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Assessment of function of knee following arthroscopic anterior cruciate ligament reconstruction using remnant preserving technique

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Abstract
Introduction: Anterior Cruciate ligament (ACL) plays an important role in the stability of the knee joint & its pivotal role in kinematics of the knee is well known. ACL injury is thought to contribute to impaired lower limb postural control. The ACL is proposed to play an integral role in the central somatosensory feedback loop by providing information regarding knee joint position and movement. The primary purpose of this study was to assess the functional outcome of Anterior Cruciate Ligament (ACL) reconstructed knee in terms of proprioception in patients who underwent ACL reconstruction using remnant preserving technique. We compared the functional outcome and proprioception in patients who underwent preoperative ACL exercises and those who did not undergo preoperative exercises. The secondary purpose was to assess the effect of Vitamin D and Body Mass Index (BMI) on functional outcome including proprioception.
Materials and Methods: This was a prospective study. 30 patients belonging to the age group of 18-50 who underwent ACL reconstruction were included in this study. A detailed history and clinical examination was done. Diagnosis was confirmed with standard clinical test & with the help of Magnetic Resonance Imaging (MRI). Those patients with established ACL injury (partial or complete) were taken up for ACL reconstruction using remnant preserving technique. Subjective assessment was done with IKDC, Lysholm-Tegner and KOOS scores. For functional assessment we measured proprioception by Joint Position Sense (JPS), TTDPM-Threshold to Detection of Passive Motion, Proprioception test A and B, Single leg standing test and Wobble board test.
Results: We found significant improvement in the proprioception and subjective scorings with IKDC, KOOS and Lysholm-Tegner postoperatively. The functional outcome in terms of proprioception was significantly better in patients who underwent preoperative ACL protocol exercises than those who did not undergo preoperative exercises. We did not get any statistical significance between the levels of Vitamin D and BMI comparing with proprioception (TTDPM).
Conclusion: ACL remnant stumps contain mechanoreceptors which if preserved during ACL reconstruction might in turn improve the postoperative functional outcomes. In our study we found that pre-operative exercises have a better functional outcome along with proprioception in patients undergoing ACL reconstruction. Hence it would be desirable to preserve the ACL remnant and to undergo preoperative exercises.

Keywords: ACL, proprioception, reconstruction, remnant, vitamin D

Introduction

Anterior Cruciate ligament (ACL) plays an important role in the stability of the knee joint & its pivotal role in kinematics of the knee is well known. ACL injury is thought to contribute to impaired lower limb postural control [1, 2, 3]. The ACL is proposed to play an integral role in the central somatosensory feedback loop by providing information regarding knee joint position and movement [4]. Injury to the ACL is postulated to disrupt neural feedback mechanisms and as a consequence has a substantial effect on motor control at the knee [5]. In addition to its influence on neural feedback mechanisms, the ACL also provides a mechanical restraint to excessive knee joint movement [6, 7]. Disruption to both the somatosensory feedback and mechanical restraint systems of the intact ACL following ACL rupture may result in impaired postural control [8, 9, 10].

ACL reconstruction (ACLR) surgery is typically recommended for unstable knee following ACL rupture to restore mechanical stability at the knee and subsequently enable a return to functional activities, including participation in sports. Thus, the reconstruction of ACL has a huge bearing on the normal day to day activities of the common man. Reconstructions of the ACL are among the most frequently performed procedures in knee surgery nowadays.

ACL Reconstruction improves stability and function of the knee. The surgical technique continues to evolve and several controversial issues exist, such as graft selection (patellar tendon, hamstring, quadriceps tendon, or allograft), and surgical technique (double versus single bundle). Conventionally the torn ligament remnants are shaved off from the knee before the graft is inserted. But recently there has been a new thinking in terms of sparing the remnants of torn ACL as much as possible while reconstructing a new ACL. The advantages postulated are that the preserved remnant provides the necessary proprioception, reinnervation, and acts as a source of revascularization.

Vitamin D which regulates calcium and phosphorus absorption also contributes to muscle function. Low vitamin D appears to

hinder strength recovery after ACL surgery and during inflammatory insult [11]. Body mass index is also believed to influence functional outcome after ACL injury [12, 13].

The primary purpose of this study was to assess the functional outcome of Anterior Cruciate Ligament (ACL) reconstructed knee in terms of proprioception in patients who underwent ACL reconstruction using remnant preserving technique. We compared the functional outcome and proprioception in patients who underwent preoperative ACL exercises and those who did not undergo preoperative exercises. The secondary purpose was to assess the effect of Vitamin D and Body Mass Index (BMI) on functional outcome including proprioception.

Materials and Methods

This was a prospective study conducted in a 2 year period. About 30 patients with ACL injury were included in this study after obtaining informed consent. A detailed history and clinical examination was done. Diagnosis was confirmed with standard clinical test & with the help of Magnetic Resonance Imaging (MRI) (Sigma HDxT- GE 1.5 Tesla) USA, done in this hospital or outside. Those patients with established ACL injury (partial or complete) were taken up for ACL reconstruction with remnant preserving technique. Functional evaluation of the reconstructed ACL was done using IKDC score, Lysholm-Tegner score and KOOS score.

Inclusion Criteria

Patients belonging to the age group of 18- 60 years with ACL injury either isolated or

1. Associated Meniscal injury
2. Medial collateral ligament injury (Grade 1,2)
3. Lateral collateral ligament injury (Grade 1,2)

Exclusion Criteria

1. Patients with associated Posterior Cruciate Ligament (PCL) injury.
2. Medial collateral ligament injury (Grade 3)
3. Lateral collateral ligament injury (Grade 3)
4. Patients with ACL reinjury.
5. Patients with associated periarticular fracture.
6. Patients with associated ipsilateral lower limb fracture.
7. Patient not willing to follow post-operative protocol.

The patients were grouped into two groups - Group A (patients who underwent preoperative ACL protocol exercises) and Group B (patients who did not do any preoperative exercises). Data was analyzed pre-operatively with assessment of clinical tests including Lachman test, Anterior Drawer test, Pivot shift, X ray Knee, MRI Knee, IKDC score, Lysholm-Tegner and KOOS scoring. BMI and preoperative Vitamin D was also checked. The patients were followed up after 6 months, average follow-up being 9 months (range 6-16 months). Post operatively objective evaluations conducted to check joint stability included Anterior Drawer test, Lachman test and Pivot-shift test.

Subjective assessment was done with IKDC, Lysholm-Tegner score and KOOS score. For functional assessment we measured proprioception by Joint Position Sense (JPS), TTDPM-Threshold to Detection of Passive Motion, Proprioception test A and B, Single leg standing test and Wobble board test. We utilised both measurement techniques, JPS and TTDPM, in order to evaluate simultaneously the static (JPS) and dynamic (TTDPM) proprioception. Plasma Vitamin D (25-OH D2 and D3) was measured by using Chemiluminescence Immunoassay (CLIA) and reference range was set according to National Institute of Standards and Technology (NIST) as deficient < 20 ng/ml, insufficient <30 ng/ml and desirable >30 ng/ml(103).

The pre and post- operative scores were compared using paired t tests. All statistical analysis was considered significant at $P < 0.05$ level of significance. The statistical data were analyzed using SPSS version 18 software.

Results

All 32 patients were examined pre-operatively on the basis of Lysholm- Tegner, IKDC Scoring systems & Ligament laxity tests. Proprioception assessment was done and was correlated with post-operative IKDC, KOOS & Lysholm-Tegner score & ligament laxity tests.

There were a total of 20 male & 8 female subjects out of the total 30. The average age of the subjects was 30.5. The average BMI was calculated to be 25.06 kg/m^2. Out of these 30 patients, 16 patients underwent preoperative ACL exercises (Group A) while 14 patients did not undergo preoperative exercises (Group B).

While assessing the mode of injury we found out that 13 patients had twisting injury, 11 patients had sports injury and 6 patients had Road Traffic Accident (RTA).We found out that 10 patients had an isolated ACL tear, 7 patients had ACL with lateral meniscus tear, 7 patients had ACL with medial meniscus tear while 6 patients had ACL with both meniscal tears. We also assessed the TTDPM in both groups and found it to be significantly better in patients who underwent preoperative ACL exercises.

We checked vitamin D pre-operatively and 6 months post-operatively. The patients were not given any vitamin D supplements but interestingly we found it to be significantly higher post-operatively. It can be attributed to patients being more active post-operatively. The IKDC, KOOS and Lysholm-Tegner scores were preoperatively calculated based on set questions & points given against each of them. The preoperative & post-operative scores were compared using paired t test. The mean pre-operative Lysholm-Tegner score for these subjects were 52.3. However, post operatively the mean Lysholm-Tegner score improved to 87.9 with a Standard deviation of 17.1. The comparison of pre-op & post-op Lysholm-Tegner score was statistically significant with a p value <0.001. Similarly, the International Knee Documentation Committee (IKDC) scores were calculated pre operatively & post operatively & was compared using Paired t test. The mean IKDC score preoperatively was 40.8. The mean post-operative IKDC score was 80.6 with a SD of 13.2. The comparison of pre op & post op IKDC score was statistically significant with a p value <0.001.

Similarly, KOOS scores were calculated pre-operatively & post-operatively & was compared using Paired t test. The mean KOOS score preoperatively was 55.2. The mean post operative KOOS score was 87.5 with a SD of 15.9. The comparison of Pre-operative & Post-operative KOOS scores was statistically significant with a p value <0.001 [Table 1]. These scores were significantly better postoperatively because the stability of the joint was regained and the proprioception improved which in turn

improved the activities of daily living and they were back to their respective work. We also compared the TTDPM values in groups with isolated ACL tears and those with meniscal injuries. We found out that it was not significant (p-value 0.76) attributing to the fact that menisci has lesser mechanoreceptors than ACL.

Table 1: Comparing IKDC, KOOS AND T-L SCORES Pre-Operative and Post- Operative

	Mean	N	Standard deviation	Standard Error Mean	P-Value
IKDC Pre-operative	40.837500	30	13.1799640	2.3299105	<0.001
IKDC Post-operative	80.659375	30	8.1803407	1.4460936	
T-L Pre-operative	52.334	30	16.9663	2.9992	<0.001
T-L Post-operative	87.900	30	9.1668	1.6205	
KOOS Pre-operative	55.275000	30	17.2373001	3.0471530	<0.001
KOOS Post-operative	87.506250	30	7.3946335	1.3071989	

We did not find any significant difference in TTDPM between patients with normal BMI and those who are overweight; though the TTDPM was better in patients with BMI <25. Correlation between BMI & postoperative IKDC, KOOS & Lysholm Tegner Score was done and this correlation was not significant.

Discussion

Surgical management of anterior cruciate ligament deficient knee has evolved a long way from primary repair to extra capsular augmentation to anterior cruciate ligament reconstructions using biologic tissue grafts. In our study we have analyzed the functional & clinical outcomes of arthroscopic ACL reconstruction with remnant preserving technique in patients who underwent preoperative ACL exercises (GROUP A) and those who did not undergo preoperative exercises (GROUP B). The principal finding of this study was that the proprioception in ACL reconstructed knees was better in those who underwent preoperative ACL exercises. Even IKDC, KOOS & Lysholm-Tegner scores were compared & were found to be significantly better postoperatively.

We found the mean values of TTDPM in two groups as- Group A (1.33) and Group B (1.59). These results are comparable with Lee *et al* [14] where the mean values at 30 degrees of TTDPM were 1.79 (in group A-remnant > 20%) and 2.18 (in group B-remnant <20%). Our results were better than Lee *et al* who also used the CPM at the speed of 0.5°/s, probably because of the effect of preoperative ACL exercises. Angoules *et al* [15] found the mean values at 15 and 45 degrees to be 2.43 and 2.73 respectively. He did the assessment by moving the knee joints passively in angular velocity of 2° per second using the isokinetic dynamometer Con-Trex MJ (Con-Trex, Zyrich, Switzerland). Our results were better probably because we used the CPM velocity at lesser speed (0.5°/s) which will detect finest changes in proprioception. Previous studies have shown how BMI influences the outcome after ACL injury [12, 13]. An elevated BMI and weight alone or in combination with a narrow notch width were predictive of ACL injury in men, and elevated BMI in combination with narrow notch width were the only predictors of ACL injury in women. The average BMI was 25.6 and 24.4 kg/m2 for the injured and uninjured groups, respectively. Kowalchuk *et al* [16] found that obese patients (BMI greater 30 kg/m2) had 0.4 times the odds of having success after reconstruction than subjects with normal BMI. In our study the average BMI was 25.06 and none of the patient had BMI greater than 30 kg/m2. This along with small sample size makes it difficult to explain statistical significance and compare it with other studies.

We found out that all of our patients had vitamin D deficiency. Plasma Vitamin D (25-OH D2 and D3) was measured by using Chemiluminescence Immunoassay (CLIA) and reference range was set according to National Institute of Standards and Technology (NIST) as Deficient < 20 ng/ml, Insufficient <30 ng/ml and desirable >30 ng/ml [17]. We found out that TTDPM (30 degrees CPM) was better in patients with Insufficient Vitamin D (<30 ng/ml) than those with Deficient Vitamin (< 20 ng/ml); though we did not find any statistical difference. This could be attributed to 2 patients who had extreme values which must have influenced the mean.

Our study had the following limitations. These were relatively small sample size, ACL reconstruction done by two arthroscopic surgeons, Subjects were from different socioeconomic strata with different activity levels which will affect the IKDC, KOOS & Lysholm- Tegner Score, and Limited period of follow up (9 months).

Conclusion

We found statistically significant results of proprioception and joint position sense in patients who underwent preoperative ACL exercises compared to those who did not undergo. Functional evaluation of the reconstructed ACL was possible with this study which we were able to correlate with the BMI and Vitamin D levels. We incidentally found significant increase in postoperative Vitamin D without giving any supplements. This study may help to throw light on the need of preoperative ACL exercises in patients undergoing ACL reconstruction surgeries and also the need to preserve the ACL remnant.

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