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ORIGINAL ARTICLE

Bilateral Disruption of Soft Tissue Extensor Mechanism of Knee: Functional Outcome and Comparison to Unilateral Injuries

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Abstract
Background: Bilateral ruptures of the extensor mechanism are rare.
Questions/Purpose: The purpose of this study was to compare the clinical outcomes of operatively treated unilateral and bilateral knee soft tissue extensor mechanism injuries and to identify risk factors for bilateral disruption.
Methods: All patients operatively treated for a knee extensor mechanism injury were entered into a database and prospectively followed. Postoperative protocol was standardized for all patients. Demographic data, baseline characteristics, range of motion, complications, pain, and functional status were assessed. The main patient-reported outcome measures used in this study were the SF-36 Health Survey and the Lysholm Scale.
Results: Patients who sustained bilateral injuries were more likely to have one or more systemic medical conditions. There was no statistical difference between the groups with regard to mechanism of injury or body mass index. The average follow-up was 29 months (range 6–60 months). Patient-reported outcomes, in the form of the SF-36 Health Survey and Lysholm scores, were not significantly different between the two groups at final follow-up. Range of motion and quadriceps strength was also similar between the two cohorts. At latest follow-up, 88% of patients with unilateral injuries and 83% of patients with bilateral disruption were able to return to their pre-injury employment.
Conclusion: Operatively treated bilateral knee extensor mechanism disruptions fare similar to unilateral injuries with regard to ultimate functional outcome. The presence of one of more preexisting medical conditions was identified as a risk factor for bilateral tendinous disruption.

Keywords bilateral · extensor mechanism knee injury · outcome scores · complications

Level of Evidence. Therapeutic Study Level III. See Levels of Evidence for a complete description.

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Introduction

Traumatic disruption of the knee extensor mechanism is defined as a rupture of the quadriceps tendon, rupture of the patellar tendon, or fracture of the patella. Most extensor mechanism disruptions result from patella fractures, while quadriceps and patellar tendon ruptures are less common [5]. These injuries occur during a strong eccentric contraction of the quadriceps muscle on a semi-flexed knee. Patients classically present with a triad of symptoms: knee pain, inability to actively extend the knee, and a palpable gap above or below the patella. These injuries require surgical intervention to restore knee function and prevent loss of active knee extension.

Soft tissue extensor mechanism injuries have been well-documented over the years, but most studies have focused on patients with unilateral injuries. Bilateral injuries are less common. The majority of bilateral injury literature consists of detailed case series that chronicle hospital courses and individual patient risk factors. To date, there are about 74 such cases described in the English literature [25]. Men over the age of 40, elderly and overweight patients, and/or patients with underlying systemic diseases all have an increased risk of experiencing a knee tendon injury [3, 6, 16, 18, 21, 24, 28]. However, this injury occurs in young, healthy patients with neither local nor systemic predisposing conditions. Bilateral tendon ruptures have also been observed in certain athletes, such as basketball players and weightlifters [7, 22].

In healthy knees, the tendons serve as connective tissue that transmits the force of muscle contraction to bones for joint movement [13]. Tendons can rupture during activities when the knee is subjected to large forces for extended periods of time. Injuries that occur in very active individuals

usually fall into this category. Some individuals may be more prone to tendon tears due to abnormal weight distribution in the knee that results from nonanatomic leg alignment. Risk of rupture may be increased by obesity. The combination of excess loading of the joint and fatty degeneration of the soft tissues can easily lead to tendon rupture [23]. Many other systemic diseases, including diabetes and renal failure, are also known to increase risk of tendon rupture.

The purpose of this study is to compare the self-reported recovery measures and clinical results for patients who have sustained bilateral and unilateral soft tissue injuries to the extensor mechanism. We hypothesize that (1) bilateral injuries would occur in patients with a systemic disease or other associated risk factors; (2) with prompt surgical treatment, bilateral injury patients should attain similar long-term outcomes and (3) experience comparable rates of postoperative complications to unilateral patients.

Methods

A total of 98 patients with 106 injuries to the knee extensor mechanism were treated by the two senior authors over a 7-year period. Fifty-two patients sustained patella fractures and were therefore excluded from this study. Forty-six patients sustained 54 ruptures of the knee extensor mechanism tendons. There were 16 patella tendon ruptures (30%) and 38 quadriceps tendon ruptures (70%) in total. Eight patients sustained bilateral injuries. Five patients (63%) had bilateral quadriceps tendon ruptures, and another two (37%) injured one quadriceps tendon and the contralateral patellar tendon. A final patient sustained sequential injuries spaced 2 years apart: the first resulted in a left quadriceps tendon rupture and the second in a right quadriceps tendon rupture. We chose to categorize this patient as a bilateral injury, because his injuries likely stemmed from a predisposition that compromised both knees.

All patients had a minimum of 6 months of follow-up at the start of this study, and final follow-up was attained at an average of 29 months (range, 6–60 months). All tendon ruptures were at the bone–tendon junction and were operatively treated by open repair of the ruptured tendon with either #2 or #5 nonabsorbable, braided sutures looped through vertical drill holes in the patella. After the tendon ends were freshened, Krackow-type sutures were placed in the tendon such that there were four tails; these were then passed through three drill holes in the patella to emerge at the distal or proximal end. Holding the knee in extension, these were tied over the bone, and retinacular repair was also done to augment the repair. Following the surgery, patients were discharged home and seen back by their treating physician at 2 weeks, 6 weeks, and then at 3, 6, and 12 months. The knee was immobilized in a knee immobilizer to limit the knee flexion to approximately 20°, and the patients were allowed to be weight bearing as tolerated. Follow-up after the first year was attained on a yearly basis during routine clinic visits with the treating surgeon. All patients that did not return for follow-up after 1 year were also contacted on the phone to answer a set of questions about their recovery.

Information obtained during follow-up visits included clinical measures such as knee range of motion (ROM), quadriceps muscle strength, and quadriceps circumference difference. Quadriceps strength was measured using manual resistance to active extension and compared to the opposite side for unilateral cases (manual muscle testing with range of 0–5). The range of motion was measured using a goniometer and the circumference using a tape measure 10 cm proximal to the patella. Both physical and emotional outcomes were quantified using the SF-36 questionnaire and Lysholm Knee Score. Finally, patients were also asked whether they had returned to all of their pre-injury activities, including sports and work. The questionnaires were administered by two trained research associates in the office at the time of the patient evaluation.

The data were analyzed using descriptive statistics. Differences in demographic variables including sex, age, body mass index (BMI), and significant medical history were examined. Group averages for outcomes were compared using a Student's t test, while differences between categorical variables were assessed using the Fischer's exact chi-square test.

Results

The only significant difference between the unilateral and bilateral groups was the presence of associated medical comorbidities (p=0.015). No other differences in demographic or outcome measures were found (Table 2). The bilateral group consisted of eight males with bilateral injuries. Four patients (50%) had significant medical histories prior to tendon rupture. Three patients had non-insulin-dependent diabetes mellitus, and one of them also had colorectal cancer. The fourth patient was obese (BMI: 39) and had chronic renal failure (Table 1). Final follow-up was obtained at a mean of 25.5 months (range: 6–60). Five patients (63%) were able to return to pre-injury activity levels, and four out of five patients (83%) who were employed before surgery returned to work. The unilateral group was comprised by 34 men (89%) and four women (11%) at an average age of 53.8 years (range: 15–88). Mean BMI in this category was 28.5 (range: 19.7–41.6), and eleven patients (28%) were obese. Three patients (10%) had significant medical histories other than obesity. Two patients had a history of seizures, and the third had chronic kidney disease. Final follow-up was obtained at an average of 25 months (range: 6–84), and nineteen patients (50%) felt they attained pre-injury activity levels. Twenty-eight of the 32 people (88%) who were employed at the time of injury returned to work.

Table 1 Detailed overview of bilateral injury patients

Case	Side of injury	Type of injury	Mechanism of injury	Medical history	BMI	Sex	Age	Complications
1	L	Q	Direct trauma	N	27	M	38	None
	R	Q	Slip and fall					
2	L	PT	Slip and fall on ice	Y	39	M	49	None
	R	Q						
3	L	Q	Slip and fall in subway	N	29	M	58	None
	R	Q						
4	L	Q	Fall in home	Y	29	M	57	Debilitating PF arthritis
	R	Q						
5	L	Q	Fall in home	Y	26	M	75	Bilateral re-rupture at 6 months; PF arthritis
	R	Q						
6	L	Q	Fall while golfing	N	29	M	52	None
	R	PT						
7	L	Q	Fall while running	N	46	M	39	Re-rupture of R PT at 3 months. Revision at 7 months post-op
	R	PT						
8	L	Q	Fall on subway stairs	Y	27	M	47	
	R	Q						

Average knee range of motion (p=0.174), quadriceps strength (p=0.636), quadriceps circumference difference (p=0.423), and extensor lag (p=0.987) were comparable between groups. No differences were found in SF-36 or Lyholm Knee scores at final follow-up.

Five unilateral and three bilateral injury patients experienced complications. In the unilateral group, within the first year, three patients re-ruptured their affected tendon; one sustained a tendon rupture with a patella fracture through the surgical drill hole. A fourth patient fractured the patella with no associated soft tissue injury. Finally, one patient reported severe recurring patellar tendinosis (Table 3). At last follow-up, two of the five patients had returned to work and baseline activity levels. Radiographic findings demonstrated four cases of non-symptomatic heterotopic ossification. Posttaumatic arthrosis led one patient to undergo a total knee arthroplasty 3 years after initial surgery. The total complication rate for patients in the unilateral group was 5/38 (14%). In the bilateral group, two patients experienced re-ruptures. One patient had bilateral re-ruptures at 6 months. The second patient re-ruptured his right patellar tendon at 3 months, and again at 7 months after initial repair (4 months after second repair). At final follow-up, the first patient had returned to baseline but had mobility limitations due to patellofemoral arthritis. The second patient had not returned to work 9 months after surgery and was subsequently lost to follow-up. One additional patient developed patellofemoral arthritis. Final follow-up was attained 2 years post-op, at which point he had not returned to work or pre-injury activity levels (Table 3). The total complication rate for bilateral injuries was 3/8 (37%).

Discussion

Bilateral knee extensor mechanism soft tissue injuries are uncommon, and are usually experienced by individuals with predisposing medical problems such as diabetes or obesity. Although several studies have looked at outcomes for unilateral or bilateral injuries separately, this study compares the two groups. Our results show no significant differences in recovery prognosis; however, bilateral injuries are seen significantly more often in patients with preexisting medical comorbidities, and these patients tend to have a higher complication rate.

This study provides insight into the recovery potential of unilateral and bilateral knee soft tissue injury, but there were some limitations. The difference in sample size between the unilateral and bilateral groups may have influenced results. However, unilateral injuries are 15 to 20 times more common than bilateral injuries [13], and the patient population analyzed here reflects the incidence of injury in this practice. We would also like to acknowledge limitations in quadriceps strength measurements which were done by two research associates subjectively and this may introduce some variability. In spite of these limitations, this study is clinically significant in its finding that bilateral injury patients can expect to recover as well as unilateral injury patients.

Despite similar prognoses between groups, bilateral patients tended to have more medical problems at the time of injury (p=0.015). In the bilateral group, three patients were diabetic and one patient had chronic renal failure. One diabetic patient had also received cancer treatment in the past, which may potentially have weakened the tendons. Multiple studies suggest that bilateral injuries are more common in patients with systemic disease [3, 6, 16, 18, 21, 24, 28]. Diabetes mellitus [2, 26] and chronic kidney disease [8, 10, 15, 17] are often cited as predisposing conditions. These diseases lead to connective tissue disorders that cause degenerative changes in the collagen fibrils and increase the risk of tendon rupture[11]. In the unilateral group, one patient had kidney disease. However, the other two unilateral patients with significant medical conditions had a history of seizures, which led to frequent falls and knee trauma. Repeated microtrauma or frequent falls on

bent knees can predispose patients to tendon rupture [1, 22, 28]. Unilateral patients thus seem to rupture healthy tendons during trauma, while bilateral patients often have medical conditions at the time of injury that may weaken their tendons.

Along with the aforementioned diseases, obesity has also been linked to knee tendon injury [20]. Neubauer et al. [19] found that among bilateral injury patients, there was a 21.4% obesity rate. Patients with BMIs over 25 are considered overweight, while BMIs over 30 are considered obese. According to these parameters, two were obese and six were overweight. In the unilateral group, 89% of patients had BMIs over 25, and 27% of patients had BMIs over 29. For obese patients, the increased risk stems both from fatty degeneration of tendons and larger loads placed on the knee joint during trauma. The excess mass causes a high energy injury that can lead to failure through the tendons even if they are healthy [13]. While systemic disease affected some of our patients, the majority of patients were obese.

There were no other demographic discrepancies between the two groups. Eighty-nine percent of the unilateral and 100% of the bilateral group were male, and the mean age for both groups was approximately 50 years old (unilateral, 53.84 years; bilateral, 51.88 years). Decreased elasticity and vascularity secondary to aging cause tendons to weaken, increasing the risk of rupture [12]. The patients seen in this practice mirror populations presented in other studies; most knee tendon tears are seen in men over the age of 50 [14, 20, 27].

At final follow-up, both groups achieved good functional outcomes according to their Lysholm Knee and SF-36 scores (Table 2). Both groups showed similar recovery of ROM, knee extension lag, quadriceps circumference, and quadriceps strength. Other studies have reported very similar outcomes to our study [14, 15, 24, 27]. De Baere et al. found that surgical repair within 2–3 weeks after injury resulted in 85–92% patient satisfaction, and 84% of patients had returned to their pre-injury occupations [4]. In our series, 88% of unilateral and 83% of bilateral patients had returned to work by their final follow-up visit. Yet only 50% of unilateral and 63% of bilateral patients reported that they had recovered their pre-injury activity levels. Similarly, Konrath et al. [14] found that 84% of patients with quadriceps tendon ruptures were able to return to work at last follow-up, but only 51% were back to their full range of activities. Some studies have found the rates of full recovery to be as low as 35% [22]. These limitations likely result from physical impairments, such as reduced ROM, extensor lags, and weakened quadriceps muscles.

Five patients in the unilateral group and two patients in the bilateral group experienced complications (Table 3). At final follow-up, three unilateral injury patients with complications had not returned to their pre-injury occupations. Two of them experienced re-ruptures, whereas the third patient had recurring tendinosis. Return to work for the bilateral patients is not reported, because one patient was retired at the time of injury and the other patient was lost to follow-up at 9 months. Other studies have found that complication rates are low as long as tendon tears are treated promptly after injury [4, 9, 19].

Bilateral disruption of the extensor mechanism is a rare injury that most commonly occurs in an older patient group and/or patients with underlying systemic medical comorbidities. Our study demonstrated a significant difference between bilateral and unilateral patients with predisposing medical conditions at the time of injury. Nevertheless, both groups may expect similar clinical and functional outcomes. Future studies can accrue more data pertaining to patient-specific postoperative care that considers medical history or BMI. Information about the effectiveness of post-op physical therapy or patient compliance with weight-bearing status may also emphasize which therapies should be employed to achieve optimal results.

Table 2 Comparison of demographic and clinical results—unilateral vs. bilateral injury patients

Measure	Unilateral (n=38)	Bilateral (n=8)	p value
Age (SD) in years	53.84 (17.47)	51.88 (11.48)	0.683
BMI (SD)	28.5 (4.75)	31.5 (6.89)	0.095
Gender (%)			0.303
Male	34 (89)	8 (100)	
Female	4 (11)	0 (0)	
Medical History (%)	3 (10)	4 (50)	0.015
Outcomes (SD) at final follow-up			
Last interval in months	25 (21.4)	25.5 (18.27)	0.936
SF-36	78.17 (21.44)	74.12 (23.24)	0.493
Lysholm	81.17 (19.73)	80.88 (21.86)	0.962
Quad Difference in cm	0.68 (1.03)	1.00 (1.71)	0.423
ROM in degrees	121.25 (12.39)	126.56 (13.75)	0.174
Extensor Lag in degrees	2.53 (5.96)	2.50 (5.48)	0.987
Strength (0–5)	4.67 (.59)	4.75 (.58)	0.636
Recovery Details (%)			
Pre-injury	18 (50)	5 (63)	0.549
Work*	28 (88)	5 (83)	0.172

*Thirty-two unilateral patients (n=32) and six bilateral patients (n=6) were employed at the time of injury. Results are based on answers from these patients only

Table 3 Postoperative complications and need for revision surgery – Unilateral vs. Bilateral injury patients

Complications	Unilateral (n=38)	Bilateral (n=8)
Complication Type (%)		
Re-rupture	2 (5)	2 (25)
Patella Fracture	1 (3)	0 (0)
Re-rupture and Patella Fracture	1 (3)	0 (0)
Recurring Tendinosis	1 (3)	0 (0)
Revision Surgeries (%)		
One Revision	3 (8)	1 (13)
Two Revisions	1 (3)	1 (13)

Disclosures Each author certifies that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article. One or more of the authors has or will received payments from a commercial entity that may be perceived as a potential conflict of interest.

Each author certifies that his or her institution has approved the reporting of these cases, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participating in the study was obtained.

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