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Case Report

A case report of the Hoffa fracture and a review of literature

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ABSTRACT

The Hoffa fracture is an uncommon fracture. There is a lot of confusion about its diagnosis and management with several conflicting reports in literature. We reported a 25-year-old patient with non-union of Hoffa fracture, and meanwhile tried to develop an algorithm-based treatment for Hoffa fractures. A systematic review of the available literature was performed. Medline, Embase, the Cochrane Library and PubMed were searched for relevant articles. Fifty-five articles were reviewed, and the clinical knowledge base was summarized. The understanding of the mechanism of trauma has become more nuanced. The literature has also evolved to classify the fracture with the purpose of surgical management in mind. This can be used to plan approach and fixation with preservation of blood supply. Classification can also prognosticate the outcomes in Hoffa fracture.

Introduction

Hoffa fractures are uncommon intra-articular fractures of the distal femur, accounting for less than 1% of femoral fractures.[1] The fracture essentially occurs in the coronal plane of the articular block of distal femur and involves one or both of the femoral condyles. These fractures are unstable intra-articular fractures that can occur in isolation or combined with complex intra-articular injuries. Frequently they are accompanied with the femoral shaft fractures.

The first-ever description of this fracture dates back to 1869 (not 1904 as is commonly believed), when a German surgeon Friedrich Busch mentioned it in an anatomical specimen from the knee joint of a cadaver.[2] The drawings of Friedrich Busch were later used by Albert Hoffa in 1888 in the first edition of his textbook, following which the fracture was recognized by his name.[3] According to the literature, 76% of Hoffa fractures are unicondylar and the rest are bicondylar. Majority of the unicondylar fractures are found in the lateral condyle, accounting for 65%–85%.[4–6] Hoffa fractures are difficult to detect. The management of these fractures is also a matter of debate.[7] Chadrabose et al.[1] showed that the lack of acquaintance with posterior cortex comminution and failure to completely remove the articular fragments or failure to maintain them in good alignment (i.e., loss of reduction) results in poor outcome in these fractures. Accordingly, revisions are often required to address the 2 factors, i.e. fixation failure and loss of reduction. Due to these factors, the surgical treatment of Hoffa fractures remains difficult task.[8]

An unusual case report is presented, which highlights the pertinent issues associated with the management of this fracture. This paper also reviewed literature on Hoffa fractures and discussed methods to assess, classify, treat and reduce this type of fracture.

Case report

A 25-year-old man presented to our outdoor patient department in 2013 with a complaint of stiffness of the right knee. He narrated that he had a fall 5 years ago (2008) and hurt his knee. He had accepted the knee cast treatment for 6 weeks, after that he was recommended for physiotherapy. He was unable to recover the full range of motion (ROM) of his knee, which has plateaued at 0–45°. He had accepted the stiffness and had gradually returned to work as an electric fitter. The documents showed that he had been treated for an undisplaced Hoffa fracture of the lateral femoral condyle on that occasion. This time, he presented to the outdoor patient department to conduct a clinical evaluation of his knee and explore any possibility of increased ROM. After assessing the work habits, examining the knee and checking the new X-ray, it was found that he had a persistent non-union of Hoffa fracture of the knee. Since the fragment was small and the pathology was 5 years, the risks and benefits of surgical intervention were discussed with him. He chose not to have surgery (Fig. 1).

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Fig. 1. Non-union of Hoffa fracture for 5 years.

In 2018, 6 months after the aforementioned visit to the hospital, he had a fall from a stool and injured the same knee. He presented to the hospital 4 weeks after the injury. The X-ray showed that the Hoffa fragment had displaced from its non-union site and had stuck in the suprapatellar region, which was confirmed by CT (Fig. 2). Although the patient was reluctant to undergo surgery, the knee was quite unstable when flexed beyond 40°, causing him to flex his knee and repeatedly pull up pain while walking. Due to the functional discomfort caused by mechanical symptoms, he agreed to take the operation. A parapatellar approach was used to retrieve and fix the fragment. The fragment was cleaned and the base of the condyle was debrided. The fracture was reduced, and fixed with 2 headless screws. The fracture healed smoothly, and the patient was painless after 2 years of the follow-up with a ROM of 0°–100° (Figs. 3 and 4).

Discussion

The case report showed that Hoffa fracture is a challenging problem on several fronts. The areas of discussion in this case report were: (1) Could the patient benefit from the surgery during his first visit? (2) An approach allowing retrieval and repair of fragments should be chosen. (3) Extent of the debridement was the crater on the femoral condyle. The debridement can promote to heal the wound without causing bone loss in a critical area. (4) An essentially avascular fragment should be fixed, as vascularity was expected to affect the choice of implant. A brittle and small bone fragment needs to be carefully fixed, where the screw heads would not remain protruding. To understand the difficulties and challenges confronting the management of a Hoffa fracture, a discussion of the current literature is presented.

Methods of literature

We performed a systematic search on Medline, Embase, the Cochrane Library and PubMed for articles published in English reporting various issues relating to the Hoffa fracture. The keywords “Hoffa fracture” and “coronal fracture of femoral condyle” were entered to search for relevant articles. There is no restriction on the date of publication. The terms were searched singly and then the number of studies was added. The following articles were included: (1) published in English, (2) case reports/case series on Hoffa fractures, and (3) articles evincing upon the surgical treatment of Hoffa fracture. After excluding studies on animal models, literature reviews, duplicate articles, articles on pediatric Hoffa fractures, letters or editorials, a total of 55 articles were reviewed by 3 authors. The authors independently reviewed the title, abstract, and/or full text using predetermined inclusion criteria to determine eligibility for the study and the inclusion in our analysis. There was no disagreement among the authors during the review process. The articles were screened on the basis of titles and abstracts, and those describing Hoffa fracture of the distal femur with or without associated knee injuries were included in the review. The aim of this study was to summarize the current state of understanding regarding various aspects of Hoffa fractures, including but not limited to the mechanisms of injury, classification systems, diagnostic aids, modalities and approaches of treatment, and outcomes of treatment (Fig. 5).

Mechanism

Conventionally Hoffa fractures occur as a result of a fall from height or a motor vehicle accident, however according to Lu et al.,[9] the exact mechanism remains unclear. High energy injury held responsible for 80.5% of cases and falls held for 9.1% of cases.[10–12] Low energy trauma held responsible for children and individuals with osteoporosis.[8] An iatrogenic mechanism has also been reported while making the femoral tunnel for the cruciate ligament in anterior cruciate ligament reconstruction.[13] The current belief is that an axial force in varus or valgus with the knee in 90° of flexion or more will cause a transfer of a shear force between the femoral condyle and the tibial plateau.[14,15] At a lower degree of flexion, the extensor mechanism is damaged below the patella, and at higher

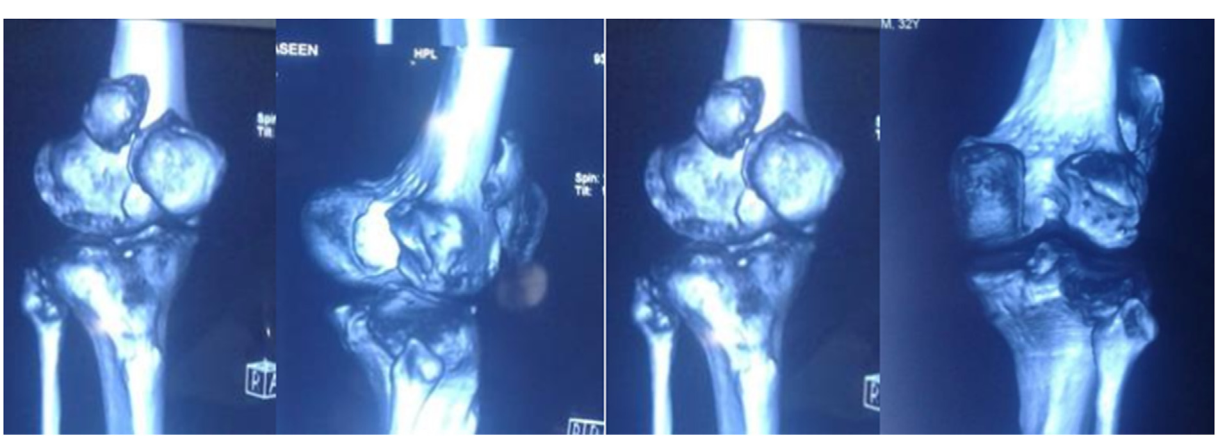

Fig. 2. CT scans show the displaced fragment.

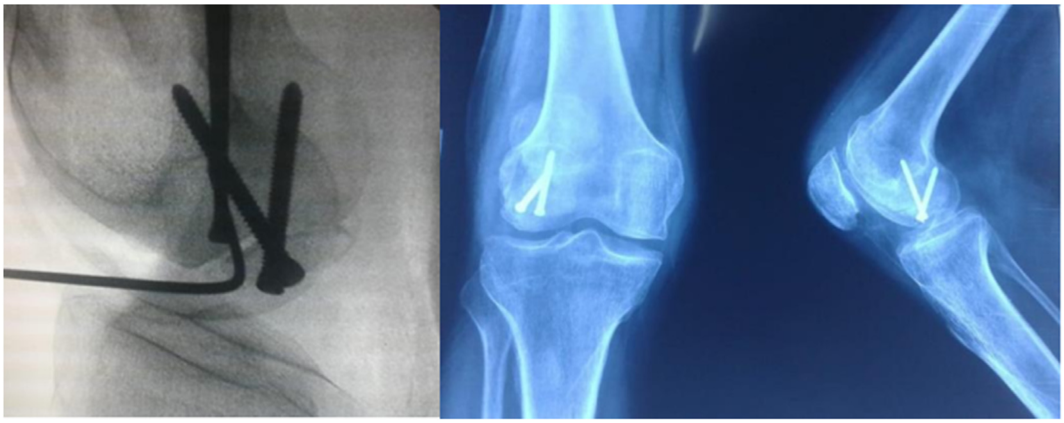

Fig. 3. Intraoperative C-arm image and 2 years post-operative image.

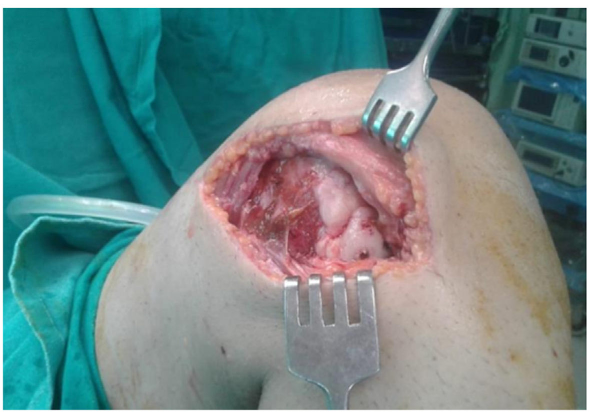

Fig. 4. Intraoperative picture shows fracture fixation through the lateral parapatellar approach.

angles the quadriceps tendon is torn. Due to the physiologic genu valgus, the force transmission affects the lateral femoral condyle more commonly.[16] The fracture line is further back from the posterior femoral cortex with higher degrees of flexion.[17] In the bicondylar fracture, the force causing the injury is directed posteriorly and cephalad.[18]

Classification

The most widely used classification method was given by Letenneur et al.,[19] which clarifies the relationship among the fracture line and ligaments and soft tissues. It also gives a basic understanding of the prognosis, especially the risk of avascular necrosis. According to the paper published by Letenneur et al.,[19] this classification does not guide the management completely (Fig. 6). Type I is the commonest type, which involves the entire condyle and the fracture line is parallel to the posterior femoral cortex. In type II, the fracture line is parallel to the base of the femoral condyle and located posterior to the attachment of the lateral collateral ligament. The fracture line of type III is oblique, which is anterior to the joint capsule, anterior cruciate ligament, lateral collateral ligament, popliteal tendon and lateral head of the gastrocnemius.

This classification system has received a few modifications, henceforth called modified Letenneur classification.[5] A variant of type I may be associated with articular comminution. Type II is subcategorized into IIa, IIb and IIc based on the size of the osteochondral fragment (Fig. 6). Type I and III fractures have a good prognosis owing to minimal disruption to the blood supply of the condyle, while type II has a higher risk of non-healing due to the poor blood supply, though this correlation has been refuted by Gavaskar et al.[20] and Lewis et al.[3]. Given the varied mechanisms of injury and complex fracture patterns observed, a lot of fractures also fall outside scope of this classification. However, it continues to be popular due to its simplicity and ease of application.

The AO-OTA classification classifies these injuries as a 33B3.2 for a unicondylar Hoffa fracture and a 33B3.3 for a bicondylar Hoffa fracture. The AO classification lacks further sub-classification of these injuries making this system feel incomplete.[21] Hence, Dua and Shamshery[22] have tried to supplement this classification to allow for surgical planning and optimization of outcomes. Bagaria et al.[23] gave a classification system based on CT scans. According to them, type 1 is with fracture fragment > 2.5 cm, type 2 with fragment < 2.5 cm, type 3 is comminuted fracture. And type 4 is subdivided into type 4a – anterior, type 4b – bicondylar, type 4c – osteochondral and type 4d – supracondylar extension. While more extensive, this classification system is difficult to apply precisely due to the very same reason. It fails to recognize the importance of posterior cortex comminution. However, it does give a more nuanced idea of management of a wider set of distal femoral fractures all of which do not fit into the classic Hoffa fracture pattern.

Chadrabose et al.[1] classified the fractures of the basis of CT scans (Fig. 7), in which considering all aspects of fracture morphology, it provides an accurate delineation of all fracture planes and comminution. According to the classification, type A has a single fracture line in the coronal plane, type B has a fracture line with articular comminution, and type C has additional fracture lines going towards the posterior cortex of the diaphysis resulting in instability. Type D is a combination of type B and type C.[1] This classification provides a simplified method of planning fracture fixation (Fig. 8).

Another CT based system given by Li et al.[24] allows the classification of comminuted femoral condyle fractures. They used the anatomic femoral line and a line parallel to the posterior femoral cortex to divide the condyle into 3 parts, and then studied the fracture line based on these 2 lines. A fracture line dividing the femoral condyle surface into 2 parts is classified as type I. Two fracture lines dividing the femoral condyle surface into 3 parts is type II. Three or more fracture lines dividing the femoral condyle surface into 4 or more parts is type III.

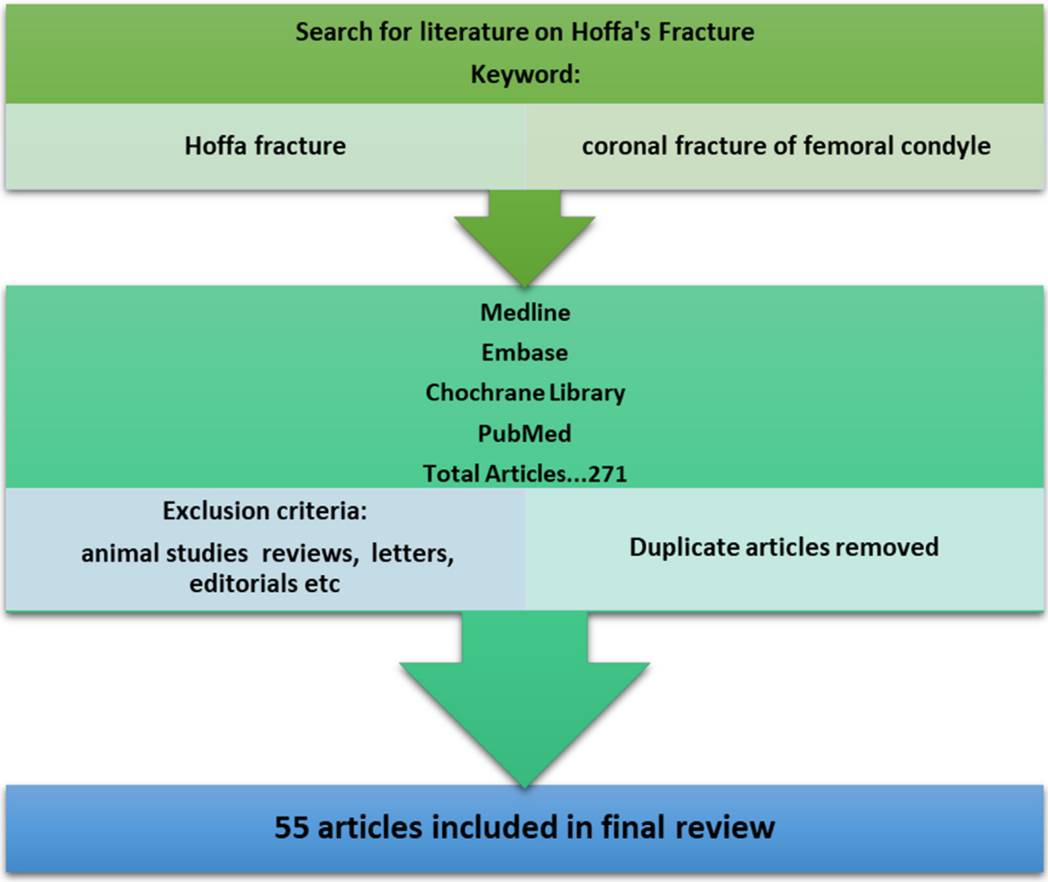

Fig. 5. Flowchart depicting the methods of selection.

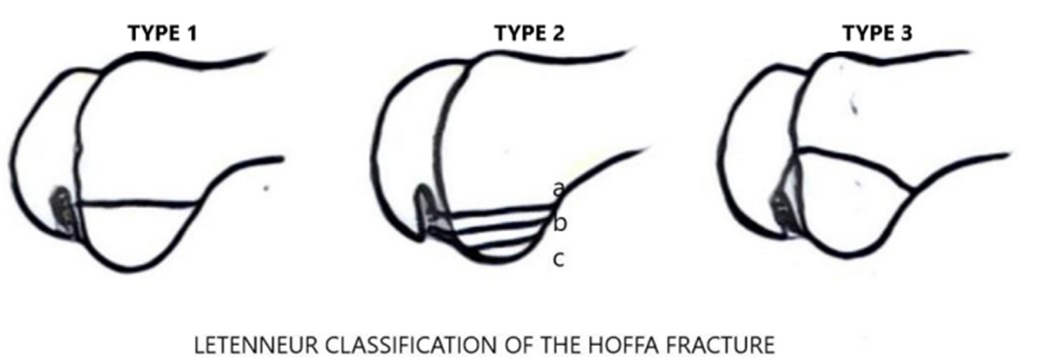

Fig. 6. The letenneur classification.

Diagnosis

Hoffa fracture is relatively difficult to diagnose especially when undisplaced.[22] For these fractures, a secondary survey needs to be conducted on patients with road traffic accidents. A heightened sense of suspicion is a key. Knee pain, swelling, skin color changes, limited knee mobility and a positive floating patella test should make the attending physician suspicious.[25–28] Ercin et al.[29] reported that medial or lateral stress test and anterior and posterior drawer test are positive in some patients. Instability may be encountered at 30° of flexion.[30]

The fracture may not be visible on X-rays as there was the bone overlap in both the anteroposterior view and lateral view. The radiographic array should include X-rays of the knee in anteroposterior, lateral, oblique and stress views. Oblique views might show undisplaced fractures, while conventional views do not.[31] CT scan is the gold standard for the diagnosis of Hoffa fracture.[32,33] MRI allows the assessment of soft tissues including the menisci, cruciates, collaterals and other soft tissues.[24]

Using 2D and 3D CT scans, Xie et al.[4] published a study of 75 Hoffa fractures, mapping the geometry and anatomy of Hoffa fractures. They mapped the fracture lines and comminution zones using both the axial and sagittal sets of images, and reconstructed

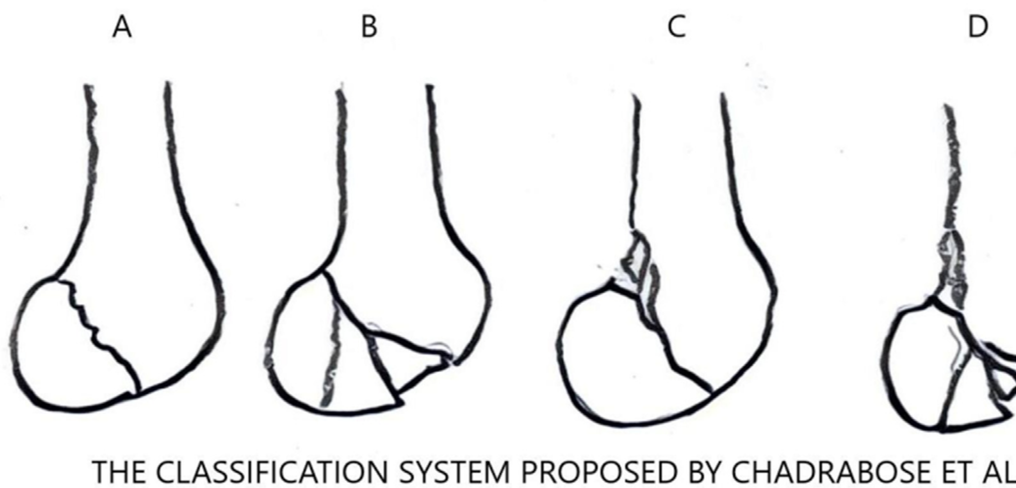

Fig. 7. The classification system of Chadrabose et al.[1]

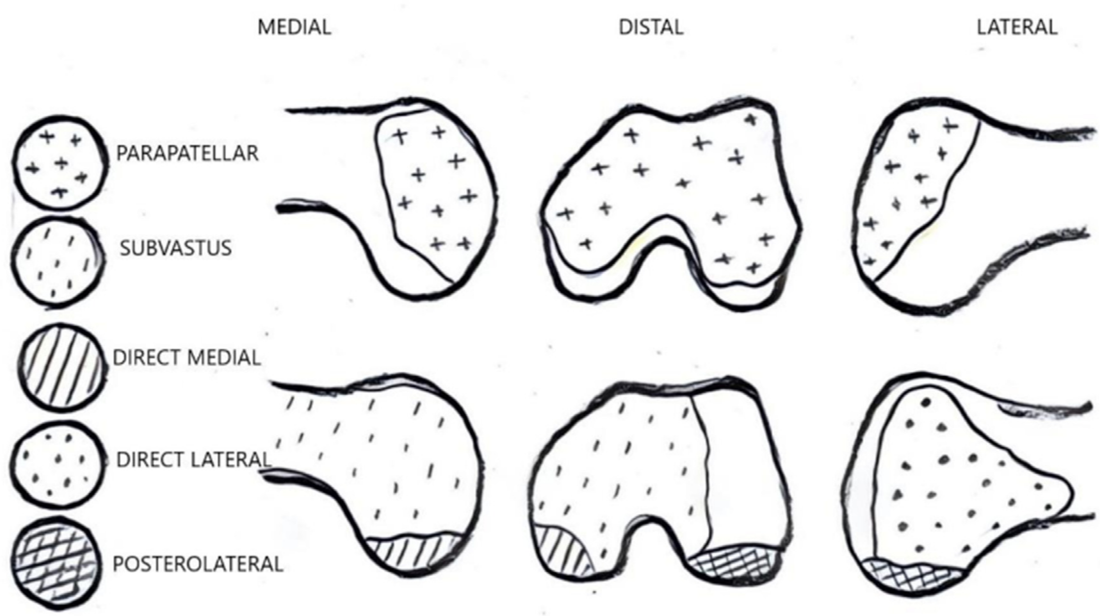

Fig. 8. The approach could be guided by the area involved.

the fracture fragments to fit a model of the distal femur using a 3D rendition of the fracture geometry. Both the axial and sagittal map showed that the fracture lines were concentrated in the middle-third area of the lateral condyle, and less commonly in the medial condyle. They also found that the weight-bearing zone of the lateral condylar articular surface frequently were in the comminution zone. They confirmed that the lateral Hoffa fractures are more common (64.5%) than medial condylar Hoffa fractures (35.5%).[4]

Implant choice

A classification of Chadrabose et al.[1] gave the very simplified implant choice. They recommended using 2 to 3 partially threaded cancellous lag screws (4 – 6.5 mm) for type A fractures, and using the posteroanterior screw if the posterior fragment is too small. Anatomical reduction and disimpaction are required for treating type B fracture. Smaller fracture fragments can be lagged with headless compression screws. They can be wedged between the larger fragments which are then lagged together. Type C fractures are fixed at the main coronal fracture with lag screws, but due to comminution, an antiglide plate is added to the posterolateral or posterior medial side to buttress the condyle. Type D requires a combination of modalities used for type B and type C. In bicondylar fractures, the fractures are assessed individually.

The use of several 3.5 mm diameter screws is recommended to fix fractures. A biomechanical study shown that several smaller diameter screws cause less damage to the joint cartilage than larger diameter screws, but both of them have the same tensile force.[34–36] Fixation with 2 or more screws can prevent rotation and rotational displacement.[37] The headless compression screws are selfcompressing, which allows a higher load limit with less soft tissue irritation.[25,38] Posteroanterior screw placement has a lower risk of displacement than anteroposterior placement.[36]

Patients who are expected to have a longer healing time and those with osteoporosis, metaphyseal extension and comminution are treated by a combination with screws and buttress plating.[39,40] The plate can be placed laterally or posteriorly as an antiglide implant.[24] New studies show that the lateral antiglide plate is biomechanically superior, which, in addition, can support a bone graft. The placement of posterior plates can also cause stripping of soft tissue and subsequent vascular side effects.[39]

Approaches

There is a minimal role for conservative treatment in the Hoffa fracture management. Undisplaced fractures if treated conservatively, should be immobilized in a cylindrical cast with the knee in 10° of flexion.[40,41] However, displacement, non-union and knee dysfunction can occur.[42–45] Like all intra-articular fractures, Hoffa fracture should also be fixed with the aims of stable anatomic reduction. Surgical planning depends on the location, characteristics, comminution and associated injuries.[18]

A proper surgical approach is important for achieving the best screw trajectory. Various screw techniques including anterior to posterior and posterior to anterior and plating are commonly used. The emerging trend of minimally invasive approach is also being tried in Hoffa fractures. Perhaps the most interesting paper written about the choice of the approach has been penned by Orapiriyakul et al.[46] They recommended approaches depending on the area of the condyle involved (Fig. 8).

The medial approaches include the medial parapatellar, medial subvastus, extensile medial subvastus and direct medial approach. The lateral approaches include the lateral parapatellar, posterolateral and direct lateral. The posterior approach can be used interchangeably with the posterolateral and posteromedial approaches.[46–49] For example, when the posterolateral approach is used to resolve the incision over the surface of the common peroneal nerve and biceps femoris, the nerve is retracted medially, and the tendon is retracted laterally to expose small fragments. Then, surgical sutures and autologous bone grafts can be absorbed for use fixed fragments.[50]

The steps of management are to determine the fracture size, determine reduction approach, and select the proper fixation technique.[46] If the medial condylar fragment is more than 28.7% of the anteroposterior diameter of the condyle or more than 19.9% of the lateral condyle, a parapatellar approach should be used. If the fragment size is small, a direct medial or posterolateral approach can be used. To achieve an anatomical fracture reduction, at least 2 sides of the bony surfaces have to be identified, which compose the articular surface and non-articular surface, either the outer side (lateral collateral ligament or medial collateral ligament side) or the inner side (cruciate ligament side). If the comminution is in the intermediate zone, i.e., between the anterior and posterior approach, a combination of those approaches should be considered. In cases of medial Hoffa fracture with comminution, a combination of approaches is recommended. Many fixation options can provide adequate stability in large Hoffa fractures using 6.5 mm anteroposterior cancellous screws with the thread crossing the fracture to allow inter-fragment compression. However, the Hoffa fragment should be used larger than 16 mm or 32 mm screws to permit adequate thread length. In small Hoffa fragments, posteroanterior headless screw fixation via the posterior approach is recommended. The use of antiglide plates can be augmented in large fracture fragments with metaphyseal extension and in cases where the screw fixation stability remains doubtful.

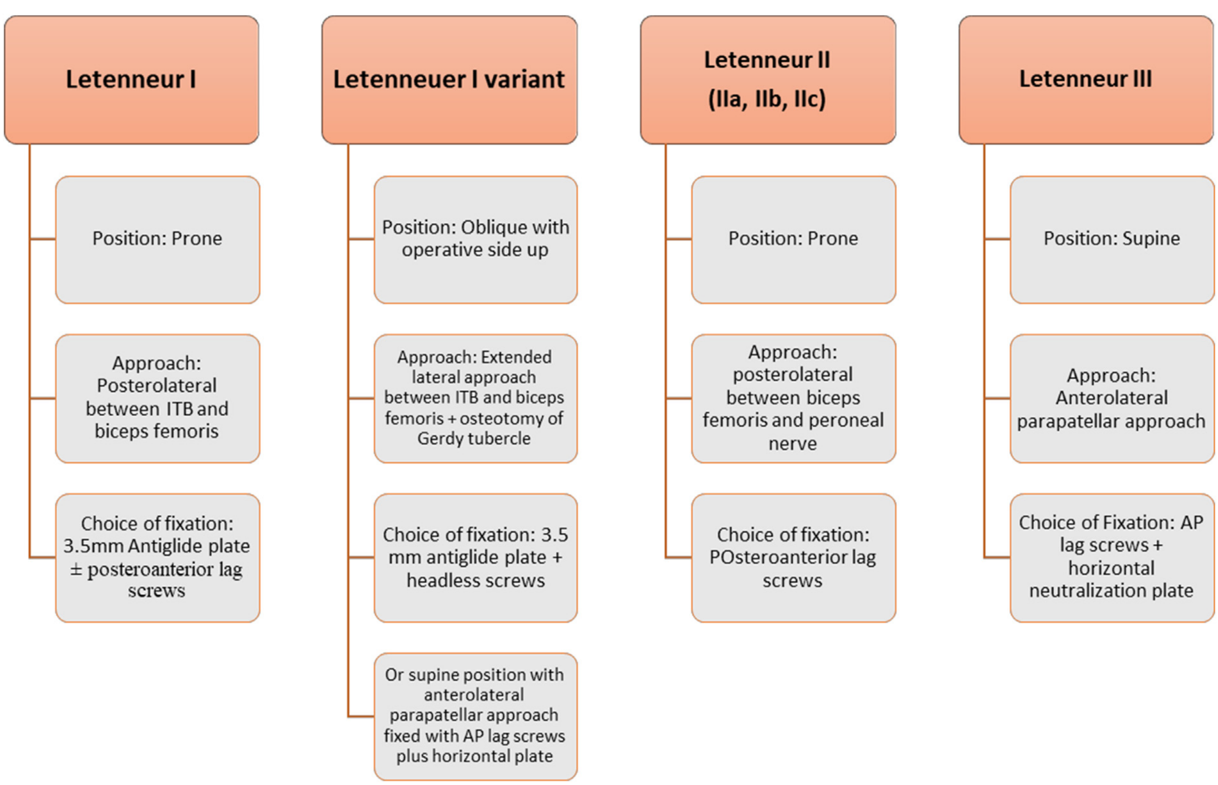

Fig. 9. Flowchart depicts planning and management of Hoffa fractures.

Table 1
The outcomes of various studies.

No.	Study	Age of patient (years)	Time interval between amputation and hip fracture	Type of amputation		Hip fracture	Method of traction/manipulation	Approach	Operative procedure
				Level	Unilateral or bilateral				
1	Boussakri et al.[11] (2015)	81	11 years	Above knee	Unilateral	Neck femur	Bone clamp in distal fragment	Hardinge	Bipolar hemi arthroplasty
2	Kandel et al.[8] (2009)	68	58 years	Above knee	Unilateral	Neck femur	Bone clamp in distal fragment	Posterior	Bipolar hemi arthroplasty
3	Perumal et al.[13] (2017)	75	Same acute traumatic event	Above knee	Unilateral	Neck femur	Two Schantz pin in distal fragment perpendicular to each other	Lateral	Bipolar hemi arthroplasty
4	Berg et al.[2] (2014)	58	________	Above knee	Bilateral (Fractured side - above knee, Unaffected side - below knee)	Neck femur	Fractured limb (above knee stump): Steinman pin in distal femur attached to traction bow with traction arm. Unaffected limb (below knee stump): placed into standard stirrup with hip flexed and abducted and secured with straps and crepe bandage	Closed reduction	DHS
5	Meena et al.[10] (2015)	28	2 months	Above knee	Unilateral	Neck femur	________	Watson Jones	DHS with valgus osteotomy
6	Freitas et al.[4] (2015)	28	11 years	Above knee	Unilateral	Neck femur	Schantz pin at level of Lesser trochanter	Closed reduction	CC screw fixation (3)
7	Anjum et al.[7] (2006)	22	______	Below knee	Unilateral	Neck femur	Skin traction attached to stump	Closed reduction	_____
8	Aqil et al.[6] (2010)	75	________	Above knee	Bilateral	Intertrochanter	Fractured limb stump: Thigh support of fracture table without any traction Unaffected limb stump: Bound firmly to gutter support in flexion and abduction	Closed reduction	DHS
9	Davarinos et al.[9] (2013)	51	________	Above knee	Unilateral	Intertrochanter	Stump firmly bound to traction end of traction table with adhesive fabric tape and crepe bandage	Closed reduction	DHS
10	Rethnam et al.[5] (2008)	73	_________	Below knee	Bilateral	Intertrochanter	Fractured limb stump: Radiolucent leg support of fracture table without any traction Unaffected limb stump: Bound firmly to leg support in flexion and abduction	Closed reduction	DHS
11	Ochi et al.[12] (2017)	97	68 years	Below knee	Unilateral	Intertrochanter	Al Harthy method- In fracture table, inverting the traction boot	Closed reduction	Cephalo-medullary nail (Gamma nail)
12	Present Study	50	Same acute traumatic event	Above knee	Bilateral	Neck femur right side	Fractured limb stump: Radiolucent table, Schantz pin in distal fragment (failed). Unaffected limb stump - Bound firmly to side attachment with roller bandage in flexion and abduction	Open reduction	CC screw fixation

-: not mentioned, DHS: dynamic hip screw, CC: cannulated cancellous.

In a paper published in 2018, Pires et al.[51] proposed an algorithmic treatment approach of Hoffa fractures based on modified Letenneur classification providing the advice regarding the approach and choice of fixation for corresponding type of fracture. Their recommendations are summarized in the following flowchart (Fig. 9 and Table 1). Arthroscopy has also been used to reduce and fix Hoffa fractures. However, it is difficult to dissect fragments for reduction and to place the screws perpendicular to the fracture line.[52,53]

Outcomes

Conservative management has universally shown unsatisfactory results and non-union. Therefore, open reduction with internal fixation is mandatory for good clinical outcomes.[8] Lewis et al.[3] reported good and fair results in surgically treated cases, but poor outcomes in conservatively managed cases. Gavaskar et al.[20] concluded that the best treatment was anatomical reduction and rigid fixation followed by early mobilization.

Screw fixation is generally accepted as a standard method for treating Hoffa fractures, but internal fixation methodology is evolving continually.[8] At least 2 screws placed parallel to each other provide reasonable biomechanical stability.[16,17] However, some studies have proposed a crossed screw method too.[54,55] Trikha et al.[5] performed a retrospective review of 32 patients with operatively treated Hoffa fractures, of which 21 (65.63%) were seen in the lateral femoral condyle and 11 (34.38%) in the medial condyle, and all of them were followed up for a period of at least 1 year (range 1–5 years). They observed that cancellous lag screws and/or antiglide plates were used in all patients as per fracture anatomy. They used knee society score, international knee documentation committee score and knee ROM at final follow-up for functional evaluation. The authors observed that all fractures united by the mean time of (11.56 ± 1.50) weeks and functional scores at the final follow-up were good to excellent (knee society score (83.19 ± 8.43), and international knee documentation committee score (81.62 ± 6.95)). Although the mean ROM was (116.41 ± 13.98) degrees, 4 patients developed stiff knees. No case of neurovascular injury, subsequent displacement or fixation failure, arthritis or avascular necrosis of femoral condyle was seen. One patient who developed infection had to undergo implant removal after fracture union.[5]

In conclusion, as an uncommon injury, the Hoffa fracture is often difficult to diagnose and may be susceptible to improper treatment. Accurate classification helps in proper planning. The key to achieve good outcome is anatomical reduction of the fracture, stable and rigid fixation using a proper implant, while maintaining the blood supply by choosing the optimum approach. Early mobilization ensures that the fruits of the surgeon's efforts and patient's patience are borne.

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Ethical statement

The research was conducted as per the guidelines of the ethical committee.

Declaration of competing interest

The author reports no conflict of interest in the formulation of this manuscript.

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Author contributions

Muzaffar Mushtaq and Shabir Ahmed Dhar wrote the initial draft of the manuscript and Tariq Ahmed Bhat and Tahir Ahmed Dar helped in assessing the literature assessment and the revision.

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