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Outcome of osteosynthesis for periprosthetic fractures after total knee arthroplasty: a retrospective study

Hasmukh Nagwadia[1] · **Prateek Joshi**[2]

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Abstract

Introduction Incidence of periprosthetic fractures around knee is going to rise in near future due to dramatic increase in total knee arthroplasty (TKA). Our study is a retrospective case series describing the outcome of osteosynthesis for periprosthetic fractures after TKA.

Materials and methods We analyzed the outcome of osteosynthesis for periprosthetic fractures with stable implants in 43 patients having 45 fractures operated between 2010 and 2015.

Results Out of 43 patients, the majority were female (M-15, F-28) with mean age of 65.95 years, majority had left knee involved (L-24, R-19), with fractures involving femur, tibia and patella, respectively, in 29, 11 and 5 patients. Fracture pattern was Rorabeck type 2 in 29, Felix type 2 in 6, type 3 in 5, Goldberg type 2 in 3, type 3a in 2, Unified classification system type A in 2, B1 in 35, C in 4, E in 2 cases. Anterior femoral cortex notching was found in 13 patients with femoral fractures. According to Tayside classification, 12 patients had type 1 and one had type 2 notching. Different implants were used according to the need of the fractures. After TKA, the mean Hospital for Special Surgery score was 84.2, which reduced to mean 76 at 9 months following osteosynthesis. Three patients had nonunion, one had delayed union and one had implant failure.

Conclusions Osteosynthesis for periprosthetic fractures around knee with locked compression plate gives promising results. Fractures involving patella are associated with inferior functional outcome. Understanding the fracture pattern and bone stock available for fixation with correct choice of implant and correct surgical technique gives promising outcome in periprosthetic fractures around knee.

Keywords Periprosthetic fractures around knee · Total knee arthroplasty · Osteosynthesis · Hospital for Special Surgery score

Introduction

Improvement in human life expectancy has resulted in substantial increases in the incidence of total knee arthroplasty (TKA) and thus the likelihood of postoperative complications. The risk of periprosthetic fracture following TKA is particularly high because most of the TKA patients are advanced in age and have osteopenia [1, 2]. Periprosthetic fractures can occur in the femur, tibia or patella, affecting the areas within 15 cm from the joint surface or within 5 cm from the intramedullary stem [1–3]. The femur is the most frequent fracture site followed by the tibia and patella. Compared to other fractures, periprosthetic fractures are more challenging to the surgeon in terms of fracture treatment and patient recovery. Poor bone stock, preexisting implant and bone cement may impede fracture reduction and fixation, predisposing to nonunion or malunion [1, 4, 5]. Accurate diagnosis and appropriate intervention are of utmost importance in the treatment of periprosthetic fractures. The purpose of this study is to analyze functional and radiological outcomes after osteosynthesis for periprosthetic fractures around knee.

✉ Prateek Joshi
prateekortho@yahoo.com

Hasmukh Nagwadia
drnagwadia@gmail.com

1 Department of Orthopaedics, Shalby Hospital, Opp. Karnavati Club S G Road, Ahmedabad, Gujarat 380015, India

2 Department of Orthopaedics, Atharva Orthopaedic Superspeciality Hospital, New Vadaj, Ahmedabad, Gujarat 380013, India

Materials and methods

Inclusion criteria

In our retrospective case series, we included 43 patients having 45 periprosthetic fractures around knee. All patients were operated between 2010 and 2015 by single senior trauma surgeon and team at a tertiary care center in western India. Only fractures with stable implants were included in our study as the aim was to analyze the outcome of osteosynthesis for periprosthetic fractures around knee.

Exclusion criteria

All fractures treated conservatively or with revision arthroplasty for unstable implants (Rorabeck type 3 femur fractures and Felix type 1 tibial fractures) were excluded from our study.

Detailed history and physical examination were conducted on first contact with the patient after sustaining injury. Predisposing factors such as female gender, osteopenia, inflammatory arthritis, increasing age, use of corticosteroids, presence of notching, manipulation for TKA, major trauma and bone osteolysis were assessed. After TKA, Hospital for Special Surgery (HSS) scores were available with us.

Radiographs in anteroposterior and lateral views were taken in all patients, and all fractures were classified based on Rorabeck classification for femur, Felix classification for tibia, Goldberg classification for patella and newly introduced unified classification system. Apart from classifying fractures, other factors were also studied in radiographs such as osteopenia, amount of bone stock available for osteosynthesis and notching of anterior femoral cortex by femoral implant in lateral view taken before fracture took place (Table 1).

After detailed preoperative work-up, written informed consent was obtained from all patients. Preoperative planning was performed with templating, following which osteosynthesis for fracture was done by single experienced trauma surgeon and his team at tertiary care center in western India dedicated to joint replacement and related surgeries. All surgeries were performed in class-100 modular operation theater with special precautions to prevent infection. Arthroplasty surgeon was on standby during all trauma surgeries. Type of implant was chosen considering fracture pattern and bone stock available for fixation. For all Lewis and Rorabeck type 2 femur fractures, anatomical locked compression plate (LCP) was the implant of choice since this implant being angle stable in nature gives robust strength of fixation, especially when distal fragment bone stock is inadequate due to the prosthesis and osteoporosis. We preferred other options of implants such as dynamic

Table 1 Classification of periprosthetic fractures around knee after TKA

Lewis and Rorabeck classification of periprosthetic femur fracture	
Type I	Non-displaced fracture with intact components
Type II	Displaced fracture with intact components
Type III	Displaced fracture with loose/failing components
Felix and associates' classification of periprosthetic tibial fractures	
Type I	Fracture of tibial plateau
Type II	Fracture adjacent to tibial stem
Type III	Fracture of tibia shaft distal to component
Type IV	Fracture of tibial tubercle
Goldberg classification of periprosthetic patella fractures	
Type I	Fracture involving implant/cement interface and/or quadriceps mechanism
Type II	Fracture involving implant/cement interface and/or quadriceps mechanism
Type III A	Inferior pole fracture with patellar ligament rupture
Type III B	Inferior pole fracture without patellar ligament rupture
Type IV	All fractures with dislocations
Unified classification system for periprosthetic fractures around knee after TKA	
Type A	*A*pophyseal fractures
Type B	Fractures involving *B*ed of the implant component
Type C	Fractures that are *C*lear of implant component
Type D	Fractures *D*ividing one bone which supports two joint replacements
Type E	Fractures involving *E*ach of two bones supporting one joint replacement
Type F	Fractures *F*acing or articulating with an implant

compression plate (DCP) and dynamic compression screw (DCS) only in patients with financial constraint but with relatively good bone stock. DCS, although being angle stable implant, uses lot of bone stock in distal fragment, whereas DCP, being non-angle stable implant, is more likely to fail in osteoporotic bone. For Felix type 2 tibial fractures, again just like Rorabeck type 2 femur fractures, there is limited bone stock available for fixation. Hence, anatomical LCP is the implant of choice for it is an angle stable implant. However for Felix type 3 fractures which are distal to the tip of implants, non-locking implants can be used should financial constraint compel, provided the bone is not too osteoporotic. Tension band wiring (TBW) with or without encirclage is the fixation method of choice for all patella fracture as it is biomechanically strongest construct in fractures with limited bone stock usually encountered when a resurfaced patella fractures. TBW was performed in transverse fracture with loss of extensor mechanism, whereas encirclage wiring was performed in comminuted displaced fractures. Patella tendon encirclage was added in fractures with patella tendon injuries.

Standard principles of fixation were followed in all cases. Third-generation cephalosporin and aminoglycosides were routinely used to prevent infection. Postoperative physiotherapy was administered on merit of each case.

Functional assessment was carried out with HSS score, and radiological assessment with regard to union of fracture was carried out at 6, 12, 24, 34 weeks, 12, 18, 24 months (minimum follow-up duration of 9 months with range from 9 months to 2 years). Complications if took place were noted and addressed accordingly.

Results

Our retrospective case series included total 43 patients with 45 periprosthetic fractures around knee. Age distribution was between 55 and 79 years, and mean age was 65.95 years. Out of 43, 28 were female and 15 were male patients. Right knee was involved in 19 and 24 had left knee involved. Femur was fractured in 29 instances, whereas tibia and patella were fractured in 11 and 5 instances, respectively (Fig. 1). As per Rorabeck classification, all 29 femur fractures belonged to type 2 and as per Felix classification; for tibia 5 belonged to type 3 and 6 belonged to type 2. As per Goldberg classification, 3 belonged to type 2 and 2 belonged to type 3a. As per unified classification system, 35 fractures belonged to type B1, whereas types A, C, E had 2, 4, 2 fractures, respectively (Fig. 2). Pre-injury lateral view radiographs of all patients who sustained periprosthetic femur fracture were reviewed to document anterior femoral cortex notching by the femoral implant. We found notching in 13 patients. According to Tayside classification, 12 patients had type 1 notching and one had type 2 notching. For femur fracture in 27 cases, distal femur anatomical locked compression plate (LCP) was used, whereas dynamic condylar screw and dynamic compression plate (DCP) were used in one each cases. For tibial fractures, LCP was used in 7 cases, and low-contact DCP and Hockey LCP were used in one case each. DCP was used in 2 cases. For patella fracture, tension band wiring was performed in 3 cases, whereas encirclage wiring and patella tendon encirclage wiring was performed in one case each (Fig. 3). With regard to HSS score, post-TKA 21 patients each belonged to excellent and good category and

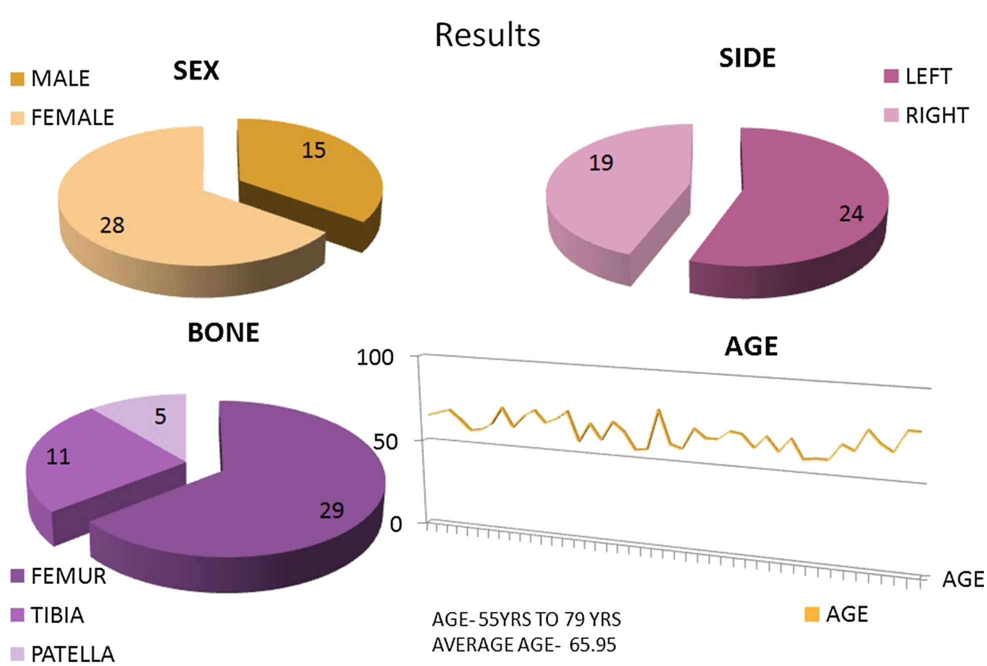
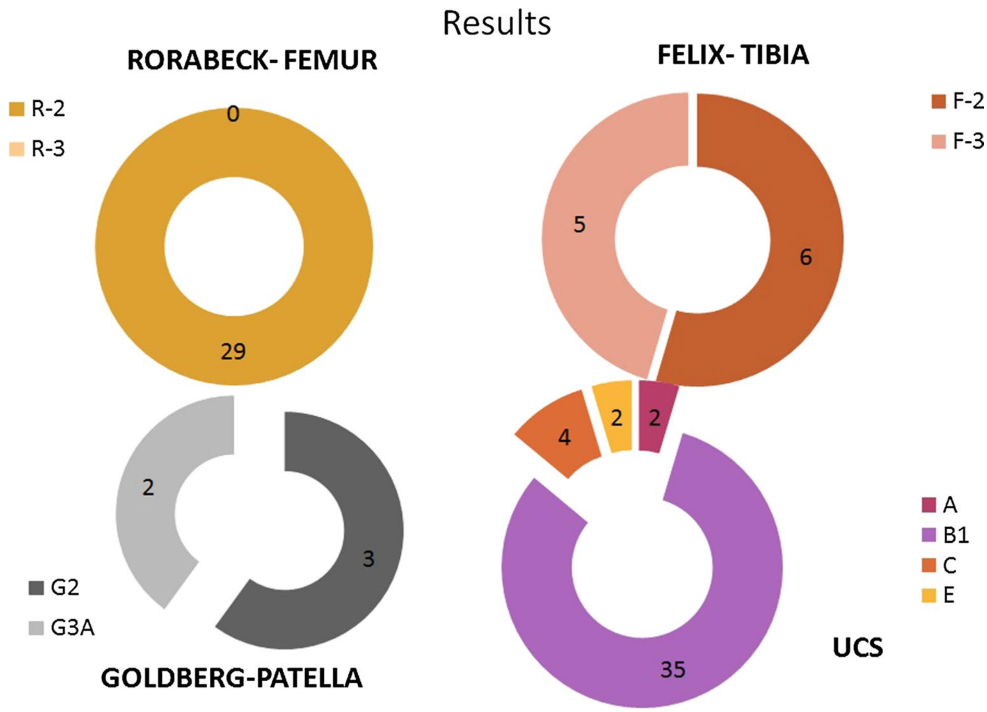


Fig. 1 Demographic data of subjects

Fig. 2 Fracture classification



one belonged to fair category. However after trauma surgery at 9 months post-op, six patients belonged to excellent category, 30 belonged to good category, 6 belonged to fair category and one had poor outcome. Mean post-TKA HSS score was 84.2, which reduced to 76 after osteosynthesis at 9 months post-op (Fig. 4). Three patients had nonunion out of which 2 were in femur fracture and one in patella fracture which also had implant failure. One femur fracture had delayed union, which went on to unit at 15 months post-op. There were no incidences of malunion, infection, DVT, pulmonary embolism (Table 2). Table 3 describes clinical outcome of fixation with regard to different fracture patterns.

Discussion

The rates of periprosthetic fractures are 0.3–2.5% after primary total knee arthroplasty (TKA) and 1.6–38% after revision TKA [6–10]. Most of such fractures result from low-velocity injuries. The risk factors include inflammatory arthropathies, chronic steroid use, age > 70 years, poor bone stock, neurological disorders and revision arthroplasty [4, 11, 12]. Prosthesis-related factors include loosening and osteolysis secondary to polythene wear. Loosening of the tibial component is more common than that of the femoral component.

The most common periprosthetic fractures after TKA are supracondylar femoral fractures (0.3–2.5%) [6–10], followed by patellar fractures (0.15–12%) [13–17] and tibial fractures (0.4–1.7%) [18, 19]. In our study, femur was fractured in 67.44% cases, tibia was fractured in 25.58% cases and patella was fractured in 11.62% cases. In one study, 30.5% of periprosthetic supracondylar femoral fractures were associated with anterior femoral notching [20]. However, in another study 30% of TKAs had a notched femur, but only 2 periprosthetic fractures occurred (both in femurs without notching) [21]. In our study, we found anterior femoral notching associated with 13 Rorabeck type 2 femur fractures, whereas in rest of 16 patients there was no nothing. The most common risk factor for periprosthetic patellar fractures after TKA is excessive patellar resection, followed by mal-alignment [22], a shorter patellar tendon [23], obesity [24], and excessive flexion of knee [25]. Excessive lateral release has a deleterious effect on patellar blood supply, which can lead to fractures [17, 22, 23].

Treatment goals are to achieve painless and stable knees with anatomical alignment and range of motion. Conservative treatment is recommended for non-displaced periprosthetic fractures. Prolonged immobilization may result in decreased range of motion, reduced walking capacity, and higher rates of malunion [3, 5]. Internal fixation is therefore preferred. Fixation with periarticular locking plates or retrograde intramedullary nails is superior to external fixation, dynamic condylar screw fixation and blade plate fixation [26–30].

Prevention of periprosthetic fractures after TKA is important. Most such fractures are associated with bone loss and implant loosening causing instability around the knee and thus fall. Improvement of bone loss prior to revision

Fig. 3 Postoperative X-rays. **a** Femur Rorabeck type 2 fracture fixed with anatomical LCP, **b** tibia Felix type 2 fracture fixed with anatomical LCP and **c** patella Goldberg type 2 fracture fixed with TBW

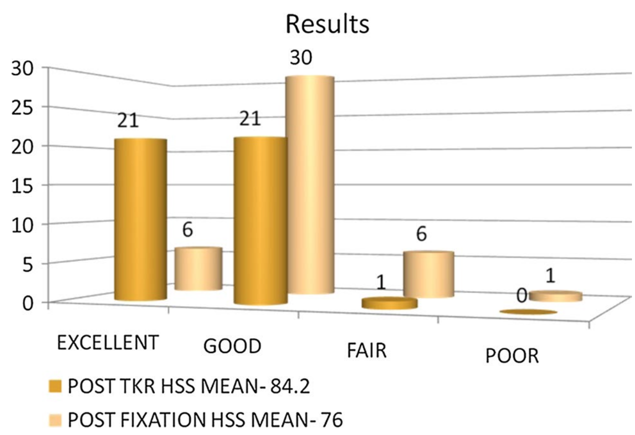


Fig. 4 Functional outcome of osteosynthesis

Table 2 Complications

Complications	Incidence
Nonunion	3
Delayed union	1
Malunion	0
Infection	0
DVT/PE	0
Implant failure	1

arthroplasty can halve the cost of management for such periprosthetic fractures [31].

Fixation with periarticular locked compression plates [29, 32–34] or retrograde intramedullary nails [35–37] is superior to cast immobilization, external fixation, dynamic compression plate fixation and dynamic condylar screw fixation. We preferred to use periarticular locked compression plates for internal fixation, as using a retrograde intramedullary nail is limited by the narrow or closed intercondylar space of the TKA prosthesis. Enlargement of the notch is often required and may raise concern about third-body wear [38]. Multiple screws are inserted at different angles, thus preventing toggling of fracture fragments and varus collapse. Traditional plate fixation is prone to varus collapse [39]. Fixed-angle blade plates or 95° condylar plates can prevent varus collapse, but are difficult to insert in the presence of prosthesis.

Rorabeck type 2 femur fractures are mostly long oblique or spiral fracture which can be addressed with open reduction and internal fixation with interfragmentary screws and neutralizing locked compression plates with minimum four locking screws engaging distal fragment. If patient has relatively good bone stock and fracture is more proximal than usual from the femoral prosthesis, non-locking implants with preferable cancellous screws in metaphyseal region of bone too can provide satisfactory stability. Felix type 2 and 3 tibial fractures should be managed with open reduction and internal fixation with locked compression plate with minimum three locking screws avoiding the tibial implant in proximal fragment. However, Felix type 3 tibial fractures can also be managed with non-locking implants with preferable cancellous screws in metaphyseal region, provided fracture is more distal and bone stock is good. Periprosthetic patellar fractures are not common. Management options include open reduction and internal fixation with screws or tension band wiring, partial patellectomy, patelloplasty and extensor mechanism reconstruction and cylindrical cast immobilization. Most such fractures are associated with a stable implant and intact extensor mechanism [23] and can be managed with immobilization in a cylindrical cast.

With the modern condylar designs of prosthesis, periprosthetic tibial fractures after TKA have become

Table 3 Clinical outcome with regard to fracture classification

Clinical outcome (HSS score)	Excellent	Good	Fair	Poor
Rorabeck type 2	2	24	3	–
Felix type 2	1	3	2	–
Felix type 3	3	2	–	–
Goldberg type 2	–	1	1	1
Goldberg type 3a	–	2	–	–
Total	6	30	6	1
Clinical outcome (HSS score)	Excellent	Good	Fair	Poor
UCCA	1	–	1	–
UCCB1	2	28	4	1
UCCC	3	1	–	–
UCCE	–	1	1	–
Total	6	30	6	1

UCC unified classification system for periprosthetic fractures, *HSS score* hospital for special surgery score rare. Such fractures are usually associated with a loose implant, deficient bone stock, and instability, and are best managed with revision arthroplasty with an intramedullary nail. In revision arthroplasty, bone defects can be treated with increased resection and component shift, use of bone grafts or prosthetic augments [40].

Osteosynthesis for periprosthetic fractures around knee with locked compression plate gives promising results. Fractures involving patella are associated with inferior functional outcome. Understanding the fracture pattern and bone stock available for fixation with correct choice of implant and correct surgical technique gives promising outcome in periprosthetic fractures around knee.

To conclude, in our study we found increased prevalence of periprosthetic fractures in elderly female population with predominant involvement of femur. Unified classification system for periprosthetic fractures is simpler and useful system. Locked compression plating is ideal implant of choice for fixation for all periprosthetic fractures; however, good outcome can be achieved with nonlocking implants too in selected type of fractures such as Rorabeck type 1 femur fractures, Felix type 2 and 3 tibial fractures provided bone is not too osteopenic.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with animals performed by any of the authors. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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