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Research Article

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Clinical and Functional Outcome of Anterior Cruciate Ligament Reconstruction with Hamstring Autograft: a Comparison study of All-Inside versus Complete Tibial Tunnel Techniques

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ABSTRACT

Purpose: The purpose of our study is to compare the clinical and functional outcomes for anatomic ACL reconstruction (ACLR) using the all-inside technique versus a complete tibial tunnel technique (min. follow-up 24 month**s).**

Materials and Methods: Patients who underwent hamstring autograft ACLR via either an all-inside approach or a complete tibial tunnel approach (femoral socket and full-length, transtibial tunnel) at a single institution between 2015 and 2022 were reviewed. Demographic information, preoperative comorbidities, surgical details, physical examination findings (pivot-shift, Lachman, and ROM) and follow-up outcomes (VAS, Tegner -Lysholm score, and IKDC were extracted from the medical record. Return to sport and failures were also analyzed.

Results: A total of 50 patients (mean ± SD age, 28 ± 8.4 years) who underwent all-inside reconstruction (median follow-up, 2.38 years; range, 2-3.2 years) and 50 (mean ± SD age, 27.9 ± 8.1 years) who underwent complete tibial tunnel reconstruction (median follow-up, 2.26 years; range, 2-3.2 years) met the inclusion criteria. Patient-reported outcomes (PROs) scores at 3, 6 months and latest follow up were comparable between the all-inside versus the complete tibial tunnel groups (VAS score [2w] 1.9 vs 2.1 - VAS score [4w] 0,4 vs 0.7 - Lysholm Tegner score [6m] 96.8 vs 95.8; P<0.001 - IKDC score[1y] 97.7 vs 97.8; P<0,001). Graft failure before the final follow-up was experienced by 8% of patients in the all-inside group compared with 12% in the complete tibial tunnel group. Mean return to everyday activities was 5.8 weeks in the all-inside versus 9.6 weeks in the complete tibial tunnel group (P <0,05).

Conclusion: Both techniques resulted in excellent physical examination findings and PROs at minimum 2-year follow-up; and successfully restored knee stability and patient function. All inside has statistically significant less pain and improved scores the first 2 and 4 weeks postoperatively.

Level of evidence: Cohort study; III.

List of Aabbreviations

ACLR	:	ACL Reconstruction
IKDC	:	International Knee Documentation Committee
PROs	:	Patient-reported outcomes
ACL	:	Anterior cruciate ligament

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CCA	:	Central Clinic of Athens
OA	:	Osteoarthritis
ROM	:	Range of Movement
VAS	:	Visual Analogue Scale
PLLA	:	Poly-L-Lactic Acid
DGST	:	Doubled Gracilis and Semitendinosus Tendon

Keywords: Anterior Cruciate Ligament Reconstruction, ACL, All-Inside, Complete Tibial Tunnel

Introduction

Anterior cruciate ligament (ACL) rupture is one of the most common sports injuries worldwide; whereas arthroscopic ACL reconstruction (ACLR) is the standard treatment, which can prevent further knee instability's damage to the cartilage and meniscus. Furthermore, ACLR helps the patients to return to their previous sports activities [1-3]. In nowadays, there are two surgical techniques that are widely used: 1) the conventional ACLR of the complete tibial tunnel approach (femoral socket and full-length, transtibial tunnel) and 2) the all-inside ACLR reconstruction (femoral and tibial sockets) [1,3].

All-inside ACLR has recently gained popularity, in part because of its bone-sparing socket preparation and the reported lower pain levels after surgery. An "all-inside" technique creates bone sockets for ACL graft passage, as opposed to more traditional full bone tunnels, and typically incorporates suspensory fixation instead of screw fixation to secure the graft. This technique may be indicated for any ACLR surgery, where adequate bone stock exists to drill sockets and to use cortical fixation. The technique may be used with all soft tissue, as well as bone plug ACL grafts and autograft hamstring or quadriceps tendon; additionally, most allograft tendon options may be performed with an all-inside technique [4-6]. All inside ACLR advantages includes 1) anatomic tunnel/ socket placement (bone preservation), 2) minimal hardware, appropriate graft tensioning and retensioning, 3) decreased postoperative pain and swelling 4) circumferential graft to bone healing, 5) use in skeletally immature patients, 6) use of only a single hamstring tendon in the graft, and 7) no complications associated with screws. Tips for successful all-inside surgery include matching graft diameter to socket diameter, drilling appropriate length sockets based on individual graft length, so as not to "bottom out" the graft and confirming cortical button fixation intraoperatively. Potential all inside ACLR complications include graft-socket mismatch, full-tunnel reaming, graft elongation from suspensory cortex fixation and loss of cortical fixation, whereas the elongated surgical learning curve should also be mentioned [4-6].

Multiple studies have shown the all-inside technique to have similar or superior biomechanical properties and clinical outcomes compared to the more traditional full-tunnel ACLR techniques. There are outcomes of all-inside versus complete tibial tunnel techniques using an allograft tendon which are comparable [7]. Nevertheless, other publications have shown improved functional outcomes between baseline and 2-year clinical follow-up when the all-inside technique is used [6,8,9].

In a cohort comparison of all-inside hamstring autograft reconstruction versus complete tibial tunnel reconstruction, Desai VS, et al has showed that both all inside and complete tibial tunnel ACLR techniques resulted in successful restoration of knee ligamentous stability, positive patient-reported outcomes, high return to sport rates, and overall comparable results. Besides, the all-inside technique demonstrated a lower failure rate [6].

The purpose of this study was to compare clinical results and patient-reported outcomes of a large group of patients who underwent hamstring autograft ACLR by an all-inside technique versus those who received a complete tibial tunnel during ACLR.

Materials & Methods

This retrospective cohort study was performed at a single institution (CCA) after approval was obtained from the institutional review board of the Orthopaedic Research Institute for Education and Training (2014A102). The patients underwent ACLR with a complete tibial tunnel approach (femoral socket and full-length, transtibial tunnel) from January 2015 to May 2021 (Group B) and ACLR with the all inside technique from June 2016 till January 2022 (Group A). Patients were included only if they had primary ACLR with semitendinosus or semitendinosus/gracilis autograft after an ACL rupture in less than 20 weeks. Exclusion criteria consisted of operation after 6 months, OA knees, revision ACL procedures, the use of allografts, the use of quadriceps or patellar tendon autografts, concomitant posterior cruciate or collateral ligament surgery (multi-ligament instability), and a lack of minimum 2-year patient follow-up. Patients were not excluded based on age, concomitant meniscus rupture or cartilage defects due to the injury.

Each patient's operative note was detailed reviewed to confirm the surgical technique performed, including the graft type and construct, fixation technique, and all the other intraoperative details as concomitant procedures. From a total of 184 patients that were initially identified for this study, the inclusion criteria finally met 100 patients. Fifty patients underwent the all inside ACLR (Group A) and 50 the complete tibial tunnel approach (Group B). Demographic information (age, gender, BMI), time from injury to reconstruction, preoperative comorbidities, surgical details, physical examination findings, and follow-up outcomes were extracted from the medical record (Table 1). Physical examination data included pivot-shift, Lachman, and ROM pre-operatively and post-operatively, whereas patient-reported outcomes included the VAS (2, 4 weeks and 3 months), Tegner -Lysholm knee score (pre-operatively and post-operatively at 3 months and 6 months), and International Knee Documentation Committee (IKDC) score (pre- and post- 6 months and 12 months). Return to everyday activities and sport were also analyzed. Moreover, failure was studied and defined as graft rupture and/or requirement for revision reconstruction and lastly patient satisfaction survey after surgery was also evaluated, at a minimum of 2 years after surgery. At the last follow up, apart from the surgeon operated the patient, also one independent consultant orthopaedic doctor (MK or BS) evaluated the final outcomes.

Surgical Technique

Patients in this study underwent primary ACLR with either an all-inside (Group A) or a complete tibial tunnel technique (Group B) according to the individual surgeon's preference. After May

2020, all the surgeons team members preferred the all inside technique. The graft constructs were composed of quadrupled semitendinosus tendon (mainly in Group A ~86%) (Figure 1) or combined doubled semitendinosus and doubled gracilis tendons (mainly in Group B ~92%) to achieve the necessary graft thickness (>8mm) (Figure 2). It is very important for us based on literature when debriding the residual ACL stump, a small portion of the native ACL fibers to be left intact, so as to allow for ingrowth of the graft as well as a landmark for tunnel drilling [10].

Figure 1: Quadrupled semitendinosus tendon with endobutton (all-inside technique) for Group A.

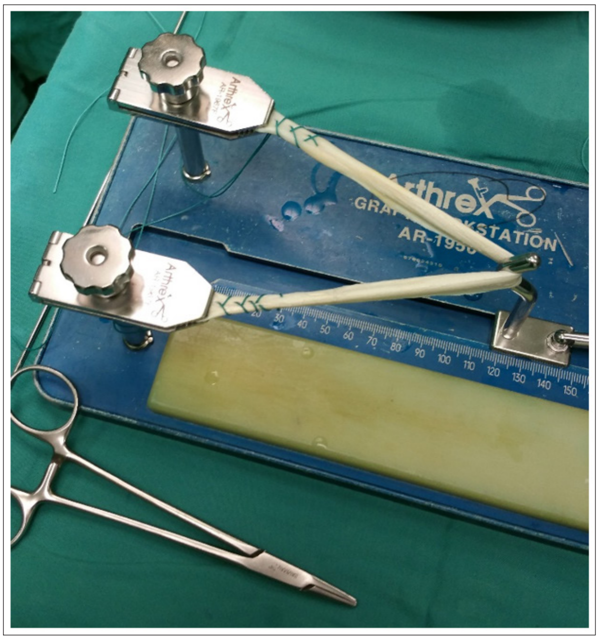

Figure 2: Combined doubled semitendinosus and doubled gracilis tendons (transtibial technique) for Group B.

For the all-inside reconstructions based on the Lubowitz study, the femoral socket was created with a low-profile reamer and drilled in anterograde fashion from within the medial portal of the knee joint or in a retrograde fashion by use of a Flipcutter (Arthrex) to an osseous depth of at least 20 mm [11]. The trans portal offset guide was positioned to create the socket at the insertion site of the direct ACL fibers with a 1-mm proximal wall. The tibial socket was created in a retrograde fashion by use of a Flipcutter (Arthrex) to an osseous depth of at least 20-25 mm (depending on the graft length) with care not to break the medial tibia cortex (Figure 3). The guide was positioned to create the socket aperture adjacent to the lateral meniscal anterior horn attachment. The graft was passed into the knee through the anteromedial portal, the femoral button was engaged on the lateral femoral cortex, and the graft was advanced into the femur through use of TightRope (Arthrex) shortening strands. The distal end of the graft was then passed into the tibial socket, and the TightRope button was engaged on the medial tibial cortex. The entire construct (GraftLink; Arthrex) was tensioned in full extension, the knee was flexed and extended (~20 times), and the graft was retensioned on both the tibial and femoral sides (Figure 4,5).

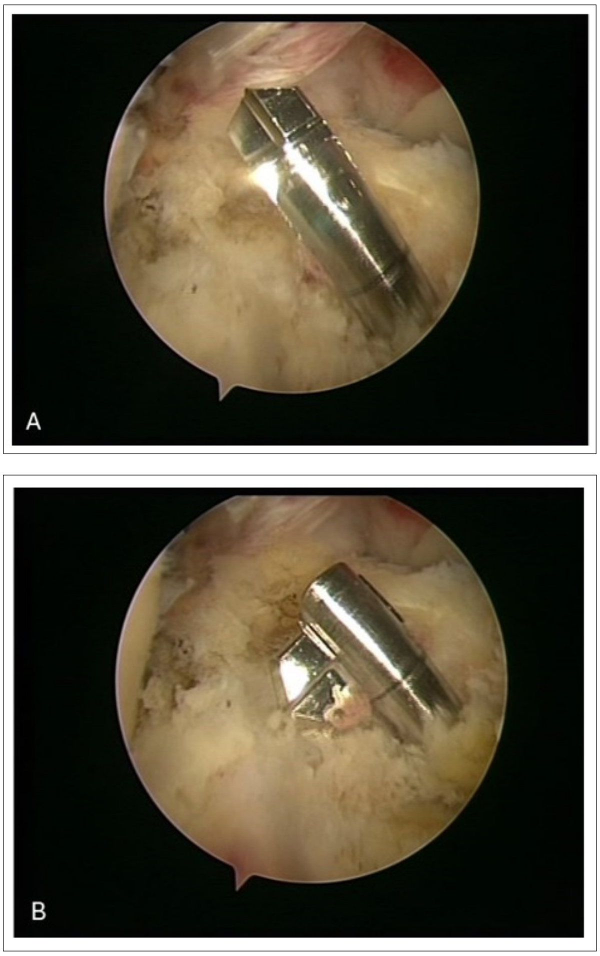

Figure 3: The Flipcutter (Arthrex) open and closed for retrograde drilling of tibia in all inside technique (Group A).

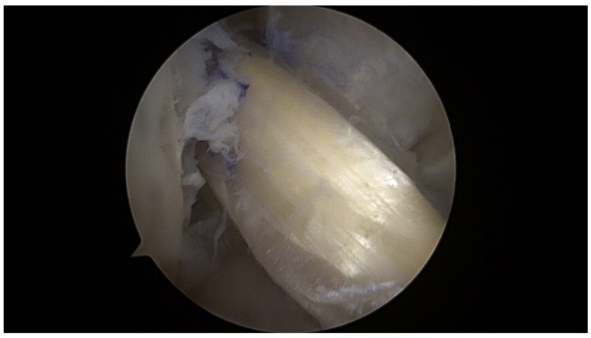

Figure 4: ACLR graft in the all inside technique (Group A).

For the complete tibial tunnel technique, a low-profile reamer was used to create a femoral socket that was at least 20 mm long. The trans portal offset guide was positioned to create the socket at the insertion site of the direct ACL fibers with a 1-mm proximal wall. The tibial tunnel was created by means of a rigid reamer. The guide was positioned to create the tunnel aperture adjacent to the lateral meniscal anterior horn attachment. The graft was passed by the anteromedial portal into the tibial tunnel, through the intra-articular space, and into the femoral socket. The cortical fixation device, either TightRope (Arthrex), or RIGIDLOOP (DePuy Mitek) was engaged on the femoral cortex. The graft was tensioned in 20-25% of flexion with the tibia anteriorly pushed; the knee was flexed and extended (~20 times) and then fixed with a tibial Bio-Compression Screw (Arthrex) and in 28 cases (56%) a titanium staple was also used for extra fixation. The screw diameter matched the tunnel size, creating a line-to-line fit (Figure 6).

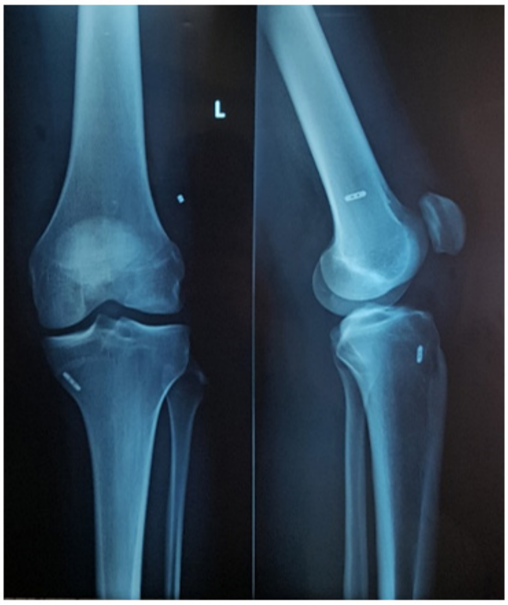

Figure 5: Postoperative X-Ray of an All inside technique (Group A)

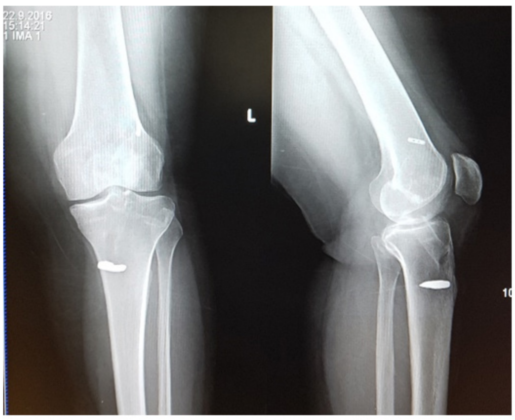

Figure 6: Postoperative X-Ray of a transtibial technique (Group B)

All patients underwent a standardized postoperative rehabilitation program, including immediate knee extension equal to the preoperative measurement, quadriceps isometric exercises from the first postoperatively day and further exercises of closed chain the first 3 weeks and afterwards of open chain. Jogging was permitted after 3 months, sports specific training (return to cutting and pivoting) from after 6 to 9 months and return to sport after 9 to 12 months. The rehabilitation protocol provides patients with early return to motion, endurance, and a graduated strengthening program. The protocol also incorporates a proprioceptive, neuromuscular training program involving multiple hop tests that teaches injury prevention strategies for both lower extremities to prevent future knee injuries upon return to sports. All patients performed postoperative rehabilitation according to the same protocol.

Statistical Analysis

Statistical analysis was performed using SPSS, version 28.0 (IBM Corp, Armonk, NY). Patient characteristics including demographic factors, time from injury to surgery, duration of patient's follow-up, physical examination findings (knee ROM, VAS, Lysholm Tegner, IKDC scores, complication rates, and final outcomes were summarized by use of descriptive statistics including mean, standard deviation, range, and percentage when necessary. Friedman analysis of variance and Wilcoxon signed-rank test were conducted for the evaluation of changes in VAS, Lysholm Tegner, IKDC and ROM parameters. A P value of less than .05 was considered statistically significant.

Ethical Approval

The local ethics committee of the Central Clinic of Athens (Orthopaedic Research Institute for Education and Training) approved the study, which was carried out according to the World Medical Association Declaration of Helsinki. Institutional review board approval and written consent from all patients were obtained [12].

Results

A total of 50 patients (mean ± SD age, 28 ± 8.4 years) in Group A, who underwent all-inside reconstruction (median follow-up, 2.38 years; range, 2-3.2 years) and 50 patients (mean ± SD age, 27.9 ± 8.1 years) in Group B, who underwent complete tibial tunnel reconstruction (median follow-up, 2.26 years; range, 2-3.2 years) met the inclusion criteria. Demographic characteristics of both groups are provided in Table 1. Concomitant injuries and operations at the time of index surgery in the 2 patient groups are described in Tables 2 and 3.

Table 1: Patients' Demographic Information

Characteristic	ALL INSIDE (Group A) n=50	Complete Tibial Tunnel (Group B) n=50	P (<0.05)
Age (years) mean±SD	28.0 ± 8.4	28 ± 8.1	NS
Sex (male/female)	32/18	31/19	NS
BMI mean±SD	24.3 ± 3.1	24.6 ± 3.4	NS
Time from injury to reconstruction (weeks) median (range)	4.9 (0-18)	5.1 (0-18)	NS
Duration of Follow-up (years) median (range)	2.38 (2-3.2)	2.26 (2-3.2)	NS

There was no statistically significant difference between the two groups on the meniscus injury, medial or lateral meniscectomy, medial or lateral meniscus suturing or the concomitant osteochondral defects. The most commonly used graft in the all-inside group was a quadrupled semitendinosus autograft (86%), and 100% of procedures used the TightRope fixation device, whereas in group B was a combined double semitendinosus with double gracilis (92%); 85% of procedures used the TightRope, and 15% the RIGIDLOOP fixation devices. The mean graft diameter was 9.2 mm (range, 8.0-10.5 mm; SD, 0.4 mm) in the all-inside group versus 8.8 mm (range, 8.0-10.0 mm; SD, 0.5 mm) in the complete tibial tunnel group (P < .0001). (Figure 3)

Table 2: Patient's With and Without Meniscal Rupture – Type of Operation

	MENISCUS INJURY NONE	MENISCECTOMY MEDIAL	MENISCECTOMY LATERAL	SUTURING MEDIAL MENISCUS	SUTURING LATERAL MENISCUS
Group A	18 (36%)	7 (14%)	15 (30%)	6 (12%)	4 (08%)
Group B	15 (30%)	7 (14%)	17 (34%)	6 (12%)	5 (10%)

Table 3: Patient's With and Without Osteochondral Defect

OCD	NONE	SMALL (<5MM)	MEDIAL (>5MM)
Group A	32 (64%)	18 (36%)	0
Group B	30 (60%)	20 (40%)	0

The patient-reported outcomes (PROs) scores (VAS score, Lachman test, pivot test, Lysholm Tegner score and IKDC scores) were measured before the operation and at 3, 6, 12 months and at the latest follow up and are presented in Table 4. More specifically the VAS score was statistically significant less in Group A in the first 2 and 4 weeks, but without difference afterwards (VAS score [2w] 1.9 vs 2.1 - VAS score [4w] 0,4 vs 0.7). There were comparable results between the all-inside versus the complete tibial tunnel groups on the Lachman, pivot test and Lysholm Tegner score at 6 months 96.8 vs 95.8; (P<0.001) and IKDC score at 12 months 97.7 vs 97.8; (P<0,001). No statistically significant difference was found in Lysholm and IKDC scores between the 2 groups of patients; however, those in the all inside group had slightly higher Lysholm Tegner and IKDC scores at the latest follow-up, as shown in Table 4, although not statistically significant.

At a mean 2-year follow-up, the mean range of motion was comparable in both groups, and specifically in the all-inside group was from full extension to 122.4º flexion (±4.2) and 7 cases with no-hyperextension in contrast to the healthy knee (range,–0.5 to –3mm based on Lachmeter), whereas in the complete tibial tunnel group it was from full extension to 123.2º flexion (±3.7) and also 7 cases with no-hyperextension in contrast to the healthy knee (range,–0.5 to –3mm based on Lachmeter).

Average return to everyday activities was 5.8 weeks in the all-inside group versus 9.6 weeks in the complete tibial tunnel group which was statistically significant (P <0,05) whereas not statistical significance was the average return in sports, specifically, 8,5 months in the Group A versus 9,3 months in the group B (Table 4). Furthermore, no statistically significant relationship was found between postoperative outcomes and fixation type, graft diameter, or graft construct.

Table 4: Patient's Outcomes and Statistics

ACLR SURGERY			
	ALL INSIDE (GROUP A) n=50	TIBIAL (GROUP B) n=50	P (0,001)
VAS PRE-	8.0 (6-10)	8.1 (6-10)	NS
VAS POST-2W	1.9 (1-3)	2.1 (1-3)	-1,180 (S)
VAS POST-4W	0.4 (0-2)	0.7 (0-2)	-0,705 (S)
VAS POST -3M	0.1 (0-1)	0.3 (0-1)	NS
Tegner Lysholm Knee PRE-	32.1 (25-40)	31.7 (25-42)	NS
Tegner Lysholm Knee POST- 3M	88.1 (81-94)	86 (81-94)	NS
Tegner Lysholm Knee POST- 6M	96.9 (91-100)	95.8 91-100)	NS
IKDS (6m)	83.9 (79.3 -87.4)	83.4 (79.3-87.4)	-1,0 (S)

Graft failure before the final follow-up was experienced by 8% of patients in the all-inside group compared with 12% in the complete tibial tunnel group. In all cases the re-rupture has to do with injury post-operatively even in sports or accidents in everyday activities; and it has not to do with the graft diameter, as even >9mm grafts re-ruptured after serious injury as mentioned in our patients. Differences in failure rates, complications, and reoperation rates between the 2 groups did not reach statistical significance. The patient satisfaction surgery after surgery was 1.3 in group A versus 1.4 in group B without any statistical significance (Table 4).

Discussion

Arthroscopic ACLR is a worldwidely performed surgical procedure the last three decades. The all-inside technique with an ST4 autologous graft has been developed by Lubowitz wince 2013 with the aim of a less invasive surgical procedure with limited donor side morbidity, an enhanced patient recovery, and lastly a better preserving bone stock procedure [11]. Although hamstring tendon autografts have been extensively studied and compared with the "gold standard" bone-patellar tendon-bone graft, the evidence on the all-inside ST4 technique with suspensory fixation is limited. Therefore, the purpose of our study was to compare this new technique with the conventional ACLR utilizing full bone tunnels, ST/G graft, and interference screw fixation on the tibial side. We hypothesized that the recent evolution of surgical instruments and techniques, with the suspensory devices that are used in most of all-inside ACLRs, might affect the clinical outcome of ACLR.

In the present study, it is comparatively analyzed the patients' clinical results and reported outcomes of a large group of patients who underwent a ST4 hamstring autograft ACLR by an all-inside technique versus a complete tibial tunnel during

ACLR, performed during the same time period. It is important to mentioned firstly that both techniques resulted in successful restoration of knee ligamentous stability, positive PROs, high return to sport rates, and overall comparable results. It is noted that ACLR, independent of the preferred technique, is a surgery with high patient satisfaction, and almost all patients felt clear improvement postoperatively. Also, the failure rates between the two groups were not significantly different; and always it had to do with new important injury.

Furthermore, it is very important to be mentioned that in the all inside group there are less pain the first four post-operative weeks and probably that's the reason of statistically significant earlier return to everyday activities. In the all-inside group, the analgesic consumption was limited to simple painkillers, as paracetamol, for 5-7 days, whereas in full tibial tunnel group, there was need for stronger painkillers, like codeine or tramadol for a period of 7-14 days. Besides, the VAS score was statistically significant less in Group A in the first 2 and 4 weeks, but without difference afterwards.

There were comparable results between the all-inside versus the complete tibial tunnel groups on the Lachman, pivot test and Lysholm Tegner score at 6 months 96.8 vs 95.8; ($P<0.001$) and IKDC score at 12 months 97.7 vs 97.8; ($P<0,001$). No statistically significant difference was found in Lysholm and IKDC scores between the 2 groups of patients; however, those in the all inside group had slightly higher Lysholm Tegner and IKDC scores at the latest follow-up, although not statistically significant as already mentioned. Lastly, the average return to everyday activities was 5.8 weeks in the all-inside group versus 9.6 weeks in the complete tibial tunnel group. Nevertheless, there were no statistical significance in returning in sports, (8,5 months in the Group A versus 9,3 months in the group B).

According to the literature, the patients who underwent full tibial tunnel ACLR showed slightly better performance in the postoperative 6–8 months' follow-up, but this difference became insignificant in further follow-up, as Baldassarri et al. stated [9]. Nevertheless, Desai found that the mean time for return to sports was longer in the patients with all-inside ACLR (12.5 vs 9.9 months) [6]. Although the return to sports is an important parameter to measure graft maturation of the ACLR, it varies between the types of sports and rehabilitation protocols [6,13]. In the systematic review and meta-analysis of Chu Wei Fu both the subjective and objective IKDC scores, Lysholm score, Tegner activity score, and KSS were measured by five studies [13]. Significant postoperative improvement was noted in both the all-inside and full tibial tunnel groups; however, no significant between-group difference was found in postoperative score measurement, as was also observed in our study [13].

In the subject of laxity after ACLR which was measured by arthrometer, four studies have presented their results. Mayr R and Monaco investigated the anteroposterior knee stability of the operative knee using the KT-1000 arthrometer (MedMetric Corporation, San Diego, CA, USA), whereas Benea H used the Rolimeter (Aircast, Europe) [14-16]. All the studies stated that knee stability improved significantly postoperatively, but no significant difference between groups was noted. In our study we used the Lachmeter (Lachmeter Company, Ribeirao Preto, Sao Paulo, Brazil) arthrometer (the digital evolution of the Rolimeter), which as the KT-1000 provides a valid measure of knee laxity of the patients with ACL injury. We also found that postoperative knee stability was comparable between the groups.

On the subject of re-rupture as presented in the meta-analysis of Chu Wei Fu there was no significant difference between groups within any study referred or after pooling of data, as also observed in our study [13]. On the important post-operative phenomenon of drill tunnel widening (bungee and windshield wiper effect) several studies investigated it and was considered to be associated with not only the method of tunnel prepared but also by the graft fixation device [14-19]. It has also been investigated the difference between tunnel widening by suspensory cortical button fixation and by interference screws [14,15,19,20]. Lubowitz had found no difference between group in tunnel diameter as measured with plain film radiography [18]. Nevertheless, in Mayr's study with computed tomography as used for measurement, a significant femoral tunnel volume increase was noted in the all-inside group at 6 months' follow-up; however, in the other study with longer follow-up times (24months) for the same groups of patients, significantly increased tibia volumes and diameters were found in the full tibial tunnel group [14,15,18].

Studies by Monaco and Colombet had found significant tibia tunnel widening in the group with interference screw fixation [15,19]. However, when analyzing the tunnel diameter change in the meta-analysis of Chu Wei Fu, individual studies and the pooled data showed significantly increased tunnel diameter in the patients with interference screw fixation [13]. As we also published a case report in 2012, PLLA Screw Fixation after ACLR complicated with a pretibial cyst formation, and three more cases has also operated since then as a screw complication [20]. The inflammatory response or foreign body reaction to the bioabsorbable screw could be the biological cause for tunnel widening or even cyst formation. Though the current evidence could not prove a correlation between tunnel widening and poor clinical outcomes or graft failure, the concern is that bone loss of the tunnel might be an obstacle for revision surgery [21].

Analyzing the importance of graft size and flexion strength Desai et al. and Kouloumentas et al. had reported that graft size in the all-inside group (mostly using ST4) was significantly thicker than in the full tibial tunnel group (mostly use DGST) [6,22]. Flexion strength was investigated by Kouloumentas and Monaco and it was observed better flexion strength in the group of patients treated with all-inside ACLR [13,15,20]. The studies stated that preservation of the gracilis tendon might be associated with minor donor site morbidity and better flexion strength recovery. One theoretical advantage of the use of an ST4 graft is preservation of the gracilis tendon, which may be associated with improved function, especially in activities requiring knee flexion. Flexion weakness is an acknowledged issue after ACLR with hamstring tendon grafts [22-25].

Kouloumentas presented in 2019, that patients treated with ACLR with an ST4 graft in an all inside technique had significantly better flexor isokinetic measurements at 180°/s than patients treated with an ST/G graft; at lower angular velocities; at 2-year postoperative follow-up although, no statistical significance was noted [22]. It was also found that isometric flexor/extensor ratio at 90° was higher in patients treated with an ST4 graft, which further supports enhanced postoperative flexor function with this technique. These findings suggest that the ST4 graft may offer some benefit in patients involved in sports that require rapid knee flexion, including soccer, or dynamic sports [13,25,26].

However, there are many factors that might influence the thickness of the tendon graft as we know, like age, gender, and body height. Thus, it must be noted that every patient cannot not achieve the ideal graft length and thickness by using the semitendinosus tendon only, and the gracilis must be secondarily harvested [13,25-27]. Nevertheless, the reported advantage of combining the all-inside technique and suspensory graft fixation includes biomechanically higher graft durability, greater preservation of flexion strength, and less bone tunnel widening in further follow-up [14-16,27].

Conclusion

ACLR is one of the most performed knee operations. It is shown that outcomes of ACLR using hamstring autograft with the all-inside technique are comparable to outcomes of the complete tibial tunnel technique. Although, the all-inside ACLR technique is not critically superior to the full tibial tunnel technique in functional outcomes, knee laxity measured with arthrometer, or tendon re-rupture rate, the advantage of using suspensory cortical button fixation is that a thicker graft could be used for reconstruction, less pain is observed the first 2 to 4 post-operative weeks (no tibial cortex breakage) and lastly less tibia tunnel widening compared with bioabsorbable interference screw fixation is observed.

Acknowledgements

None

Author Contributions

The following authors have conceived and designed the study (D. Nikolopoulos, G. Safos, N. Sergides), supervised the conduct of the study (all authors), analyzed the data (D. Nikolopoulos, S. Bonazzos, K Moustakas, G. Kyriakopoulos), wrote the initial drafts (D. Nikolopoulos, G. Safos, P. Safos, S. Baltzis), critically revised the manuscript (all authors) and ensure the accuracy of the data and analysis (all authors). The statistical analyses performed by A. Moutsios-Rentzos and D. Nikolopoulos. The authors' confirm that all authors have seen and agree with the contents of the manuscript and agree that the work has not been submitted or published elsewhere in whole or part.

Conflict of Interest Statement

None

Funding Statement

No funding was received for conducting this paper.

Availability of Data and Materials

Data has not been made publicly available, though datasets generated during the current study can be made available from the corresponding author on reasonable request.

Declarations

Ethics Approval and Consent to Participate

The local ethics committee of the Central Clinic of Athens (Orthopaedic Research Institute for Education and Training) approved the study, which was carried out according to the World Medical Association Declaration of Helsinki. Institutional review board approval and written consent from all patients were obtained [12].

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they do not have any competing interests.

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