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Serial Casting as a Method of Restoring Normal Ranges of Lower Limb Movement in Patient after Damage to the Central Nervous System: A Case Report

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Abstract

Objective: The process of casting contracted lower limbs and its effects in a patient after damage to the central nervous system is described.

Case report: A 57-year-old patient, half a year after sudden cardiac arrest, suffered as a result of myocardial infarction. The consequence of this incident was damage in the central nervous system, which was the cause of spasticity and, as a consequence, contracture in the joints of the lower limbs. Before physiotherapy, a functional test was carried out, which included: measurement of the passive ranges of lower limb movement, assessment of spasticity with the Ashworth scale and determination of independence with the FIM scale. Every day for two months, the patient used three individual therapies and verticalization. Every three days he had the cast on his lower limbs changed.

Results: As a result of the therapy, a significant improvement in the range of motion was achieved, a decrease in spasticity measured by the Ashworth scale was observed, as well as an improvement during everyday activities on the FIM scale.

Conclusion: Casting is an effective method supporting the treatment of contractures of the lower limbs caused by increased muscle tension of neurological origin.

Keywords: Serial casting; Contractures; Spasticity; CNS damage

Introduction

Disability and loss of independence of a patient after damage to the central nervous system is a significant problem for health care and physiotherapy. It is assumed that regaining functional fitness and returning to professional life depends primarily on properly conducted rehabilitation. Current strategies for neurological rehabilitation rightly focus on maximizing therapy during the first six months of improvement. Due to this, the plasticity process within the central nervous system is significantly intensified. In a situation where rehabilitation is not carried out properly or is disturbed by independent external factors, there may be permanent disorders in the musculoskeletal system. This is observed as permanent restrictions on the range of motion caused by increasing spasticity in the limbs, so-called spastic contractures. The resulting range of movement restrictions make it difficult for the patient to rebuild normal functions. Contractures in the lower limbs additionally prevent proper phased verticalization, where an upright position is a key factor in regaining mobility. Contractures are a very common complication of paresis and spasticity as a result of damage to the upper motor neurons. Contracture formation is a complex process and involves many structures: ligaments, muscles and tendons. Reducing movement restrictions by traditional methods is often ineffective, which is why it is worth supporting them with casting [1-3]. Persistent shortening of soft tissue structures caused by spasticity can lead to:

- Reduction in the number of sarcomeres,
- Shortening of sarcomeres,
- Reduction in muscle fibre length due to the reduction in the number and/or length of sarcomeres,
- Tendon shortening [4-6].

In order to maintain an optimal level of patient function and independence, exercises in full range of joint mobility and restoration of normal muscle tone are necessary. Orthoses and scales are helpful in carrying out these tasks. However, frequent complications of their use in patients with high spasticity are, among others: abrasions, wounds, bruises and ischemia. Such side effects significantly reduce the patient's comfort of life and hinder the implementation of the physiotherapy process, so they are not willingly used by patients and physiotherapists. With large contractures, and a desire to restore normal range of motion in the joints, the application and use of orthoses is impossible. The only option to regain full mobility is cyclical casting [7]. Casting should only be undertaken as part of comprehensive treatment and should be used in such a way as not to interfere with the rehabilitation process. The aim of the study was to assess the impact of cyclical casting of the lower limbs, as a complement to traditional rehabilitation, to improve the range of motion and the functional state of the patient after damage to the central nervous system.

Case Presentation and Therapy

The paper describes the process of phased casting of contracted

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lower limbs of a 57-year-old patient. As a result of myocardial infarction in August 2017 he suffered from sudden cardiac arrest and temporary brain hypoxia. After restoration of vital functions, he was in the Intensive Cardiac Surveillance Department, where non-invasive ventilation was used, but due to an increase in respiratory failure he required the implementation of invasive ventilation. After six days, as a result of respiratory infection, the patient was transferred to the Department of Anaesthesiology and Intensive Care. In the following days, the patient was extubated and a PEG probe was installed. After two weeks, the patient's condition improved and he was transferred to the Department of Internal Medicine. Over time, the first signs of spastic muscle tension began to appear in the lower limbs. Therefore, computed tomography with contrast was performed on the patient's head. The study did not show any signs of intracranial bleeding or areas of pathological strengthening after contrast administration. However, cortical atrophy was observed, most severe in the frontal and parietal lobes of the brain. After another month of treatment, the patient was discharged to the Care and Treatment Institution. Spasticity in the lower limbs was already clearly visible and began to hinder the care and exercise of the patient. After four months in the facility, a decision was made to consult to refer the patient to intensive, specialist rehabilitation. During the study, strong spasticity and significant contracture were observed in the hip, knee and ankle joints. The medical history and documentation showed that the patient had not been upright for several weeks. The decision was made to transfer the patient as soon as possible to the patient unit in the Rehamed-Center in Tajecina. Upon admission to the ward, a physiotherapeutic examination was performed, during which the patient was found to have:

- Four-limb spastic paralysis,
- Contractures of the lower limbs (Figures 1 and 2),
- No manual functions of the hands,
- Pressure ulcer in the lumbosacral region,
- State of amputated left toe of the left foot,
- Lack of adaptation of the circulatory and respiratory system to a sitting position,
- Lack of independence when turning in bed, transfers and everyday activities.

In addition, the patient had type II diabetes. Due to the fact that the lack of uprightness and lower limb exercises would worsen the patient's health situation, it was decided to take steps to restore the patient's normal range of motion. Therefore, an individual rehabilitation program was undertaken. Every day, from Monday to Friday, the patient used three individual therapies (PNF, Bobath, functional therapy) and one verticalization (sitting attempts at the beginning). Despite the implemented improvement process, the effects of reducing spasticity and increasing the range of motion in the lower limbs were unsatisfactory. The orthopaedic equipment used in the form of orthoses did not maintain the ranges of movement achieved after the exercises. In addition, redness and slight abrasions were observed at the sites of greatest pressure on the limbs. Many attempts were made to match different types of orthopaedic equipment for the patient, but none of them brought the expected results. It was decided to give up on orthopaedic equipment and a program of cyclical casting was implemented. The whole therapy remained unchanged. Casting was always done after stretching exercises, in the position of maximum, painless extension of the knee joints. They were performed every three days, which allowed frequent monitoring of the condition of the skin and each time increasing the range of motion. Initially, the cast covered the lower limb including the foot, in order to protect the Achilles tendons against too much pressure. In order to assess the effects of the implemented rehabilitation program, including individual therapy, verticalization and casting of the lower limbs, objective tests were conducted before it began. The passive ranges of lower limb movement were measured, spasticity was assessed by the Ashworth scale, and independence during daily activities by the FIM scale. The tests were carried out five times: before casting, after two, five and eight weeks of casting and one month after its completion to verify the durability of therapy.

Figure 1: Lower right limb before casting.

Figure 2: Lower left limb before casting.

The procedure for putting on the cast began with putting on a seamless knitted sleeve. It was always slightly longer than the casted part of the body. This sleeve fitted to the limb to protect the skin against maceration and abrasion of protruding bony parts. Then a cast undercoat made of synthetic cotton was applied to the sleeve. This ensured moisture transport, prevented abrasions and prevented the material from slipping by making a good fit. The cast foundation was applied uniformly thick along the entire length of the limb so that no bends were formed. The next layer was stretchy corrugated paper, which separated the lining material from the applied cast dressing. Then, after immersing the cast band in water, it was applied in a circular motion, applying another layer at 1/3 of the height of the previous layer. The ends of the sleeve were rolled up to protect the skin against damage from the edges of the cast. Finally, to finish, a cast band was applied to the curled sleeve ends (Figures 3 and 4).

Figure 3: Right lower limb in a cast.

Figure 4: Left lower limb in a cast.

After a month of casting and reaching a reduction in the right knee extension deficit to 15°, it was decided to replace the cast with a stabilizer (Figure 5). This was done to relieve the patient of the weight of the cast and to reduce costs. After a week of using the stabilizer, the patient complained of increasing pain in the knee joint, and abrasions appeared on the skin. Therefore, it was decided to cast the limb again (Figure 6). In further procedures, the applied cast no longer covered the feet, because the obtained range of motion and reduction of spasticity eliminated the threat of too much pressure on the Achilles tendons. Thanks to this, the patient was able to fully load the feet and lower limbs during verticalization (Figure 7). After another month of casting, the full range of mobility of the right knee joint was obtained, and the extension deficit in the left was reduced to 10° (Figures 8 and 9). The final effect of the improvement program was for the patient to start learning how to walk with a frame and a verticalization table with the Erigo walking function and to improve the functional state (Figures 10 and 11).

Results

Goniometric measurements of lower limb movement ranges performed before therapy showed significant contractures. After the process of improving and casting, i.e., after two months, the ranges of passive movements tested had improved significantly and remained for another month after the end of casting (Table 1). The Ashworth scale was used to assess spasticity. Initially, muscle tension in the right lower limb was rated at 3 points, and in the left at 4, while after casting, a reduction in spasticity was achieved to level 1 in the right lower limb, and in the left to 2 points according to the Ashworth scale. This result was maintained for another month (Table 2). Everyday activities were assessed using the FIM scale (parts regarding self-sufficiency, mobility and wheelchair mobility). At the beginning of the rehabilitation

Figure 5: Right lower limb in the stabilizer.

Figure 6: Right lower limb re-casted.

Figure 7: Patient verticalization in lower limb casts.

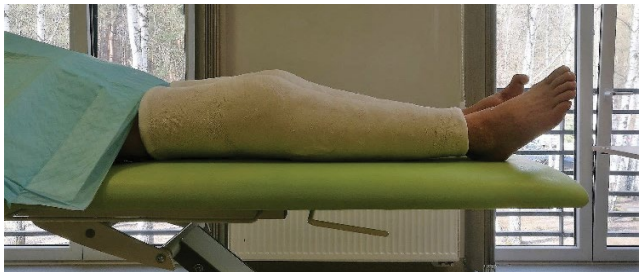

Figure 8: Right lower limb after two months of casting.

Figure 9: Left lower limb after two months of casting.

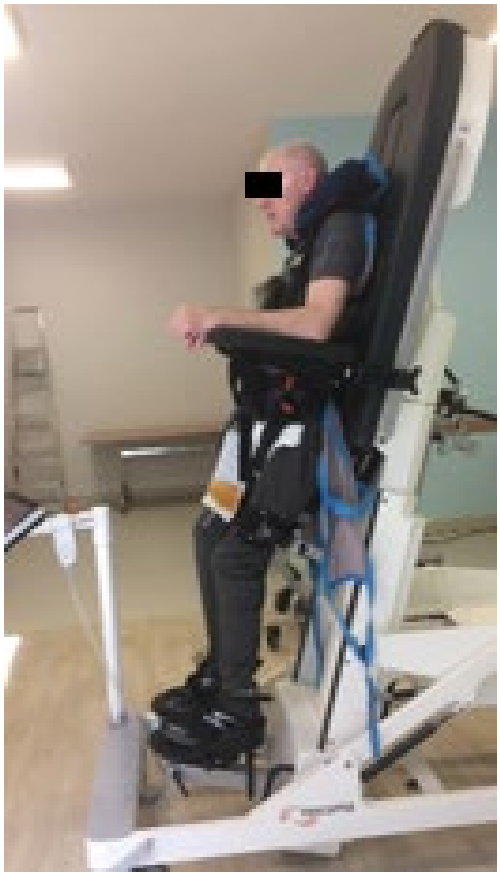

Figure 10: Verticalization in the Erigo vertical table.

Figure 11: Verticalization in the Erigo vertical table.

Measurement	Before casting	After two weeks	After five weeks	After eight weeks	One month after finish of casting
Right knee extension deficit	90°	50°	15°	0°	**0°**
Left knee extension deficit	100°	80°	45°	10°	**10°**

Table 1: Change in extension deficits in the right and left lower limb knees.

Parameter	Before casting	After two weeks	After five weeks	After eight weeks	One month after finish of casting
Ashworth scale lower right limb	3	2	2	1	**1**
Ashworth scale lower left limb	4	4	3	2	**2**

Table 2: Change in the severity of spasticity of lower limbs according to the Ashworth scale.

process, the patient did not receive any point out of 70 possible. After the rehabilitation, the patient was able to help during most everyday activities and obtained 19 points on the FIM scale. After another month, the result improved to 32 points (Figure 12).

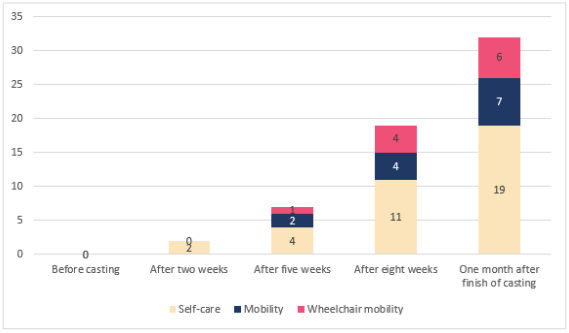

Figure 12: Change of results obtained on the FIM scale.

Discussion

Although the use of casting in adult patients after damage to the central nervous system was already known in the 1960s, there are only a dozen or so scientific reports on this method of treating contractures. These publications concerned the use of casting to eliminate contracture of elbow, wrist, knee and ankle joints. In most of the articles available, motion range measurement, spasticity assessment using the Ashworth scale and function evaluation scales were used to assess casting performance [8]. In the United Kingdom, between 11% and 84% of patients after craniocerebral trauma suffer from contractures, while in people with hemiplegia after severe stroke, the reported incidence of contractures ranges from 43% to 100%. Studies in Australia show that half of all adults hospitalized for stroke develop at least one contracture [9]. Pohl et al. conducting a study on a group of 41 patients with spasticity to assess the effects of casting defined ROM as a percentage of the maximum normal passive range of motion. They found that casting improved the range of motion of the knee joints by an average of 24% of the full range of motion. They also proved that this effect persists one month after the end of casting [10]. Lehmkuhl et al. analysing the material of 7 patients after craniocerebral trauma or stroke, with which casting was used as a technique to combat contractures, found an improvement in the range of knee joint mobility by an average of 18.2° [11]. Booth et al. conducted a study on a group of 42 patients after craniocerebral trauma. As a result of using casting of the lower limbs for a period of 7 to 92 days, patients obtained improvement in knee joint range by an average of 17-26° [12].

Our research has shown that after implementing an eight-week program involving the casting of lower limbs, the correct range of motion was restored in the right knee joint. The deficit was reduced by as much as 90°. In the case of the left knee joint, the full extension range was not achieved, the deficit remained at 10°. The ranges of motion obtained also remained one month after cessation of casting. Farina et al. used rigid orthoses after botulinum toxin injection in a group of 6 patients after stroke. From day 10 after injection, for 4 months, patients put on rigid orthoses overnight and achieved an average 1 degree reduction in spasticity on a modified Ashworth scale. In the control group (7 patients) after using only botulinum toxin, spasticity increased by an average of 0.5 degrees. Therefore, they proved that prolonged stretching of spastic muscles after botulinum toxin injection gives better results compared to the injection alone [13]. In the case report of our patient, after two months of casting, the intensity of spasticity in the right and left lower limbs was reduced by 2 points according to the Ashworth scale, which was of great importance for improving the quality of therapy. Pohl et al. analysing the material of 41 patients noted an improvement in patient independence at all levels of the FIM scale [10].

Conclusion

The functional independence of our patient, measured by the FIM scale, increased after two months of casting by 19 points. In addition, one month after the end of casting and freeing the limbs, the result improved by another 13 points. The results of research by Pohl et al. show that the time intervals between cast changes should be less than 5 days. Due to more frequent cast changes, they achieved better results than changes every 7-10 days because the incidence of complications and the need to stop treatment decreased. We changed our patient's cast every 3 days, each time increasing the range of extension movement in the knee joint. Apart from slight redness, we did not notice any major skin problems throughout the entire casting period. Casting is an effective method supporting the treatment of contractures of the lower limbs caused by increased muscle tension of neurological origin. Properly used, it can quickly improve the patient's functions and quality of therapy without complications.

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