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Anterior Cruciate Ligament Mechanoreceptors Regeneration Following Reconstruction Using Autografts

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Anterior Cruciate Ligament (ACL) reconstruction is a widespread surgical intervention conducting for a common knee injury which results in ligamentous rupture and deficiency [1,2]. With the increased number of people who participate in sports activities these surgical procedures are expected to increase in the upcoming years.

A variety of surgical procedures and also different types of autografts, artificial grafts, and allografts have been used with satisfactory results [3,4].

In recent years two different types of autografts, the Bone Patellar Bone Tendon (BPBT) and the four Strand Hamstrings (4SH) tendons have become the most frequently used graft types for ACL ligament reconstruction [4-8].

Many research papers have demonstrated the regeneration of the tissues, in the area that provides these autografts [9-17].

Magnetic Resonance Imaging (MRI) has documented regeneration of the 1/3 of the patellar tendon which continues to process for 2 years [13-16]. In histological studies, the tendon appears to have a tissue structure that resembles that of a normal tendon [17].

The rebirth of the hamstring grafts consisted of gracilis and semitendinosus tendons is spectacular, since the largest section of the main body of the tendon is surgically detached when degenerated, to be used in ACL restoration procedures as autografts. Regenerated tissue checked by MRI, ultrasound and biopsies although inferior, it has structure and possibly features similar to the original tissue [18-20].

Surgical reconstruction of the ruptured ligament aims to restore not only the static but also the dynamic joint stability, which is considered necessary for the restoration of the knee functionality [21].

ACL plays a critical role to the knee functionality as a static and a dynamic joint stabilizer. This ACL fundamental dynamic role and its crucial contribution to the knee proprioception are guaranteed by the presence of an adequate number of specific ligament mechanoreceptors [21-24].

Proprioceptive deficits following ACL rupture and ligament deficiency are well documented [25-29]. The restoration of the proprioception after ACL reconstruction is also supported in a significant number of research papers [27-30].

Albeit restoration of proprioceptive deficits is possibly supplied by the regeneration of the mechanoreceptors of the autografts, the mechanism which achieves this process is not yet clarified.

Notably interesting appears to be the study of mechanoreceptors regeneration after a surgical reconstruction of the ligament.

Denti et al. [31] reported that in experimental sheep, anterior cruciate ligament reconstruction with autologous patellar tendon resulted in the presence of mechanoreceptors in the reconstructed anterior cruciate ligament. Mechanoreceptors were absent in cases that artificial grafts were used. Additionally in two unsuccessful grafts, there were found histologically normal mechanoreceptors in the 9th and the 10th year postoperatively.

Aune et al. [32] working on laboratory animals and human ACLs, studied the innervation of the BPBT graft and suggested the reinnervation of the graft. In a rat model, in the 4th postoperative week, immunoreactivity for substance P was confirmed by histological methods. After the fourth postoperative week the grafts were deemed sustainable, and except for that until the 16th postoperative week sensorineural peptides like calcitonin gene-related peptide and protein gene product 9.5 were detected in these grafts.

Furthermore indication of fully integrated regenerative process was found in all biopsies that examined human specimens isolated from patellar tendon from the 5th to the 37th postoperative month Nonetheless, evidence suggesting immune activity of neural peptides was not detected [32].

In another study Barrack et al. [33] used BPBT grafts in male adult dog models, suggested the regeneration of some nerve elements of the grafts, at least in some cases 6 months postoperatively. Apart from the histological indication of the graft, the researchers managed to confirm the return of the Somatosensory Evoked Potentials (SEP), in 2 of the 6 cases of the laboratory animals.

In rabbits, Simuzu et al. [34] by using BPBT managed to detect an increasing number of mechanoreceptors in the graft at the 4th week after the ligament reconstruction, so that at the 8th week the total amount of mechanoreceptors had reached the normal amount of those in the control group.

In a very interesting study, Ochi et al. [26] recorded somatosensory evoked potentials after electric stimulation in intact and in ruptured ligaments before and after their reconstruction. SEP were detectable in all intact ligaments as well as in those which had undergone a reconstruction with hamstrings graft 18 months after the surgery. On the contrary, in case of a rupture SEP could be detected in half of the cases in the injured group. The authors suggest sensory reinnervation of the reconstructed ACL which is closely related with the knee functionality.

Finally Georgoulis et al. [22] examined neural mechanoreceptors that were present in the remnants of ruptured ACL in a timeframe that included the period from the 3rd week to the 42nd week that followed an injury. They confirmed the existence of viable mechanoreceptors in patients with an ACL vestige grafted onto the Posterior Cruciate Ligament (PCL). They proposed that in case that the reinnervation of the Anterior Cruciate Ligament gives as an end result the restitution of the ligament, a detectable amount of ACL that would act as a source, would be extremely beneficial for the operated.

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It is therefore clear from the aforementioned studies that there is evidence of regeneration of the nerve elements of the autografts, which are used for the ligament reconstruction. ACL mechanoreceptors are an integral part of the complex mechanism of the proprioceptive sensitivity of the knee. Their rebirth probably has a positive impact in the proprioceptive improvement, which is recorded after reconstruction of a ruptured ligament with the two most frequently used types of autografts, BPBT and four strand hamstrings.

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