

CLINICAL ARTICLE

Effects of Judet Quadricepsplasty in the Treatment of Post-traumatic Extension Contracture of the Knee

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Objective: To investigate the clinical outcomes and the affecting factors of Judet's quadricepsplasty on the stiffness of post-traumatic knee flexion.

Methods: A retrospective survey was analyzed from June 2015 to October 2018. A total of 15 patients (eight males, seven females; mean age, 48.27 years) with extension contracture of the knee were treated by Judet's quadricepsplasty. All cases were injuries induced by fracture trauma. The mean interval between the initial procedure and quadricepsplasty was 56.2 months (range, 13–276 months). The knee range of motion (ROM) was assessed with a goniometer. The results of the procedure were analyzed by measuring the degrees of flexion of the operated knees at different time points (before, immediately after, and late postoperatively). We evaluated Hospital for Special Surgery (HSS) score, Judet's criteria, change in the degree of knee flexion, and complications.

Results: All patients were followed up for 14 to 47 months, with an average of 31.53 months. The degree of flexion increased from 23.33° (range, 10°–50°) preoperatively to 107.33° (range, 100°–125°) intraoperatively, followed by a slight fall in the range of flexion in the late postoperative period, which reached an average of 95.33° (range, 60°–115°) in the last follow-up. The knee joint function was assessed according to the Judet's criteria, eight cases (53.33%) achieved excellent results, six (40%) good, one (6.67%) fair, and zero (0.00%) poor results at final follow-up. The long-term excellent and good rate was 93.33%. The range of flexion of the knee during operation and at the last time of follow-up was better than that before surgery ($P < 0.001$). The final flexion was significantly lower than that measured at immediate postoperative ($P < 0.001$). The mean postoperative HSS score for the entire group was 93.73 (range, 89–96). Fifteen excellent results were obtained according to the HSS knee score. Skin infection was seen in one patient (6.67%). There were no complications such as deep sepsis, intraoperative rupture of the quadriceps tendon, fracture of the lateral femoral condyle, skin dehiscence.

Conclusion: Judet quadricepsplasty is an effective method to treat knee extension contracture and improve knee range of motion (ROM). It should be performed by an experienced orthopaedic surgeon and followed by physiotherapy with continuous passive motion (CPM). The knee ROM obtained with the surgery has an excellent long-term effect.

Key words: Fracture; Judet; Knee extension contracture; Quadricepsplasty

Introduction

The incidence of post-traumatic extension contracture of the knee (PECK) is increasing year by year¹. It is a common complication of lower limb fractures, especially femoral fractures, and brings many inconveniences to patients' daily lives. PECK is a very debilitating condition. Despite it having been widely reported, the management of PECK represents a

dilemma faced for orthopaedic surgeons. Many methods have been adopted to cure PECK, including conservative treatment and operative treatment. There is practically no use anymore for conservative treatment such as exercises, rehabilitation, and manipulation under anesthesia, no matter how much time has passed since the injury event². It is filled with some potential complications: cartilage damage,

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Disclosure: On behalf of all authors, the corresponding author states that there is no conflict of interest.

Received 29 November 2019; accepted 20 December 2020

fracture, tendon rupture, failure of fixation construct, etc. Therefore, surgery may be an applicable treatment method. The surgical treatment of PECK has varied from simple arthroscopic surgical techniques to lyse adhesions to more extensive quadricepsplasty over the past 40 years. The surgeon evaluates the knee range of flexion, age, injury to operation interval, and etiology of the patient to determine the most suitable operation method. Arthroscopic surgery has the advantage of being minimally invasive, relatively simple, and with a low rate of associated complications. However, it is difficult to use in severe PECK. So quadricepsplasty is considered to improve flexion for patients with severely stiff knee.

Few articles have reported on this subject in medical literature within the last decade. Quadricepsplasty is a standard method for PECK, the most common of which are Thompson quadricepsplasty techniques, Judet quadricepsplasty techniques, and their modifications³. It is reported that some patients who have received Thompson quadricepsplasty developed severe knee extension lag⁴⁻⁹. A study showed that most patients achieved an active flexion of more than 100° after Judet quadricepsplasty¹⁰. Moreover, only 11% of patients developed a significant extension lag; significantly less than the 33%–66% of the lag observed with the Thompson procedure^{6, 7}. Therefore, Judet quadricepsplasty is an effective treatment for PECK⁸. Judet quadricepsplasty is a stepwise release of the knee and quadriceps muscle. This technique allows for a graded release without the disruption of the vastus medialis obliquus, vastus lateralis, or rectus femoris¹¹. Each successive step determines whether one continues with the next step of the release depending on the amount of knee motion recovered. However, there is no consensus regarding the ideal treatment strategy. We undertook this research to assess the clinical outcomes, complications, and results obtained with Judet quadricepsplasty technique in 15 cases of PECK.

The purpose of this paper was to: (i) evaluate patients with PECK who received Judet quadricepsplasty; (ii) present the operative techniques, the clinical outcomes, the postoperative rehabilitation program, and complications; and (iii) analyze the factors that contribute to a successful outcome.

Materials and Methods

Inclusion and Exclusion Criteria

The inclusion criteria for this study were as follows: (i) patients were diagnosed with PECK; (ii) patients experienced non-surgical treatment such as physiotherapy or manipulation release after injury for over 12 months, and the ROM of the knee was still less than 60°¹; (iii) patients were treated with Judet quadricepsplasty at our hospital between June 2015 and October 2018; and (iv) patients with a follow-up period of at least 12 months.

Exclusion criteria were as follows: (i) patients were diagnosed with severe osteoarthritis by radiographic examination such as X-ray or computed tomography (CT); (ii) patients were diagnosed with neurological diseases such as hemiplegia; and (iii) patients' quadriceps muscle power was less than IV.

Patient Information

There were 15 patients in this group, including eight males and seven females; 10 patients with left leg and five patients with right leg. Their average age was 48.27 years (range, 35–61 years). There were nine femoral fractures, two patella fractures, one femoral and patella fracture, and five tibial plateau fractures. Twelve patients were treated by an open reduction and internal fixation; two patients were treated by external Ilizarov fixator; one patient was treated by cast immobilization. The mean interval between the initial procedure and quadricepsplasty was 56.2 months (range 13–276 months).

Surgical Technique

Anesthesia and Position

After general anesthesia, the patient was placed in a supine position. The operative field was exposed through the three approaches in the supine position with hypotensive anesthesia reducing the systolic blood pressure to 90–100 mmHg.

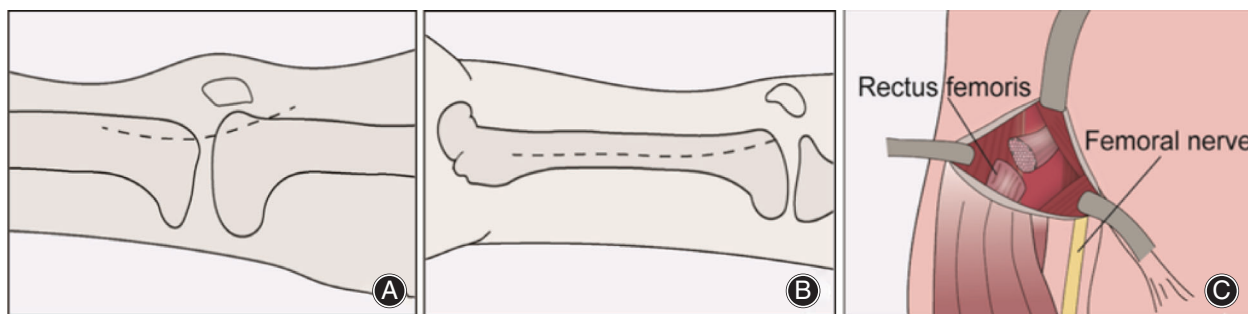


Fig 1 (A) The medial incision used in the Judet quadricepsplasty is shown. (B) The lateral incision used in the Judet quadricepsplasty is shown. (C) The bikini line inguinal incision and rectus femoris release.

Approach and Exposure

The operation is usually performed through two to three incisions (Fig. 1). The first incision is the medial parapatellar incision, the second incision is a lateral cut that extends from the pole of the patella up to 5 cm below the greater trochanter, and the third incision is a small bikini line inguinal incision.

Judet Quadricepsplasty

The surgical technique is performed in five steps^{4,12,13} (Figs 1,2,3). First, through the lateral incision, we can release the lateral knee joint capsule, the lateral retinacular tissues, the vastus lateralis, and the vastus intermedius. Second, through the medial parapatellar incision, we can release the medial retinaculum, the suprapatellar recess, the intraarticular adhesions, and the vastus medialis. If the knee flexion is less than 100° during the operation, it continues. Third, a small bikini incision is made to find the rectus and cut off. Fourth, the lateral incision extends to 5 cm below the greater trochanter. The vastus intermedius is lifted extraperiosteally from the lateral and anterior surfaces of the femur and resected with careful hemostasis, and the lateral femoral fascia is cut from the outside. Fifth, partially releasing and extending fascia lata and thigh anterior fascia. At

this moment, we generally can get at least 100°–110° of flexion. Local injection of “cocktail” (ropivacaine 100 mg and betamethasone sodium phosphate 5 mg) can relieve pain. After strict hemostasis, the surgical incisions are closed with a suction drain inserted.

Postoperative Management

The postoperative stage is crucial. Patient coordination, pain control, and physical therapy are essential components to get an excellent surgical effect. So, we can use analgetic and ice packs to reduce swelling. Tranexamic acid can be used within 24 h after surgery. According to the volume of drainage, the drainage tube is removed 24 to 48 h after surgery. All patients completed a postoperative rehabilitation program. The day after surgery, passive motion of the knee should be started, and continuous passive motion (CPM) can be used in the recovery room. In the hospital, the patients are instructed to build quadriceps by active physiotherapy. After discharge, they continue.

Outcome Evaluation

The Degree Of Knee Flexion. The degree of knee flexion was measured for each patient by a single assessor using a goniometer. Evaluation of the change in knee flexion was

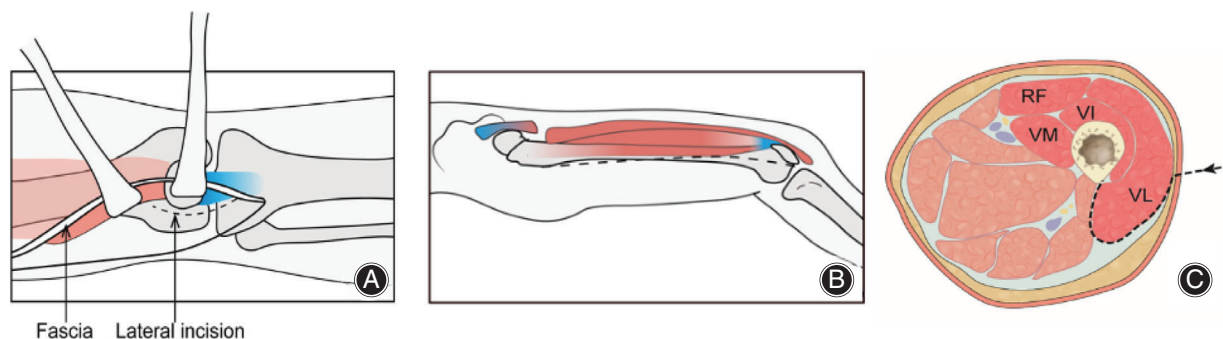


Fig 2 (A) Release the knee adhesions from the lateral side. (B, C) Cross-section of distal 1/3 of femur showing the adhesions and the surgical approach. VL, vastus lateralis; VM, vastus medialis; VI, vastus intermedius; and RF, rectus femoris.



Fig 3 Description of case 4 (see Table 1). Sequelae of patella fracture treated with open reduction and internal fixation (ORIF), with severe lack of knee flexion. Phase 4 of the Judet procedure led to a significant flexion gain.

performed by comparing the preoperative, intraoperative, and the final follow-up outcomes.

Judet's Criteria. The Judet's criteria was adopted to evaluate the patients' clinical outcomes in this study. Excellent was achieved when the final flexion was greater than 100°; good when the flexion was between 80° and 99°; fair when the flexion was between 50° and 79°; poor when the flexion was less than 50°¹⁴.

The Hospital for Special Surgery (HSS) Knee Score. The Hospital for Special Surgery (HSS) Knee Score was also adopted in this study. There was a total of 100 points from pain (30 points), function (22 points), range of motion (18 points), muscle strength (10 points), flexion deformity (10 points), instability (10 points), and subtraction (one cane, 1 point; one crutch, 2 points; two crutches, 3 points; extension lag of 5°, 2 points; extension lag of 10°, 3 points; extension lag of 15°, 5 points; each 5° of varus, 1 point; each 5° of valgus, 1 point)¹⁵. High HSS score was correlated with the degree of function.

Statistical Analysis

Statistical analyses (arithmetic means, standard deviations, and ranges) was performed with a commercial software package SPSS (SPSS for windows, Version 19.0; Chicago, IL). The paired *t*-test was used for comparison at the preoperative, intraoperative, and last follow-up time points for knee flexion. $P < 0.05$ were considered statistically significant.

Results

General Results

The same surgeon performed all these operations. Mean operation time was 1.6 h (range, 1–3 h). The overall mean blood loss was 120 mL (range, 50–300 mL). The mean hospital stay was 7.5 days (range, 5–14 days). The average follow-up was 31.53 months (range, 14–47 months). In seven patients, the rectus (the last three phases described in the procedure) was detached. During the follow-up, all patients recovered their preoperative occupation and exercise.

The Degree Of Knee Flexion

The degree of flexion increased from 23.33° (range, 10°–50°) preoperatively to 107.33° (range, 100°–125°) intraoperatively, followed by a slight fall in the range of flexion in the late postoperative period, which reached an average of 95.33° (range, 60°–115°) in the latest follow-up. Compared with immediate postoperative, the average loss in the flexion of the knee was 12° (11.18%) (range, 0°–40°), with a final flexion achieved of 72° (range, 45°–90°). Compared with preoperative, the immediate postoperative flexion average increased 84° (360.05%) (range, 60°–95°). Specific data is shown in Table 1. The range of flexion of the knee during operation and at the last follow-up was better than that

before operation ($P < 0.001$). The final flexion was significantly lower than that measured at immediate postoperative ($P < 0.001$) (Table 2).

Judet's Criteria

According to the Judet's criteria¹⁴, the outcome was excellent in eight cases (53.33%), good in six (40%) cases, fair in one (6.67%) case, and poor in zero (0.00%) cases at final follow up. The long-term excellent and good rate was 93.33%.

The Hospital for Special Surgery (HSS) Knee Score

The HSS score increased from 80.00 (range, 69–86) preoperatively to 93.73 (range, 89–96) postoperatively. The mean comparison test shows a statistically significant difference between preoperative and postoperative condition ($P < 0.001$). The surgery average increased a 13.73 (17.00%) improvement in HSS score. Fifteen excellent results were obtained according to the HSS knee score postoperatively.

Complications

Skin infection occurred in only one patient, which was treated successfully through wound dressing.

Discussion

Post-traumatic joint stiffness may lead to disability. Some joints, such as the wrist or ankle, can bear significant movement loss and still maintain an acceptable function. However, a stiff knee seriously threatens the functional activities of patients¹⁶. PECK is a serious complication after peri-articular knee fractures. The main factors which limit knee flexion are as follows^{14, 17}: (i) intrinsic adhesions from the deep surface of the patella to the femoral condyles; (ii) capsular contracture, posterolateral arch structure, cruciate ligament extensive contracture; (iii) quadriceps muscle adhesion, shortening, and fibrosis; (iv) skin contracture or scar adhesion around the knee joint, which causes the surrounding muscle contracture. Therefore, completely releasing the adhesions and adding good physiotherapy plays an important role in treating PECK.

Although Judet quadricepsplasty has been used for more than 50 years, it is still an effective method in the treatment of knee stiffness caused by various reasons. It achieves controlled knee ROM by continuously releasing the intrinsic and extrinsic factors that restrict knee flexion, and it also provides an opportunity to stop as soon as adequate flexion is obtained¹², therefore minimizing disturbance to the knee extensor mechanism. We can continuously assess the knee ROM during the surgery. Furthermore, to get a satisfactory ROM, we can also release the adherent extensor mechanism¹⁴. In our cases, we all loosened the ligament and joint capsule (the first and second steps in the procedure). Only in seven cases did we relax the rectus femoris (the last three stages of the procedure), and we achieved the goal that all patients' knee ROM is more than 100°.

The complications of the original Judet quadricepsplasty were around 23%, including deep sepsis,

TABLE 1 Summary of the study cohort data and final results

Case	Gender	Age (years)	Side (R-L)	Etiology	Treatment	Injury to Operation Interval (months)
1	M	41	L	Femoral fracture	ORIF	56
2	M	54	L	Tibial plateau fracture	ORIF	28
3	F	49	L	Femoral and patella fracture	ORIF	78
4	F	53	R	Patella fracture	ORIF	26
5	M	44	L	Femoral fracture	ORIF	18
6	M	66	L	Femoral fracture	ORIF	13
7	F	61	L	Tibial plateau fracture	External fixation	24
8	F	38	L	Femoral fracture	ORIF	96
9	M	48	R	Femoral fracture	ORIF	30
10	M	54	L	Tibial plateau fracture	Cast fixation	48
11	F	39	R	Femoral fracture	ORIF	18
12	F	54	R	Tibial plateau fracture	ORIF	24
13	F	47	L	Tibial plateau fracture	External fixation	84
14	M	52	L	Femoral fracture	ORIF	276
15	M	35	L	Femoral fracture	ORIF	24
average		48.27				56.2

Preoperative Flexion (deg)	Intraoperative Flexion (deg)	Flexion Loss (deg)	Final Flexion (deg)	Flexion Gain (deg)	Follow-up (months)	HSS score (pre/post-operative)	Complication
15	110	5	105	90	47	79/95	
10	100	10	90	80	45	83/93	
30	115	10	105	75	45	71/95	Skin Infection
15	100	40	60	45	43	69/89	
30	110	10	100	70	42	81/94	
45	120	15	105	60	40	83/95	
30	110	0	110	80	38	86/96	
50	110	10	100	50	37	83/94	
30	100	0	100	70	32	81/94	
15	100	20	80	65	20	69/92	
10	105	20	85	75	19	83/93	
30	125	10	115	85	19	81/96	
15	100	10	90	75	16	84/93	
10	105	10	95	85	16	83/94	
15	100	10	90	75	14	84/93	
23.33	107.33	12.00	95.33	72.00	31.53	80.00/93.73	

F, female; HSS, Hospital for Special Surgery; L, left; M, male; ORIF, open reduction and internal fixation; R, right.

TABLE 2 Comparison of knee range of flexion (mean \pm SD)

	Range of flexion		Statistic
Preoperative–Intraoperative	23.33 \pm 12.77	107.33 \pm 7.99	$t = -32.417; P = 0.000$
Preoperative–Last follow-up	23.33 \pm 12.77	95.33 \pm 13.69	$t = -22.045; P = 0.000$
Intraoperative–Last follow-up	107.33 \pm 7.99	95.33 \pm 13.69	$t = 4.842; P = 0.000$

quadricep tendon rupture, skin dehiscence, delayed wound healing, patella fracture, lateral femoral condyle fracture, and extensor lag, etc.^{18, 19}. Fracture is one of the potential complications of quadricepsplasty²⁰. There were no fractures in our cases. Our experience is that we should gradually release adhesions, gradually increase knee ROM, and avoid violent bending the knee during the surgical process. In our cases, there were no complications, such as deep sepsis, skin necrosis, and extensor lag. Only one case of skin infection occurred, and it recovered completely after

dressing treatment. In this study, our experience is that skin sutures should be retained up to 3 to 4 weeks after surgery^{21, 22}. To maintain the knee ROM without losing active extension, we have to ensure appropriate postoperative management^{21, 23}. Early systemic, holistic active and passive exercises are essential for recovery. Exercises with CPM must be performed as soon as possible after operation^{4, 24}. Therefore, we routinely injected “cocktail” (ropivacaine 100 mg and betamethasone sodium phosphate 5 mg) into the local during the operation and used analgesics after the

surgery. Moreover, patients could start exercise and physiotherapy as soon as possible.

Our data indicated that the degree of flexion has a slight fall in the last follow-up compared with intraoperative. The reasons may be as follows: (i) the knee joint is in a relaxed state under anesthesia; (ii) after leaving the hospital, patients cannot exercise properly, effectively, and timely due to fear and pain; (iii) although we give a full release, some patients' knee ROM still has a fall, possibly due to a long time passing after injury, muscle tissue fibrosis, and loss of normal contraction function; (iv) slight adhesion is found at the surgery site again. As for how to reduce the knee ROM loss after surgery, our experience is strict hemostasis, minimizing the damage based on complete release, and paying attention to early functional exercise.

Besides, non-surgical treatment such as physiotherapy or manipulation release was adapted after injury for more than 12 months, and the ROM of the knee was still less than

60°^{1,4}. Although a minimum of 60° flexion is acceptable for walking, it is not enough for daily activities. We want to reach at least 110° for young patients²⁵. Our research shows that the effect of surgery is closely related to patient compliance and positive physiotherapy. Therefore, it is crucial to grasp the surgical indications and make proper patient selection. Patient compliance and enthusiasm are essential for a satisfactory result.

Conclusion

Above all, Judet quadricepsplasty is an effective method to treat PECK and improve knee ROM. It has an advantage of full release and curing knee stiffness for various reasons. It should be performed by experienced orthopaedic surgeons and followed by active and passive exercises with CPM. The knee ROM obtained by the surgery has an excellent long-term effect.

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