

# Methods of Graft Fixation in Arthroscopic Anterior Cruciate Ligament Reconstruction using Hamstring Tendon Graft: A Systematic Review and Meta Analysis

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## Abstract

**Background:** The anterior cruciate ligament (ACL) injury is one of the most frequent injuries of the knees in orthopedic operations.

**Aim:** To review the effectiveness of various graft fixation methods used in arthroscopic ACL reconstruction with hamstring tendon graft.

**Materials and methods:** The study utilized several databases, including MEDLINE, AMED, CINAHL, EMBASE, and the Cochrane Library, to search for published research on anterior cruciate ligaments. High-quality papers published after 2009 were included, with a focus on studies in English. The web search was conducted from August 2023 to August 2024.

**Results:** The pooled estimate for follow-up duration was 13.77 months (95% CI: 11.67 to 15.87,  $p$ -value less than 0.001), meaning the average monitoring time across studies was about 14 months. The statistically significant  $p$ -value indicates that this finding is reliable, and the confidence interval suggests that most studies reported follow-up times within a similar range. The pooled Tegner score was 5.35 (95% CI: 4.89 to 5.80,  $p < 0.001$ ), indicating that the functional activity levels measured by the Tegner scale were moderately high in the included studies. The confidence interval is relatively narrow, reflecting a reliable estimate, and the  $p$ -value supports statistical significance.

**Conclusion:** This study reviews various fixation methods, finding no significant difference in clinical outcomes or graft failure rates, but suggests tailoring the choice to individual patient and surgeon's experience.

**Keywords:** ACL; Arthroscopic; Graft

## 1. Introduction

The ligament damage of the anterior cruciate is a prevalent injury of the knee in orthopedic surgery, often occurring throughout non-contact sports, particularly during pivoting and cutting exercises.<sup>1</sup>

ACL reconstruction (ACLR) is a prevalent orthopedic operation aimed at reinstating the original function of the anterior cruciate ligament and ensuring translational and rotational knee stability. The annual frequency

of 1<sup>st</sup> and revision anterior cruciate ligament reconstruction is rising, with around eighty thousand to a hundred thousand individuals in the United States receiving the treatment each year, with revision rates ranging from 4.1 percent to 13.3 percent of all 1<sup>st</sup>-year ACLR.<sup>2,3</sup>

The goal of a systematic review is to evaluate the efficacy of various graft fixation techniques used in arthroscopic anterior cruciate ligament (ACL) reconstruction with hamstring tendon graft.

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Accepted 19 January 2025.

Available online 31 March 2025

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<https://doi.org/10.21608/aimj.2025.446483>

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## 2. Patients and methods

The study utilized several databases, including MEDLINE, AMED, CINAHL, EMBASE, and the Cochrane Library, to search for published research on anterior cruciate ligaments. High-quality papers published after 2009 were included, with a focus on studies in English. The web search was conducted from August 2023 to August 2024.

**Femoral fixation:** Suspension devices: Bone types are divided into cortical, cortical-cancellous, and cancellous subdivisions, with cortical suspension apparatuses like buttons, swing bridges, and ligament plates, and cancellous devices like Linx-HT. Compression devices (e.g., interference screw), Hardware-free devices (e.g., Press-fit bone plug), and Hardware devices (e.g., Buttons, cross pin, and interference screw).

**Tibial fixation:** Intratunnel devices (e.g., bioabsorbable interference screw), Extratunnel devices (e.g., suspensory fixation), and press fit bone plug.

**Inclusion Criteria:** Studies on adult cases had arthroscopic anterior cruciate ligament reconstruction with Semitendinosus and Gracilis graft, studies with adult patients aged 18-45 years, all types of study designs except case report and case series, studies published after 2009, and full-text studies and Studies in English.

**Exclusion Criteria:** Studies on adult patients undergoing arthroscopic ACL reconstruction using grafts other than Semitendinosus and Gracilis, studies involving patients aged less than 18 years or more than 45 years, case reports and case series studies, studies published before 2009, and abstract-only studies. All investigations involving cases with trauma, vertebral fractures, inflammatory illnesses, malignancy, pediatric ACL cases, revision cases, infections, and metallic screw fixation were excluded.

The study evaluates the outcomes of different arthroscopic ACL reconstruction methods using clinical data, scoring systems, and patient evaluations. It also assesses the benefits and drawbacks of hamstring tendon graft fixation methods.

### Data Collection and Analysis

Trials were independently reviewed and selected, with discrepancies resolved through consensus. Data was extracted by multiple reviewers, and disagreements resolved through discussion. Trial authors were contacted for clarification.

**Assessment of heterogeneity:** The study used subgroup analysis to assess heterogeneity, considering the I<sup>2</sup> statistic, the Chi<sup>2</sup> test, and confidence interval overlap. The ranges of 0%-40%, 30%-60%, 50%-90%, and 75%-100% were used to interpret I<sup>2</sup> data.

**Evaluation of reporting biases:** If sufficient

investigations (a minimum of ten) are available, they will assess publication bias.

### Data synthesis

The study reported results from similar trial groups using fixed-effect and random-effects models, considering factors like heterogeneity and study quality. Results were reported with 95% confidence intervals, and when pooling was not feasible, individual trial data were presented for illustrative purposes.

### Ethical Considerations

The investigation protocol obtained ethical permission from the Research Ethics Committee of the Faculty of Medicine, Al-Azhar University, Cairo.

## 3. Results

Figure 1 showed that A total of 892 articles were screened using various databases, with 38 meeting eligibility criteria. After screening, 529 articles were excluded, and 491 articles were excluded for systematic review.

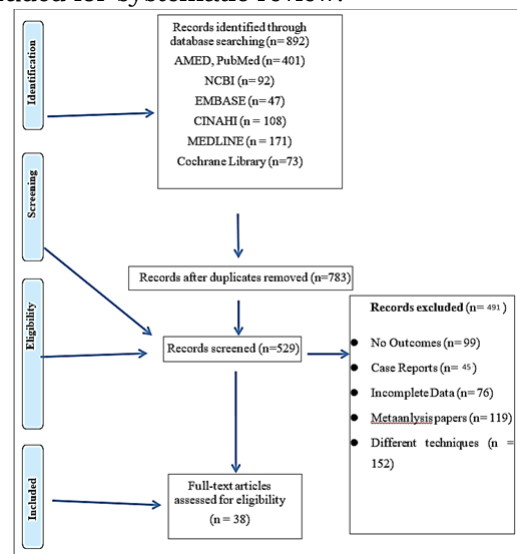


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 flowchart of the article selection process.

Table 1. Characteristics of fourteen involved studies.

AUTHOR (YEAR)	STUDY DESIGN	GRAFT TECHNIQUE	SAMPLE SIZE	OUTCOMES
LIN ET AL. <sup>4</sup>	Retrospective study	cortical hybrid or suspension (cortical compression and suspension)	102	There was no discernible difference between cortical suspension and hybrid in terms of the enlargement of the bone tunnel or the clinical result.
XU ET AL. <sup>5</sup>	Retrospective comparative study	The case had suspensory cortical button fixation on both the femur & tibia with normal anterior cruciate ligament techniques, an interference screw of bioabsorbable tibia, and a six-strand hamstring tendon autograft.	48	On the tibia side, tunnel widening following ACL reconstruction was considerably higher in the traditional procedure than in the all-inside technique.
ABUDAQQA ET AL. <sup>6</sup>	Retrospective study	An interference screw that is secured with a staple for the tibial side	497	For tibial-side fixation in anterior cruciate ligament reconstruction, utilizing an interference screw instead of a staple had no appreciable effect on time of operation, rate of reoperation, rates of failure, or complications.

COPPOLA ET AL. <sup>7</sup>	Retrospective study	adjustable-length loop cortical buttons vs. PEEK interference screw	18	PEEK screw fixation resulted in a much wider final femoral tunnel width as than button fixation methods.
HENG ET AL. <sup>8</sup>	Prospective study	adjustable-loop device vs fixed-loop device (FLD)	105	Clinical outcomes were analogous among FLD and adjustable-loop devices for suspensory fixation of hamstring tendon autograft in anterior cruciate ligament reconstruction with a minimum of two years of monitoring.
YUAN ET AL. <sup>9</sup>	Retrospective study	The research explores the effectiveness of fixation of RigidFix cross pins in the tibial tunnel when used with a hamstring tendon graft.	53	RigidFix cross pins in tibial and femoral tunnels can fold hamstring tendon into thicker grafts, providing better 5-year results for ACL fixation compared to interference screws.
SENIGAGLIESI ET AL. <sup>10</sup>	Retrospective study	Autograft of Hamstring tendon, trans tibial method, & apparatus of femoral cortico-cancellous screw suspension	93	The autograft of hamstring tendon & cortico-cancellous screw suspension mechanism yields satisfactory clinical outcomes.
RAHARDJA ET AL. <sup>11</sup>	Cohort study	Suspensory Versus Interference	6145	The application of an interference screw on the tibial side throughout primary anterior cruciate ligament reconstruction led to an increased revision rate than an adjustable loop suspensory apparatus.
ASIF ET AL. <sup>12</sup>	Prospective randomized study	Graft fixation utilizing adjustable-loop and fixed-loop tools.	43	Anterior cruciate ligament reconstruction utilizing adjustable and fixed-loop suspensory tools for graft attachment yields similar and satisfactory clinical outcomes.
DE AQUINO SANTOS ET AL. <sup>13</sup>	Comparative study	p double bundle vs osteo-lateral bundle (PLB) tibial fixation: without utilization of an interference screw	23	The native insertion of semitendinosus and gracilis tendons, devoid of extra fixation devices, exhibited mechanical superiority compared to interference screws.
ROGER ET AL. <sup>14</sup>	single-center randomized single-blinded trial	4-strand semitendinosus (ST) graft with adjustable cortical fixing at the tibial and femoral locations	60	The 4ST approach preserves the gracilis tendon, so maintaining the medial muscle and might enhancing function and reducing donor-side morbidity.

Figure 2 showed that, A: According to age: The study population's mean age was estimated to be 28.67 years, indicating a precise estimate of approximately 29 years across all studies, indicating a statistically significant result. B: The study found a significant male predominance, with a high proportion of 79.0%, confirming statistical significance and a narrow confidence interval.

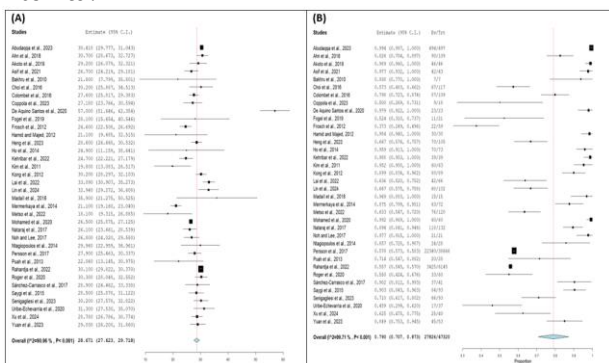


Figure 2. (A): Forest plot of Gender. (B): Forest plot of Age.

Figure 3 showed the average monitoring time

across studies was 14.3 months, with a pooled estimate of 13.77 months (95% CI: 11.67 to 15.87).

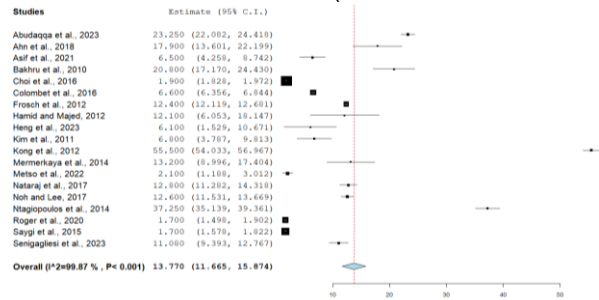


Figure 3. Forest plot of Follow-up period.

Figure 4 showed the pooled Tegner score was 5.35 (95% CI: 4.89 to 5.80,  $p < 0.001$ ), indicating that the functional activity levels measured by the Tegner scale were moderately high in the included studies. The confidence interval is relatively narrow, reflecting a reliable estimate, and the  $p$ -value supports statistical significance.

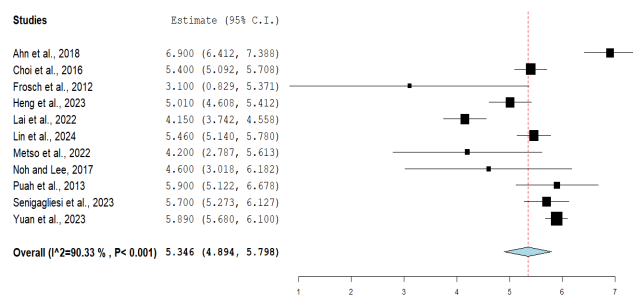


Figure 4. Forest plot of Tegner

Figure 5 showed that the Lysholm score, a measure of knee function, was found to be high in all studies, with a narrow confidence interval indicating consistent results, and a  $p$ -value indicating statistical significance.

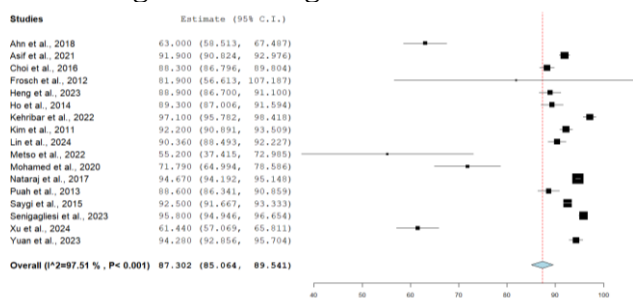


Figure 5. Forest plot of Lysholm.

Figure 6 showed that the pooled IKDC score, 67.78, indicates moderate knee function, despite a wider confidence interval indicating a broader range of scores across studies.

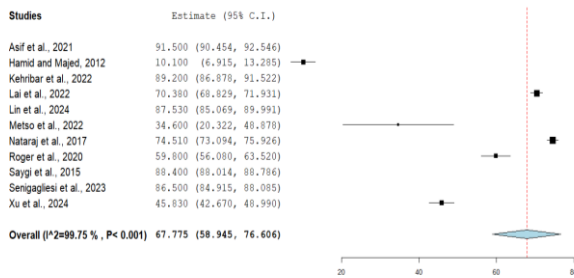


Figure 6. Forest plot of IKDC.

Figure 7 showed that the Lachman test results, with a pooled estimate of 6.92, indicate robust results across studies, despite some variability due to the wide confidence interval.

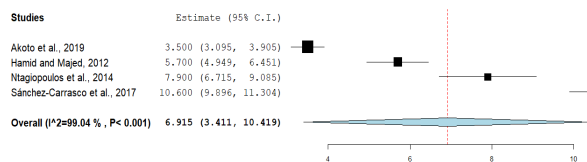


Figure 7. Forest plot of Lachman

#### 4. Discussion

One of the most frequent injuries of the knees in younger people is a rupture of the anterior cruciate ligament.<sup>15</sup>

With the utilization of a hamstring tendon graft, this systematic review attempts to evaluate the efficaciousness of various graft fixation techniques in arthroscopic anterior cruciate ligament reconstruction.

Xu et al.<sup>5</sup> stated that the broadening of the tibial tunnel following ACLR with a hamstring-tendon autograft was significantly higher with adjustable-loop femoral cortical suspensory fixation compared to interference screw fixation at the two-year monitoring. Nonetheless, the clinical results in both groups were similar during the two-year monitoring. According to Lin et al.<sup>4</sup>, there was no discernible difference between cortical suspension devices and hybrid in terms of the enlargement of the bone tunnel or the clinical result.

Abudaqqa et al.<sup>6</sup> reported that a combination of interference & staple screw has been utilized in 167 cases (33.6 percent), whereas a single interference screw has been utilized in 330 cases. No significant distinction existed between the two groups regarding operating time, rate of complication, or rate of failure. The average monitoring duration was 23.25 ( $\pm$ 13.29) months, indicating that the addition of a staple to the interference screw for tibial-side fixation in ACLR doesn't significantly affect operating time, rates of reoperation, comorbidities, or

failure rates.

When comparing the PEEK interference screw to the adjustable-length loop cortical group with femoral screw fixation, Coppola et al.<sup>7</sup>, 2023[67] determined that the PEEK interference screw illustrated a mean tunnel volume change of  $108.15 \pm 13.7$  percent on the tibial side &  $124.07 \pm 25.38$  percent on the femoral side. A tunnel volume alteration of  $111.12 \pm 12.72$  percent was seen on the tibial side of the group that utilized femoral button fixation, while the femoral side demonstrated a tunnel volume alteration of  $130.96 \pm 21.71$  for the same group. An equivalent P-value of 0.562 indicates that the differences in femoral tunnel volume alteration did not meet the criteria for statistical significance.

Heng et al.<sup>8</sup> compared fixed-loop devices with adjustable-loop devices on 105. Clinical outcomes were comparable among ALDs and FLDs for suspensory fixation of hamstring tendon autograft in ACL reconstruction, with insignificant variations observed at a minimum monitoring of two years. No research identified a clinical distinction among FLDs and ALDs regarding knee stability, PROMS, or revision rates. The evidence quality has been rated as "very low" because of research designs, bias risk, and heterogeneity.

Yuan et al.<sup>9</sup> discovered that RigidFix cross pins fixation in tunnel of tibia for ACL reconstruction yields superior five-year outcomes compared to the interference screw, & that the hamstring tendon could be configured into a thicker graft when RigidFix cross pins are utilized in both tibial & femoral tunnels.

Senigagliesi et al.<sup>10</sup> indicate that ACL reconstruction utilizing Hamstring Tendon autograft & a cortico-cancellous screw suspension tool yields satisfactory clinical outcomes following a decade of monitoring, in spite of a reported low incidence of graft failure, with almost fifty percent of cases exhibiting knee osteoarthritis of grade II or higher.

Rahardja et al.<sup>11</sup> compare suspensory and interference methods. The research found that hamstring tendon autografts secured with an adjustable loop suspensory instrument on the femoral side throughout 1st ACL reconstruction exhibited a greater revision rate when an interference screw, with or without a sheath, was utilized on the tibial side compared to a suspensory tool.

After operations, Asif and others,<sup>12</sup> observed a significant increase (p-value less than 0.05) in the Lysholm score, mean IKDC score, & thigh circumference within each individual group. However, the comparison of the two groups' alterations in thigh circumference (p-value equal 0.9), Lysholm score (p-value equal 0.5), and IKDC score (p-value equal 0.3) revealed statistically insignificant variations.



Santos et al.<sup>13</sup> compared postero-lateral bundle tibial fixation to double bundle fixation without using an interference screw. The group A exhibited a maximum force (MF) of  $315.4 \pm 124.7$  Newtons, a maximum tension of  $13.57 \pm 3.65$  Newtons per millimeter, a maximum elongation of  $19.73 \pm 4.76$  millimeters, a force at the limit of proportionality of  $240.6 \pm 144.0$  Newtons, & an elongation at the limit of proportionality of  $14.37 \pm 6.58$  millimeters.

Roger et al.<sup>14</sup> after two years, the mean isokinetic strength deficit with respect to the healthy side. The proportion of the same figure on the healthy side is used to report strength on the operated side. SD indicates standard deviation, n.s. Indicates insignificant (P-value more than 0.05), ST/G refers to the semitendinosus & gracilis tendons autograft group, and 4ST signifies the single semitendinosus autograft group.

As noted by Biau et al.<sup>16</sup>, there are currently several devices available for hamstring graft repair, and most clinical investigations have not demonstrated any discernible variations amongst them. But even a dependable fixation device can malfunction if the bone tunnels are not positioned correctly, if there has been a device malfunction, or if the post-operative rehabilitation regimen is not rigorously adhered to. The rehabilitation program was the same for all four study groups, and all reconstructions were completed by two skilled knee surgeons in our study.

While Ranjan et al.<sup>17</sup> discovered that the International Knee Documentation Committee score was 85.2 in the fixed group and 84.3 in the adjustable group, they also observed that the Lysholm scores were equal in both groups, at 91.8.

International Knee Documentation Committee scores of 79.43 in the FLD & 78.6 in the adjustable group were found by Ahn et al.<sup>18</sup>.

Lysholm scores were 94.32 & 94.23 in the adjustable & fixed groups, according to Sheth et al.<sup>19</sup> In the fixed group, they discovered an IKDC score of 92.03, and in the adjustable group, 92.16.

After two years of monitoring, Dave et al.<sup>20</sup> stated that tibial and femoral tunnel widening has been induced by the application of an EB—EB-Mersilene construct on the femoral side throughout reconstruction of ACL.

Iorio et al.<sup>21</sup> found that when anatomical fixation using strong, rigid fixation devices has been utilized in arthroscopic ACL reconstruction with the insertion of a quadrupled hamstring autograft, the degree of TW was decreased.

#### 4. Conclusion

The systematic review and meta-analysis conducted in this study suggest that various fixation methods, such as compression, suspensory, and hybrid techniques, can be effectively utilized, each with its own advantages and potential risks. The results of the included studies indicate that there is no significant difference in clinical outcomes between the different fixation methods, with comparable scores on measures such as the Tegner, Lysholm, and IKDC scales, as well as similar rates of graft failure and tunnel widening. However, some studies suggest that certain fixation methods may offer advantages in specific scenarios, such as reduced tunnel widening or improved graft stability. Ultimately, the choice of fixation method should be tailored to the individual patient and the surgeon's experience and preference.

#### Disclosure

The authors have no financial interest to declare in relation to the content of this article.

#### Authorship

All authors have a substantial contribution to the article

#### Funding

No Funds : Yes

#### Conflicts of interest

There are no conflicts of interest.

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