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Clinical observation of C3-type patellar fractures treated by operation methods with or without a turned-over patella

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ABSTRACT

Objective: To evaluate the clinical efficacy of operation methods with or without a turned-over patella for treatment of C3-type patellar fractures.
Methods: A total of 68 patients with C3-type patellar fractures undergoing open reduction and internal fixation were retrospectively selected and treated with a turned-over patella surgery (turned-over patella group, n = 30) or conventional therapy without turning over the patella (conventional group, n = 38). The intraoperative and postoperative indicators of the two groups were assessed and comparatively analyzed.
Results: The bedridden time was significantly shorter in the turned-over patella group than in the conventional group (P = 0.002), while the range of motion (ROM) of knee joint was significantly higher in the turned-over patella group (P = 0.044). The Lysholm score was slightly higher in the turned-over patella group than in the conventional group, but the difference was not statistically significant (P = 0.055). No significant difference was observed between the two groups in terms of the operation time (P = 0.096), intraoperative blood loss (P = 0.543), time of weight bearing (P = 0.312), fracture healing time (P = 0.272), or complications (P = 1).
Conclusion: The turned-over patella operation method exhibited some superiority to conventional reduction-fixation approach for treatment of C3-type patellar fractures in terms of efficacy and safety by enlarging the ROM of the knee joint and promoting functional recovery.

Introduction

Patellar fractures are intra-articular fractures [1,2]. The incidence in adults is about 1%, accounting for about 10% of all fractures [2]. The patella is the largest sesamoid in the human body and is located in the quadriceps tendon in front of the knee joint, where it provides increased mechanical advantage for knee extension [3]. When the knee joint is stretched, the patella can increase the strength arm of the quadriceps by about 30%. The articular surface of the patella is the thickest in the human body with measurements to about 5.5 mm [4]. The main roles of the patellar articular surface are to conduct and enhance the quadriceps muscle, help maintain the stability of the knee joint, and protect the knee joint.

The treatment of patellar fractures before the 20th century was controversial and often involved in non-surgical treatment [5–7]. However, the increase in aseptic technique during surgery has now made surgery the first choice for patellar fractures. The current view is that the ultimate goals of treatment of patellar fractures are to restore the extensor function, reduce the loss of bone mass, ensure the integrity of the joint, and allow early functional exercise of the affected limb [8].

C3 type patellar fractures not only damage the structure of the knee extension device, but are also characterized by the presence of multiple fracture fragments on the articular surface [9–12]. Moreover, some articular surface bones may also collapse or fall off into the joint cavity, and these can readily cause traumatic iliofemoral arthritis if the fracture block is not well restored. Furthermore, if the fixation is unreliable, the displacement of the fracture can result in knee pain and traumatic arthritis during activity and bracing of the limbs for a period of time would be prone to cause knee joint adhesion and activity restriction, thereby affecting knee function.

The traditional surgical method for C3 fractures is to reveal a reduction fracture in front of the patella. However, this cannot fully reveal the displacement of the comminuted fracture on the articular surface and the reduction and fixation of the fracture, making ideal reduction and reliable fixation of some fracture blocks difficult to achieve [13]. Some scholars have reported that the patellar articular surface can be fully exposed by cutting the patellar ligament to turn

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over the patella, and this is beneficial for the reduction of a severe fracture of the patella on the articular surface [5,14]. However, cutting the patellar ligament creates a risk of poor healing or reduced strength of patellar ligament, and leaves a defect that prevents patients from immediately exercising after the surgery.

In our previous surgeries, we used the longitudinal incision valgus patella method for knee arthroplasty, which fully exposes the articular surface and can also be performed to treat severely comminuted fractures of the patella. The present study is a retrospective review of the clinical data of patients treated for C3-type patellar fractures at our hospital, and a comparison of the differences in the therapeutic effects between reduction with the turned-over patella method and reduction with the conventional prepatellar exposure method. The aim was to provide guidance for the selection of surgical methods in treating patients with C3-type patellar fractures.

Materials and methods

General information

This retrospective study was approved by the ethics committee of the Wuxi Ninth People's Hospital Affiliated with Suzhou University. Written informed consent was obtained from each patient. A total of 68 patients with C3-type patellar fractures underwent open reduction and internal fixation from January 2012 to December 2017 in our hospital according to the International Association of Internal Fixation (AO/ASIF). The 68 enrolled patients were divided into 2 groups according to the different surgical methods: a group that underwent reduction with a turned-over patella (turned-over patella group, n = 30) and a group that underwent reduction with conventional reduction-fixation (conventional group, n = 38). These patients included 40 males and 28 females (aged 35–53 years). They were followed up for 12–30 months, with an average of 18 months. The patients' general information is listed in Table 1.

Inclusion criteria were the following: patients treated with open reduction; patients with C3-type patellar fractures; patients with complete follow-up data; and patients without other diseases that could affect the results of our study.

Exclusion criteria were the following: patients with a non-articular surface comminuted fracture; patients younger than 14 or older than 75 years; patients with old fractures; patients with incorporated adjacent fractures; and patients who did not comply with treatment.

Surgical methods

The patient was placed in a supine position after anesthesia at the waist, and a tourniquet was used to stop bleeding at the same time. A 7–9 cm longitudinal incision was made in the anterior region of the knee joint.

Turned-over patella group

The aponeurosis on the surface of patella was separated to expose the patella, followed by a longitudinal cutting of the expansion and joint capsule from the medial parapatellar region. The patella was then turned over to reveal the articular surface. The joint cavity was rinsed, and broken ends of fractured bone, intraarticular blood clots, and free broken bone pieces were removed, as well as any small free-falling articular surfaces. Under direct vision, a patchwork method was used to gradually reduce the articular surface fractures, restoring the smoothness and integrity of the joint surface to the greatest extent. Upon achieving a good reduction, the fractures of articular surface were fixed using Kirschner wires or screws, where the smaller bone block was fixed with a 0.8–1.5 mm Kirschner wire, and the larger one was fixed with a 2.0 mm Kirschner wire or screw. One Kirschner wire can fix two or more fracture fragments. Upon completion of the articular surface fracture, the patella was reversed and fixed with either a 1 mm steel wire in front of the patella or combined with a "8" steel wire on the surface of patella. The knee joint was flexed to check the firmness of the fracture block fixation. The incision was fully drained, and the expansion and joint capsule were sutured.

Conventional group

The aponeurosis on the surface of patella was separated to expose the patella, and only a partial articular surface at the fracture gap could be seen directly. The articular surface was assumed to be in good alignment according to the good alignment between the patella surface and the surrounding tissues. Alternatively, the smoothness of the patella articular surface was checked by touching it with a finger from a wound or an incision made in both sides of the patella extension. If the surgeon believed that the fracture was well restored, the fracture was then fixed with a Kirschner wire or screw and a ring-fastening steel wire or tension-band. Once the fracture block was firmly fixed, the torn expansion and joint capsule were sutured.

Postoperative treatment

After the surgery, the patient's knee extension was maintained for 4–6 weeks, and isometric exercise of the quadriceps femoris was then under taken for one week. Upon removal of the plaster cast, the knee joint was gradually flexed and the lower limb activities were gradually increased.

Observation indicators

Short-term indicators included the patient's operative time, intraoperative blood loss, bedridden time, and time of weight bearing. Time of weight bearing was an indirect indicator of short-term recovery of knee joint function, such as recovery of early quadriceps function.

Long-term indicators included fracture healing time and complications. At the final follow-up, the range of motion (ROM) of the knee joint was recorded, and the recovery of knee joint function was assessed by Lysholm's scoring criteria [15].

Table 1
General information for the patients in two groups.

	Patella turned over group	Conventional group	t/χ^2	*P* value
Cases (n)	30	38		
Gender (male/female)	17/13	23/15	−0.018	0.979
Age	35.86 ± 14.66	38.77 ± 14.29	−0.435	0.665
Injured leg (left/right)	16/14	19/19	−0.325	0.745
Time from injury to operation (days)	6.52 ± 1.87	6.61 ± 1.59	−0.341	0.734

Statistical analysis

SPSS 16.0 statistical software was used for analysis. The measurement data were shown as mean ± SD, and the difference between the groups was analyzed with an independent samples *t*-test. The enumeration data were shown as n, analyzed with the Chi-square (χ^2) test. Value of $P \leq 0.05$ was taken as statistically significant.

Results

Comparison of the patients' general information between groups

As shown in Table 1, no significant differences were noted between the turned-over patella group and conventional group in terms of the patients' basic information, including age, gender, injury location, and time from injury to operation ($P > 0.05$).

Comparison of short-term indicators between the two groups

The bedridden time was significantly shorter in the turned-over patella group than in the conventional group ($P = 0.002$). However, no significant differences were found in the operation time ($P = 0.096$), intraoperative blood loss ($P = 0.543$), or time of weight bearing ($P = 0.312$) between the two groups ($P > 0.05$) (Fig. 1).

The incisions in both groups were healed by first intention without infection, hematoma, or skin necrosis. Early rehabilitation exercises were performed after surgery, and the patients were encouraged to perform isometric contraction and gradual flexion of the knee joint. Based on the stability and healing condition of the fracture, the patients began to do exercises out of the bed, undertook gradual weight-bearing, and then progressed to complete weight-bearing after fracture healing.

Comparison of long-term indicators between two groups

The range of motion (ROM) was significantly higher for the turned-over patella group than for the conventional group ($P = 0.044$). Although the difference was not statistically significant ($P = 0.055$), the Lysholm score was slightly higher in the turned-over patella group than in the conventional group. No obvious difference was evident between the two groups in terms of fracture healing time ($P = 0.272$) (Fig. 2).

Complications included 3 and 6 cases of screw path loosening or steel wire breakage in the turned-over patella group and the conventional group, respectively. All these cases occurred after fracture healing and were not accompanied by infection, deep venous thrombosis, failure of internal fixation, or other adverse complications. Therefore, no significant difference was noted in the incidence of complications between the two groups ($P = 1$) (Fig. 2). Typical cases from the turned-over patella group and the conventional group are shown in Figs. 3 and 4, respectively.

Discussion

The patella is an important knee extension device. It's surface is arc-shaped and relatively flat; however, its articular surface at the bottom is not flat [16–18]. The patellar articular surface

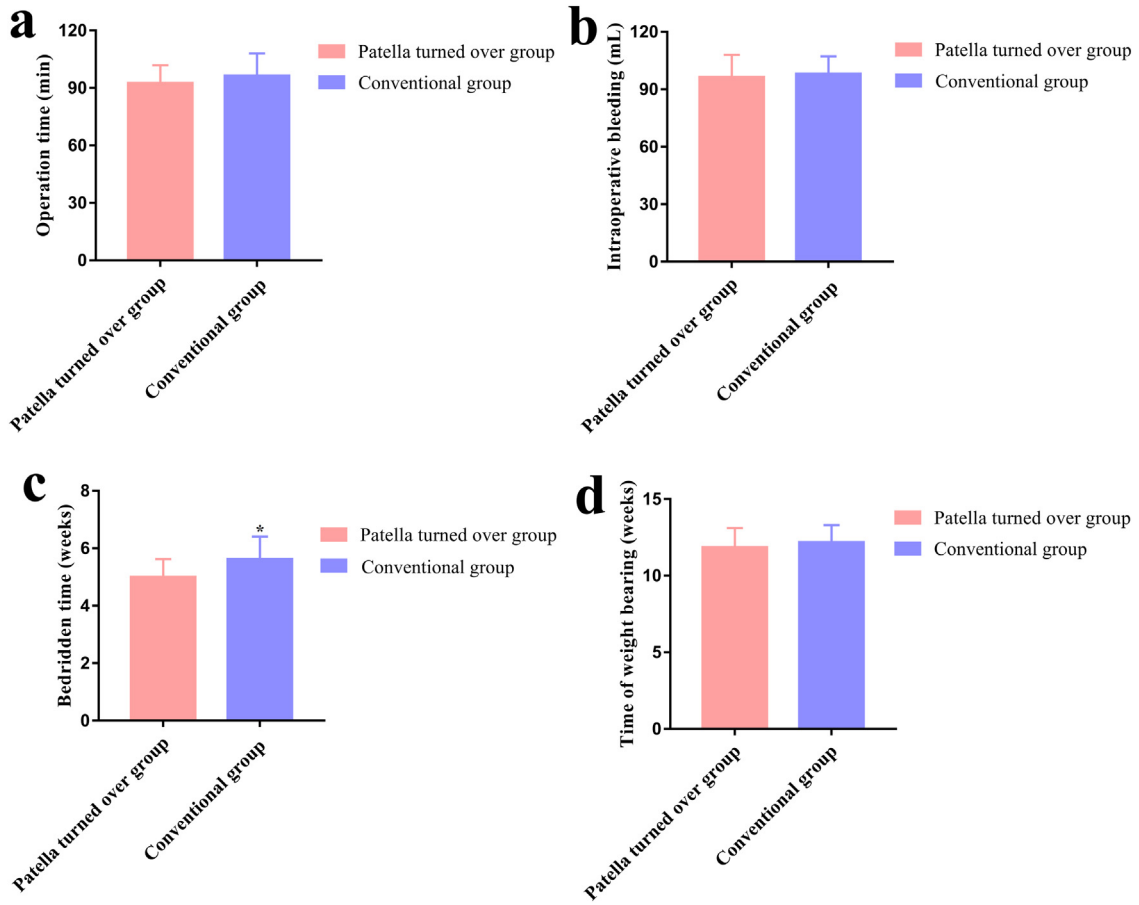

Fig. 1. Comparison of short-term postoperative indicators between two groups.
a. Operation time (min). b. Intraoperative bleeding (mL). c. Bedridden time (weeks). d. Time of weight bearing (weeks).

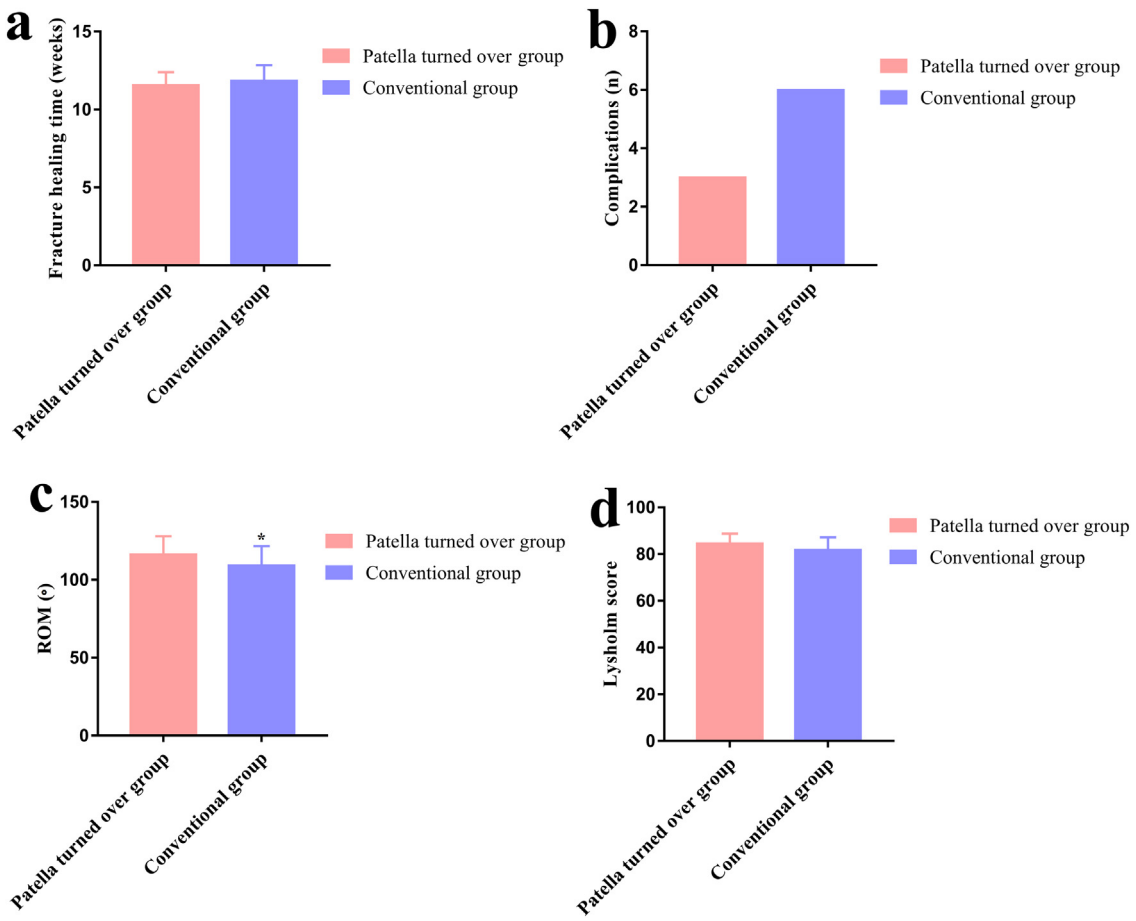

Fig. 2. Comparison of long-term postoperative indicators between two groups.
a. Fracture healing time (weeks). b. Complications (n). c. ROM (°). d. Lysholm score.

corresponds to the internal and external slopes of the femoral intercondylar notch. Knee joints are key weight-bearing joints and are therefore important in the daily life and work of patients [19]. Consequently, pain and adhesions will affect the functional recovery of affected limbs. Patellar fractures can easily cause knee joint pain and muscle motor dysfunction, thereby seriously affecting the work and life of patients [20].

The type of patellar fracture is related to its injury mechanism. The different types of patellar fractures can be treated with different internal fixation methods, and combined surgical approaches are often applied in clinical practice. The ideal surgical treatment for C3-type patellar fractures is anatomical reduction and reliable fixation, which can benefit patients by allowing early rehabilitation exercise, thereby reducing the incidence of complications, such as joint adhesions and traumatic arthritis [21,22].

The use of reduction with the conventional prepatellar exposure method allows only part of the articular surface at the fracture gap to be seen directly. The articular surface is then assumed to be in good alignment according to the good alignment between the patella surface and the surrounding tissues or the smoothness of the patella articular surface can be checked by touching it with a finger from a wound or an incision made on both sides of the patella extension [5,23,24]. This method has a good reduction and fixation effect for simpler type-C fractures. However, for the complex intra-articular fractures with multiple fracture fragments, such as articular surface collapsing fractures or smaller intra-articular fracture fragments achieving anatomic reduction and fixing all the fracture blocks is difficult because of poor visualization, and the postoperative functional recovery is adversely affected [9,25]. As reported in some studies, the excellent cure rate for severe patellar comminuted fractures is about 70–80% [6,26–28], indicating the occurrence of complications, such as traumatic arthritis, joint adhesions, and pain, caused by unstable fixation in some of patients with severe comminuted fractures [22,29].

The reduction method with the turned-over patella fully reveals the entire patellar articular surface, which facilitates the anatomical reduction of severely comminuted patellar fractures of the articular surface under direct vision. The lateral parapatellar arthrotomy described by Gardner et al. [13] is adopted and the patella is internally rotated 90°, which allows easy visualization of the patella joint surface. In the present study, we used the midvastus approach to allowing exposure of the articular surface. Both the lateral and internal arthrotomies are able to direct expose the articular surface for subsequent reduction and stabilization of patella fractures. However, the outward rotation of the patella is easier than internal rotation; therefore, the midvastus approach is conventionally used in total knee arthroplasty [30]. The reduction method with the turned-over patella also facilitates the fixation of multiple fractures using multiple Kirschner wires or screws. Moreover, one Kirschner wire can also fix multiple adjacent bone blocks to restore the smoothness of the patellar articular cartilage

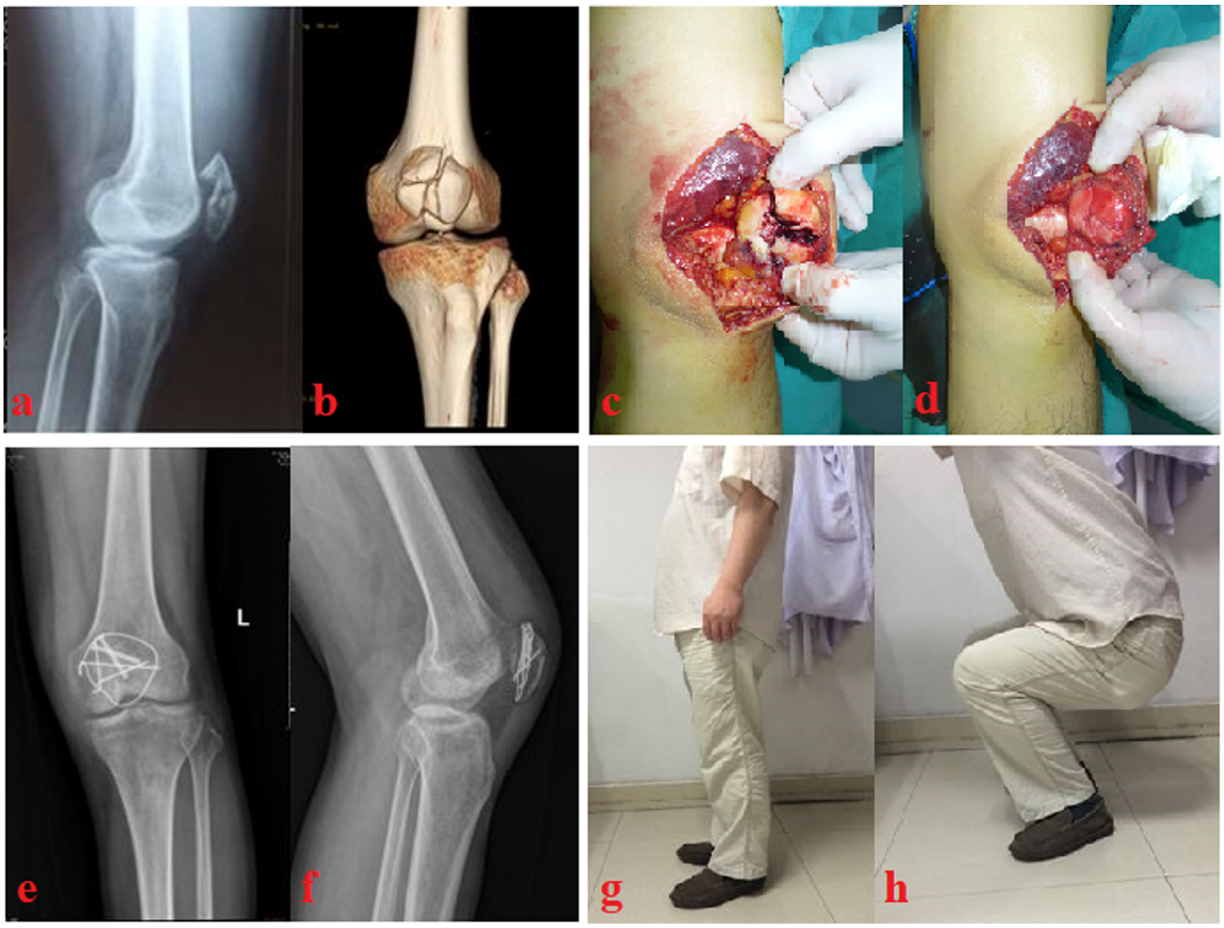

Fig. 3. A 50-year-old male patient received reduction with patella turned over.
a, b. C3-type patellar fracture revealed by the preoperative X-ray and computed tomography (CT) films; c. A longitudinal incision was made and the patella was turned over to expose the articular surface fracture; d. The smooth articular surface after reduction and internal fixation; e, f. Postoperative 3-month X-ray film of healed fracture; g, h. Postoperative 12-month functional appearance.

and the integrity of patella. Even if a small number of small bone blocks in the middle are not treated with direct internal fixation, the patella can be tied around with a thick wire to tighten and close the smashed patella being, effectively fixing all the bone fragments [24,29,31]. In addition, any free and small bone fragments and articular surfaces can be removed, rather than being left in the joint cavity, thereby avoiding traumatic arthritis. Because the patellar ligament is not cut, and the expansion section is only longitudinally incised and sutured, a knee extension device structure repaired and fixed by this method can achieve a fixed effect similar to that of a patellar transverse fracture fixed with a Kirschner wire tension band, which can undergo axial traction and knee flexion. A Kirschner wire combined with steel wire fixation had been verified as a simple and effective fixation method for patellar fractures by mechanical experiments and clinical practice and enables early postoperative knee joint flexing [29,32].

Our results indicated that the bedridden time was significantly shorter for the turned-over patella group than for the conventional group (Fig. 1). We believe that the patients in the turned-over patella group received anatomic reduction and reliable fixation, and that these patients could flex their knee joints immediately after the operation and start their rehabilitation exercises 4–5 weeks after the operation, without causing a displacement of fracture fragments. However, reliable fixation in the conventional group was not guaranteed; therefore, these patients were recommended to walk with crutches for about 6 weeks after surgery. In the turned-over patella group, flexion of the knee joint began earlier, so the ROM of knee joint was better than in the conventional group (Fig. 2). Although the difference in functional recovery of the knee joint between the turned-over patella group and conventional group was not statistically significant, a tendency was evident for the turned-over patella group to score better than the conventional group (Fig. 2).

In conclusion, no significant difference was evident between the turned-over patella group and the conventional group with respect to surgical trauma, fracture healing time, complications, and functional recovery. A reduction using the turned-over patella method can fully reveal the entire patellar articular surface, thereby facilitating the anatomical reduction and effective fixation of all fracture fragments, and ensuring postoperative recovery by early rehabilitation exercises. Moreover, the range of knee joint activity was better in the turned-over patella group than in the conventional group, and over the turned-over patella group showed a tendency to have a better functional recovery than was observed in the conventional group. Therefore, the turned-over patella approach is an effective and safe method to treat C3-type patellar fractures and provides a basis for selecting the surgical approach for C3-type patellar fractures.

Fig. 4. A 35-year-old male patient received reduction with conventional prepatellar exposure.
a, b. C3-type right patellar fracture revealed by the preoperative X-ray and computed tomography (CT) films; c, d. Postoperative 3-month X-ray film of healed fracture; e, f. Postoperative 12-month functional appearance showing the limited range of motion (ROM) of the knee joint.

Conflict of interest

The authors have no actual or potential conflicts of interest to declare.

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None.

Ethical approval

The study was approved by ethics committee of Wuxi the Ninth People's Hospital Affiliated to Suzhou University.

Consent for publication

The study was undertaken with the patient's consent.

Availability of data and material

Not applicable.

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