Case Report
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Selective Fascicular Involvement of the Median Nerve Trunk Causing Pseudo-Anterior Interosseous Nerve Syndrome: Ultrasound and MR Imaging Features

Yoon Young Jung[1], Yun Sun Choi[1], Chang-Hun Lee[2], Ohyun Kwon[3], and Minchul Kim[1]
Departments of [1]Radiology, [2]Orthopedic Surgery, and [3]Neurology, Nowon Eulji Medical Center, Eulji University, Seoul, Korea.

Fascicular involvement of the median nerve trunk in the upper arm is uncommon in cases of peripheral neuropathy, and its symptoms are consistent with those of anterior interosseous nerve (AIN) syndrome. We report three cases of focal anterior interosseous fascicular involvement in the median nerve trunk presenting as AIN palsy. Our report emphasizes the unique ultrasonographic and magnetic resonance imaging (MRI) features of swelling, hourglass-like constriction and torsion, and entwinement of the nerve fascicle of the dorsal region of the median nerve, which were confirmed surgically. On MRI, all patients showed denervation changes in the AIN territory, as well as in the median nerve territory, without compressing structures.

Key Words: Anterior interosseous nerve syndrome, median nerve, hourglass-like constriction, fascicular torsion, ultrasonography, magnetic resonance imaging

INTRODUCTION

The anterior interosseous nerve (AIN) is a nearly pure motor branch of the median nerve and is important for function of the hand and fingers, especially the thumb. Patients with AIN syndrome (AINS) present with spontaneous acute weakness of the distal phalanx and a reduced ability to flex the thumb and/or index and middle fingers, during forearm pronation. Recently, with the aid of high-resolution magnetic resonance imaging (MRI) and ultrasonography (US), fascicular involvement of the median nerve trunk in the upper arm has been proposed as a new pathogenic mechanism in clinical cases presenting with symptoms of AINS.[1-6] However, with most articles in the literature focusing on the neurological or surgical aspects of AINS,[1-4] clinicians and radiologists have little information on the imaging features of this disease. Here, we present three cases of selective fascicular involvement of the median nerve in the upper arm, presenting as symptoms of AINS.

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Corresponding author: Yun Sun Choi, MD, PhD, Department of Radiology, Nowon Eulji Medical Center, Eulji University, 68 Hangeulbiseok-ro, Nowon-gu, Seoul 01830, Korea.
Tel: 82-2-970-8290, Fax: 82-2-970-8346, E-mail: cys0128@eulji.ac.kr

•The authors have no potential conflicts of interest to disclose.

CASE REPORT

Case 1

A 23-year-old man presented with weakness in his right thumb and index finger during a 2-week period. Applying the Medical Research Council (MRC) scale, we graded flexion of the interphalangeal joint of the thumb and flexion of the distal interphalangeal joint of the index finger as grade 1 and pronation of the forearm as grade 4. The patient was also unable to make an "O" shape using his thumb and index finger ("OK" sign).

A 3T MRI (Skyra; Siemens Health Care, Erlangen, Germany) scan of the elbow and forearm revealed no mass-like lesions along the course of the median nerve or the AIN. Fat-suppressed (FS) T2-weighted fast spin echo (FSE) images showed high signal intensities in the pronator teres, flexor carpi radialis (FCR), flexor digitorum superficialis (FDS), and flexor digitorum profundus (FDP) muscles of the elbow (Fig. 1A) and within the pronator quadratus and flexor pollicis longus (FPL) muscles of the distal forearm (Fig. 1B). These image findings suggested a more proximal median nerve lesion, proximal to

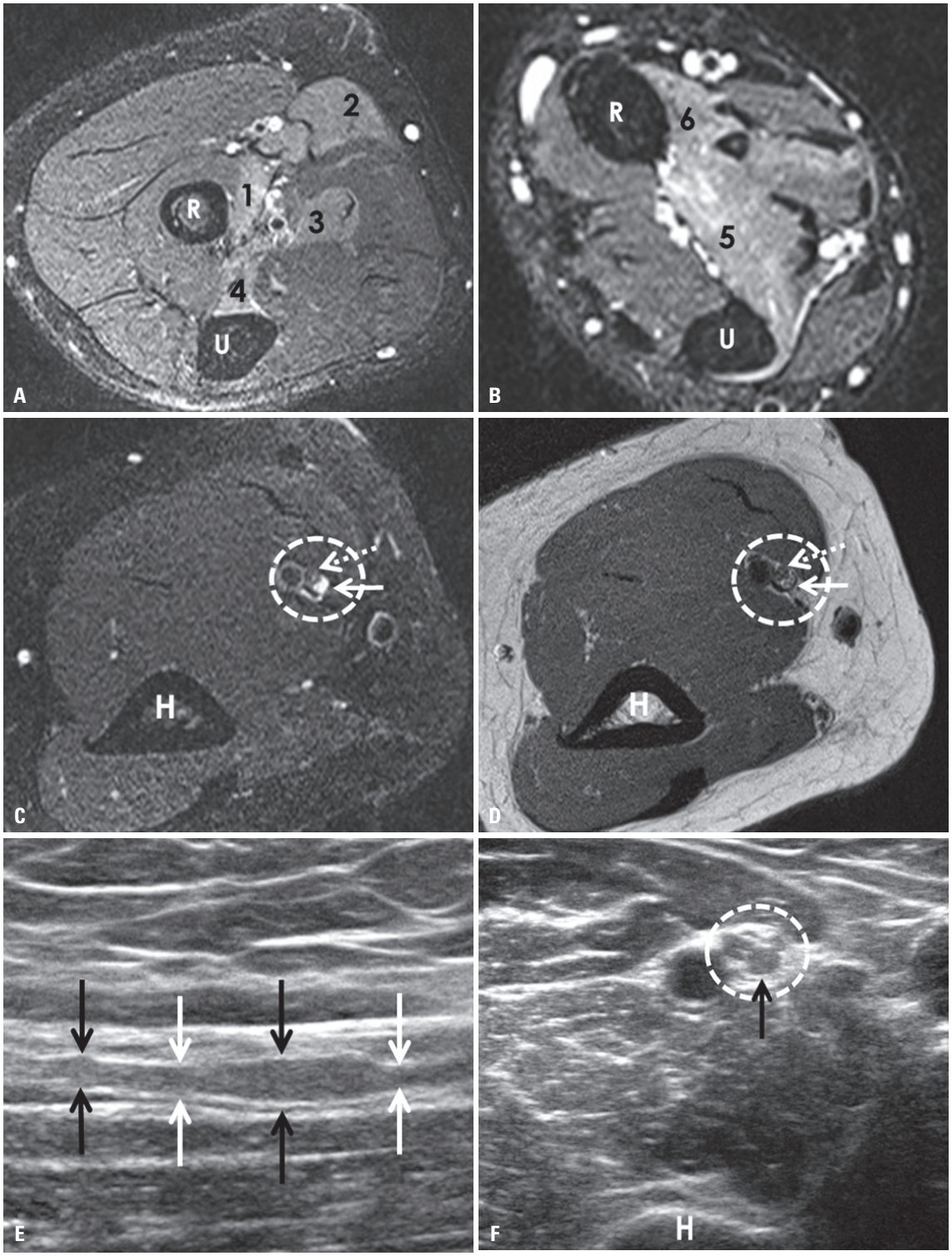

Fig. 1. A 23-year-old man with incomplete constriction of the dorsal fascicle of the right median nerve and pseudo-AIN syndrome. (A) Axial FST2-weighted FSE image of the right elbow in the supine shows high signal intensities in the pronator teres (1), the flexor carpi radialis (2), some portions of the flexor digitorum superficialis (3), and the deep portion of the flexor digitorum profundus (4) muscles. (B) Axial FST2-weighted FSE image of the distal forearm shows high signal intensities within the pronator quadratus (5) and flexor pollicis longus (6) muscles. (C and D) Axial FST2-weighted (C) and proton-weighted (D) FSE images of the distal upper arm show a high signal intensity and enlargement of the dorsal fascicle (arrows) of the median nerve (dotted circle), corresponding to the fascicle that will form the AIN further distally. Note the normal, isointense signal intensity (dotted arrows) (relative to muscle) of remaining fascicular bundles of the median nerve (dotted circle). (E) Longitudinal ultrasonographic image of the median nerve at the distal upper arm level shows fusiform swelling (black arrows) and incomplete constriction (white arrows) of a fascicle of the median nerve. (F) On axial ultrasonographic image, the dorsal fascicle (black arrow) of the median nerve shows uneven swelling. AIN, anterior interosseous nerve; FS, fat-suppressed; FSE, fast spin echo; R, radius; U, ulna; H, humerus.

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the origin of the AIN that branches off from the median nerve. FST2-weighted and proton-weighted FSE images of the distal upper arm revealed a high signal area in the dorsal fascicle of the median nerve (Fig. 1C and D). Electromyography results were suggestive of proximal median neuropathy with fascicular involvement of the muscles innervated by the AIN. Ultrasound (iU22; Philips Medical Systems, Bothell, WA, USA) revealed fusiform swelling and incomplete constriction of the dorsal fascicle of the median nerve trunk (Fig. 1E and F).

According to clinical and imaging findings, the final diagnosis was pseudo-AINS caused by selective fascicular involvement of the median nerve in the upper arm. At that time, he was presumptively diagnosed with neuralgic amyotrophy. The patient underwent intravenous steroid pulse therapy with methylprednisolone (1 g/day) for 3 consecutive days. Despite slight improvement in pain initially after therapy, muscle strength with flexion of the interphalangeal joint of the thumb remained MRC grade 1. However, muscle strength has slowly but steadily improved to near normal as of 4 years after onset of clinical signs of AINS.

Case 2

A 59-year-old man presented with a 2-month history of swelling and flexion difficulty of his right thumb, index, and third fingers. The patient was also unable to make the "OK" sign. Electromyography results were suggestive of a median nerve trunk lesion above the elbow level.

MRI of the distal arm to proximal forearm revealed multiple focal constrictions and signal changes in the median nerve, mainly the AIN fascicle (Fig. 2A and B). We also noted high signal intensities reflective of denervation in the pronator teres, FPL, FCR, palmaris longus, FDS, the radial part of the FDP, and the pronator quadratus muscles on FST2-weighted FSE images. Ultrasound revealed fusiform swelling and hourglass-like complete constrictions and torsions of the dorsal fascicle of the median nerve trunk (Fig. 2C and D). During surgery, his median nerve, mainly the AIN fascicle, showed torsion at more than eight sites along the level superior to the elbow (Fig. 2E). Interfascicular adhesiolysis and detorsion were performed. At 3 months after surgery, the patient's pain was relieved, and he was able to flex the index and third fingers.

Case 3

A 45-year-old man presented with a 4-month history of flexion difficulty of his left thumb, index, and third fingers. He had a history of slipping down in the parking lot. The patient was unable to make the "OK" sign. Atrophy of the thenar and forearm muscles was observed. Electromyography results were suggestive of a median nerve trunk lesion above the elbow.

MRI of the distal arm to proximal forearm revealed swelling and hyperintensity with suspicious torsion of the dorsal fascicle of the median nerve, mainly the AIN fascicle, on FST2-weighted and proton-weighted FSE images (Fig. 3A and B). There were denervation-related signal alterations and fatty changes in the pronator teres, FCR, FDS, FPL, the radial part of the FDP, and the pronator quadratus muscles on MRI (Fig. 3C and D). Ultrasound revealed mild swelling and rotation of the dorsal fascicle of the median nerve trunk (Fig. 3E and F). During surgery, entwinement and constriction of the AIN fascicle was noted at the level superior to the elbow (Fig. 3G). Untwisting and decompression of the AIN fascicle were performed. At 1 month after surgery, the patient was able to flex the thumb and index finger, and the thenar muscle function had recovered.

Informed consent was obtained from all patients for this report.

DISCUSSION

In this report, all patients presented clinically with findings suggestive of AINS and more proximal lesions with selective fascicular involvement of the median nerve trunk, which courses to the AIN more distally.

The AIN arises from the median nerve, at an average of 5.2 cm distal to the intercondylar line. It originates from the nerve fascicles of the dorsal region and the dorsolateral fascicles of the median nerve, and innervates the FPL, FDP (including the index and sometimes third fingers), and pronator quadratus muscles.[7,8] Pseudo-AINS has been found to occur in association with supracondylar fractures of the humerus, proximal radius fracture, partial damage to the median nerve in the antecubital fossa during catheterization of the brachial artery or venipuncture, median nerve entrapment by an accessory bicipital aponeurosis, nerve inflammation, or fascicular constriction/torsion of nerve.[1-4,7]

Hourglass-like constrictions of peripheral nerves in the upper arm cause a rare form of neuropathy, often characterized by the sudden onset of pain in the shoulder or arm, followed by muscle weakness and atrophy, with limited sensory involvement.[4,6,9-13] The symptoms of one of our patients were similar to those described in previous reports[4,5,14] and were also in accordance with the recently reported criteria for neuralgic amyotrophy.[5,6,14]

Imaging modalities, such as US and MRI, may be useful tools for diagnostic examination of selective fascicular involvement of the proximal median nerve before the AIN branch arises.[1,3,5,9,10] Within a peripheral nerve, individual nerve fibers are grouped together as fascicles. It is difficult to prove the existence of selective fascicular nerve lesions in spontaneous neuropathy using only clinical and electromyography findings. On the basis of retrospective analysis of 14 patients with neuralgic amyotrophy who underwent US and surgery, Arányi, et al.[5] categorized the four types of morphological alterations of the affected nerve as follows: focal or diffuse nerve/fascicle enlargement, incomplete nerve constriction, complete nerve constriction with torsion (hourglass-like appearance), and fascicular en-

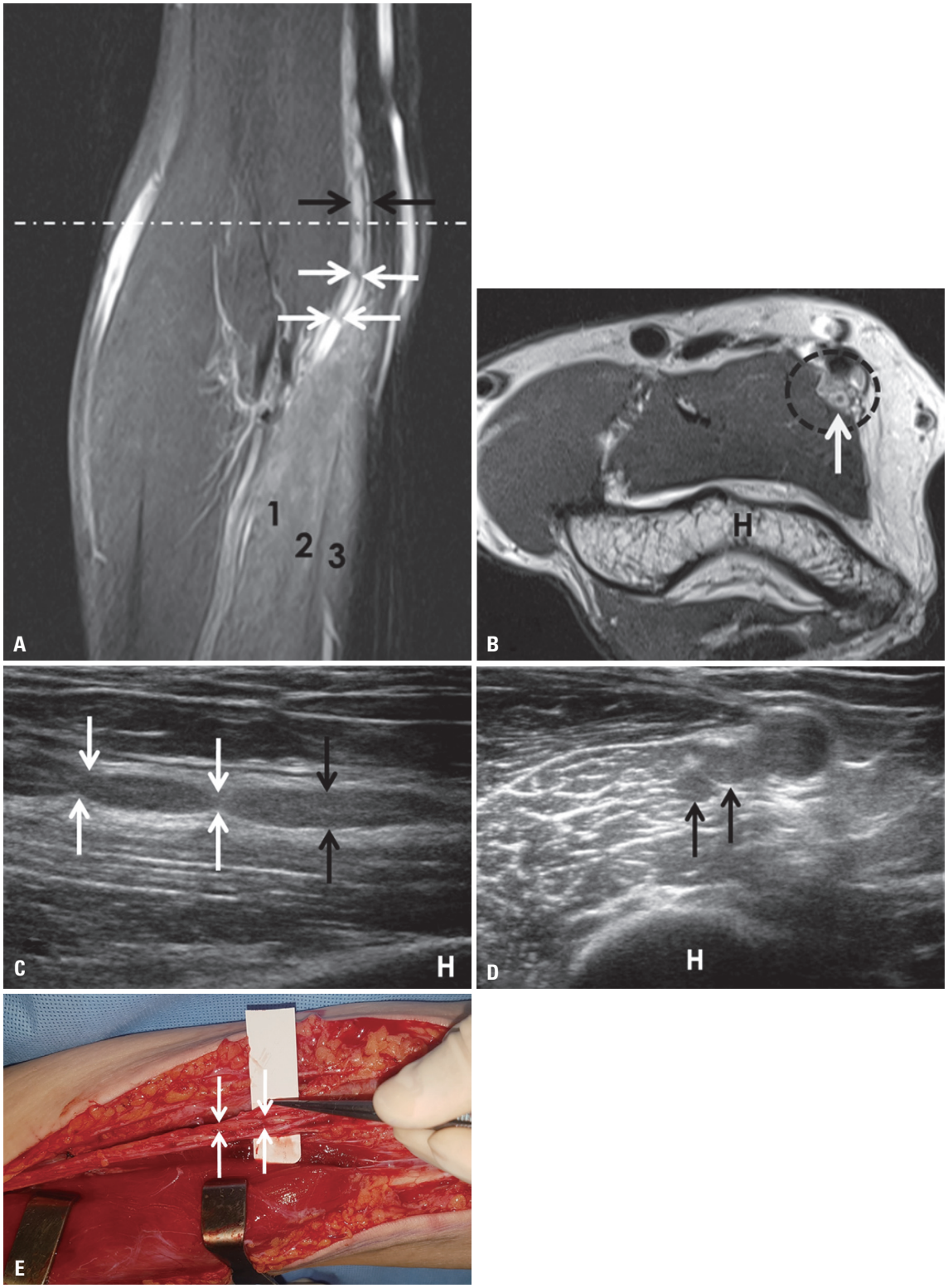

Fig. 2. A 59-year-old man with hourglass-like constrictions and torsions of the dorsal fascicle of the right median nerve and pseudo-AIN syndrome. (A and B) Coronal FST2-weighted FSE image of the right distal arm to proximal forearm (A) shows multiple focal constrictions (white arrows) of the median nerve with uneven swelling (black arrows), in addition to high signal intensities in the pronator teres (1), the flexor carpi radialis (2), and the palmaris longus (3) muscles. Axial proton-weighted FSE image (B) obtained at a dashed line level (immediately above the constriction site) shows a peripheral hyperintensity and central hypointensity; bullseye sign (arrow) in the dorsal fascicle of the median nerve (dotted circle). (C and D) Longitudinal (C) and axial (D) ultrasonographic images of the median nerve at the distal upper arm level show fusiform swelling (black arrows) and hourglass-like constrictions and torsions (white arrows) of the fascicle of the median nerve. (E) On the surgical image of the median nerve at the distal upper arm and elbow levels, the dorsal fascicle of the median nerve shows multiple torsions (white arrows) above the elbow. AIN, anterior interosseous nerve; FS, fat-suppressed; FSE, fast spin echo; H, humerus.

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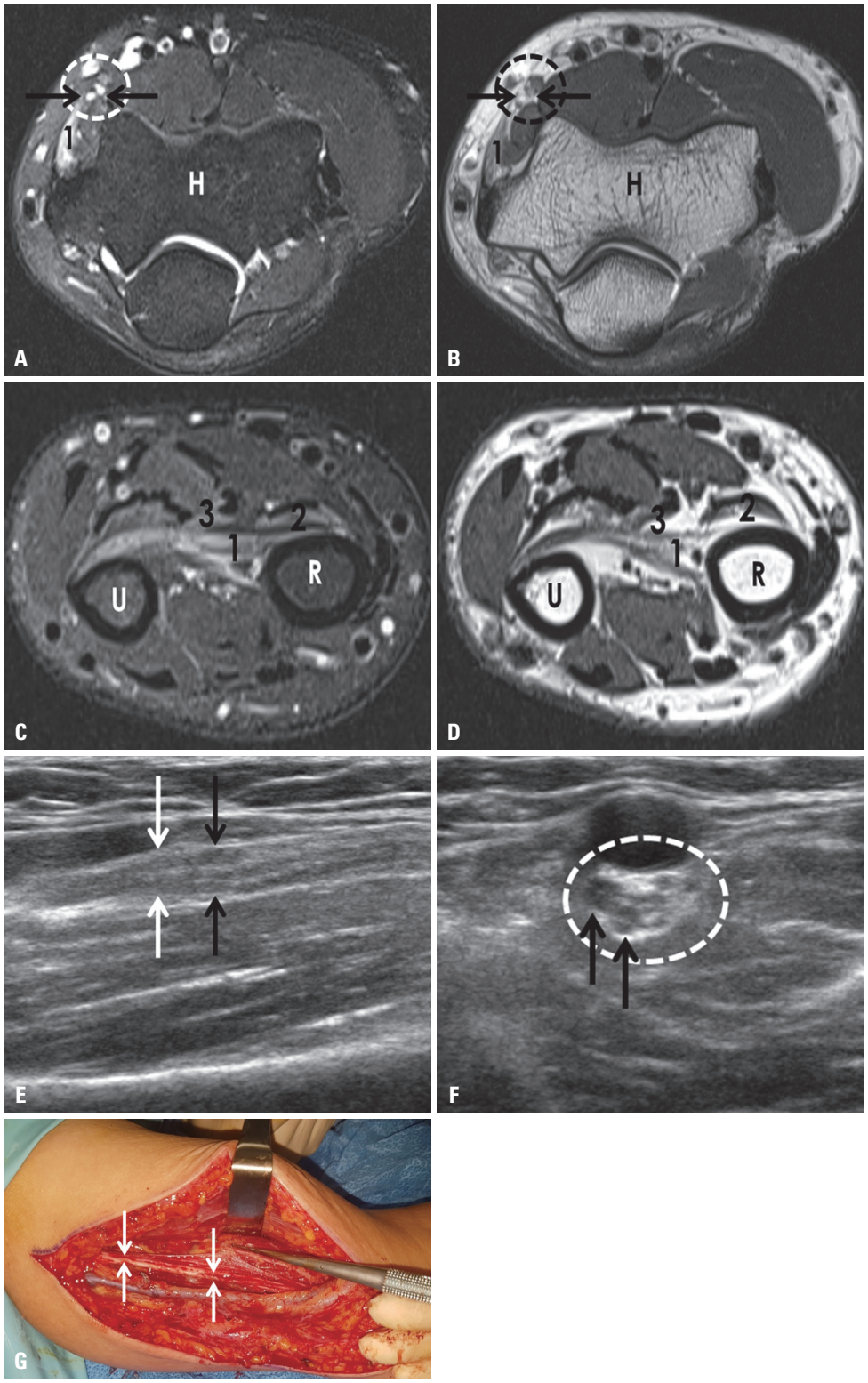

Fig. 3. A 45-year-old man with entwinement and constriction of the dorsal fascicle of the left median nerve and pseudo-AIN syndrome. (A and B) Axial FST2-weighted (A) and proton-weighted (B) FSE images of the left elbow show focal swelling (black arrows) in the dorsal fascicle of the median nerve (dotted circle) with high signal intensity in the pronator teres muscle (1). (C and D) Axial FST2-weighted (C) and T1-weighted (D) FSE images of the distal forearm show denervation-related high signal intensities and fatty changes in the pronator quadratus (1), flexor pollicis longus (2), and the radial part of flexor digitorum profundus (3) muscles. (E and F) Longitudinal (E) and axial (F) ultrasonographic images of the distal upper arm show entwinement (white arrows) and mild swelling (black arrows) of the fascicles of the median nerve (dotted circle). (G) During surgery, there were two points of entwinement (white arrows) and a constriction of the AIN fascicle above the elbow. AIN, anterior interosseous nerve; FS, fat-suppressed; FSE, fast spin echo; R, radius; U, ulna; H, humerus.

twinement (gradual rotation of fascicles, suggestive of twisting of the fascicles around each other, instead of a parallel course). Constriction is thought to be the precursor of torsion. According to the previously described classification system,[5] our patients' conditions could be categorized as multiple incomplete constrictions, complete hourglass-like constrictions/torsions, and entwinement of the dorsal fascicle of the median nerve on US. The US findings were well correlated with the MRI findings in all three patients. On high-resolution MRI, the motor fascicles forming the AIN were affected, whereas other median nerve fascicles seemed to be relatively unaffected. In two of the three patients, fascicular constriction/entwinement neuropathy was confirmed by exploratory surgery. In one patient, immediately proximal to constriction sites, the site of narrowing showed a MRI bullseye sign: an indicator of peripheral nerve constriction.[15] T2-weighted images of the elbow and forearm also revealed multiple high signal intensities in the muscles (FDP, FPL, and pronator quadratus) innervated by the AIN, as well as in the proximal muscles (pronator teres, FCR, and some portions of the FDS) innervated by the median nerve. These MRI findings were helpful in discriminating pseudo-AINS from AINS itself, as well as in determining the sites and extent of the lesions. MRI could also exclude external compression, nerve tumor, or diffuse neuritis.

Since most patients with AINS recover spontaneously, primary conservative treatments are considered, although there is some controversy regarding treatment.[7,16,17] However, in patients with pseudo-AINS as a result of nerve fascicular constriction/torsion, as reported here, it may be difficult to expect recovery without surgical treatment.[3,4] Moreover, localization of the classically described AINS and pseudo-AINS is crucial in surgical management.[16,17]

In summary, we report cases of selective fascicular involvement of the median nerve trunk mimicking AINS. High-resolution US and MRI, including MR neurography, can play a significant role in the diagnosis of this condition and in deciding the treatment course.

AUTHOR CONTRIBUTIONS

Conceptualization: Yun Sun Choi and Ohyun Kwon. Data curation: all authors. Formal analysis: Yun Sun Choi and Yoon Young Jung. Investigation: all authors. Methodology: all authors. Project administration: Yun Sun Choi. Resources: all authors. Supervision: Yun Sun Choi. Validation: Yun Sun Choi, Yoon Young Jung, and Ohyun Kwon. Visualization: Yoon Young Jung, Yun Sun Choi, and Minchul Kim. Writing—original draft: Yoon Young Jung and Yun Sun Choi. Writing —review & editing: Yun Sun Choi, Yoon Young Jung, Chang-Hun Lee, and Ohyun Kwon. Approval of final manuscript: all authors.

ORCID iDs

Yoon Young Jung https://orcid.org/0000-0002-5287-9171
Yun Sun Choi https://orcid.org/0000-0001-7082-3991
Chang-Hun Lee https://orcid.org/0000-0003-4330-7726
Ohyun Kwon https://orcid.org/0000-0001-9806-814X
Minchul Kim https://orcid.org/0000-0002-4614-1146

REFERENCES

1. Godel T, Pham M, Kele H, Kronlage M, Schwarz D, Brunée M, et al. Diffusion tensor imaging in anterior interosseous nerve syndrome-functional MR neurography on a fascicular level. Neuroimage Clin 2019;21:101659.
2. Noda Y, Sekiguchi K, Tokuoka H, Oda T, Hamaguchi H, Kanda F, et al. Ultrasonographic findings of proximal median neuropathy: a case series of suspected distal neuralgic amyotrophy. J Neurol Sci 2017;377:1-5.
3. Pham M, Bäumer P, Meinck HM, Schiefer J, Weiler M, Bendszus M, et al. Anterior interosseous nerve syndrome: fascicular motor lesions of median nerve trunk. Neurology 2014;82:598-606.
4. Yasunaga H, Shiroishi T, Ohta K, Matsunaga H, Ota Y. Fascicular torsion in the median nerve within the distal third of the upper arm: three cases of nontraumatic anterior interosseous nerve palsy. J Hand Surg Am 2003;28:206-11.
5. Arányi Z, Csillik A, Dévay K, Rosero M, Barsi P, Böhm J, et al. Ultrasonographic identification of nerve pathology in neuralgic amyotrophy: enlargement, constriction, fascicular entwinement, and torsion. Muscle Nerve 2015;52:503-11.
6. Pan Y, Wang S, Zheng D, Tian W, Tian G, Ho PC, et al. Hourglass-like constrictions of peripheral nerve in the upper extremity: a clinical review and pathological study. Neurosurgery 2014;75:10-22.
7. Chin DHCL, Meals RA. Anterior interosseous nerve syndrome. J Hand Surg Am 2001;1:249-57.
8. Caetano EB, Vieira LA, Sabongi Neto JJ, Caetano MBF, Sabongi RG. Anterior interosseous nerve: anatomical study and clinical implications. Rev Bras Ortop 2018;53:575-81.
9. Qi HT, Wang XM, Li SY, Wang GB, Wang DH, Wang ZT, et al. The role of ultrasonography and MRI in patients with non-traumatic nerve fascicle torsion of the upper extremity. Clin Radiol 2013;68:e479-83.
10. Nakashima Y, Sunagawa T, Shinomiya R, Ochi M. High-resolution ultrasonographic evaluation of "hourglass-like fascicular constriction" in peripheral nerves: a preliminary report. Ultrasound Med Biol 2014;40:1718-21.
11. Lundborg G. Commentary: hourglass-like fascicular nerve compressions. J Hand Surg Am 2003;28:212-4.
12. Deng H, Lu B, Yin C, Xu Y, Ding Y, Mi Y, et al. The effectiveness of ultrasonography in the diagnosis of spontaneous hourglasslike constriction of peripheral nerve in the upper extremity. World Neurosurg 2020;134:e103-11.
13. Maldonado AA, Amrami KK, Mauermann ML, Spinner RJ. Reinterpretation of electrodiagnostic studies and magnetic resonance imaging scans in patients with nontraumatic "isolated" anterior interosseous nerve palsy. Plast Reconstr Surg 2016;138:1033-9.
14. van Alfen N, van Engelen BG. The clinical spectrum of neuralgic amyotrophy in 246 cases. Brain 2006;129(Pt 2):438-50.
15. Sneag DB, Saltzman EB, Meister DW, Feinberg JH, Lee SK, Wolfe SW. MRI bullseye sign: an indicator of peripheral nerve constriction in parsonage-turner syndrome. Muscle Nerve 2017;56:99-106.
16. Ulrich D, Piatkowski A, Pallua N. Anterior interosseous nerve syndrome: retrospective analysis of 14 patients. Arch Orthop Trauma Surg 2011;131:1561-5.
17. Rodner CM, Tinsley BA, O'Malley MP. Pronator syndrome and anterior interosseous nerve syndrome. J Am Acad Orthop Surg 2013;21:268-75.

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