

A QUANTITATIVE ASSESSMENT OF PROPRIOCEPTIVE FUNCTION IMPROVEMENT AFTER ARTHROSCOPIC ACL RECONSTRUCTION SURGERYDobson Dominic¹, P. Saravanan², Sai Kishore³**HOW TO CITE THIS ARTICLE:**

Dobson Dominic, P. Saravanan, Sai Kishore. "A Quantitative Assessment of Proprioceptive Function Improvement after Arthroscopic ACL Reconstruction Surgery". Journal of Evolution of Medical and Dental Sciences 2015; Vol. 4, Issue 38, May 11; Page: 6565-6571, DOI: 10.14260/jemds/2015/952

ABSTRACT: OBJECTIVE: To quantify the deficit in proprioceptive function in Anterior Cruciate Ligament (ACL) deficiency and to quantify the improvement after Arthroscopic ACL Reconstruction. Type of Study: Prospective cohort study. **METHODS:** The study included 73 patients (49 men, 24 women; mean age 26.8 years; range 21 to 40 years) who underwent Arthroscopic ACL reconstruction. Arthroscopic ACL reconstruction was performed using either a patellar tendon or a hamstring auto graft. All patients followed a standard rehabilitation program. Proprioceptive function in the form of (B. I) Balance Index Score was tested using Kinesthetic Ability Trainer (SPORT KAT 1750) preoperatively and at the end of third and sixth months after surgery. Their contralateral knees served as control. Results were statistically analyzed by Paired t-test using SPSS 16.0. **RESULTS:** Mean B. I Score in ACL insufficient limb was 2203.19 and of normal contralateral limb was 1573.01 at the time of presentation, with a mean deficit of 630.18 ($p < 0.001$). The injured limb showed significant improvement in proprioception from preoperative B. I Score of 2203.19 to B. I Score of 1221.95 at the end of 6 months after Arthroscopic ACL Reconstruction ($p < 0.001$). **CONCLUSION:** There is a significant deficit in proprioceptive function in the ACL insufficient limb compared to the normal contralateral limb. Proprioceptive function improves significantly after Arthroscopic ACL Reconstruction. **KEYWORDS:** Kinesthetic Ability Trainer, Arthroscopic ACL reconstruction, Proprioception, B. I Score Balance Index Score.

INTRODUCTION: Injury to Anterior Cruciate Ligament (ACL) leading to functional instability of the knee is a common occurrence in young individuals. ACL injuries leading to altered neuromuscular function has been identified as a key factor for functional instability of the affected limb¹. Effects of ACL insufficiency on mechanical function of the knee has been extensively researched. There is varied literature with no clear consensus on the proprioceptive function and neuromuscular sensory function in an ACL insufficient knee.^{1,2}

Proprioception has been defined by various authors as a combination of joint position, kinesthesia and also sensation of equilibrium contributing to postural control and sense of balance.^{3,4,5,6}

Evaluation of position sense in the joint and kinesthesia alone do not provide adequate information on functioning of proprioceptive reflexes that seem to be responsible for the joint functional stability.^{7,8}

TDPM (Threshold To Detect Passive Motion) and JPS (Joint Position Sense) test different receptors and different components of proprioception.^{7,8} There are other receptors for proprioception that are not tested by these methods of evaluation and hence are not practical tools of assessment in knee injury.⁷

ORIGINAL ARTICLE

The symptom of instability suffered by patients after joint injury does not reflect the conscious perception of where the joint is in space, but reflex control of its activity by its musculature.² Therefore measurement of JPS or kinesthesia alone is not necessarily the right approach to reveal a neurological defect after joint injury,⁷ hence a more functional test like postural sway (The degree of sway measured by Balance Index) which is measured by kinesthetic ability trainer is of more use functionally for the assessment of proprioceptive function.^{9,10} Impairment of proprioception may lead to increased postural sway and potentially loss of balance.¹¹ Also, compromised knee proprioception after ACL injury have prompted researchers to study standing balance in patients with such injuries.^{12,11}

Functional assessment of peripheral, visual and vestibular contributions to neuromuscular control, is best assessed by postural sway measurements for the lower extremity.⁹ Stabilometric methods and instrumentation may provide a relatively accurate method for these measures.¹⁰

Gray et al. in 1985 defined Postural control as an ability to stand with as little sway as possible.¹³ Ochsendorf et al in 2000 postulated that the ability to maintain balance demands the coordinated actuation of joint, muscle, visual and vestibular receptors¹¹.

MATERIALS AND METHODS: Patients presenting with symptoms of instability after a history of injury to knee were evaluated clinically with Lachman and Anterior drawer's tests. ACL tear was confirmed by MRI and all patients underwent Arthroscopic ACL Reconstruction, and all patients underwent a Neuro-muscular Training Program designed to return them to pre-injury levels.

A total number of 123 patients who had anterior cruciate ligament insufficiency of knee were included in the study.

Inclusion Criteria:

- Patients clinically and radiologically diagnosed to have isolated ACL deficiency with a normal contralateral lower limb.
- Arthroscopic ACL reconstruction with or without partial Menisectomy.

Exclusion Criteria:

- Any history of previous knee surgery.
- Significant spine disorders.
- Patients on psychotropic drugs, sedatives, vasodilators, anti-hypertensives, anticholinergics.
- Pain Score on standing (Visual Analogue scale - VAS) - greater than 4.
- Post op complications.
- Loss to follow up.

Of the 123 patients with ACL involvement, only 73(n=73) were found to be matching our criteria and hence were included in our study. Their mean ages were 27 years, with Male: Female ratio being 49:24.

Proprioceptive function testing was carried out preoperatively, postoperatively at 3 months and at 6 months Proprioceptive function testing was carried out using Kinesthetic Ability Trainer (SPORT KAT 1750).

Balance index (BI) score reflects the subject's ability to keep the platform at or near the reference position. Balance index scores range from zero to 6000, and the lower the score, better the proprioceptive function.

ORIGINAL ARTICLE

Study Design: The study was conducted in the Sports Medicine unit, Department of Orthopaedics, Chettinad Academy of Research and Education (CARE) between July 2014 and February 2015.

PROCEDURE (Testing Protocol): Each patient signed an informed consent and completed a questionnaire regarding past medical history and activity level. A standard set of instructions were given before each trial. The one-leg static balance test was performed with the person standing on uninjured leg first and then on the injured leg. The subject stepped onto the platform held the handrail, and placed the feet within the outline of the original foot placement. When the command “go” was given, the patient removed hands from the hand rail and stood as still as possible, and tried not to grab the handrail. The static test was performed on 1 foot with the arms crossed over the shoulders and other extremity at 20 degree flexion. Subject was told to keep the cursor at the center of the screen for 30 seconds while keeping their balance. During the measurement period the opposite leg was not allowed to touch the platform. The result was scored as the Balance index (B. I) score by the equipment. The test was repeated 3 times and mean B. I score was calculated.

OPERATIVE TECHNIQUE:

- Arthroscopic ACL reconstruction was done using a Standard technique under Spinal Anesthesia with pneumatic tourniquet control. All the surgeries were done by a single surgeon who is a senior consultant at the Department.
- The Auto graft chosen was Hamstring graft using Semi Tendinosis (ST) and Gracillis (G).
- In all the procedures Anatomical ACL reconstruction was done.
- The fixation was done using Endobutton in femoral side and Bio absorbable interference screw in tibial end for hamstring graft.
- Knee was immobilized with a knee brace immediately after the surgery.

POST OPERATIVE MANAGEMENT - REHABILITATION PROTOCOL:

- All patients followed standard rehabilitation protocols designed for ST/G graft.
- All patients were immobilized with knee immobilizer in extension for a period of 3 weeks.
- They were allowed immediate weight bearing as tolerated.
- Rehabilitation period consisted of 4 stages.

STAGE 1- (0-2 weeks):

- Immobilization in extension with knee brace
- Swelling control by Cryotherapy

STAGE 2- (3-8 weeks):

- Full weight bearing.
- Patellar mobilization.
- Hamstring stretches.
- Co-contraction exercises.
- ROM & Strengthening exercises.
- Straight Leg Raise in all planes.
- 1/2 Squats.
- Single leg standing neuromuscular training.

ORIGINAL ARTICLE

STAGE 3- (9-12 weeks):

- Close Kinematic Chain and Open Kinematic Chain strengthening exercises Unstable surface neuromuscular training using wobble board.

STAGE 4- (13-16 weeks):

- Advanced strengthening exercise.
- Advanced neuromuscular training in Kinesthetic Ability Trainer.

STAGE 5- (16-24):

- Plyometrics.
- Sports specific training.

STATISTICAL METHODS:

- Paired t-test was used to find the significance difference between the paired samples,
- In both the above statistical tools the probability value $P < .05$ is considered as significant level.
- The results were analysed using the Statistical Product and Service Solutions software (SPSS) 16.0 version.

RESULTS: The Mean BI score in the injured leg was 2203 at the time of presentation while the Mean BI score in the normal contralateral limb was 1573. The Mean BI score deficit between the injured and the normal contralateral limb was 630. There was a significant difference in proprioception between the injured limb and the normal contralateral limb ($p < 0.001$).

The Mean BI score of the injured limb significantly improved to 1222 ($p < 0.001$) 6 months after Arthroscopic ACL Reconstruction.

Proprioceptive function of injured limb 6 months after Arthroscopic ACL Reconstruction was comparable with that of the normal control limb ($p < .001$).

Bivariate Comparison of Balance Index Scores using Paired Sample t-test (Pair 1, 2 & 3).

Bivariate Comparison using Paired Sample t-test.

Table 1: Shows the Bi-Variate Comparison between the injured limb and the contralateral limb. The lower the score is, the better the proprioception.

PAIRS	GROUPS	MEAN S. D	T-VALUE	P-VALUE
Pair 1	Injured Limb	2203. 19	855. 15	9. 702**
	Contralateral Limb	1573. 01	638. 75	
Pair 2	Injured Limb	2203. 19	855. 15	11. 469**
	Contralateral Limb	1221. 95	423. 44	
Pair 3	Injured Limb	1221. 95	423. 44	5. 199**
	Contralateral Limb	1573. 01	638. 75	

Table 1

** Highly Significant at $P < 0.001$.

ORIGINAL ARTICLE

DISCUSSION: Most of the studies on Proprioceptive function assessment in ACL insufficient limbs have assessed joint position sense and kinesthesia.^{7,8} They have not been able to conclusively prove the effect of Arthroscopic ACL Reconstruction on the proprioceptive function because an important functional component of proprioceptive function postural balance has not been extensively researched.^{14,15}

Several authors obtained different results depending on the type of proprioceptive test used and different results have been observed in the same subject groups.⁷ For example, Barrett et al showed that JPS was significantly improved by reconstruction of the cruciate ligaments.⁶ However, MacDonald et al found that in patients with reconstruction of the anterior cruciate ligament (ACL) proprioception did not improve when measured by a kinaesthesia test.¹⁶ Such contrasting results are may be due to different testing modalities and protocols used and that some authors used contralateral knee as their control while others used an external control, thus leading to conflicting observations.

TDPM and JPS test different receptors and different components of proprioception.⁷ Also there are other receptors for proprioception that are not tested by these methods of evaluation and hence they may not be practical tools of assessment in knee injury.⁸ A more functional test like postural sway (the degree of sway as indicated by Balance Index) measured with kinesthetic ability trainer could be used for the assessment of proprioceptive function.^{10,11}

There are very few studies,^{7,10} which have assessed the proprioceptive function using kinesthetic ability trainer which measures the Postural sway using Balance Index.

Our study measured the proprioceptive function using single leg stance test in a kinesthetic ability trainer. However, we found a significant deficit in proprioceptive function in the ACL deficient limb compared with the contralateral limb, this was found to be in accordance with similar studies by Arockiaraj et al and Jerosch et al who assessed postural sway.^{17,18} Similarly, studies by Barrett et al and Corrigan et al who evaluated proprioception using JPS and TDPM found a significantly lower proprioceptive activity in injured knees as compared to the uninjured knees.⁶

Current research findings on the effects of ACL reconstruction on knee proprioceptive function gives no clear consensus.^{19,12}

We found there was a significant improvement in proprioceptive function in the injured limb from time of presentation to 6 months after arthroscopic ACL reconstruction, the proprioceptive function of the ACL Reconstructed limb at the end of 6 months was found to be comparable to that of the preoperative proprioceptive function of the contralateral normal limb. Arthroscopic ACL reconstruction has significantly helped in the improvement of the injured limb. Reconstruction of a mechanical restraint (ACL graft) seemed to have a significant positive impact on early and progressive improvement in proprioception.^{5,20,21}

Arthroscopic ACL Reconstruction Seems to Improve Proprioceptive Function by:

1. By restoring a more physiological joint movement, cortical interpretation is enhanced.⁵
2. By regeneration of mechanoreceptors.^{22,23}

By restoring mechanical stability with ACL reconstruction and by restoring a more physiological joint movement, cortical interpretation is enhanced and hence resulting in the improvement in proprioceptive function.

CONCLUSION:

- There is a significant deficit in proprioceptive function in ACL deficient limb compared to normal contralateral control limb at the time of presentation.
- Proprioceptive function of the affected limb showed significant improvement after Arthroscopic ACL Reconstruction at the end of 6 months.
- Proprioceptive function 6 months after surgery in the ACL reconstructed limb was comparable to the pre-operative proprioception levels of the contralateral normal limb.
- Arthroscopic ACL Reconstruction significantly improves proprioceptive function.

LIMITATION: There is a lack of normative value for proprioception assessment. A wider follow up may throw light in detail analysis of proprioceptive function in patients who undergo Arthroscopic ACL Reconstruction.

REFERENCES:

1. Liu-Ambrose T. The anterior cruciate ligament and functional stability of the knee joint Issue. *BCMJ* 2003; 45 (10): 495-499.
2. Lephart S M. Reestablishing proprioception, kinesthesia, joint position sense, and neuromuscular control in rehabilitation techniques in *Sports Medicine*; 2nd ed; 1993.
3. Lephart S M, Kocher, Borsa B A, Harner C D. Proprioception following anterior cruciate ligament reconstruction. *J Sport Rehabil* 1992; 1: 188-196.
4. Lephart S M. Proprioceptive considerations for sport rehabilitation. *J Sport Rehab* 1994; 3 (2): 115.
5. Beard D J, Kyberd P J, Fergusson C M, Dodd C A F. Proprioception after rupture of the anterior cruciate ligament. An objective indication of the need for surgery? *J Bone Joint Surg Br* 1993; 75 (2): 311-5.
6. Barrett D S. Proprioception and function after anterior cruciate reconstruction. *JBS [BR]* 1991; 73- B.
7. Grob K R, Kuster M S, Higgins S A, Lloyd D G, Yata H. Lack of correlation between different measurements of proprioception in the knee. *J Bone Joint Surg [Br]* 2002; 84-B: 614-8.
8. Pap G, Machner A, Nebelung W, Awiszus F. Detailed analysis of proprioception in normal and ACL deficient knees. *Bone Joint Surg [Br]* 1999; 81-B: 764-8.
9. O'Connell M, George K, Stock D. Postural sway and balance testing: a comparison of normal and anterior cruciate ligament deficient knees. *Gait Posture* 1998; 8: 136-42.
10. Lysholm M, Ledin, T, Odkvist L M, Good L. Postural control-a comparison between patients with chronic anterior cruciate ligament insufficiency and healthy individuals. *Scand J Med Sci Sports* 1998; 8: 432-8.
11. Ochsendorf D F, Mattacola C G, Arnold B L. Effect of orthotics on postural sway after fatigue of the plantar flexors and dorsiflexors. *J Athl Training* 2000; 35 (1): 26-30.
12. Noyes F R. *Noyes' Knee disorders: Surgery, Rehabilitation, Clinical Outcomes: Expert Consult*. 2009.
13. Gray J, Taunton J E, McKenzie D C, Clement D B, McConkey J P, Davidson R G. A survey of injuries to the anterior cruciate ligament of the knee in female basketball players. *Int J Sports Med* 1985; 6: 314-316.

ORIGINAL ARTICLE

14. Reider B, Arcand MA, Diehl LH. -Proprioception of the knee before and after anterior cruciate ligament reconstruction. *Arthroscopy*. 2003; 19: 2-12.
15. Schultz R A, Miller D C, Kerr C S, Micheli L. Mechanoreceptors in human cruciate ligaments-a histological study. *J Bone Joint Surg Am* 1984; 66 (7): 1072-6.
16. MacDonald P B, Hedden D, Pacin O, Sutherland K. Proprioception in anterior cruciate ligament-deficient and reconstructed knees. *Am JSports Med* 1996; 24: 774-8.
17. Arockiaraj J, Korula R J, Oommen A T, Devasahayam S, Wankhar S, Velkumar S, Poonoose P M. Proprioceptive changes in the contralateral knee joint following anterior cruciate injury. *JBS* 2013; 95-B: 188-91.
18. Jerosch J, Pfaff G, Thorwesten L, Schoppe R. Effects of a proprioceptive training program on sensorimotor capacities of the lower extremity in patients with anterior cruciate ligament instability. *Sportverletz Sportschaden* 1998; 12 (4): 121-30.
19. Schutte M J, Dabezies E J, Zimny M L, Happel L T. Neural anatomy of the human anterior cruciate ligament. *J Bone Joint Surg Am* 1987; 69 (2): 243-7.
20. Lee H M, Cheng C K, Liao J J. Correlation between proprioception, muscle strength, knee laxity, and dynamic standing balance in patients with chronic anterior cruciate ligament deficiency. *The Knee* 2009; 16: 387-391.
21. Borsa P A, Lephart S M, Irrgang J J, Safran M R, Fu F H. The effects of joint position and direction of joint motion on proprioceptive sensibility in anterior cruciate ligament-deficient athletes. *AJSM* 1997. 25 (3).
22. Hansen M S, Dieckmann B, Jensen K, Jakobsen B W. The reliability of balance tests performed on the kinesthetic ability trainer KAT 2000. *Knee Surg Sports TraumatolArthrosc* 2000; 8 (3): 180.
23. Ochi M, Iwasa J, Uchio Y, Adachi N, Sumen Y. The regeneration of sensory neurones in the reconstruction of the anterior cruciate Ligament. *J Bone Joint Surg [Br]* 1999; 81-B: 902-6.

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