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Evaluation of functional outcomes following anterior cruciate ligament augmentation

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ABSTRACT

Background: The anterior cruciate ligament (ACL) is the ligament of the knee, which plays a role for maintaining joint stability, which when damaged causes instability in movements. While ACL reconstruction aims to repair the torn ligament, patients are not confident in the stability and function of their knees. ACL augmentation preserves the neurovascular bundle, which can retain the proprioception and joint sensations. The aim of the study was to evaluate the functional outcome of patients post ACL Augmentation surgery.
Methods: This study was a cross-sectional, survey-based, observational one which included 38 patients who underwent arthroscopic ACL augmentation involving the anteromedial (AM) or posterolateral (PL) bundle. Knee function was assessed using the Lysholm and IKDC scoring systems during follow-up.
Results: Among 38 patients 25 were male and 13 were female with the most common age group being 31 to 40 years followed by 21 to 30 years. In terms of function, both scoring systems showed statistically significant improvement post-surgery.
Conclusions: ACL augmentation has significant positive functional outcomes as demonstrated by remarkable increases in the Lysholm and IKDC scores. These findings support the theoretical benefit that preserving the intact neurovascular fibers is beneficial and augmentation is a successful method for treating partial ACL tears.

Keywords: ACL augmentation, Proprioception, Lysholm knee score, IKDC subjective knee form

INTRODUCTION

The anterior cruciate ligament (ACL) of the knee is the central mechanism in a complex human movement that coordinates joint stability. When it is torn, it not only causes a disruption in the anatomy, but also leads to losing the confidence in movement itself due to instability. Surgical treatment of ACL injury has advanced within recent decades from simple reconstruction methods to augmentation measures in which the intact ligament remains as it is and is not removed.[1]

Ideally, ACL surgery would always be able to achieve near-native knee kinematics, attain early functional restoration, and reduce the possibility of graft failure or re-injury.[1] Both mechanical and psychological preparedness to resume sporting activity would be restored in patients. But this is hardly accomplished. Despite the technically successful reconstructions, many patients do not return to their preinjury level of sport even after 2 years.[2] The objective laxity perhaps is being corrected but the feeling of trust in the knee is usually lagging. Thus, this discrepancy between structural recovery and functional recovery complicates the measurement of actual recovery.

To overcome this limitation, different methods have been suggested with time; such as: single or double bundle reconstruction and now recently, augmentation. While ACL reconstruction is the substitution of the entire ligament, ACL augmentation tries to maintain proprioception and blood flow to the ligament by preserving the existing ligament fibers, and only repairing the damaged part.[3] It is developed to save the rest of the ligament fibers and restore the absent bundle which has shown favorable functional outcomes in previous studies, which may contribute to be beneficial in terms of morbidity reduction and improved graft healing.[4] The Lysholm knee scoring scale and International Knee documentation committee (IKDC) subjective knee evaluation are highly dependable and responsive scales to assess the functional outcomes of the ACL surgery, since recovery following the surgery is determined by measuring the pain, psychological confidence and performance in day-to-day activities.[5]

The aim of the study was to evaluate the functional outcomes at the postoperative period of patients who underwent ACL augmentation using the Lysholm and IKDC scoring systems, to compare the functional status changes between the preoperative and postoperative scales, and to add evidence on whether ACL augmentation could meet the theoretical benefit of functional improvement.

METHODS

Study design and setting

Since this was a study with no attempt to test a new surgical trick or intervention, only the cross-sectional type of study was needed, and this was precisely a cross-sectional survey-based, observational one because it was necessary to know how people really felt post-ACL augmentation, more specifically to repairs involving the anteromedial (AM) or the posterolateral (PL) bundle. This enabled us to collect honest information on patient reports of function and recovery and not subject anyone to another session of physical examination or imaging. We did not want to find out the objective measures, such as joint laxity or MRI changes, but rather what was important to patients, like if they could walk without being in pain, climb stairs or return to any athletic activity without hesitation.

The point was to measure the real-world outcomes with reference to patient-reported outcome measures (PROM) that are already well validated which include the Lysholm Knee Scoring Scale and the International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Form. They both are common methods of evaluating subjective experience: pain, swelling, confidence in movement, etc. into significant scores.[5-7] It is not an ideal system, of course, memory and perception may be mixed over time. However, in the case of a cross-sectional profile of lived recovery it is very effective. The general structure was also in line with the STROBE principles of observational studies, which assisted in maintaining its structure and clarity.[8]

The research was conducted at Starcare Hospital at Kozhikode, Kerala, which is a busy tertiary care facility and thus is not exempted in the number of sport and trauma cases of the knee. The patients who had undergone arthroscopic ACL augmentation involving the AM or PM bundle between the years January 2021 and January 2025 were included in our study, though additional meniscal repair was done in presence of intraoperative findings. The follow-up was not done until at least six months later when the early rehabilitation phase was completed. The survey would be administered over two months, in the fall of 2025 between October and November by means of structured phone interviews.

Participants

In the end, we obtained 38 patients which qualified. Every one of them had gone through ACL augmentation during the specified period and in which a follow up of a minimum period of 6 months had been completed. They obtained their information out of surgical records, and each was contacted in his or her turn. Participation was done verbally after obtaining consent, according to the ethical standards of the hospital or the Declaration of Helsinki.[9] The intervention was not new or clinically dangerous, so another institutional review board approval was not required but ethical oversight of the department was ensured. We selected patients aged between 16 and 55 years and male or female patients who had undergone arthroscopic AM or PM bundle augmentation with or without meniscal repair.

Exclusion criteria

Patients who had complete ACL reconstruction, multi-ligament injuries, revision surgeries, and incomplete follow-ups were not included. The point was to hold the group as close as possible to homogenous i.e. partial ACL tears treated with augmentation thereby being able to concentrate on pure functional recovery.

Equipment and materials

In order to collect data, we adopted a Functional outcome assessment form (see supplementary material 1). It is an administered questionnaire based on two proven scoring systems the Lysholm knee score and the IKDC subjective knee form.[5-7] They are responsive to change, and are effective in assessing the results of ACL, and they are good scales in which to measure functional recovery. The Lysholm score concentrates on such symptoms as pain, limp, swelling, instability and ability to climb stairs. The IKDC subjective knee form, however, creates a wider picture, under which pain and function are augmented with day-to-day activities and sport performance. They are both rated on a scale out of 100 with a higher rating showing a better functioning of the knee. Patients may use English or

Malayalam so as not to have lingual issues. The interviews have been undertaken by one trained investigator in order to ensure consistency and minimize bias of the interviewer.

Study procedures

The identification of patients began with hospital operative registry. The patients were contacted by phone and consent was given after their contact information was confirmed. The duration of each conversation was about ten minutes; each was a two-part format: before and after surgery. First of all, the participants were questioned to remember preoperative symptoms: pain, instability, or problems with daily activities. Their recollections were rated on Lysholm and IKDC criteria. During the second half, they rated their knee functionality at least 6 months after surgery. The comparison of the scores before and after the operation gave an idea of perceived change.

Recall bias was a concern. The interviewer minimized it with definite, activity-related examples instead of abstract numerical prompts and clarified answers with standard scoring instructions in the original manuals.[6,7] Completed forms were recorded right after completion and eventually tabulated in an encrypted database for analysis.

Outcome measures

The main outcome was the postoperative Lysholm and IKDC scores registered in the six months after the operation that depicted the complete recovery of the knees in terms of functions. The improvement between preoperative and postoperative scores were included as the secondary outcomes and provided us with the insight regarding the level of perceived functional change.

Statistical analysis

All collected data were entered and verified using Microsoft Excel and analysed using Python programming. Quantitative variables such as Lysholm and IKDC scores were expressed as mean and standard deviation, while variables such as age group and gender were presented as frequency and percentage. Comparison of preoperative and postoperative Lysholm and IKDC scores was done using the paired t-test. The difference in improvement between males and females was analysed using Welch's t-test, and the relationship between age and improvement in scores was assessed using Pearson's correlation test. A p value of <0.05 was considered statistically significant. Visualizations including boxplots, line (spaghetti) plots, pie charts, bar charts, and scatterplots were created to display the key findings clearly and support the statistical results.

RESULTS

The participants had a mean age of 32.05±9.52 years. Most patients were between 31 and 40 years of age (36.8%), followed by 21-30 years (34.2%). Males accounted for 65.8% of the study population, while females represented 34.2%, indicating a male predominance among ACL augmentation cases.

Both Lysholm and IKDC scores showed a marked postoperative improvement, increasing from mean preoperative values of 63.99 and 59.6 to 89.69 and 87.87, respectively. The improvement was statistically significant ($p<0.001$), indicating substantial recovery in knee function after ACL augmentation.

Females showed slightly higher mean improvements in Lysholm score (26.25 vs 25.40). Males showed a slightly higher mean improvement in IKDC score (28.86 vs 27.12). The differences between male and female participants were not statistically significant ($p>0.05$), suggesting that postoperative recovery was comparable across genders.

The relationship between age and postoperative improvement was weak and statistically insignificant for both Lysholm ($r=-0.12$, $p=0.472$) and IKDC ($r=0.21$, $p=0.198$) scores, indicating that patient age did not have a meaningful effect on the extent of functional recovery.

Table 1: Characteristics profile of the study participants.

Characteristics	N (%)
Age group (years)	
≤20	3 (7.9)
21-30	13 (34.2)
31-40	14 (36.8)
41-50	7 (18.4)
>50	1 (2.6)
Mean±SD	32.05±9.52
Gender	
Male, n (%)	25 (65.8)
Female, n (%)	13 (34.2)

Table 2: Comparison of preoperative and post-operative functional outcome scores.

Functional outcome scores	Pre-operative	Post-operative	P value
Lysholm	63.99±4.79	89.69±4.16	<0.001*
IKDC	59.6±5.36	87.87±5.35	<0.001*

Note: *-significant.

Table 3: Comparison of functional improvement by gender.

Outcome	Mean±SD		
	Male	Female	P value
Lysholm improvement	25.40±2.71	26.25±2.89	0.389
IKDC improvement	28.86±3.79	27.12±3.06	0.135

Table 4: Correlation between age and improvement in functional outcome scores.

Relation	Pearson r	P value
Age-Lysholm improvement	-0.12	0.472
Age-IKDC improvement	0.21	0.198

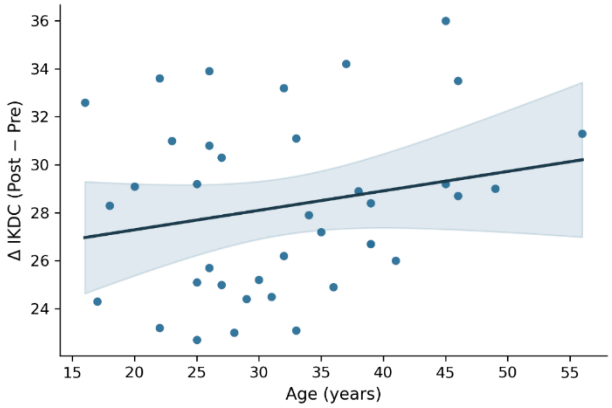

Figure 1: Relationship between age and improvement in IKDC score.

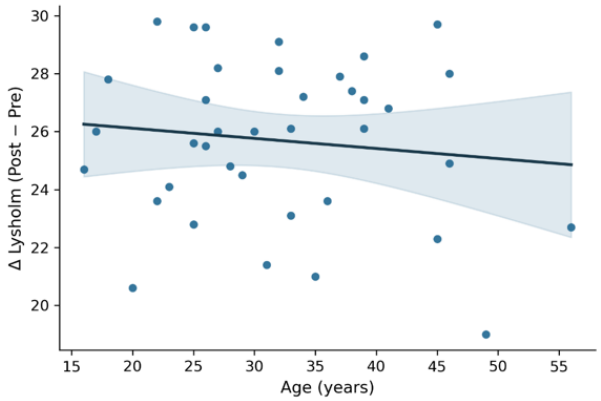

Figure 2: Relationship between age and improvement in Lysholm scores.

DISCUSSION

The major observation of the current study was that the functional outcomes, based on the Lysholm and IKDC scores, had improved substantially following selective ACL augmentation. Patients moved from moderate preoperative restrictions to almost normal postoperative functioning, and the same was applicable among the age groups and between males and females. These advances aid in supporting the theoretical hypothesis that maintaining ACL bundle intact is important with regard to the postoperative recovery in preservation of proprioceptive fibers, vascular routes and the native collagen structure, which enable graft assimilation, neuromotor control, and knee joint steadiness.[10]

Preservation of the remnant fibers of the anterior cruciate ligament (ACL) could help in the provision of residual stability to the injured knee. The evidence behind this is shown by Crain et al who found that some scar patterns in the ACL remnant could reduce anterior tibial translation, implying the presence of some mechanical constraint in remnant tissue.[11] The biological relevance of preservation of the tissue remnant has been demonstrated by Bray et al., who showed that there were observable vascular changes in remnant tissue of partially injured ligaments indicating biological activity.[12] Adachi et al demonstrated that ACL harbors mechanoreceptors that are imperative in sense of position of the joint, and that preservation of native fibers could be beneficial in the recovery of proprioception following reconstruction.[13] This fact was also supported by Georgoulis et al. who demonstrated that retention of native fibers may be beneficial in recovering proprioception after reconstruction because of the presence of viable mechanoreceptors within the ACL remnants.[14] In terms of clinical outcomes, remnant-preserving techniques have shown to be the same, or even better, in terms of outcomes, to conventional ACL reconstruction. Hu et al. have conducted a systematic review finding equal or slightly better Lysholm and IKDC scores after selective augmentation, better anterior stability and fewer tibial tunnel widenings.[15] Xie et al have supported the hypothesis by observing improved pivot-shift grading and reduced tunnel widening in patients undergoing remnant-preserving reconstruction.[16] Evidence of sensory neuron regeneration after remnant-augmented ACL reconstruction by Ochi et al and reviews by Muneta and Koga and by Rothrauff et al. also confirmed the premise of fast graft integration and recovery.[17-19] Objective biomechanical studies supported the premise. Kondo et al. demonstrated the best graft morphology and increased stability in remnant-preserving double-bundle reconstruction.[20] ACL remnants contain rich vascularity and neural elements, which are further supported by histological studies by Sonnery-Cottet et al and Nayak et al as the reasons behind their preservation during reconstruction.[21,22]

These theoretically determined biomechanical patterns are in line with the theoretical foundation of ACL augmentation that is to provide sufficient anterior stability without compromising the intact bundle. Both the Lysholm and IKDC scores in our study show the great postoperative outcomes resulting in the idea of selective augmentation to restore necessary biomechanical function.

There are a number of limitations that should be considered. The small sample size limits the possibility to distinguish the demographic latent effects of the outcome. The lack of comparison group will not allow conclusive finding on whether it is superior or identical to full reconstruction. The scoring system based on telephone creates bias associated with recall, specifically in the case of retrospective preoperative scoring. Also, there was no objective stability testing, like KT-1000 arthrometry or pivot-shift grading, which limited the correlation of subjective with mechanical stability. Follow-up through

MRI was not also included so graft maturation and remnant preservation was not measured.

Future studies should involve prospective randomization trials between augmentation and reconstruction in Kerala so as to produce region-specific evidence. The objective laxity test, proprioceptive test, and MRI evaluation of graft remodeling should be incorporated in the clarification of hypothetical benefits. The long-term outcome of the study, i.e., that took place more than five years later, will be the answer to the question concerning the longevity of the positive short-term outcome. Lastly, qualitative studies based on patient confidence, readiness to resume activities, and perceived stability might be used to gain further knowledge on functional recovery.

CONCLUSION

To conclude, this study proves that ACL augmentation is associated with significant positive outcomes in knee functioning, remarkable increases in the Lysholm and IKDC scores, and also no demonstration of demographic differences in the recovery. The findings are in line with world literature supporting remnant-sparing ACL procedures and are one of the first Kerala based evidence showing the efficacy of these techniques. Despite the limitations, partial ACL tear can be treated by selective augmentation, and its results highlight the possibility of success of this method.

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