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The role of proprioceptive system in the rehabilitation of patients after Achilles tendon reconstruction

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Abstract

Achilles tendon injury is a major clinical problem because it prevents proper functioning of the patient. The recommended procedure in the event of tendon rupture is surgical treatment - reconstruction of tendon reconstruction. The aim of surgical treatment of Achilles tendon rupture is to bring back its function by restoring the correct length and tension of the tendon and to obtain the highest possible functional state of the patient. The selection of the optimal post-operative rehabilitation programme with a predominance of functional physiotherapy elements is an essential part of the treatment of Achilles tendon rupture. A proper rehabilitation after the surgery enables the patient to achieve better functional results. During the surgery proprioceptors are damaged, that is why the treatment working on three levels of motor control should be introduced as fast as possible, such as kinesthetic or proprioceptive training.

Key words: Achilles tendon injury, proprioceptive training.

Introduction

Achilles tendon injury is a major clinical problem because it prevents proper functioning of the patient and brings down the quality of life. The increasing number of people occasionally performing extreme physical activity results in a variety of dysfunctions within the musculoskeletal system and in injuries, including the Achilles tendon rupture.

The most important causes of heel tendon rupture include not only direct trauma that can be close (eg. sudden impact to the strained tendon) or open (eg. the cut with glass) but also indirect trauma, which is more common and occurs during a sudden and strong muscle contraction. Most indirect injuries occur in the place of pre-existing degenerative, inflammatory and vascular lesions, associated with overload or proprioceptive disorders. Moreover, diseases such as diabetes, lupus, gout, hyperthyroidism, pituitary adenomas, rheumatoid arthritis, collagenosis also predispose patients to Achilles tendon damages. The procedure recommended in case of heel cord rupture is the surgery of reconstruction of

tendon continuity. The aim of surgical treatment of Achilles tendon rupture is to bring back its function by restoring the correct length and tension of the tendon and to obtain the highest possible functional state of the patient. Successful surgical procedure depends on the appropriate choice of tendon conjunction in relation to the type of damage [1-3].

The choice of the optimal post-operative rehabilitation programme with predominance of functional physiotherapy elements is an essential part of the treatment of Achilles tendon rupture. Properly chosen rehabilitation helps to achieve better functional results after the surgery. Surgical treatment and proper rehabilitation provide recovery of ankle mobility in patients after heel cord reconstruction. During the surgery proprioceptors are damaged. That is why it is important to introduce a procedure working on three levels of motor control as soon as possible. Kinesthetic or proprioceptive trainings are good examples [4-6].

Rehabilitation program should be based on the principles of working on different levels of motor control in order to obtain the highest degree of functionality of the tendon that has been operated. The task of proprioceptive programme aims at re-education of changed pathways of somatosensory control. Proprioceptive training shortens the period of recovery and enables the patient to regain full control over the joint. That is why the elements of this particular training should be chosen for each patient after any surgery within the musculoskeletal system. The re-education of dynamic proprioception can be performed with the use of modern equipment for training and diagnostics, for example MTD balance control platform. Sensorimotor training should be graded in terms of difficulty, gradual reducing the surface for standing, reducing the stability of the area, increasing the point of body weight, limiting of visual control, performing multiple tasks at the same time [2,7-11].

The characteristics of somatosensory control pathways

Proprioception means the ability to recognize both the movement in the joint and the joint position. The choice of surgical technique, the nature and severity of the injury and the type of rehabilitation programme affects proprioception. Until recently, the ligaments and the joint capsule were regarded as the main stabilizer of the joint. Current research shows that the functional stability of the joints corresponds to the mechanisms of feedback which has its origin in the proprioceptors. With proprioception it is possible to program neuromuscular motor control what is necessary to perform precise movements and to induce muscle reflex that is responsible for the dynamic stability of the joint [12-15].

Each receptor is stimulated by a particular type of energy. In musculoskeletal system there are sensitivity receptors which are stimulated by muscle work, either static or dynamic. The receptors' main task is to receive and to encode the information coming from both the

external and internal sources. Receptors transmit nerve impulses with the use of afferent pathways to the central nervous system, then the information travels through efferent pathways to the executive organ (effector), which is the muscle. These elements above form so-called reflex arc. The receptors located in the musculoskeletal system are the first element of the reflex arc. They are responsible for sensing not only tension and stretching of the muscles and tendons, but also the pressure put on the joint surfaces. The proprioceptors include: bulbous corpuscles (Ruffini endings), lamellar corpuscles (Pacinian corpuscles), Golgi organ and free nerve endings of unmyelinated fibers. These are the receptors responsible for receiving information about changes in the muscle tone and muscle length, position of the limbs in relation to the torso, the movement of the body in space. Kinesthetic receptors are those that are found in the joints and tendons [12,14,16].

According to Sherrington [12,17] who takes into account the location and origin of the stimulus for the receptors in tendons and ligaments, the reflex arc includes Golgi organ corpuscles, sensitivity cells and free nerve endings. Mechanoreceptors quickly adapt to the activation of the stimulus and they are sensitive to changes in the joint position, especially at high values of flexion and extension. Mechanoreceptors are considered to be specific mediators of motion in the joint, and Pacinian corpuscles are the examples. Golgi organ is irritated by the rapid increase in muscle tone, for example in the case of strong muscle contraction or during a strong stretch. Ruffini ending organs adapt slowly, their role probably concerns the recognition of joint position. The information about external signals is transmitted to the CNS from the receptors present in the joints, muscles, skin, organs of vision, and the labyrinth [18,19].

Body movement, both rotational and in a straight line, is received by the receptors located in the labyrinth which is an organ responsible for the body balance. Impulsation from the proprioceptors is not felt under physiological conditions, because it raises the awareness only in a small degree. Its presence can be established only indirectly.

Impulsation from the proprioreceptors is perceived by the sensory neuron located in the spinal ganglia. In the spinal cord these neurons' projections form synapses with neurons of the second row in the back pathways. In this way, they start the core-cerebellar pathway or they enter gracile fasciculus and cuneate fasciculus, where the first row neuron sends the projection to the opposite side of the medulla oblongata and runs in the Reil's band to the posterolateral nucleus. In the nuclei of thalamus, a third row neuron sends the projection to the sensory area of somatosensory cortex. Thus deep sensation conducted to the cerebral

cortex via lateral-funiculus pathway is partially recognized. The proprioceptive information flowing into the cerebellum is beyond the consciousness [12].

Sculco and Inglis [20] in the basis of their own observations, concluded a theory of disturbances in the braking process in proprioceptors in a musculotendinous unit. In a healthy tendon, the impulsation coming from the proprioceptors is responsible for braking mechanism that protects the musculotendinuous unit against excessive stretching and too strong and violent triceps surae contraction, what could lead to some damage. Freeman was the first to note that mechanoreceptors damage caused by an ankle injury predisposes the joint to chronic instability. He also observed a reduction in the ability to maintain the correct position of the whole body while hitting the ball after the ankle sprained.

According to the literature, trauma within the ankle causes a significant deterioration of kinesthesia and proprioception. Reduced ability to reproduce the passive joint position by the patient may occur, as an example. Tendon injury can cause disturbances in proprioception what contributes to the functional instability that can be followed by the microinjuries and a tendon re-rupture [4,18,19,21,22].

The role of proprioception of the lower limbs in the locomotion control and the influence of the rupture of Achilles tendon on proprioception and kinetic changes in the ankle joint are still unknown. The injury of tendon structures causes a decrease in the conductivity of proprioceptive information from the damaged joint [11,13,18,19].

Neuromuscular control takes place via proprioception and it includes three levels of motor activation:

1. Spinal reflexes mediate movement patterns derived from higher levels of the nervous system. Exercises of dynamic joint stabilization improve the function of this level.
2. The information upcoming from joint mechanoreceptors, vestibular system and eyes is transmitted to the brain stem. Exercises of posture and balance are recommended to improve the function at this level.
3. The highest level is the central nervous system (motor cortex, basal ganglia and cerebellum). Any body movement and position of the joints at this level is felt consciously [14, 22, 23]

Functional Improvement plan after the Achilles tendon reconstruction

During the surgery the receptors of deep sensation are damaged, thus it advised to establish a procedure covering three levels of motor control as soon as possible. The procedure may include eg. kinesthetic or proprioceptive training. The rehabilitation programme should be based on the principles of impact on different levels of motor control,

so as to obtain the highest degree of functionality of the operated tendon. The task of proprioceptive rehabilitation is the re-education of altered somatosensory control paths.

The objectives of proprioceptive re-education:

- restoring the sense of body position and movement in the joint and muscle tension,
- transition from bilateral to unilateral actions,
- changing of actions performed with eyes open to those performed with eyes closed,
- proceeding from actions done on a stable surface to those done on an unstable surface,
- provoking reactions from different receptors of deep sensation in order to improve the balance through exercises in different positions of the joint.

The programme of dynamic proprioceptive re-education is based on principles aimed at restoring the ability to perform specific movements for each discipline. It consists of:

- exercises with limited effort and then exercises requiring the use of greater force (the load is increased),
- exercises at a slow pace, after which there is acceleration,
- exercises that require the participation of will and concentration, then exercises performed freely (relaxation),
- proceeding from walking to running (acquiring one-legged stance phase),
- running and sprint (speed),
- jumping and direction changing (multi-direction load).

Dynamic proprioceptive re-education is advised for athletes who want to return to sport or for young patients dealing with an extensive physical activity. Dynamic re-education reproduces the efficiency and control of the joint, thereby it prevents from damage. In Sweden, in 1993, Peterson introduced some elements of proprioceptive exercises for athletes in first league clubs. After a year, they noticed the reduction in number of injuries by 42% compared to athletes who had not followed the programme [12,13,19].

Proprioceptive training shortens the period of recovery and it enables the patient to regain full control over the joint, so this type of rehabilitation should be applied to each patient after surgery within the musculoskeletal system. The re-education of dynamic proprioception can be performed with the use of modern equipment for training and diagnostics, such as MTD Control Balance Platform [22].

Sensorimotor training should be graded in terms of difficulty, ie. decreasing the surface for standing, decreasing the stability of the surface, lifting of body weight point, reduction of visual control, performing multiple tasks at the same time. At the beginning of

proprioceptive rehabilitation the balance training should be introduced first. It should be made more difficult in the course of time and the patient's progress. Exercises in a closed bio-kinematic chain are the element of proprioceptive rehabilitation, they improve the nutrition of the articular surfaces and structures of capsules and ligaments [24,25,26].

Calcaneal tendon is highly elastic and if it stretches to more than 8% of the original length, plastic deformation may appear. Therefore, stretching exercises should be introduced not earlier than 2 months after the surgery, initially in a sitting position, and later in the standing position. Along with the increase in the degree of the load put on the tendon, there should be concentric-eccentric exercises implemented. They affect connective tissue: improve the elasticity and strength of the tendon, prepare tendons for load transfer, cause muscle mass increase. During concentric workout, muscle insertions come closer, while during eccentric workout – they come further. Calf triceps is in a concentric contraction, eg. in case of running up or climbing uphill, when the foot is set at maximum dorsiflexion in order to proceed to the plantar flexion (muscle and tendon are close). The eccentric work is noticed during activities such as braking eg. jumping down or running down the stairs (a muscle and tendon are outlying). The eccentric training involving the recruitment of additional motor units will gain strength increase by 30% more than the concentric exercise [1,5,10]

It is important to learn the correct gait pattern and how to rebound a foot from the ground. When the crutches are put away and the limb starts to bear the full load, the training of static and dynamic proprioceptive reeducation should be introduced in order to improve the balance in static and dynamic conditions [12,14,18]. The primary objective of the final phase of rehabilitation should be the recovery of the conscious joint sensation, so that the involuntary muscle stabilization can be initiated. It protects the patient against re-injury. The muscles of the lower limb must be reconstructed in all three planes of motion: sagittal, frontal and transverse [27,28,29].

Conclusions

1. Achilles tendon injury is a serious therapeutic problem.
2. The recommended procedure in the event of tendon rupture is surgical treatment - reconstruction of tendon reconstruction.
3. The choice of the optimal post-operative rehabilitation programme with predominance of functional physiotherapy elements is an essential part of the treatment of Achilles tendon rupture.

4. Rehabilitation program should be based on the principles of working on different levels of motor control in order to obtain the highest degree of functionality of the tendon that has been operated.

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