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Optimizing ACL Reconstruction: A Comparative Analysis of Clinical Outcomes between Double Bioabsorbable Interference Screws and Hybrid Fixation Techniques

Tommy Widjaya[1], Otman Siregar[1], Husnul Fuad Albat[1]
[1]Department of Orthopaedics and Traumatology, Faculty of Medicine, Universitas Sumatera Utara, Medan
***Corresponding Author Email:** Tommy.widjaya7@gmail.com

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ABSTRACT

Background: Anterior Cruciate Ligament (ACL) rupture is a prevalent injury necessitating reconstruction to restore stability and prevent osteoarthritis. The choice of graft fixation—specifically between aperture fixation using interference screws and suspensory fixation using buttons—remains a subject of debate regarding their impact on functional recovery.

Objective: This study aims to compare the clinical functional outcomes of patients undergoing ACL reconstruction using the Double Bioabsorbable Interference Screw (DBIS) technique versus a combination of Femoral Button and Tibial Bioabsorbable Screw (Hybrid technique), utilizing the International Knee Documentation Committee (IKDC) score.

Methods: An observational analytic study with a case-control design was conducted at RSU Haji Medan. The study involved 50 patients divided equally into two groups (n=25 for DBIS, n=25 for Hybrid). Inclusion criteria were primary isolated ACL reconstruction, age 18-59 years, and at least 6 months post-operation. Functional outcomes were assessed using the IKDC score pre-operatively and at 1, 3, and 8 months post-operatively. Data were analyzed using independent t-tests.

Results: The DBIS group had a significantly younger mean age (41.48 ± 4.03 years) compared to the Hybrid group (43.92 ± 2.97 years, p=0.019). Gender distribution was balanced (p=0.777). IKDC scores showed significant improvement over time in both groups. However, there were no statistically significant differences in IKDC scores between the DBIS and Hybrid groups at any time point: Pre-operative (41.04 vs 40.84, p=0.881), Month 1 (50.08 vs 50.24, p=0.875), Month 3 (67.12 vs 67.48, p=0.767), and Month 8 (87.72 vs 88.48, p=0.448).

Conclusion: Both DBIS and Hybrid fixation techniques result in comparable and favorable functional outcomes at 8 months post-surgery. The choice of fixation may depend on surgeon preference and cost rather than short-term clinical superiority.

INTRODUCTION

The Anterior Cruciate Ligament (ACL) is a primary stabilizer of the knee joint, critical for controlling anterior tibial translation and rotational loads upon knee flexion. [1]Rupture of the ACL is a prevalent orthopedic injury, particularly among active individuals aged 15–29 years, often resulting in significant morbidity, including chronic pain, functional impairment, reduced quality of life, and an increased risk of early-onset osteoarthritis. [2]

While structured rehabilitation is an option, ACL reconstruction remains the gold standard for restoring mechanical stability and preventing secondary damage to menisci and articular cartilage.[3] Compared to conservative management, reconstruction is often deemed more cost-effective and protective of long-term joint health. The procedure typically involves the use of autografts, such as hamstring tendons, due to their favorable

morbidity profile compared to bone-patellar tendon-bone (BPTB) grafts. However, the success of hamstring autograft reconstruction relies heavily on the method of graft fixation, which influences the mechanical behavior of the graft during the critical early healing phase.[4,5]

Two dominant fixation philosophies have emerged: aperture fixation and suspensory fixation. Aperture fixation, typically utilizing interference screws, compresses the graft against the tunnel wall, theoretically facilitating bone-to-tendon healing and providing immediate stiffness.[6] Bioabsorbable screws have become popular to avoid the need for hardware removal and to allow for MRI imaging without artifacts, although concerns regarding variable absorption rates and inflammatory reactions exist.[7]

Conversely, suspensory fixation, such as the Endobutton, relies on cortical anchorage. This technique offers high ultimate load strength but introduces a longer working length of the graft within the tunnel. This has raised concerns about the "bungee effect" (longitudinal elongation) and the "windshield wiper effect" (transverse motion), which may lead to tunnel widening.[8,9]

A "Hybrid" approach, combining a femoral cortical button with a tibial interference screw, attempts to leverage the strengths of both methods: the high pull-out strength of cortical suspension and the aperture compression of a screw. However, whether this hybrid configuration translates to superior clinical outcomes compared to a Double Bioabsorbable Interference Screw (DBIS) technique—where screws are used at both femoral and tibial sites—remains a point of contention. Existing literature offers conflicting evidence, and studies specifically evaluating these techniques in the Indonesian demographic are limited. [10]

This study aims to bridge this gap by evaluating and comparing the clinical functional outcomes, as measured by the International Knee Documentation Committee (IKDC) scores, between patients treated with the DBIS technique and those treated with a Hybrid (Button and Bioabsorbable Screw) technique at RSU Haji Medan. We hypothesize that while biomechanical principles differ, functional outcomes at mid-term follow-up will be comparable between the two groups.

METHODS

Study Design and Setting

This was an observational analytic study utilizing a case-control design. The research was conducted at the Department of Orthopaedics and Traumatology, RSU Haji Medan. Data collection, including medical record review and patient interviews, was conducted in September 2025. The study received ethical approval from the Ethics Commission of the Faculty of Medicine, Universitas Sumatera Utara.

Population and Sample

The study population comprised patients who underwent ACL reconstruction at RSU Haji Medan.

- **Inclusion Criteria:**
  1. Patients aged 18–59 years.
  2. Patients undergoing isolated primary ACL reconstruction.
  3. At least 6 months post-operative follow-up.
  4. Completion of at least 3 months of post-operative physiotherapy.
- **Exclusion Criteria:**
  1. Bilateral ACL injury.
  2. Revision surgery.
  3. Multi-ligamentous injuries or concomitant fractures.
  4. Incomplete medical records or refusal to participate.

Sample Size

A total of 50 subjects were recruited, divided equally into two groups:

1. **Group A (DBIS):** 25 patients underwent reconstruction using Double Bioabsorbable Interference Screws (femoral and tibial).
2. Group B (Hybrid): 25 patients underwent reconstruction using a Femoral Button and a Tibial Bioabsorbable Screw.

The sample size was calculated to achieve a 95% confidence level (Z\alpha=1.96) and 90% power (Z\beta=0.842).

Surgical Technique

- **DBIS Technique:** Bioabsorbable interference screws were used to secure the hamstring autograft at both the femoral and tibial tunnels. The interference screw provides aperture fixation by compressing the graft against the cancellous bone wall.
- **Hybrid Technique:** A cortical suspension device (Endobutton) was used for femoral fixation, relying on the flip-button mechanism on the lateral femoral cortex. Tibial fixation was achieved using a bioabsorbable interference screw.

Outcome Measures

The primary outcome was the IKDC Subjective Knee Form score, assessed at four time points: Pre-operative, 1 month, 3 months, and 8 months post-operative. The IKDC form evaluates symptoms (pain, stiffness, swelling, giving way) and function (activities of daily living and sports activities) on a scale of 0–100, with 100 representing perfect function.[8,9]

Statistical Analysis

Data were analyzed using statistical software. Normality was tested using the Shapiro-Wilk test. Demographic characteristics were compared using independent t-tests for continuous variables and Chi-square tests for categorical variables. Comparison of IKDC scores between groups was performed using the independent t-test (for normally distributed data) or Mann-Whitney U test (for non-normal data). A p-value of <0.05 was considered statistically significant.

RESULTS

Demographic Characteristics

The demographic profile of the study participants is summarized in Table 1. The mean age of the DBIS group was 41.48 ± 4.03 years, which was significantly younger than the Hybrid group at 43.92 ± 2.97 years (p=0.019). However, the gender distribution was balanced between groups, with no significant difference (p=0.777), minimizing gender as a confounding variable.

Table 1. Characteristics of Study Subjects by Surgical Group

Variable	DBIS (n = 25)	Button and Bioabsorbable Screw (n = 25)	p-value
Age, years (mean ± SD)	41.48 ± 4.03	43.92 ± 2.97	**0.019[1]**
Gender, n (%)			0.777[2]
Male	13 (52.0%)	12 (48.0%)	
Female	12 (48.0%)	13 (52.0%)	

Note: [1]Independent t-test, [2]Chi-square test

Functional Outcomes (IKDC Scores) The functional outcomes were tracked longitudinally from the pre-operative phase to 8 months post-surgery. Both groups demonstrated a robust and progressive improvement in IKDC scores.

As detailed in **Table 2**, the pre-operative baseline scores were nearly identical (41.04 vs. 40.84, p=0.881), indicating a similar level of initial disability and functional impairment between the two cohorts.

At 1 month post-op, scores improved to approximately 50 in both groups with no significant difference (p=0.875). This trend continued at 3 months, where scores reached approximately 67 (p=0.767).

At the final follow-up of 8 months, both groups achieved high functional scores (87.72 vs. 88.48), with no statistically significant difference (p=0.448). The statistical analysis (ANOVA and t-tests) confirmed that the variation in scores was not driven by the fixation technique used.

Table 2. Comparison of IKDC Scores Between Groups

Variable	DBIS (n = 25) Mean ± SD	Button and Bioabsorbable Screw (n = 25) Mean ± SD	p-value
IKDC Pre-operative	41.04 ± 4.49	40.84 ± 4.88	0.881
IKDC Month 1	50.08 ± 3.51	50.24 ± 3.62	0.875
IKDC Month 3	67.12 ± 4.21	67.48 ± 4.33	0.767
IKDC Month 8	87.72 ± 3.34	88.48 ± 3.68	0.448

DISCUSSION

This study sought to determine if the choice of fixation device—specifically Double Bioabsorbable Interference Screw (DBIS) versus a Hybrid Button/Screw construct—influences the short-to-mid-term functional recovery of ACL reconstruction patients. The principal finding of this study is that both techniques yield statistically equivalent functional outcomes as measured by the IKDC score up to 8 months post-operatively.

Demographic Influences and Biological Healing

We observed a significant age difference between the groups, with the Hybrid group being slightly older (mean 43.9 years) than the DBIS group (mean 41.5 years). Literature suggests that advancing age can negatively impact patient-reported outcomes due to decreased trabecular bone quality, slower inflammatory response, and

less efficient collagen remodeling.[11,12] However, despite the Hybrid group being older, their functional scores were not inferior to the younger DBIS group. This finding implies that within the productive age range of 18–59, the biological potential for graft integration remains sufficient to support rehabilitation regardless of the fixation method used. Alternatively, the cortical stability provided by the button fixation might compensate for any potential age-related delays in cancellous bone healing.

The gender distribution was balanced (approx. 50:50). This is a strength of the study, as female gender is often associated with different neuromuscular control patterns (e.g., greater dynamic valgus) and potentially different recovery trajectories. [13] By ensuring gender parity, the confounding effect of sex on the comparative analysis was minimized.

Clinical Equivalence of Fixation Methods

The baseline IKDC scores (~41) were consistent with severe functional limitation typical of ACL-deficient knees. The progression to ~88 at 8 months represents a successful clinical outcome, often defined as a score >85. The lack of significant difference between the two groups ($p > 0.05$ at all time points) aligns with the findings of global meta-analyses. For instance, Yan et al. (2021) and Elias et al. (2025) reported no consistent superiority of interference screws over cortical buttons in terms of functional scores or graft failure rates. [15,16]

Biomechanically, these results support the concept that initial fixation strength in both methods is supramaximal to the forces exerted during early rehabilitation. The "bungee effect" associated with suspensory fixation, often cited as a theoretical disadvantage leading to tunnel widening, did not translate into functional instability or lower IKDC scores in our Hybrid group.[17,18] This suggests that any potential micromotion occurring with button fixation is either clinically negligible or adequately stabilized by the tibial interference screw and subsequent biological healing.

The aperture fixation provided by the DBIS technique theoretically reduces the working length of the graft, increasing stiffness. However, our clinical data implies that this increased stiffness does not necessarily result in better patient-perceived function during the first 8 months. It is possible that the biological process of ligamentization—which occurs between 6 to 12 weeks—is the great equalizer, overshadowing the mechanical differences of the implants once the graft incorporates.

Clinical Implications

For the orthopedic surgeon, these findings imply that the choice between DBIS and Hybrid fixation can be flexible. If a patient has poor bone quality in the femur, a cortical button might be preferred for its reliance on cortical rather than cancellous bone. Conversely, if minimizing foreign material or cost is a priority, and bone stock is good, DBIS remains a valid and effective option.

CONCLUSION

There is a statistically significant age difference between the groups, with the Hybrid group being older; however, gender distribution is equal. Most importantly, there is no significant difference in clinical functional outcomes between ACL reconstruction using the Double Bioabsorbable Interference Screw (DBIS) technique and the Hybrid (Femoral Button and Tibial Screw) technique. Both methods result in significant improvement in IKDC scores from pre-operative baselines to 8 months post-surgery.

SUGGESTIONS

Future Studies: Should involve larger sample sizes and multicenter designs to improve generalizability.

Longer Follow-up: Extending follow-up to 2 years or more is recommended to assess long-term complications such as tunnel widening, graft failure, and osteoarthritis development.

Objective Measures: Incorporating objective stability testing (e.g., arthrometer) alongside subjective scores would provide a more comprehensive assessment of graft integrity

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