KNEE PROPRIOCEPTION – THEORETICAL FRAMEWORK

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Abstract: *Proprioception could be defined as the perception of limb position in the space. In last few decades, extensive research has been conducted, dedicated to the sensory role of anterior cruciate ligament and to the analysis of how its damage influences knee joint function. Even though knee proprioception is a widely studied topic, we still do not understand exactly the role of intact and injured anterior cruciate ligament in proprioception and what factors affect proprioceptive rehabilitation after anterior cruciate ligament reconstruction. The aim of this paper is to synthesize the theoretical framework of knee proprioception and the sensory role of anterior cruciate ligament. This study can be viewed as providing a theoretical foundation for a very complex research question.*

Anterior cruciate ligament reconstructions are frequently performed on young, active patients. Surgical reconstruction of ruptured ligament aims at restoring not only the static but also the dynamic joint stability, which is considered necessary for restoration of knee functionality.

Post-operative rehabilitation is a long-lasting process, a full recovery can take months. After full rehabilitation and recovery, patients should not have functional limitations, but some patients with a clinically adequate repair and good ligament tension continue to complain about a feeling of instability. Deficits of dynamic stability are hypothesized to be determined by incomplete recovery of proprioception. Fremerey et al. (1) have demonstrated the highest correlation that exists between proprioception and patient satisfaction after anterior cruciate ligament reconstruction.

Proprioceptive terminology

The term proprioception is used to describe a sense or perception of the movements and position of the body, especially its limbs, gained from sensory nerve terminals in muscles, tendons and joint capsule.(2) It combines different sensory inputs from a variety of receptors called mechanoreceptors. Proprioception has three components: a static recognition of joint position, detection of movement and acceleration, and a closed loop efferent activity, which starts reflex response and regulates muscles.(3) Static proprioception or somesthesia includes the conscious recognition of the orientation of the different body parts. Dynamic proprioception or kinesthesia reflects the sense of limb movements and speed changes.(4) Some medical conditions such as ligament injuries, osteoarthritis, rheumatoid arthritis, diabetic neuropathy may result in proprioceptive impairments.(5,6) Sometimes, it can be impaired spontaneously, especially when one is tired.

Effects of anterior cruciate ligament injury on knee proprioception

Proprioceptive deficit following anterior cruciate ligament rupture or reconstruction are well documented.(7,8) In last few decades, extensive research has been conducted, dedicated to the sensory role of anterior cruciate ligament and to the analysis of how its damage influences knee joint function. It is known that ligament injury causes not only mechanical instability, but also compromise the neuromuscular control and proprioception due to loss or damage of proprioceptive receptors in the ligament. Gómez-Barrena et al. (9) suggest that the loss of anterior cruciate ligament mechanoreceptors may determinate central nervous system modifications that are not compensated for by other nervous structures. This hypothesis can explain why bilateral deficit in knee joint proprioception could be present after unilateral anterior cruciate ligament injury, but it means also, that complete proprioceptive rehabilitation can't be accomplished.(10)

A large number of histological studies have examined the structure of sensory nerve endings in the anterior cruciate ligament and many proprioceptors, such as Ruffini and Paccini endings or Golgi tendon organs have been found.(11,12) Those studies showed that a significant number of receptors exist in the fibers of anterior cruciate ligament, but the maximum concentration of the nerve endings in the knee is mainly in close proximity to the bone, at the attachment sites of anterior cruciate ligament, especially at tibial insertion. In the last few years, many authors have tried to identify whether any proprioceptive potential exists in the anterior cruciate ligament remnant. They concluded that the presence of tibial remnant containing mechanoreceptors and free neural ends is able to enhance graft reinnervation, revascularization and ligamentization, favouring proprioceptive training and rehabilitation. The remnant tissues enhance mechanical stability and proprioceptive function suggests that preservation of these tissues may decrease the probability of anterior cruciate ligament reinjury.(13,14) However, opinions are divided regarding the importance of remnant preservation. Hong et al. (15) showed that remnant-preservation technique is not superior to ligamentoplasty without remnant preservation. More than that, remnant preservation may predispose to the risk of impingement against the reconstructed graft and residual stump.

Recent advancements in tissue engineering and regenerative medicine have determined increased interest in

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reviewing anterior cruciate ligament repair. The use of new tissue engineering techniques, such as growth factors, stem cells or bio-scaffolds, has been the focus of current research in anterior cruciate ligament injury management.(16) These techniques have the potential to preserve the native insertion and proprioceptive function, which may ensure better and faster rehabilitation of knee stability and joint mechanics.

Proprioception rehabilitation

Proprioception and neuromuscular control must be regained after ligamentoplasty of the anterior cruciate ligament, especially if the main objective of rehabilitation is to return to high level sports and decreasing the risk of long term complications, such as graft failure or chronic knee laxity. Little is known whether proprioceptive training can restore proprioceptive deficit or whether compensatory pathways can be established.

Successful restoration of proprioception depends on surgery timing, timing of initiation of rehabilitation and the type of recommended exercises. Denti et al. (17) demonstrated that the time between injury and surgery can affect the chances of proprioceptive recovery. They showed that normal mechanoreceptors persisted in residual stump for about three months. After that period, the number of normal receptors gradually decreases and one year later, they were totally absent, so we can deduce that after more than three months post-injury, the chances of complete proprioceptive rehabilitation diminish gradually.

Training of the proprioceptive ability should begin in the first phase of rehabilitation process with exercises performed in open kinetic chain. The initiation of closed kinetic chain activities in second phase of rehabilitation improves periarticular muscles strength and knee stability and may have facilitated the recovery of neuromuscular control and proprioception. Zhou et al. (18) have shown that there is a positive correlation between proprioception and periarticular muscles strength.

Although proprioception is a widely studied issue, future studies are needed to understand exactly the role of intact and injured anterior cruciate ligament in knee proprioception and the factors that influence proprioceptive rehabilitation.

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