別紙様式第４

学　位　論　文　要　旨

博士課程 ㊙・乙	第59号	氏　名	川　野　彰　裕

［論文題名］

Ultrasonographic Evaluation of Changes in the Muscle Architecture of the Gastrocnemius with Botulinum Toxin Treatment for Lower Extremity Spasticity in Children with Cerebral Palsy

脳性麻痺下肢痙縮患者に対するボツリヌス毒素療法の腓腹筋筋形状変化に関する超音波エコーによる検討

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［要　旨］

【Background】 Spasticity, one of the upper motor neuron signs, is a prominent motor disorder in patients with cerebral palsy. Spasticity is characterized by velocity-dependent increases in tonic stretch reflexes accompanied by increased tendon reflexes. As a result, the condition of the muscle tone changes, and muscle or tendon shortening affects the range of motion and causes contracture. Botulinum toxin A (BoNT-A) treatment involves injecting BoNT-A to relax muscle spasticity. Using ultrasonography, this study examined changes in the muscle architecture before and after treatment to evaluate the influence of BoNT-A injection on muscles. **【Methods】** The participants included 18 children (mean age, 6.2 years) with cerebral palsy who were treated with BoNT-A for lower extremity spasticity and 27 healthy children (mean age, 6.4 years) as a control group. In all cases, BoNT-A was injected into the gastrocnemius muscle. The muscle length, muscle width, and pennation angle (which indicates the degree of muscle fiber tone), were measured using B-mode ultrasonography before and 12 weeks after injection. **【Results】** The muscle length and muscle width were shorter in the cerebral palsy group than in the control group. The pennation angle in the cerebral palsy group significantly decreased after injection from 28.2 ± 3.6° to 25.8 ± 2.5° in the resting position of the ankle and from 18.6 ± 2.8° to 15.9 ± 1.7° in the maximum dorsiflexion position of the ankle. In the control group, the pennation angle was 25.9 ± 3.2° in the resting position of the ankle and 15.1 ± 2.5° in the maximum dorsiflexion position of the ankle. The rate of increase of fascicle length during passive movement from the resting position of the ankle to the maximum dorsiflexion position was 143.9% in the cerebral palsy group, which was significantly less than the value of 157.7% in the control group. After BoNT-A treatment, the rate of increase of fascicle length in the cerebral palsy group increased to 155.1%. **【Discussion】** Ultrasonography enables noninvasive, real-time evaluation of in vivo information. Many studies using

ultrasonography have reported on the structure and characteristics of muscles and tendons. The principle of evaluating the muscle architecture using ultrasound is based on an ultrasonic reflection method, in which sound waves reflect from structures with different in vivo tissue densities, such as collagen fibers. Ultrasonography enables the quantitative evaluation of changes in the muscle architecture associated with contraction. In pennate muscles such as the gastrocnemius, muscle fascicles are arranged obliquely, and the pennation angle, which indicates the position of muscle fascicles relative to the aponeurosis, has been reported to considerably affect the muscular force during contraction. Muscle contraction leads to an increase in the physiological cross-sectional area following an increase in the pennation angle and a shortening of fascicle length, which results in increased muscle tension. The typically developing children in the control group in this study did not differ from the children in the CP group in physical characteristics such as age, height, and weight, and they were therefore considered a suitable control group. However, there were significant differences between the groups in thigh and lower leg circumferences, which may have been due to muscle atrophy associated with paralysis in the CP group.Ultrasonography revealed that the muscle width and fascicle length were significantly shorter in the CP group than in the control group, suggesting muscle atrophy associated with paralysis. In addition, the pennation angle in the resting position was greater in the CP group than in the control group. This finding conflicts with previous studies; however, in cases of spastic paralysis, the muscle fibers constantly contract from the influence of muscle tone, which may lead to an increased muscle tone.After BoNT-A treatment, the pennation angle and fascicle length in the CP group became similar to of the values in the control group, both in the resting position and in the maximum dorsiflexion position. The decrease in the pennation angle in the resting position after treatment may have been due to routine reduction in the muscle tone. In addition, the decrease in the pennation angle and the increase in the muscle elongation rate after BoNT-A treatment suggest reductions in the muscle contraction and muscle tone, causing structural changes in flaccid muscle fibers. The decrease in the pennation angle indicates an increase in fascicle length. The increase in fascicle length indicates that the muscle fiber has elongated, leading to an improvement in the muscular range of motion. In many children with spastic paralysis, the gastrocnemius is easily elongated and joint contracture or disuse muscle atrophy has not progressed. At this point, the symptoms are reversible. However, fascicle length declines with physical growth, and if the mobility gradually decreases, secondary muscle contracture or shortening occurs, which eventually leads to irreversible joint contracture. The results of this study indicate that BoNT-A treatment works effectively to help spastic muscles become more dynamic. **【Conclusions】** The decrease in the pennation angle after BoNT-A treatment is considered to be the result of a reduction of spasticity and subsequent structural changes in flaccid muscle fibers.

備考　論文要旨は、和文にあっては2，000字程度、英文にあっては1，200語程度とする。