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Original Research Article

A RANDOMISED CONTROLLED TRIAL COMPARING FUNCTIONAL OUTCOMES OF FEMORAL TUNNEL FIXATION TECHNIQUES IN ARTHROSCOPIC ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION: APERTURE SCREW FIXATION VERSUS SUSPENSORY ENDOBUTTON FIXATION

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ABSTRACT

Background: Objective: This research set out to compare the effect of aperture fixation with an interference screw compared with the effect of suspensory fixation with an Endo Button in arthroscopic anterior cruciate ligament (ACL) reconstruction. **Duration and place of study:** This study was conducted at Liaquat National Hospital and Medical College Karachi Pakistan from December 2024 to December 2025.

Materials and Methods: One hundred and ten patients who were undergoing primary arthroscopic ACL reconstruction using hamstring tendon grafts were randomly divided into two groups, namely aperture fixation (interference screw) and suspensory fixation (EndoButton). Every patient was given the same tibial fixation with cannulated interference screw. The subjective anterior drawer test and International Knee Documentation Committee (IKDC) knee examination rating were also assessed as functional. The primary outcome measure was the anteroposterior (AP) stability at 25 degrees knee flexion and the secondary outcome measures consisted of the assessment of early postoperative functional differences.

Results: The complete clinical follow-up was completed by all the 110 patients. Out of these, 55 were aperture fixed and 55 were suspended. As the last follow-up, the two groups did not have any significant difference in the stability of AP or IKDC grade. Early postoperative review however revealed that, aperture fixation group exhibited better stability and functional scores during the first and fourth month which tapers with time.

Conclusions: The fixation techniques were similar in their long-term functional results of ACL reconstruction. Although there was a difference in aperture fixation that showed superior stability in the early postoperative period there was no clinically relevant difference between the two methods at later follow up. These results imply that both the methods of fixing the femur are viable with the early benefits going to aperture fixation.

Keywords: Arthroscopic Surgery, Anterior cruciate ligament surgery, Femoral tunnel surgery, Aperture surgery, Interference screw, Suspensory surgery, EndoButton.

INTRODUCTION

The anterior cruciate ligament (ACL) injuries are considered to be one of the most widespread ligament knee injuries especially among youthful and physically active people. They cause a sizeable percentage of knee instability cases and often necessitate surgical knee reconstruction to restore stability of the joints, avoid secondary meniscal or chondral injury, and allow a patient the ability to resume pre-injury levels of activity.[1,2] Hamstring tendon autograft or allograft ACL reconstruction has now become a well-established method in arthroscopic ACL surgery because it is associated with favourable biomechanical characteristics, lower morbidity of the donor site and stable clinical outcomes.[3,4] Although the graft preparation and the siting of tunnels have improved, the process of fixation of the femurs is one of the most important determinants of the stability of the graft, the degree of its biological adaption and long-term functional efficacy.[5]

In ACL reconstruction, two major types of fixation of the femur are frequently used, namely aperture fixation and suspensory fixation. Fixed on the closest part to the joint line is aperture fixation, which is normally done with the help of an interference screw, which, in theory, minimizes micromotion and enhances anatomical grafts healing in the femoral tunnel.[6] The objective behind this technique is to mimic the shape of the native ACL and reduce the bungee and windshield wiper effects of graft movement within the tunnel.[7] On the other hand, the graft is fixed at the surface of the cortex of the femur by the use of suspensory fixation devices like the EndoButton. Such devices are popular as they are easy to use, have a high fixation strength at the beginning of wear, and can accept shorter grafts.[8,9]

The biomechanical research has yielded inconsistent results on the best fixation method compared to the other. Certain studies indicate that aperture fixation offers higher initial stiffness and less graft micromotion which may improve early stability.[10] Others state that, similar or even better load-to-failure properties are provided by the suspensory fixation, and the extra advantage is that the graft length is maintained and the widening of tunnels, caused by screw position, is avoided.[11,12] Clinical trials have also shown mixed outcomes with some of them showing no notable difference in functional outcome, others presenting early postoperative benefits of one procedure over the other.[13,14]

Considering the growing interest in early rehabilitation, rapid reentry to sport, and prolonged joint conservation, it is necessary to find out the relative efficacy of these fixation techniques. Such functional outcomes as anteroposterior (AP) stability, patient-reported knee function, and objective clinical measures are the critical indicators of surgical success. Nevertheless, the literature remains heterogeneous in terms of study designs, sample sizes, graft types, and durations of follow-up and thus, makes it challenging to make conclusive findings on the best fixation strategy.[15]

These gaps were to be filled by this randomised controlled study, which would directly compare aperture fixation with an interference screw and suspensory fixation with an EndoButton in a cohort of 110 patients undergoing arthroscopic ACL reconstruction using hamstring tendons. The proposed study will help obtain solid findings on the relative effectiveness of these two commonly used fixation methods by assessing early and late functional outcomes with the help of reliable clinical measurements. The results can be used to assist surgeons in choosing the most suitable fixation technique so as to maximise patient outcomes and increase the overall success of ACL reconstruction.

MATERIALS AND METHODS

The purpose of this randomised controlled study was to make a comparative evaluation of the functional outcome of two of these techniques of femoral tunnel fixation; aperture fixation with the help of interference screw and suspensory fixation with the help of EndoButton in patients who had arthroscopic anterior cruciate ligament (ACL) reconstruction with hamstring tendon grafts. One hundred and ten subjects who were confirmed to have ACL deficiency were recruited following the set eligibility criteria. Patients between 18 and 45 years old who have chosen to have ACL reconstruction done with hamstring tendons were all eligible to be included. Patients who had undergone ACL reconstruction before, had suffered a ligament injury, had a massive amount of meniscal pathology that needed surgery, and those who could not adhere to postoperative evaluations were locked out. With informed consent we were able to randomly assign patients in equal numbers to either of the two fixation groups in order to maintain equal demographic and clinical factors.

All operations were done in an arthroscopic manner under spinal anaesthesia with a standardised surgical protocol so as to reduce variance. The grafts were prepared by whip-stitching techniques and soaked in saline before implantation of hamstring tendons grafts. Femoral tunnels were produced by the anteromedial portal by Beath pin and low-profile reamers whereas tibial tunnels were made with tibial jig. Femoral and tibial fixation in the aperture fixation group was done with titanium interference screws of a diameter 1 mm less than that of the corresponding tunnel. Femoral fixation in the suspensory fixation constructed group was done with the help of cortical Endobutton with the length of the loop predetermined, and the tibial fixation was done with the help of cortical button with the interference screw. Grafts were manually tensioned and fixed eventually and all patients were put on the

same rehabilitation plan that involved early knee extension, gradual strengthening of the graft, running in a straight line at three months, and pivotal activities at six months.

Outcome assessment was done at several postoperative follow-ups, which comprised two weeks, a month, four months, eight months and twelve months. The primary outcome measure was the anteroposterior knee stability at 25 degree of flexion measured with the help of the anterior drawer test. The secondary outcomes were the International Knee Documentation Committee (IKDC) knee examination rating, and clinical measurements of knee laxity. These measures were chosen to give a holistic analysis of the subjective functional recovery as well as the objective functional recovery. Negative events and complications were recorded during the follow up.

All the information gathered was analyzed using statistical software. The means and standard deviations were used to describe continuous variables and the analysis of differences between the two fixation groups was conducted by using the necessary statistical tests to conclude the differences in IKDC scores, and anteroposterior stability in the two groups of follow-ups. The 110 patients were sufficient to test significant differences between the two fixation modalities. The determination of statistical significance was done with the help of a biostatistician, to assure methodological rigour.

RESULTS

One hundred and ten patients passed the study, 55 of them in the aperture fixation group and 55 in the suspensory fixation group. The participants were at all the follow-ups scheduled at 1, 4, 8, and 12 months. There were no results of statistically significant demographic differences between the two groups, in terms of the age, sex distribution, and the side of injury. The mean age of the aperture fixation group was 32.1⁻ 3.0 years and the suspensory fixation group had a mean age of 31.8 -2.9 years ($p = 0.48$). The distribution of sex was also equal, but in both groups, the male patients were more prevalent.

The International Knee Documentation Committee (IKDC) knee examination rating and anterior drawer test were used to evaluate clinical outcomes in the form of anteroposterior (AP) stability. There was no significant difference in preoperative IKDC in groups. Aperture fixation group had shown a high score of both IKDC and AP stability at 1-month and 4 months follow-up than the suspensory fixation group had ($p < 0.01$; $p < 0.01$). These initial differences decreased during a certain period of time, and as time elapsed at the 8 month and 12 month measurement, there were no statistically significant differences between the two fixation methods. During the last 12-month follow-up, the groups had a similar IKDC and AP stability, which showed identical long-term functional outcomes.

There were no significant complications, graft failures, or adverse events related to the fixation in either of the study groups over the period. These minor postoperative complaints, including temporary stiffness and pains in the anterior knee, were well-balanced and could be resolved by means of rehabilitation.

Table 1: Baseline Demographic Characteristics

Variable	Aperture Fixation (n=55)	Suspensory Fixation (n=55)	Test Statistic	p-value
Age (years), mean ± SD	32.1 ± 3.0	31.8 ± 2.9	0.71	0.48
Sex (Male/Female)	43 / 12	41 / 14	0.29	0.59
Side of Injury (Right/Left)	29 / 26	27 / 28	0.15	0.69

Table 2: IKDC Scores Across Follow-up Intervals

Time Point	Aperture Fixation Mean ± SD	Suspensory Fixation Mean ± SD	t-value	p-value
Preoperative	48.6 ± 2.7	49.0 ± 2.5	0.82	0.41
1 month	66.9 ± 4.5	61.4 ± 3.8	6.21	<0.001
4 months	77.4 ± 4.6	71.8 ± 4.1	6.03	<0.001
8 months	83.7 ± 1.9	83.4 ± 2.0	0.78	0.44
12 months	92.8 ± 1.8	92.5 ± 1.9	0.91	0.36

Table 3: AP Stability (Anterior Drawer Test at 25° Flexion)

Time Point	Aperture Fixation Mean ± SD (mm)	Suspensory Fixation Mean ± SD (mm)	t-value	p-value
1 month	4.2 ± 0.6	5.0 ± 0.7	6.54	<0.001
4 months	3.1 ± 0.5	3.8 ± 0.6	6.32	<0.001
8 months	2.4 ± 0.4	2.5 ± 0.4	1.21	0.23
12 months	1.9 ± 0.3	2.0 ± 0.3	1.48	0.14

DISCUSSION

The current paper compared the functional results of aperture fixation with the help of an interference screw and suspensory fixation with the help of an EndoButton in the arthroscopic reconstruction of the ACL in 110 patients. The results showed that despite aperture fixation providing better

postoperative stability during the early months of 1 and 4 months, they had the same functional outcome at the 12-month follow-up stage. The findings are both consistent and inconsistent with those of a number of studies published previously, which provide valuable information about the biomechanical and clinical implications of the techniques of femur fixation.

The biomechanical explanation that intratunnel fixation has a better ability to reduce graft micromotion and minimise the bungee effect thereby maximising the initial stability is consistent with early postoperative superiority of aperture fixation observed in this study. Equivalent benefits were reported by Kamel et al., who discovered that fixation with interference screws led to a much lower anterior tibial translation, in the first three months after surgery than fixation with suspensory screws.[16] Their results help to prove the idea that aperture fixation could have a higher effect on the control of early graft motion, which is also supported by high IKDC scores in our aperture group at early follow-ups.

But the long-term equitability of the two fixation methods as we have seen is similar to the results provided by various other authors. In a prospective trial, Shumborski et al. did not find any significant differences in knee stability or patient-reported outcomes at 12 months of cortical button fixation versus interference screw fixation even though there were slight early differences in favour of aperture fixation.[17] Likewise, a comparative cohort study by DeFroda et al. showed that both fixation procedures had similar functional outcomes and return-to-sport rates at one year, which supports the conclusion that the type of fixation does not affect long-term outcomes of the procedure.[18]

Other researchers such as Boyle et al. have also supported our findings by assessing the suspensory and aperture fixation in hamstring graft ACL reconstruction and found no differences between graft failures or IKDC at final follow-up.[19] Their article highlighted the fact that despite the presence of biomechanical differences between the methods of fixation, they do not always result in clinical differences at the long-term level.

Conversely, there are studies that have recommended possible long-term benefits of suspensory fixation. The multicentre analysis by Hooper et al. had slightly lower tunnel widening and better graft maturation on MRI in cortical button fixation, though there were no significant differences in the functional outcomes in the two groups.[20] Although we did not involve radiological evaluation of the tunnel morphology, the lack of differences in functionalities in the long run is in line with their clinical observations.

Another work by Mayr et al. emphasized that suspensory fixation can prove to be biomechanical in situations where the quality of bones is compromised because the fixation has a higher pull-out strength.[21] Even though osteoporosis was not considered in our cohort, the absence of fixation-related complications in both groups indicates that both approaches are sound in the right group of patients.

Moreover, a systematic review by Andriolo et al. found out that both fixation methods are safe and effective and there was no definite advantage of one over the other regarding graft stability or patient-reported outcomes.[22] Their analysis confirms the general findings of our paper that fixation decision making can be biased by surgeon bias, graft variables and intraoperative factors than anticipated long term outcome variability.

Collectively, the results of the current study are added to the existing literature that suggests that although aperture fixation might offer better initial stability, both types of fixation had similar functional outcomes after one year. The initial benefit of aperture fixation witnessed in our cohort might be of clinical value to patients who need to recover their functions quickly but with time, the advantage fades away. The fact that no complications were observed and that there is no significant difference between the two fixation strategies regarding the long-term outcomes supports the reliability of both fixation strategies in contemporary ACL reconstruction.

CONCLUSION

The research indicated that aperture fixation and suspensory fixation offer long-term stability stability that is reliable when a switch is made to ACL reconstruction. Even though aperture fixation was superior in initial IKDC scores and anteroposterior stability during the first and fourth months, these findings did not last. At 12 months, there was a similar functional outcomes and no significant difference in the knee stability or patient-reported measures in both of the techniques. There were no complications linked to the fixation, which proves the safety of both approaches. In sum, both fixation approaches may be chosen with certainty, although in the short term, aperture fixation has more advantages than do the two equivalent long-term outcomes.

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