4% of all reviewed cases the diagnosis was evaluated without the support of MRI. Thus, MRI investigation is useful in special situations like neglected cases with inconclusive complaints, patients with reduced compliance [26], and in partial tendon lesions which can treated conservatively [2, 3, 10, 34].

Early surgical repair of complete QTR is generally recommended [8, 17, 24, 30, 34] as poor functional outcome can be expected after conservative treatment. Operative difficulties may occur in neglected cases due to soft-tissue retraction and scar formation of the tendon [31] and so Scuderi [27] advised surgical tendon repair within the first 48–72 h after the injury. Some authors report less favourable functional out-come [24, 31] due to a persisting atrophy of the quadriceps muscle and limited motion in patients with a delayed repair of more than 1 [33] or 2 weeks [29]. Our report supports Konrath's et al. [13] results who found no direct correlation in out-comes of strength, function or activity and the delay of repair, if this period was not exceeding long. If operative repair was performed after a 2 weeks interval, the rate of full functional recovery decreased from 50% down to 21.4%.

In our opinion the quality of postoperatve physiotherapy considerably yields to the final outcome, but in most reports no informations of a detailed treatment protocol are provided. Recently published data [13, 20, 35, 36] suggests that a reduction in the rate of flexion deficits and the risk of thromboembolic complications can be achieved by allowing early active motion with the use of controlled motion braces and physiotherapy. Promising reports [13] indicate no increased rate of tendon re-ruptures and recommend plaster cast immobilization only for unreliable patients.

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