Case Report: Zen meditation-integrated CBT normalized the impaired brain function of a chronic low back pain patient—from the findings of brain blood flow SPECT imaging

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Abstract

Background: Mindfulness meditation for chronic pain is popular globally, but evidence of its efficacy is limited. Moreover, there are no established methods on the objective evaluation of the effectiveness of interventions for chronic pain. In this study, a chronic low back pain patient was treated with traditional Japanese Buddhism meditation-integrated cognitive behavioral therapy and the pre- and post-intervention brain single-photon emission computed tomography (SPECT) images were compared.

Case: A 45-year-old man was experiencing continuous back pain after a vehicular accident and experienced insufficient improvement after drug treatment. The patient underwent a 3-month outpatient mindfulness meditation-integrated cognitive behavioral therapy program executed by a multidisciplinary team: physician visits (once a week for 30 min), multidisciplinary medical and meditation education (Zen breath counting meditation and mantra), physiotherapy interventions (twice weekly), occupational therapy interventions (twice weekly), psychiatric occupational therapy interventions (twice weekly), and nutritional interventions (twice weekly). After treatment, the patient reported a decrease in subjective pain overall, based on whether or not a pain attack occurred. Brain SPECT imaging revealed an improvement in excess blood flow from the right temporoparietal junction to the inferior parietal lobe.

Conclusions: These findings indicate that Zen meditation is an effective intervention method for chronic pain and SPECT is a useful tool for measuring its effectiveness.

Keywords
chronic pain, mindfulness, Zen meditation, cognitive behavioral therapy, brain single-photon emission computed tomography
**Introduction**

In Japan, chronic pain is a highly prevalent (26.4%) major health care issue. In 2012, Ogawa et al. reported that 72.4% of patients discontinue treatment provided by health care providers due to treatment ineffectiveness.

Chronic pain is now considered a dysfunction of the central nervous system. A number of neuroimaging techniques developed to evaluate chronic pain have revealed reconstructions and changes in the networks of the brains of patients with chronic pain; however, data on the efficacy of neuroimaging techniques in real-life clinical conditions are scarce. It is important to conduct studies evaluating brain biomarkers of pain to assess their behavior at the individual level.

Various therapeutic approaches, including cognitive behavioral therapy (CBT), exercise therapy, multidisciplinary approach, and mindfulness meditation have been shown to be effective for chronic pain, and combination treatment with these approaches has been recommended. However, none of these approaches have included the practice of Zen meditation in their programs.

In this case, we utilized single-photon emission computed tomography (SPECT) of the brain alongside Zen meditation-integrated CBT provided by a multidisciplinary team. We assessed the pre- and post-intervention changes in the brain scans as well as in physical, psychological, and quality of life (QoL) tests.

**Case report**

**Case presentation**

The patient, a 45-year-old Japanese male taxi driver collided with a passenger vehicle in November 2015 and he bruised his back. Since then, he had been experiencing continuous back pain. Due to the frequent pain attacks, he sought relief through orthopedic surgery, massage, and osteopathy. In July 2019, he was referred to us by the rehabilitation department of a university hospital. The patient’s medical history included head trauma when he was 10 years old, bruising on the head, and 5-day hospitalization due to an unknown cause. He complained about cramp-like pain all over the paraspinal muscles on both sides of the back, which was centered on L4-5. There was no sensory impairment in the lower limbs, muscle atrophy, or the Lasègue’s sign, and the deep tendon reflex was normal. Simple lumbar spine radiographs and lumbar spine magnetic resonance imaging (MRI) showed no abnormalities.

Based on the aforementioned clinical and imaging findings, the patient was diagnosed with nonspecific chronic low back pain.

**Investigations**

Pre- and post-intervention evaluations included: (1) brain SPECT with 99mTc-ethyl cysteinate dimer and two-tailed view analysis using the easy Z-score imaging system (eZIS) (August 1, 2019 and April 10, 2020); (2) a pain diary in which the degree of pain was recorded using the Numerical Rating Scale (NRS) every hour for 1 week before the intervention and before/after the program (scores calculated as the daily average at the time of an attack and at the time of no attack); and (3) psychological, QoL, and physical strength examinations, including the Pain Catastrophic Scale (Japanese version), Pain Self-Efficacy Questionnaire (Japanese version), Beck Depression Inventory, 12-item Short Form Health Survey (Japanese version), and physical strength examinations.

**Treatment**

The pre-intervention period was from October 3 to December 21, 2019. During the pre-intervention period, the effectiveness of pharmacotherapy was verified. Duloxetine has been tested in several randomized control trials (RCTs) for chronic low back pain and is strongly recommended in systematic reviews. In this case, duloxetine use was initiated from the initial consultation, with dosage increases each week from 20 mg/day to 60 mg/day. The patient was administered three tablets daily, ingested orally after each meal, starting with breakfast. As the drug administration alone did not lead to sufficient improvement, a 3-month Zen meditation-integrated CBT outpatient program was conducted. The intervention period was from January 8 to March 26, 2020. Before commencement of physician visits (once a week for 30 min), a brain SPECT eZIS image was obtained, and a treatment agreement was decided on with the goal of “normalization of brain function,” instead of healing of pain. During the program, drug administration was continued, and guidance was provided in terms of medical education about pain and breathing methods. The patient was advised to practice Zen breath counting meditation for 15 min twice a day with the following mantra “Leave pain alone. Do not fight against or escape from pain. Enjoy a bright and cheerful life” (Supplementary Video 1, which can be found as Extended data). His physician was a certified rehabilitation doctor of the Japanese Association of Rehabilitation Medicine and a licensed Buddhism priest who had practiced meditation for 40 years. Twice weekly physiotherapy interventions, in addition to actual physical therapy sessions, provided guidance on stretches to be performed at home and
on a training plan involving walking. During twice weekly occupational therapy sessions, guidance was provided on body mechanics as well as an activity for application (“bookshelf construction”). Counselling and yoga sessions were conducted twice a week by the psychiatric occupational therapy team. The Department of Nutrition conducted dietary checks twice a week and provided nutritional guidance. During the course of the treatment, a conference was held by the members of the multidisciplinary team once a week to present information and to allow for optimal patient support. Pre-intervention and post-intervention examples can be found as Supplementary Videos 2 and 3 in Extended data.44

Outcome and follow-up
Subjective pain (NRS score) decreased both at the time of an attack and no attack. All test values were maintained or improved (Table 1).

The brain SPECT (eZIS) examination revealed that excess blood flow from the right temporoparietal junction (TPJ) to the inferior parietal lobe (IPL) had improved (Figures 1 and 2).

At the follow-up visit to our clinic, the patient could walk without crutches after 3 months and could run after 4 months of the program (Supplementary Videos 4 and 5, which can be found as Extended data44).

Discussion
Mindfulness meditation for chronic pain is popular globally, but evidence of its efficacy is limited.16,29,30 In the case, Zen meditation-integrated CBT was found to be effective for improving chronic pain, as evidenced by improvements in excess regional cerebral blood flow and improvements in subjective pain scores.

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NRS = Numerical Rating Scale; QoL = quality of life; SF-12 = 12-Item Short Form Health Survey; BDI = Beck Depression Inventory; PCS = Physical Component Summary Score; MCS = Mental Component Summary Score; RCS = Role Component Summary.
The brain SPECT findings before the intervention showed decreased blood flow in the bilateral dorsolateral frontal lobe and extensive increased blood flow in the IPL, anterior insula, and temporal lobe, centered on the right TPJ. Previous studies on cerebral blood flow in chronic pain have highlighted hyperperfusion of the somatosensory cortex and hypoperfusion of the frontal, cingulate, medial temporal, and cerebellar cortices in patients with hyperalgesic fibromyalgia. We have previously reported decreased blood flow in the bilateral dorsolateral prefrontal cortex and increased blood flow in the parietal lobe and cerebellum in patients with chronic low back pain.

Using MRI, decreased grey matter density in the prefrontal cortex and thalamus has been reported. The development of functional connectivity MRI has revealed that the right TPJ is the core region of the salience network (SN), and that the IPL is the core region of the default mode network (DMN). In chronic pain, the brain functional network at rest is impaired, and the DMN and SN are in a fused state. Additionally, Doll et al. reported that more mindful individuals show a stronger negative correlation between the DMN and SN. In this case report, improved clinical test results and normalization of cerebral blood flow in the right TPJ and IPL by SPECT are consistent with the aforementioned hypothesis.

Zen breath counting is a traditional Buddhism mindfulness practice in Japan and was integrated into the program. While practicing Zen breath counting meditation, the participants are trained to “Let random thoughts arise and vanish as they will. Do not dally with them and do not try to expel them, but merely concentrate on counting your breath” by the master. We reformed this mantra to “Leave pain alone. Do not fight against or escape from pain, but merely concentrate on enjoying a bright and cheerful life.”

A common issue in pain management programs is the motivation of patients to engage in the program. From a behavioral therapy standpoint, the principle is that staff should be nonresponsive to the pain behavior to avoid reinforcing...
the patient’s pain behaviors. However, this attitude often jeopardizes the therapist-patient relationship and leads to treatment interruptions.

In this program, we presented brain SPECT images to the patient before the start of the program and highlighted the overactivity of the right TPJ. To normalize the brain function and to reduce the unconscious focus of attention on pain, the staff advised against responding to the pain behavior. In addition to teaching, various skills including physical exercises, body mechanics to prevent pain, nutritional managements, and breath counting meditation, a multidisciplinary team support during the program resulted in the reduction of subjective pain, behavioral change, and improvement of brain function by increasing physical activity and development of the ability to practice applied activities by the patient in his daily life.

In terms of the limitations of the study, the improvement in the NRS score in this case was 0.8 at the time of no attack and 1.5 at the time of attack (Table 1). It has been noted that the change in the NRS score must be higher than or equal to 2 to objectively assess the improvement in pain; however, this study did not include physical function as a marker of validity. According to the multifaceted model of pain, pain is composed of not only nociception from the peripheral tissue but also pain sensation in the nervous system, suffering in the brain, and pain behavior that the patient expresses. According to this model, verbal responses alone are not sufficient for objective assessment of pain, and improvements in physical activity should also be considered. In this case study, the physical strength examination results showed significant improvement (Table 1); therefore, it is appropriate to judge that the intervention was effective, although the change in the NRS score was less than 2.

Chronic pain can last for 6 or more months. Because the pain is spread across all parts of the body, not all chronic pain presents with a uniform cerebral blood flow state. Differing findings on cerebellar blood flow on SPECT have been reported. The possibility that blood flow status may be altered by the period after the onset of chronic pain cannot be ruled out. Hence, it is necessary to investigate more cases in the future.

In addition to Zen meditation, the program included exercise therapy, rehabilitation, cognitive therapy, yoga, and a multidisciplinary approach in parallel. It is a challenge to explore the effectiveness of different therapy strategies for chronic pain patients by analyzing the effect of specific interventions on the brain morphologically and functional alternations, as well as on clinical measures of pain.

To the best of our knowledge, this is the first report that has implemented Zen meditation to the therapy program for patients with chronic pain, and the first to use brain imaging for assessment of its effectiveness.

**Patient’s perspective**

“Before this program, my back hurt irregularly every day and I could not keep standing. I was in so much pain that I could not even walk. It was painful all over my body when the weather was bad. I could not carry anything heavy when I was shopping. I could not go out for a long period of time by myself.

The back pain that appeared irregularly every day was painful, and it was hard not knowing if it would ever go away. I thought that I would never get better; it was hard. I could not see the future. It hurt, because of which I tried to not do any activities and only lie on the bed as still as possible.

However, after this program, I am only in pain once or twice a week, which is not as bad as before. Strong pain in the back appears once or twice a week. When the weather is bad, my body is sluggish, and my joints hurt.

I can run a little bit. Overall, I am in a good condition. Now, I can go out on my own.

If I take the worst pain days as 100, my pain is 35 now.

To continue and to maintain the recovery I have had, I am aware of taking three meals regularly, losing weight, and continuing to walk and train daily. I am going to do my best without getting bogged down.

When the back pain appears, I will start moving and find out what I can do, instead of staying still and putting up with the pain.”

**Consent**

Written informed consent for publication of their clinical details and clinical images was obtained from the patient.
Data availability
Underlying data
All data underlying the results are available as part of the article and no additional source data are required.

Extended data

This project contains the following extended data:
- Sample_video_1.mp4
- Sample_video_2.mp4
- Sample_video_3.mp4
- Sample_video_4.mp4
- Sample_video_5.mp4

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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References

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