

# Evaluation of Joint Position Sense after ACL Reconstruction with Hamstring Tendon Auto Graft

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**Abstract Background:** Use of STG (Semitendinosus and gracilis) graft is one of the standard techniques for anterior cruciate ligament (ACL) reconstruction. The purpose of this study was the comparison of joint position sense (JPS) in involved and uninvolved knees of ACL reconstructed athletes and control group. **Methods:** Fifteen elite athletes (7 handballs, 8 soccer players) with a unilateral ACL rupture who had received a hamstring tendon auto grafts ACL reconstruction, matched by motor dominance and sport to fifteen healthy elite athletes, were subjects of our study. The injured group experienced an average of 19.9 months from surgery to participation in the research. The Biodex System III Isokinetic dynamometer and Active Angle Reproduction test with angle of 30° knee flexion were used for evaluation of knee JPS. **Results:** No significant difference was found between involved and uninvolved knees of ACL reconstructed group and between involved knee of ACL reconstructed and control group ( $p < 0/05$ ). **Conclusion:** The present study revealed that athletes with ACL reconstructed knee may have not experience JPS malfunction. This fact suggests that proprioceptive acuity has multimodal characteristics and is not always primarily dependent on the sensory information of ligament mechanoreceptors. There is the possibility of offsetting this deficit by regeneration of sensory neurons in the reconstructed ligament or by rehabilitation program.

**Keywords:** joint position sense, anterior cruciate ligament reconstruction, hamstring (STG) tendon auto graft

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## 1. Introduction

ACL injury is more frequent in athletes, and usually causes long time absence from sports activities, and is associated with an increased risk of recurrent knee injury [1,2]. Estimated rates of reconstructions performed per year in the United States ranges from 60,000 to 175,000 [3,4]. Previous studies reported that in athletes the rate of return to sports was 70-80% [5,6]. However, there are some complications after ACL reconstruction. Contralateral ACL injury is one of the most serious complications after reconstruction [7].

Knee joint function is complex and does not depend on ligament stability alone, but also on the dynamic interaction between the central nervous system and the periarticular muscles. This is achieved by means of various mechanoreceptors and free nerve endings, which have been identified in the articular and periarticular knee joint structures [8]. They are found in particularly high numbers in the area close to the insertion of the ACL [9].

Proprioceptors are the components of somatosensation that provides information about the orientation and motion of body segments and the state of the muscles. This information is conveyed largely through muscle spindles and Golgi tendon organs [10]. To

investigate the role that Proprioceptors plays in planning and controlling movements, proprioception has been removed through either surgery or by studying rare sensory neuropathy conditions, or has been distorted by the use of vibration [10]. Following the pioneering findings of Mott and Sherrington [10], many studies have examined the role of proprioception in movement control by examining movements in non-human primates who have undergone partial dorsal rhizotomy surgery, including the studies of Gilman et al. [11], Taub et al. [12], Polit and Bizzi [13] and Gauthier and Mussa Ivaldi [10], among others. It has been well established that animals proprioceptively differenced in this way show substantial impairments in accuracy and coordination during multijoint reaching and natural unrestricted movements [10].

Proprioception appears have critical role for controlling other aspects of limb mechanics, in addition to the effects of intersegmental dynamics. For example, Ghez et al. [14], showed that deafferented patients were unable to account for direction dependent variations in limb inertia during reaching movements, which resulted in substantial errors in movement distance and direction. Because direction dependent variations in limb inertia vary with limb configuration, this finding underscored the importance of proprioception in providing configuration information [14], showed that deafferented patients were unable to

account for direction dependent variations in limb inertia during reaching movements, which resulted in substantial errors in movement distance and direction. Because direction dependent variations in limb inertia vary with limb configuration, this finding underscored the importance of proprioception in providing configuration information [14]. The critical role of proprioception in providing initial information of the postural state of the motor apparatus for movement planning is also supported by the study of Larish et al. [15]. This study also showed that when the limb was vibrated in the absence of visual feedback prior to the movement, final position was systematically altered [15]. Barrack et al. [16] reported decreased proprioception in knees with a ruptured ACL on the basis of an evaluation of the joint position sense. Ochi et al. [17] also studied joint position sense in knees with a ruptured ACL and demonstrated decreased joint position sense in patients with marked knee instability. However, there are also reports denying a relationship between ACL injury and changes in proprioception [5].

However, ACL injuries induces changes in the kinematics of the knee joint, instability, and proprioception impairment [18]. Injury to the ACL will result in a loss of both mechanical stability and proprioceptive feedback at the knee, directly affecting functional joint stability and can lead to further deterioration of the knee joint integrity [19]. Due to instability of the joint, repetitive injury and degenerative changes occur and the sports activity and even the daily life of the person are confused [20]. These cases determine the necessity for the ACL reconstruction surgery.

Therefore, it is becoming increasingly clear that knees with ruptured ACL gradually develop changes not only in performance but also in proprioception. However, as reported by Noyes et al. [21], we encounter individuals who readily perform high levels of athletic activities despite injury to the ACL [22].

Previous studies revealed that an integral element in achieving a favorable outcome following ACL reconstruction is participation in the postoperative rehabilitation [23]. The mechanical restraint and proprioceptive function of the ACL both help to provide functional joint stability of the knee during movement. Therefore, it is essential to monitor the restoration of proprioception after an ACL injury or ACL reconstruction/rehabilitation for safe and functional return to sport and should be considered in the evaluation of surgery results by orthopedic surgeons [24].

Although, different types of autograft and allograft have been used in ACL reconstruction for many years, recently the hamstring tendon has become the preferred autogenous graft [25,26]. In our comprehensive survey, we found that a few research has been done for the assessment of knee joint proprioceptive function after ACL reconstruction with STG graft. Hence, the aim of this research was to evaluate knee joint proprioception in elite athletes after ACL reconstruction with STG graft.

## 2. Materials and Methods

The participants were 30 male soccer and handball elite players who competing at premier leagues and Iranian national teams, and were classified as control (non-injured) and ACL-reconstructed (injured) groups. The participants

in the control group consisted of 15 healthy elite athletes (8 soccer and 7 handball aged  $23.06 \pm 3.1$  years, height  $184.4 \pm 7.8$  cm, Weight of  $85.2 \pm 1.1$  kg; mean  $\pm$  s) with no previous history of lower-extremity orthopedic pathology. The participants in the ACL-reconstructed group consisted of 15 elite athletes (8 soccer and 7 handball mean aged  $23.8 \pm 3.5$  years, Height  $180.4 \pm 7.6$  cm, & Weight  $76.4 \pm 1.02$  kg) who had undergone a unilateral ACL reconstruction with STG tendon graft. The injured group matched by motor dominance and sport with fifteen healthy elite athletes. The "accessible" sampling method was used for selecting the samples. The injured group experienced an average of 19.9 months (range  $8 \pm 60$  months) from surgery to participation in the research. In this study we have some limitations to initiate the testing protocols, such as subjects and physicians permissions, and the number of subjects ready to take part in this study. All participants demonstrated a full, pain-free range of motion at the knee joint at the time of testing, and were excluded if they experienced any pain, effusion or edema during the test procedure.

Exclusion criteria included multiple surgical procedures in the involved knee, contralateral knee pathology, and age less than 18 years, limited ROM due to surgery, injury of the ankle and hip joint, time lapse of less than 6 months after ACL reconstruction, patellofemoral joint dysfunction and unstable co-existing cardiovascular, neurological, psychiatric or psychological conditions.

Biodex System 3 Isokinetic Dynamometer (Biodex Medical Inc., Shirley, NY, USA.) and active angle reproduction test were used to assess knee JPS. Visual cues were eliminated by a blindfold.

On the test day participants have to wear light clothes, and they completed a consent form. Personal information list completed with the investigator. Each subject was seated on the biodex isokinetic dynamometer with hip flexion of  $100^\circ$  and the axis of their knee joint aligned with the axis of the dynamometer arm. The ankle strap of the dynamometer arm was applied to the ankle 2 inches above the medial malleolus. The thigh strap also was applied. The dynamometer was calibrated by asking the participant to hold the knee at 0 degrees of extension, and the position checked using a hand held goniometer. The participant's knee was then returned to an angle of  $90^\circ$  degrees. Starting at  $90^\circ$  of knee flexion, the subject actively moved the limb to the target angle of  $30^\circ$  of flexion at an angular velocity approximating  $5^\circ$ .s. This angle is in the working range of the knee during daily weight-bearing activities. Subjects were instructed to voluntarily contract their muscles. The limb was maintained at the target angle for 10 seconds to enable the subject to remember the position. After the limb was passively returned to  $90^\circ$ , there was a 5-second pause, and the cycle was performed again. This time the subject activated a handheld stop button when he felt the target angle had been achieved. Once the button had been activated, patients were not permitted to correct the angle. The angle was identified from the onscreen goniometer. Three readings were taken, and the absolute difference between the perceived angle and the target angle was calculated for each reading. We used the average of these three scores as the error score for each subject.

SPSS software (ver. 16) was used for data analyzing. One-way ANOVA was used for comparing the average

absolute error of the target angle for the operated knee, as regards with the healthy leg of the person himself and the matched knee of control group. Statistics significance were carried out at an alpha level of  $P < 0.05$ .

### 3. Results

Demographic data of the injured and healthy groups are shown in Table 1. The mean values and standard deviation of the reproduced angle absolute error for the injured and healthy group are shown in Table 2. Kolmogorov-Smirnov test ( $P < 0.05$ ) was used to analyze the normality of the data and the Q-Q plots and box plots were also used for more assurance. ANOVA test showed that there is no significant difference between the average values of error score in ACL reconstructed knee as compare to contralateral knee and the knee of control group. ( $F = 1.21$ ,  $P = 0.3$ ).

**Table 1. Demographics characteristics of Subjects (mean± standard deviation)**

	Weight(kg)	Height(cm)	Age(y)
<b>Injured group(n=15)</b>	76.4 ± 1.02	180.43 ± 7.63	23.86 ± 3.58
<b>Control group(n=15)</b>	85.23 ± 1.17	184.47 ± 7.82	23.06 ± 3.10

**Table 2. Absolute error of active angle reproduction test (Mean± standard deviation)**

	Reconstructed knee	Uninjured knee	Matched knee of Control group
Absolute error	4.02 ± 1.55	3.12 ± 1.44	3.92 ± 2.11

### 4. Discussion

According to the results of this research, there was no significant difference between the JPS at the injured knee in comparison with contralateral knee and the knee of control group. As mentioned before the most important role of ligaments like ACL is providing the joint mechanical stability. Disruption of this support mechanism changes the joint kinematics and induces joint instability and osteoarthritic changes [27].

However, Kennedy et al. [28] reported that clinical symptoms characteristic of knees with ACL injury occur due to the disappearance of mechanoreceptor feedback in addition to altered kinematics. This report was followed by studies on proprioception of knees with a ruptured ACL [16,29,30]. Also some researcher like Barrack et al. [16] demonstrated a correlation between the magnitude of joint instability and the reduction of proprioception in knees with a ruptured ACL, and Ochi et al. [17] performed an electrophysiological study of knees with a ruptured ACL using somatosensory evoked potential (SEP) and concluded that SEP was low in patients with reduced joint position sense. Their findings also showed that sensory reinnervation occurred in the reconstructed human ACL and was closely related to the function of the knee [17]. Fremerey et al. [31] assessed knee proprioception using the angle reproduction test after reconstruction of the ACL. Six months after reconstruction, restoration of proprioception was seen near full extension and full flexion. In the intermediate motion range, no

improvements could be demonstrated. Al-Othman [32] also demonstrated the complete recovery of proprioception following ACL. In a research by Hopper et al. [33] no significant difference observed in JPS between reconstructed and uninjured knees or between the flexion and extension tasks, that is compatible with the findings of our study.

Research by Risberg et al. [34] also indicates that there were no significant differences in proprioception between the ACL-reconstructed knee and the contra-lateral uninjured knee 1 year or more after surgery. Bonfim et al. [20] did not find an improvement of proprioceptive function following ACL reconstruction in comparison with a control group. Other authors also report persistent impairment of proprioception [35,36]. Wilke and Froböse [37] found that the patient's position influenced the results of the joint position sense test. Proprioceptive information is different in the supine position as compared with standing and sitting positions because muscle recruitment is altered in the horizontal position.

Regarding the position of the knee, there are various results among different studies. The selected angle for the present research was chosen according to Grood and Noyes [38] investigation. The reason for this selection is that at 30° flexion of the knee, this joint is in a loose-packed position, where the ACL mechanical function is at its minimum. Hence, the neuromuscular mechanisms related to the joint stability of this ligament around this angle are most important. One research [33] also indicates that muscle-tendon receptors have greater role regarding joint receptors in providing JPS. Lephart et al. stated that the knee JPS could be improved by balance exercises [39]. In this study we examined subjects who were given rehabilitation by strength training, in the acute period after ACL injury and had no marked difficulty in daily activities including walking.

The existing differences between the studies could be related to the numbers of subjects involved, the surgery methods used in reconstruction of ACL, different angles in performing the test, rehabilitation programs, sport skills patterns and testing methods (active or passive, weight bearing or non-weight bearing). Therefore, regarding the unification between the two groups by consideration of sport activity levels, age and sex; it seems that lack of Proprioceptive information resulted from the reconstructed ligament to be offset by other proprioceptive sources. Also, there is the possibility for the joint mechanical receptors not to have a primary role in provision of JPS, or for the regeneration of sensory nerves in the reconstructed ligament to offset the loss of proprioception.

### 5. Conclusion

The following conclusions were reached from the results of our study, the results by this study showed that there is no significant difference in the knee JPS at the injured knee in comparison with contra-lateral knee and the knee of control group. It seems that the knee joint proprioception has a multimodal characteristic, not limiting to sensory information of the ligaments mechanoreceptors. There is also the possibility that the

rehabilitation program or innervations of reconstructed ligament could offset this deficit.

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