Observational Study

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Surgical treatment of tardy ulnar nerve palsy due to non-neurogenic heterotopic ossification in the elbow

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Abstract

Heterotopic ossification (HO) is characterized by the formation of pathological bone within the soft tissues. HO predominantly affects elbow joints and may be accompanied by tardy ulnar nerve palsy. This study aimed to explore the clinical and functional outcomes of patients with tardy ulnar nerve palsy caused by HO following surgical treatment, with a review of the relevant literature.

A retrospective study was conducted on 4 patients with tardy ulnar nerve palsy caused by HO, who underwent anterior subcutaneous ulnar nerve transposition between 2015 and 2020. The patients were followed up for more than 1 year and the cause of HO was also identified. Clinical and functional outcomes were evaluating using the grip strength and pinch strength, visual analog scale (VAS) pain score and Quick disabilities of the arm, shoulder and hand (DASH) score. The causes of HO were repetitive micro-trauma in 1 case and excessive physical or rehabilitation therapy in 3 cases. The average follow-up period was 15.6 months (range; 12–21 months). The grip strength increased from an average of 14kg to 26.5kg. The pinch strength increased from an average of 1.5 kg to 3.63 kg. The Quick DASH score decreased from an average of 55.6 to 6.15. The VAS score for pain decreased from an average of 7 to 0.25. Rapid surgical treatment, including removal of the heterotopic bone and ulnar nerve anterior transposition, might improve outcomes in patients with tardy ulnar nerve palsy caused by HO.

Abbreviations: CT = computed tomography, DASH = disabilities of arm, shoulder and hand, HO = heterotopic ossification, ROM = range of motion, VAS = visual analog scale.

Keywords: decompression, elbow, heterotopic ossification, ulnar nerve palsy

1. Introduction

Heterotopic ossification (HO) is a condition in which ossification occurs outside of the bone structure. However, its etiology and pathogenesis are currently unknown. The elbow joint displays a uniquely high frequency of HO.[1] While the risk factors for HO at the elbow joints are yet to be clarified, HO is the direct cause of elbow joint injuries. The incidence of elbow joint HO is approximately 3% for simple dislocations and 20% for complex dislocations with a fracture.[1,2] However, it might be 5 to 10% in patients with brain damage. Elbow joint injuries with brain damage are the cause of most HO in the elbow joints. HO can also result from musculotendinous junction surgery for burns or biceps brachial injury[1,3,4] and high-intensity physical therapy or passive manipulation for elbow joint stiffness.[1,5,6]

HO of the elbow joints may present with localized pain, tenderness, and swelling in the early phase. In later phases, it may result in progressive loss of range of motion (ROM).[5] An extensive HO at the elbow joints can induce contracture, cause discomfort, and lead to complete stiffness. However, HO at the elbow rarely causes neurological symptoms through ulnar nerve compression.[7–12]

We performed surgical treatment for patients with rare tardy ulnar nerve palsy caused by HO of the elbow joint and evaluated their clinical outcomes. The results are presented here, along with a literature review.

1.1. Consent

This study received approval from the Institutional Review Board at Jeonbuk National University Hospital (CUH 2023-10-032). Informed consent was obtained from the patient for the publication of this case report details.

2. Material and methods

2.1. Patients

Data from 4 patients with tardy ulnar nerve palsy caused by elbow joint HO between 2015 and 2020 who underwent ulnar

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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nerve decompression and anterior transposition and were followed up for more than 1 year were analyzed retrospectively. Patients included 3 males and 1 female with a mean age of 41 years (range, 17–57 years). Left-side injuries occurred in 2 cases. Right-sided injuries also occurred in 2 cases.

Four patients developed paresthesia in their fourth and fifth fingers. One patient had severe elbow joint pain with the ROM restricted to approximately 50°. The physical examination used the McGowan classification, a tool developed in the 1950s and extensively used in Japan, Europe, and the U.S. The classification system consisted of 3 grades: grade I (minimal damage: convulsion and numbness without atrophy or weakness of the intrinsic ulnar muscles), grade II (moderate damage: voluntary motion with interosseous muscle weakness and atrophy), and grade III (severe damage: interosseous muscle paralysis and distinct weakness of the intrinsic hand muscles).[13] All patients had elbow joint hyperflexion. Three of the 4 patients had McGowan grade III and 1 patient had McGowan grade II. Electromyography and nerve conduction studies showed tardy ulnar nerve palsy at the elbow joint area in 3 patients (Table 1).

A simple imaging test was conducted for all patients to obtain anteroposterior, lateral, and oblique images before the operation. Computed tomography (CT) and magnetic resonance imaging were conducted for 2 patients determined to require the respective tests (Fig. 1).

2.2. Surgical technique

Surgery was performed under general anesthesia. After palpation of the medial epicondyle at the elbow joint, the epicondyle, olecranon, and course of the ulnar nerve were identified. A 10 cm radius skin incision was made (Fig. 2). Ho on the medial side of the olecranon compressed the ulnar tunnel, HO on the anterior side of the elbow joint (Fig. 3). To avoid ulnar nerve damage, an incision was made and the ulnar nerve and surrounding soft tissues were detached. After removing the HO tissues between the medial epicondyle and olecranon, elbow flexion was confirmed at approximately 100°. A fascial sling was made to branch the ulnar nerve anterior subcutaneous transposition (Fig. 4). Case 1 had a limited ROM at 50° to 100° flexion-extension due to severe elbow joint pain. Because the transverse and posterior parts of the medial collateral ligaments were torn at the ulnar nerve attachment, a suture anchor (#3-0, SutureTak anchor, Arthrex) was applied to fit it. After meticulous bleeding was observed and washed, a silicon drainage tube was inserted for subsequent skin and subcutaneous sutures. An aseptic long-arm splint was applied to the neutral position of the forearm for 4 weeks postoperatively, after which active joint motion was initiated. No preventive drugs or radiation therapy were administered to prevent HO recurrence.

2.3. Clinical evaluation

For clinical and functional assessments, elbow joint ROM, dynamometer-based grip strength and pinch strength were measured before and after the operation and at the final follow-up. The Quick disability of the arm, shoulder and hand (DASH) score was obtained. For pain, visual analog scale (VAS) scores were obtained before surgery and at the final follow-up (Table 2).

2.4. Statistical analysis

IBM SPSS version 20.0 (IBM Corp., Armonk, NY) was used for statistical analysis. We used a paired t-test to compare the preoperative and follow-up ROM, grip strength and pinch strength, VAS score for pain, and Quick DASH score. P values < .05 were considered statically significant.[14] Although the number of cases is small, it can be assumed that ROM, grip strength, pinch strength, VAS score for pain, and Quick DASH score follow normal distribution because these data satisfy a skewness <3 and kurtosis <7. Thus, a paired t-test was used. The confidence interval was set at 95%.

3. Results

The average period from symptom onset to operation was 7.8 months (range, 4–12 months). The average postoperative outpatient follow-up was 15.6 months (range, 12–21 months). The elbow joint ROM increased from a preoperative average of 95° (range, 50°–130°) to an average of 121° (range, 105°–140°) at the final follow-up but it was not statistically significant (P = .171) (Fig. 5). Grip strength was enhanced (P = .013) from a preoperative average of 14kg (47.3% of the unaffected side) to an average of 26.5kg (89.5% of the unaffected side) at the final follow-up. The pinch strength was also enhanced (P = .024) from a preoperative average of 1.5kg (45% of the unaffected side) to an average of 3.63kg (110% of the unaffected side) at the final follow-up. The Quick DASH score reflecting clinical outcome improved (P = .021) from a preoperative average of 55.6 (range, 20.5–81.8) to an average of 6.15 (range, 2.3–13.6) at the final follow-up. The VAS score for pain decreased (P = .009) from an average of 7 (range, 5–10) preoperatively to an average of 0.25 (range, 0–1) at the final follow-up (Fig. 6). Therefore, the grip strength, pinch strength, Quick DASH score and VAS score showed statistically significant differences. The average size of the HO detected in 3 patients during the operation was 1.4cm (range, 1.0–2.3cm) at the posteromedial side of the elbow joint. HO in 1 patient was found at the site of ulnar nerve attachment to the medial collateral ligaments (Table 2). No complications were observed during the final follow-up.

Table 1

Demography of the patients.

Patient no.<?Note to TS: Char=Text?>	Age (yr)	Sex	Involved extremity	Intervals between symptom onset and surgery (mo)	Causes of HO*	McGowan grade	EMG[λ]/NCV[Δ]
1	53	F	Rt	4	Medical epicondyle Fx[†]	3	Ulnar neuropathy
2	17	M	Rt	12	Overuse(Pitcher)	2	N/S
3	57	M	Lt	9	Elbow Open Fx and D/L[‡]	3	Ulnar neuropathy
4	35	M	Lt	6	Medial epicondyle Fx	3	Ulnar neuropathy

* Heterotopic ossification;
† Fracture;
‡ Dislocation;
λ Electromyography;
Δ Nerve conduction velocity

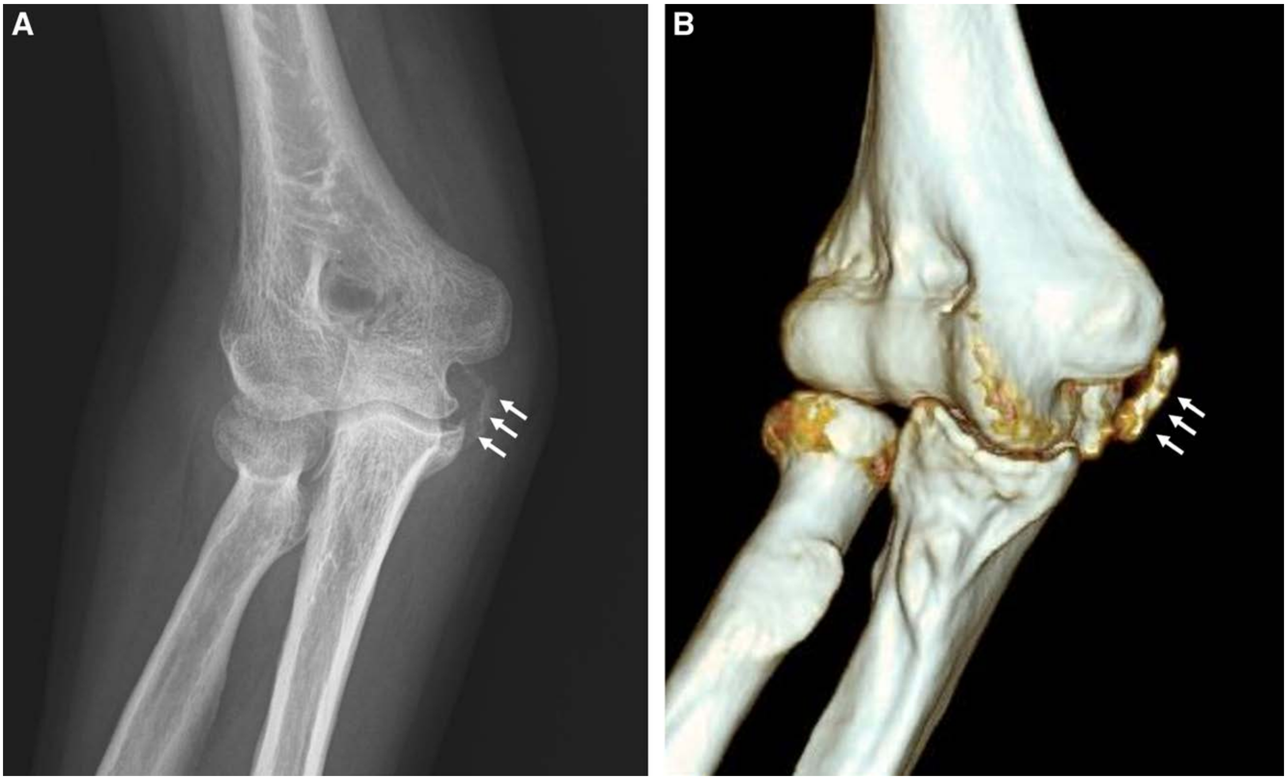

Figure 1. Right elbow joint plain oblique (A) and computed tomography (B) images of the right elbow joint of a 53-yr-old female patient showing well-defined heterotopic bone (arrows) at the medial epicondyle.

Figure 2. The medial side of the elbow joint of the same patient prior to skin incision.

4. Discussion

HO is a condition in which ossification occurs outside of the bone. However, its etiology and pathogenesis are unknown. Meanwhile, studies by several studies suggested that bone formation could be induced by inductive agents (mainly growth factors) for osteogenic precursor cells and the cellular environment in the process of inappropriate differentiation of pluripotent mesenchymal stem cells into osteoblastic cells.[3,5] Garland et al have also suggested a genetic link of HO with certain human leukocyte antigens.[8]

Elbow joints have a higher HO frequency than other joints for unexplained reasons. Elbow joint HO is often caused by trauma, such as fractures and dislocations with brain damage. Burn injuries from heat or electricity, high-intensity physical therapy, and passive manipulation of the elbow joint stiffness are also causes.[5] This study found that excessive physical therapy after trauma caused HO in 3 patients. Elbow joint HO rarely causes symptoms, although symptomatic patients usually experience limited joint motion and pain. Compressive ulnar neuropathy caused by HO of the elbow joint is rare.[8–12]

Regarding anatomical features of the elbow joints, the ulnar nerve passes through a narrow cubital tunnel wrapped around the supra-epitrochlear and surrounding tissues. If HO occurs medially or posteromedially at the elbow joints, ulnar nerve compression is possible. The cubital tunnel volume increased with elbow joint extension but decreased to 55% of the maximal volume with flexion. At elbow joint flexion, the cubital tunnel cross-section changed from circular to elliptical or flat triangular in shape.[15] Due to these anatomical features, the ulnar nerve is predicted to be readily exposed to compression, tension, and friction from the basal structures if HO occurs at the elbow joint with flexion contracture. However, the mechanism underlying compressive ulnar neuropathy resulting from HO of the elbow joint remains unclear.

Regarding surgical management strategies for ulnar neuropathy associated with elbow HO, Chao et al[10] have reported that elbow HO occurring after trauma or repetitive manipulation is more frequently involving multiple planes rather than a single plane and often accompanied by compressive ulnar neuropathy, unlike neurogenic HO. Therefore, they emphasized the need for complete radiographic examination, including anteroposterior view, lateral, cubital tunnel view, and CT scans and electrophysiological study for accurate evaluation of ulnar nerve palsy during preoperative assessment and surgical planning. While the timing of surgical treatment for HO remains unclear, they recommended early surgical resection and ulnar nerve decompression, especially in cases with compressive neuropathy. In all 16 patients, they accessed the ulnar nerve via a posterior longitudinal incision and performed HO resection, ulnar nerve neurolysis, and anterior transposition. Additionally, to improve elbow ROM, they performed elbow posterolateral arthrotomy, anterior capsulotomy, and, in 2 patients, V-Y lengthening of the triceps fascia. At an average follow-up of 21 months, they reported an improvement in elbow ROM from a preoperative average of 47.2° to a final follow-up average of 80.3°. Complete neurologic recovery was achieved in 15 of 16 patients, with 1 patient not recovering due to a 12-month preoperative duration of ulnar nerve neuropathy. They also recommended medication, programmed rehabilitation, and appropriate physical therapy to prevent HO recurrence. We also attempted to perform complete radiologic examinations including CT scans. Although all patients were associated with trauma, HO did not occur in multiple planes. It was located on the medial side of the elbow. Thus, surgical incision and approach were made on the medial side. HO affecting the elbow ROM was removed. Intraoperative assessment revealed an elbow ROM of approximately 100°. Since pain was identified as the primary cause of ROM limitation, no additional arthrotomy or capsulotomy was performed. In our case, there was a patient with ulnar nerve neuropathy symptoms which persisted for 12 months before surgery. However, complete neurological recovery was achieved postoperatively. Such rapid recovery might be because the patient was an adolescent.

Jeong et al[16] have reported favorable treatment outcomes in patients with ulnar neuropathy caused by HO due to childhood trauma. However, they could not explain why symptoms appeared 20 years after the initial trauma without prior symptoms. Several international case reports have highlighted posteromedial HO-related ulnar neuropathy and cubital tunnel syndrome.[9,11,17–20]

Salazar et al[12] have reported results of surgical management of 18 patients with ulnar nerve bony encasement due to HO (13 burns, 4 traumas, 1 closed head injury). Surgical approach varied depending on burn scar location, previous incision, skin condition, and HO extent. HO resection and anterior ulnar nerve transposition were performed in 16 patients with preoperative ulnar neuropathy symptoms, while in situ release was performed in 2 patients without such symptoms. Postoperatively, HO prophylaxis and regimented rehabilitation, including continuous passive motion machines, were used. Subjective neuropathy symptoms were improved in 11 patients. Complete resolution was achieved for 5 patients and 2 remained asymptomatic. Factors such as sex, age, medical comorbidities, and time-to-surgery had no statistically significant effect on ulnar nerve symptom improvement. Mean flexion-extension arc of motion improved from 14° preoperatively to 98° at final follow-up. In our cases, no special HO or continuous passive motion machines were used postoperatively. Instead, gradual active ROM exercises were encouraged after 4 weeks of long-arm splint fixation. Although not statistically significant, the ROM increased from an average of 95° preoperatively to 121° at the final follow-up.

Lee et al[21] have reported that surgical treatment for elbow HO can improve functional outcomes regardless of causes. The overall complication rate was 22.6%, including recurrence, fracture, infection, nerve palsies, wound complications requiring coverage, and loss of motion without recurrence. Brain injury patients exhibited the highest complication rate, while burn injury cases had the lowest complication rate. Understanding these complications can help physicians educate and manage patient expectations for surgical outcomes. Fortunately, there were no complications in our cases.

Figure 3. An image of the surgical site during operation, showing compression on the ulnar nerve (yellow band) caused by heterotopic ossification (arrows).

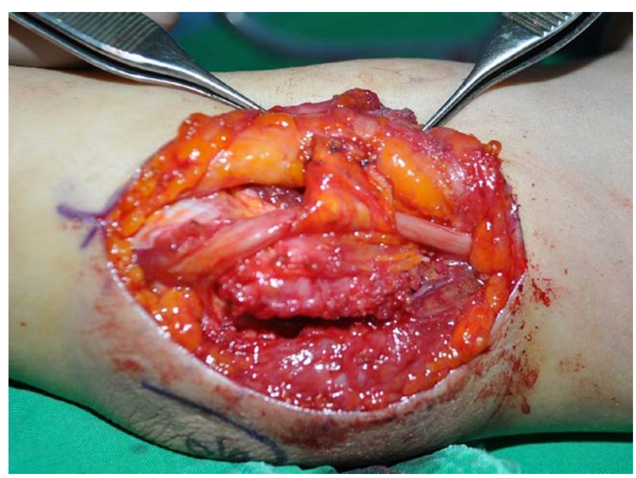

Figure 4. An image of the surgical site during operation, showing anterior transposition of the ulnar nerve through the use of a fascial sling.

Table 2

Demography of the patients.

				Elbow ROM†		VAS‡		Grip/ Pinch		Quick DASH§	
Patient No.	Age (yr)	Sex	Size of HO*(cm)	Pre OP	Final F/U	Pre OP	Final F/U	Pre OP	Final F/U	Pre OP	Final F/U
1	53	F	1.2 × 1.1	50–100	10–130	10	0	5/0	18/2.5	81.8	13.6
2	17	M	1.0 × 0.9	10–140	0–140	5	0	28/3	34/4.5	20.5	2.3
3	57	M	2.3 × 2.0	15–105	10–115	6	0	11/1	28/2	55	5.2
4	35	M	1.0 × 0.8	20–130	10–130	7	1	12/2	25/3	65	3.5

* Heterotopic Ossification;
† Range Of Motion;
‡ Visual Analog Scale
§ Quick disability of the Arm, shoulder and hand
DASH = disabilities of arm, shoulder and hand.

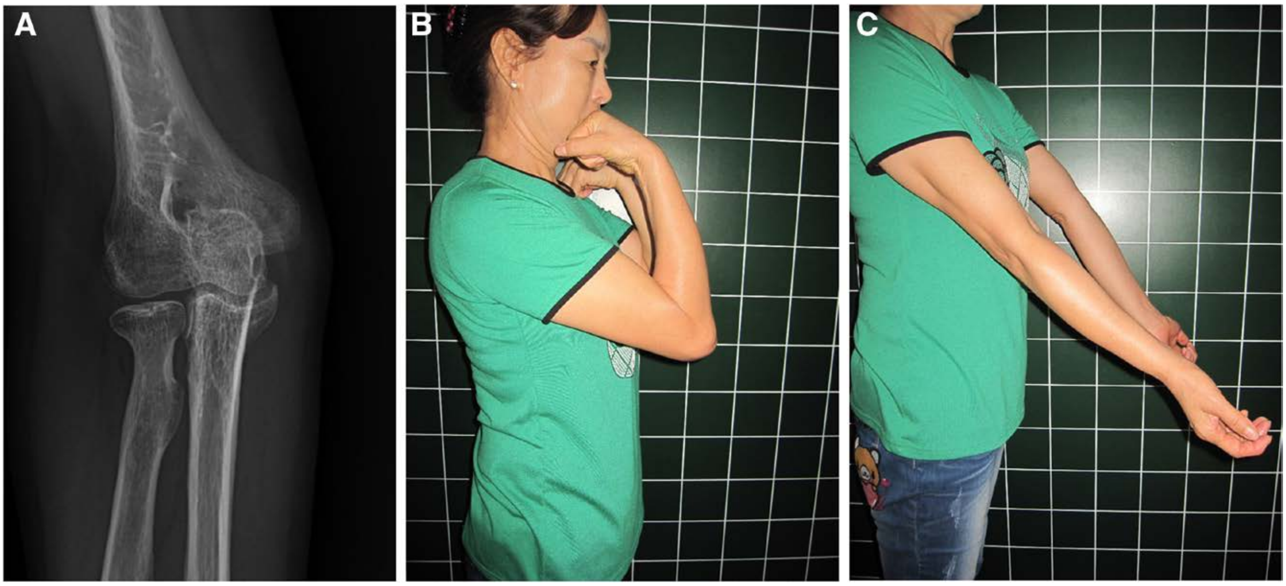

Figure 5. Right elbow joint plain oblique (A) and elbow joint motion (B, C) images in the same patient at the follow-up 13 mo later indicating no recurrence of heterotopic ossification and normal range of motion (ROM) for the elbow joint.

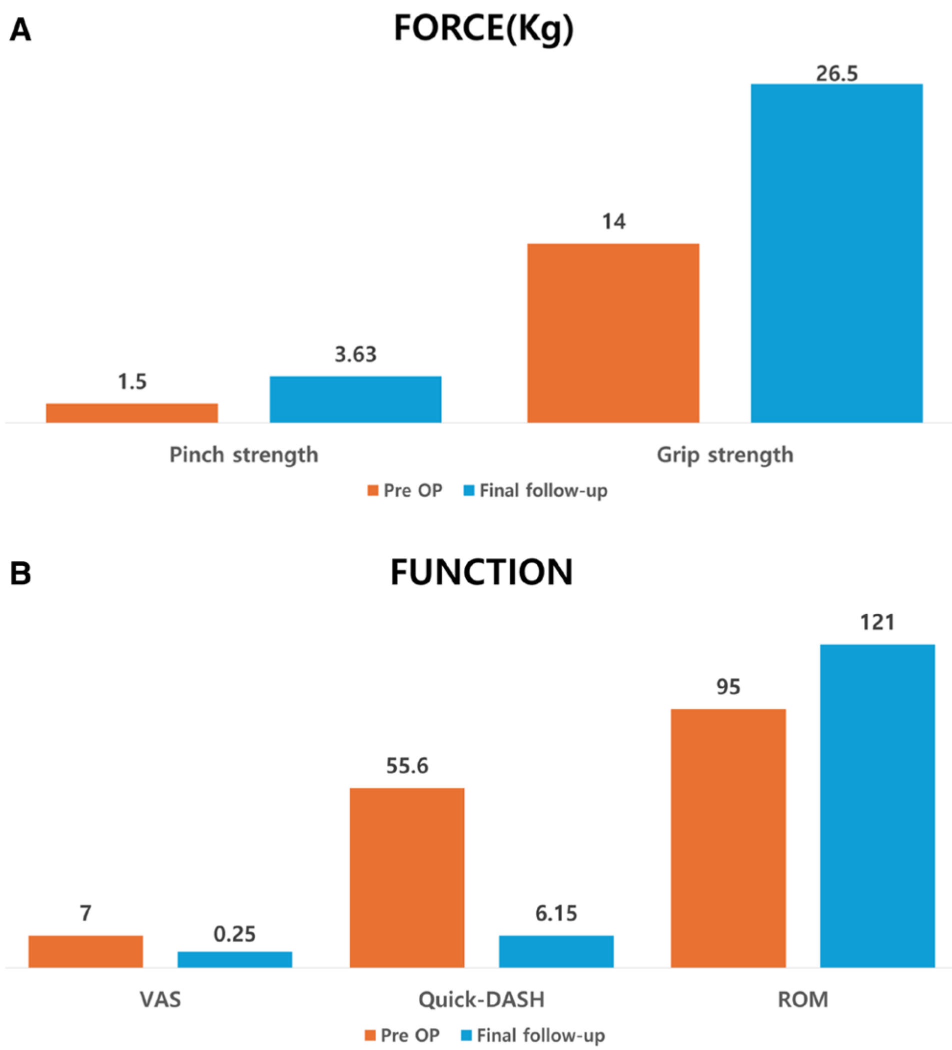

Figure 6. Graphical representation of average values of pinch strength, grip strength (A), visual analog scale (VAS) score for pain, Quick Disability of the Arm, Shoulder and Hand (DASH) score, and range of motion (ROM) (B) preoperative and at final follow-up.

This study had certain limitations. First, the number of cases was small as data were obtained over 6 years from 1 hospital by a single senior surgeon. Second, data were retrospectively analyzed without comparison with a group undergoing delayed surgery after HO maturation. Third, the average follow-up period of 15.6 months was insufficient to fully evaluate elbow ROM improvement. It is believed that further improvement can be achieved over time. Hence, not analyzing more long-term functional results involving the injured elbow is a limitation. Furthermore, while preparing this paper, there is still no consensus on the timing of surgery, the use of prophylaxis to prevent HO recurrence after surgery, or joint exercise therapy among practitioners. Further research is warranted to provide better treatment outcomes for patients and to help physicians achieve more efficient treatment. Additionally, since HO does not occur in all cases of elbow trauma, burns, or brain injury, research to identify common genetic characteristics in patients with HO is also needed in the future.

5. Conclusion

Forceful and repetitive physical therapy or manipulation to recover joint movement rapidly after elbow trauma or surgery-induced immobilization should be avoided. This study demonstrated that urgent surgical treatment, including HO resection and ulnar nerve anterior transposition, could lead to favorable outcomes in patients with compressive ulnar neuropathy caused by elbow joint HO. Furthermore, a compressive understanding of the surgical treatment of elbow HO with ulnar nerve neuropathy, including potential complications, can help educate and inform patients who are undergoing surgical treatment for HO.

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Conceptualization: Se Hwan Lee, Young-Keun Lee, Dong Hee Kim, Jae Hun An.
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