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Femoral head impaction fracture: a new technique for closed reduction and biological stabilisation

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SUMMARY

Impaction femoral head fractures are seldom diagnosed or treated, even though they can be present in between 39% and 57% of acetabular-fracture dislocations or hip dislocations. These fractures can cause residual hip pain, instability, avascular necrosis (AVN) and early joint wear, potentially necessitating a total hip arthroplasty. Treatment options range from expectant management, which carries a high risk of AVN, to controlled hip dislocation and mosaicplasty, the latter demonstrating variable results.

We present the case of a woman in her 50s with an impaction femoral head fracture treated via closed reduction with a bent rod using a predrilled tunnel created with the dynamic hip screw reamer, followed by biological stabilisation with allografts, bone morphogenetic protein-2 and stem cells to provide the appropriate environment for bone healing. This minimally invasive technique offers a viable treatment option for impaction femoral head fractures, with low morbidity and favourable short and mid-term follow-up outcomes. Further studies can validate the results of this technique.

BACKGROUND

Hill-Sachs-type impaction fractures of the femoral head were first described in 1990 as a cause of hip instability.[1 2] This term refers to the well-studied wedged impaction fracture of the proximal humerus secondary to a shoulder dislocation. Impaction fractures of the femoral head may occur following a hip dislocation or a fracture dislocation of the acetabulum. They present as an indentation of the femoral head caused by its impact with the acetabular rim.

Femoral head fractures occur in 6%–15% of hip dislocations,[3] but impaction fractures are rarely diagnosed and may go undetected in plain radiographs or even CT scans.[1] Poletti *et al* reported a prevalence of 39% in patients with acetabular fractures when evaluated with a CT scan and 57% in cases of hip dislocation.[4]

Similarly to the shoulder joint, the location of the impaction fracture correlates with the direction of the hip dislocation and might be the sole indicator of a dislocation in cases of instantaneous hip relocation.[5] Noteworthy, as in the shoulder, impaction injuries of the femoral head can be a source of instability, redislocation and development of avascular necrosis (AVN) and degeneration at a later stage.[6]

Although the Pipkin classification[7] has been widely used to classify and treat femoral head fractures, it does not consider the presence of focal cortical impactions (subchondral notches).[4] Despite impaction fractures being more often related to dislocations or fracture dislocations, they can also occur in their absence. This can occur due to various mechanisms, and in the absence of a dislocation, the impaction of the femoral head is usually superior.[4]

Patients with larger impaction fractures are at a higher risk of conservative management failure due to potential complications such as AVN of the femoral head or osteoarthritis, increasing the likelihood of requiring a total hip arthroplasty (THA) in their subsequent years.[4 5 8]

Several techniques have been described to treat impaction fractures of the femoral head, ranging from THA, chondrocyte transplantation and mosaicplasty,[9] some of which may require a hip dislocation.

We describe a technique for femoral head disimpaction using closed reduction methods followed by augmentation of the subchondral void created with biological-based therapies.

CASE PRESENTATION

A woman in her 50s, driver of the car, was brought by ambulance to the emergency department (ED) following a road traffic accident having sustained multiple injuries. She was immobilised in a spinal board. She was managed according to the advanced trauma life support protocol. As she was haemodynamically unstable (blood pressure 90/70 mm Hg and pulse rate 120 beats per minute), she received blood products and volume replacement. The patient was reporting bilateral groin pain, unable to move both hips, thoracic pain, difficulty in breathing and pain in her left heel. There was no neurovascular deficit in the lower extremities.

INVESTIGATIONS

Anterior–posterior (AP) and lateral chest X-rays revealed multiple rib fractures; a trauma CT scan revealed lung contusion bilaterally, multiple bilateral rib fractures, a left acetabulum fracture-dislocation and a right ischiopubic ramus fracture with an ipsilateral impaction femoral head fracture (figure 1). Furthermore, a left calcaneal fracture was diagnosed. The right femoral head impaction fracture was classified as 31.C2.2 according to the OTA/AO classification.[10]

TREATMENT

The left hip fracture dislocation was reduced promptly in the theatre and the patient was then taken for supportive care to the intensive care unit

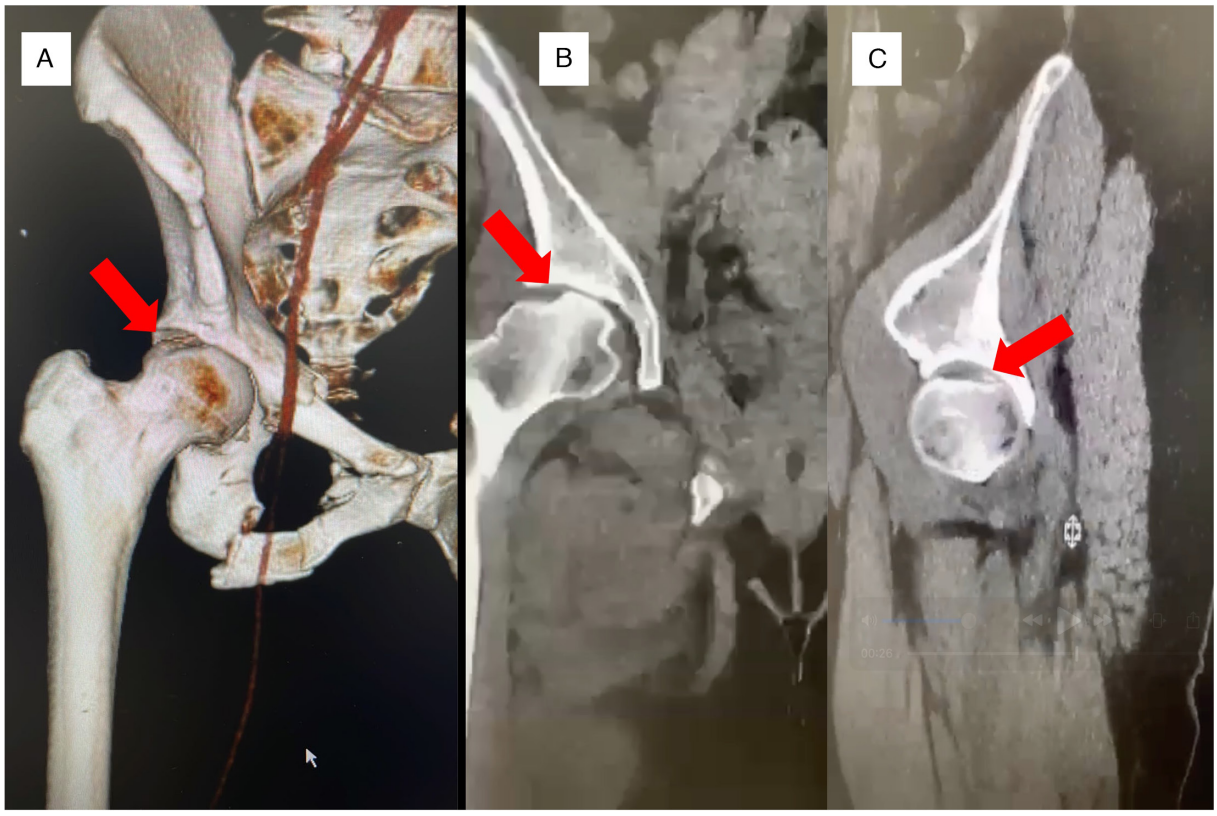

Figure 1 (A) Three-dimensional pelvic reconstruction model. (B) Slice of coronal CT. (C) Slice of sagittal CT; red arrows point at the impacted right superior lateral femoral head impacted lesion.

due to the chest injury. Due to the lung contusion sustained and the necessity to undergo prolonged reconstruction of the bilateral hip injuries, the patient was managed with the prompt individualised safe management protocol.[11] 7 days later, when the patient had been physiologically optimised and the respiratory system was no longer a concern, she was taken to the operating room. The operative plan was discussed with the patient and written informed consent was obtained.

A dose of prophylactic antibiotics was administered 30 min prior to the incision, followed by asepsis procedures and the placement of surgical drapes. The patient was positioned prone on a radiolucent table. Using a Kocher-Langenbeck approach, the left acetabular fracture was treated with open reduction and internal fixation using a combination of three reconstruction plates and a posterior to anterior column screw (cannulated 7 mm). The right pubic ramus was also stabilised with a 7.0-mm cannulated screw.

After confirming the patient's haemodynamic stability, another dose of prophylactic antibiotic was administered. The patient was then transferred and positioned supine on a fracture table. Using a traction table, at approximately the level of the lesser trochanter, a mini-open lateral hip approach was performed. Dissection was carried out in layers using a retrovastus approach to the lateral cortex of the femur. A guide wire was directed to the subchondral position of the femoral impaction area under fluoroscopic guidance. Once the position was verified using AP, lateral and oblique view of the femoral head, the dynamic hip screw (DHS) triple reamer was employed over the previously placed guide wire. After creating the tunnel with the DHS reamer, a 4-mm rod was prebent to achieve an approach angle as perpendicular as possible to the impaction area of the femoral head. Using a T-handle chuck, the Nancy nail was advanced to the centre of the subchondral depression through the bone tunnel that had been created, and the articular surface was elevated with a hammer under fluoroscopic guidance (figure 2A–D).

Once the spherical shape of the femoral head was restored, the nail was removed and the tunnel along the subchondral defect was grafted with a mixture of bone marrow aspirate (harvested from the right iliac crest), allograft cylindrical blocks and bone morphogenetic protein - 2 (BMP-2), (figure 2E–H). Finally, the wound was washed out and closed in layers.

OUTCOME AND FOLLOW-UP

Due to the multiple injuries sustained, the patient remained hospitalised for several weeks. During this time, the physical therapy team initiated a range of passive and active motion exercises of both hip joints. Full weight bearing started after a period of 12 weeks. Physiotherapy sessions included strengthening and stretching exercises of all hip muscle groups, lumbar spine and lower extremities. Three times a week, the rehabilitation protocol included cycling sessions without resistance, swimming and walking on the treadmill. The duration and intensity of the sessions were gradually increased every 4 weeks.

Clinical and radiological follow-up investigations were conducted at 1, 3, 6, 12 and 24 months. No signs of AVN were detected radiologically, and the patient remains clinically asymptomatic at the 2 years follow-up (figure 3). The Harris hip score was excellent (91 points).[12]

DISCUSSION

Isolated traumatic femoral head impaction fractures are rare and often go unnoticed.[9] Recommendations for treating these

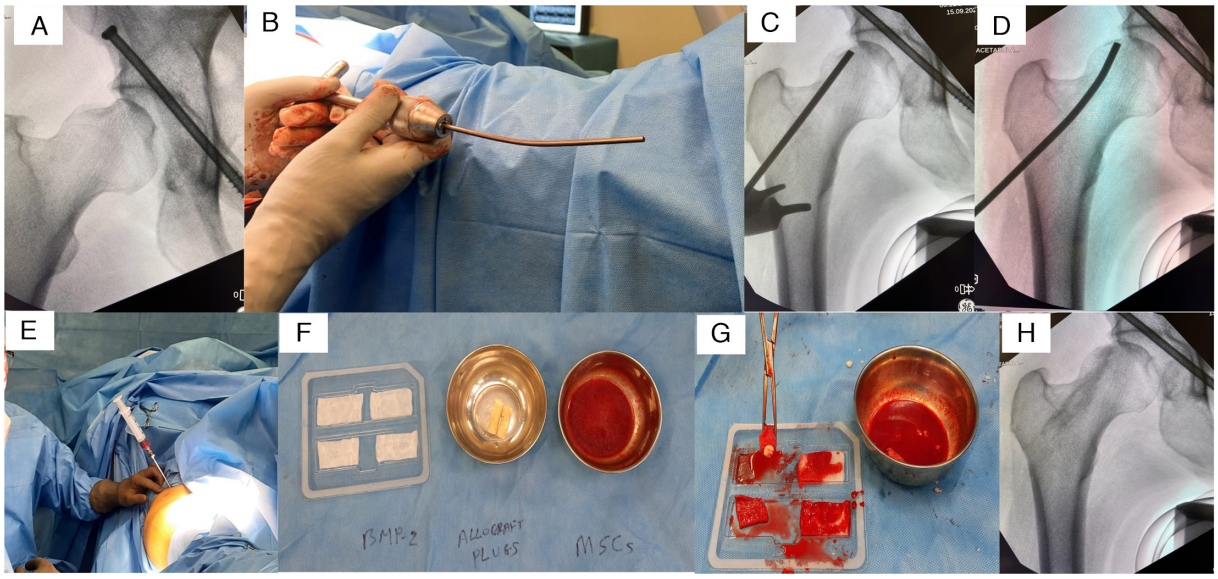

Figure 2 (A) Intraoperative anterior–posterior fluoroscopic image with right femoral traction showing the superior lateral femoral head impaction lesion. (B) Prebent rod loaded on a T-handle chuck for indirect closed reduction through the bone tunnel created with the dynamic hip screw triple reamer. (C) Intraoperative fluoroscopic image showing targeting of the impacted femoral head lesion prior to reduction. (D) Intraoperative fluoroscopic lesion showing reduction of the impacted area with the rod. (E) Intraoperative image showing bone marrow aspiration from the right iliac crest. (F) Biological treatment used with bone morphogenetic protein-2 (BMP-2), allograft cylinders and bone marrow aspirate. (G) Wrapping of collagen sponge of BMP-2 loaded with bone marrow aspirate around the allograft plugs. (H) Intraoperative fluoroscopic films showing the delivery of the biological-based therapy at the subchondral area of the previous impaction injury.

fractures are poorly described in the literature.[13] Non-operative treatment has traditionally been used for such fractures,[14] but it often yields unsatisfactory results, with osteoarthritis or AVN being the main complications.[8 9 15]

In this case, we treated a femoral head impaction fracture using a closed reduction technique.

A small lateral skin incision to the proximal femur gave access to the lateral cortex of the femur allowing targeting of the impacted femoral head area with a guide wire under fluoroscopic control. A bone tunnel was then created with the triple DHS reamer, which facilitated indirect reduction of the impacted area using an appropriately bent 4-mm rod. The void that had been created following the elevation of the impacted femoral head fragment was then grafted with a combination of bone marrow aspirate, BMP-2 and allogeneic cancellous cylindrical blocks. The objective was twofold: first, to provide adequate structural subchondral support for maintenance of reduction, and second, to create the right physiological conditions for bone guide regeneration in a timely fashion. The allograft cylindrical grafts (osteoconductive matrix) were loaded with bone marrow aspirate containing progenitor cells. The BMP-2 inductive molecule was also implanted to provide the local environment with the appropriate signalling pathways priming for mitogenesis and differentiation of the progenitor cells to osteoblasts (bone forming cells). The above strategy has been shown to be a successful strategy for bone repair.[16]

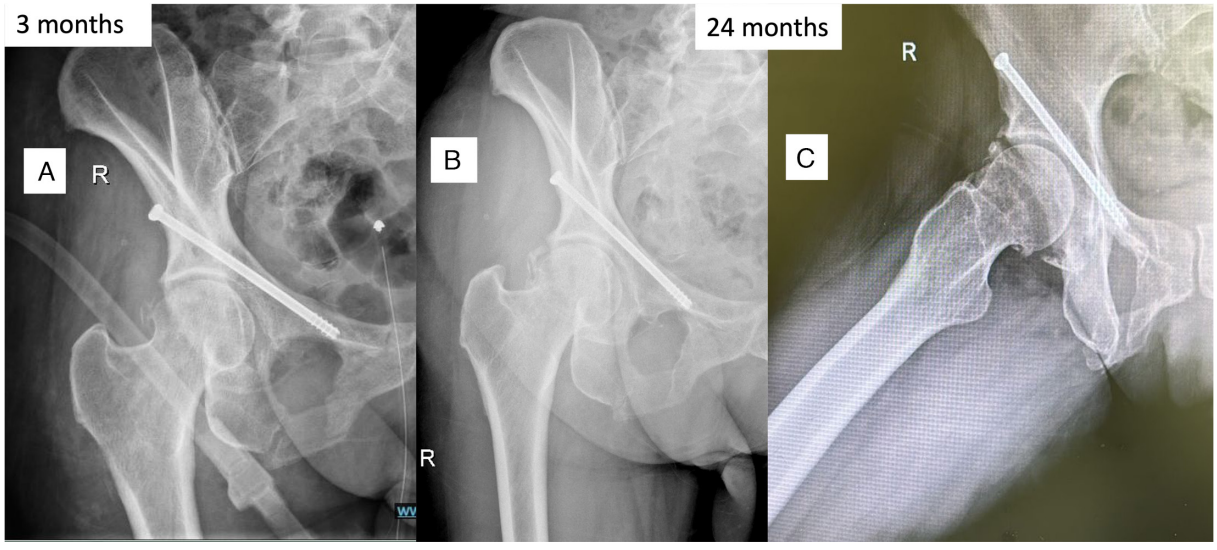

Figure 3 Anterior–posterior radiograph right hip at: (A) 3 months; (B) 24 months; (C) lateral right hip at 24 months, all showing healing of the previous impaction area with a congruent hip joint.

Our objective to get the affected impacted area to heal in a timely fashion, while providing the right environment for neo-angiogenesis vital for articular cartilage nourishment and maintenance of its vitality, was proven to be successful as at the 2-year follow-up; clinical and radiographic assessment revealed a fully functional painless right hip joint with no radiological features of secondary cartilage collapse or development of AVN. We believe that this technique can be successfully applied for the management of femoral head impaction lesions greater than 10 mm.

There is limited information published on this specific type of fracture, and there is no consensus on the best treatment option.[15] Anterior, anterolateral and posterior approaches have been described for treating femoral head fractures, with or without a concomitant acetabular fracture depending on the localisation of the lesion.[16–19]

Osteochondral allografting requiring open approach to the femoral head has a success rate of around 80%,[20] but it carries risks such as disease transmission,[21] inflammatory reactions, delayed graft integration and graft rejection.[13 22 23] Mosaicplasty or wedge osteochondral grafts can treat osteochondral collapse due to AVN and impacted femoral head fractures. The direct anterior approach has shown good results for such lesions,[9] avoiding the need for hip dislocation, thus reducing morbidity. However, the overall complication rate for this procedure is around 9%.[24] It is crucial to note that a non-dislocation approach for mosaicplasty requires careful consideration of the defect's location as not all areas can be reached without dislocation. Additionally, harvesting osteochondral fragments from a non-bearing surface of the femoral head can lead to incongruity between articulating cartilage surfaces and loss of fit between the labral seal and the femoral head.[13]

Controlled hip dislocation with a Gibson approach is another method described for treating complete femoral head fractures[25] as well as impacted femoral head fractures. This procedure has its own set of complications, such as heterotopic ossification, sciatic nerve injuries, superior gluteal artery injury, delayed trochanteric union[26] and the risk of femoral neck fractures due to the zone of weakness at the osteochondral autograft donor site.[13]

The surgical technique described here allows for precise planning and access to any part of the femoral head for disimpaction and biological augmentation/stabilisation without the need for dislocation. This technique also avoids the donor site morbidity associated with the osteochondral grafts, which can be a source of subsequent pain.[9]

Although arthroplasties can be used for these lesions, especially in the elderly, they are not indicated as the first line of treatment in young patients for whom joint preservation procedures are the preferable option.[16 27]

Learning points

- We propose this close reduction technique for patients with impacted femoral head fractures because it restores femoral head sphericity without requiring a large surgical approach that can cause morbidity and the need for osteochondral grafts.
- Additionally, grafting the subchondral area using an osteoconductive matrix, progenitor cells and an osteoinductive factor (Bone Morphogenetic Protein - 2) creates desirable conditions for neo-angiogenesis and osteogenesis, providing a timely healing process while minimising the risk of avascular necrosis of the femoral head.
- The technique described here can be considered in the surgeon's armamentarium when managing such difficult femoral head lesions.
- Its effectiveness can be validated further in the future by prospective cases studies.

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