Early Surgical Management for Heterotopic Ossification about the Elbow Presenting as Limited Range of Motion Associated with Ulnar Neuropathy

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Background: The formation of heterotopic ossification (HO) about the elbow after traumatic injury has been well documented in the literature. The optimal treatment, however, for ectopic bone associated with restricted range of motion and ulnar nerve entrapment syndrome has not been established.

Methods: Seven elbows with HO in 7 patients admitted to Chang Gung Memorial Hospital from April 1998 to January 1999 presented with limited range of motion and associated ulnar nerve neuropathy. All of these patients received early surgical excision of HO combined with release of the encased ulnar nerve and anterior transposition, followed by early gentle passive physical therapy and active exercise within the pain-free range of motion postoperatively.

Results: Almost full range of motion and complete functional ability following surgery were recovered in 6 of the 7 patients, while 1 patient who suffered from multiple traumatic injuries had limited improvement from 45° ankylosis to 10°~90° of a flexion-extension motion arc.

Conclusion: Our results suggest that early surgical management combined with gentle physical therapy postoperatively is a feasible modality for treating patients with post-traumatic HO about the elbow presenting as limited range of motion and associated ulnar nerve compression syndrome.

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Key words: heterotopic ossification, range of motion, ulnar nerve compression syndrome.

The formation of mature lamellar bone in extraosseous soft tissue is termed heterotopic ossification (HO). Its true mechanism remains uncertain although many theories have been proposed.[1,2] HO can result from a variety of local or systemic insults. Patients who sustain direct traumatic injury (fracture, dislocation, or both), neurological trauma, thermal burn, and some individuals with genetic disease are at recognized high risks for HO. In addition, certain surgical approaches and forceful passive manipulation of affected joints stiffened by previous long-term immobilization have been highly

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associated with the development of HO, and may furthermore accelerate its formation.[3] However, direct trauma is the most frequent cause of HO about the elbow.[1] Thompson and Garcia reported that approximately 3% of their patients with elbow injury (fracture, dislocation, or both) developed HO.[4] Josefsson et al. observed a 1.9% incidence of HO in elbow dislocation patients.[5]

The unique anatomic relationship of the ulnar nerve at the elbow places it at high risk for injury.[6,7] Apfelberg and Larson described how the volume of the cubital tunnel is greatest with the elbow held in extension and that alteration of the cross section occurs from a smooth rounded surface to a flattened triangular or elliptic surface during elbow flexion. This produces a 55% decrease in volume of the cubital tunnel. Therefore, the ulnar nerve is subjected to compression, traction, impaction, and friction forces against unyielding structures within the normal range of motion of the elbow.[8] This explains how cubital tunnel syndrome may develop when the vulnerable ulnar nerve is entrapped due to the space-occupying nature of ectopic bone with its proclivity to violate anatomic planes.[1]

Most investigators have agreed that resection of HO is the mainstay of treatment, but the timing of the operation is critical. The optimal timing has been suggested to be a delay of 12 to 18 months until radiographic evidence of maturation of HO is apparent.[9-11] This prolonged delay usually contributes to aggravation of pain, severe stiffness or muscular atrophy, secondary contracture, and impaired function of the affected upper extremity. Thus, early surgical management has been considered particularly in cases of an entrapped ulnar nerve with poor progression not amenable to conservative medical or physical therapy.[12-14]

METHODS

We collected and analyzed the medical records and radiographs of 7 patients including 5 male and 2 female, ranging in age from 17 to 46 years, who had been treated at Chang Gung Memorial Hospital between April 1998 and January 1999. All of these patients had sustained a traumatic injury, resulting in fracture or dislocation at the elbow (3 left elbow dislocations, 1 right elbow dislocation, 1 medial epicondyle fracture of the left humerus, 1 coronoid fracture of the left ulna, and 1 left radial neck fracture). They had initially received conservative treatment consisting of splinting or casting after closed reduction, followed by a period of immobilization for about 1 month, which caused stiffness or secondary contracture with decreased range of motion in the affected elbow. Chinese traditional medication or physiotherapy by bone setters or physical therapists was also given during this period. However, the application of overly aggressive forceful manipulation had worsened the affected elbow, resulting in progressive restriction of the range of motion and ulnar nerve neuropathy in all patients. Clinical symptoms and signs in these patients included stiffening of the elbow joint with limited range of motion, secondary contracture, and tardy ulnar nerve palsy with intrinsic muscle weakness and wasting. Both Wartenberg's sign and Froment's sign were positive in all of these patients. The formation of HO about the elbow was diagnosed based on careful physical examination and radiographic evidence (Fig. 1).[15,16] Serum alkaline phosphatase (SAP) was also measured in 6 of the 7 patients allowing a definitive diagnosis.

Unlike classical treatment, our method consisted of early surgical intervention via a posterior approach, which involved delicate dissection and resection of the HO (Fig. 2), meticulous hemostasis, and evacuation of bone dust or demineralized bone powder from the surgical wound, combined with adhering soft tissue relief, ulnar nerve anterior transposition after adequate neurolysis, and good postoperative wound drainage.[17,18] Acceptable improvement in the restricted range of motion of the affected elbow was achieved intraoperatively (with recovery of nearly the full range of motion in 6 patients and recovery from fixed 45° to 10°~90° in flexion-extension in 1 patient). Both gentle passive physical therapy or use of an assisted continuous passive motion machine and active exercise within the pain-free range of motion was begun immediately on the first postoperative day.[2,12,19] Neither long-term chemotherapy nor prophylactic radiotherapy was used in these patients.

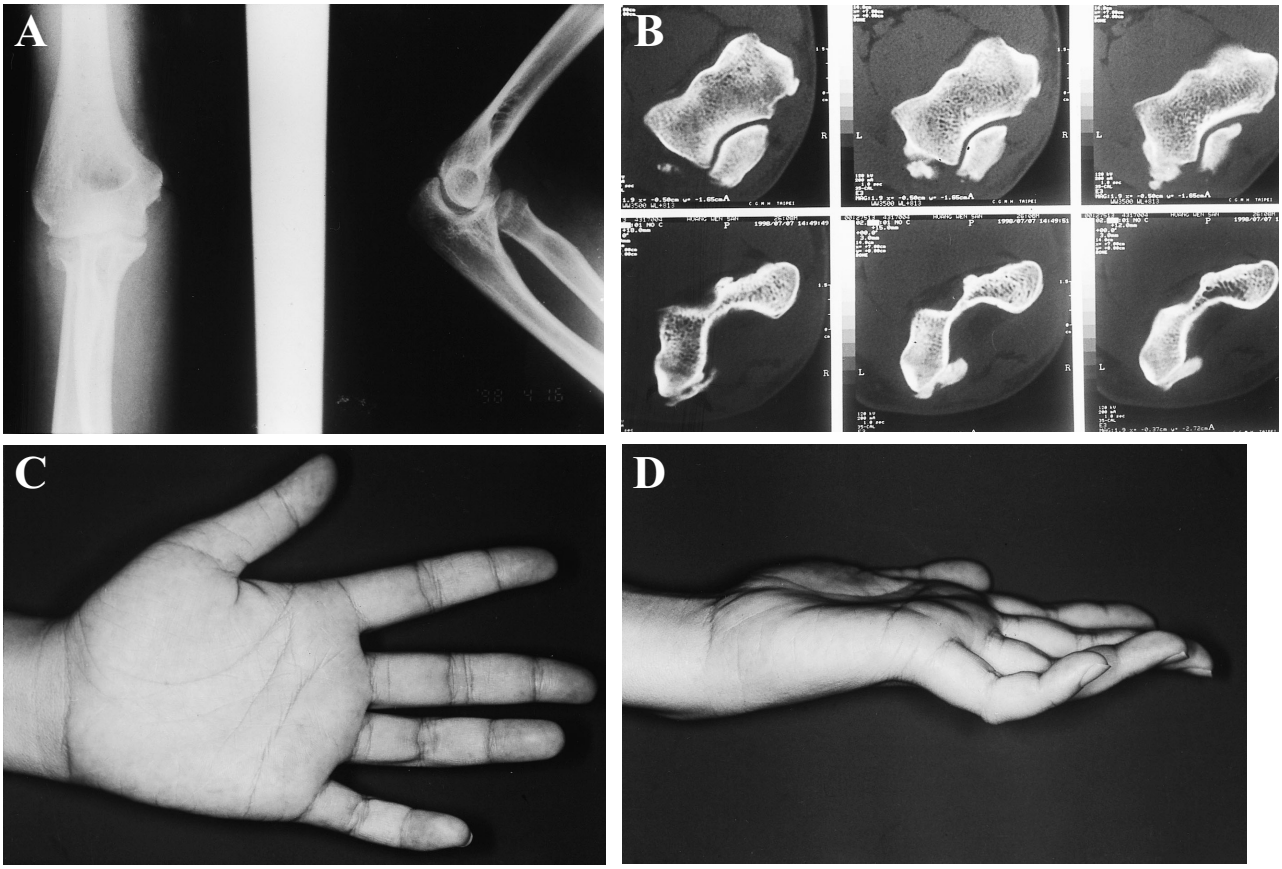

Fig. 1 (A) Radiograph showing heterotopic ossification over the medial and lateral sides in a patient (no. 6) with limited elbow motion. (B) CT revealing heterotopic ossification over the cubital tunnel. (C) Ulnar nerve palsy with adductor insufficiency. (D) Ulnar nerve palsy with claw digit deformity.

Fig. 2 Arthrotomy via a posterior approach showing the swollen ulnar nerve and extensive heterotopic ossification.

RESULTS

A decreased range of motion from 55° to 95° preoperatively with nearly full recovery postoperatively in flexion-extension of an assumed 140° maximum range of motion was achieved in 6 of the 7 patients. Two elbows gained a 55° range of motion in flexion-extension, while the others improved to 65°, 75°, 85°, and 95° ranges, respectively. These 6 patients could perform normal functional activities and maintain their independence or return to work as before. Their results were satisfactory. One patient who had suffered from multiple trauma including skull bone fracture, cervical spine injury, and medial epicondyle fracture of the left humerus had limited improvement from complete ankylosis at 45° to a

Table 1. Details of the Types of Injuries, Clinical Findings, Operative Timing, Comparison of Preoperative to Postoperative Range of Motion of the Elbow, and Duration of Follow-up for 7 Patients

Case no.	Age (y/o)	Gender	Injury mechanism	Injury pattern	SAP	Tardy ulnar palsy	Timing of operation since initial injury	Pre-op ROM (o)	Post-op ROM (o)	Gain (o)	Follow up (mon)
1	28	M	motorcycle accident	right elbow dislocation	NA	positive	5 mon later	40 to 85	0 to 140	95	15
2	30	F	motorcycle accident	left ulnar coronoid fracture	50	positive	4 mon later	25 to 90	0 to 130	65	15
3	41	M	motorcycle accident	medial epicondyle fracture of the left humerus	87	positive	7 mon later	fixed 45	10 to 90	80	18
4	17	M	accidental fall	left elbow dislocation	177	positive	12 mon later	5 to 90	0 to 140	55	18
5	46	M	accidental fall	left elbow dislocation	65	positive	6 mon later	5 to 90	0 to 140	55	16
6	26	F	accidental fall	left radial neck fracture	45	positive	5 mon later	30 to 85	0 to 130	75	18
7	27	M	accidental fall	left elbow dislocation	78	positive	4 mon later	45 to 90	0 to 130	85	18

Abbreviations: M: male; F: female; SAP: serum alkaline phosphatase; OP: operation; NA: not available; Pre-op: preoperative; Post-op: postoperative; ROM: range of motion.

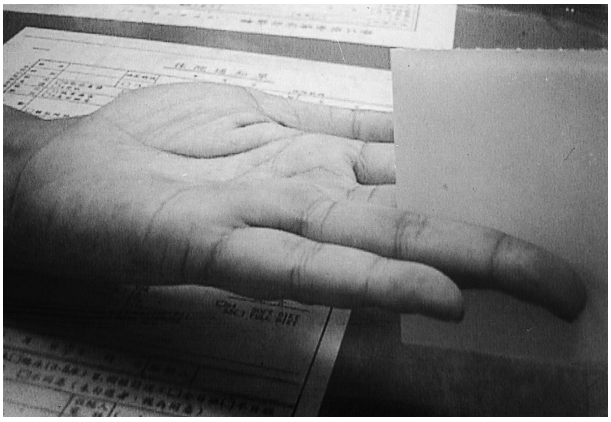

Fig. 3 Complete recovery of motor function.

10°~90° range of motion in flexion-extension. A motion arc of 80° was insufficient to easily deal with daily life. The delay in surgery may have been 1 of the reasons responsible for this undesirable outcome. The average preoperative range of motion in flexion-extension was 54° compared to 127° postoperatively. Ulnar nerve entrapment syndrome subsided and recovered to normal motor and sensory function after neurolysis and nerve transposition in all patients (Fig. 3). None of the patients complained of ulnar nerve dysfunction in the outpatient department follow-up for over 12 months. Details of the injury mechanism and pattern, clinical presentations, operative timing after initial injury, comparison of preoperative and postoperative range of motion of the elbow, and duration of follow-up for these 7 patients are shown in Table 1.

DISCUSSION

The elbow is notorious for its propensity to develop HO after fracture or dislocation, especially in patients with either neurological injury or a thermal burn.[20-22] Fracture about the elbow is frequently associated with HO adjacent to the fracture structure. Simple elbow dislocation without fracture can incite HO due to soft tissue trauma.[9] It also appears to be correlated with the duration of immobilization and the frequency of forceful passive manipulation.[3,4] In our series, 4 patients with simple elbow dislocation, 1 with a radial neck fracture, 1 with an ulnar coronoid fracture, and 1 with a humeral medial epicondyle fracture developed HO after initial traumatic

injury with closed reduction; their conditions were probably aggravated by long-term immobilization combined with excessive passive stretching manipulation. These patients presented with severe ankylosis with limited range of motion and ulnar nerve compression neuropathy.[23,24]

The classification proposed by Hastings and Graham is most frequently used to categorize the progression and prognosis of HO for upper-extremity lesions. Class I includes radiological evidence without functional deficit. Class II includes restriction of motion in either flexion-extension, pronation-supination, or both. Class III includes almost complete ankylosis of a particular joint.[1] Six patients in our series were classified as class II, and only 1 patient was class III preoperatively. This 41-year-old male patient with complete ankylosis of the left elbow was a victim of a motor vehicle accident. He had sustained multiple traumatic injuries resulting in skull bone fracture, cervical spine injury, and medial epicondyle fracture of the left humerus. Neurological injury may predispose a patient to the development of HO as has been demonstrated in many studies,[1,2,20] but the mechanism responsible for this development remains uncertain. This patient first underwent an operation for skull bone fracture and cervical spine injury. After 7 months and several attempts at aggressive manipulation for the progressively stiffening elbow, he complained of severe ankylosis with compromised range of motion and tardy ulnar nerve neuropathy. Plain film revealed a large area of HO around the injured elbow joint in the vicinity of the fracture. Surgical management involved resection of the HO combined with ulnar nerve anterior transposition after neurolysis of the encircled ulnar nerve from severe scar tissue and V-Y flap lengthening of the triceps. Severe periarticular scarring and soft tissue ossification rendered surgical intervention difficult, and we were unable to achieve an ideal functional range of motion.

The most popular assay to monitor patients at high risk for the development of HO is SAP activity.[25] Orzel and Rudd reported that SAP is a sensitive indicator of HO, rising well in advance of symptoms and radiographic soft tissue calcification. In their series, the average peak SAP was 3.5 times the normal level, beginning in the first month and peaking in about 12 weeks, suggesting that it can be a reliable screening tool.[26] Wittenberg et al. described how SAP significantly increased 6 weeks after initial injury and was a useful investigation for diagnosis.[20] SAP measurement was performed in 6 of 7 patients in our series with normal results in 5 patients and an elevated level in 1 patient. This finding is similar to some other studies which demonstrated no significant difference in SAP levels between matched populations with or without HO.[2,21]

Current treatment or prevention strategies for HO include various combinations of surgical, radiotherapeutic, physiatric, and pharmacological regimens, but an appropriate standard of care for specific subsets of patients remains ill-defined.[2] Radiation therapy provides effective prophylaxis for HO about the hip in patients at high risk.[27,28] It decreases both the incidence and severity of postoperative HO if administered within 72 to 96 hours after injury. Currently, a single dose of 700 to 800 rads appears to be as effective as larger fractionated doses and provides much-simpler administration.[29,30] However, it is not suitable for cases of fracture-dislocation at the elbow after surgery. The surgical incision cannot be easily isolated from the radiation ports, and therefore wound healing may be compromised.[31] Although some investigators have stated that wound healing is not impaired regardless of whether radiation is delivered preoperatively or postoperatively because the total dose to the surgical wound is low,[2] we did not apply radiation therapy in our series.

Chemotherapeutic agents commonly used to prevent HO include diphosphonates and nonsteroidal anti-inflammatory drugs (NSAIDs). Diphosphonates are no longer used due to rebounding calcification after discontinuance and undesirable side effects of gastrointestinal disturbance and osteomalacia.[1] NSAIDs have been extensively tested and have shown efficacy in preventing HO about the hip joint.[32] Indomethacin is the most popular NSAID used for prophylaxis. To our knowledge, there is no study which specifically examines its effect on HO about the elbow. Although some authors have recommended 75 mg indomethacin orally twice a day or 25 mg orally 3 times a day for 3 to 6 weeks postoperatively, the optimal timing and duration for the use of NSAIDs to treat HO about the elbow have not been thoroughly investigated.[2,33] In our series, NSAIDs were administered for postoperative analgesia, but not for as long a period as suggested by several previous studies.

Early resection of HO before it matures can greatly increase stiffness because of reformation. The optimal time for resection is difficult to determine. The desire to delay surgery until HO has become metabolically quiescent must be balanced against the risks of progressive soft tissue contracture, potential articular cartilage destruction, and prolonged infirmity.[1] Resection of HO is generally delayed until 12 to 18 months after the past trauma.[9-11] The duration of the delay has been somewhat correlated with the time required for maximal recovery after neurological injury and radiographic maturation of the HO. However, this delay usually causes exacerbation of pain, severe stiffness, secondary contracture, and even complete ankylosis in the injured elbow. Hastings and Graham advised that surgical treatment be delayed for 6 months after the initial trauma.[1] Recent reports have documented good results with early intervention of from 4 to 8 months after injury.[10,33] Our results support the findings of those previous studies that HO about the elbow associated with restricted range of motion and neurovascular compression should be the standard indication for surgical intervention.[9] In our series, surgery was performed as early as the appearance of clinical progression complicated by HO. The mean time to surgery was 6 months (4 to 12 months) after the initial traumatic injury, and the results were encouraging.

Appropriate management of HO of the elbow requires the integration of surgery with a sequence of postoperative adjuvant modalities. Surgery plays a prominent role in treatment plans and is indicated if the elbow is considered functionally impaired or if there is intractable pain. A postoperative physical therapeutic program is also necessary and can begin as early 24 to 72 hours after surgery.[2,12,19] It involves assisted active range-of-motion exercises, gentle passive stretching, and terminal resistance training. Some authors even suggest that the range of motion be maximized with gradual physical therapy rather than using surgical excision to release the muscle contracture.[2] However, passive stretching is contraindicated after HO is suspected, but continuous active exercise within the pain-free range of motion is recommended.[34,35]

Prevention of HO is always preferable to treatment.[9] High-risk injuries involving complex fracture or dislocation that are accompanied by significant soft tissue damage or hematoma formation at the elbow should be carefully followed-up for the development of HO. Preventive measures like minimizing additional traumatic insult by judicious surgical technique (including as much atraumatic practice as possible, rigid fracture fixation, thorough irrigation of soft tissues after fracture repair, prevention of bone dust deposition and deep infection, meticulous hemostasis, and good postoperative wound drainage) and avoiding prolonged immobilization and overzealous passive stretching manipulation of the injured extremity appear to help reduce the risk of HO formation.[36] However, once a diagnosis of HO about the elbow is confirmed, particularly in cases associated with progressive restricted range of motion and ulnar nerve compression neuropathy, early surgical treatment followed by early gentle passive physical therapy and active exercise within the pain-free range of motion postoperatively is a feasible modality which should be considered.[35,36]

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早期手術處理手肘異位性骨化出現關節活動受限合併尺神經壓迫症

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背 景：創傷後所造成的手肘異位性骨化在許多文獻被證實，但對於合併有關節活動受限與尺神經壓迫症候群之情形，卻尚未確立理想的處理方式。

方 法：有7位手肘異位性骨化合併有關節活動受限及尺神經病變的病患，從1998年4月到1999年1月間，於長庚紀念醫院住院接受治療。處理的步驟爲早期外科手術切除手肘異位性骨化，以釋放受壓迫之尺神經，同時合併神經轉位手術。術後並儘早配合和緩地被動性復健治療及無痛範圍地自主性運動。

結 果：六位病患手肘活動度及功能幾近完全恢復，僅有一位多處創傷病患，由術前固定於45度角之手肘僵硬關節，術後侷限地進步到10度至90度的活動範圍。

結 論：對於這類創傷後所造成的手肘異位性骨化，合併有關節活動受限及尺神經壓迫症候群之病患，早期手術處理，並配合術後儘早溫和地復健運動，是一種可行的治療方法。

(長庚醫誌 2002;25:245-52)

關鍵字：異位性骨化，關節活動範圍，尺神經壓迫症候群 。

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