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ORIGINAL ARTICLE • HIP - OSSIFICATIONS

Results from the surgical resection of severe heterotopic ossification of the hip: a case series of 26 patients

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Abstract
Introduction Surgical resection of heterotopic ossification (HO) around the hip joint is often challenging. The aim of this study is to evaluate the clinical and radiological outcomes following surgical resection of Brooker's type III and IV HO of the hip.
Methods We retrospectively reviewed clinical and radiological data, between November 2006 and January 2013, of all patients who underwent surgical resection of severe HO of the hip. Brooker's grading, range of motion and the Harris Hip Score before and after surgery were recorded in all cases. The combined radiation (700 cGy preoperatively) and indomethacin regimen was used to prevent heterotopic ossification recurrence.
Results Twenty-six patients (22 males and 4 females) were included in our study. Mean patient age was 47.38 years (range 24–72). The HO was graded as Brooker grade III in 3 patients (11.5%) and Brooker grade IV in 23 patients (88.5%). Mean time interval between HO development and resection was 40.8 months (range 13–156 months). All patients had CT scans prior to surgery. Mean follow-up was 31.4 months (range 24–40 months). There was no severe HO recurrence. Complications included one intraoperative injury of a femoral artery branch, one intraoperative femoral neck fracture treated with intramedullary nailing, one sciatic nerve injury and one superficial infection treated conservatively.
Conclusions Surgical resection of severe HO of the hip along with preoperative radiation and indomethacin provides excellent results; however, the complication rate is relatively high. Careful evaluation of the preoperative CT scan and wide exposure are required in order to identify all the involved neurovascular structures.

Keywords Heterotopic ossification · Brooker classification · Surgical resection

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Introduction

The basic pathogenetic defect in heterotopic ossification (HO) is inappropriate and rapid metaplastic osteogenesis, resulting in formation of lamellar corticospongiosal bone in atypical, extraskeletal tissues [1, 2]. Hip is the most frequently affected joint, and the extra-articular bone tissue can cause limitation of range of motion (ROM) or even total joint ankylosis. The pathophysiology and etiology of the disease remain unclear [3]. Risk factors for hip HO include severe trauma, brain/spinal cord injury, neurological compromise (prolonged coma in young patients), antegrade femoral nail entry side (worse with piriformis

Table 1 Brooker classification

Grade I	Bone islands within the soft tissues
Grade II	Bone spurs from the pelvis or proximal end of femur, with at least 1 cm between opposing bone surfaces
Grade III	Bone spurs from the pelvis and/or proximal end of femur, with <1 cm between opposing bone surfaces
Grade IV	Apparent ankylosis of the hip

fossa entry point), severe burns, internal fixation of acetabular fractures (extended iliofemoral most common), hemiarthroplasties and total hip arthroplasties [4]. The common feature of all these conditions is immobilization due to trauma, surgery, or advised therapeutic rest followed by mobilization with exercise or spasticity. The most common classification for HO was described by Brooker et al. [5] and identified four grades of HO based on anteroposterior radiograph of the pelvis (Table 1).

Surgery is the only effective treatment for established hip HO [3]. It requires wide exposure in order to identify all the involved neurovascular structures. Indications for surgery include severe loss of motion causing difficulties in the daily activities and personal hygiene. Especially for patients with spinal cord injury, HO removal may allow patients to sit up. The time of resection is controversial, and it is defined by marked decrease in bone scan activity and normalization of serum alkaline phosphatase (ALP), 6 months following general trauma, 1 year following spinal cord injury or 1.5 years following traumatic brain injury [6]. However, excessive delay of surgical management increases risk of complications and hip ankylosis. Prevention of HO recurrence can be achieved by administration of nonsteroidal anti-inflammatory drugs (especially indomethacin) and perioperative localized radiotherapy [7–9]. The aim of this study is to evaluate the clinical and radiological outcomes following surgical resection of Brooker's type III and IV HO of the hip and to describe the surgical challenges and difficulties during surgical resection of HO of the hip.

Materials and methods

To determine the outcome of the surgical excision of severe HO of the hip, a retrospective case series study was conducted between November 2006 and January 2013. We reviewed clinical and radiological data of all patients who underwent surgical resection of severe HO of the hip (defined as Brooker grade III and IV). Patients with Brooker I and II HO of the hip were excluded. Informed consent was obtained from all patients, and approval from our institution's ethics board was obtained before the study. Indications for surgery were severe loss of motion causing difficulties in the daily activities and personal hygiene. Demographic data, cause of HO, Brooker's grading, time from initial injury to HO resection, surgical approach, duration of surgery, hospitalization and follow-up were recorded. All patients had anteroposterior and lateral pelvis radiographs and CT scans prior to surgery, to determine the exact location of HO. Range of motion and the Harris Hip Score before and after surgery were recorded in all cases.

All of the surgeries were performed by the same surgeon. The surgical goal was resection of the necessary amount of bone to allow full ROM of the hip. According to the location of HO, defined by the preoperative CT scan, an anterior or posterior approach was performed. When a posterior approach was used, the sciatic nerve was exposed from the distal aspect of the wound, around the insertion of the gluteus maximus tendon. Manipulation of the hip was performed intraoperatively after the resection of HO to evaluate the hip ROM and potential bone impingement. Hypotensive anesthesia and a wound drain were used in all patients [10]. Postoperatively, patients received vancomycin IV for 2 days and enoxaparine 40 mg subcutaneously for 30 days. A combined radiotherapy (700 cGy 2–4 h preoperatively) and indomethacin regimen (75 mg/day for 2 weeks) was used to prevent HO recurrence. When HO excision was combined with THA, full weight bearing was allowed immediately after surgery, while in patients with head/spinal cord injuries, physiotherapy was initiated the first postoperative day.

Statistical analysis was performed using the PASW 18 (SPSS release 18.0; SPSS Inc., Chicago, Illinois). Student's unpaired t test was used to compare continuous values. A probability p value less than 0.05 was considered statistically significant.

Results

Demographic data of the study population are listed in Table 2. Twenty-six patients (22 males and 4 females) were included in our study. Mean age was 47.38 years (range 24–72). Among the three patients with preoperative HO classified as Brooker III, there was no recurrence. From the remaining patients with Brooker IV HO, only four redeveloped small bony islands in the soft tissues (Brooker I). There was no severe HO recurrence. The average preoperative motion in flexion and extension was 29° (range 0°–44°). At the latest follow-up, mean flexion–extension arc was 108° (range 91°–135°) (p value <0.01). Harris Hip Score was improved dramatically in all cases from a mean preoperative value of 58.1 to a mean postoperative value of 82.5 (p value <0.001). Preoperative and postoperative X-rays of a 30-year-old male with Brooker IV HO are shown in Figs. 1 and 2.

Table 2 Characteristics of the study population

Cases (*n*)	26
Female (%)	84.6
Mean age (years)	47.38 (range 24–72)
Mean follow-up (months)	31.4 (range 24–40)
Mean interval between HO development and resection (months)	40.8 (range 13–156)
Mean surgical time (min)	132 (range 98–178)
Mean hospitalization (days)	5.9 ± 1.8 (range 3–14)
Reason for HO	53.8% head or spinal cord injury
	23.1% THA
	15.4% femoral head fracture
	7.7% acetabular fractures
Grading of HO	Brooker grade III: 3 patients (11.5%)
	Brooker grade IV: 23 patients (88.5%)
Surgical approaches	Posterior approach: 22 patients
	Anterior approach: 4 patients

In our study group, the rate of complications was 15.4%. We encountered one intraoperative injury of a femoral artery branch ligated by vascular surgeons. One patient developed sciatic nerve palsy postoperatively and was treated conservatively. One patient developed a superficial wound infection from methicillin-resistant staphylococcus aureus (MRSA) 4 weeks postoperatively and was treated conservatively with IV ciprofloxacin and rifampin for 2 weeks. One intraoperative femoral neck fracture occurred in a patient with a Brooker IV HO when the joint was mobilized after HO excision and was treated with intramedullary nailing. No deep vein thrombosis or pulmonary embolism was observed during the study period.

Discussion

Clinical and radiological results from the surgical excision of HO of the hip are scarce in the literature. Moore reported on the surgical resection of HO of ankylosed hips in 13 patients with a traumatic brain injury, with an immediate postoperative average arc of motion of 85° [11]. Meiners et al. [12] reported on hip HO resection of 41 hips in spinal cord injury patients, with an average hip motion arc of 82.68° at 4.2 years of follow-up. In a study by Genet et al. [13], authors reported a mean final ROM of 63° (0°–100°) after HO excision in ankylosed hips. Cobb et al. [14] performed symptomatic HO resection in 53 cases following THA, with a statistically significant increase in hip range of motion after 3.5 years of clinical follow-up. A study by Melamed et al. [15] mentioned an average 92.5° of hip arc motion in a series of 8 hips with HO, at 1 year postoperatively. In our study, at the last follow-up, the mean ROM of hips was 108°, which is in accordance with the literature.

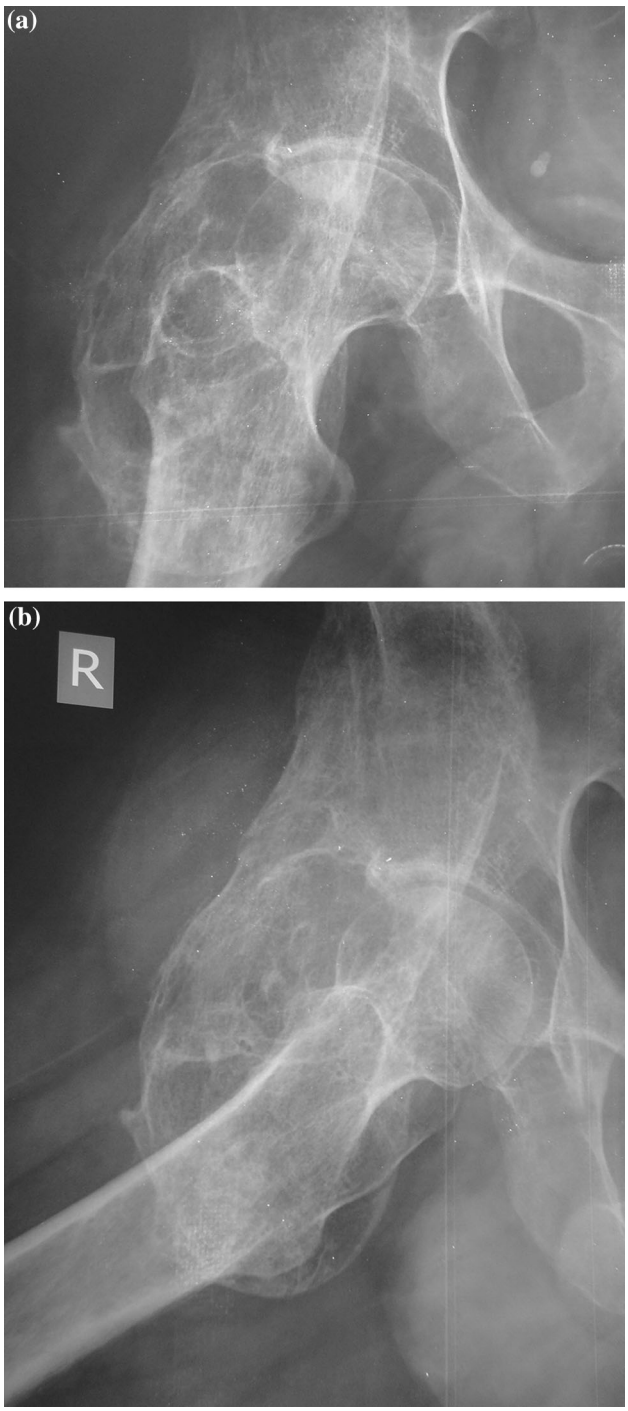

Fig. 1 **a**, **b** Preoperative X-rays of a 30-year-old male with Brooker IV HO after traumatic brain injury

The timing of surgical excision of HO of the hip is debatable. In the past, delayed surgical HO resection was recommended to allow for maturation of the HO and

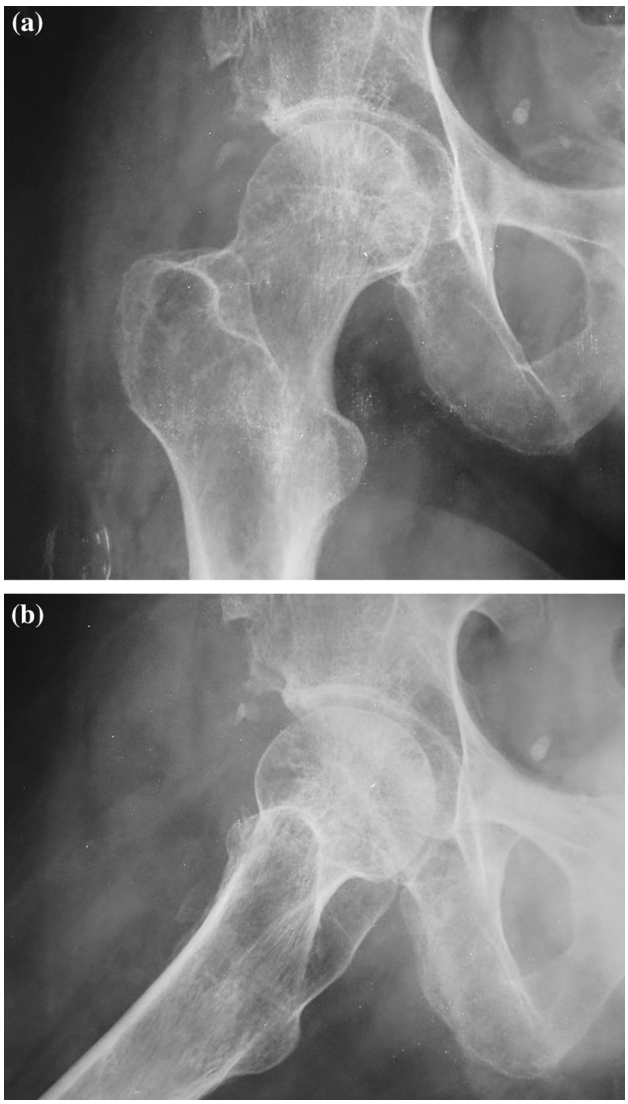

Fig. 2 **a**, **b** Postoperative X-rays of the same patient, 32 months after surgical resection of HO

thereby theoretically reducing the risk of recurrence. In patients with spinal cord injuries, two studies reported a mean time to hip HO resection after injury of 50.6 and 82.1 months, respectively [12, 16]. Similarly, Genet et al. [13] recommended a mean delay of 36.8 months between traumatic neurological injury and HO excision. A similar delay of an average of 15 months was recommended by Ippolito et al. [17]. Cobb et al. [14] reported HO resection after THA with a median to HO resection of 13 months. Garland has recommended different schedules for surgical intervention, depending on the etiology of the condition underlying the heterotopic ossification: 6 months after direct traumatic musculoskeletal injury, 1 year after spinal cord injury and 1.5 years after traumatic brain injury [6]. In our study, the mean time between HO development and resection was 40.8 months, and our criteria for surgery were severe loss of motion and decreased function, before serious complications arise.

Recurrence of HO after excision has been correlated with the maturity of the HO at the time of the excision. Garland and Orwin [16] reported a recurrence rate of 79% in patients with spinal cord injuries, suggesting Brooker's classification as the best predictor of recurrence. Garland [6] found a correlation between HO recurrence and the neurological recovery of patients with central nervous system injury. On the other hand, the study by Ippolito et al. [17] found no correlation between recurrence and the time that elapsed from head injury to operation, but old ossifications continued to show osteogenic activity at the histological level. Wu et al. [18] reported 33.3% mild HO recurrence and no severe HO recurrence. Moore et al. [11] reported a 15% rate of re-ankylosis among 20 patients with excision of Brooker IV HO of the hip. We did not observe any severe HO recurrence in our study group, attributing this fact to the meticulous technique of resection, proper preoperative planning and postoperative radiation along with indomethacin administration.

Nonsteroidal anti-inflammatory drugs (NSAIDs) and radiotherapy are commonly accepted methods to prevent HO formation following surgical HO resection [19–21]. Indomethacin remains the "gold standard" for HO prophylaxis following total hip arthroplasty and is the only drug proven to be effective against HO following acetabular surgery [8]. However, there is no universal consensus as to which therapeutic protocol is the best. Perioperative radiation is thought to be effective by blocking osteoblasts differentiation. Several studies have suggested that there is no statistically significant difference between the use of preoperative (<4 h preoperatively) or postoperative (<72 h postoperatively) radiotherapy [22]. We suggest that preoperative radiation is equally useful but more convenient for the patient as the absence of radiotherapy departments in the majority of hospitals would otherwise require postoperatively patient transfer in an appropriate center.

As the resection of HO of the hip is technically demanding, the rate of complications is relatively high. Sciatic nerve injury is a common complication as in many cases the nerve is fully surrounded by ectopic tissue. Our results were similar to these reported by Wu et al. [18] who had 5.6% sciatic nerve injury. Koulouvaris et al. [23] reported the use of nerve stimulator for the identification of sciatic nerve. Additionally, the dissection can be performed from the distal aspect of the wound where the anatomy is relatively normal. The risk of intraoperative femoral neck fracture in patients with HO of the hip is relatively high, especially when the hip is ankylosed. Wu et al. [18] reported one iatrogenic fracture of the femoral head in a series of 18 cases of HO resection due to internal fixation

of acetabular fractures. In a series of 183 hips with HO because of traumatic neurological injury, the incidence of intraoperative femoral neck fractures during HO excision was 13.7% [13]. We encountered only one case of intraoperative femoral neck fracture (incidence 3.8%) in a patient with traumatic brain injury, treated with intramedullary nailing with good results. However, we suggest that hip replacement implants need to be in the surgical room in case of a femoral neck fracture. In terms of infections, we encountered only one superficial infection by MRSA treated successfully with IV antibiotics. Garland reported superficial wound infections in 9 of 24 patients (38%) and deep persistent infections in 8 of 24 hips (33%) after excision of HO in patients with spinal cord injuries [16]. We consider that perioperative radiation therapy causes healing problems and increases susceptibility to infections.

Our study is limited by the relatively low number of patients. Moreover, this was a retrospective case series study, without matched controls subjects. Recruitment of patients with HO becomes more difficult as methods of prophylaxis result in decrease in HO incidence. More studies are needed to fully assess the clinical and radiological outcome of the HO excision and to identify the risk factors for HO recurrence.

Surgical resection of severe HO of the hip along with preoperative radiation and indomethacin provides excellent results; however, the complication rate is relatively high. The excision of the HO of the hip is a demanding procedure which requires surgical expertise and should be performed in tertiary referral centers. Occasionally surgeons must be prepared to address vascular injuries, femoral neck fractures, and potentially to replace the joint. Careful evaluation of the preoperative CT scan provides valuable information and wide exposure is required to identify all the involved neurovascular structures. Further studies are required in order to fully evaluate the results of HO resection, avoidance of complications and the risk factors for HO recurrence.

Compliance with ethical standards

Conflict of interest All authors declare that they have no conflict of interest.

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