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Original article

Effects of conservative treatment of 2-week rigorous bed rest on muscle disuse atrophy in osteoporotic vertebral fracture patients

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Abstract

Objective: Osteoporotic vertebral fracture (OVF) is conventionally treated with conservative management such as bed rest, but a relatively prolonged bed rest has the potential risk of muscle disuse atrophy. This study aimed to examine whether the 2-week of rigorous bed rest affects muscle disuse atrophy in OVF patients.

Patients and Methods: A total of 54 OVF patients (16 males; 38 females; mean age, 80.2 ± 9.2 years) were treated with an initial 2-week rigorous bed rest by hospitalization with persistent rehabilitation. Cognitive function, swallowing function, grip strength, and lower extremity circumference were evaluated at three-time points (admission, end of bed rest, and discharge).

Results: Of the 51 patients who were able to walk independently before the injury, one patient (2.0%) had to use a wheelchair after the injury. During hospitalization, cognitive function decline was observed in 33.3% of patients, but not in patients with Revised Hasegawa's Dementia Scale score ≥25 at admission. Swallowing function decline was observed in one patient, and none of the patients developed aspiration pneumonia during hospitalization. The grip strength significantly improved both at the end of bed rest (P=0.04) and discharge (P=0.02). Although the lower extremity circumference significantly decreased at the end of bed rest (P<0.01), it was recovered afterward. The lower extremity circumference did not significantly differ between the admission and discharge (P=0.17).

Conclusion: Our results suggested that conservative treatment of OVF through an initial 2-week rigorous bed rest with persistent hospital rehabilitation poses a low risk of muscle disuse atrophy. If cognitive dysfunction is observed on admission, close monitoring for exacerbation should be performed during the hospital stay.

Key words: osteoporotic vertebral fracture, bed rest, disuse atrophy, cognitive function, muscle strength

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Introduction

Osteoporotic vertebral fracture (OVF) is a well-known disease that usually occurs in elderly patients resulting in increased morbidity and mortality[1, 2]. Moreover, OVF is more common among Japanese elderly people than among Caucasian elderly people[3]. OVF is conventionally treated with conservative management comprising bed rest, analgesic therapy, and wearing orthosis[4–6]. However, the standard treatment remains controversial because of different empirical approaches[7].

Although patients with OVF usually have a good clinical course with conservative treatment, 10% to 35% of patients, mainly those with OVF in the thoracolumbar transitional region (T11 to L2), had worse performance in activities of daily living, due to delayed union or non-union[8]. The Japanese Orthopedic Association recommends avoiding rigorous bed rest and promotes early rising because even 3-week bed rest cannot prevent vertebral body collapse for acute OVF patients. Meanwhile, a survey of the Japanese Orthopedic Association found a non-union rate of conservative

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treated acute OVF patients was 37%[9]. Furthermore, bed rest of the initial 2-week has been recommended for acute OVF patients[10].

We believe that initial conservative intervention is important for early pain relief, improvement in activities of daily living, and prevention of refractory cases. In a previous study, we had performed conservative therapy with a unified protocol of an initial 2-week rigorous bed rest followed by weight-bearing activities, resulting in good clinical outcomes (bone union rate at 6 months, 78%; non-union rate, 12%; surgical transfer rate, 10%; delayed paralysis rate, 0%)[11].

However, this protocol has the potential risk of disuse atrophy in elderly patients due to the relatively long period of rigorous bed rest[11]. Disuse atrophy is the loss of skeletal muscle mass due to inactivity or lesser than "normal" use[12]. It is characterized by cardiovascular vulnerability, obesity, musculoskeletal fragility, depression, and premature aging[13].

The purpose of this study was to examine whether 2-week of rigorous bed rest affects disuse atrophy in OVF patients based on the changes in cognitive function, swallowing function, and muscle strength.

Patients and Methods

Patients

A total of 54 patients diagnosed with OVF and hospitalized between September 2019 to April 2020 were included. Patients who could not complete 2-week of rigorous bed rest due to complications such as dementia and pneumonia and who underwent surgery 2-week after admission due to complications of paraplegia and diffuse idiopathic skeletal hyperostosis were excluded.

Protocols

We followed the protocol described by Abe *et al.*[11] Magnetic resonance imaging, computed tomography scan, and dynamic X-ray in standing and supine positions confirmed fractures[14]. Patients with a definitive diagnosis of OVF were instructed to lie in a supine position and were not allowed to sit even while eating or during bowel movement during the initial 2-week[10]. They were allowed to roll over to a semi-Fowler's position with 20–30° elevation of the head to maintain the patient's kyphosis, so that the patient's back fitted well alongside the bed surface. Regular on-bed physical therapy (joint range of motion exercise and muscle training without weight-bearing to the vertebrae) was started immediately after the admission to prevent joint contracture and muscle atrophy. Two weeks after admission, they were allowed to get out of bed for the rehabilitation program, which mainly included standing up, walking, muscle training of lower extremities, and wearing a ready-to-use Jewett brace (Nakamura Brace Co., Ltd., Shimane, Japan), which restricts lumbar flexion and could be worn even if patients had severe thoracolumbar kyphosis. All patients were instructed to wear the orthosis for 12-weeks until the pain and vertebral instability were resolved. The patients were allowed to take non-steroidal anti-inflammatory drugs according to pain severity.

Outcome measures

Cognitive function, swallowing function, and muscle strength, which relate to rehabilitation among the indicators of disuse atrophy, were evaluated at three-time points (admission, end of bed rest after 2-week, and discharge).

The Revised Hasegawa's Dementia Scale (HDS-R)[15, 16], which comprises a series of items that measure orientation, memory, attention/calculation, and verbal fluency, was used to evaluate global cognitive function[17]. The maximum HDS-R score is 30 points, with a score ≤20 indicating dementia. The Dysphagia Scoring System (DSS)[18] consists of four grades: 0, able to eat a normal diet; 1, able to eat some solid food; 2, able to eat semi-solid food only; 3, able to swallow liquids only; 4, complete dysphagia. In the Repetitive Saliva Swallowing Test (RSST)[19, 20], which screens for functional dysphagia, the patient was asked to swallow his/her saliva as many times as possible in 30 seconds, and <3 swallows per 30 seconds suggest functional dysphasia. Grip strength, which is correlated to muscle strength and is a predictor of mortality, hospital length of stay, and physical function[21], and femoral and lower-leg circumference, which is correlated to muscle strength and is useful for determining the developmental state of muscles and bones[22–25], were used to evaluate relative muscle strength. In addition, the walking ability before the injury and at the time of discharge was evaluated and characterized as independent gait, crutch gait, walker gait, or wheelchair (i.e., unable to walk).

Ward nursing staff using an original reporting form measured HDS-R, DSS, and RSST. Grip strength (kg) on both sides was measured by a grip dynamometer (YDD-110; Tsutsumi, Tokyo, Japan) in unified positions (supine on admission and sitting after finishing the bed rest with mid-position of the shoulder, elbow, and forearm). Physiotherapists measured the femoral and lower-leg circumferences with a tape measure placed 10 cm above the superior pole of the patella and at the maximum circumference of the lower-leg with the subject in a supine position.

Statistical analyses

All data were expressed as mean ± standard deviation. The rates of change (%) in grip strength, femoral circumference, and lower-leg circumference from admission to the end of bed rest and to discharge were calculated and compared with those at the time of admission by paired t-test. All statistical analyses were performed using GraphPad

Prism 8 (GraphPad Software, San Diego, CA, USA). A significance level of $P<0.05$ was used for all comparisons.

Ethical approval

The study was approved by the Ethics Committee of Kenpoku Medical Center Takahagi Kyodo Hospital (no. R2-2) and conducted according to the principles of the Declaration of Helsinki. The requirement for informed consent was waived owing to the retrospective nature of the study.

Results

A total of 54 patients were included (males, 16; females, 38; mean age, 80.2 ± 9.2 years). The mean length of stay in the hospital was 40.6 ± 25.9 days (range, 15–152 days). The affected vertebrae are shown in Figure 1. Fifty patients had a single vertebral fracture, and four patients had multiple vertebral fractures.

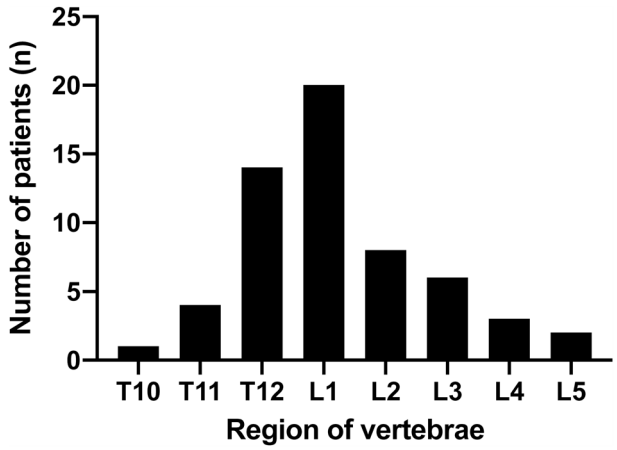

Figure 1 The affected vertebrae level.

Walking ability

Of the 51 patients who were able to walk independently (including those using assistive devices) before the injury, only one patient (2.0%) had to use a wheelchair after the injury. Of the 45 patients who were able to walk independently without an assistive device before the injury, 24 (53.3%) required some kind of assistive device at the time of discharge (Figure 2).

Cognitive function

Of the 15 patients whose cognitive function could be evaluated at all three-time points, 5 (33.3%) had cognitive dysfunction (HDS-R <20). During hospitalization, a decline in cognitive function was observed in five patients (33.3%). Although at the admission, patients with cognitive dysfunction tend to have a further decrease in cognitive function during hospitalization (20% of HDS-R >0 at admission, 60% of HDS-R <20 at admission), no significant difference was observed (P=0.12). Meanwhile, during hospitalization, no decrease in cognitive function was observed in patients with HDS-R ≥25 at admission (Figure 3).

Swallowing function

The DSS was 0 (normal) in all patients at admission, and none of the patients reported decreased DSS during hospitalization. The RSST was normal in all cases at admission; however, it decreased in one patient at the end of bed rest and showed no improvement until discharge. None of the patients developed aspiration pneumonia during hospitalization.

Muscle strength

The rates of change in the grip strength were 6.7 ± 1.7% and 9.7 ± 2.2%, at the end of bed rest and discharge, respectively. Significant improvement was observed at both the time points (P=0.04 at the end of bed rest, P=0.02 at discharge).

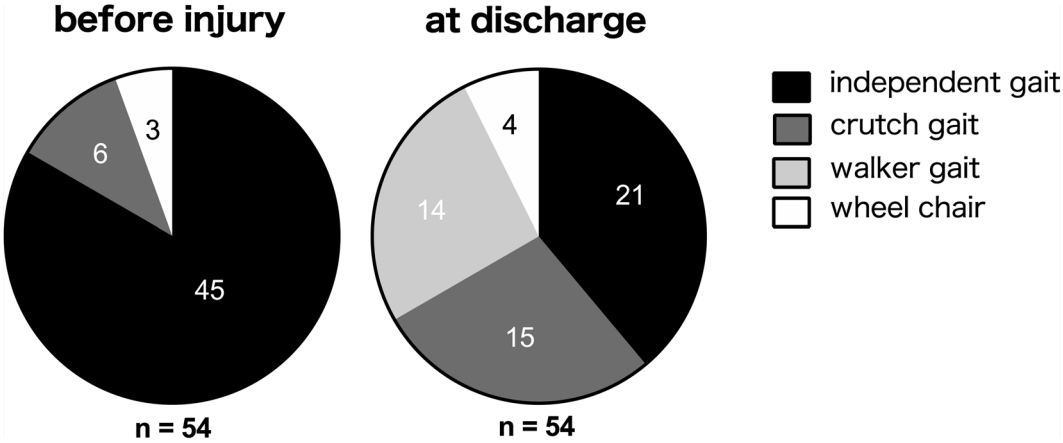

Figure 2 Walking ability before injury and at discharge.

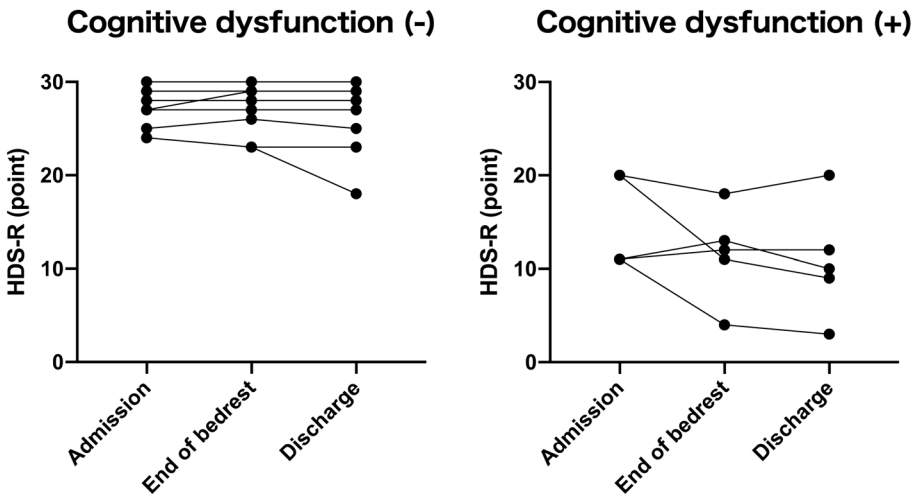

Figure 3 The course of HDS-R divided by cognitive function on admission.

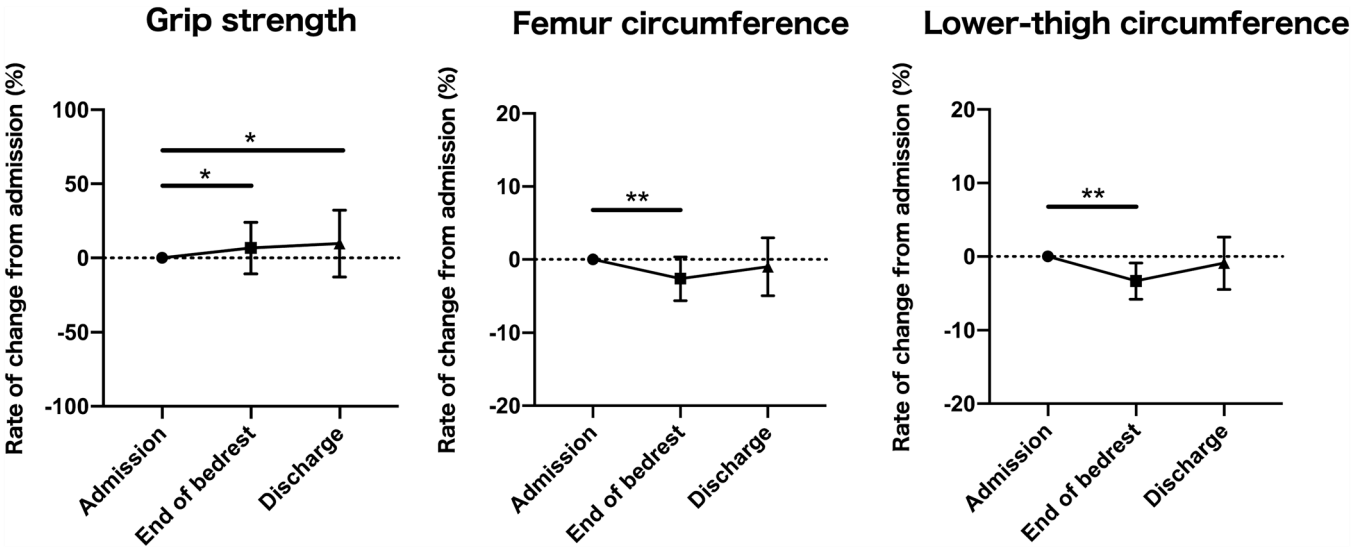

Figure 4 The rate of change from admission of grip strength and femur/lower-thigh circumference. *P<0.05, **P<0.01.

The rates of change in the femur/lower-leg circumference were −2.6 ± 2.9%/−3.3 ± 2.4% and −0.9 ± 3.9%/−0.9 ± 3.5% at the end of bed rest and at discharge, respectively. Although both the circumferences had a significant decrease at the end of bed rest (P<0.01), both recovered by the time of discharge (P=0.17) (Figure 4).

Discussion

In this study, we examined if 2-week of rigorous bed rest contributes to disuse atrophy using a cognitive function scale, a swallowing function scale, and several indexes that are correlated with muscle strength (grip strength, femoral circumference, and lower-thigh circumference).

Cognitive function

Cognitive decline was observed in one-third of the cases in which HDS-R could be investigated at the three-time points. Determining whether bed rest reduced cognitive function was difficult because of the changes in the living environment and the onset of delirium by admission to the hospital. Meanwhile, no cognitive decline was observed in patients with HDS-R score ≥25, suggesting that the degree of cognitive function at admission might be affected by the progression of cognitive decline during hospitalization. To prevent cognitive decline during hospitalization, early termination of bed rest and using Jewett corset for patients with cognitive function decline during bed rest, based on the results of HDS-R at admission, should be considered.

Swallowing function

At admission, DSS scores of all the patients were grade 0 (normal) and remained at the same level during discharge. No complication related to swallowing dysfunction was observed during bed rest. Our result suggests that bed rest has little effect on swallowing function since eating and drinking during bed rest were not restricted. However, eating and drinking in the supine position (with the headrest inclined by 20–30°) or the lateral position were required for all patients, and the aspiration risk in these positions is considered to be higher than that in the sitting position. To prevent aspiration during bed rest, providing adapted meals for patients by accurately evaluating their swallowing function during admission is necessary.

Muscle strength

In this study, the patients' grip strength increased from admission to discharge. At the time of admission, pain due to fracture might negatively affect the maximum grip strength. Moreover, the difference in measurement position (supine at the time of admission and sitting at the end of bed rest and discharge) might also affect the maximum grip strength.

In the present study, although a significant decrease in the circumference of both the femur and the lower-leg was observed at the end of bed rest, both recovered at the time of discharge, and no significant difference was observed compared with the values recorded during admission. However, poor reproducibility and accuracy of limb circumference measurement should be considered because it measures not only the muscle but also the surrounding soft tissues[26]. Nevertheless, our results suggest that the muscle atrophy that results from a 2-week bed rest is reversible.

Bed rest can lead to rapid muscle deconditioning and atrophy[27]. Studies in young healthy adults have shown that, after 2-week of immobilization, there was a 5–9% loss of quadriceps muscle mass and 20–27% decrease in quadriceps muscle strength[28, 29]. These effects are often accelerated and more pronounced in older adults, with a 3- to 6-fold greater rate of muscle loss when compared to those seen in young adults[30, 31]. To prevent irreversible muscle atrophy during the period of bed rest, aggressive and persistent rehabilitation while avoiding painful stress on the fracture site is necessary. Moreover, patients should be cautioned against carrying out this protocol at home because it poses the risk of developing disuse syndrome and requires careful monitoring of cognitive dysfunction.

Limitations

The limitations of this study are the small number of cases, the lack of verification of cases unable to complete the 2-week bed rest, and the simple evaluation of disuse syndrome. For a more accurate evaluation of the risk of disuse syndrome using this protocol, further studies should be done to evaluate swallowing function using esophagography and change in muscle mass using a dual-energy X-ray absorptiometric scan.

Conclusion

Our results suggest that conservative treatment of 2-week rigorous bed rest with persistent hospital rehabilitation for OVF patients poses a low risk of disuse atrophy, and initial bed rest for OVF patients with instability of fracture site can be performed safely. If cognitive dysfunction is observed on admission, the patient should be closely monitored for exacerbation during the hospital stay.

Conflict of interest: The authors declare no conflicts of interest associated with this manuscript.

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