An Uncommon Trauma: Hoffa's Fracture Associated with Tibial Avulsion Fracture of the Posterior Cruciate Ligament

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Case report

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Abstract

Background

Since Hoffa fractures are usually the result of high-energy injuries, many additional accompanying injuries have been described. This is the first paper representing the lateral condyle Hoffa fracture accompanying tibial avulsion fracture of the posterior cruciate ligament (PCL).

Case Presentation

A 42-years-old male presented with swelling and instability in his left knee after falling during parachute landing. He was diagnosed with simultaneous Letenneur Type I lateral condyle Hoffa fracture and tibial avulsion fracture of the PCL. He was operated on with a single posterior incision for both fractures. Multiple cannulated lag screws were used for the fixation of the Hoffa fracture, and a buttress plate was used for additional stability. PCL avulsion fracture was fixed with a cannulated screw with a washer. The patient was allowed for full-weight-bearing and range of motion at the sixth week after the operation. No complications occurred during follow-up.

Conclusion

Care should be taken in terms of additional injuries that may accompany Hoffa fractures. The posterior approach allows easy access to both fractures with a single incision. Using a buttress plate after the fixation of the Hoffa fracture with multiple lag screws provides additional stability.

Background

Coronal fracture of the distal femur is called Hoffa's fracture, and medial or lateral condyle may be included [1]. This fracture pattern is classified as Type B3.2 in AO classification[2]. Generally, the mechanism of the injury is a direct impact when the knee is flexed, caused by high-energy traumas. The main cause of these fracture patterns is known as traffic accidents (80,5% of the patients), especially motorcycle crashes[3; 4]. Unicondylar femoral fracture is a very rare type of fracture that represents 0,65% of all femoral fractures[5]. While Hoffa fractures are generally seen as isolated fractures, they can sometimes be seen with different accompanying injuries. Femoral shaft and supracondylar fractures, dislocations of the knee, eminentia fractures, patellar tendon ruptures, patella fractures, and patellar dislocation are the reported associated injuries with Hoffa's fracture [6; 7].

This type of fracture is likely to be missed in the first standard radiographic evaluation in the emergency department. The trauma series radiographs and computed tomography (CT) are essential for diagnosing this unique fracture type. Also, magnetic resonance imaging (MRI) could help to diagnose associated injuries.

Avulsion fractures of the posterior cruciate ligament (PCL) are also rare injury types. Knee hyperextension or direct force pushing the tibia posteriorly when the knee is flexed are the possible injury mechanisms [8;
To our knowledge, lateral condylar Hoffa fracture associated with a tibial avulsion fracture of the PCL has not been reported before. We want to present our patient with this unusual trauma that occurred with parachuting.

**Case Presentation**

A 42-years-old male patient had a falling accident during a parachute landing. After the injury, he was admitted to the emergency service of the local state hospital; his plain radiographs (Fig. 1), CTs (Fig. 2,3), and MRI (Fig. 4) were taken, and he was informed about the need for the surgery because of the lateral femoral condyle Hoffa fracture and associated tibial avulsion fracture of the PCL. A long leg cast was applied, and he was discharged because he wanted to be operated in another center. Then he applied to our outpatient clinic three days after the injury, and he was hospitalized to be operated on.

At the presentation, the cast was removed for the examination, and it was seen that the knee edema was not as severe as to prevent the operation, and the neurovascular condition was good. After the tomography and X-Ray results are examined, Hoffa fracture is classified as Letenneur Type I[10], and Type I of the Bagaria classification[11]. It was planned preoperatively to perform the open reduction and fixation of Hoffa's fracture with more than two screws and support the fixation with a buttress plate. Also, it was aimed to perform a fixation to the tibial avulsion of the PCL with the same incision with a lag screw. After the preoperative preparations are completed, he was operated in the day of hospitalization.

Under general anesthesia, the patient was examined, and a marked posterior drawer test due to the PCL avulsion was present. Lachman and anterior drawer tests were negative; however, lateral opening with varus stress test was obtained due to the lateral condyle Hoffa's fracture. In our MRI examination, we thought that there might be a suspicious injury due to the corrugation appearance in the anterior cruciate ligament (ACL), and the ACL was found to be loose as a result of the examination under anesthesia. It was decided to reexamine the ACL after lateral condyle fracture fixation to determine whether this was due to the injury of the ACL or the fracture of the lateral condyle to which the ACL was attached.

The patient was positioned prone, and a lazy S-shaped skin incision in the popliteal fossa was made and extended proximally and distally (Fig. 5A). The proximal side of the incision was started in the lateral side of the thigh to reach the lateral condyle easily, and after the transverse part on the popliteal fossa, it was extended to the medial cruris. Dissection was performed, and the common peroneal nerve was identified (Fig. 5B). To reach the lateral condyle Hoffa fracture, biceps femoris muscle was retracted laterally; simultaneously, the common peroneal nerve was retracted medially as Tan et al. described [12]. After irrigation of the fragments to remove the bone clots, the fracture was exposed clearly. Once the reduction was made, the fixation was carried out with three 4,5 mm cannulated, partially threaded cancellous screws as a lag screw. Afterwards, fracture fixation is augmented with a buttress plate to achieve anti-shearing strength and provide stable support (Fig. 5C). The plate was placed posteriorly due to the fracture line. Then, the reduction and fixation were checked with fluoroscopy. After that, the interval
between the medial head of gastrocnemius and semimembranosus was used to reach the tibial avulsion fracture site of PCL as described by Burks and Schaffer[13]. To expose the posterior capsule, the gastrocnemius muscle was retracted laterally. After capsulotomy, the avulsion fracture of PCL was reached. With irrigation, blood clots were removed from the fracture site, and then bone bed was prepared. After anatomic reduction was achieved, fixation was completed using a 4.5 mm cannulated, partially threaded cancellous screw with a washer. Fixation was checked under fluoroscopy, and then anterior and posterior drawer tests were performed gently to check PCL and ACL, and the stability was confirmed. Thus, it was observed that the ACL injury, which we suspected in the preoperative MR images and the examination under anesthesia, was due to the lateral condyle fracture and disappeared after fixation. A hinged, long leg brace was applied and locked in 0° knee extension.

During the first week after the operation, the knee was kept in full extension, and leg rises were instructed several times a day. In the second week, the continuous passive motion (CPM) device was started with full extension and 60-degree flexion. Isometric and passive ROM exercises were gradually increased as tolerated for three weeks. On the fifth week of the operation, the callus formation was observed with a plain radiograph and started weight-bearing as tolerated. At the end of the sixth week, the patient was allowed full weight-bearing and active ROM. After the operation, the patient was called for routine polyclinic controls, and radiological and clinical follow-ups were performed (Fig. 6,7). No complications were encountered in the follow-up of the patient.

**Conclusion**

The mechanism of occurrence of Hoffa fracture is not fully understood[12]. The most likely scenario is when the knee flexes >90°, and an axial force in the varus or valgus direction is transferred from the proximal femur to the femoral condyle[3; 14]. When the high-energy trauma reaches the distal femur, the lateral condyle is often damaged before the medial condyle due to the physiological genu valgus of the knee joint. Therefore, in Hoffa fractures, lateral condyle fractures are more common than medial condyle fractures[15; 16]. The use of conservative treatment is very limited, Thus it can be attempted only in non-displaced fractures, considering the loss of reduction is very common[4]. Due to the fact that Hoffa fractures are intra-articular and need for a perfect reduction, surgical intervention is required for successful treatment.

PCL tibial-sided bony avulsion is one of the rarest patterns of PCL injuries[17] and is usually seen after motorcycle injuries. Conservatively treated displaced PCL bony avulsion outcomes were not successful, so that surgical intervention to achieve anatomic reduction and stable fixation is recommended for displaced fractures[8]. We preferred the plane between the semimembranosus and medial head of gastrocnemius to reach the PCL bony avulsion after the fixation of lateral condyle Hoffa fracture as described by Burks and Schaffer[13]. This approach is very helpful for the surgeon because the neurovascular bundle is protected and does not have to be explored by retracting medial gastrocnemius laterally, and it provides the surgeon a safe and good visualization. We preferred cannulated screws with a washer for fixation, as suggested by many studies previously[9; 18; 19].
It seems to be the first paper that presented the tibial side PCL bony avulsion accompanying lateral condyle Hoffa fracture. In a recent comprehensive review, literature was searched for Hoffa's fracture and associated injuries around the knee joint, and 11 of 187 papers were selected as eligible for the study, and none of the studies reported an injury similar to our case[7]. Only one case was reported as a PCL injury, not the PCL bony avulsion, by Ocguder et al. [6], and their case was presented as tibial eminentia fracture with PCL injury from femoral side attachment associated with medial condyle Hoffa fracture. They treated the PCL injury by re-attaching with an anchor.

Although the patient has not fully explained the mechanism of the injury, we think that this injury occurred as a result of direct hitting the ground while the knee is flexed during parachute landing; first, the Hoffa fracture of the femur lateral condyle occurred, and then, as a result of the posterior displacement of the tibia, bony avulsion of the PCL was revealed.

We chose the surgical treatment option because both fractures were intra-articular, and they play an essential role in the stability of the knee. It is mandatory to achieve a perfect reduction and stable fixation, which could be achieved only with good exposure. We applied the posterior approach, preferring to reach both fractures with a single incision. We modified the incision by extending its proximal-lateral leg to place the buttress plate that we planned for the Hoffa fracture. The most crucial step to reach the lateral condyle safely is identifying the common peroneal nerve in this approach. By retracting the common peroneal nerve gently to medial and biceps femoris muscle laterally, it becomes straightforward to reach the fracture. Additionally, we prepared a suitable area for the plate by stripping the gastrocnemius muscle's lateral head towards the proximal of the fracture line gently. The distal portion of the incision allows a convenient approach to reach the PCL bony avulsion site. We did it comfortably by retracting the gastrocnemius muscle laterally without the need to explore any vascular or nerve structures. Kapoor et al. reported that they used a direct posterior approach with lazy-S incision for open reduction and internal fixation of medial Hoffa fracture Type IIc with two posteroanterior Herbert screws[20].

Fixation of the Hoffa fractures used to be provided by the lag screw technique using cancellous or cortical screws; or using headless compression screws. Whichever type of screw is used for fixation, it is recommended to use two or more screws to prevent rotational displacement[21]. Although several studies reported that good clinical outcomes were achieved using larger diameters of cancellous screws as 6, 5 or 7 mm[22; 23]; using a larger number of smaller diameter screws has the advantage of having the same tensile strength while causing less damage to the articular cartilage[24; 25]. Apart from the need for countersink and the time spent for this in the operation, the inability to provide sufficient compression are the disadvantages of the use of cancellous screws. But no need to countersink and no soft tissue irritation are the advantages of headless compression screws[26]. In addition, headless screws provide higher axial compression, resulting in increased fracture stability[27]. Also, the direction of the screw insertion is essential for stability; it was shown that posterior to anterior directed lag screws provided more stable fixation than anterior to posterior[24].
Using a buttress plate to achieve additional stability in the treatment of Hoffa fractures is recommended by many authors[28; 29]. 1/3 tubular plate, reconstruction plate, or LCP plate could be used for buttress effect added to the lag screws[26; 29; 30]. It could be placed posterior or laterally according to the extension of the fracture line and position of the screws. A recent biomechanical study showed that positioning the buttress plate laterally provides greater anti-shearing strength than posteriorly[31]. Also, the lateral placement of the buttress plate does not require stripping the gastrocnemius lateral head as in its posterior placement; it does not have the risk of causing problems with the blood supply of the fracture fragments.

Considering the rules on fixation and stability of the Hoffa fracture mentioned above, the posteroanterior direction of lag screws placement and supporting the fracture site with a buttress plate are advantageous for the fracture stability in our patient. Posterior placement of the buttress plate and the use of the cancellous screws, not the headless screws, could be counted as the disadvantages of our technique according to the literature. However, we did not encounter any problems in terms of fracture healing and joint functions. At the end of the third month after the surgery, the patient reached the full range of motion and full weight-bearing without any pain or limitation.

In conclusion, Hoffa fracture generally occurs due to high-energy trauma and is often accompanied by additional pathologies. Lateral condyle Hoffa fracture accompanying tibial avulsion fracture of the PCL has not been reported yet. The posterior approach is advantageous in that it enables us to reach both fractures with a single incision. Perfect reduction and stable fixation of these two simultaneous intra-articular fractures are essential. Using a buttress plate was useful for augmentation after the fixation of the Hoffa fracture with the lag screws.

**Abbreviations**

- **PCL**: Posterior cruciate ligament
- **ACL**: Anterior cruciate ligament
- **ROM**: The range of motion

**Declarations**

**Conflict of interest**: The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

**Ethical approval**: This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Acibadem University (Date 21.02.2021 /No. 2021-
Consent to participate: Informed consent was obtained from the individual participant included in the study.

Consent to publish: Written informed consent was obtained from the patient for publication of this Case report and any accompanying images. A copy of the written consent is available for review by the Editor of this journal.

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Author contributions

BC collected and analyzed the data of the patient and was a major contributor in writing the manuscript. SK has drafted the work and substantively revised it. All authors contributed to the study conception and design. All authors read and approved the final manuscript

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References

1. Hoffa A. Lehrbuch der Frakturen und Luxationen. Stuttgart: Verlag; 1904.
2. (1996) Fracture and dislocation compendium. Orthopaedic Trauma Association Committee for Coding and Classification. J Orthop Trauma, 10 Suppl 1:v-ix, 1-154.
3. White EA, Matcuk GR, Schein A, et al. Coronal plane fracture of the femoral condyles: anatomy, injury patterns, and approach to management of the Hoffa fragment. Skeletal Radiol. 2015;44(1):37–43.
4. Zhou Y, Pan Y, Wang Q, Hou Z, Chen W. Hoffa fracture of the femoral condyle: Injury mechanism, classification, diagnosis, and treatment. Med (Baltim). 2019;98(8):e14633.
5. Manfredini M, Gildone A, Ferrante R, Bernasconi S, Massari L. Unicondylar femoral fractures: therapeutic strategy and long-term results. A review of 23 patients. Acta Orthop Belg. 2001;67(2):132–8.
6. Ocguder A, Bozkurt M, Kalkan T, Ugurlu M, Kiliçarslan K. Hoffa fracture, eminentia fracture and posterior cruciate ligament damage: An unusual knee injury. Injury Extra. 2008;39:88–91.
7. Pathak S, Salunke A, Karn S, et al. Hoffa’s Fracture with Associated Injuries Around the Knee Joint: An Approach to a Rare Injury. Cureus. 2020;12(4):e7865.
8. Hooper PO 3rd, Silko C, Malcolm TL, Farrow LD. Management of Posterior Cruciate Ligament Tibial Avulsion Injuries: A Systematic Review. Am J Sports Med. 2018;46(3):734–42.
9. Katsman A, Strauss EJ, Campbell KA, Alaia MJ. Posterior Cruciate Ligament Avulsion Fractures. Curr Rev Musculoskelet Med. 2018;11(3):503–9.

10. Letenneur J, Labour PE, Rogez JM, Lignon J, Bainvel JV. [Hoffa's fractures. Report of 20 cases (author's transl)]. Ann Chir. 1978;32(3–4):213–9.

11. Bagaria V, Sharma G, Waghchoure C, et al. A proposed radiological classification system of Hoffa's fracture based on fracture configuration and consequent optimal treatment strategy along with the review of literature. SICOT J. 2019;5:18.

12. Tan Y, Li H, Zheng Q, Li J, Feng G, Pan Z. A modified posterolateral approach for Hoffa fracture. Eur J Orthop Surg Traumatol. 2014;24(7):1321–3.

13. Burks RT, Schaffer JJ. (1990) A simplified approach to the tibial attachment of the posterior cruciate ligament. Clin Orthop Relat Res(254):216–219.

14. Gavaskar AS, Tummala NC, Krishnamurthy M. Operative management of Hoffa fractures—a prospective review of 18 patients. Injury. 2011;42(12):1495–8.

15. Jain A, Aggarwal P, Pankaj A. Concomitant ipsilateral proximal tibia and femoral Hoffa fractures. Acta Orthop Traumatol Turc. 2014;48(4):383–7.

16. Sharath RK, Gadi D, Grover A, Gour SK. Operative Treatment of Isolated Bicondylar Hoffa Fracture With a Modified Swashbuckler Approach. Arch Trauma Res. 2015;4(4):e25313.

17. Giordano BD, Dehaven KE, Maloney MD. Acute femoral "peel-off" tears of the posterior cruciate ligament: technique for arthroscopic anatomical repair. Am J Orthop (Belle Mead NJ). 2011;40(5):226–32.

18. Keyhani S, Soleymanha M, Salari A. Treatment of Posterior Cruciate Ligament Tibial Avulsion: A New Modified Open Direct Lateral Posterolateral Approach. J Knee Surg; 2020.

19. Seitz H, Schlenz I, Pajenda G, Vecsei V. Tibial avulsion fracture of the posterior cruciate ligament: K-wire or screw fixation? A retrospective study of 26 patients. Arch Orthop Trauma Surg. 1997;116(5):275–8.

20. Kapoor C, Merh A, Shah M, Golwala P. A Case of Distal Femur Medial Condyle Hoffa Type II(C) Fracture Treated with Headless Screws. Cureus. 2016;8(9):e802.

21. Ostermann PA, Neumann K, Ekkernkamp A, Muhr G. Long term results of unicondylar fractures of the femur. J Orthop Trauma. 1994;8(2):142–6.

22. Lewis SL, Pozo JL, Muirhead-Allwood WF. Coronal fractures of the lateral femoral condyle. J Bone Joint Surg Br. 1989;71(1):118–20.

23. Viskontas DG, Nork SE, Barei DP, Dunbar R. Technique of reduction and fixation of unicondylar medial Hoffa fracture. Am J Orthop (Belle Mead NJ). 2010;39(9):424–8.

24. Jarit GJ, Kummer FJ, Gibber MJ, Egol KA. A mechanical evaluation of two fixation methods using cancellous screws for coronal fractures of the lateral condyle of the distal femur (OTA type 33B). J Orthop Trauma. 2006;20(4):273–6.
25. Westmoreland GL, McLaurin TM, Hutton WC. Screw pullout strength: a biomechanical comparison of large-fragment and small-fragment fixation in the tibial plateau. J Orthop Trauma. 2002;16(3):178–81.

26. Min L, Tu CQ, Wang GL, et al. Internal fixation with headless compression screws and back buttress plate for treatment of old Hoffa fracture. Chin J Traumatol. 2014;17(2):79–83.

27. Somford MP, van Ooij B, Schafroth MU, Kloen P. Hoffa nonunion, two cases treated with headless compression screws. J Knee Surg. 2013;26(Suppl 1):89–93.

28. Soni A, Sen RK, Saini UC, Singh D, Chaudhary S. Buttress plating for a rare case of comminuted medial condylar Hoffa fracture associated with patellar fracture. Chin J Traumatol. 2012;15(4):238–40.

29. Tetsunaga T, Sato T, Shiota N, et al. Posterior buttress plate with locking compression plate for Hoffa fracture. J Orthop Sci. 2013;18(5):798–802.

30. Kaul R. Buttress plate-assisted fixation for lateral hoffa fractures: A case report and review of literature. J Mar Med Soc. 2020;22:250–4.

31. Sun H, He QF, Huang YG, Pan JF, Luo CF, Chai YM. Plate fixation for Letenneur type I Hoffa fracture: a biomechanical study. Injury. 2017;48(7):1492–8.

Figures
Figure 1

Preoperative radiographs of the knee a Anteroposterior and b Lateral, black arrow shows lateral condyle Hoffa fracture, and white arrow shows tibial avulsion fracture of the posterior cruciate ligament. It is seen that these types of fractures are challenging to detect by standard radiographic evaluation.

Figure 2

Preoperative computed tomography images of the knee a Sagittal image, the white arrow shows lateral condyle Hoffa fracture, b Sagittal image, the white arrow shows tibial avulsion fracture of the posterior cruciate ligament, c Coronal image, the white arrow shows lateral condyle Hoffa fracture, d Coronal image, the white arrow shows tibial avulsion fracture of the posterior cruciate ligament, e Axial image, the white arrow shows lateral condyle Hoffa fracture, The size of the fragment is >2.5 cm from the tip of the posterior-most point of the posterior condyle, and therefore it was classified as Type 1 of the Bagaria classification.
Figure 3

a and b Preoperative three-dimensional reconstructed computed tomography images, black arrow shows lateral condyle Hoffa fracture, white arrow shows tibial avulsion fracture of the posterior cruciate ligament.

Figure 4
Preoperative Magnetic resonance images of the knee a Sagittal PD image, the white arrow shows lateral condyle Hoffa fracture b Sagittal PD image, the white arrow shows tibial avulsion fracture of the posterior cruciate ligament c Axial T1 image, the white arrow shows lateral condyle Hoffa fracture.

![Preoperative Magnetic resonance images of the knee](image)

**Figure 5**

Intraoperative images a The patient was positioned prone, and a lazy-S skin insicion was used for approach. b After incision, the common peroneal nerve was dissected by passing through the skin layers. c After the reduction and fixation of the lateral condyle Hoffa fracture, the view after the placement of the antiglide plate.

![Intraoperative images](image)

**Figure 6**

Postoperative radiographs of the knee a Anteroposterior, b Lateral views.

![Postoperative radiographs of the knee](image)
Figure 7

Postoperative computed tomography images shows fixation of the fractures a, b Sagittal images, c Axial image