Femoral and Tibial Fixation Combinations in Primary ACL Reconstruction: An Analysis of Revision Rates, Utilization Trends, and Patient-Reported Outcome Measures

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INTRODUCTION: Previous literature has suggested that the method of graft fixation in primary anterior cruciate ligament (ACL) reconstruction may impact graft stability and risk of revision, particularly in the early postoperative period. However, most previous studies have evaluated femoral and tibial fixation techniques separately and have not trended these techniques over time. Thus, the purpose of this study was to (1) investigate the association between femoral and tibial fixation combinations with rates of revision and patient-reported outcome measures (PROMs) and (2) describe the temporal evolution of such fixation techniques.

METHODS:

This study utilized the Swedish National Knee Ligament Registry (SNKLR) to identify patients aged $\geq$13 years who underwent primary hamstring tendon autograft ACL reconstruction between 2005 and 2018. Exclusion criteria included prior knee surgery, double-bundle ACL reconstruction, concomitant fracture (e.g., patella, femur, tibia, or fibula), other ligament injuries, and neurovascular injuries. Additionally, fixation methods exclusive to transtibial techniques (e.g., Rigidfix and Transfix) were excluded given the superiority of tibial-independent drilling techniques in restoring native ACL anatomy. Femoral fixation techniques included fixed suspensory fixation, adjustable suspensory fixation, and interference screw, and tibial fixation techniques encompassed these three techniques plus retroscrew and suture post. The primary outcome was the 2-year ipsilateral revision rate by different femoral and tibial fixation technique combinations. Secondarily, fixation combinations were trended over time, and PROMs were evaluated using the Knee Injury and Osteoarthritis Outcome Score (KOOS).

RESULTS:

This study included 23,247 patients (56.3% men) with a mean ± SD age of 27.2 ± 10.4 years and BMI of 24.5 ± 3.3 kg/m^2. Of these, 614 (2.6%) patients underwent revision ACL reconstruction within the 2-year study period. Regarding femoral fixation, fixed suspensory was the most common (53.8%), followed by adjustable suspensory (38.2%) and interference screw (8.02%). In contrast, interference screw (58.0%) was the most common fixation technique for tibial fixation, followed by suture post (24.4%), adjustable suspensory (16.9%), retroscrew (0.6%), and fixed suspensory (0.1%). Multivariable Cox regression analysis revealed the following femoral/tibial fixation combinations to be associated with significantly lower revision rates: fixed suspensory/interference screw (hazard ratio [95% CI] = 0.799 [0.672 – 0.949]; p = 0.011) and adjustable suspensory/interference screw (hazard ratio [95% CI] = 0.771 [0.624 – 0.951]; p = 0.016) (**Fig. 1**). Additionally, older age, female sex, longer period between injury and surgery, and greater diameter of the hamstring tendon autograft were associated with significantly lower revision rates ($p < 0.05$ for all). Moreover, different fixation techniques were associated with significantly different 2-year KOOS sports/recreation and QoL scores; specifically, tibial-sided interference screw was associated with significantly lower scores, while tibial-sided suture post resulted in significantly higher scores (**Tables 2-3**). Finally, the utilization of fixation combinations has evolved substantially over time, most notably with a decrease in femoral-sided fixed suspensory fixation in exchange for adjustable suspensory fixation (**Fig. 2**).

DISCUSSION AND CONCLUSION:

Although many combinations of femoral and tibial fixation devices were associated with similar 2-year revision rates following primary ACL reconstruction, fixed suspensory (femoral-sided) / interference screw (tibial-sided) and adjustable suspensory (femoral-sided) / interference screw (tibial-sided) were associated with significantly lower revision rates. Interestingly, tibial-sided interference screw was associated with significantly lower KOOS sports/recreation and QoL scores, while tibial-sided suture post resulted in significantly higher scores. These findings should be interpreted in the context of evolving utilization trends identified in this study and may aid surgeons in selecting appropriate fixation devices for primary hamstring tendon autograft ACL reconstruction.

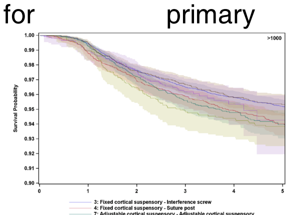

Figure 1. Failure curves for fixation combinations that included >1,000 cases during the study period.

Table 1. Knee Injury and Osteoarthritis Outcome Score (KOOS) sports/recreation subscale at 2-year follow-up.

Variable	Value	KOOS – sports/recreation Mean (SD)	Beta (95% CI)	p-value
Femoral - tibial fixation combination	Fixed cortical suspensory - Fixed cortical suspensory	50.00 (31.89)	-16.47 (-42.99;10.04)	0.22
	Fixed cortical suspensory - Adjustable cortical suspensory	74.03 (23.84)	7.58 (-1.27;16.43)	0.093
	Fixed cortical suspensory - Interference screw	64.70 (27.36)	-2.78 (-3.83;-1.74)	**<0.0001**
	Fixed cortical suspensory - Suture post	72.26 (24.68)	7.22 (5.95;8.48)	**<0.0001**
	Fixed cortical suspensory - Retroscrew	58.00 (44.38)	-8.47 (-32.19;15.24)	0.48
	Adjustable cortical suspensory - Fixed cortical suspensory	63.00 (36.50)	-3.47 (-27.19;20.25)	0.77
	Adjustable cortical suspensory - Adjustable cortical suspensory	65.63 (26.76)	-0.98 (-2.42;0.47)	0.18
	Adjustable cortical suspensory - Interference screw	63.63 (28.13)	-3.33 (-4.75;-1.91)	**<0.0001**
	Adjustable cortical suspensory - Suture post	71.58 (25.43)	5.43 (3.27;7.58)	**<0.0001**
	Interference screw - Fixed cortical suspensory	90.00 (17.32)	23.54 (-7.07;54.15)	0.13
	Interference screw - Adjustable cortical suspensory	64.13 (26.94)	-2.35 (-10.75;6.05)	0.58
	Interference screw - Interference screw	63.11 (28.24)	-3.62 (-5.56;-1.69)	**0.0002**
	Interference screw - Suture post	73.89 (28.81)	7.43 (-10.25;25.11)	0.41
	Interference screw - Retroscrew	63.13 (26.90)	-3.36 (-9.20;2.48)	0.26
Age at surgery (years)	13-<21	66.69 (26.51)		
	21-<32	66.33 (26.39)		
	32-67	66.39 (28.17)	-0.02 (-0.07;0.02)	0.29
Sex	Female	64.27 (27.43)		
	Male	68.81 (26.44)	4.54 (3.53;5.54)	**<0.0001**
Meniscal injury (medial and/or lateral)	No	67.36 (26.85)		
	Yes	65.30 (27.26)	-2.06 (-3.08;-1.04)	**<0.0001**
Cartilage, topical injury	No	67.50 (26.60)		
	Yes	63.31 (28.15)	-4.19 (-5.36;-3.02)	**<0.0001**
Body mass index (kg/m^2)	15.4-<22.9	70.37 (24.97)		
	22.9-<25.3	69.82 (25.93)		
	25.3-49.8	64.16 (28.08)	-0.92 (-1.10;-0.75)	**<0.0001**
Months between injury and surgery	0.1-<5.3	68.08 (26.86)		
	5.3-<12.1	66.90 (26.19)		
	12.1-551.0	64.48 (27.93)	-0.02 (-0.03;-0.00)	**0.011**
ACL diameter (mm)	5.0-<8.0	64.05 (27.46)		
	8.0-<9.0	67.41 (26.82)		
	9.0-11.0	66.58 (27.04)	1.24 (0.58;1.90)	**0.0002**

All tests are performed with univariable linear regression.
P-values, Beta and R-square are based on original values and not on stratified groups.
KOOS, Knee Injury and Osteoarthritis Outcome Score; SD, standard deviation.

Table 2. Knee Injury and Osteoarthritis Outcome Score (KOOS) Quality of Life (QoL) subscale at 2-year follow-up.

Variable	Value	KOOS – QoL Mean (SD)	Beta (95% CI)	p-value
Femoral - tibial fixation combination	Fixed cortical suspensory - Fixed cortical suspensory	43.75 (8.84)	-17.55 (-41.25;6.15)	0.15
	Fixed cortical suspensory - Adjustable cortical suspensory	65.10 (20.07)	3.82 (-4.09;11.74)	0.34
	Fixed cortical suspensory - Interference screw	60.03 (24.24)	-1.99 (-2.93;-1.06)	**<0.0001**
	Fixed cortical suspensory - Suture post	65.47 (23.41)	5.19 (4.06;6.33)	**<0.0001**
	Fixed cortical suspensory - Retroscrew	53.75 (22.79)	-7.55 (-28.75;13.66)	0.49
	Adjustable cortical suspensory - Fixed cortical suspensory	66.25 (26.74)	4.96 (-16.24;26.16)	0.65
	Adjustable cortical suspensory - Adjustable cortical suspensory	60.42 (23.85)	-1.01 (-2.30;0.28)	0.12
	Adjustable cortical suspensory - Interference screw	59.36 (24.93)	-2.27 (-3.54;-1.00)	**0.0005**
	Adjustable cortical suspensory - Suture post	64.85 (22.86)	3.78 (1.85;5.70)	**0.0001**
	Interference screw - Fixed cortical suspensory	81.25 (22.53)	19.96 (-7.40;47.33)	0.15
	Interference screw - Adjustable cortical suspensory	57.97 (24.43)	-3.34 (-10.84;4.17)	0.38
	Interference screw - Interference screw	59.49 (24.50)	-1.94 (-3.67;-0.22)	**0.028**
	Interference screw - Suture post	71.53 (22.34)	10.24 (-5.56;26.05)	0.20
	Interference screw - Retroscrew	57.38 (25.74)	-3.94 (-9.17;1.28)	0.14
Age at surgery (years)	13-<21	59.25 (24.39)		
	21-<32	59.85 (23.74)		
	32-67	64.69 (24.03)	0.23 (0.19;0.27)	**<0.0001**
Sex	Female	60.48 (23.86)		
	Male	62.15 (24.49)	1.67 (0.77;2.57)	**0.0003**
Meniscal injury (medial and/or lateral)	No	62.06 (24.26)		
	Yes	60.29 (24.04)	-1.78 (-2.69;-0.87)	**0.0001**
Cartilage, topical injury	No	61.63 (24.19)		
	Yes	60.26 (24.12)	-1.37 (-2.42;-0.32)	**0.010**
Body mass index (kg/m^2)	15.4-<22.9	63.60 (22.69)		
	22.9-<25.3	63.51 (23.84)		
	25.3-49.8	60.63 (24.53)	-0.42 (-0.58;-0.26)	**<0.0001**
Months between injury and surgery	0.1-<5.3	62.11 (24.39)		
	5.3-<12.1	61.49 (23.68)		
	12.1-551.0	60.19 (24.45)	0.01 (-0.01;0.02)	0.24
ACL diameter (mm)	5.0-<8.0	59.25 (24.24)		
	8.0-<9.0	62.13 (24.08)		
	9.0-11.0	61.32 (24.24)	0.90 (0.31;1.49)	**0.0027**

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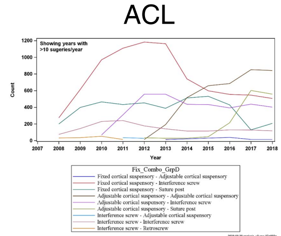

Figure 2. Utilization trends of femoral – tibial fixation combinations by year.