



Case Study

## Long-term effects of combined botulinum toxin treatment and rehabilitation on upper limb muscle spasms: a case report

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**Abstract.** [Purpose] We report our experience with a patient with a central spinal cord injury who showed improved finger and upper limb functions after long-term treatment with a combination of rehabilitation and botulinum toxin type A. [Participants and Methods] The patient had spasms and pain that gradually became more profound and was given botulinum toxin type A at 1 year 3 months after sustaining a spinal cord injury. We administered 14 botulinum toxin type A injections periodically for 7 years 4 months after the injury. We administered the injections at an average interval of 5.6 months. Splints that allowed extension and improved finger muscle tone and contracture were made for the patient. [Results] The patient experienced gradual alleviation of the spasms in the proximal upper limb muscles and improved range of motion after receiving five doses of botulinum toxin type A. The spasms and range of motion in the fingers gradually improved around 4 years after the injury through splint therapy and a combination of botulinum toxin type A administration and rehabilitation. [Conclusion] The combination of botulinum toxin type A, splint, and rehabilitation therapies can lead to positive improvements in finger spasticity and range of motion and is recommended for hypertonias cases with severe contractures.

**Key words:** Carry-over effect, Concomitant use of splint, Restoration of hand function

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### INTRODUCTION

Using botulinum toxin type A (BoNT-A), it is possible to actively and properly control muscle spasms and simultaneously implement rehabilitative activities, such as stretching and exercise therapy<sup>1-3)</sup>. Although there have been reports on functional improvement in proximal upper limb muscles from the combined use of BoNT-A and rehabilitation<sup>4, 5)</sup>, there are few reports on functional improvement in distal muscles, particularly those of the fingers. There are also insufficient reports on the long-term effects of BoNT-A<sup>6)</sup>. In this study, we report our experience of a patient with spinal cord injury who underwent long-term combined treatments using BoNT-A and rehabilitation. The patient showed improved motor functions in the fingers and upper limb, and regained some hand movements that led to improvements in activities of daily life (ADL).

### PARTICIPANT AND METHODS

The patient was a 60 year-old man who had central spinal cord injury (C4). At an initial evaluation 9 months after the injury, the patient was quadriplegic (C5 level, quadriparesis, severe distal, and severe right-sided paralysis) and used an

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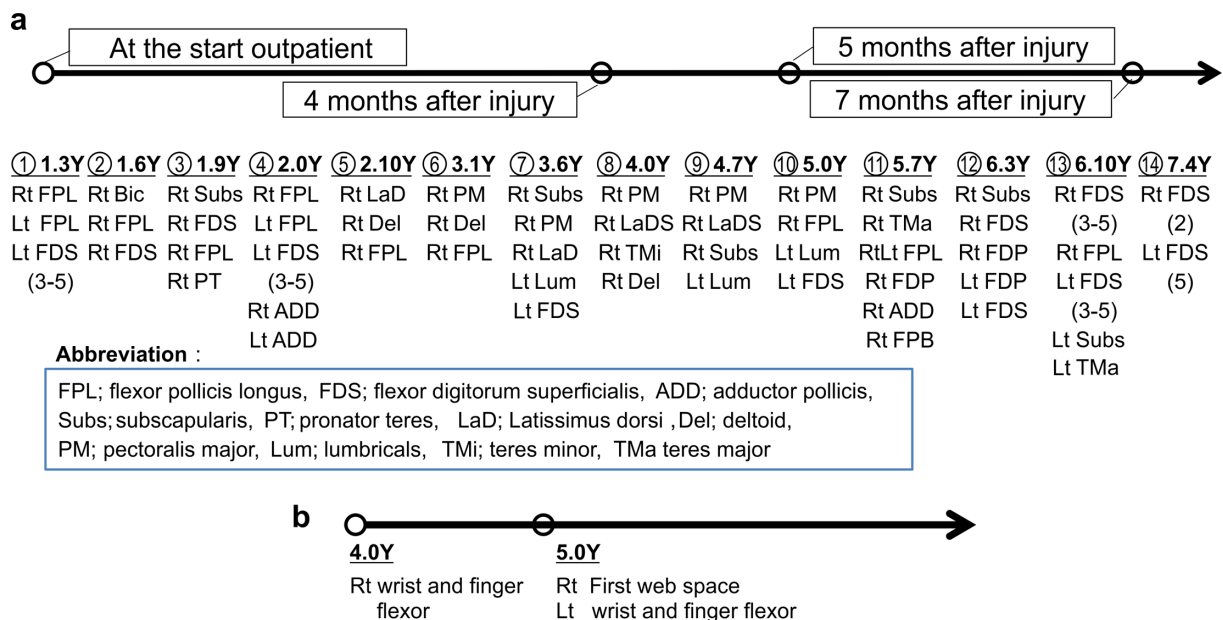
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electronic wheelchair. There were no abnormalities in his mental functions. There was moderate contracture from the wrist joint to the fingers. Although the muscle tone was increased in the extremities and the trunk, it was significantly increased in the upper limbs and associated with pain in the extremities. The Modified Ashworth scale (MAS) scores were more severe in the right finger flexors than in the left. We identified hypoesthesia on both sides below the C5 level and skin hypersensitivity at the C7–C8 level. The patient was almost fully assisted in all ADLs. His Motor Functional Independence Measure (M-FIM) score was 34 points. The ADL he could perform included eating using his left hand (with self-help tools like spoons and forks) and independent motion using an electronic wheelchair (lever operated) but required assistance for all other activities.

Outpatient rehabilitation involved physical therapy and occupational therapy twice weekly, but because spasms and pain gradually became more profound, we started giving the patient BoNT-A about 1 year and 3 months after the injury. We gave a total of 14 BoNT-A injections periodically for 7 years and 4 months after the injury. We injected 2–5 proximal upper limb muscles and 2–4 distal upper limb muscles during each treatment. The injections were given at an average interval of 5.6 months (3 to 10 months) (Fig. 1a). About 4 years after the injury, we attempted to tape the patient’s hands, but redness and itchiness ultimately made taping difficult; therefore, splints were used instead of tapes. The redness and pain associated with the use of splint were tolerable, thus, the patient wore the splints for several minutes during the day and gradually increased the wearing time until he could wear them for 6–8 hours at night. The splints were remade and appropriately corrected to allow easy extension of the splint as the muscle tone and contracture of the fingers improved (Figs. 1b and 2). The study was approved by the Fuchinobe General Hospital Ethics Committee (Approval No. 18-003). The participant provided written informed consent.

## RESULTS

After 7 years of sustaining spinal cord injury, passive range of motion (ROM) (right/left) showed significant improvement 4 months after commencing BoNT-A therapy (145/180 for shoulder flexion, 140/145 for elbow flexion, and –20/0 for extension). The joints of the fingers showed clear improvements after about 4 months (Fig. 3a) and there was improvement in automatic exercise and improvements in passive ROM<sup>2</sup>). The MAS scores similarly indicated the alleviation of spasm in the proximal upper limb muscles after about 4 months. There were improvements in the distal upper limb muscles, and the improved scores were 1/0 for elbow flexors, 2/1+ for wrist flexors, and 1–3/1–3 for finger flexors (Fig. 2 and Fig. 3b). Sensory disorders in the C7 region improved, and skin hypersensitivity gradually reduced about 3 months after the injury. Aside from using his left hand to eat and operate an electronic wheelchair, the patient continued to require full assistance in ADL, and his M-FIM score was 42 points. Owing to the increase in the ROM of the patient’s upper limb, he required less



**Fig. 1.** Patient’s progress over time while receiving BoNT-A, splint frequency and rehabilitation.

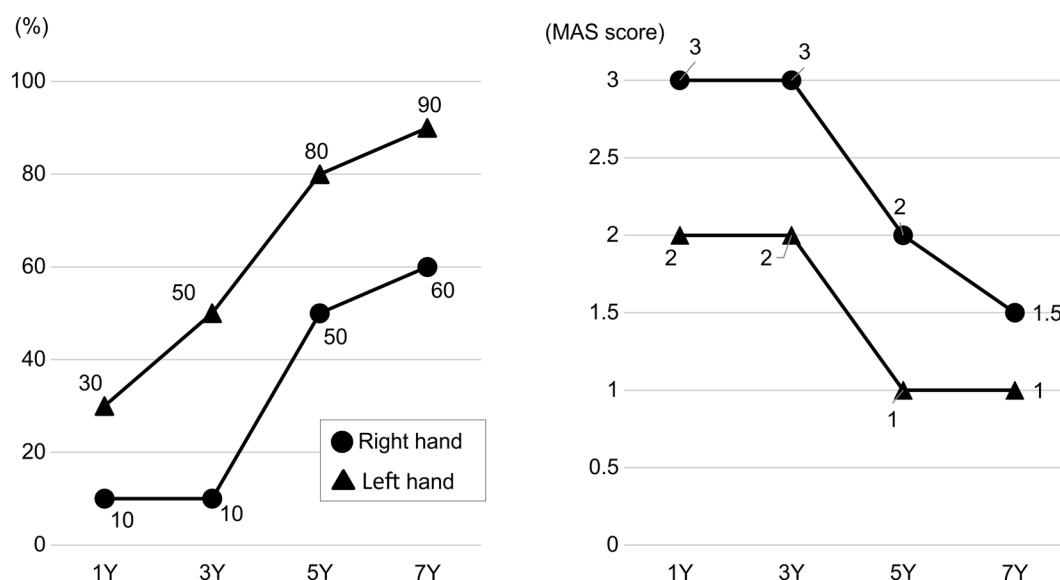
1a. BoNT-A of upper extremity dispensing interval average 5.6 months (range 3–10M).

1b. Splint progress 4 months after injury.

BoNT-A: botulinum toxin type A; FPL: flexor pollicis longus; FDS: flexor digitorum superficialis; ADD: adductor pollicis; Subs: subscapularis; PT: pronator teres; LaD: Latissimus dorsi; Del: deltoid; PM: pectoralis major; Lum: lumbricals; TMi: teres minor; TMa: teres major.



**Fig. 2.** Progression in the usage of the splint types.  
ROM: range of motion; MAS: Modified Ashworth Scale; FDS: flexor digitorum superficialis; PIP: proximal interphalangeal joint.



**Fig. 3.** Graph of ROM and MAS scores over time showing improvements in motor function and usage of the hands.  
**3a.** Passive ROM of the index finger's PIP joint.  
**3b.** Modified Ashworth Scale (MAS) FDS of Index.  
FDS: flexor digitorum superficialis; MAS: Modified Ashworth Scale; PIP: proximal interphalangeal joint; ROM: range of motion.

assistance with wearing clothes, donning and doffing clothes, and for sanitary purposes (Fig. 4). The patient was capable of cooperative movements when assistance was provided, such as extending the standing time by holding onto the handrail with the left elbow to remain standing. The patient's left hand, which was always capable of eating movements, increased in its range of use after the intervention, as the speed of eating became faster. In addition, he could also operate his smartphone and the elevators, smoke cigarettes, and write letters and numbers with his left hand (Fig. 4). We noticed the patient's proactive mindset with changes in behavior, such as finding wearable assistive instruments for his right side by himself and actively advising that the splint was not fitting as improvements progressed in the fingers.

## DISCUSSION

It has been reported that even though the effect of BoNT-A wears off after 3–4 months, combining BoNT-A treatment with rehabilitation could have a carry-over effect<sup>3–5</sup>. This patient began to experience gradual alleviation of spasms in the proximal muscles of the upper limb and improvement in ROM, 2 years following the injury, after receiving 4–5 BoNT-A injections, and these trends supported the carry-over effect theory. In addition, the spasms and ROM in the fingers gradually improved about 4 years after the injury through the combination of splint therapy, administration of BoNT-A, and rehabilitation. Previous reports have indicated that the combination of BoNT-A and splint therapy can lead to positive improvements



**Fig. 4.** Improvement in motor function and usage of the hands.

in finger spasticity and ROM<sup>7, 8)</sup>. There are also several reports indicating that taping is more effective than splints<sup>9, 10)</sup>. We think this is because taping complements the fingers' state as they change in form and functionality. As this patient presented with skin hypersensitivity about 2 years after the injury, the use of taping was considered difficult; therefore, splint therapy was used when skin hypersensitivity alleviated. Extension using splints prevented the deterioration of skin hypersensitivity and led to improvements in ROM. We believe that gradually modifying the shape of the splint to allow proper extension according to the changes in the patient, makes this measure effective<sup>9, 10)</sup>. We suggest that sustained extension (after correcting the splint in accordance with the improvement in the distal muscles and finger joint contracture) is effective in cases such as this patient. In the future, we would like to determine what level of extension of the splint would be effective in cases with finger spasms.

### *Conflict of interest*

The authors have no conflicts of interest to disclose regarding this work.

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