Locking Plate Alone or in Combination With Cannulated Screws for Hoffa Fractures: a Retrospective Cohort Study

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Abstract

Purpose: Locking plate or screws have been used for Hoffa fractures; however, evidence to support the effectiveness of the procedure remains scarce. The present study aimed to determine the efficacy of distal femur condyle locking plate (DFCLP) alone or in combination with cannulated screws for Hoffa fractures.

Methods: In this cohort study, 13 patients with isolated Hoffa fractures were enrolled during the study period (May 2014 to February 2019) and retrospectively analyzed. Patients underwent open reduction and internal fixation by DFCLP alone or in combination with cannulated screws followed by early active rehabilitation postoperatively. The primary outcome was evaluated with Knee Society Score (KSS), the range of movement (ROM), International Knee Documentation Committee (IKDC) scoring system and the stability of the fixation site of the patients during the 24-month follow-up period.

Results: A total of 13 patients completed the 24-month follow-up assessment and achieve bone re-union at Hoffa fracture sites. The average follow-up period was 24.5 months (ranging from 24 to 28 months), and the average time to healing was 3.5 months (ranging from 3 to 4 months). The mean ROM was determined as 119°, the mean KSS was 87.9, and the mean IKDC score was 84.2. It is worth mentioning that 2 patients suffered from knee joint stiffness and osteoarthritis during the 24 months follow-up. Eleven patients (84.6%) achieved satisfactory knee joint function through early postsurgical rehabilitation.

Conclusion: In patients with Hoffa fractures, treatment with DFCLP alone or in combination with cannulated screws followed by early active rehabilitation resulted in great stability and satisfactory functional results after 24 months.

Introduction

Hoffa fractures, also known as posterior coronal plane shear fractures of the femoral condyle, are rare injuries accounting for only around 8.7%~13% of distal femur fractures^[1,2]. They were originally described by Friedrich Busch and then named in 1904 by Albert Hoffa^[1-3]. It is an unstable intra-articular fracture that is involved in 17% of supracondylar and intercondylar fractures^[3].

Hoffa fractures are most commonly associated with high-energy trauma and typically occur when the knee is in a flexed position with excessive axial forces resulting in shearing of condyles, particularly from motor vehicle accidents and falls from a height^[4,5]. These fractures can often be overlooked in plain radiographs and could be associated with further displacement if not identified soon. Therefore, computed tomography (CT) is the recommended imaging modality for examinations^[3]. Non-operative treatments have traditionally yielded poor results^[4], whereas open reduction with internal fixation combined with early rehabilitation is the ideal treatment approach for better functional outcomes^[5].

Nowadays, various surgical approaches and fixation methods have been established and widely practiced^[1–4, 12, 15]. However, no standard treatment method exists for Hoffa fractures. Moreover, there are many problems linked with the internal fixation method, and the unstable nature of Hoffa fractures could result in displacements of fractured fragments and non-union^[3–6], increasing the patient's disease and economic burden. In our study, distal femur condyle locking plate (DFCLP) specially designed for Hoffa fractures could achieve enough stability. To date, no literature on this type of fixation method of Hoffa fractures exist.

The purpose of this study is to evaluate the clinical performance of surgical treatments and early rehabilitations on Hoffa fractures in 13 patients fixed by DFCLP alone or in combined with cannulated screws, which provide rigidity and achieve active rehabilitation sooner.

Materials And Methods

1.1 Patients

Using the orthopaedic trauma files in our institute, data were gathered for this retrospective study. Initially, data from a total of 657 patients who had suffered from intra-articular distal femur fractures between May 2014 and Feb 2019 were identified through searching from a prospective orthopaedic database, out of which there were 19 cases (2.89%) with Hoffa fractures. Patients who had undergone conservative treatments, open or pathological fractures, any additional supra-condylar or inter-condylar fractures, severe neurovascular injury and any previous surgery of the involved knee were all excluded. In the end, a total of 13 patients who had suffered Hoffa fractures were enrolled in the study. All patients underwent surgery with DFCLP fixation alone or in combination with cannulated screws followed by early active rehabilitation. The DFCLP and cannulated screws were provided by Jiangsu Jinlu Medical Company. Study subjects include 13 patients, the attendance on the follow-up appointments were perfect and no patients dropped out. Our work complies with the STROBE criteria.

Before the surgery, the involved leg was fixed with plaster to avoid further injury. Meanwhile, X-ray, MRI, and CT scanning were performed to determine the fracture types and the conditions of soft tissues. The patient sample comprised of 9 males and 4 females with an average age of 49.9 years (ranging from 26 to 64 years old) at the time of surgeries. The fracture side, mechanisms of injuries, time of operation and follow-up period were all recorded. All fractures were closed and categorised according to the Letenneur descriptions^[7]. The fractures included 10 lateral (77%) cases and 3 medial cases (23%). Misdiagnosis occurred in 1 (7.7%) patient who suffered from continuous pain and limited knee flexion, and 4 weeks elapsed since the initial injury to being diagnosed.

For all patients, DFCLP was favoured over other fixation devices. Screws were placed according to fracture fragment. The general patient demographic data are shown in Table 1.

Table 1
Demographic data of the patients.

Case	Age/Gender	Injury Mechanism	Fracture subtype	Surgical Approach	Late diagnosis(weeks)	Follow-up(months)
1	60/F	High-velocity fall	a/MC	medial	-	24
2	46/M	High-velocity fall	b/LC	lateral	4	24
3	61/M	Motor vehicle accident	a/LC	lateral	-	26
4	37/M	Motor vehicle accident	b/MC	medial	-	24
5	51/M	Heavy object smashing	a/LC	lateral	-	24
6	52/M	Motor vehicle accident	a/LC	lateral	-	28
7	64/F	High-velocity fall	a/LC	lateral	-	24
8	45/M	High-velocity fall	a/LC	lateral	-	24
9	46/M	Motor vehicle accident	a/LC	lateral	-	24
10	26/F	Motor vehicle accident	a/LC	lateral	-	24
11	63/F	High-velocity fall	a/MC	medial	-	24
12	54/M	High-velocity fall	a/LC	lateral	-	24
13	44/M	High-velocity fall	a/LC	lateral	-	24
M: male F: female MC: medial condyle LC: lateral condyle ACL: anterior cruciate ligament LCL: lateral collateral ligament MCL: medial collateral ligament						

1.2 Surgical management

The operation was performed by professional orthopaedic surgeons. Open reduction through the modified medial or lateral approach was used to treat all fractures. Patients were placed supine on the operating table with the involved knee bent at 60° and a soft pad inserted under the popliteal fossa.

Patients were under general or spinal anaesthesia for the surgery; tourniquets were used during the surgery to limit blood flow.

The medial approach incision was made at the level of the femoral adductor tubercle, which was curved parallel to the tibial margin, and the incision was stopped at the lower margin of the tibial plateau. The sartorius anterior margin was identified first and separated along the space between itself and the vastus medialis. Then, the knee was flexed and pulled back the sartorius to expose the adductor magnus tendon and the adductor tubercle, and the adductor magnus tendon was pulled back last to expose the fracture. The lateral incision approach extends downwards along the lateral femoral axis across the lateral femoral condyle, turns to the tibial tubercle, enters along the anterior or posterior side of the iliotibial tract, cuts fascia in front of the lateral muscle septum, and pulls the lateral femoral muscle upward to expose the fracture and articular surface. The hematoma was cleaned, and the articular surface reduced with forceps. The intact fragment of the Hoffa fracture was reduced and temporarily fixed by Kirschner wires in the anteroposterior or posteroanterior position. The direction of Kirschner wire was as far vertical to the fracture line as possible. Biplanar fluoroscopic imaging was used to confirm the reduction.

Afterward, DFCLP or cannulated screws were placed to fix fractures. The ideal screw directions would be perpendicular to the fracture line of the major coronal plane along the longest axis of the medial femoral condyle. There are many sizes of screws that can be used, depending on fracture fragment size, ranging from mini fragment implants (2.0 and 2.4mm) to 3.5mm cortical screws, and 4mm or 6.5mm cannulated screws. Meanwhile, DFCLP was placed on the side of the femoral condyle for preventing the fragment from gliding vertically as well as fixing it with angular stability. However, it should be evaluated accurately how the plate was placed to prevent the screws from interfering with each other. Direct fluoroscopic visualization was then used to confirm the precision of the reduction and implant placement. The stability and motion range of the knee were checked for, followed by the deflation of the tourniquet and closure of the wound over suction drains. No external fixation was used after operation.

During the last follow-up appointment, all patients were assessed using the following methods: PA, physical examination, and lateral radiographs. A goniometer was used to measure the bilateral knee range of motion (ROM) and any restriction was recorded. An independent assessor who was unaware of the types of surgical treatment and fracture carried out all evaluations. The Knee Society Score (KSS) and International Knee Documentation Committee (IKDC) was used to evaluate the functional outcomes. Any stability, type of fixation, bone union time, and complications were noted. The details are presented in Table 2.

Table 2
Functional results and complications of the patients.

Case	Fixation	Knee ROM(degree)	SCORE		Bone union time(months)	Stability	Complications
			KSS	IKDC			
1	Plate and screws	0-130	88	88.5	3	Stable	-
2	Plate	0-120	90	86.2	3	Stable	-
3	Plate	0-125	91	87.4	4	Stable	-
4	Plate	0-110	86	75.9	4	Stable	-
5	Plate	0-115	85	82.8	3	Stable	-
6	Plate	0-120	84	81.6	3	Stable	Stiffness
7	Plate and screws	0-120	91	89.7	4	Stable	-
8	Plate	0-125	90	85.1	3	Stable	-
9	Plate and screws	0-100	80	74.7	4	Stable	Stiffness osteoarthritis
10	Plate	0-120	88	83.9	3	Stable	-
11	Plate and screws	0-120	89	85.6	3	Stable	-
12	Plate and screws	0-125	92	87.4	4	Stable	-
13	Plate and screws	0-120	90	85.2	4	Stable	-
ROM:range of motion							
KSS:Knee Society Clinical Score							
IKDC:International Knee Documentation Committee							

1.3 Rehabilitation

In order to restore optimum functions of the injured knee joint, a comprehensive early active rehabilitation program was adhered to. The functional outcome analyses were conducted according to the Knee Society Score (KSS), range of movement (ROM), International Knee Documentation Committee (IKDC), and the fixation stability of the patients.

One of the most crucial targets during the early stage of the postoperative rehabilitation was to minimize swelling and pain, thus elevation of the affected leg combined with non-steroidal anti-inflammatory drugs were recommended. When the pain and swelling subsided, the continuous passive motion (CPM) system was used for helping the knee joints to do extension and flexion exercises in all patients from day 3 postoperatively [2]. On day 7 post-operatively, the degree of knee flexion increased from 0° to 60°. Starting from the 2nd week, the frequency of the exercise was increased to 2 to 3 times a day, to achieve a 10° to 15° advance in the range of knee flexion every day. By the end of week 3 post-operatively, patients were encouraged to reach a milestone of between 100° to 130° of flexion. In the fourth week, patients were allowed to perform a full range of motion for 30 to 40 mins 2 to 3 times a day. During weeks 6 to 8 after surgery, patients began practicing walking without bearing weights using crutches, which is followed by partial weight-bearing walks at around week 10. For patients who had been discharged, the weight born was gradually increased following the guidance of the clinician given through telerehabilitation. Full weight-bearing walks were allowed once signs of bone reunion were detected on radiographs from weeks 14 to 28 postoperatively.

After being discharged, patient follow-up was carried out every month for the first 3 months using X-ray or CT imaging, then every 3 months in the following 9 months, and finally at the 12th and 24th months.

Results

Patients who participated in this study were all cooperative and the full clinical data were gathered. The bone reunion was observed in all patients on their Hoffa fractures sites, with the articular surface of femoral condyles reduced anatomically. The average follow-up period was 24.5 months (ranging from 24 to 28 months). Six patients were treated by DFCLP in combination with cannulated screws and the remaining 7 patients were treated by DFCLP alone. The mean ROM was 119° (ranging from 100° to 130°). The mean KSS was 87.9 (ranging between 80 and 92 points) with 11 patients evaluated as excellent, 2 as good, and zero bad case. The mean KSS was 87.7 for patients with medial Hoffa fractures and 88.1 for those with lateral Hoffa fractures. The mean IKDC score was 84.2 (ranging from 74.7 to 89.7 points), with 10 evaluated as excellent, 3 as good, and no bad case. The mean IKDC score was 83.3 for patients with medial Hoffa fractures and 84.4 for those with lateral Hoffa fractures. The X-ray image CT scans were used to assess the healing of the fractured site. The results indicated that at month 3, the bone union was evident in 7 patients (54%), at month 4, bone union was seen in 6 patients (46%). In the end, all fractures had healed, and knee joint stability was achieved in all patients. However, 2 patients suffered from knee joint stiffness and osteoarthritis during the follow-up period. Eleven patients (84.6%) in total regained satisfactory function of their knee joint and ability to walk with decent clinical results obtained through early postoperative rehabilitation. Additionally, no limb-length discrepancy, non-union, postoperative infection, bone resorption, or secondary displacement happened, and patients were all free from pain and able to walk without any aid.

In our study, the patient of case 1 (a 60-year-old female) got the left medial Hoffa fracture (type Letenneur III) from a High-velocity fall. A DFCLP and four cannulated screws were placed at the medial distal

femoral condyle. Twenty-four months after the operation, nearly 0°–130° range of motion was obtained in the patient with a good functional recovery (Fig.1). Another patient of case 6 (a 52-year-old male) suffered the left lateral Hoffa fracture (type Letenneur III) from a Motor vehicle accident. A DFCLP alone was placed at the lateral distal femoral condyle. Twenty-four months after the operation, nearly 0°–120° range of motion was obtained in the patient with satisfactory functional results (Fig.2).

Discussion

In this present study, we have found that DFCLP alone or in combination with cannulated screws followed by early active rehabilitation are efficacious in providing stability and improving function after 24 months in patients with Hoffa fractures. Hoffa fractures are very uncommon and previous studies on the effects of Hoffa fracture had all been case reports and small case series, investigation on a larger scale was indeed lacking [2, 5, 17]. Most studies recommended open reduction and internal fixation as the ideal treatment modality [2, 5, 9–12]. Hoffa fractures involving medial condyles were even rarer than the lateral condyle as mentioned in the past literature [2, 5, 12]. The present study recruited 10 lateral and 3 medial Hoffa fractures, which were thought to be the consequences of the particular injury mechanism involving the genu valgum in the knee joint as explained before by White et al [6]. In the present study, high-energy trauma is the typical injury mechanism mostly seen in the setting of motor vehicle accidents and high-velocity falls. According to White et al. [6], the knee was placed at 90° or more in a flexed position, hence the femoral condyle would be more prone to be subjected to direct anteroposterior force, thereby inducing Hoffa fractures.

One (7.7%) patient of the present study was diagnosed 4 weeks after the initial injury. The patient presented with continuous pain and limited knee flexion. Making accurate diagnoses of this fracture is challenging, and it is often overlooked on plain radiographs – the rate of correctly identifying coronal plane fractures using plain radiographic imaging is only 69%. Nork et al. [3] highly recommended a preoperative CT scanning to detect any associated coronal fractures. Onay et al. [5] also suggested the crucial need of CT scans to distinguish coronal fractures more accurately as these fractures can be easily neglected on plain radiographs. It is believed that CT scan is the best method for diagnosing and improving the diagnostic yield when there is clinical and radiological suspicion of Hoffa fractures.

No consensus has been reached in the most suitable surgical approach and for the fixation devices so far [10–12], careful selection on a case to case basis in addition to the fracture classification has been recommended [13–14]. The current series indicated the use of a direct lateral approach for 10 patients and a medial approach for 3 patients. Nowadays, locking plate or screws have been recommended for Hoffa fractures [15–18]. There are two directions of screw fixation including anterior-posterior (AP) and posterior-anterior (PA) [8, 20–23]. AP screw fixation is suitable for type Letenneur I and II, which has larger fracture fragments. The screws should be parallel to the oblique plane of the medial and lateral condyle of the femur, 25° to the medial condyle and 10° to the lateral condyle [8, 12, 14]. It is commonly accepted to have screw heads recessed beneath the articular surface. PA screw fixation is suitable for type II, which has

smaller fracture fragment. However, this method has a higher risk of damaging the nerves and vessels. Xu et al. [28] proposed the triangular cross fixation with three screws for the treatment of Hoffa fractures, which proved to be as effective as the traditional fixation with two screws for parallel compression. The deficiency of screws is that they are insufficient to resist the sheer force of plane as well as varus and valgus stress during flexion and extension of knees, therefore, simple screw fixation has a higher rate of failure [8,16–18]. Due to the different positions, it can be divided into the posterior anti-sliding plate and the lateral buttress plate. The design of the posterior anti-sliding plate is more consistent with the mechanical principle of Hoffa fractures. Gao et al. [2] reported that the use of posterior anti-sliding plate can enhance the fixation stability and allows early rehabilitation. However, the use of this plate may damage blood supply and hamper knee joint flexion. In addition, the latest biomechanical studies have shown that the shear strength of the lateral buttress plate is stronger than that of the posterior anti-sliding plate [24–25]. Li et al. [14] pointed out that the posterior anti-sliding plate could not be placed directly behind the femoral condyle due to the blocking of the attachment point of the gastrocnemius, and the lateral buttress plate could play the same role. Recent reports on Arthroscopy-assisted fixations have also received some attention, which are less invasive and can pinpoint damages which may have been overlooked with the open technique [26–27].

In the present study, we used the lateral buttress plate, DFCLP, or in combination with cannulated screws to treat Hoffa fractures, which could provide sufficient stability of the fixation and permit early rehabilitation. A systematic plan of early active rehabilitation was carried out to achieve maximum restoration of the injured knee joint. In the end, 11 patients (84.6%) patients regained sufficient knee joint function and ability to walk with decent clinical results through this fixation method and early postsurgical rehabilitation. Moreover, DFCLP has many advantages in terms of design for Hoffa fractures (Fig. 3). First of all, its anatomic design could better fit the surface of medial and lateral condyle of femur. Secondly, 10 fix screw holes are evenly distributed on the condyle, which can better fix the fracture fragments. Eight of them are arranged in arc along the boundary and could fix the joint surface effectively. Thirdly, multiplanar fixation via 3.5 mm screws could improve the stress and stability. In addition, there are six sutural pores in the distal plate, which can reinforce the suture of the joint capsule and small fragments, improving the stability. Finally, the proximal plate presents a slope inserting design, so the proximal screws could be fixed through minimally invasive approaches.

In conclusion, our results show that DFCLP alone or in combination with cannulated screws followed by early active rehabilitation are efficacious in providing stability and improving function after 24 months in patients with Hoffa fracture.

The scope of this retrospective cohort study was limited largely by a small sample size, and more high-quality random clinical trials with larger sample size are necessary to verify the current results. The lack of control groups and the limited patient sample were due to the rarity of Hoffa fractures. Meanwhile, the enrolled patients of the present study do not include Letenneur II type C fracture, which makes the study flawed. Besides, our follow-up time is mean 24.5 months, and we need a study with a longer follow-up

time. Our long-term goal is to elucidate the effectiveness of functional outcomes long-term, with high-quality follow-up and large samples.

Declarations

Ethical standard

All procedures followed were in accordance with the ethical standards of responsible committee on human experimentation (institutional and national) and with Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients for being included in the study.

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Conflicts of interest

All named authors hereby declare that they have no conflicts of interest to disclose.

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Figures

Figure 1

a-b)3-D CT of left knee showed a type Letenneur III medial Hoffa fracture. c-d)AP/Lateral radiograph of left knee showed that the fracture was reduced and fixed with a DFCLP and four cannulated screws. e-f)The patient could acquire nearly 0°-130° range of motion after 24 months postoperatively with a good functional recovery.

Figure 2

a-c) Lateral radiograph and 3-D CT of left knee showed a type Letenneur III lateral Hoffa fracture. d-e) AP/Lateral radiograph of left knee showed that the fracture was reduced and fixed with a DFCLP alone. f-g) The patient could acquire nearly 0°-120° range of motion in 24 months after the operation with satisfactory functional results.

Figure 3

Mode pattern of anatomic locking plate on distal femur lateral condyle and internal condyle.