Heterotopic ossification after arthroscopy for hip impingement syndrome

Guan-Ying Gao, Xin Zhang, Ling-Hui Dai, Hong-Jie Huang, Rui-Qi Wu, Xiao-Dong Ju, Yu Mei, Xing-Yue Niu, Jian-Quan Wang, Yan Xu

Institute of Sports Medicine, Beijing Key Laboratory of Sports Injuries, Peking University Third Hospital, Beijing 100191, China.

Abstract

Background: Heterotopic ossification (HO) is a known complication of hip arthroscopy. We investigated incidence of HO after hip arthroscopy and determined whether revision for HO improved outcome.

Methods: A retrospective study was conducted on 242 patients (140 men and 102 women, mean age: 36.2 ± 9.5 years) who underwent hip arthroscopy for femoroacetabular impingement (FAI) between January 2016 and January 2018. The average follow-up period was 22.88 ± 11.74 months (range: 11–34 months). Thirteen (5.37%) cases of HO (six men and seven women, five left hips and eight right hips; mean age: 37.5 ± 4.7 years) were observed. Among them, four cases with HO with obvious pain symptoms and persistent non-remission underwent revision surgery to remove HO. Monthly follow-up was conducted. Visual analog scale (VAS), modified Harris Hip Score (mHHS), and non-Arthritis Hip Score (NAHS) were evaluated and compared between HO and non-HO patients. Independent sample *t* test, Mann-Whitney *U* test and the Chi-square test were used for inter-group comparisons. HO degree was evaluated using Brooker classification. Symptoms and function were evaluated before and after revision.

Results: A total of 242 patients were involved in this study. Thirteen cases (5.4%) had imaging evidence of HO. Nine (9/13) were classified as Brooker stage I, three (3/13) Brooker stage II, and one (1/13) Brooker stage III. HO was detected by ultrasonography as early as 3 weeks after operation. After primary surgery, the mHHS of the HO group and non-HO group increased by 13.00 (8.50, 25.50) and 24.00 (14.00, 34.50) points ($Z = -1.80$, $P = 0.08$), NAHS increased by 18.00 (9.50, 31.50) and 26.00 (13.50, 36.00) points ($Z = -1.34$, $P = 0.18$), and VAS decreased by 3.00 (2.00, 4.00) and 4.00 (3.00, 4.50) points ($Z = -1.55$, $P = 0.12$). Average follow-up time after revision was 9.00 ± 2.94 months; mHHS increased by 34.75 points ($t = -55.23$, $P < 0.01$) and NAHS by 28.75 points ($t = -6.03$, $P < 0.01$), and VAS decreased by 4 points ($t = 9.80$, $P < 0.01$). HO and non-HO patients were similar for demographic and surgical data, and clinical and functional scores.

Conclusion: HO incidence after arthroscopic treatment of FAI is similar to that found in previous studies. Most HO have no effect on clinical symptoms. Patients who undergo revision HO resection show improvement in pain and joint function.

Keywords: Heterotopic ossification; Hip; Arthroscopy; Femoroacetabular impingement

Introduction

Heterotopic ossification (HO) is the formation of bone in non-skeletal tissue, usually in muscles and articular capsules; it is caused by changes in the mechanisms regulating osteogenesis.[1] HO is a common complication after hip surgery; incidence in patients without preventative treatment is reported to be as high as 44%.[2] Lesion types range from tiny ossifications to massive bone deposition in the whole joint. Large lesions can cause hip pain, impingement, and reduced range of motion, which may require surgical resection.[3]

HO is a well-known complication after open hip arthroplasty procedures such as total hip replacement, open reduction and internal fixation of hip, pelvic fractures, and joint reconstruction surgery.[4] The reported incidence of HO after total hip arthroplasty is 2% to 90%.[5] Rath *et al*[2] compared patients with HO after hip arthroscopy with those that did not and found no difference in functional outcomes. Ehud *et al*[6] evaluated 100 control patients and 63 study patients who underwent hip arthroscopic surgery and reported HO present in 36 of the 100 control patients. They suggested HO prophylaxis protocols may be considered after hip arthroscopic surgery. Beckman *et al*[7] evaluated 108 patients randomized to take naproxen or a placebo postoperatively and found an HO prevalence of 46% in the placebo group *vs*. 4% in the naproxen group after 1-year follow-up. They suggested that prophylaxis with naproxen was effective in reducing the prevalence of HO without medication-related morbidity.

Access this article online

Quick Response Code:

Website: www.cmj.org

DOI: 10.1097/CM9.0000000000000153

Correspondence to: Prof. Yan Xu, Institute of Sports Medicine, Beijing Key Laboratory of Sports Injuries, Peking University Third Hospital, 49 North Garden Road, Haidian District, Beijing 100191, China
E-Mail: yanxu@139.com

Chinese Medical Journal 2019;132(7)

Received: 12-12-2018 **Edited by:** Peng Lyu

The purpose of this study was to investigate HO incidence after hip arthroscopy and to review the pain and functional scores of patients undergoing revision surgery for HO, to determine whether surgical intervention improves clinical outcomes.

Methods

Ethical approval

The study was conducted in accordance with the *Declaration of Helsinki* and was approved by the Ethics Committee of the Third Hospital of Peking University (No. M2015074). All participants provided written informed consent.

Patients

A retrospective study was conducted on 242 patients (140 men and 102 women, mean age: 36.2 ± 9.5 years) who underwent hip arthroscopy for femoroacetabular impingement (FAI) between January 2016 and January 2018 and were followed up by radiography, computed tomography (CT), and ultrasonography. The average follow-up period was 22.88 ± 11.74 months (range: 11–34 months). Among them, 13 patients were found to have HO after surgery, and four cases underwent a revision operation because of obvious symptoms and persistent non-remission. The incidence of HO and the clinical effect of revision surgery for HO were evaluated.

The main surgical indication in this study was a diagnosis of FAI. Patients were excluded if their pre-operative pelvic radiography showed HO. Thirteen patients in whom HO was found after surgery were included in the study. No HO preventative treatment was given following surgery. Pain was assessed using the modified Harris Hip Score (mHHS), Non-Arthritis Hip Score (NAHS), and visual analog scale (VAS; 1: painless and 10: worst pain) after primary and revision surgery. Patient satisfaction was scored from 1 to 10 (1 point: unsatisfactory, 10 points: very satisfactory). Four patients who underwent revision hip arthroscopy had persistent hip pain after primary hip arthroscopy, and non-surgical treatment such as physical therapy, activity regulation, and oral anti-inflammatory drugs were ineffective for at least 3 months.

Ultrasound of patients after hip arthroscopy

Doctors specializing in musculoskeletal disorders for more than 10 years performed ultrasonography, and were blinded to the radiography, magnetic resonance imaging (MRI), and CT results. The patient was placed in a supine neutral position with slight external rotation and hip abduction. Acetabular apex, articular capsule, acetabular labrum, and femoral head and neck were identified by a transverse tilt plane parallel to the axis of the femoral neck. Then, the transducer was moved medially and laterally to evaluate the anterior quadrant of the hip acetabulum labrum. Dynamic examinations of passive flexion (0°–90°), adduction (0°–20°), and internal rotation (0°–30°) of the hip joints were performed to evaluate the positional relationship between the acetabular labrum and femoral head and between the femoral neck and labrum. The total time of ultrasound examination for one hip was between 5 and 10 min.

Surgical technique

The patient was placed on an orthopedic traction bed to protect the perineum, and lower limb traction was performed on the operative side. Under fluoroscopic guidance of the C-arm of the X-ray machine, the hip joint gap on the traction side reached 8 to 10 mm, and the hip joint was adducted and internal rotated. According to the methods of Philippon and Sehenker,[8] fluoroscopy-guided puncture was performed to establish an antero-lateral arthroscopic approach, with a 70° arthroscopic anterolateral approach established under the supervision of the central compartment of the hip. The articular capsule was moderately incised using electrocautery. The labrum, acetabular articular surface, femoral head cartilage, acetabular parietal cartilage, and ligamentum teres were examined in the central compartment. Labial suture or labioplasty were performed on the lacerated and degenerated acetabular labrum according to the injury condition. After the treatment of the central compartment, the lower extremities were relaxed and the arthroscope was inserted into the peripheral compartment. The location of HO was determined by radiography and arthroscopy. Electrocautery was used to remove fibrous tissue from the areas of HO. Radiofrequency, drilling, and nucleus pulposus forceps were used to remove the HO. The HO was osteotomized to allow removal through the arthroscopic portals. Type and location of femoral head and neck deformities and osteochondral lesions were observed. Clearance of the ectopic ossification was detected by three-dimensional (3D) CT reconstruction before and after the operation. Patients then received 60 mg etoricoxib once a day for 6 weeks, for HO prevention.

Isometric contraction exercises of the ankle, quadriceps femoris, and the muscles around the hip joint were performed 1 to 2 days after the operation. After 3 to 7 days, the affected limb could be supported to walk with partial weight, and passive hip movement was initiated within the painless range. Between 4 and 6 weeks of operation, partial weight-bearing was carried out, while continuing passive hip movement. Active hip movement was begun within a tolerable range of motion, including adduction, abduction, and internal and external rotation; strengthening of hip abduction with forward flexion and backward extensor strengthening exercises was also performed. After 6 weeks, walking with full weight-bearing was permitted along with normal functional activities involving walking and standing. After 3 to 6 months, all daily activities were gradually restored, including walking, jogging, and other sports.

Evaluation

The 242 FAI patients underwent standard and Dunn radiography, and 3D CT reconstruction in the supine position. Ultrasound and physical examination of the hip joint were performed regularly after the operation to

evaluate hip joint motion. Regular telephonic follow-up was conducted to investigate improvement of symptoms and recovery of joint function. VAS, mHHS, and NAHS were conducted.

Ultrasound examination was performed by a senior surgeon 2, 3, and 4 weeks after surgery and 1 month later. Only those patients who developed HO underwent repeat radiological examination. Thirteen patients with HO were followed up for 6.0 to 17.9 months, with an average of 12.1 months. HO was classified according to the Brooker classification [Figure 1].[9]

Statistical analysis

SPSS version 20.0 (SPSS Inc., Chicago, IL, USA) was used to process the data. Continuous variables were described using the mean ± standard deviation (SD), and categorical data were expressed as a percentage (%). Discrete variables were shown as medians accompanied by interquartile

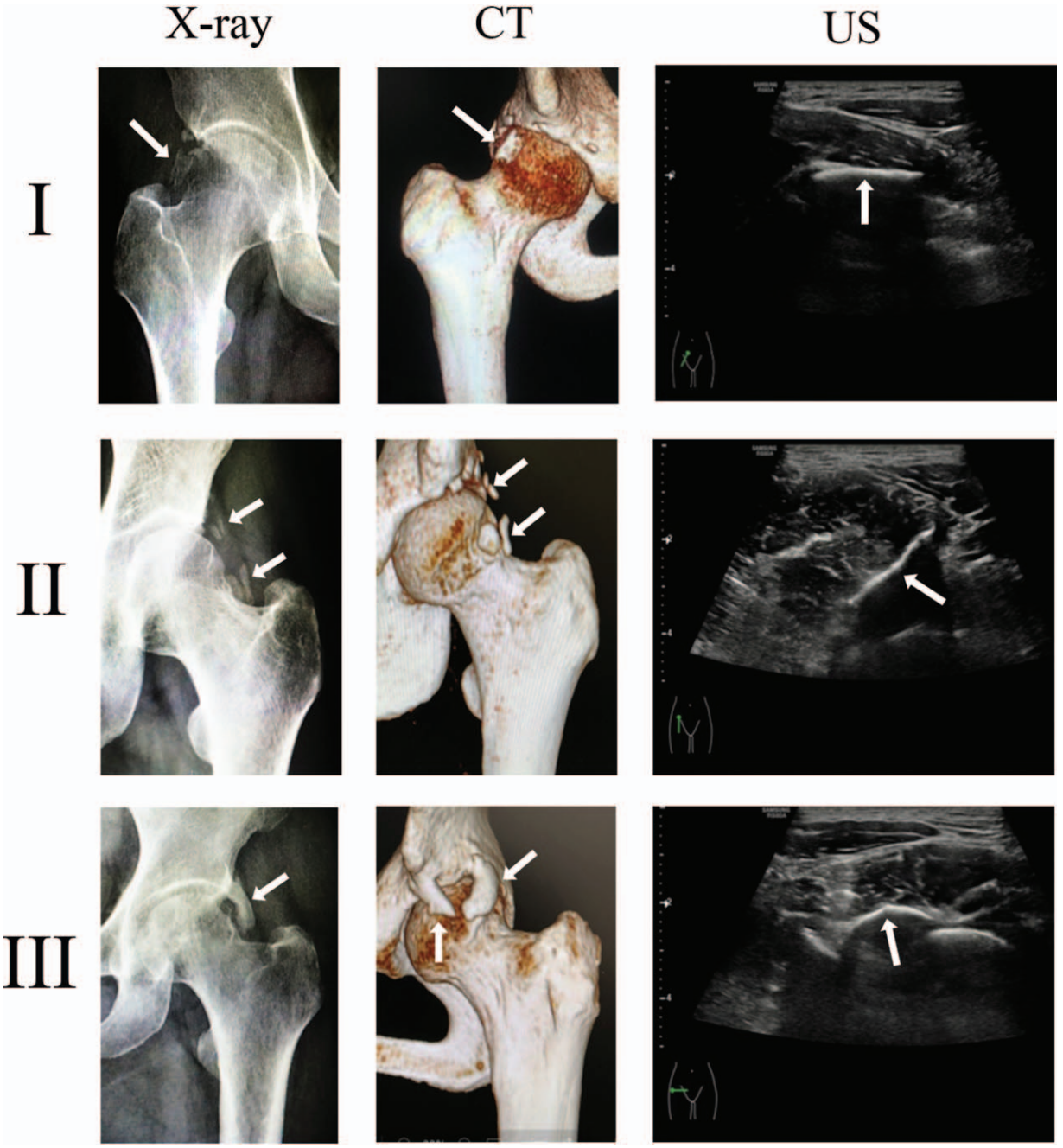

Figure 1: X-ray, CT and ultrasound of heterotopic ossification after hip arthroscopy in this study, showing heterotopic ossification stage I to III according to Brooker classification. White arrows show the position of heterotopic ossification. Isolated bony islands were observed in stage I, bone spurs from the pelvis or proximal end of the femur with more than 1 cm of space between opposing surfaces were observed in stage II, and bone spurs from the pelvis or proximal end of the femur with less than 1 cm of space between opposing surfaces were observed in stage III. The heterotopic ossification is identified by highly echogenic areas with attenuation or complete disappearance of the acoustic signal distal to these areas in ultrasound. CT: Computed tomography; US: Ultrasound.

range and were compared with the Mann-Whitney *U* test. Continuous variables with a normal distribution in the baseline data between groups were examined using the independent samples *t* test. The two-tailed paired *t* test was used to evaluate significance between preoperative and postoperative groups. Percentages were compared using the Chi-square test. The bilateral $P < 0.05$ was considered statistically significant.

Results

This retrospective study was conducted on 242 patients (140 men and 102 women, mean age: 36.2 ± 9.5 years) who underwent hip arthroscopy for FAI between January 2016 and January 2018. The average follow-up period was 22.88 ± 11.74 months (range: 11–34 months). Thirteen (5.37%) cases of HO (six men and seven women, five left hips and eight right hips; mean age: 37.5 ± 4.7 years) were observed among the 242 patients. Patient data are shown in Table 1. No significant differences in age, gender, and operation times were observed between the HO and non-HO groups [Table 1]. The mHHS of the HO group and non-HO group increased by 13.00 (8.50, 25.50) and 24.00 (14.00, 34.50) points ($Z = -1.80$, $P = 0.08$), NAHS increased by 18.00 (9.50, 31.50) and 26.00 (13.50, 36.00) points ($Z = -1.34$, $P = 0.18$), and VAS decreased by 3.00 (2.00, 4.00) and 4.00 (3.00, 4.50) points ($Z = -1.55$, $P = 0.12$). There were no significant differences in mHHS, VAS, and NAHS scores between the HO and non-HO groups [Table 1]. HO was detected by ultrasound examination 3 weeks after operation at the earliest. For primary surgery, 12 patients in the HO group and 221 in the non-HO group underwent femoral osteoplasty; eight patients in the HO group and 160 in the non-HO group underwent acetabuloplasty; one patient in the HO group and 19 in the non-HO group underwent iliopsoas release; six patients in the HO group and 110 in the non-HO group underwent chondroplasty; one patient in the non-HO group underwent removal of a loose body; two patients in the HO group and 39 in the non-HO group underwent trochanteric bursectomy; and 12 patients in the HO group and 216 in the non-HO group underwent labral treatment. Four patients underwent revision surgery and HO resection because of obvious pain symptoms and persistent non-remission. The average follow-up time after revision surgery was 9.00 ± 2.94 months. All 13 patients with HO were graded by Brooker classification [Figure 1]. Nine (9/13) showed Brooker stage I, three (3/13) showed Brooker stage II and one (1/13) showed Brooker stage III. No stage IV HO was found. Before primary operation, mean mHHS was 62.50 ± 5.32; NAHS 62.02 ± 4.13; and VAS 5.36 ± 0.37. Before the revision operation, the mean mHHS was 53.75 ± 3.27; NAHS 51.75 ± 5.71; and VAS 5.50 ± 0.50. At the final post-operative follow-up, the average mHHS was 88.50 ± 4.04; NAHS 80.50 ± 4.65; and VAS 1.50 ± 0.58 [Table 2]. In revision surgery, four patients underwent concomitant femoral osteoplasty, one underwent subspine release, one underwent iliopsoas release, two underwent iliotibial band release, two underwent trochanteric bursectomy, and four underwent labral treatment. Before and after revision surgery, the mHHS increased by 34.75 points ($t = -55.23$, $P < 0.01$), NAHS increased by 28.75 points ($t = -6.03$, $P < 0.01$), and VAS decreased by four points. ($t = 9.80$, $P < 0.01$). Each patient who had revision surgery improved on all three scales. The mean satisfaction score was 8.46.

Discussion

HO incidence after hip arthroscopy for FAI was much lower than that after hip arthroplasty

The results of previous studies and a comparison of our data with those of previous studies suggest that HO incidence after arthroscopic treatment of FAI is much lower than that after hip arthroplasty for the same condition. Ganz *et al*[10] reported that HO incidence after hip arthroplasty for FAI was as high as 37%. Clohisy *et al*[11] reported four cases (11.4%) of grade I HO in 35 patients who underwent hip arthroscopic exploration combined with femoral head and neck plasty. Randelli *et al*[12] retrospectively reviewed 300 cases of FAI treated by hip arthroscopy. HO was found in five cases (1.6%). Byrd and Jones[13] reported HO of the articular capsule in one of 207 patients (1%) who underwent arthroscopic treatment of FAI. HO grade was not reported, but the patient's mHHS was higher than others. In this study, the total incidence of HO was 5.37% (13/242) in patients who underwent arthroscopic FAI. No significant differences in age, sex, and treatment diagnosis [Table 1] were found. Significant differences in mHHS, VAS, and NAHS scores were not observed between patients without HO resection and revision surgery and before HO formation. The

Table 1: Baseline characteristics in patients who were found HO after hip arthroscopy *vs.* patients without HO.

Parameters	HO ($n = 13$)	No HO ($n = 229$)	Statistics	*P*
Male	6	134	1.77*	0.18
Age (years)	37.5 ± 4.7	36.2 ± 9.7	1.09†	0.20
Change in α angle between baseline and follow-up (degree)	11.70 (5.45, 16.00)	12.50 (7.85, 17.50)	−0.84‡	0.40
Change in CE angle between baseline and follow-up (degree)	10.10 (5.55, 12.90)	7.30 (3.40, 9.95)	−1.65‡	0.10
Change in mHHS between baseline and follow-up	13.00 (8.50, 25.50)	24.00 (14.00,34.50)	−1.80‡	0.08
Change in NAHS between baseline and follow-up	18.00 (9.50, 31.50)	26.00 (13.50,36.00)	−1.34‡	0.18
Change in VAS between baseline and follow-up	3.00 (2.00, 4.00)	4.00 (3.00, 4.50)	−1.55‡	0.12
Follow-up (weeks)	22.6 ± 9.1	23.1 ± 9.1	−0.68†	0.36

Values are presented as mean ± standard deviation or median (Q1, Q3). *x^2 value; †*t* value; ‡*Z* value. HO: Heterotopic ossification; CE: Center-edge; mHHS: modified Harris Hip Score; NAHS: Non-Arthritis Hip Score; VAS: Visual analogue scale.

Table 2: Scores before primary surgery, before revision surgery and in the lastest post-operative follow-up.

Parameters	Before primary surgery	Before revision surgery	Lastest post-operative follow-up	*t*	*P*
mHHS	62.50±5.32	53.75±3.27	88.50±4.04	4.04*	<0.01
				−7.17†	<0.01
				−55.23‡	<0.01
NAHS	62.02±4.13	51.75±5.71	80.50±4.65	4.13*	<0.01
				−8.11†	<0.01
				−6.03‡	<0.01
VAS	5.36±0.37	5.50±0.50	1.50±0.58	−5.23*	<0.01
				22.43†	<0.01
				9.80‡	0.03

Values are presented as mean±standard deviation. *Before primary surgery *vs.* before revision surgery. †Before primary surgery *vs.* lastest post-operative follow-up. ‡Before revision surgery *vs.* lastest post-operative follow-up. mHHS: Modified Harris Hip score; NAHS: Non-Arthritis Hip Score; VAS: Visual analogue scale.

incidence of HO after hip arthroscopy was much lower than that after open surgery. This may be because, first, open surgery for FAI involves dislocation of the hip joint, trauma, and bleeding, which may cause HO; and second, continuous washing of bone debris and suction of hematoma during arthroscopy might reduce the incidence of HO.

Only four patients with intractable pain or limited hip movement underwent revision surgery. Post-operative patients showed significant improvement in pain and functional outcome scores. The study also found that pain was the main cause of revision surgery, rather than a limited range of motion of the joints. Cases classified as Brooker grade III and IV are suitable for revision surgery owing to the reduction of range of motion and stiffness. However, most of the patients who underwent revision in this study had Brooker grade I or II HO. After revision, the range of motion, pain, and function scores were significantly improved, and patient satisfaction was high.

Advantages and limitations of ultrasonography in HO detection compared with radiography, CT, and MRI

Ordinary plain film (X-ray) is a projection imaging method that produces two-dimensional images by X-ray radiation. It is widely used in the clinic because of its low cost. Radiographs cannot provide 3D information; in the imaging of HO, this leads to an overlap of HO tissue with other bone tissue, and easily causes misdiagnosis of HO. CT can provide 3D images of the hip joint from which the location and volume of HO can be clearly observed, but the cost of CT is higher. Moreover, both radiography and CT can expose patients to high doses of radiation, and only detect late mature HO.[14] MRI can display early soft tissue imaging of HO, but its resolution is low, and it is expensive and relatively insensitive to bone tissue.[15] Ultrasonography is radiation-free, inexpensive, and portable for bedside monitoring or outpatient follow-up.[16] A previous study has shown that ultrasound is very sensitive to soft tissue calcification, and its use can effectively detect early immature HO and distinguish mature HO from surrounding soft tissue with high specificity.[17] In this study, hip joint HO was detected by ultrasound examination as early as 3 weeks after surgery. During the follow-up period, not only was the formation of HO observed by ultrasound, but the recovery of labrum, muscle, and other tissues was also dynamically observed by real-time imaging. However, diagnosis of HO using ultrasound scanning requires the experience of ultrasound specialists —most orthopedic doctors cannot independently detect HO with it.

Prevention of HO after hip arthroscopy

Once HO lesions occur, preventing the further formation and maturation of HO lesions by non-surgical measures is difficult. Therefore, primary prevention of HO after surgery is important. External radiotherapy can be used, as well as drug treatment. External radiotherapy affects rapidly dividing cells by altering the structure of nuclear DNA. Previous studies have reported that external radiotherapy is clinically effective in reducing the incidence of HO after hip surgery.[18] The recommendation for external radiotherapy is a single-dose regimen of 600 to 800 Gy after surgery.[19] Drugs used for HO prevention include non-selective cyclooxygenase (COX) inhibitors, selective COX-2 inhibitors, aspirin, BMP-1 receptors and inhibitors, BMP antagonists, riboflavic acid receptor C agonists, free radical scavengers, and bisphosphonates. BMP1 receptor inhibitors, BMP antagonists, riboflavic acid receptor C agonists, and free radical scavengers have not been proven to be effective in humans.[20] Aspirin is superior to coumarin in HO prevention after total hip arthroplasty.[21] Non-steroidal anti-inflammatory drugs (NSAIDs) inhibit arachidonic acid conversion to prostaglandins through arachidonase, thereby inhibiting prostate production. There are two COX enzyme subtypes, which differ in distribution and expression. COX-2 subtype is more easily expressed in a proinflammatory state and, hence, selectively targeted. This isomer may be advantageous in the prevention of inflammatory conditions, avoiding many of the adverse effects of NSAIDs[22] that simultaneously lead to COX-1 and COX-2 inhibition. Ehud *et al*[6] evaluated 100 control patients and 63 study patients who underwent hip arthroscopic surgery; radiographic findings of HO were present in 36 of the control patients, with 17, 15, and 4 classified as Brooker grade I, II, and III, respectively. They suggested HO prophylaxis protocols based on short-term etodolac treatment may be

considered after hip arthroscopic surgery. Beckman *et al*[7] evaluated 108 patients randomized to take naproxen or a placebo for 3 weeks post-operatively and found a prevalence of HO of 46% (22/48 in the final analysis) in the placebo group *vs*. 4% (2/48) in the naproxen group at 1-year follow-up. They concluded that prophylaxis with naproxen was effective in reducing the prevalence of HO, without medication-related morbidity. Beckman *et al*[23] prospectively explored the role of NSAIDs in preventing HO after hip arthroscopy and found an HO prevalence of 25.0% (23/92) in the control group and 5.6% (11/196) in the study group. The authors asserted that routine NSAID prevention reduced but did not limit the incidence of HO in patients undergoing hip arthroscopy. In this study, 242 patients with FAI did not receive HO preventative measures after operation, and four patients who underwent revision surgery took NSAIDs orally for 6 weeks.

Clinical effect of arthroscopic HO resection

In the present study, the 13 patients with HO who underwent hip arthroscopy were mostly asymptomatic without functional limitation; of these, four had persistent pain or limited range of motion of the hip joint, and conservative treatment was ineffective for them. Removal of immature HO can lead to complications and recurrence. When evaluating the maturity of HO, the imaging manifestations should be consistent with the bone mineral density of the dense cortex, the serum alkaline phosphatase level should be within the normal range, and bone scan results should return to normal or near normal.[24] Beckmann *et al*[23] reported on nine of 34 patients with HO 12 months after surgery who underwent arthroscopic heterotopic bone resection. This 12-month period was used to ensure the full HO maturity. In the study, four patients who underwent HO resection were given NSAIDs orally for 6 weeks. Brooker grade III and IV cases are suitable for revision surgery owing to considerable stiffness and reduction in motion range. However, the majority of the patients who underwent revision in the present study had Brooker I or II grade disease. The main reason patients agree to or request revision surgery for HO is persistent pain, rather than limited range of motion of joints. After revision, range of motion, pain, and function scores of all the patients in the study were significantly improved, and patient satisfaction was high. However, HO resection can also cause bleeding, wound healing problems, edema of surrounding tissue, infection, and possible recurrence of HO. Therefore, careful review of the surgical indications is necessary.

Although the large sample size provided a substantial amount of evidence to support our findings, the retrospective nature of this study constituted inherent potential limitations.

In conclusion, incidence of HO after arthroscopic treatment of FAI in this study is similar to that of previous studies on this topic. In most cases, HO has no or little effect on the clinical symptoms and joint function of patients, with no need for revision surgery observed. Patients who undergo hip revision by HO resection show improvement in pain and joint function scores, but caution is advised due to the risk of complications and recurrence. Oral NSAID treatment is helpful in the prevention of HO after primary hip arthroscopy. Ultrasound imaging is highly sensitive for HO and can detect and distinguish immature from mature HO. It can hence be employed as a potential dynamic method for detecting HO.

Funding

The work was supported by grants from the Beijing Natural Science Foundation (No. 7162201), National Natural Science Foundation of China (No. 81672182, No. 81871761, No. 7192221), and Beijing New-star Plan of Science and Technology (No. xxjc201711).

Conflicts of interest

None.

References

1. Kaplan FS, Hahn GV, Zasloff MA. Heterotopic ossification: two rare forms and what they can teach us. J Am Acad Orthop Surg 1994;2:288–296.
2. Rath E, Sherman H, Sampson TG, Ben Tov T, Maman E, Amar E. The incidence of heterotopic ossification in hip arthroscopy. Arthroscopy 2013;29:427–433. doi: 10.1016/j.arthro.2012.10.015.
3. Bedi A, Zbeda RM, Bueno VF, Downie B, Dolan M, Kelly BT. The incidence of heterotopic ossification after hip arthroscopy. Am J Sports Med 2012;40:854–863. doi: 10.1177/0363546511434285.
4. Bhardwaj S, Bal A, Mohan H. Heterotopic omental ossification in response to spilled contents of a mature cystic teratoma: an unusual reaction. Histopathology 2002;41:561. doi: 10.1046/j.1365-2559.2002.01457_2.x.
5. Banaszkiewicz PA. The long term results of low friction arthroplasty of the hip performed as a primary intervention. J Bone Joint Surg-Br 1972;54:61–76. doi: 10.1302/0301-620X.54B1.61.
6. Rath E, Warschawski Y, Maman E, Dolkart O, Sharfman ZT, Salai M, *et al*. Selective COX-2 inhibitors significantly reduce the occurrence of heterotopic ossification after hip arthroscopic surgery. Am J Sports Med 2016;44. doi: 10.1177/0363546515618623.
7. Beckmann JT, Wylie JD, Potter MQ, Maak TG, Greene TH, Aoki SK. Effect of naproxen prophylaxis on heterotopic ossification following hip arthroscopy: a double-blind randomized placebo-controlled trial. J Bone Joint Surg-Am 2016;97:2032–2037. doi: 10.2106/JBJS.N.01156.
8. Philippon MJ, Schenker ML. Arthroscopy for the treatment of femoroacetabular impingement in the athlete. Clin Sports Med 2006;25:299–308. doi: 10.1016/j.csm.2005.12.006.
9. Brooker AF, Bowerman JW, Robinson RA, Riley LH Jr. Ectopic ossification following total hip replacement. Incidence and a method of classification. J Bone Joint Surg Am 1973;55:1629–1632.
10. Ganz R, Gill TJ, Gautier E, Ganz K, Krügel N, Berlemann U. Surgical dislocation of the adult hip a technique with full access to the femoral head and acetabulum without the risk of avascular necrosis. London: Springer; 2014. doi: 10.1007/978-1-4471-5451-8_144.
11. Clohisy JC, Zebala LP, Nepple JJ, Gail P. Combined hip arthroscopy and limited open osteochondroplasty for anterior femoroacetabular impingement. J Bone Joint Surg Am 2010;92:1697. doi: 10.2106/JBJS.I.00326.
12. Randelli F, Pierannunzii L, Banci L, Ragone V, Aliprandi A, Buly R. Heterotopic ossifications after arthroscopic management of femoroacetabular impingement: the role of NSAID prophylaxis. J Orthop Traumatol 2010;11:245–250. doi: 10.1007/s10195-010-0121-z.
13. Byrd JWT, Jones KS. Arthroscopic femoroplasty in the management of cam-type femoroacetabular impingement. Clin Orthop Relat Res 2009;467:739–746. doi: 10.1007/s11999-008-0659-8.
14. Vanden Bossche L, Vanderstraeten G. Heterotopic ossification: a review. J Rehabil Med 2005;37:129–136. doi: 10.1080/16501970510027628.

15. Ledermann HP, Schweitzer ME, Morrison WB. Pelvic heterotopic ossification: MR imaging characteristics. Radiology 2002;222:189–195. doi: 10.1148/radiol.2221010552.
16. Ekiz T, Yıldızgören MT, Yetişgin A. Musculoskeletal ultrasonography bypasses the diagnostic and radiological challenges in heterotopic ossification. Singapore Med J 2014;55:604–605. doi: 10.11622/smedj.2014162.
17. Falsetti P, Acciai C, Palilla R, Carpinteri F, Patrizio C, Lenzi L. Bedside ultrasound in early diagnosis of neurogenic heterotopic ossification in patients with acquired brain injury. Clin Neurol Neurosurg 2011;113:22–27. doi: 10.1016/j.clineuro.2010.08.012.
18. Ayers DC, Evarts CM, Parkinson JR. The prevention of heterotopic ossification in high-risk patients by low-dose radiation therapy after total hip arthroplasty. J Bone Joint Surg-Am 1986;68:1423–1430. doi: 10.2106/00004623-198668090-00016.
19. Gross CE, Frank RM, Hsu AR, Aidnag D, Steven G. External beam radiation therapy for orthopaedic pathology. J Am Acad Orthop Surg 2015;23:243–252. doi: 10.5435/jaaos-d-15-00218.
20. George P, Margaritis K, Evaggelos T, Nectarios K, Eleftherios T. Pharmacological treatment of heterotopic ossification following hip surgery: an update. Exp Opin Pharmac 2012;13:619–622. doi: 10.1517/14656566.2012.662342.
21. Bek D, Beksaç B, Della Valle AG, Sculco TP, Salvati EA. Aspirin decreases the prevalence and severity of heterotopic ossification after 1-stage bilateral total hip arthroplasty for osteoarthrosis. J Arthrop 2009;24:226–232. doi: 10.1016/j.arth.2007.11.008.
22. Borer JS, Simon LS. Cardiovascular and gastrointestinal effects of COX-2 inhibitors and NSAIDs: achieving a balance. Arthr Res Ther 2005;7 (Suppl 4):S14–S22. doi: 10.1186/ar1794.
23. Beckmann JT, Wylie JD, Kapron AL, Hanson JA, Maak TG, Aoki SK. The effect of NSAID prophylaxis and operative variables on heterotopic ossification after hip arthroscopy. Am J Sports Med 2014;42:1359–1364. doi: 10.1177/0363546514526361.
24. Shehab D, Elgazzar AH, Collier BD. Heterotopic ossification. J Nucl Med 2002;43:346–353.

How to cite this article: Gao GY, Zhang X, Dai LH, Huang HJ, Wu RQ, Ju XD, Mei Y, Niu XY, Wang JQ, Xu Y. Heterotopic ossification after arthroscopy for hip impingement syndrome. Chin Med J 2019;132:827–833. doi: 10.1097/CM9.0000000000000153