

The healing effect of the all inside technique is superior to the traditional technique in the reconstruction of the anterior cruciate ligament

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Abstract

Our main objective was to examine the curative effect of all inside technique and traditional technique in anterior cruciate ligament (ACL) reconstruction. In our retrospective study at the First People's Hospital of Jiashan County, we analyzed 88 participants with ACL injuries (50 males, 38 females, average age 27 years). They were randomly divided into two groups: traditional ACL reconstruction (42 participants) and all inside ACL reconstruction (46 participants). We measured and recorded the Visual Analog Scores (VAS), International Knee Documentation Committee (IKDC), Lysholm scores, operation time, graft diameter and length between the traditional technique group and all inside technique group. There were statistically significant differences in the Lysholm scores and IKDC scores between traditional and all inside technique groups. The all inside technique showed a higher efficacy and effective post-operative recovery with minimal pain and recurrent injuries. Our findings showed that the differences in gender, age, side of injury and operation time were not significant ($p > 0.05$). Follow-up was conducted at 6 months and 12 months post operations (mean, 7.5 ± 1.1 months). All inside technique minimizing tissue disruption, optimizing graft placement and facilitating early recovery have a significant impact on patient outcomes.

Key Words: Lysholm, IKDC; ACL; VAS; all inside technique; traditional technique.

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The anterior cruciate ligament (ACL) is a critical component of the knee joint, playing a pivotal role in maintaining stability and controlling motion.¹⁻³ Rodriguez et al., suggested that the significance of the ACL becomes apparent when it sustains an injury, as a tear or rupture can lead to debilitating symptoms, including pain, instability, and limitations in daily activities and sports participation.⁴ According to An et al., in response to ACL injuries, surgical intervention has emerged as a cornerstone approach to restoring knee joint function and preventing long-term joint damage.⁵ Consequently, ACL reconstruction has become a widely accepted approach to restoring knee joint stability and function in individuals suffering from ACL injuries. According to Marieswaran et al., the ACL is one of the four primary ligaments within the knee joint, situated centrally to provide critical stability.⁶ Its primary function is to prevent excessive anterior translation of the tibia relative to the femur and control rotational forces during knee motion. Due to its crucial role in knee joint

stability, injuries to the ACL are relatively common, especially in activities involving pivoting, cutting, and sudden direction changes.⁷ A diverse array of surgical techniques has evolved over time for ACL reconstruction, each with unique characteristics and goals. The primary objective of these procedures is to replace the injured or torn ACL with a graft, often harvested from the patient's own tissues or procured from a donor source.

Mengaji et al., suggested that traditional ACL reconstruction techniques represent a time-tested and widely adopted approach to addressing ACL injuries.⁸ This method involves the creation of tunnels within both the tibia and femur to facilitate the secure placement of the graft. These tunnels serve as anchor points for the graft material, enabling it to mimic the function of the damaged ACL.^{9,10} One of the critical decisions in traditional ACL reconstruction is the choice of graft material. Orthopaedic surgeons typically consider autografts and allografts.^{11,12}

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According to Baawa-Ameyaw et al., autografts involve using the patient's own tissue to reconstruct the ACL.¹³ The most commonly utilized autografts are sourced from the patient's patellar tendon or hamstring tendon. The choice between these two depends on various factors, including the surgeon's preference, patient characteristics, and individual knee anatomy. Solie et al., suggested that patellar tendon autografts are renowned for their robustness and ability to restore stability effectively.¹⁴ Hamstring tendon autografts, on the other hand, are valued for their less invasive harvesting technique and potential for reduced postoperative morbidity.¹⁵

According to Lee et al., allografts employ tissue harvested from cadaveric donors. This approach eliminates the need for harvesting tissue from the patient's body, potentially reducing donor site morbidity. Allografts can be derived from various sources, including Achilles tendon, patellar tendon, or hamstring tendon.^{16,17} While allografts offer advantages related to surgical simplicity and decreased donor site complications, there is a debate about their long-term outcomes compared to autografts.

According to Martinez-Cano et al., the traditional ACL reconstruction procedure typically involves an arthroscopic approach. Small incisions are made around the knee joint, allowing for the insertion of an arthroscope (a small camera) and specialized

instruments.¹⁸ The torn ACL remnants are removed, and the tunnels are created in both the tibia and femur using precision drills. The graft is then prepared and positioned in these tunnels. Fixation devices such as screws, interference screws, or suspensory devices are used to secure the graft firmly in place.¹⁹⁻²¹

The All Inside Technique, as proposed by An et al.,⁵ represents a modern shift in ACL reconstruction, aiming to minimize tissue disruption while restoring ACL function.¹⁹ Unlike traditional methods with tibial and femoral tunnels, it relies on an internal approach, anchoring the graft within the knee joint itself.²² This technique starts with arthroscopy and small incisions, preserving healthy tissue and using internal anchoring mechanisms like bioabsorbable implants, sutures, or fixation devices instead of external tunnels.²³

Aboalata et al., introduced the Anterior Internal Substitution Technique (AIST) as an innovative ACL reconstruction approach, known for favourable patient outcomes and faster recovery.²⁴ AIST involves arthroscopy, with small incisions for instrument insertion, akin to traditional and all inside techniques. AIST is distinct for its internal graft placement within the knee joint, differing from traditional methods with external tunnels.²⁵ It secures the graft internally using techniques like sutures, implants, or specialized devices. Our main objective is to assess the curative effect of all inside technique and traditional technique in anterior cruciate ligament reconstruction.

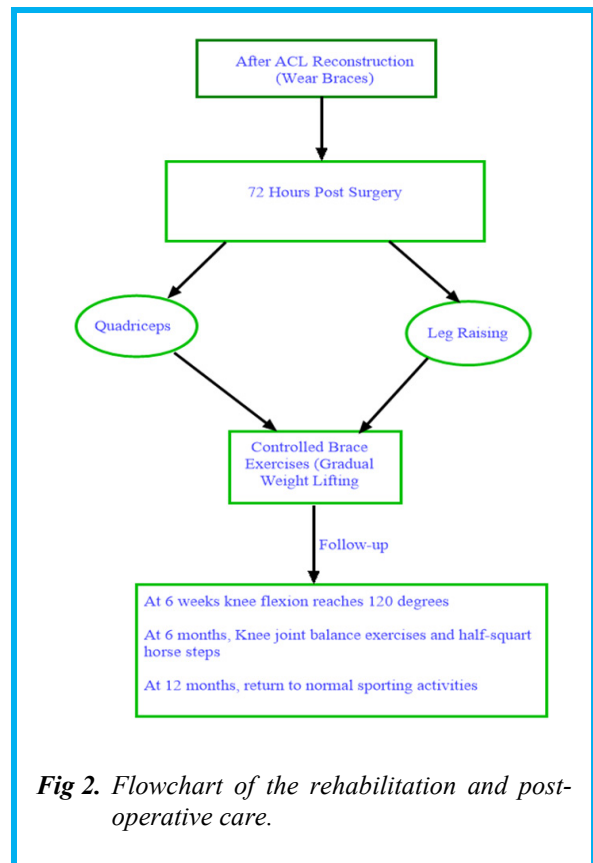
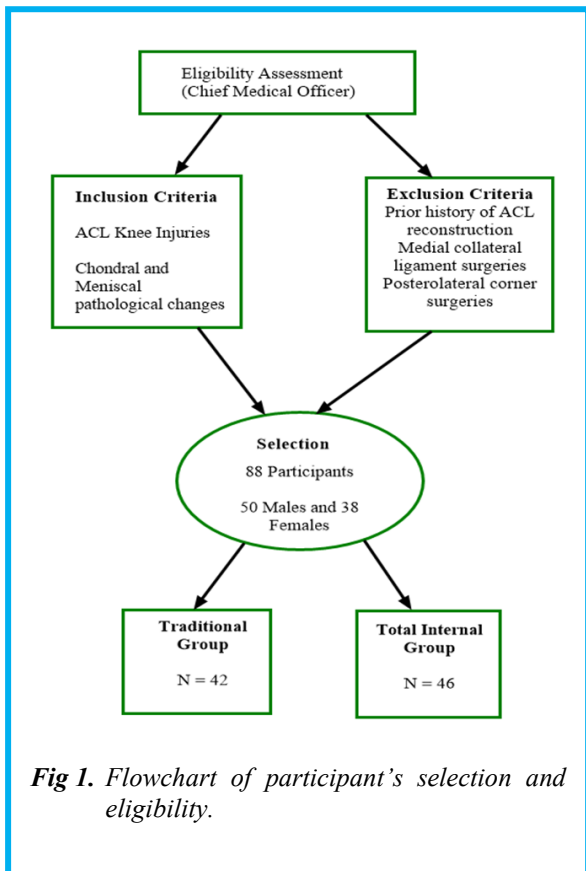


Table 1. Baseline characteristics of selected participants.

Variable	p-value
Gender (M/F)	0.834
Age	0.786
Side of Injury	0.443

Note: M/F = Males/Females.

Table 2. IKDC Scores between Experimental Groups.

IKDC score	All inside technique	Traditional	χ^2 value	p- value
Grade A	35	25	3.557	0.033**
Grade B	10	14		
Grade C	1	3		

Note: ** $p < 0.05$. IKDC = International Knee Documentation Committee.

Materials and Methods

Participants

We conducted a retrospective study involving 88 participants from the First People's Hospital of Jiashan County. All participants were recruited from January 2018 to July 2023 with ACL injuries and were admitted at the department of Orthopaedics. Our study consisted of 50 males and 38 females, with an average age of 18 to 40 years ($M = 27$, $SD = 4$ years). The participants were randomly assigned into the two treatment groups; 42 participants in the traditional group and 46 participants in the all inside group. Our study was approved by the Ethics Committee of the First People's Hospital of Jiashan County and carried out according to the Helsinki Declarations. All participants issued informed consent to undertake the study and all personal identifiers were removed from the study.

Eligibility Criteria

We assessed eligibility to participate in the study before all participants completed the consent forms and were enrolled in the study (Figure 1). The eligibility process was facilitated by the Chief medical officer at the Hospital. The inclusion criteria involved participants who had ACL-knee injuries who were subjected to reconstructive surgery based on autograft tissues. Moreover, we included patients with pathological changes in the chondral and meniscal sections. However, these pathological changes were treated based on the surgeon's discretion who recorded and observed all changes. Our exclusion criteria involved patients who had prior history of ACL reconstruction, patients who were subjected to medial collateral ligament surgeries, or posterolateral corner surgeries were removed from the study.

Surgical Operations

In the all inside technique group, the ipsilateral semitendinosus muscles were subjected to several loops of tight ropes designed in a quadrupled fashion. Two

front loops were situated on the tibia and sewed with a fibre loop in a zigzag manner to make the ends robust and strong. The remnant ACL fibres were used as a baseline (reference point) with a pin situated at the top with a guide fibre loop. The lateral femur was completely removed to ensure that the femoral socket was situated adjacent to the ACL through the anteromedial portal. We ensured that the femoral socket was placed closer to the ACL such that the minimum graft in the femoral socket was 20 mm with a pin used as a guide to placing the fibre wire for sewing the section.

We measured the intra-articular graft distance using an articular ruler which was summed together with the length of the graft situated in the femoral socket. The total measurement was defined as the maximum depth of the graft within the tibia. The socket of the tibia was derived from the anatomical site extracted from the anterior horn of the lateral meniscus. A flip cutter was then drilled onto the joint and inverted to produce a reamer that was retro-cut into the tibia. The reamer was drilled 5 mm deeper to permit optimum tension within the grafts using the all-

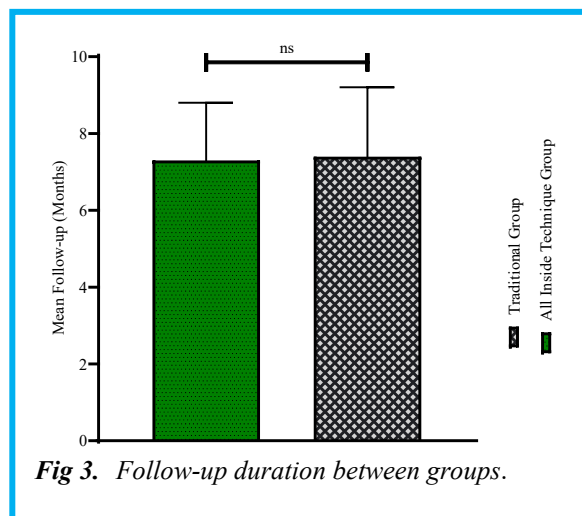


Fig 3. Follow-up duration between groups.

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Table 3. Lysholm Scores Between Experimental Groups.

Group	Patient	Preoperative	6 months post	12 months post
All inside technique group	46	65.3 ± 5.6	85.3 ± 5.5	98.7 ± 6.8
Traditional	42	62.6 ± 4.8	77.6 ± 6.1	83.5 ± 6.6
<i>t</i> value		0.865	0.979	0.321
<i>P</i> value		0.736	0.034**	0.023**

Note: Note: ****p*<0.05. post = duration after surgical operation.

inside technique. After which, the flip cutter was removed and a tiger stick was used through the flip cutter hole to the joint and retrieved as a shuttle baste within the tibia. The autograft was then adjusted using tight rope to the required depth while shortening the strands.

In the traditional technique, at section A, the fibre wire was utilised in sewing the region at 2 cm on every side of the ipsilateral semitendinosus and the gracilis tendons. We inserted the tibia, point to point while locating the femoral lateral condyle and fixing it using Endobuttons. The position of the autograft was adjusted at 30 degrees to the knee and fixed using a screw.

Rehabilitation and post-operative care

We used the same rehabilitation protocols for the treatment groups, all the limbs were tightened with braces after undergoing surgical operations (Figure 2). All patients were subjected to quadriceps exercises 72 hours after surgical operations preceded by leg raising exercises within 96 hours. Subsequent exercises involved lifting of gradual weights under controlled braces. The complexity and duration of the exercises increased weekly until full recovery. Furthermore, the chuck braces restricted joint and knee flexion activities within a 30° range. The knee flexion and extension range of motion

reached 90° within 1 week after the operation, and the knee flexion and extension range reached 120° 6 weeks after the operation. The brace was removed 3 months after the operation, and knee joint balance exercises and half-squat horse steps were gradually started, 6-8 months. Return to daily exercise after the month.

Treatment Outcomes

We measured the operation time, graft diameter, knee joint function score (knee joint International Knee Documentation Committee (IKDC) score and Lysholm score at 1 week, 6 months, and 1-year follow-up were compared between the two groups. Also, we determined the Visual Analog Scores (VAS). All participants were subjected to robust clinical evaluations by doctors and physicians before undertaking subsequent measurements.

Statistical Analysis

All statistical analyses were performed in Graph Pad prism version 9.5.1 at a significance *p*< 0.05 (version 9.5.1 for macOS, GraphPad Software, San Diego, California USA). We used ANOVA to compare the sample means of the two treatment groups and conducted follow-up tests for further analysis. Descriptive statistics were presented as mean ± standard deviation

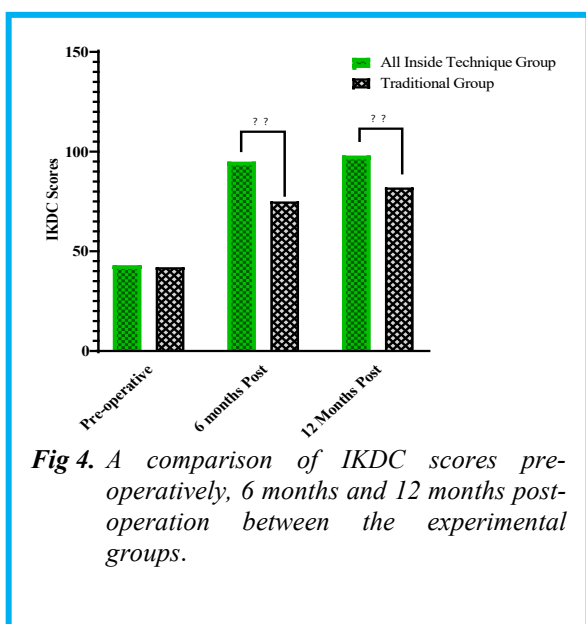


Fig 4. A comparison of IKDC scores pre-operatively, 6 months and 12 months post-operation between the experimental groups.

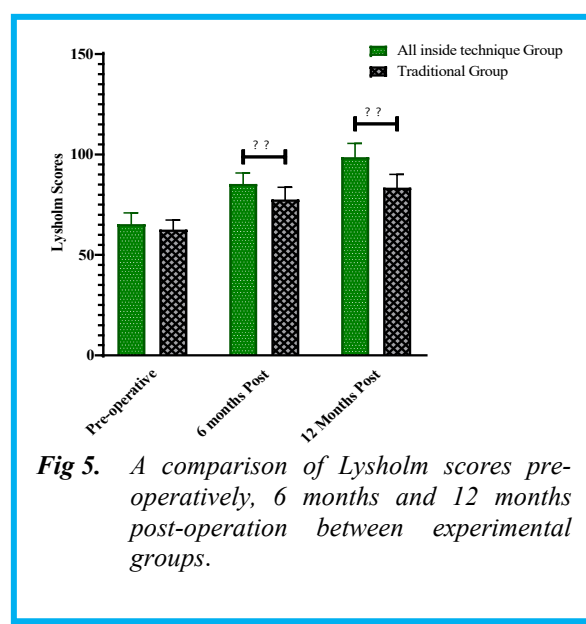


Fig 5. A comparison of Lysholm scores pre-operatively, 6 months and 12 months post-operation between experimental groups.

Table 4. VAS Scores Between the experimentalgGroups.

Time	All inside technique	95%CI	Traditional	95%CI	P value
Week 1	4.5 ± 0.4	0.8	3.5 ± 0.6	0.7	0.004**
6 months	1.7 ± 0.6	0.4	0.9 ± 0.3	0.4	0.015**
12 months	0.5 ± 0.8	0.2	0.2 ± 0.2	0.3	0.008**
Group	Patient	Preoperative	6 months post	12 months post	
All inside technique group	46	65.3 ± 5.6	85.3 ± 5.5	98.7 ± 6.8	
Traditional	42	62.6 ± 4.8	77.6 ± 6.1	83.5 ± 6.6	
t value		0.865	0.979	0.321	
P value		0.736	0.034**	0.023**	

Note: **p < .05. CI = Confidence Interval.

Results

Our findings showed that the differences in gender, age, and side of injury were not significant (p > 0.05) (Table 1). All the participants were subjected to a follow-up duration of 6 months and 12 months post operations (mean, 7.5 ± 1.1 months). Our analysis of the follow-up duration revealed no statistically significant differences between the treatment groups (Figure 3). In our analysis of IKDC score, we observed three patients with grade C knee functions in the traditional group while one patient had grade C knee function in the all inside technique group. Comparative analysis of IKDC scores showed statistically significant differences between the treatment groups (p < 0.05), (Table 2).

All the participants were subjected to a follow-up duration of 6 months and 12 months post operations (mean, 7.5 ± 1.1 months). Our analysis of the follow-up duration revealed no statistically significant differences between the treatment groups (Figure 3).

Our analysis of the Lysholm scores showed that patients had scores greater than 95 degrees in the all inside technique group while the traditional group had scores between 70 and 83. These differences were statistically significant (p < 0.05) (Table 3 and Figure 5). Our analysis of VAS scores showed that the all inside technique group had significantly higher scores compared to the

traditional group (Table 4). In the all inside technique group, all participants were pain free at 6 months of follow-up while in the traditional group, pain disappeared completely at 1 year of follow-up. At 1-year of treatment, we did not observe any significant complications such as recurrence of ligament injuries, presence of secondary infections and inflammatory reactions between the two treatment groups. Our analysis of the operation time, graft diameter and length revealed that there was no statistically significant difference in operation time between the two groups. The intraoperative graft diameter and length of the traditional technique group were significantly larger than those of the all inside technique group (p < 0.05) (Table 5).

Discussion

Our study explored the impact of the application of all inside technique techniques and traditional techniques in arthroscopic ACL reconstruction on surgery-related indicators and prognosis. We showed that the all-internal technique requires less grafts during arthroscopic ACL reconstruction than the traditional technique group, but the operation time of the two methods is almost the same, and both methods can be achieved in the nearly 1-year follow-up with better recovery. Thus, the amount of hamstring muscle resection obtained by the all inside technique during ACL reconstruction surgery with autologous tendon

Table 5. Comparison of operation time, graft diameter and length between the traditional technique group and all inside technique group.

Group	Number of cases	Operation time (min)	Graft diameter (mm)	Graft length (mm)
Traditional	42	100.3±14.2	9.0±0.9	8.2±0.23
All inside technique	46	102.6±15.8	8.0±0.6	6.7±0.34

Note: min = minutes. mm = millimeter

transplantation is relatively small compared to the traditional technique.

We suggest that although the diameter of the graft obtained by the all inside technique is thin, it has reached an average of (8.0 ± 0.6) mm, which is larger than the minimum diameter of 8 mm considered by American scholars for single-beam reconstruction.²⁶ Similarly, Colombet et al., showed that the graft healed better after 1 year with double-suspension fixation using the all inside technique than with interface screws because although the bone tunnel formed by the reverse drill is shorter, it increases the tendon-bone contact area and forms a longer bone tunnel leading to a good healing environment.²⁷

Connaughton et al., showed that double-suspension fixation with the all-internal technique may cause joint leakage and increase tibial wound infection.²⁸ However, theoretically, the interface screws are hollow and locked and cannot avoid joint fluid leakage. Moreover, if the graft matches the bone tunnel, the joint probability of fluid leakage should be greatly reduced. In our study, there were no obvious cases of wound infection, so no comparisons were made.

Our study showed that the postoperative IKDC score and Lysholm score of both groups were higher than those before surgery, suggesting that both surgical methods have a certain effect in ACL reconstruction. In addition, further comparison between groups found that there was a statistical difference between the two groups with the all inside technique group having higher scores than the traditional group. The preservation of the hamstrings helps maintain posteromedial stability of the knee joint and enable early return to sporting activities.⁵

Our findings were partially consistent with a retrospective study by Connaughton et al., they showed that there were no statistically significant differences in the operation time.²⁸ Lysholm scores and IKDC scores between participants in the traditional and all-all inside groups. However, their findings showed that post-surgical operation VAS scores of the total-internal technique group was significantly higher than the traditional group. Thus, they concluded that efficacy and efficiency of both procedures was similar with the total-internal technique having lower post-operative pain and increased recovery during rehabilitation.

These findings were replicated by Benea et al., who suggested that in ACL reconstruction in the all inside technique resulted in pain at the site of the allograft in the short term and it was only feasible to eliminate only one tendon to reduce the chances of intensive post-operative pain.²² Moreover, Benea et al., proposed that the VAS scores in the post-operative pain in the all inside technique was extremely lower compared to the traditional techniques.²² These findings were similar to our analysis of VAS score which revealed a similar trend with the all inside technique having lower scores compared to the traditional group. These low VAS scores can be attributed to the diameter of the tibial tunnel in the

all inside group which was 3.5mm and reduced by 50% compared to the traditional group which recorded 7 mm to 8 mm. Furthermore, in the total-internal group, we only used the semitendinosus muscle as the allograft which significantly reduced the possibility and spread of damage to the surrounding tissues.

Our study proposes that the observed difference in IKDC scores between the all inside technique group and the Traditional ACL Reconstruction group at both the 6-month and 12-month post-operative assessments is of particular significance. Similarly, Takahashi et al., postulated that all inside technique, as an innovative approach, minimizes collateral tissue damage during surgery.²⁹ The absence of tibial and femoral tunnels reduces the trauma to the surrounding structures, preserving their integrity. This feature translates into less postoperative pain and a quicker recovery process. Furthermore, all inside technique utilizes grafts that are anchored internally within the knee joint, eliminating the need for graft harvesting from elsewhere in the patient's body. This internal graft placement is a fundamental characteristic of all inside technique and distinguishes it from traditional techniques. As a result, all inside technique effectively eliminates donor site morbidity concerns, as there are no external graft donor sites that can cause discomfort or complications.

Previous studies by Lubowitz et al.,³⁰ and Segawa et al.,³¹ postulated that the lack of hamstring tendons in the knee increases the rate of reducing the flexion of the internal rotations force within the knee by 10%. Similarly, Yosmaoglu et al., showed that extensive and careful preservation of the gracilis muscles increases the probability and speeds up post-operative recovery among athletes.³² Moreover, it increases the degree of comfort and quality of life during rehabilitation after ACL reconstruction. These benefits accrue to athletes who engage in exercises that required more than 70 degrees of knee flexion. We propose that preservation of the gracilis muscles has significant effects in increasing the rate of recovery and improvement in knee flexion.

Our findings contradict with Volpi et al., who proposed that increased rate of restoring the joint movement and functionality of the knee was similar in patients treated with all inside techniques and traditional techniques.³³ Their study suggests that the bone tunnel drilled in the tibia in the all inside technique was carried out from the outside then inside with the tunnel having thin outside sections and thicker inner sections. This method of drilling tunnels ensures that the leakage of joint fluids is minimal and lowers the risk of secondary infections and recurrent injuries.

According to Hacken et al.,³⁴ all inside technique's absence of donor site morbidity contributes to reduced pain and discomfort post-surgery, enhancing patient comfort and satisfaction. Reduced morbidity facilitates a smoother rehabilitation process, as patients experience less pain during recovery, enabling them to engage more effectively in rehabilitation exercises. The sustained

reduction in morbidity with all inside technique ensures that patients are less likely to experience chronic complications related to donor sites, leading to better long-term outcomes.³⁵

In our study, in the all inside technique we used the semitendinosus tendon as graft that resulted in effective reduction in losses of the internal rotation at the knee flexion and led to significant post-operative outcomes during rehabilitation. However, we observed 3 patients with signs of numbness in the traditional group and one patient in the total-internal group which were mostly caused by injuries to the inferior patellar branch of the saphenous nerves. These injuries were mostly likely during the extraction of the tendons that caused numbness around the medial section of the proximal knee. Andernord et al., showed that ACL reconstruction in the early stages after injuries increases the possibility of stiff knees and therefore, subsequent operations should be performed after about 14 days of injury to reduce the adverse effects of post-operation fibrosis at the joint.³⁶

Our study suggests that all inside technique contributes to early functional recovery, as evidenced by higher IKDC scores at the 6-month and 12-month post-operative assessment. We propose that the absence of external tunnels means that the knee's anatomical structures are preserved to a greater extent in all inside technique. This preservation is particularly important for maintaining knee stability and facilitating early rehabilitation.^{37,38} Patients in the all inside technique group are less likely to experience the destabilizing effects of extensive tissue disruption, which can impede early functional recovery. Additionally, all inside technique minimizes tissue disruption during ACL reconstruction surgery.⁵ Unlike traditional techniques that involve creating tunnels in the tibia and femur, all inside technique does not require the formation of these tunnels. Consequently, there is less trauma to the surrounding ligaments, cartilage, and soft tissues. This reduced tissue disruption is a crucial factor in early functional recovery.

A study by Kouloumentas et al., suggested that the adoption of adjustable or fixed loop buttons in the femoral ends increases the mechanical strength required for early recovery knee exercises during biomechanical tests.²⁰ The increased utilization of these loops in the femoral ends resulted in early functional recovery in the all inside treatment group compared to the traditional group. In contrast, a randomized controlled study by Boyle et al., involving 188 patients with ACL injuries showed no statistically significant differences in the KT-1000, failure time of allografts and rates in patients subjected to adjustable or fixed loop buttons in the femoral ends.³⁹ Instead, they proposed that the adoption of the tibial lateral fixation technique was shifted from the traditional techniques involving inter-facial screw extrusions to suspended fixed screw extrusions. These findings were echoed by Mayr et al., who performed biomechanical tests and postulated that inter-facial screw extrusions have a lower degree in permitting elongation

of grafts and had an average anti-pull-out performance.⁴⁰ In contrast, adoption of the suspended fixed screw extrusions increased the load bearing and limit on the knee with no graft displacement during rehabilitation compared to the inter-facial screw extrusions.

Our study was consistent with Rassi et al., in showing that all inside technique the combination of reduced tissue disruption, preserved knee anatomy, and potentially enhanced graft integration creates an environment conducive to optimized rehabilitation.⁴¹ Patients in the all inside technique group are more likely to progress through early rehabilitation milestones with greater ease and efficiency. This early progress is a key factor in achieving early functional recovery.²¹ Therefore, patients in the all inside technique group continue to experience improved knee function and quality of life over an extended timeframe. The persistence of higher IKDC scores in the all inside technique group suggests that the advantages observed at the 6-month assessment are not transient but rather consistent and enduring. This consistency in patient outcomes is a significant benefit for individuals seeking lasting improvements in knee function.

In conclusion, our findings suggest that the all inside technique has a higher efficacy and efficiency compared to traditional techniques in improving knee flexion and functionality. Moreover, it results in low post-operative pain and minimal recurrent ACL injuries, ensuring effective tendon utilization coupled with low destruction of the proximal tibial cortex due to the use of a single hamstring muscle. The outstanding knee function achieved in the all inside group can be attributed to optimal graft sizing and tensioning, minimized risk of graft impingement, load distribution, synovial tissue preservation, early mobilization, enhanced graft maturation, reduced risk of graft failure and of patient-specific complications.

List of acronyms

ACL -anterior cruciate ligament

AIST- Anterior Internal Substitution Technique

IKDC- International Knee Documentation Committee

VAS -Visual Analog Scores

Contributions of Authors

All authors participated in the development of the study design, data collection, data interpretation, writing and done the revision. All authors read and approved the final edited manuscript.

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Conflict of Interest

The authors declare they have no conflicts of interest.

Ethical Publication Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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