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Surgical resection of severe heterotopic ossification after open reduction and internal fixation of acetabular fractures: A case series of 18 patients

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ABSTRACT

Objective: To evaluate the clinical results of surgical resection of severe heterotopic ossification (HO) after the open reduction and internal fixation (ORIF) of acetabular fractures.

Methods: A retrospective chart review was performed between October 2005 and November 2010 on patients undergoing severe HO resection following an acetabular fracture ORIF. Our primary outcome was functional status evaluated by the Harris hip score (HSS). HO resection and hip release was performed using a Kocher–Langenbeck approach in all cases, and a combined radiation and indomethacin regimen was used to prevent HO recurrence. Plain radiographs were also used to evaluate the hip joint for arthritic changes and HO recurrence.

Results: A total of 18 patients (17 males and 1 female) were included in our study analysis. The mean patient age was 36.8 (range: 22–54 years old) when HO resection surgery was performed. The mean time interval between acetabular fracture ORIF and HO resection was 9.9 months (range: 3–30 months): it was within 6 months in 7 patients, 6–12 months in 8 patients, and >12 months in 3 patients.

The HO was graded as Brooker grade III in 8 patients and grade IV in 10 patients. The mean time interval between HO resection and the latest follow-up was 4.5 years (range: 2.1–7.8 years). The mean Harris hip score (HHS) was 84.5 (range: 38–100), with a clinical outcome rating of excellent in 9 patients, good in 3 patients, fair in 4 patients, and poor in 2 patients (good and excellent rating accounted for 66.7%). The mean hip joint motion arc was 194° (range: 90–260°).

Complications included one intraoperative femoral neck fracture, 1 sciatic nerve injury, 2 femoral head avascular necrosis, and 6 mild HO recurrences (33.3%). There was 28.6% recurrence if HO resection was within 6 months and 36.4% if >6 months. There were no cases of severe HO recurrence, wound infections, deep vein thrombosis, or pulmonary embolism.

Conclusion: The early surgical resection of severe HO after an acetabular fracture ORIF can provide satisfactory results, however the complication rate is relatively high.

Introduction

The operative treatment of displaced acetabular fractures has been widely accepted after the pioneer work of Judet and Letournel [13,14]. Although operative treatment of these fractures can yield good clinical and radiographic results, there are still some postoperative complications that can influence the final outcome. The formation of heterotopic ossification (HO) is a common complication that can present as early as 2 weeks following surgery and patients can present with limited joint range of motion and pain. In the meta-analysis by Giannoudis et al. [7], the overall incidence of HO was 25.6% after the open reduction and internal fixation (ORIF) of displaced acetabular fractures and the incidence of HO was related to the surgical approach. The iliofemoral and an extended Kocher–Langenbeck approach were associated with a higher incidence of HO. The development of severe HO (Brooker grade III or IV) can lead to limited hip joint mobility, and as a result can affect the final postoperative outcomes. In the meta-analysis of 13 studies (1424

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acetabular cases), the overall incidence of severe HO formation was 5.7% [7]. Although there are some studies reporting the results of hip HO resection after spinal cord injury, traumatic brain injury, and total hip arthroplasty (THA) [4,6,12,17,20], there are no reports about the resection of severe HO following an acetabular fracture ORIF, except for our preliminary results of five cases [25]. The objective of this study was to report on the functional outcomes of a series of patients who underwent severe HO resection following an acetabular fracture ORIF.

Patients and methods

Local ethics committee approval was obtained prior to data collection. We retrospectively reviewed the medical records of all cases of severe HO resection and hip release admitted to our institution between October 2005 and November 2010. Our inclusion criteria included patients with severe HO (defined as Brooker grade III and IV) [2] and hip joint stiffness following an acetabular fracture ORIF who underwent HO resection. Our exclusion criteria included patients who underwent a primary combined HO resection and total hip arthroplasty (THA), or if lost to follow-up. Our primary outcome measure was functional outcome assessed by the Harris hip score (HSS). Our secondary outcome measures included HO recurrence, intraoperative fractures, sciatic nerve injuries, conversion to THA, and radiographic evaluation according to Matta's criteria [15]. Data regarding age, gender, serum alkaline phosphatase, mechanism of injury, fracture type according to the Letournel classification [13], surgical approach used, quality of reduction on radiographs according to Matta's criteria, severity of the HO according to Brooker's classification, time from initial injury to HO resection, duration of follow-up, surgery duration, estimated blood loss, number of blood units transfused, hip and knee range of motion was collected.

Surgical procedure

All of the surgeries were performed under general anaesthesia with the patient placed in the lateral decubitus position. The compromised hip and lower extremity were draped free. A Kocher–Langenbeck approach was used, through the previous surgical scar, for all patients. After the fascia lata was incised and gluteus maximus was split, the sciatic nerve was exposed from the distal aspect of the wound due to the distorted anatomy by the HO proximally. A nerve stimulator was also used in all cases to help us identify and protect the sciatic nerve. A wound drainage system was used in all patients.

Postoperative care

Deep vein thrombosis prophylaxis was used in all patients, with low molecular weight heparin and intermittent pneumatic compression devices. Prophylactic intravenous antibiotics were used for 5 days. Active hip joint motion was encouraged from postoperative day 1. A combination of indomethacin and radiation was used for HO recurrence prophylaxis. All patients received 6 weeks of oral indomethacin. If the patient received postoperative radiation, a single dose of 7 Gy was used; On the other hand, if preoperative radiation was used a single dose of 8 Gy was given within 4 h of HO resection. The wound drainage system was not removed until the drain output was less than 100 ml per day.

Our results will be expressed as means for continuous variables (i.e. Harris hip score, age, time from initial injury to HO resection, duration of follow-up, surgery duration, estimated blood loss, mean number of blood units transfused, hip and knee range of motion) and as percentage for frequency distribution.

Results

Patient demographics

A total of 34 patients underwent HO resection at our institution, of which 20 patients met our inclusion criteria. One patient was excluded for loss of follow-up, after moving to a different province, and one who patient underwent a primary combined HO resection and THA was also excluded. Eighteen patients (17 males and 1 female) were included in our results analysis. The mean age was 36.8 (range: 22–54 years old) at the time of HO resection. The mechanism of injury and acetabular fracture characteristics are described in Table 1.

Five of the patients had their initial acetabular fracture ORIF performed at our institution and the other 13 patients were referred from other hospitals. Fracture repair was performed through a Kocher–Langenbeck approach in 15 patients and a combined Kocher–Langenbeck and ilioinguinal approach in 3 patients (2 both column fractures, Fig. 1, and 1 transverse and posterior wall fracture, Fig. 2). According to Matta criteria [15], the postoperative reduction was classified as anatomical in 12 patients, imperfect in 4 patients, poor in 1 patient, and surgical secondary congruence in 1 patient.

The HO formation was classified as Brooker grade III in 8 patients and grade IV in 10 patients. In 3 patients who's HO was graded as grade IV on X-ray, the hip joint was not totally ankylosed on physical examination and on CT scan there was still some discontinuity of the HO (Fig. 3); in the other 7 patients there was no motion of the compromised hip joint. The remaining 11 patients had very limited hip joint motion with a mean hip motion arc of 32.8°, and 2 patients had ipsilateral knee stiffness. According to Matta criteria [15], the preoperative radiographs of the compromised hip joint was graded as excellent in 1 hip, good in 13 hips, fair in 3 hip, and poor with intra-articular hardware in 1 hip.

The mean time interval between the acetabular fracture ORIF and HO resection was 9.9 months (range: 3–30 months). It was within 6 months in 7 patients, 6–12 months in 8 patients, and >12 months in 3 patients (at 14, 21, and 30 months, respectively).

Operative findings

In 14 patients the sciatic nerve was pushed medially by the HO, while in the other 4 patients the sciatic nerve was enclosed by

Table 1
Mechanism of injury and acetabular fracture characteristics.

Mechanism of injury	
Traffic accident	$n = 14$
Fall from height	3
Crush injury	1
Involved side	
Left	9
Right	9
Acetabular fracture type[a]	
Posterior wall	6
Transverse with an associated posterior wall	6
Pure transverse	2
Both column	2
Posterior column and posterior wall	1
T-shaped	1
Fixation approach	
Kocher–Langenbeck	15
Combined Kocher–Langenbeck and ilioinguinal	3
Radiographic reduction[b]	
Anatomical	12
Imperfect	4
Poor	1
Surgical secondary congruence	1

[a] According to Letournel classification [13].
[b] According to Matta criteria [15].

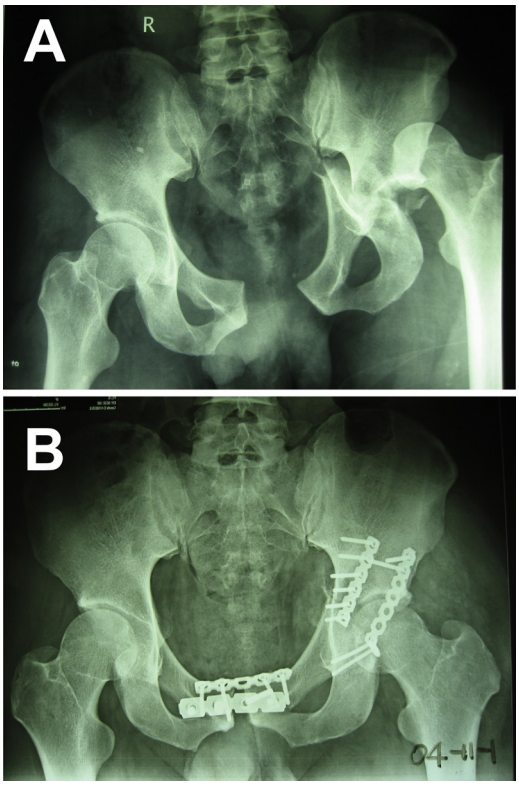

Fig. 1. (A) Anteroposterior radiographs of a 29 year old male who had a fall from height. The patient sustained a left transverse and associated posterior wall acetabular fracture with a posterior hip dislocation, left femoral head fracture, and left mangled extremity with a resultant left below the knee amputation. (B) This patient underwent acetabular fracture ORIF through a Kocher–Langenbeck approach.

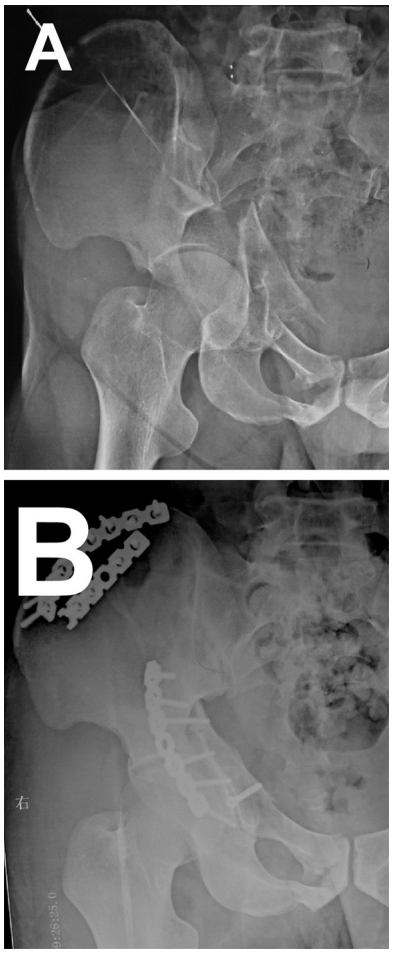

Fig. 2. (A) Anteroposterior radiographs of a 38 year old male who had a fall from height. The patient sustained a right both column fracture acetabular fracture and (B) underwent acetabular fracture ORIF through a combined Kocher–Langenbeck and ilioinguinal approach.

the HO or pushed laterally to the greater sciatic notch of the ilium, which increases the risk of an iatrogenic sciatic nerve injury. If the time interval between ORIF and HO resection was short, it was relatively easy to find the demarcation between the HO and normal cortical bone. However, if the time interval was long it was more difficult to identify the HO borders and we need to use the implant as a reference or extend our dissection more proximally and distally to identify the normal cortex. In most cases, the middle section of the short external rotators was replaced by HO, including the gemelli and obturator internus. However, the posterior capsule was not commonly affected.

Manipulation of hip joint was performed after the HO was resected to evaluate the hip range of motion and if bony impingement was noted, further resection was performed (Fig. 4). We also found that, in most cases, the range of motion was limited secondary to severe scarring around the piriformis fossa near the insertion of the piriformis and gluteus minimus. After scar resection and soft tissue release in this area was performed the hip range of motion was usually improved, especially rotational mobility. If the degree of fracture healing was deemed to be adequate according to the preoperative imaging and intraoperative findings, then implant removal was performed after the hip joint motion was satisfactory to decrease the risk of an iatrogenic fracture with manipulation. Implant removal was performed in 15 cases; additionally the authors recommend removing all posterior implants, when possible, as this is a good indicator of a complete HO resection and soft tissue release.

Although the intraoperative hip joint motion was satisfactory in all patients after HO resection, there were four patients with unsatisfactory postoperative X-rays. Some residual HO on the greater trochanter was common, however in two patient there was excessive residual bone on the greater trochanter and in one patient there was excessive residual bone on both the femoral and acetabular sides. In one case, the excess heterotopic bone on the acetabular side was preserved to provide some stability to the hip joint (patient had a history of hip subluxation and femoral head flattening).

The mean operative time was 146 min (range: 85–400 min). The mean blood loss was 1380 ml (range: 500–4000 ml). The mean number of blood transfusions was 3.9 units (range: 0–13 unit).

Outcomes

The mean interval between HO resection and the latest follow-up for all patients was 4.5 years (range: 2.1–7.8 years). The mean HHS was 84.5 (range: 38–100) and was rated as excellent in 9 patients, good in 3 patients, fair in 4 patients, and poor in 2 patients, with the good and excellent ratings accounting for 66.7%. The mean arc of motion of the hip joint was 194° (range: 90–260°) (Fig. 5B). With the exception of 1 patient with a THA, the radiological outcomes were good in 10 hips, fair in 5 hips, and poor in 2 hips. Of the two patients with poor clinical and radiological outcomes, one was due to AVN and collapse of a femoral head and the other was a patient with poor preoperative radiographic appearance (hip subluxation, femoral head flattening, and intra-articular hardware).

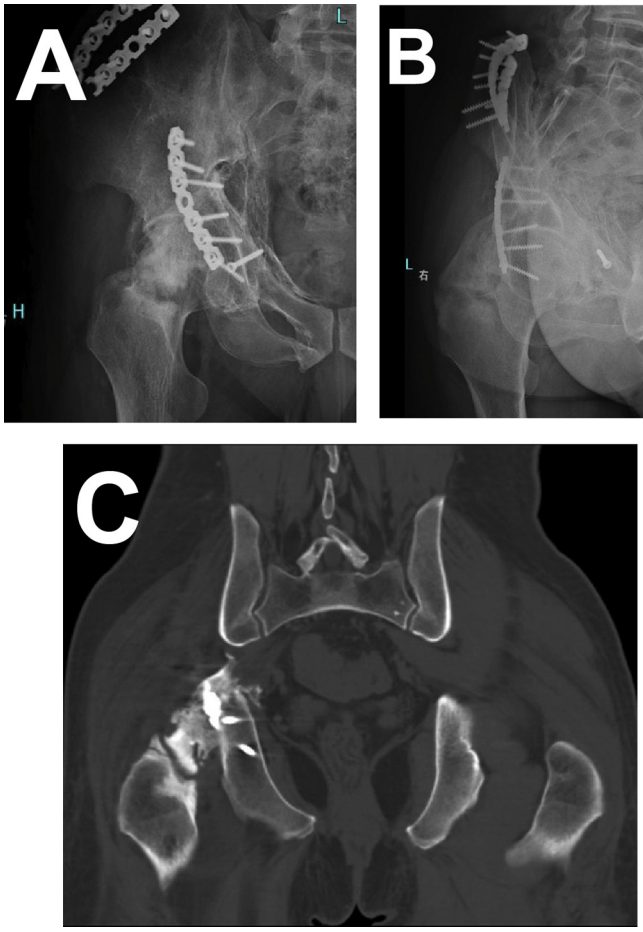

Fig. 3. (A) Anteroposterior and (B) obturator oblique radiograph of the 38 year old patient, 10 months after his right acetabular fracture ORIF, showing fracture healing and development of severe HO. (C) CT scan showing the hip was not totally ankylosed.

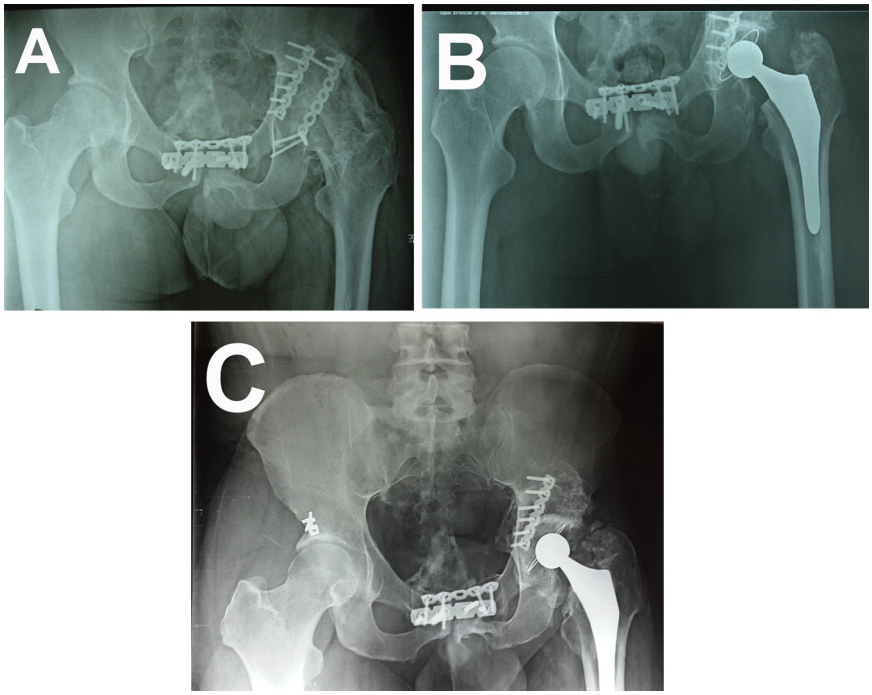

Fig. 4. (A) Anteroposterior radiograph of the 29 year old patient. The patient developed left sided HO (Brooker grade IV) and underwent HO resection 30 months after his acetabular fracture ORIF. After the HO resection, we started to manipulate the hip when he sustained an iatrogenic femoral neck fracture. (B) Postoperative anteroposterior radiograph after undergoing a hybrid THA with a cemented cup and cementless stem following his femoral neck fracture. At the 6.3 year follow-up, the patient complained of minimal pain and (C) anteroposterior radiograph showed HO recurrence (Brooker grade II) and no signs of prosthesis loosening.

We encountered two cases with ipsilateral hip and knee stiffness, both of which had an acetabular and ipsilateral femoral shaft fracture. The arc of motion of knee joint was 0–15° and 0–40° respectively, before the hip HO resection. We performed a staged procedure with the hip surgery done first, followed by the knee joint releases at 12 and 13 months respectively. At the 6.6 year follow-up, one patient had a hip motion arc of 90° and the knee motion arc of 0–140°. At the 3.8 year follow-up, the other patient had a hip motion arc of 190° and knee motion arc of 0–95°.

Complications

An iatrogenic fracture of the femoral neck occurred in one patient (5.6%) during the HO resection (Fig. 4). Avascular necrosis of femoral head developed in two patients (11.1%). One patient had a severe collapse of the femoral head with poor clinical outcomes and a THA was performed 2.4 years after the HO resection. The other patient at the 3.8 year follow-up, had minimal hip pain with X-ray showing slight head collapse with mild joint narrowing and sclerosis.

Six patients (33.3%) had HO recurrence, all of which were mild (defined as Brooker grade I and II) with no severe HO recurrence (Figs. 4 and 5). Of the 7 patients who had HO resection performed within 6 months, there were 2 recurrences (28.6%). Of the remaining 11 patients who had HO resection performed beyond 6 months, there were 4 recurrences (36.4%).

Five sciatic nerve injuries were present, only 1 (5.6%) was due to the HO resection. In 2 patients the sciatic nerve injury was present after the acetabular fracture, and in the other 2 patients it was present after the acetabular fracture ORIF. At the time of the latest follow-up, the sciatic nerve injury was fully recovered in 2 patients, partially recovered in 2 patients, and not recovered in 1 patient. No wound infections, deep vein thrombosis, or pulmonary embolism where noted during the study period.

Discussion

Heterotopic ossification is a common complication after the operative management of displaced acetabular fractures, especially when using an iliofemoral and an extended Kocher–Langenbeck approach. McLaren reported 55% of patients developed HO after ORIF of acetabular fractures necessitating dissection of the gluteal muscles, with 40% having severe HO [16]. Johnson et al. [10] reported 85% of acetabular fractures that were stabilised through an extended iliofemoral approach developed HO, 62% were Brooker grade III and IV. In this case series, all 18 patients had undergone an acetabular fracture ORIF through a Kocher–Langenbeck approach and 3 of them through a combined ilioinguinal approach.

Meiners et al. [17] reported on hip HO resection of 41 hips in spinal cord injury patients, with an improved average hip motion arc of 61° at the time of follow-up (mean follow-up of 4.2 years). Moore [20] reported on the surgical resection of hip HO in patients with a traumatic brain injury (13 hips), which can give satisfactory results. All hip joints were ankylosed prior to surgical resection, with an immediate postoperative average arc of motion of 85°. Cobb et al. [4] performed symptomatic HO resection in 53 cases following THA, with a statistically significant increase in hip range of motion obtained at the final follow-up, 3.5 years. However, there are no reports about HO resection following an acetabular fracture ORIF, except for our preliminary result of five cases [25].

In patients with HO formation following an acetabular fracture, there are several factors that will influence the final outcome of HO resection, such as quality of fracture reduction and the development of post-traumatic hip arthritis, when compared to patients with HO resection following a traumatic brain injury, spinal cord injury, or THA. Therefore, the preoperative hip joint status should be carefully assessed and recorded as patients with severely limited hip joint motion may not complain of hip pain. As in our case series, patients who had a poor preoperative joint status

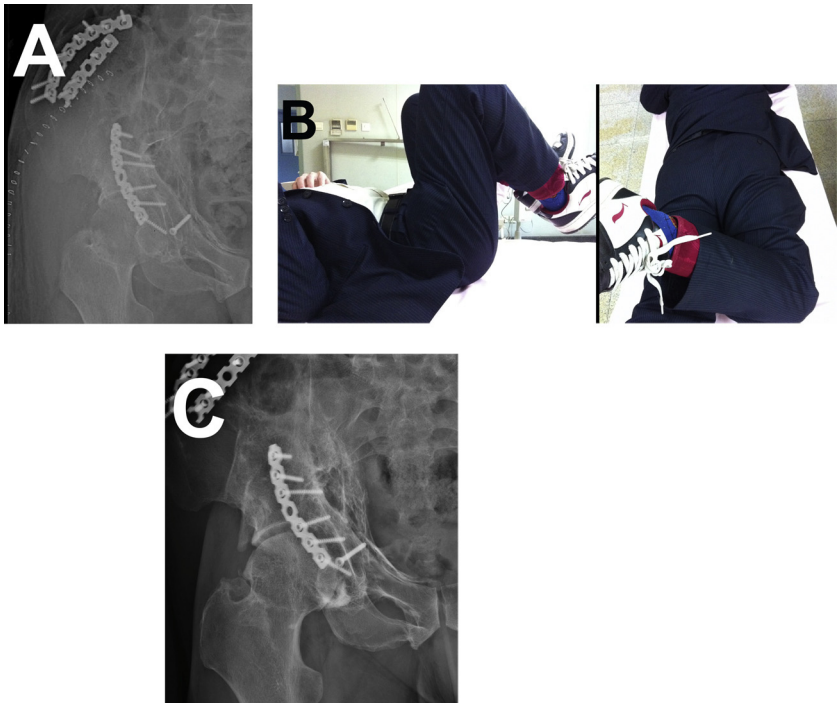

Fig. 5. (A) Anteroposterior radiograph of the 38 year old patient following right HO resection 1 year after his acetabular fracture ORIF. (B) At the 4.5 year follow-up, the patient complained of moderate pain and his right hip motion arc was 240° and the HHS was 71. (C) At this time, his anteroposterior radiograph showed HO recurrence (Brooker grade II).

continued to have a poor clinical and radiological outcome after HO resection.

Radiographs and CT scans are very useful tools used to preoperatively evaluate the severity of arthritic changes and HO formation, and to assess the acetabular fracture healing. If the patient complained of severe hip pain related to activity and there was evidence of severe post-traumatic arthritis or AVN of the femoral head, performing HO resection only was contra-indicated and a simultaneous THA was recommended. In our case series, one patient denied a simultaneous THA although he had hip subluxation, femoral head flattening, and intra-articular hardware. Therefore, 5 months following his initial surgery only HO resection and implant removal was performed.

In the past, delayed surgical HO resection was advocated to allow for maturation of the HO and thereby theoretically reducing the risk of recurrence. Garland and Orwin [6] performed hip HO resection in patients with spinal cord injuries, with a mean time to surgery after injury of 50.6 months. Meiners et al. [17] performed hip HO resection in spinal cord injury patients with a mean time to surgery after injury of 82.1 months. Cobb et al. [4] reported HO resection after THA with a median to HO resection of 13 months. Garland [5] recommended that HO resection should be performed at different time intervals according to the HO aetiology: traumatic HO should be resected at 6–9 months, spinal cord injury at 1 year, and traumatic brain injury HO at 1.5 years.

Clinical and radiographic appearance, alkaline phosphatase level (ALP), and bone scans have all been used to assess the maturation of HO, although the specific parameters used for each are controversial. Tibone et al. [22] found that radiographs were of no value in judging HO maturity. The bone scan correlated well with the level of the ALP in judging the maturity of HO, and the authors suggested that HO maturation usually does not occur until after 1–1.5 years. In their case report, Biering-Sorensen and Tondevold [1] did not perform hip HO resection until the serum ALP level was normal and the bone scan was stable. However, bone scans were not routinely used in our study.

If we can accurately determine the degree of HO maturation using the above mentioned methods is still debated. Additionally, knowing if the maturity of the HO at the time of surgical resection is directly related to the rate of recurrence is yet to be determined. Garland and Orwin [6] reported a recurrence rate of 79%, although it was a delayed resection. Garland [5] found the patients with a near normal neurologic recovery had minimal to no HO recurrence with improved limb function and increased joint motion, whereas patients with a poor neurologic recovery and persistent spasticity were associated with HO recurrence and no functional limb improvement. Hence, maybe systemic rather than local factors are responsible for the development of HO.

Serum ALP was an important factor we used to determine the timing of HO resection. If it was more than 3 months after the acetabular fracture ORIF and the serial ALP had decreased to normal (<150 IU/L), we would prepare for HO resection rather than waiting for 9–12 months. In our case series, we did not experience an increased rate of HO recurrence with early HO resection vs. late resection. Thus, we recommend early HO resection following an acetabular fracture ORIF, as it allows for the demarcation between heterotopic and normal cortical bone to be identified relatively easy during surgery. Additionally, the scarring and fibrosis of the joint will be less severe and subsequent rehabilitation should be easier as the patient does not experience as much deconditioning while waiting for surgery. In our case series, the iatrogenic femoral neck fracture likely occurred from the presence of disuse osteoporosis (ipsilateral below the knee amputation) and total joint ankylosis for an extended period of time (Fig. 4). However, this may have been prevented if the HO resection interval was shorter than 30 months. The femoral neck fracture occurred after the HO was resected and we started manipulating the hip joint. After the femoral neck fracture, a hybrid THA was performed with a cemented cup and cementless femoral stem. Follow-up X-rays showed mild HO recurrence and no signs of prosthesis loosening (Fig. 4C).

Non-steroidal anti-inflammatory drugs (NASIDs) and radiation are commonly used methods to prevent HO formation following the operative treatment of acetabular fractures [3,9,11,19] and following surgical HO resection [1,21,23,24]. In combination, the use of indomethacin and radiation has proven to be very effective in the prevention of HO formation following acetabular fracture surgery. Moed and Letournel [18] used this combination in 53 patients with 54 fractures of the acetabulum following reconstruction through a posterior or extended iliofemoral approach, of which 44 fractures showed no HO formation and 10 had Brooker grade I (18.5%). Thus, a combination of indomethacin and radiation was used in this study to prevent HO recurrence. The first patient that underwent HO resection in our study received postoperative radiation, however it was very inconvenient as there is no radiation department in our institution. Gregoritch et al. [8] reported that prophylactic radiation of the operative site within 4 h prior to elective THA appeared to be comparable to the currently accepted postoperative treatment regimens in preventing clinically significant HO. Consequently, the other 17 patients in our study received preoperative radiation, with good results.

Unlike hip HO resection after a traumatic brain injury or spinal cord injury, the prior acetabular ORIF resulted in extensive scar formation requiring additional surgical dissection. This makes the HO resection in these cases more difficult and soft tissue complications are more likely, such as wound infections or sciatic nerve injury. Fortunately, there were no wound infections in our case series although it was a common complication after hip HO resection [6,17].

As report by Koulouvaris et al. [12], an iatrogenic sciatic nerve injury is another common complication as it may be pushed or even enclosed by the HO. In our case series, we encountered one sciatic nerve injury due to HO resection. To decrease this complication risk, the authors found using a nerve stimulator to be very helpful in identifying the sciatic nerve. Additionally, the dissection can be performed from the distal aspect of the wound where the anatomy is relatively normal. To decrease the risk of femoral head AVN one should try to protect the vascularity of the femoral head by preserving the posterior capsule, which was not commonly affected by the HO. If the proximal HO border is difficult to identify, excessive resection of posteromedial aspect of the greater trochanter should be avoided in order to protect the medial circumflex femoral artery.

As with any retrospective case series there are some limitations to our study. There were no matched control subjects to rigorously evaluate the use of ALP as an absolute marker for HO maturity or assess risk factors for HO recurrence. Additionally, we did not take into consideration the comorbidities or functional status of patients who underwent early HO resection vs. late resection, which may bias our results in favour of early resection; although most late resections were secondary to delayed referrals. Ideally a prospective randomised study needs to be performed in order to tease out the ideal timing of HO resection and the risk factors associated with higher rates of HO recurrence, however due to the low numbers of severe HO following acetabular fracture ORIF this study would not be feasible.

Conclusion

In summary, HO resection and hip release after ORIF of an acetabular fracture is a difficult procedure, and the risks and benefits of the operation need to be thoroughly discussed with the

patient prior to surgery. There are several factors that need to be considered before undertaking the HO resection and include: the joint status, the timing of the HO resection, the postoperative rehabilitation plan, the HO prophylaxis regimen, and most importantly the surgeon must be aware and prepared for the difficulties of this operation. The authors recommend early HO resection following acetabular ORIF, if possible, as by doing so reasonable outcome can be expected without an increased risk of HO recurrence and possibly a decreased complication rate.

Conflicts of interest

The authors have no conflicts of interest to disclose.

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