Original Articles

DOI 10.18019/1028-4427-2018-24-1- 6-12

Surgical repair of juxta-articular distal femur fractures and posttraumatic conditions

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Objective To retrospectively review surgical repair of juxta-articular distal femur fractures and posttraumatic conditions. **Material and methods** The review included 65 patients with juxta-articular distal femur fractures and posttraumatic conditions repaired with plating (n = 44), intramedullary nailing (n = 16) and transosseous osteosynthesis (n = 5) between 2009 and 2016. The patients were divided into 2 groups depending on time of injury. SOI-1 was used for outcome measure. **Results** Functional recovery was observed in 71 to 97 % (average, 89.1 ± 0.6 %) of the first group at short-term follow-up and an average of 94.7 ± 0.45 % of anatomical and function norm at a long term. Short-term anatomical and functional outcomes ranged from 63 to 93 scores in the second group and were an average of 82 ± 0.7 % of the norm. **Conclusion** Better outcomes were obtained in the first group (an average of 94.7 ± 0.45 % of anatomical and functional norm). Plating with accurate bone reduction and reliable fixation provided throughout consolidation phase showed better outcomes in both groups of patients. Intramedullary nailing was practical for straightforward supracondylar injuries type 33A1. Transosseous osteosynthesis could be advocated for open and gunshot injuries to minimise risk of infection and provide stable bone fixation.

Keywords: distal femur, fracture, plating, intramedullary nail, transosseous osteosynthesis, DCS, LCP plate

INTRODUCTION

Fractures of the distal femur are complicated injuries that can be challenging to treat. Although intraarticular and juxta-articular fractures of the distal femur account for 6 to 8 % of all skeletal injuries, and between 6 to 25 % of femur fractures, their incidence is likely to increase with the rising geriatric population [1, 2, 3, 4]. Distal femur fractures can result from either high energy injuries in young adults or low energy injuries in elderly patients with osteoporotic bone. Patients suffering this injury are at a high risk of complication given the prevalence of medical comorbidities in this cohort [5]. Structural specifics of the distal femur compromise stability of metal fixators in epimetaphyseal (cancellous) bone. Posttraumatic knee extension contracture is a common complication due to a long period of immobilisation [6, 7]. Distal femoral fractures can be treated with plates, intramedullary nails and external fixation. Application of intramedullary nails for juxta-articular fractures of the distal femur is currently confined to supracondylar fractures type A [8] with retrograde nailing being traumatic for the knee joint.

However, with all the advanced technologies available to repair distal femur fractures the estimated 5 to 45 % of the outcomes remain fair and poor due to delayed consolidation, nonunion, muscle hypertrophy, local osteoporosis, bone deformity and disturbed knee function [9, 10]. The usage of stimulation techniques for compromised osteogenesis is important for delayed consolidation and posttraumatic conditions [11, 12].

Objective. The aim of this study was to retrospectively review surgical repair of juxta-articular distal femur fractures and posttraumatic conditions.

MATERIAL AND METHODS

Sixty-five 20 to 78 year-old patients admitted with a juxta-articular fracture of the distal femur and the sequelae at the University hospital for surgical treatment between 2009 and 2016 between were enrolled in the study. There were 34 (52.3 %) females and 31 (47.7 %) males. The patients were subdivided into two groups. The first group included 26 (40.6 %) patients with an acute juxta-articular fracture of the distal femur. The second group was comprised of 39 (59.4 %) patients with nonunion and malunited fractures of the distal femur. The injury was caused by a fall at home in 41 (63 %) cases and fall from a height of more than 1 metre in 9 patients (13.8 %). The elderly, females in particular, presented with distal femur fracture as a result of falls from a standing height. The

Kauts O.A., Barabash A.P., Barabash Yu.A., Grazhdanov K.A., Rusanov A.G. Surgical repair of juxta-articular distal femur fractures and posttraumatic conditions. *Genij Ortopedii*. 2018. T. 24. No 1. pp. 6-12. DOI 10.18019/1028-4427-2018-24-1-6-12. (In Russian)

injury occurred as a result of vehicle accidents in 15 (23.2 %) mostly young patients. Physical examination, radiological appearance and CT scans were used to identify the fracture pattern, type and location, and interpret results of osteosynthesis.

Outcome measures included SOI-1 standardised rating scale for acute bone fractures and posttraumatic conditions. [13]. According to SOI-1, outcomes of juxta-articular fractures of the distal femur and the sequelae were evaluated with 16 items scored or rated as a percentage of anatomical and functional standard measures.

Statistical analysis of the findings was bimodal. First, hypothesis was designed to test equality of samples of analysed attributes based on equal mean values (the Student's t-test) and dispersion (Fisher's test). Second, relationship between different parameters was tested calculating correlation coefficient (r) with correlation analysis. Calculations were produced using personal computer, Statistica 6.1 software (StatSoftInc., Russia) and MicrosoftExcel 2007.

RESULTS

The results of surgical treatment of all 65 patients with juxta-articular fractures of the distal femur and the sequelae were reviewed in the study. Two groups of patients were identified. Patients of both groups were treated with locking compression plate (LCP) with angular stability (n=39) and dynamic condylar screw (DCS) (n = 5) that constituted 67.7 % of all procedures performed. The technique was employed for acute injury (n = 14) and posttraumatic conditions (n = 30). Indications to plating included all AO/ASIF types of extraarticular fractures of the distal femur, 33A1, 33A2, 33A3. The technique was applied in patients without severe comorbidities and allowed for accurate reduction and reliable fixation in acute case that was especially practical with 33A2 и 33A3 fractures. The practice was helpful in nonunions providing appropriate bone adaptation and stimulation of the compromised osteogenesis with repair of bone defect if any. A weak point with plate fixation was a severe trauma due to extensive dissection of soft tissues resulting in impaired vascularity.

There is a clinical instance of a 54-year-old female patient I. of the first group who fell on ice suffering a closed juxta-articular fracture of the distal femur typically translated and angulated (right side) and a closed fracture of the lateral tibial condyle (right side) repaired with plating (**Fig. 1 a**). She was referred to SarNIITO hospital 5 days after injury from a municipal hospital of Saratov where she was conservatively treated with skeletal traction. The next day she underwent fixation of the right femur and tibia using plates with angular stability (**Fig. 1 b**). The bone appeared to be stable at 1 month, healed at 3 months with further regenerate restructuring and the plates were removed at 21 months (**Fig. 1 c**). A good anatomical and functional result was achieved.

There is a clinical instance of surgical rehabilitation of a patient group II treated with plating. The 22-year-old male patient sustained a closed juxta-articular comminuted displaced fracture of the distal femur (right side) resulting from motor vehicle accident. The fracture was plated at a local hospital. No consolidation occurred with nonunion developed and metal construct deformed. He was referred to SarNIITO hospital 17 months after injury (**Fig. 2 a**). Metal construct was removed, nonunion site debrided and longitudinal osteotomy performed at fragments' ends (**Fig. 2 b**), and the bone was fixed with dynamic condylar system (DCS) (**Fig. 2 c**). The plate was removed after 14 months (**Fig. 2 d**). A good anatomical and functional result was achieved.

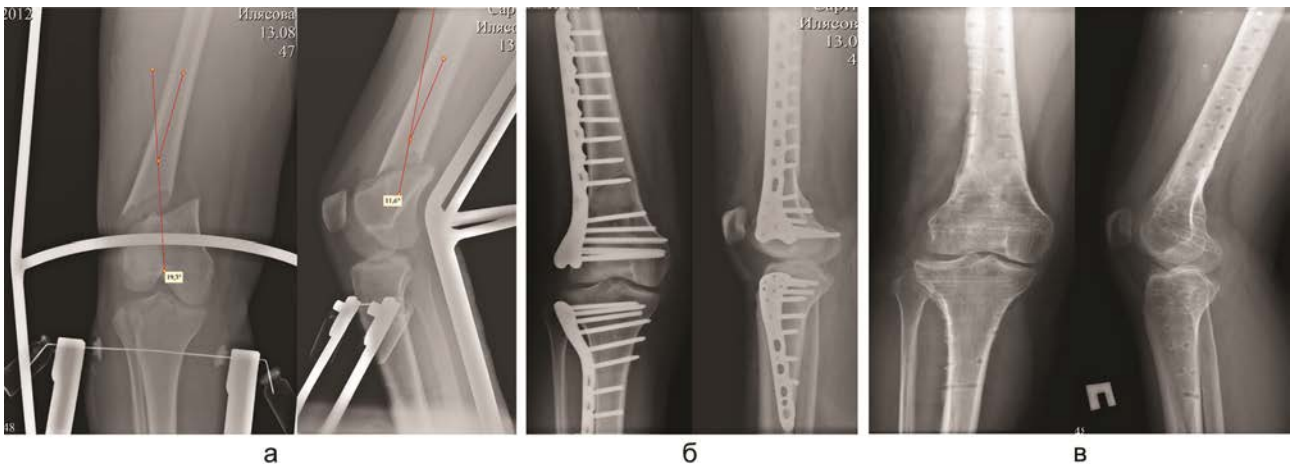

Fig. 1 Radiographs of the distal femur of patient I. showing (**a**) preoperative skeletal traction; (**b**) bone fixation with plates and (**c**) metal construct removed

Fig. 2 Radiographs pf the distal femur of a male patient K. showing (**a**) preoperative view, (**b**) intraoperative view, (**c**) bone fixation one day postsurgery, (**d**) bone consolidation before plate removal

The practice with interlocking intramedullary nail has been well established in osteosynthesis of long bones. Juxta-articular fractures of the distal femur is a challenging location for intramedullary nailing due to enlarging shape of the marrow canal, a relatively small juxta-articular fragment and a tendency to occasional displacement.

Retrograde interlocking intramedullary nailing was primarily used for supracondylar type 33A1 fractures in 7 (26.9 %) patients of the first group and 9 (23 %) cases of the second group. Intramedullary nails provide reliable bone fixation and allows for early ambulation of patients that is important for elderly patients.

A clinical instance of retrograde interlocking intramedullary nailing used for a nonunited fracture of the distal femur in a 44-year-old female patient D. (group II) who sustained the injury at home. A closed fracture of the distal femur (right side) was treated with transosseous osteosynthesis using half-pin fixator at a local hospital. The fracture did not heal in a 4 month period. External fixation device was removed and plaster cast applied and the patient was referred to SarNIITO hospital for definitive treatment (**Fig. 3 a**). Retrograde interlocking intramedullary nailing of the right femur was produced at SarNIITO hospital (**Fig. 3 b**), the fracture healed and the construct was removed after 12 months (**Fig. 3 c**).

Transosseous osteosynthesis with external fixation devices is another option for addressing the fractures [14]. The method was applied for 5 patients of group I. External fixation was employed for open and gunshot injuries of the distal femur (n = 3) to avoid infection and in 2 older patients with severe comorbidity who had an open operative intervention as a contraindication.

A clinical instance of surgical treatment performed for a 23-year-old male with juxta-articular gunshot injury to the distal femur (right side) and bone displacement using external fixation (**Fig. 4 a**). The patient was referred to SarNIITO hospital 7 days of injury from a regional hospital. Compression-distraction osteosynthesis with external fixation device using wires and half-pins was performed for the patient (**Fig. 4 b**). A 7-month follow-up showed bone stability, signs of consolidation (**Fig. 4 c**) confirmed by clinical test, the frame was removed with further restructuring of the regenerate bone noted radiologically (**Fig. 4 d**).

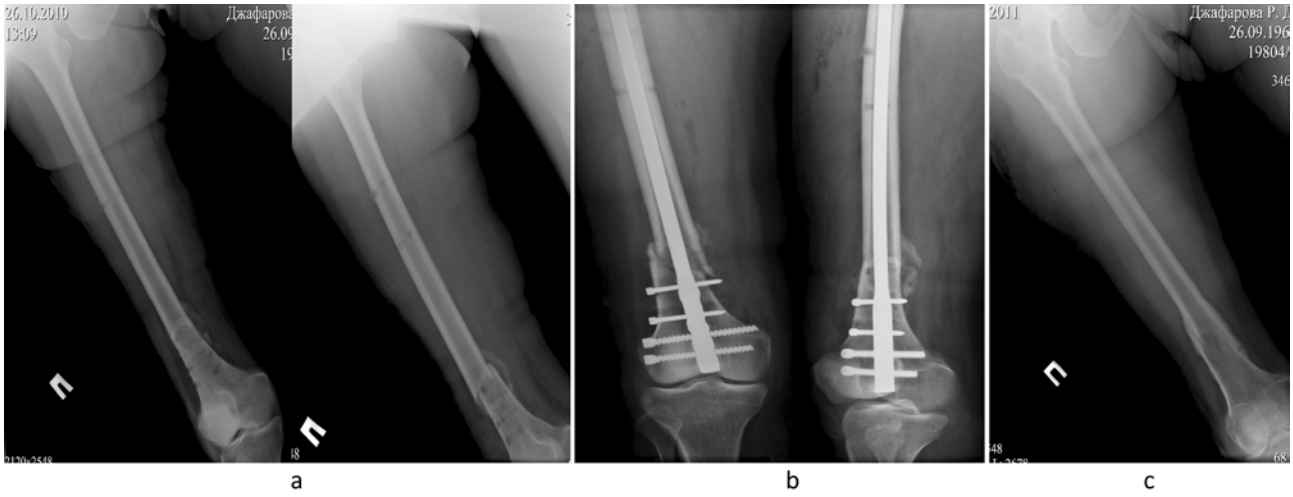

Fig. 3 Radiographs of the distal femur (right side) of a female patient D. showing (**a**) preoperative view, (**b**) intraoperative view and (**c**) bone consolidation with metal construct removed 12 months following surgical intervention

Fig. 4 Radiographs of a gunshot injury to the distal femur in a male patient S. showing (**a**) preoperative view, (**b**) intraoperative view, (**c**) signs of bone consolidation at 7-month follow-up and (**d**) further restructuring of regenerate bone after frame removal

Orthopaedic table and image intensifier were used for all surgical procedures. Open bone reduction was produced in plating and IM nailing, and a fracture was reduced closely with transosseous osteosynthesis. External immobilisation was not used postoperatively, and standard antibiotic and venous thromboembolism prophylaxis administered. Routine postoperative radiographs were taken on the day of surgery. The length of in-patient stay was 11 to 14 days. Sutures were removed with wounds healed 12 to 14 days postsurgery.

Ambulation was patient-specific considering a somatic condition. Patients were recommended to start exercising the knee joint and maintain weight-bearing on the operated limb considering reliability of bone fixation at the fracture site. The majority of the patients were allowed to sit up in bed by the end of the first postoperative day, sit on the side of the bed and exercise the knee joint on days 2 to 3 postsurgery, get out of bed and stand up next to bed on day 3 postsurgery. Physiotherapist started working with the patients on postoperative days 3 to 5 teaching them how to walk with crutches with 10 to 15 % of the weight on the operated leg and helped them walk on their own on postoperative day 7.

Radiological assessment of the fracture consolidation was performed at 1, 2, 3, and 12 month follow-up to recommend the patient how much weight was to be borne by the operated limb. Severe articular injury necessitated delayed weight-bearing and early motion. Full weight-bearing could be advocated at 3-to-4-month follow-up with radiologically satisfactory callosity and absence of pain.

The efficacy and effectiveness of treatments of the juxta-articular distal femur fractures were evaluated with SOI-1 standardised rating scale for acute bone fractures and posttraumatic conditions. According to SOI-1, outcomes of juxta-articular fractures of the distal femur and the sequelae were evaluated with 16 items scored or rated as a percentage of anatomical and functional standard measures. The parameters rated included,

- presence and intensity of pain;
- bone consolidation;
- bone realignment;
- anatomical shortening of injured bone;
- failures in callosity and soft tissue scars;
- functional position of the joints;
- range of motion in the joints;
- trophics of soft tissues;
- neurological deficiency;
- integrity of soft tissues;
- infection;
- vascular disorders;
- cosmetic defect;
- a need of further treatment;
- anatomy of the involved segment;
- functional fitness of the involved limb.

The parameters and associated scores were summarised with the total score showing the quality of the outcome. Short-term (3 months postsurgery) and long-term follow-ups were evaluated in 54 (83 %) patients ($p < 0.05$). Three-month follow-up of group I showed restored functions of 71 to 97 % of anatomical and functional standard measures or 89.1 ± 0.6 scores. Postoperative complications, incomplete bone reduction and limited range of motion in the knee joint observed in several cases had a negative impact on anatomical and functional outcome. Low score of two patients were caused by delayed consolidation of unstable comminuted fractures at the short-term follow-up. Long-term outcomes demonstrated 94.7 ± 0.45 scores (or percent) of anatomical and functional standard measures. Short-term outcomes in group II ranged between 63 and 93 scores with an average of 82 ± 0.7, i.e. 82 ± 0.7 % of anatomical and functional standard measures.

The reasons behind the low outcomes in group II were patient specific. Impaired fracture healing, leading to delayed union or nonunion represent a difficult challenge for the surgeon. Impaired fracture healing, leading to delayed union or nonunion, is associated with a number of risk factors including Compromised biology of the segment, scars and adhesions at the site of the surgery hamper accurate bone reduction, and poor osteogenic properties and frequent osteoporosis are important predisposing factors contributing to fixator failure and delayed consolidation. In spite of the above circumstances we managed to achieve good and fair results in most of the cases at a long-term follow-up.

Long-term outcomes of group II showed restored functions with an average of 90.2 ± 0.4 % of anatomical and functional standard measures at one and more than one year of surgical treatment.

DISCUSSION

The diversity of surgical options for the management of distal femoral fractures reflects the challenges inherent in these injuries. Considering anatomical structures of the distal femur, patients' age and a need of durable fixation of the knee joint to facilitate callus formation an appropriate technique is to be used to ensure reliable bone healing within short period of time with minimal consequences for the knee.

Review of outcomes of juxta-articular fractures of the distal femur surgically treated at our hospital showed more favourable results with the usage of plate osteosynthesis that is in line with other authors [1, 8,

10]. Open methods were practical in achieving accurate bone reduction, reliable fixation of the fracture with the possibility of stimulating osteogenesis that resulted in good outcomes even in the group with old fractures and nonunions.

Application of intramedullary nails for juxta-articular fractures of the distal femur is reportedly confined to supracondylar fractures type A [8]. The results of our study suggest that the practice is primarily efficient for straightforward supracondylar fractures 33A1 in the group of patients with acute injuries. This technique applied for comminuted fractures type 33A2 and 33A3 and the sequelae showed unrewarding outcomes.

Transosseous osteosynthesis is reported to be efficient in 97.4 % of the patients with distal femoral fractures [15, 16]. External fixation was used in 7.6 % of our patients with acute fractures only. Application of transosseous osteosynthesis was practical for infection prevention in open and gunshot injuries providing fracture stabilisation and ambulation of patients with comorbidities who had an open operative intervention as a contraindication resulting in good outcomes.

CONCLUSIONS

1. A variety of modern constructs for osteosynthesis has shown to be effective for the treatment of acute fractures of the distal femur and the sequelae. Patients of group I showed most favourable outcomes with an average of 94.7 ± 0.45 % of anatomical and functional standard measures.

2. Plates with angular stability and dynamic condylar system (DCS) can be indicated for any pattern of juxta-articular fractures of the distal femur demonstrating better outcomes in both groups of patients with accurate bone reduction and reliable fixation provided throughout consolidation phase.

3. Retrograde intramedullary nailing was a good surgical option for straightforward acute supracondylar injuries type 33A1 ensuring stable fixation and early ambulation of the patients.

4. Transosseous osteosynthesis could be advocated for open and gunshot injuries to minimise risk of infection facilitating stable bone fixation. It can also be employed for distraction at the first stage of treatment prior to intramedullary nailing.

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Received: 13.04.2017

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