Effects of Rehabilitation of Spinocerebellar Degeneration Patients Using HAL Lower Limb Type: Focus on Cerebral Volumetric Changes

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Background

Spinocerebellar degeneration (SCD) is a disease characterized by ataxia due to neurodegeneration of the cerebellum and its input-output pathways. Traditionally, degeneration of the cerebellum, brainstem and spinal cord was thought to be central to the pathogenesis of SCD, but there have been reports of increased brain volume, suggesting that the cerebral cortex compensates for the loss of cerebellar function. The Hybrid Assistive Limb (HAL), which has attracted attention as a rehabilitation tool for SCD, is a rehabilitation robot that can improve, assist, extend and regenerate physical function. However, the rehabilitation effect of HAL is often evaluated in terms of physical function, movement ability, and patient sensation, and there are no reports evaluating its effect in terms of brain volume changes.

Purpose

We report a patient with SCD in whom the effect of rehabilitation using the lower limb type of HAL could be evaluated by structural changes in the cerebrum.

Methods

【Case Info】

- Age: 70s
- Gender: male
- About disease : Diagnosed with SCD in 20XX
- Rehabilitation: Started in 20XX+14 using HAL lower limb type

【Rehab Protocol】

- Frequency: Annual treatment with a 2-week hospital stay
- Therapy: Combination of TRH therapy and rehabilitation

〈HALex Training〉

- Standing Balance Practice
- Gait Training: 100m × 2 sets per day for approximately 10 days

〈Additional Rehabilitation〉

- OT (Occupational Therapy): Upper limb functional training
- ST (Speech Therapy): Language function training

【Analysis and Evaluation】

- Cerebral Volume Assessment: Examined 68 areas[Fig,4] using surface-based morphometry[Fig,5] from 3Tesla MRI images (T1)[Fig,6]
- Ataxia Evaluation: Scale for the Assessment and Rating of Ataxia (SARA)

What is HAL(Hybrid Assistive Limb) ?

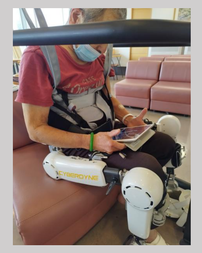
The world's first wearable cyborg developed by Cyberdyne Inc. of Japan.



Fig,1

・The mechanism of HAL Lower Limb Type

Bio-Electrical Signal Detection: When a user attempts to move, the brain sends signals to the muscles. HAL detects these faint bio-electrical signals (BES) on the skin's surface using non-invasive sensors.



Fig,2

・Signal Processing: The detected signals are analyzed to understand the user's intended movement.

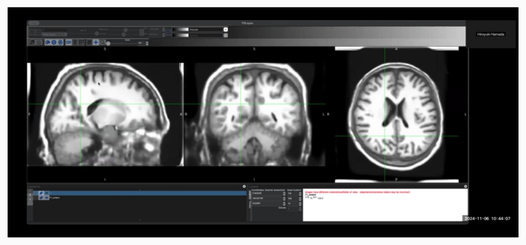
・Motor Assistance[Fig,1]: Based on the processed signals, HAL activates motors located at the hip and knee joints to assist the user in performing the desired movement.

・Feedback Loop[Fig,2]: The movement generates sensory feedback, which is sent back to the brain. This feedback helps reinforce neural pathways, promoting neuroplasticity and improving motor function over time[Fig,3].

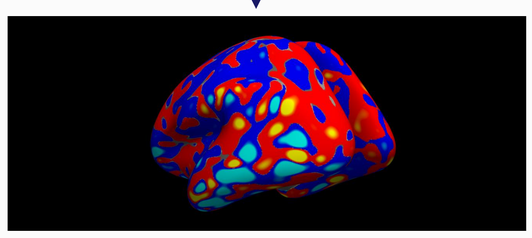


Fig,3

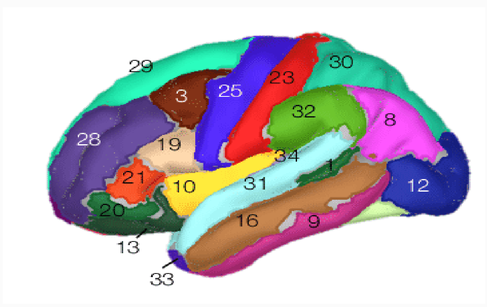
This innovative system enables users to regain mobility and perform movements even if their natural motor functions are impaired.

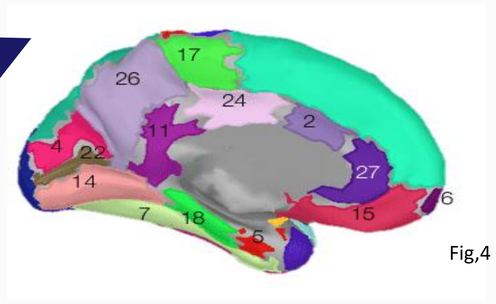


Fig,6



Fig,5

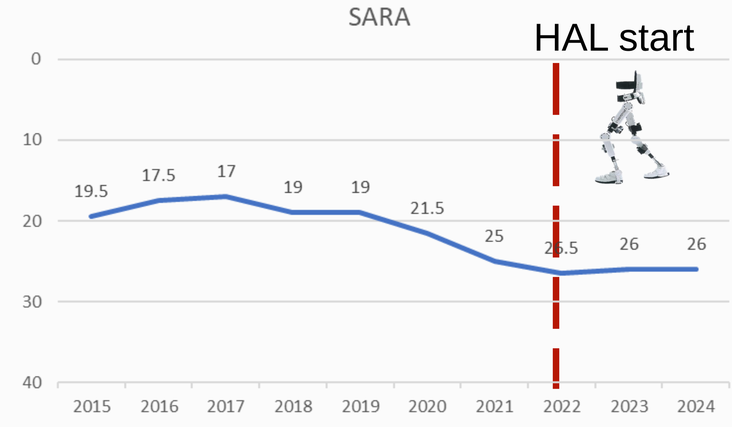




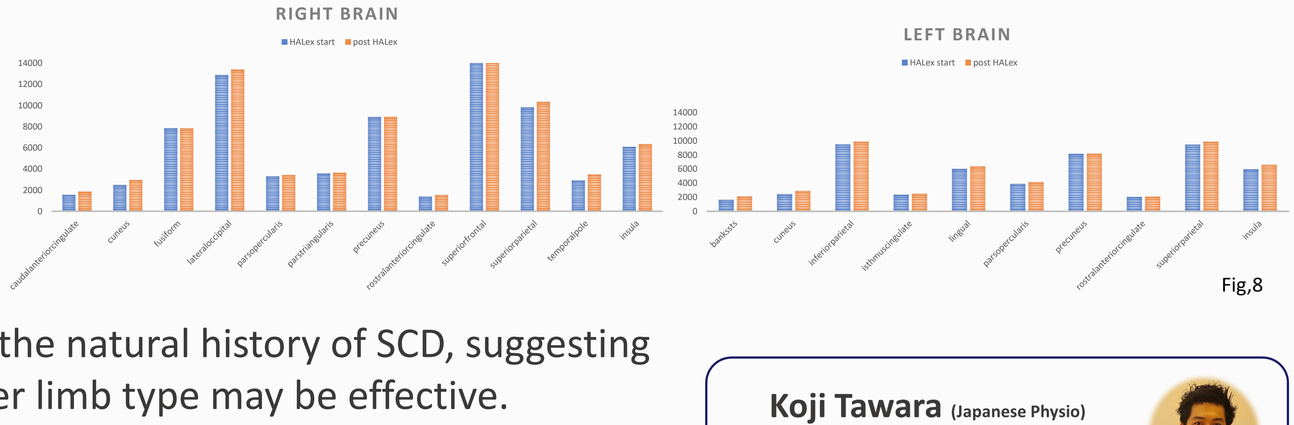
Fig,4

Results

SARA did not show a marked worsening of symptoms compared to the natural history of SCD[Fig,7]. An increase in volume was observed in the frontal and parietal lobes, as well as in the insular cortex and cingulate gyrus, which are associated with motor function and bodily sensation[Fig,8].



Fig,7



Fig,8

Conclusions

This report suggests that rehabilitation using the HAL lower limb type results in volumetric increases in frontal and parietal lobes, insular cortex and cingulate gyrus, which are associated with motor function and bodily sensation in patients with SCD.

These results suggest a mechanism by which cerebral plasticity compensates for cerebellar dysfunction.

In addition, changes in SARA scores were not significantly worse than the natural history of SCD, suggesting that interactive biofeedback through rehabilitation using the HAL lower limb type may be effective.

Cerebral volumetric change may become an important tool in investigating the effectiveness of advanced rehabilitation devices such as ROBOT.

Koji Tawara (Japanese Physio)

