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Original research article

Femoral tunnel widening after anterior cruciate ligament reconstruction with hamstring graft: A comparitive analysis between three different fixation methods

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Abstract

Background: Comparative analysis of three different fixation techniques for femoral tunnel widening following hamstring graft anterior cruciate ligament reconstruction.

Materials and Methods: The prospective comparative study was used. All the patients operated from November 2021 to October 2022 at Department of Orthopedics, Lakshmi Narayana Institute of Medical Sciences, Puducherry, India, with unilateral Anterior Cruciate Ligament tears which fit into the criteria were included in the study.

Results: 15 patients had interference screws, 13 had rigidfix, and 23 had endobutton on the femoral side of 51 patients. In the Endobutton group, the IKDC 2000 Subjective Knee Evaluation score improved by 37.82 points (range, 23 to 48), in the Transfix group by 40.92 points (range, 32 to 50), and in the bioscrew group by 38.5 points (range, 27 to 48). Transfix group (31.56%) has larger midlevel (C2S2) widening than interference screw (22.45%) and endobutton (20.01%). Interference screws (35.89%) had larger tunnel widening than transfix (30.26%) and endobutton (21.85%) at aperture level (C3S3).

Conclusion: Endobutton reduced femoral tunnel widening more than Transfix and Interference screws. Transfix group's sagittal sections had higher tunnel widening at the aperture and midway than coronal sections due to transtibial technique's obliquity, which caused more tunnel widening. Screw entrance at aperture level caused interference group tunnel widening. However, At one year, all groups had similar clinical findings and knee laxity. These findings need more large-scale controlled investigations.

Keywords: Prospective comparative study, hamstring graft, femoral tunnel widening, ACL.

Introduction

Rupture of the anterior cruciate ligament (ACL), a common knee ligament injury, is more common in physically active people than in the general population [1]. Osteoarthritis after knee trauma, pain, functional restrictions, and a lower quality of life can all result from this ACL injury [2, 3].

For femoral graft fixation during anterior cruciate ligament (ACL) reconstruction, several options are available. The ideal method for femoral fixation has not been determined, despite the fact that several techniques are available. The intra-osseous interference screws fixation, transfemoral cross-pin fixation, and cortical button fixation are the three most popular methods for femoral fixation.

Recent meta-analyses found no statistically significant difference between cortical button femoral fixation and cross-pin femoral fixation in terms of clinical outcomes or postoperative knee laxity [4, 5].

Methodology

51 patients who underwent single bundle ACL reconstruction using a 4-strand semitendinosus and gracilis tendon autograft at Department of Orthopedics, Lakshmi Narayana Institute of Medical Sciences, Puducherry, India, from November 2021 to October 2022 were included in the study. The study included 42 men and 9 women out of them.

Inclusion criteria

- Age: 15-50y
- Unilateral ACL tear
- ACL with meniscal rears

Exclusion criteria

- Bilateral acl tears

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- ACL with PCL tears
- Associated fractures
- H/o previous knee surgery
- Mechanical or anatomic malalignment

Results

Gracilis tendon and 4-strand semitendinosus tendon autografts were used in a prospective case series of 51 patients who underwent single bundle ACL reconstruction. The study consisted of 42 men and 9 women from among them. Three fixation devices were used on femoral side namely interference screw, rigid fix and endobutton. Interference screw was used in all cases on tibial side. Intraoperatively tunnel diameter was measured and noted.

Postoperatively all patients were followed at one week, one month, 3months, 6 months and one year. Patients were instructed about physiotherapy and were evaluated periodically. At the end of one year all patients were undergone CT scan evaluation and analysis was done.

Table 1: Sex and age distribution.

Patient	Cases
Males	42
Females	9
Age<35 Years	31
Age>35 Years	20

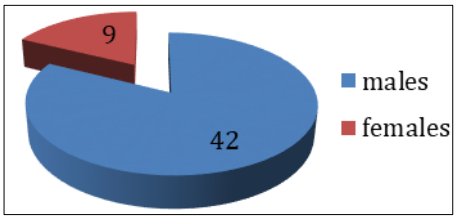

Fig 1: Sex distribution

Table 2: Distribution of fixation devices

Type of fixation	51 patients
Rigid fix (transfix)	13
Bioscrew (interference screw)	15
Endobutton	23

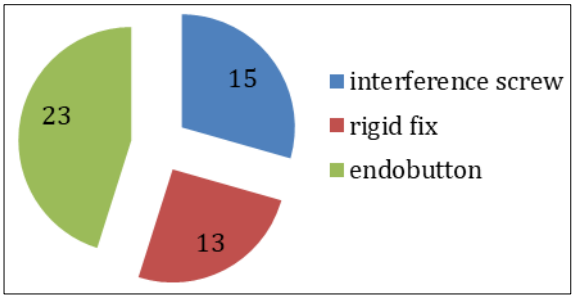

Fig 2: Distribution of fixation devices

In 51 patients, the graft was secured on the femoral side with an endobutton in 23, rigidfix in 13, and interference screws in 15. All of the screws on the tibial side were bioresorbable.

Table 3: Clinical scores

Clinical scores	Pre OP	6 months	1 year
IKDC	44	69	83
Lysholm	51	74	88

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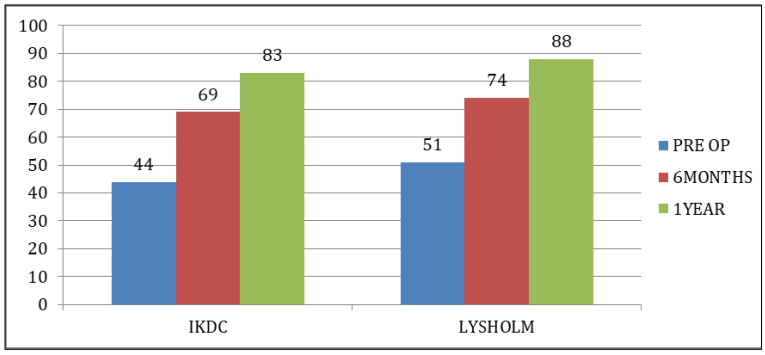

Fig 3: Clinical Scores

On average IKDC score was 44 preoperatively, which after the end of 6 months and one year increased to 69 and 83 respectively in all the patients. On the other side LYSHOLM score was 51 preoperatively, which at the end of 6 months and one year postoperatively increased to 74 and 88 respectively.

Table 4: Clinical scores in different age groups

	Number of patients	Pre OP IKDC	Pre OP Lysholm	Post op IKDC	Post op Lysholm
Group 1 Age <35y	31	45	52	85	87
Group 2 Age >35y	20	43	51	79	86

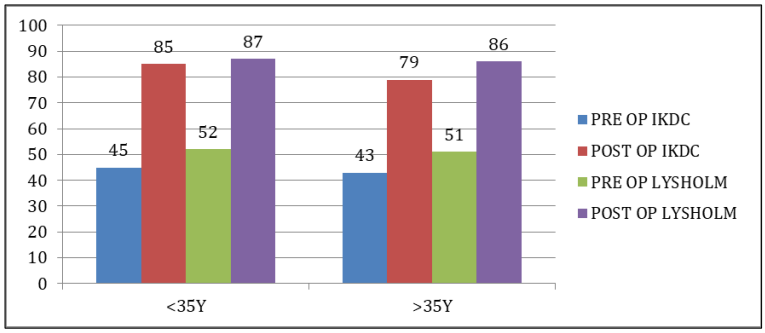

Fig 4: Clinical scores in different age groups

Preoperative and postoperative clinical scores were computed in two different age groups. In comparison to older age groups, younger age groups show greater improvement in IKDC scores. In LYSHOLM scores, both values were equal. Given that neither group has any osteoarthritic changes, there is no statistically significant difference between the two groups (P>.05).

Improvement in clinical scores

Clinical results

Clinically all the patients were evaluated, and clinical scores were collected. These scores were compared with preoperative scores and tabulated in the columns. The Lysholm score grew by an average of 37.30 points (range, 26 to 45) in the EndoButton group, 35.07 points (range, 28 to 44) in the Transfix group, and 35.26 points (range, 25 to 43) in the Bioscrew group at the end of the year (P>.05).

The mean improvement in the IKDC 2000 Subjective Knee Evaluation score (range: 23–48) was 37.82 points for the EndoButton group (P>.05), 40.92 points for the Transfix group (P>.05), and 38.5 points for the bioscrew group (P>.05). For all three groups, the clinical outcomes are essentially identical. The three groups did not significantly differ in the widening of either of the clinical scores.

Table 5: Average improvement of clinical scores in different fixation devices

	IKDC Score Improvement	Lysholm score improvement
Rigid Fix	40.92	35.07
Bioscrew	38.5	35.26
Endobutton	37.82	37.30

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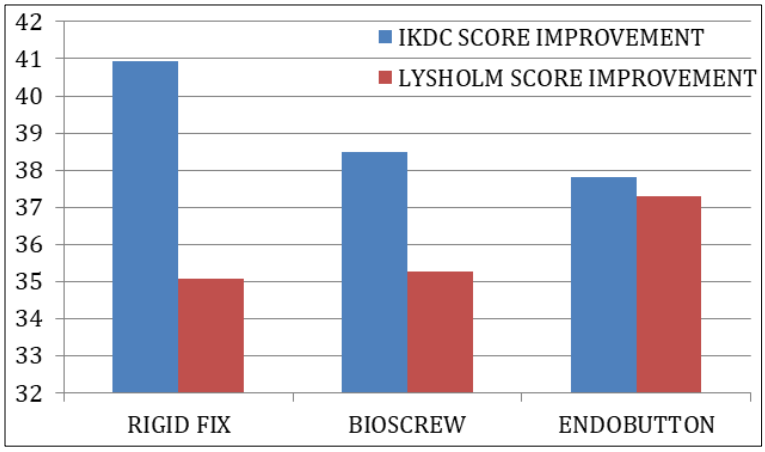


Fig 5: Average improvement of clinical scores in different fixation devices

Radiological outcome

CT scan was used for all bone tunnel measurements after the end of one year postoperatively. Oblique sagittal and oblique coronal views were reconstructed and interpreted by a radiologist and there after measured twice by consensus of 2 orthopaedic surgeons. Tunnel diameters were measured at three levels in the femoral side at suspension level (C1S1), midlevel (C2S2) and aperture level (C3S3). Tunnel widening was measured comparing the intraoperative and post operative tunnel measurements.

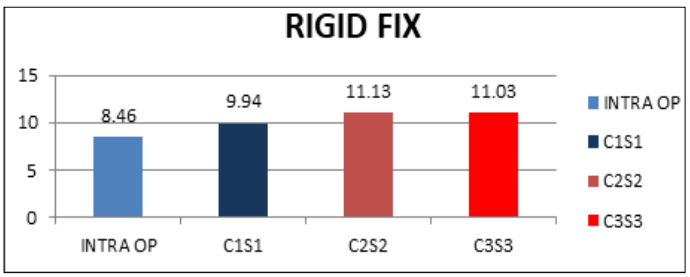
Except in the Transfix group, where the widening was highest at midway (C2S2 >C3S3>C1S1), the femoral tunnel diameters showed a progressive increase at all levels at one year. More widening was seen at the aperture, followed by midway and suspension point. At the suspension point (C1S1) in all three fixation devices, the widening was least.

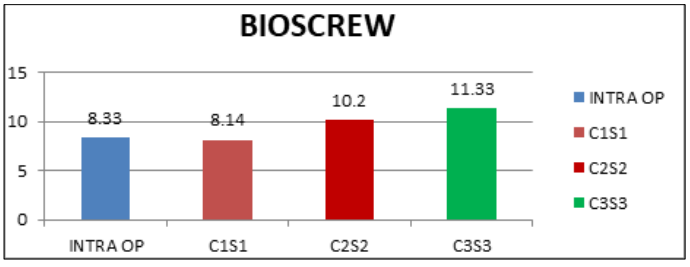
At the aperture level (C3S3), interference screw fixation widening is greater while endobutton fixation widening is less. Widening was greater in the transfix group and less in the endobutton group at midlevel (C2S2) and suspension point (C1S1). In a comparison of the three groups, the endobutton group exhibits less tunnel widening than the transfix group.

According to Nebelung *et al*., [6] classification of tunnel widening, there was massive enlargement on the femoral side in two cases of the transfix group at midlevel (C2S2), and there was massive enlargement in three other cases (C3S3), two of which involved interference screws and the third involved an endobutton group. At midlevel (C2S2), 6 cases in the EndoButton group, 4 cases in the Transfix group, and 4 cases in the interference screw group all demonstrated clear enlargement on the femoral side. Five cases of endobutton, seven cases of interference screw, and six cases of transfix group showed clear enlargement at (C3S3) Aperture level. In the majority of cases, the enlargement was merely marginal.

Table 6: Measurements of tunnel diameter (mm)

	Intra OP	C1S1	C2S2	C3S3
Rigid FIX	8.46	9.94	11.13	11.03
Bioscrew	8.33	8.14	10.20	11.33
Endobutton	8.1	8.75	9.84	9.92





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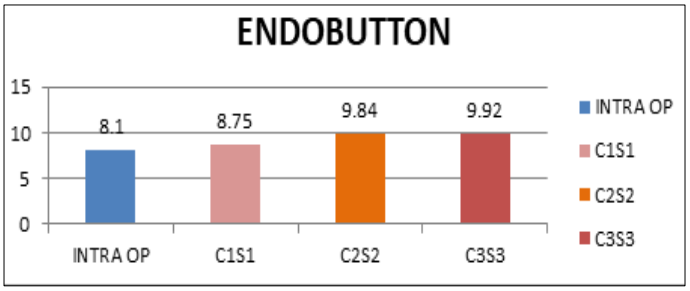

Fig 6: Tunnel diameters in different fixation devices

Table 7: Tunnel widening in millimeters (MM)

Tunnel Widening	Rigid Fix	Bioscrew	Endobutton
C1S1 Level	1.48	0.41	0.62
C2S2 Level	2.67	1.87	1.67
C3S3 Level	2.56	2.99	1.77

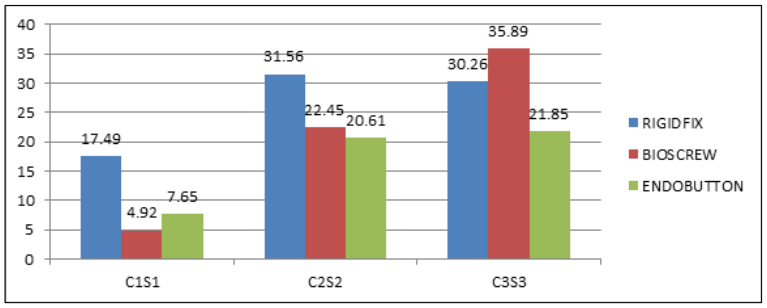

Fig 7: Tunnel widening in percentage (%)

Tunnel widening measured in percentages in three fixation devices at three levels. At the suspension (C1S1) point, there is more tunnel widening in transfix group compared to other two fixation devices with significance of P value <.05. In midlevel (C2S2) also there is more tunnel widening in transfix group compared to other two groups without any statistical significance (*P*>.05). In interference screw and endobutton groups there is less tunnel widening compared to other studies. At aperture level (C3S3) widening is more in interference screw fixation and least in endobutton fixation. At aperture level (C3S3) there is more widening in interference screw will be explained by entry of the screw at the aperture level.

Table 8: Tunnel widening in percentage (%)

Tunnel widening in percentage (%)	Rigid fix	Bioscrew	Endobutton
Suspension Point (C1S1) Level	17.49	4.92	7.65
Mid Point (C2S2) Level	31.56	22.45	20.61
Aperture Level (C3S3)	30.26	35.89	21.85

At the suspension (C1S1) level, the tunnel widening is 17.49% which is significantly more compared to interference screw group (4.92%) and endobutton group (7.65%) with statistical significance (*p*<.05) in transfix group. At midlevel (C2S2) widening is more in transfix group (31.56%) compared to interference screw group (22.45%) and endobutton group (20.01%). At aperture level (C3S3) level it is the interference screw group (35.89%) showing more tunnel widening compared to transfix (30.26%) and endobutton (21.85%). At midlevel and aperture level there is no significant difference between the three groups (*P*>.05).

Discussion

In order to provide each patient with a strong graft with fixation that can withstand the stress placed on the knee, ACL surgery is performed. The primary goal of this study was to examine how the graft fixation complex contributed to the development of Tunnel Widening following hamstring ACL surgery. Although its impact on graft incorporation has not yet been established, tunnel widening after ACL reconstruction has been amply demonstrated to be a negative finding. No relationship exists between tunnel widening and the early functional outcome (up to 2 years). The only study in which a cause-and-effect relationship was established between tibial tunnel widening on lateral radiographs and anterior knee laxity was Kate E. Webster *et al.*'s [7] analysis. Because bone grafting is required to fill in the widened bone tunnels as the first stage of a two-stage procedure, tunnel widening may make revision ACL surgery more difficult.

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On all groups of sagittal sections from the femoral side, the tunnel widening at the aperture and midway was greater than on the coronal sections, whereas it was roughly the same at the proximal end. This result could be explained by the graft's obliquity with respect to the sagittal plane, which might have magnified the windshield-wiper effect more potently in the mediolateral direction than the anteroposterior direction.

According to Philip Cheung *et al.* [8], the overall mean tunnel widening at all measured sites was 2.7 mm for cross pins and 1.8 mm for bioscrews at the 2-year follow-up and 2.5 mm at the 5-year follow-up, respectively. In comparison to the bioabsorbable screw group, the femoral tunnel widened more in the cross pin group.

Peter Fauno, *et al.* [9] came to the conclusion that using fixation points close to the joint reduced Tunnel Widening significantly compared to a system where the distance between the fixation points was great. He came to the conclusion that major contributing factors to the development of Tunnel Widening following ACL surgery are the location of the fixation sites and the type of fixation device.

As per the grading of tunnel widening suggested by Nebelung *et al.*, [6] two cases had massive enlargement on femoral side in the transfix group at midlevel (C2S2) and Three cases showed massive enlargement at aperture level (C3S3) among which two are interference screw and the other one is endobutton. Clear enlargement was seen on the femoral side in 6 cases in the EndoButton group and 4 cases in the Transfix group and 4 cases in interference screw group at midlevel (C2S2). At (C3S3) Aperture level 5 cases in endobutton, 7 cases in interference screw and 6 cases in transfix group showed clear enlargement. The majority of cases only had marginal enlargement.

In contrast to drilling through the tibial tunnel, Yan Xu *et al.* [10] demonstrated that drilling the femoral tunnel through the medial portal produced a tunnel that was lower, more posterior, and less vertical. With more anterior, more proximal, and more vertical femoral tunnels, femoral and tibial tunnel enlargements were greater. The femoral tunnel can be drilled from the medial portal, which will lead to smaller postoperative tunnel enlargements even though there were no clinical differences between the two groups. In our study also we used transtibial technique for transfix and medial portal techniques for interference screw and endobutton. In our study, rigidfix showed more tunnel widening compared to other fixation devices may be due to the use of transtibial technique. Due to the obliquity of the tunnel, there was no clinical difference in the tunnel widening at the aperture and midway in either group compared to the coronal sections.

Sabat *et al.*, [11], In comparison to the EndoButton group, the Transfix group experienced significantly less femoral tunnel widening. In a cadaveric study, To *et al.* discovered that the fixation method, rather than the graft itself, was largely responsible for the stiffness of a graft-graft fixation complex and that the close-to-joint transcondylar fixation method was superior to the EndoButton method. But in our study, tunnel widening was more in transfix group at mid (C2S2) level compared to endobutton and interference screw.

At suspension point (C1S1), widening is more in transfix group compared to other two groups. Transfemoral biodegradable implants may fracture or deform after surgery for tensioned hamstring tendon ACL reconstruction, according to Andrew J. Cossey *et al.*'s [12] analysis. Although there was no evidence of a negative effect in their series, more analysis is required before this device can be suggested for ACL reconstruction. ACL graft rigid fixation for the duration of the healing process is also questioned by him. In our study there is more tunnel widening at suspension point (C1S1) level showing poor fixation strength compared to other two fixation methods. In their study, Jason P. Klein *et al.* [13] demonstrate that femoral cross pin fixation and quadrupled hamstring autografts result in significant tunnel widening. However, neither the functional knee scores nor the postoperative ligament laxity seem to be significantly impacted by the widening.

Florian S. Kamelger, *et al.* [14] came to the conclusion that enlargement of the bone tunnel is frequently linked to the suspension fixation of hamstring grafts during ACL reconstruction. The femoral bone tunnel may enlarge due to material properties and implant design that limit graft-tunnel motion. Suspensory graft fixation may still be a desirable fixation method in primary and revision ACL reconstruction with improved implant design.

At aperture level (C3S3), widening was more in bioscrew followed by rigidfix and endobutton. However, all interference screws provided adequate fixation strength, according to Chad J. Micucci *et al.*, analysis [15], and there was no statistically significant difference in ultimate strength or graft slippage with different screw diameters. However, there is no much of difference in the operating time and cost of the surgery between these three fixation methods.

Comparing at all three levels, widening was more in rigidfix and least in endobutton. Shorter size of endobutton and snugly fitting graft are the two reasons for lesser tunnel widening in this group. However there is no statistical significance (P>.O5) in between radiological outcome and clinical outcome. Clinical results were almost same for all the three groups at the end of one year. Our study's use of a consistent fixation technique across all groups on the tibial side may have allowed for a more accurate comparison on the femoral side.

The study's strength is the use of CT scanning to measure bone tunnel diameters, which may yield more

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accurate results than radiographic measurements even when the tunnel wall is not sclerotic. The study's other strength is that only one surgeon operated on every case. According to Kate E. Webster *et al.* [7], there was no difference between the group-averaged CT and radiographic measurements for the tibia, but the radiographic measurements for the femoral tunnel were unmistakably larger than the CT measurements, especially for the anteroposterior view. Individual radiograph and CT measurements showed a moderate discrepancy.

The study's flaw is its small sample size, which may have contributed to beta error. Despite this study's limitation—the use of different techniques for all groups to create the femoral tunnels the best technique was used for each type of femoral fixation. The lack of a baseline CT scan for further comparison in the immediate postoperative days is another limitation of the study. This may be preferable to comparing with intraoperative drill diameters, which can be inaccurate due to the oblique course of drilling and wobbling during the procedure. Another flaw in the study is the shorter time frame used to compare the clinical outcomes.

Conclusions

When compared to the Transfix and Interference screw groups and the EndoButton group, femoral tunnel widening was significantly lower in the EndoButton group. Transfix demonstrated that, when compared to other fixation devices where medial portal technique was used, more tunnel widening may be caused by the use of transtibial technique. The transtibial technique, which is most likely the reason why the tunnel's obliquity causes more tunnel widening, caused the tunnel to be wider at the aperture and halfway on the sagittal sections of the transfix group than on the coronal sections. Minimal tunnel widening in this group can be attributed to the shorter endobutton size and the closely fitting graft. The entry of the screw at this level was used to explain why the interference group at the aperture level of the tunnel widened more. The clinical outcomes and laxity of the knee joint, however, were the same in all groups after a year. To support these findings, more similiar controlled studies involving a larger sample size are necessary.

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Conflict of interest: None

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