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The Judet Quadricepsplasty: Long-Term Outcome of 21 Cases

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Background: The lack of knee flexion represents a possible complication in severe femur fractures. In 1956, Judet proposed a quadricepsplasty technique that allowed for a graded release without the disruption of the vastus medialis obliquus, vastus lateralis, or rectus femoris.

Methods: This article reports the clinical outcome of 21 cases of Judet quadricepsplasty after an average follow-up of 101.0 months (range, 21–204 months). The

definitive flexion gain was classified as excellent, good, fair, or poor. Excellent when >100 degrees, good when >80 <99 degrees, fair when >50 degrees <79 degrees, poor when <50 degrees. The flexion and extension strength were graded from 0 to 5, according to the Daniel's scale.

Results: The average strength score was 4.71 in flexion, 4.81 in extension. The average definitive flexion was 95.67 degrees (range, 54–128 degrees) and the av-

erage definitive flexion gain was 72.43 degrees (range, 40–122 degrees). When the patients were grouped on the basis of the definitive flexion, excellent results were observed in eight cases (38.10%), were good in nine (42.86%), and fair in four (19.05) with zero poor results.

Conclusions: Our experience has shown that, even if first proposed in 1956, the Judet procedure still gives a reproducible amount of good results.

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The lack of knee flexion represents a possible complication in severe femur fractures; the causes of most of such contractures are fibrosis and/or scarring of all or part of the quadriceps.¹

The morbid anatomy of knee stiffness was first described by Nicoll and he divided the pathogenetic mechanisms that determine the lack of distal excursion of the patella during flexion into four entities (1) extrinsic fibrosis of the vastus intermedius, tying down the deep surface of the rectus femoris tendon to the front of the femur suprapatellar pouch and above; (2) intrinsic adhesion from the deep surface of the patella to the femoral condyles and adhesion of tibial to femoral joint surfaces; (3) extrinsic fibrosis and shortening of the lateral expansion of the vasti and their adherence to the lateral aspect of the femoral condyles; and (4) extrinsic shortening of the rectus femoris.²

In 1944, Thompson proposed a quadricepsplasty to treat the extension contracture of the knee. His procedure proposes that both vastus lateralis and medialis be isolated from the rectus femoris and divided close to their patellar insertion; thus, allowing for the identification of the interval between the vastus intermedius and the rectus femoris, releasing the former while leaving the rectus femoris intact.³

However, several authors reported severe residual extension lag in a number of patients when adopting this procedure.^{4–9}

This lag was related to the weakening of the extensor apparatus of the knee.

In 1956, Judet et al. proposed an alternative quadricepsplasty technique. This technique allowed for a graded release without the disruption of the vastus medialis obliquus, vastus lateralis, or rectus femoris.¹⁰ The results of the Judet procedure reported in literature compare favorably with those of the Thompson quadricepsplasty. Judet himself reported¹¹ that most of the patients achieved an active flexion of more than 100 degrees and that there was only 11% of patients with a significant extension lag, significantly less than the 33 to 66% of the lags observed with the Thompson procedure.^{6,7}

This article reports the clinical outcome of 21 patients treated with the Judet quadricepsplasty, who had a minimum 2-year follow-up at 6 monthly intervals.

PATIENTS AND METHODS

A total of 24 patients with severe extension contracture of the knee secondary to extra-articular fracture of the femur, were treated with a Judet quadricepsplasty, in the period 1980 to 2000. All the procedures were performed by two surgeons (AB, JD).

Three patients, all living in different areas, did not adhere to the 6 monthly check-ups, and were therefore, considered as lost at follow-up: consequently, the study cohort includes 21 patients (15 men, 6 women). The average age was 29.57 years (range, 18–42 years). The description of the patient cohort is reported in Table 1.

Operative Technique

The surgical procedure was performed in three phases, as described by Judet^{10–12} and, more recently, by Daoud¹ and Bellmans⁴:

1. Release of the medial and lateral retinacula and release of the adhesions in the suprapatellar gutter and between the

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Table 1 Summary of the Study Cohort Data

| Case | Age | Sex | Side (r-l) | Open Fracture | Multiply Injured Patient | First Treatment | Complications and Sequelae | Second Treatment |
|------|-----|-----|------------|---------------|--------------------------|-------------------|----------------------------|------------------------------------|
| 1 | 18 | m | r | | | ORIF | Plate rupture | Ilizarov frame |
| 2 | 28 | f | r | x | | ORIF | Nonunion | Bone autograft + Ilizarov frame |
| 3 | 30 | m | l | | x | Ilizarov frame | Nonunion | Internal osteosynthesis |
| 4 | 42 | m | r | | | ORIF | Infected nonunion | Surgical cleaning and cast |
| 5 | 30 | m | l | x | | External fixation | Nonunion | Internal osteosynthesis |
| 6 | 42 | m | l | x | | External fixation | Infected nonunion | Bone autograft + Ilizarov frame |
| 7 | 18 | m | l | | | Ilizarov frame | Nonunion | Bone autograft + external fixation |
| 8 | 23 | f | l | x | x | External fixation | Refracture | Bone autograft + Ilizarov frame |
| 9 | 41 | m | r | | | Ilizarov frame | Nonunion | Bone autograft + Ilizarov frame |
| 10 | 23 | f | l | x | | External fixation | Infected nonunion | Bone autograft + Ilizarov frame |
| 11 | 26 | m | l | | x | ORIF | Nonunion | Intramedullary nail |
| 12 | 41 | f | l | x | x | ORIF | | |
| 13 | 42 | f | l | | x | External fixation | | |
| 14 | 34 | m | r | x | | External fixation | | |
| 15 | 23 | m | r | | | External fixation | Nonunion | Ilizarov frame |
| 16 | 31 | m | r | x | | Ilizarov frame | Nonunion | Ilizarov frame |
| 17 | 30 | m | l | | | Ilizarov frame | | |
| 18 | 22 | m | r | | | Ilizarov frame | Refracture | Cast |
| 19 | 27 | m | l | x | | External fixation | | |
| 20 | 29 | f | l | x | x | External fixation | Nonunion | Bone autograft + Ilizarov frame |
| 21 | 21 | m | r | x | | External fixation | Valgus deformity | Osteotomy + Ilizarov frame |

patella and the femoral condyles, through a longitudinal lateral, and/or medial parapatellar incision; moreover, when a scar on the pin tract site was found, also this was released.

2. Release of the vastus intermedius through a long posterolateral incision extending from the superior pole of the patella to the greater trochanter, the vastus lateralis was divided from the linea aspera; thus identifying the vastus intermedius, which was then lifted off the anterior and lateral surfaces of the femur extraperiosteally (Fig. 1A–B);
3. If the flexion was still limited after manipulation subsequent to phases 1 and 2, then a further phase, phase 3, was performed and consisted of the proximal antero-lateral extension of the incision and the detachment of the rectus femoris from its insertion at the anterior inferior iliac spine.

The day after surgical procedure, passive motion of the knee was started using a dedicated passive motion device. Drainages were removed on the third postoperative day. Active assisted exercises were begun as soon as possible, i.e. depending on the patient's general recovery, on average about 1-week postsurgery.

Data Collection and Statistic Analysis

The data were collected prospectively both during hospitalization and at follow-up. The time elapsed from the trauma to the Judet procedure was defined as the preoperative interval.

The range of motion of the affected knee was measured with a manual goniometer, at all the observation times measurements were performed, without any warm-up period, using five grade steps, choosing the lower step in doubtful cases.

The preoperative flexion (F_1) was measured during hospitalization, as were the rate of flexion reached intraopera-

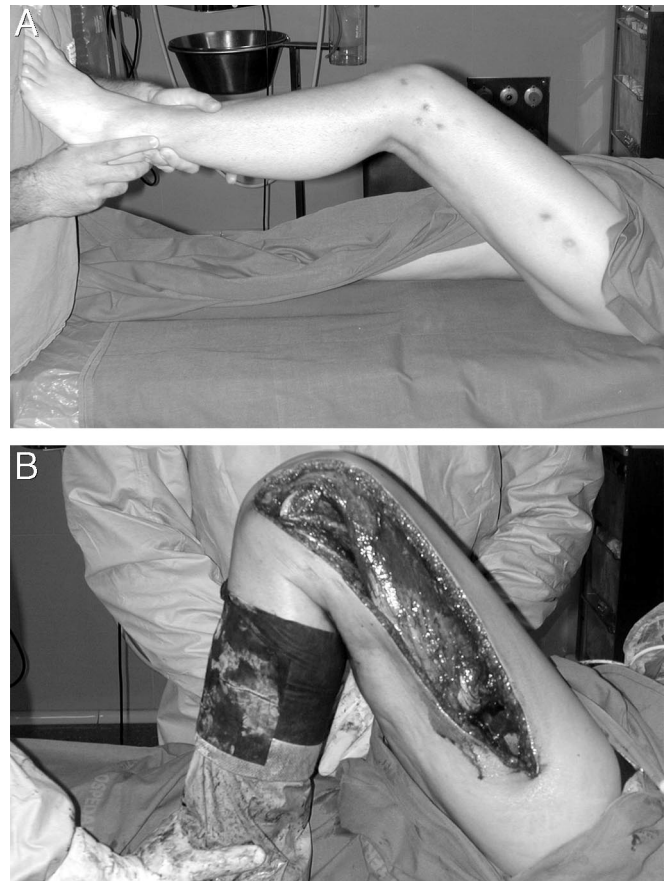


Fig. 1. Description of case 19 (see Table 1–2). (A) Sequelae of diaphyseal femoral fracture treated with external fixation, with severe lack of knee flexion. (B) Phase 2 of the Judet procedure, with detachment of the vastus intermedius, which led to a significant flexion gain.

Table 2 Results of the Clinical Observations

| Case | Preoperative Interval (months) | Follow-up (months) | Preoperative Flexion (F ₁) | Intraoperative Flexion (F ₂) | Postoperative Flexion (F ₃) | Definitive Flexion (F ₄) | Flexion Strength | Extension Strength |
|------|--------------------------------|--------------------|----------------------------------------|------------------------------------------|-----------------------------------------|--------------------------------------|------------------|--------------------|
| 1 | 13 | 204 | 5 | 85 | 85 | 120 | 5 | 5 |
| 2 | 25 | 121 | 30 | 130 | 90 | 130 | 5 | 5 |
| 3 | 27 | 85 | 10 | 110 | 30 | 50 | 5 | 5 |
| 4 | 88 | 91 | 20 | 120 | 45 | 70 | 5 | 5 |
| 5 | 24 | 60 | 40 | 100 | 80 | 75 | 4 | 5 |
| 6 | 77 | 21 | 5 | 90 | 90 | 80 | 5 | 3 |
| 7 | 36 | 125 | 30 | 90 | 80 | 90 | 5 | 5 |
| 8 | 17 | 88 | 15 | 100 | 95 | 130 | 5 | 5 |
| 9 | 17 | 184 | 10 | 80 | 50 | 80 | 5 | 5 |
| 10 | 23 | 145 | 5 | 130 | 70 | 90 | 5 | 5 |
| 11 | 18 | 155 | 30 | 110 | 90 | 90 | 5 | 5 |
| 12 | 38 | 50 | 30 | 100 | 100 | 90 | 5 | 5 |
| 13 | 60 | 98 | 40 | 130 | 90 | 100 | 5 | 5 |
| 14 | 24 | 108 | 20 | 110 | 90 | 125 | 5 | 5 |
| 15 | 48 | 77 | 50 | 100 | 90 | 90 | 4 | 5 |
| 16 | 24 | 125 | 45 | 120 | 90 | 110 | 4 | 4 |
| 17 | 35 | 114 | 10 | 100 | 70 | 90 | 3 | 4 |
| 18 | 53 | 112 | 10 | 110 | 90 | 90 | 5 | 5 |
| 19 | 10 | 48 | 30 | 110 | 60 | 70 | 5 | 5 |
| 20 | 70 | 83 | 30 | 90 | 90 | 120 | 5 | 5 |
| 21 | 18 | 27 | 20 | 120 | 100 | 100 | 5 | 5 |

tively (F₂) and the duration of the surgical procedure; the intraoperative flexion gain (ΔF_2) was calculated as the difference between F₂ and F₁. The postoperative flexion (F₃) was measured, as was the postoperative flexion gain, at 1 month from procedure. (ΔF_3) was calculated as the difference between F₃ and F₁. Both the definitive flexion (F₄) and the definitive flexion gain ($\Delta F_4 = F_4 - F_1$) were measured at the last visit.

The Judet classification was adopted⁸ i.e. classified as excellent when >100 degrees, good when >80 <99 degrees, fair when >50 <79 degrees, poor when <50 degrees. The flexion and extension strengths were graded from 0 to 5 according to the Daniel's scale and the patients were asked to fill in the SF36 form.

Statistic analysis was performed with a commercial software package (SAS ver. 8.1, SAS Institute Inc., Cary, N.C.): the ANOVA test for repeated measures and the Newman-Keuls test were used to check for the presence of any difference among the flexion reached at the varying observation times (F₁, F₂, F₃, F₄); the linear regression was used to study the correlation between the definitive flexion gain ΔF_4 with the length of the follow-up and of the preoperative interval.

The comparison between the SF36 scores in the study cohort and those observed in the general Italian population was performed by the *t* test with summary data. Statistical significance was stated at $p \leq 0.05$ for all the tests performed.

RESULTS

The results of the clinical observation are reported in Table 2. The average preoperative flexion was 23.10 degrees (range, 5–50 degrees). The average preoperative interval was

35.5 months (range, 10–88 months), and the average follow-up was 101.0 months (range, 21–204 months). The average rehabilitation period after the procedure was 14.5 weeks (range, 7–38 weeks). The vastus lateralis was not detached from the linea aspera in 9 out of 21 surgical procedures and only in three cases was it necessary to detach the rectus (the third phase described in the procedure).

Five complications arose related to the Judet procedure (23.8%), they were deep sepsis (2 cases), intraoperative rupture of the quadriceps tendon (1 case), skin necrosis (1 case), and fracture of the lateral femoral condyle (1 case). The average score was 4.71 in flexion, 4.81 in extension.

The average definitive flexion was 94.76 degrees (range, 50–130 degrees) and the average definitive flexion gain was 72.14 degrees (range, 35–115 degrees); when the patients were grouped on the basis of the definitive flexion, according to Judet,⁹ the results were excellent in 8 cases (38.10%), good in 9 cases (42.86%), fair in 4 cases (19.05), and poor in 0 cases (Fig. 2).

The preoperative flexion was significantly lower than that measured at all the other observations ($p < 0.001$); the postoperative flexion was significantly lower when compared with both the intra-operative and definitive flexion ($p < 0.005$).

The definitive flexion gain did not correlate with either patient age or sex ($p > 0.05$) or with the preoperative interval ($p = 0.255$), whereas it was reversibly correlated with the preoperative flexion ($r = -0.505$; $p = 0.019$) and directly correlated with the length of the follow-up ($r = 0.394$; $p = 0.05$).

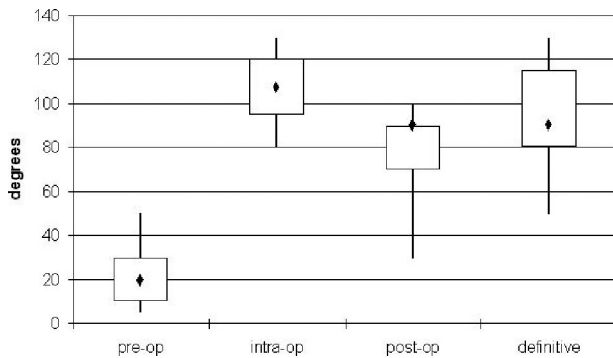


Fig. 2. Tukey box-whiskers plot of the knee flexion in the study cohort at the set observation times: each mark represents, from the bottom upward, the 1st, 25th, 50th, 75th, and 100th percentiles. The whiskers of the plot represent the bottom and the top fourths of the data, and the box represents the middle 50%. The 50th percentile (median) is indicated inside the box.

There was a 23.8% decrease in the “physical activity” score ($p < 0.001$) and a 23.9% decrease in the “role and physical health” score ($p = 0.018$) on the SF 36 form, compared with the general population, whereas no significant difference was observed in the other scores.

DISCUSSION

The study cohort included patients with a minimum of a 2 year follow-up, as, according to Judet, after 2 years the function regained should be almost the definitive one.^{12,13} As to the patients lost at the follow-up, their clinical result at the last check was almost comparable to that of the study cohort, and therefore it is probable that they had a similar long-term outcome.

As the functional limitation of patients with an associated diagnosis of articular fracture involving the knee could also be determined by osteoarthritic changes, they were excluded.

Therefore, 80.96% of the patients we examined had a definite flexion of more than 80° and were classified either as excellent, 38.10% or good, 42.86%, according to the Judet scale: the average definitive flexion gain was 72.14 degrees.

Despite the high amount of positive results, the complication rate was high (23.8%), and deep infection occurred in two cases; this complication might be related both to the early start of the postoperative rehabilitation and the presence of a possibly infected pin site, along the surgical wound.

Eighteen patients in the study cohort had at least one treatment with a monolateral or circular external fixator; in these cases the pin site tethering may strongly contribute to joint stiffness.

There are few reports in literature as to the long-term outcome of such quadricepsplasty. The largest one remains Judet’s own, who reported 45.28% of excellent and 39.62% of good results in 55 quadricepsplasties, in 1959¹¹: these results are very close to our findings.

Merchan reports 66.6% of good or excellent results on 21 cases at an average follow-up of 5.7 years.¹⁴ The difference between Merchan’s results and ours may be explained by the different selection criteria used: i.e. although we excluded any patients with an articular fracture, at least 7 of the 21 patients reported by Merchan had articular fractures involving the knee.

Bellmans⁴ reported the results of 16 cases of quadricepsplasty at an average follow-up of 22 months. He found an average flexion gain of 68 degrees with a maximal flexion of 90 degrees or more in 69% of the cases.⁴ At first glance these results seem worse than both those of Judet and ours; however, there was a significant correlation between the length of the follow-up and the amount of flexion, which may not only explain this difference but also confirm the advantages of a prolonged rehabilitation period after the surgical procedure.

Similar results were recently published by Ali¹⁵ on 10 cases of quadricepsplasty performed after the treatment of femoral fractures with external fixation, with an improvement in the knee flexion from an average of 33 degrees preoperatively to an average of 88 degrees at an average follow-up of 24 months.

Noteworthy was the fact that the definitive flexion gain we measured was significantly greater in those patients who had the worse preoperative flexion and was not affected by the preoperative interval. This would, therefore, imply that the strongest indication for this surgical procedure is patients with a severe lack of flexion and that the time lapse from trauma to surgery is not significant.

Even though proposed in 1956, the Judet procedure seems to give a reproducible amount of good results today and still holds its leading role in the treatment of extra-articular knee stiffness.

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