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Systematic Review

Comparative analysis of the outcome between aperture and suspensory graft fixation methods in anterior cruciate ligament reconstruction surgeries: a systematic review

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ABSTRACT

Human knee joint is a complex hinge joint which is relatively unstable compared to other joints of the body. The ligaments of the knee stabilize the joint during the different range of motion and are under continuous tension. This results in anterior cruciate ligament (ACL) being injured during unnatural movement of the joint particularly in sports. With the advent of arthroscopy and better understating of ligament injuries with the use of MRI, the ligament reconstruction procedures have increased. The Reconstructive procedures for the ACL impart use of an Autograft which is secured in the bony tunnels of femur and tibia using various methods. As with any fixation these materials are subjected to various biological and mechanical forces. Suspensory or aperture graft fixation are the two most commonly employed methods in recent times. Both these methods have different tensile strengths and failure rates. Various studies have been conducted to assess the outcomes of these methods to evolve the most suitable and fail-safe method of securing the ACL allograft in the bony tunnels.

Keywords: ACL reconstruction, Aperture fixation, Suspensory fixation, Interference screws, Tightropes, Adjustable loops, Interference screw, Endobutton

INTRODUCTION

Anterior cruciate ligament (ACL) is a dynamic stabilizer of the knee. It has two bundles anteromedial bundle and posterolateral bundle. It prevents the anterior tibial translation (anteromedial) and acts as a secondary stabilizer for tibial rotation (posterolateral).[1] It is most commonly injured in sporting activities like soccer, basketball, skiing and football. The male to female ratio of 1:4.5 particularly due to the landing biomechanics and quadriceps dominant neuromuscular activation patterns.

ACL reconstruction is done using an autograft or an allograft. Hamstring graft, central quadriceps tendon graft and bone patellar tendon bone graft are amongst the commonly used grafts.[2] The grafts are secured in the tunnels made through the femur and tibia at its anatomical footprint. The graft then during the stages of healing integrates with the bone in the tunnels giving it adequate strength.[3-5] The graft is secured in these tunnels using either suspensory or aperture fixation method or both. The failure of the ACL reconstruction procedure depends on the strength and mechanics of the fixation methods.

ACL graft can be secured in the tunnels by either direct or indirect method. Direct method also termed as Aperture fixation is by the means of interference screw, staples, washers and cross pins. Indirect method also known as suspensory fixation is via polyester tape/titanium button and suture post.[6,7] Graft fixation is an ongoing weak link during rehabilitation process considering the early ROM, weight bearing and return to sporting activities.[8,9] There has been an ongoing debate amongst the orthopods regarding the suitable method of fixation.

This review was conducted to evaluate several clinical studies using different methods of graft fixation in the tunnels after ACL reconstruction. Evaluation was done by measuring the various clinical and functional outcomes. This study will clarify the myths and aid surgeons in their decision making regarding the use of fixation methods during ACL reconstruction surgeries.

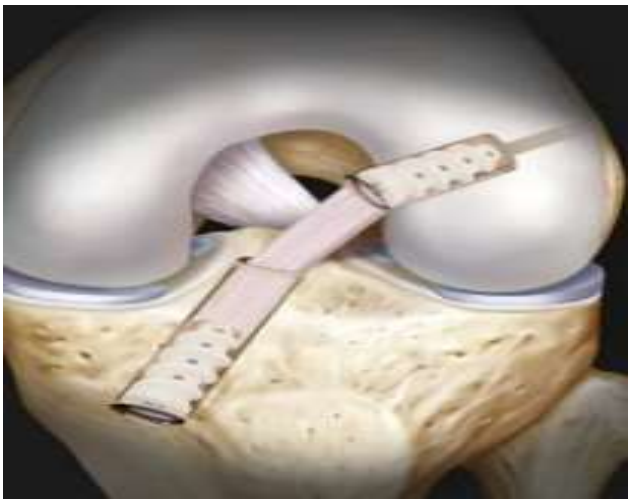

Figure 1: Aperture graft fixation with screw in both femoral and tibial tunnel.

Figure 2: Suspensory graft fixation with button in both femoral and tibial tunnel.

METHODS

A total of 50 articles were screened from PubMed, ResearchGate, Google Scholar for abstracts. The study period was from November 2023-April 2024. After reading the full text 7 articles were selected for the literature review. A total of 381 knees underwent ACL reconstruction with the use of platelet activated products which were reviewed here. All the knees were operated with autografts using hamstring tendons. Either aperture or suspensory fixation or both was used to secure the graft. Clinical and functional outcomes were measured post-operatively 3, 6, 12 and 24 months after surgery.

Inclusion criteria

Randomized controlled and cohort studies using aperture or suspensory or both fixation methods were selected, only ACL tear patients were selected, only hamstring autograft employing studies were shortlisted and only English articles were selected for study.

Exclusion criteria

Multi-ligament injury articles were excluded, duplicated or overlapping data, review articles or scientific conference abstracts, cadaver or model studies and unreported data were excluded from the study.

RESULTS

A prospective cohort study on 30 knees was done. Group 1 had aperture fixation (interference screw) in both femur and tibia. Group 2 had suspensory fixation (endobutton) in femur and screw in tibia. Clinical parameters were Latchman's test, Anterior drawer test and pivot shift test. Functional assessment was with Tegner Lysholm knee scoring. Clinical parameters were 100% negative at 12 months in both groups. Lysholm knee score improved significantly from pre-operative values in both groups $p<0.001$ but there was no significant variation in post-operative values of both groups.[10]

Table 1: Tegner-Lysholm score between both groups.[10]

Tegner Lysholm knee score	N	Mean	SD	P value
Group 1	15	96.07	5.625	0.749
Group 2	15	95.4	5.667	

A prospective cohort study was conducted on 80 knees, 40 employing screws in tibial side and 40 with titanium button on tibial side. Clinical parameters were Latchman's test, pivot shift test, frequency of graft failure and KT-1000 arthrometer. Functional assessment was with IKDC knee scoring. Post-operative difference at 1 year Latchman test (p=0.8217), pivot shift (p=0.0774), KT arthrometer (p=0.6838), IKDC score (p=0.9601), no statistical difference in both groups.[11]

Table 3: IKDC comparision.[11]

Variables	IKDC score		P value
	Mean	SD	
Interference group	78.08	2.595	0.9601 (NS)
Suspensory group	78.1	2.523	

*NS=Not significant.

A prospective randomized study included 25 patients having femur fixation with screw and 25 patients having femur fixation with endobutton. Both groups had tibia fixation with Bioscrew. Clinical parameters were Latchman's test, pivot shift test. Functional assessment was with IKDC knee scoring. Tunnel widening was measured at 1 year using CT scan. Clinical and functional parameters were better in aperture fixation group but the difference was not statistically significant. There was more femoral tunnel widening in suspensory group at 1 year follow-up with difference being statistically insignificant.[12]

A total of 47 patients were randomized to either 23 screw fixations in both tunnels or 24 endobutton fixation in both tunnels. Clinical outcome assessed with KT-1000 arthrometer. Tegner scoring, IKDC score and hop testing and tunnel widening was evaluated. Tunnels diameters in tibia were consistently larger in the screw group ($p<0.001$) and there were no changes in femur tunnel volumes in two groups ($p=0.080$). At 6 months 3 patients in button group had re-rupture while 0 in screw group. At final follow-up 25% screw group had KT laxity >3 mm whereas 44% with button had laxity $p=0.602$.

There was no difference in IKDC, Lysholm and Tegner score.[13]

The 70 patients underwent block randomization, 35 having fixed loop suspensory femoral fixation and 35 with screw femoral fixation, tibia was fixed with sheath screw in both groups. KT-1000 was used and Lysholm score, Tegner scoring and IKDC, tunnel widening using MRI was calculated. At final follow-up there was no difference in laxity in both groups. Functional scores were not statistically significant between both the groups. Tunnel widening was more in suspensory group but the difference was not statistically significant (Table 6).[14]

A comparative study on 40 knees was conducted, 20 had aperture fixation in both femoral and tibial tunnel, 20 had suspensory in femoral and screw in tibial tunnel. Clinical parameters were Latchman's test, anterior drawer test and pivot shift test. Functional assessment was with Tegner Lysholm knee scoring. All clinical parameters were 100% negative in post-operative final follow-up in both the groups. Tegner Lysholm score improved from pre- to post-operative final follow-up but difference was not statistically significant between both groups (Table 7).[15]

Table 4: Tunnel widening comparison between two groups.[12]

Fixation method	Initial tunnel postoperatively measurements in mm		Tunnel widening at end of 12 (mean percentage months)			
	Femoral tunnel (mean) mm	Tibial tunnel (mean) mm	Femoral Coronal	Tibial Coronal	Femoral Sagittal	Tibial Sagittal
Suspensory A	8±0.589	8.33±0.481	42.321±3.787	27.492±2.060	37.252±2.262	30.679±2.176
Aperture B	7.95±0.474	8.957±0.705	34.778±2.113	25.404±1.384	28.991±2.285	26.758±2.015
P value	0.521	0.605	0.071		0.963	

Table 5: Tunnel volume comparison.[13]

Groups	Postoperative	Tunnel volume comparison (cm^3)			Location (%)	
		6 months	2 years	5 years	AJ	
Tibial tunnel volume						
Screw	2.9±0.2	3.3±0.2	3.1±0.2	1.9±0.2	41.9 8.2	
Button	1.7±0.1	1.9±0.2	1.8±0.2	1.3±0.1	43.2±2.7	
P value	<0.001	<0.001	0.001	0.009	(0.666) NS	
Femoral tunnel volume					PA	PD
Screw	1.6±0.1	1.9 0.1	1.8±0.1	1.2±0.1	24.5±6.0	38.4 8.8
Button	1.6±0.1	1.8±0.1	1.8±0.1	1.3±0.1	30.3±6.6	36.6±9.8
P value	0.607	0.520 NS	0.755 NS	0.314 NS	0.055 NS	0.666 NS

*Data are shown as means with SD. AJ-tibial tunnel location along Amis and Jakob line in percent, PA-posterior-anterior distance from posterior contour of lateral femoral condyle in percent, PD-proximal-distal distance from Blumensaat line in percent. NS-not significant.

Table 6: Tunnels diameters at 12 months post-op.[14]

Variables (Preoperative and at 24 months ' follow-up)	Cortical button		P value	AperFix		P value
	Low diameter graft (8) (n=5)	High diameter graft (28.5) (n=19)		Low diameter graft (8) (n=17)	High diameter graft (28.5) (n=7)	
IKDC 2000 preop	74.28±9.69	66.2±11.43	0.153	10.23±61.04	56.28±21.6	0.633
IKDC 2000 24 months	98.36±2.4	92.85±12.62	0.604	97.37±3.72	93.7±7.08	0.134
Lysholm preop	86±9.57	82.32±11.28	0.484	84.89±8.97	82.17±13.72	0.066
Lysholm 24 months	1000	96.79±5.48	0.132	97.01±3.63	97.3±3.58	0.922
Tegner preop	4.4±0.55	3.74±1.37	0.137	3.36±1.45	3.23±1.53	0.625

Continued.

Variables (Preoperative and at 24 months ' follow-up)	Cortical button		P value	AperFix		P value
	Low diameter graft (8) (n=5)	High diameter graft (28.5) (n=19)		Low diameter graft (8) (n=17)	High diameter graft (28.5) (n=7)	
Tegner 24 months	8±1.41	7.79±1.4	0.88	8.22±1.23	7.84±1.54	0.323
KT 1000 preop	8.9±2.41	8.66±1.94	0.843	9.01±1.88	8.3±3.19	0.134
KT 1000 24 months	5.4±1.52	5.24±1.86	0.844	5.56±1.56	5.35±1.76	0.262

IKDC-International knee documentation committee.

Table 7: Association between Tegner-Lysholm score group 1 and 2 post-op.[15]

Tegner Lysholm knee score	N	Mean	SD
Group 1			
Pre-OP	20	42.47	11.14
AT 12 months	20	95.07	4.62
Group 2			
Pre-OP	20	40.33	11.14
AT 12 months	20	94.40	4.66
Tegner Lysholm knee score			
Group 1	20	95.07	4.62
Group 2	20	94.40	4.66

The 64 patients randomized to group 1 (32) femoral and tibial fixation with interference screw, group 2 (32) femoral and tibial fixation with cortical button. Clinical outcome measured for laxity with KT-1000 arthrometer. Functional outcomes measure with knee society score, IKDC, SF-12 questionnaire. At final follow-up there was no significant difference in both groups for Laxity as measured with KT (p=0.36.). At 2 year follow-up KSS p=1.05 and 0.774 for pain and function respectively. IKDC subjective score p=0.087. SF-12 score at final follow-up p=0.272, 0.818 physical and mental score respectively.[16]

Table 8: KSS pain and function score comparision.[16]

Variables	Suspensory	Aperture	Statistics
Pain score			
Preoperative	69.6±18.3	79.3±14.6	0.008
Postoperative			
1.5 weeks	72.4±20.6	79.0±16.0	0.047
6 weeks	93.4±12.0	95.0±6.5	0.664
12 months	96.1±8.7	96.2±8.4	0.696
24 months	92.4±14.3	97.9±3.0	0.105
Function score			
Preoperative	68.5±25.1	66.7±24.9	0.710
Postoperative			
1.5 weeks	17.9±23.5	26.3±27.5	0.164
6 weeks	81.3±15.5	81.7±14.0	0.772
12 months	95.7±9.3	98.1±6.8	0.938
24 months	97.6±6.2	95.7±13.6	0.774

Table 9: IKDC subjective score comparison.[16]

Variables	Suspensory	Aperture	Statistics
Preoperative	46.9±14.3	52.2±14.0	0.121
Postoperative			
6 weeks	60.0±12.5	61.5±11.1	0.992
12 months	80.1±14.1	85.7±10.4	0.222
24 months	83.8±16.5	85.4±8.3	0.807

DISCUSSION

This review was conducted to assess the outcome of suspensory and cortical fixation of ACL allograft to bone tunnels. A meta-analysis on this topic in 2017 has shown similar outcomes in the study and control group.[17] Multiple other articles have compared the outcomes of these two methods and hence we have numerous data to review results of the same.

The need for developing an ideal method of graft fixation which will stand the test of time has always been of interest to surgeons. Over the last decade several studies have been published trying to figure out the outcomes of suspensory and aperture fixation of ACL allograft.[18,19] There is a literature consensus that the graft moves in the tunnels during the early rehabilitation phase resulting in erosion of tunnels and weakening of the fixation device.[20,21] The first 12 weeks are very crucial to integration of the graft with bony tunnels.[22-24] Various biological augments can be used to aid the healing of graft and the prevent tunnel widening.[25]

In our review of 7 articles the outcomes of suspensory and aperture fixations were found to be similar at final follow-up. The knee laxity was less compared to pre-operative values but the difference was not statistically significant in both study groups. The Tibial tunnel showed the increased diameters in the aperture groups but the difference was not significant on CT or MRI. The Femoral diameters were same in both the groups of fixations. The graft failure rate was higher in the suspensory group mostly likely due to the strain on the polyester fiber network.

However, this difference between the study and control group was found to be not significant. The functional scores were same in both the groups at final follow-up though they significantly improved from pre-operative values.

However, this review had two limitations, First, in combining randomized control trials and cohort studies simultaneously, the bias caused by different types of trials could not be eliminated. Second, the method of fixation of femoral and tibial tunnels was not uniform in all studies.

CONCLUSION

Our review suggests that there is no difference in the clinical and functional outcomes of ACL graft fixation methods. However, the aperture method of fixation yielded a slightly better results at final follow-up with lesser rate of graft re-ruptures.

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