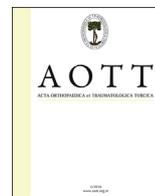




Contents lists available at ScienceDirect

## Acta Orthopaedica et Traumatologica Turcica

journal homepage: <https://www.elsevier.com/locate/aott>

# Appropriate excision time of heterotopic ossification in elbow caused by trauma



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## ARTICLE INFO

## Article history:

Received 14 September 2016

Received in revised form

23 November 2017

Accepted 24 November 2017

Available online 28 December 2017

## Keywords:

Elbow

Heterotopic ossification

Trauma

Timing of excision

## ABSTRACT

**Objective:** The aim of this study was to investigate the optimal timing for the resection of heterotopic ossification (HO) of the elbow.

**Methods:** We retrospectively reviewed 42 patients who were treated operatively for heterotopic ossification of the elbow from March 2010 to December 2014 at our institution. The patients were divided into early (before 12 months) and late (after 12 months) excision groups. In the early excision group (17 patients), the average time from the initial injury to HO excision was 7.4 (3–11) months, and in the late excision group (25 patients), the average time was 33.5 (12–240) months. Every patient was evaluated by range of motion (ROM), the Mayo Elbow Performance Score (MEPS), postoperative complications and HO recurrence.

**Results:** The preoperative mean ROM in the late excision group was greater than that of the early excision group, suggesting that the ROM is expected to increase even without surgery. Both early and late surgery increased ROM and MEPS, but early surgery improved ROM and MEPS more than late surgery did ( $p < .05$ ).

**Conclusions:** Early excision of HO can provide better elbow function, as indicated by ROM and MEPS. Considering that there were no notable differences in postoperative ROM and MEPS, HO recurrence, or postoperative complications, we concluded that early excision is safe and that the time from an elbow injury to surgery may be shortened.

**Level of Evidence:** Level III, therapeutic study.

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## Introduction

Compared with other joints, the elbow commonly shows growth of a heterotopic ossification (HO), a generally acknowledged complication following an elbow injury. The specific cause of post-traumatic HO may be multifactorial, but it remains unclear,<sup>1,2</sup> requiring further study. The development of HO around the elbow may impair the range of motion (ROM) and even lead to complete loss of movement.<sup>3,4</sup> If non-operative treatment cannot result in a functional ROM, surgery becomes the effective method to restore elbow function. Many authors have reported that the time from

initial injury to surgical release is always more than one year until the maturation of HO occurs in order to avoid recurrence.<sup>5–10</sup> However, as time goes by, the elbow function becomes worse as a result of soft tissue contracture and muscular atrophy.<sup>11</sup> The purpose of this study was to compare the improvements of ROM and the Mayo Elbow Performance Score (MEPS)<sup>12</sup> after surgery between the early excision group and the late excision group. In addition, we investigated whether the time from an elbow injury to surgery might be shortened.

## Methods

## Patients

After obtaining institutional review board approval, we retrospectively analyzed all patients who were treated with open surgical release at our institution between March 2010 and December 2014. Inclusion criteria: (1) post-traumatic stiff elbow with an ROM

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Peer review under responsibility of Turkish Association of Orthopaedics and Traumatology.

less than 100°; (2) preoperative X-ray images were observed in HO and were confirmed during surgery; and (3) imaging of bone and joint development in good condition with no deformity. Exclusion criteria: (1) elbow stiffness caused by skin or muscle contracture; (2) HO caused by burns or central nervous system injury; and (3) limited ROM in patients with trauma history before the injury. Fifty-one patients satisfied the inclusion criteria and eight patients were excluded after checking the medical records and plain films. In December 2015, we investigated 43 patients who were treated; we were unable to contact one patient. Overall, 42 patients received telephone interviews with more than 12 months of medical records; the average follow-up time was 37 (12–65) months. To avoid HO recurrence and postoperative complications and to compare the outcome between early surgical excision of HO and late surgical excision, we established a time limit of 12 months to define early (<12 months) and late (>12 months) surgical excision<sup>8,13</sup>. In the early excision group, 17 patients had an average time of 7.4 (3–11) months before surgery; the late excision group, 25 patients had surgery after an average time of 33.5 (12–240) months.

### Surgery

The indication of surgical excision was at least three months after injury and continual loss of elbow flexion of the upper limb in daily activities. All surgeries were performed with the patient in the supine position and under general anesthesia with a tourniquet. While protecting and preserving important structures, surgical approaches were individualized considering the location of the HO, previous incisions, and skin condition. In the early excision group, medial and lateral approaches were utilized in 14 patients, a medial approach in two, and a lateral approach in one. In the late excision group, medial and lateral approaches were utilized in 13 patients, a medial approach in four, a lateral approach in five, an anterior approach in one, and a posterior approach in two. With the release of contracted capsular structures, HO excision, and ligament reconstructions, we achieved our goal in all patients (i.e., obtaining >130° of flexion and <10° of flexion contracture by passive motion intraoperatively).<sup>14</sup> Intraoperative ROM measured with a sterile goniometer in the flexion–extension arc of all patients was recorded. In addition, the ulnar nerve was released in 37 patients with ulnar nerve symptoms and transferred anteriorly into the subcutaneous layer.

### Aftercare

A unilateral hinged external fixator was applied for protection on all patients for as long as four weeks (4–6 weeks) postoperatively. Physical therapy consisted of active assisted and mild passive flexion and extension exercises and was initiated on the second postoperative day continuing until the ROM was no longer changed by the flexion and extension exercises. The exercise was tailored to each patient's individual conditions and usually continued for 4–6 months. All of the patients received indomethacin for 4 weeks at a dose of 25 mg three times a day to prevent HO recurrence. No radiotherapy was used for any patient.

### Data measures and evaluation

Data from all patients regarding sex, age, involvement of dominant elbow, type of injury, surgical approach, and initial treatment were collected. Preoperative biplanar radiographs were obtained to assess the location of heterotopic ossification as medial, lateral, anterior, or posterior. Computed tomography (CT) with 3-dimensional reconstruction was not routinely utilized to evaluate HO; quantitative analysis of HO was not done. The elbow

flexion and flexion contracture arc was measured with a goniometer, and the MEPS was evaluated before the surgical excision of HO. In addition, ulnar nerve palsy was assessed by electrophysiological studies only when ulnar nerve dysfunction was suspected prior to surgery. The final ROM and MEPS were assessed at the final follow-up. Medical records covering more than 12 months were available for 13 patients. Twenty-nine patients who did not visit after one year postoperatively were interviewed by telephone; these patients stated that the final ROM was essentially unchanged from the time of discharge. Therefore, we defined the final ROM of those patients as the joint activity measured at the last visit. Postoperative complications and recurrence of HO were also reviewed.

### Statistical analysis

All independent variables were coded as continuous or categorical data. The ROM and MEPS were assessed by the independent sample T test. Fisher's exact test was used to assess categorical variables. The level of significance was predetermined at P values < .05. Statistical analysis was performed using SPSS 22 software (IBM, Armonk, NY, USA).

### Results

#### Comparison of ROM and MEPS after surgery between the early excision group and the late excision group

The comparison of clinical characteristics of patients showed no significant difference between the two groups regarding sex, age, involvement of dominant elbow, type of injury, location of HO, surgical approach, initial treatment, follow-up time, postoperative complications, or recurrence of HO (Table 1). The ROM and MEPS of the two groups before surgery and at the final follow-up were summarized in Table II. In the early excision group, the average postoperative flexion was 114°(50°–135°), which had improved from 63°(10°–100°) preoperatively with an average improvement of 51°(–5° to 105°). The average flexion contracture decreased from 47°(5°–90°) preoperatively to 16°(0°–50°) postoperatively with an average improvement of –31°(–70° to 0°). The average total arc of motion increased from 16°(0°–70°) preoperatively to 98°(20°–125°) postoperatively, with an average improvement of 82°(15°–120°). In the control group, the average postoperative flexion was 112°(80°–135°), which had improved from 81°(5°–120°) preoperatively with an average improvement of 31°(0°–105°). The average flexion contracture decreased from 45°(0°–95°) preoperatively to 19°(0°–70°) postoperatively with an average improvement of –26°(–80° to 10°). The average total arc of motion increased from 35°(0°–90°) preoperatively to 93°(50°–130°) postoperatively, with an average improvement of 57°(0°–120°). The average MEPS increased from 37 (20–55) preoperatively to 91 (60–100) postoperatively with an average improvement of 54 (5–80) in the early excision group, and the average MEPS increased from 47 (20–70) preoperatively to 85 (55–100) postoperatively with an average improvement of 38 (15–80) in the late excision group. In all clinical variables, the preoperative flexion (P = 0.045), total arc of motion (P = 0.013) and MEPS (P = 0.027) had significant differences between the two groups (Table 2). Additionally, the preoperative mean ROM in the late excision group is greater than that of the early excision group; thus, it can be concluded that as time passes, the ROM increases even if no procedure is done. In addition, differences of improvement in flexion (P = 0.042), total arc of motion (P = 0.024) and MEPS (P = 0.001) between the two groups were significant (Table 2), suggesting that early or late surgery both increased ROM

**Table 1**  
Comparison of patient clinical characteristics.

Variable	Early excision group (n = 17)	Late excision group (n = 25)	P value
Gender, n			.731
Male	13	17	
Female	4	8	
Age, average (range), y	37 (20–63)	36 (17–62)	.800
Involvement of dominant elbow, n			.531
Yes	8	15	
No	9	10	
Type of injury, n			.146
Distal humeral fracture	4	12	
Proximal radial or ulnar fracture	7	10	
Elbow dislocation/fracture-dislocation	6	3	
Location of heterotopic ossification, n			.951
Medial	3	3	
Lateral	2	4	
Anterior	13	18	
Posterior	14	19	
Surgical approach, n			.329
Medial and lateral approaches	14	13	
Medial approach	2	4	
Lateral approach	1	5	
Anterior approach	0	1	
Posterior approach	0	2	
Initial treatment, n			.374
Nonoperative	1	5	
Operative	16	20	
Time to index surgery, average (range), mo	7.4 (3–11)	33.5 (12–240)	.010
Follow-up time, average (range), mo	42 (16–63)	33 (12–65)	.067
Postoperative complications	3	4	.888
Recurrence of heterotopic ossification	4	6	.972

**Table 2**  
Comparison of preoperative and postoperative ROM<sup>a</sup> and MEPS.<sup>b</sup>

Variable <sup>c</sup>	Early excision group	Late excision group	P value
Preoperative			
Flexion,°	63 (10–100)	81 (5–120)	.045
Flexion contracture,°	47 (5–90)	45 (0–95)	.818
Total arc of motion,°	16 (0–70)	35 (0–90)	.013
Postoperative			
Flexion,°	114 (50–135)	112 (80–135)	.682
Flexion contracture,°	16 (0–50)	19 (0–70)	.587
Total arc of motion,°	98 (20–125)	93 (50–130)	.556
Improvement <sup>d</sup>			
Flexion,°	51 (–5–105)	31 (0–105)	.042
Flexion contracture,°	–31 (–70 to 0)	–26 (–80 to 10)	.576
Total arc of motion,°	82 (15–120)	57 (0–120)	.024
MEPS			
Preoperative	37 (20–55)	47 (20–70)	.027
Postoperative	91 (60–100)	85 (55–100)	.187
Improvement	54 (15–80)	38 (15–80)	.001

<sup>a</sup> ROM, range of motion.<sup>b</sup> MEPS, Mayo elbow Performance Score.<sup>c</sup> All measurements are presented as average (range).<sup>d</sup> Improvement of Flexion contracture needs to have the “–” sign convention consistent with comments in the Abstract, Methods, and Results sections.

and MEPS, but early surgery statistically improved ROM and MEPS more than late surgery.

#### Evaluation of potentially shortening the time from elbow injury to surgery

Ten patients showed radiographic recurrence of HO; clinical recurrence associated with dissatisfied ROM was observed only in three patients after comprehensive rehabilitation exercises (Table 3). In one patient, repeat excision of HO was performed 17 months after the first surgery. After the second excision, HO did not recur and the final follow-up ROM was increased. The other two

patients accepted the result (i.e., recurring HO) but refused a second surgery (Table 3). One patient had persistent ulnar nerve palsy during the final follow-up (Table 3). However, no patient showed worsening ulnar nerve palsy after the surgery. Two patients developed infections immediately after the surgery; both patients were cured by irrigation and debridement with systemic administration of antibiotics (Table 3). However, the infection still affected the final ROM in one patient. One patient had elbow instability and underwent a secondary surgery to reconstruct elbow stability by medial and lateral collateral ligament reconstruction (Table 3). There was no notable difference concerning postoperative complications ( $P = 0.888$ ) or recurrence of HO ( $P = 0.972$ ) between the early and late excision groups (Table 1).

## Discussion

The existence of HO of the elbow can impede patients' personal lives, especially when the dominant extremity is affected. The surgical release of elbow stiffness caused by HO after trauma allows patients to regain satisfactory elbow ROM. The purpose of our study was to compare improvements of ROM and MEPS after surgery between the early excision group and the late excision group. In addition, we wished to know whether the time from elbow injury to surgery might be shortened.

The formation of HO around the elbow can manifest from two to 12 weeks after trauma, traumatic brain injury, or burn.<sup>15</sup> The maturation of HO has been considered important for the timing of surgical excision. In plain films, the maturation of bone is indicated by smooth, well-demarcated cortical margins<sup>16</sup> and defined trabecular markings, generally about three to six months after HO onset.<sup>17</sup> In previous studies of patients with post-traumatic HO, surgical excision of HO was usually delayed from the time of injury to surgery for 12–24 months.<sup>5–10,18</sup> Hastings et al<sup>19</sup> delayed surgery to reduce recurrence of HO until the HO appeared mature in the plain film as well as a bone scan and serum alkaline phosphatase

**Table 3**  
Patients with postoperative complications.

Patient	Sex	Complication	Preoperative ROM, <sup>a</sup>	Final follow-up ROM, <sup>a</sup>	Time to index surgery, mo	Prophylaxis of HO	Reoperation
1	Male	Symptomatic recurrence of HO	25	120 <sup>a</sup>	24	Indomethacin <sup>b</sup>	Yes
2	Male	Symptomatic recurrence of HO	15	50	10	Indomethacin	No
3	Male	Symptomatic recurrence of HO	75	100	48	Indomethacin	No
4	Male	Ulnar nerve symptom	10	120	8	Indomethacin	No
5	Male	Infection	10	130 <sup>a</sup>	36	Indomethacin	Yes
6	Male	Infection	0	60 <sup>a</sup>	22	Indomethacin	Yes
7	Male	Elbow instability	10	95 <sup>a</sup>	6	Indomethacin	Yes

<sup>a</sup> ROM is measured after the second operation.

<sup>b</sup> Indomethacin was also used for HO prophylaxis after the second operation.

became normal. However, during this period, the function of the elbow is significantly diminished because of secondary contracture caused by soft tissue contracture and muscular atrophy.<sup>11,18,20</sup> Currently, there is no clear evidence that late excision of HO can decrease recurrence and result in better ROM and MEPS.<sup>21</sup> Koh et al<sup>22</sup> concluded that the time from the initial injury to the index surgical release was the only independent variable affecting the final ROM and delayed surgery (>19 months), adversely affecting the final ROM. Baldwin et al<sup>23</sup> also suggested that waiting longer than 12 months decreases the probability of achieving functional ROM. In addition, some authors have reported that early excision can achieve satisfactory outcomes, and they believe that surgical delay of HO is unnecessary.<sup>4,16,18,24</sup>

In our study, surgical excision of HO was performed an average of 7.4 (3–11) months after the injury in the early excision group. Both groups showed considerable improvements in ROM and MEPS. Although there was no significant difference in the final follow-up ROM and MEPS between the two groups, early surgery statistically improved ROM and MEPS more than late surgery. Patients with HO after elbow trauma are often limited in flexion and extension function, and the functional ROM required for normal daily activities is 30°–130°,<sup>25</sup> suggesting that it is more important to restore flexion. Compared with the late excision group, the flexion arc of the elbow joint was worse in the early excision group preoperatively and the improvement of flexion was better post-surgically.

No significant difference was observed regarding the rate of postoperative complications including symptomatic recurrence of HO, ulnar nerve, infection, and elbow instability, between the early excision group (n = 3) and the late excision group (n = 4). No notable difference was observed between the early excision group and the late excision group in the final follow-up of ROM (P = 0.556) and MEPS (P = 0.187). In addition, because of more improvements of ROM (P = 0.024) and MEPS (P = 0.001), we believe that early surgical treatment of elbow stiffness caused by post-traumatic HO can result in good clinical scores and increased elbow movement.

HO recurrence is a serious complication, often compromising the long-term result.<sup>26,27</sup> Although some patients can be asymptomatic or minimally symptomatic after rehabilitation exercises, others may still experience restriction in elbow motion; in this situation, re-excision of the HO may be the most effective way to increase the ROM. In our study, of the 10 patients with recurrence of HO, only three patients had severe limitations in elbow function. Two of the three patients refused to undergo another operation; the remaining one patient chose to undergo a second surgical resection of HO, and the postoperative elbow function improved well.

Previous studies reported that periarticular HO may lead to cubital tunnel syndrome.<sup>28,29</sup> Although there were 37 patients with ulnar nerve symptoms resulting from compression in our study,

only a small number of patients had severe ulnar nerve palsy symptoms, and most of the rest were mild symptoms before surgery.<sup>30</sup> Most of the patients recovered full ulnar nerve function attributed to thorough operative resection of HO and submuscular ulnar nerve transfer. Only one patient had persistent ulnar nerve palsy without deterioration after surgery; the elbow activity was not affected.

The incidence of joint infection is very low, and the risk factors include diabetes mellitus, immune suppression, joint surgery or injection, and infection of overlying skin.<sup>31</sup> Once the joint infection is diagnosed, surgical intervention and antibiotic therapy may need to start as soon as possible to avoid permanent damage to the joint cartilage. In our study, two patients had an elbow joint infection after surgery. Unfortunately, the elbow function of one patient was still affected after early debridement and appropriate antibiotic treatment.

Following capsular structure release and excision of the HO to regain motion in a stiff elbow, the joint with ligament reconstructions may still be unstable. External hinged fixation can be used in this situation to provide sufficient stability to allow for soft tissue healing without limiting early postoperative motion.<sup>32</sup> Thus, we recommend the routine use of external fixation after HO resection of the elbow. However, we still performed a second surgical reconstruction of elbow joint stability in a patient after excision of HO. Fortunately, the patient's elbow function was partially restored without elbow instability.

Several authors support the use of single-dose radiotherapy to prevent HO of the elbow because radiotherapy is a safe and efficacious treatment and leads to excellent function of the vast majority of patients.<sup>4,22,33,34</sup> A meta-analysis showed that low-dose (<2500 cGy) radiotherapy was an effective way to prevent HO development, and multi-fraction radiation was superior to single fraction radiotherapy, whether postoperative or preoperative.<sup>35</sup> However, several authors disagree with the use of prophylactic radiotherapy because using radiotherapy to prevent HO after elbow injury may increase the incidence of nonunion in the fracture site and the risk of causing a malignancy.<sup>16,36–38</sup> When considering the costs and risks of radiotherapy, we did not use it as prophylaxis for recurrence of HO in our study. Moreover, additional studies are encouraged to determine the safety and efficiency of radiotherapy prophylaxis.

There were three limitations in this study. First, our research was a retrospective type of study with inherent deficiencies that could lead to confusion or observer bias. Second, our preoperative evaluation of HO was based only on X-ray plain films without quantification of HO by using computed tomography scans. Third, we were unable to measure the final ROM of 29 patients; they said in a telephone interview that the final ROM basically did not change from the discharge time. As the ROM reaches a plateau over time, we define the ROM measured at the time of discharge as the final ROM.<sup>39–41</sup>

## Conclusions

Early excision of HO can result in better elbow function, as indicated by the ROM and MEPS. Considering no notable difference in postoperative ROM and MEPS, recurrence of HO and postoperative complications, early excision is safe, and the time from the elbow injury to surgery may be shortened.

## Acknowledgements

We thank Jin-Hai Guo MD, Shi-Zhou Wu MD, Department of Orthopedics, West China Hospital, Sichuan University for help with data collection and their extraordinary commitment to this project.

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