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Modified Lemaire Procedure Combined with Arthroscopic Anterior Cruciate Ligament Reconstruction in Treatment of High Grade Anterolateral Rotational Knee Instability

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ABSTRACT

Background: The combined anterior tibial translation (ATT) and tibial internal rotation (TIR) is known as anterolateral rotational knee instability (ALRI). It is brought on by damage to the knee's anterolateral (AL) soft tissue structures and anterior cruciate ligament (ACL). Even after proper anatomic repair, it remains a common reason for ACL reconstruction (ACLR) failure. **Objective:** To assess the clinical and functional results of treating high-grade ALRI by combining arthroscopic ACL restoration with lateral extra-articular tenodesis (LEAT) performed using a modified Lemaire method. **Patients and Methods:** This study enrolled 30 cases with high-grade ALRI treated in the Department of Orthopedic Surgery at Menoufia University Hospital from November 2019 to February 2021. **Results:** Hard endpoint and delayed hard endpoint Lachman and Glide Pivot Shift (PS) were significantly increased postoperatively than presurgically; whereas, soft endpoint Lachman, Clunk and Gross Pivot Shift, Anterior drawer test (ADT) and McMurray test were significantly diminished postoperatively than presurgically ($P<0.05$). Lysholm and IKDC subjective scores increased considerably postoperatively than preoperatively; extension deficit and flexion range significantly decreased postoperatively ($P<0.05$). **Conclusion:** Laboratory investigations of the constraint offered by the lateral anatomical structures and the assessment of the decrease of rotational laxity have accumulated data in favor of a lateral extra-articular surgery to an intra-articular ACL restoration.

Keywords: ALRI, ACL, Iliotibial band, LEAT.

INTRODUCTION

ALRI is a tibia movement that combines TIR and ATT. It is brought on by damage to the knee's AL soft tissue structures and ACL [1]. Originating from the medial surface of the lateral femoral condyle, the ACL is a strip of thick connective tissue that travels obliquely across the intercondylar cleft before ending on the medial tibial eminence [2]. Its dimensions are 4 to 10 mm in width, 25 to 35 millimeter (mm) in length, and around 10 mm in breadth [3]. Based on their tibial implantation, it is separated into two bundles: the anteromedial (AM) and the posterolateral (PL) [3].

The PL bundle, which is almost horizontal, is believed to be better able to tolerate internal tibial rotation, whereas the AM bundle, which is nearly vertical in the coronal plane, can primarily endure ATT and a little amount of rotating tibial stress [4]. According to descriptions, the anterolateral ligament (ALL) and the ALC are examples of the soft tissue structures found in the anterolateral knee. The knee's ALC is composed of the lateral meniscus, the capsule-osseous layer, the lateral meniscus, the iliotibial band (ITB) with its deep components, the Kaplan fibers, and the AL capsule, which contains the mid-third capsular ligament [5].

Laboratory findings indicate that the ITB and its connection to the distal femur via Kaplan fibers offer the most isometric AL structure and the primary restraint to TIR, with the ACL only being significant at complete knee extension, despite the recent interest in the ALL. Extra-articular reconstructions were often used to treat ACL deficiencies in the 1970s and 1980s. However, separate treatments like Lemaire, Macintosh, and Lose procedures had unacceptable failure rates. As a result, combined non-anatomic intra-articular and extra-articular approaches were later created as "over the top" Macintosh approaches [6].

In 1989, during an extra-articular repair consensus meeting, the American Orthopedic Society for Sports Medicine (AOSSM) advised against its usage because of its poor long-term results, which include joint over-constraint, residual instability, and graft failure. A critical review of earlier LEAT associated with anatomic intra-articular ACLR in the treatment of ALRI has been prompted by recent extensive research on the anterolateral capsular anatomy, which has reignited interest in the function of the lateral capsular structures in supplying rotational stability [7]. In 1975, Lemaire reported the first extra-articular operation that used a long strip of the ITB to treat chronic ACL insufficiency. Then, in 2002, Christel and Djian simplified the original approach by describing a minimally-invasive process that only included a single bundle transplant. The "Modified Lemaire Procedure" that is currently regarded as the standard LEAT technique was derived from this change [6]. The goals of a main surgery that uses LEAT are to reduce the likelihood of re-injury and improve control over ALRI. LEAT can be advised for cases that are more susceptible to re-rupture, such as pivot shift grades 2 and 3, generalized ligamentous hyperlaxity, Segond fractures, chronic injuries (> 12 months), or pivoting sports in elite competitive athletes, even though the indications are not well defined [8]. Additionally, it is frequently taken into consideration while doing a revision ACLR by strengthening and stabilizing the knee's external aspect [9]. We aimed to assess the clinical and functional results of treating high grade ALRI by combining arthroscopic ACL restoration with LEAT utilizing a modified Lemaire method.

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PATIENTS AND METHODS

This study included 30 patients with high-grade ALRI in the Department of Orthopedic Surgery at Menoufia University Hospital, during the period from November 2019 to February 2021.

Inclusion criteria: Age from 20 to 40 years old, Male sex, High grade ALRI, Genurecurvatum, Generalized ligamentous hyper-laxity, Residual rotational instability following ACLR, Revision ACLR without an obvious cause for failed surgery. Exclusion criteria included patients' ages less than twenty or more than 40 years old, pivot shift test grade 1, genu varum more than 5 degrees, posterior tibial slope more than ten degrees, and multi-ligamentous knee injuries.

Presurgical assessment:

Clinical evaluation: Complete history taking such as personal history comprising age, occupation, and special habits, history of current sickness, side affected and mechanism of injury, and history including previous treatment, medical comorbidities, and surgical operations.

Complete clinical examination such as inspection**,** palpation**,** range of motion (ROM)**,** special tests and neurovascular status.

Radiological evaluation: X-rays: Bilateral anteroposterior (standing), lateral and skyline knee views, Magnetic Resonance Imaging (MRI).

Operative technique: Lateral extra-articular tenodesis (LEAT) employing a modified Lemaire surgery using the iliotibial tract and intra-articular arthroscopic anatomic ACL repair.

Postoperative follow-up: All cases were-followed up for six months. First weeks: Wound management, pain and swelling control, early ROM exercises, accomplishing and keeping complete extension, static quadriceps muscle workouts, and knee X-rays. Second week: Stitches are removed, and physiotherapy begins. Continue physiotherapy in the fourth week, and then once a month until six months.

Postoperative evaluation: By the IKDC score.

IKDC: The IKDC Questionnaire is a purely subjective assessment that assigns patients a functional overall rating (patient-recorded). The questionnaire assesses three classes: manifestations, sports activity, and knee function. The manifestations subscale aids in detecting factors, which include pain, rigidity, oedema, and knee giving way. Meanwhile, the sports activity subscale emphasizes motions. movements which include stair climbing, chair raising, squatting, and leaping. The knee function subscale asks cases a single basic question: How does their knee feel now compared with before the injury?

Surgical approach: All surgeries were carried out under general anaesthesia and a tourniquet was applied high on the thigh. Presurgical prophylactic antibiotics (one-two grams of 4th generation cephalosporins, cefepime) were administered within 60 minutes of the procedure. All procedures were conducted using spinal anaesthesia. All subjects were supine, with lateral side support for appropriate valgus stress and a foot stopper to stabilise the leg throughout varying grades of knee flexion. To assess ACL damage and rule out related ligamentous injuries, a routine examination under anaesthesia included bilateral Lachman, anterior drawer, PS, posterior drawer, varus, and valgus stress tests. A tourniquet was applied to the proximal thigh, followed by sterilizing and draping.

In every instance, autografts of hamstring tendons (HT) were used. AL, AM, and auxiliary AM (AAM) portals were the three portals used to maximize visualization. While the tibial tunnel was performed medially and in line with the posterior border of the anterior horn lateral meniscus, the femoral tunnel was made in the I.D.E.A.L site of the anatomical femoral tunnel, which corresponds to approximately two millimeter in addition to the planned tunnel radius from the posterior and proximal articular margins. With the exception of one revision instance (when QT was employed), where femoral fixed buttons and tibial bioabsorbable interference screws (ISs) were utilized to secure the grafts, grafts were always fastened using these methods.

Operative procedure:

Arthroscopic anatomic SB-ACLR

Meniscal injuries were managed with partial meniscectomy (three patients; two medial and one lateral) or meniscal repair (five patients; three medial and lateral, one medial and one lateral) with tightening of meniscal sutures prior to ACL graft tibial fixation, following routine diagnostic arthroscopy.

Modified Lemaire procedure

The following technique was used to execute the modified Lemaire operation on 35 knees. In the 90° flexed position, the knee was ready and draped. From tubercle of iliotibial tract, the ITB was located and cut into a 10 mm × 80 mm strip. It was whip stitched and sectioned proximally. At the isometric point, the ITB graft was passed beneath the LCL in a tunnel distinct from the one used for the ACLR graft. An absorbable IS with a constant diameter of seven mm was then used to secure the ITB graft (CONMED, USA).

Ethical consideration: Prior to the start of the trial, each patient completed a written informed consent form outlining its purpose. The Menoufia University Hospital's Ethical Scientific Committee approved the study plan. Throughout its implementation, the study complied with the Helsinki Declaration.

Statistical Analysis: Microsoft Excel software was used to code, input, and analyse data gathered from history, examinations, and outcome measurements. SPSS version 25.0 was then used to import the data. Quantitative data were presented as mean $\pm$ Standard deviation (SD). Qualitative data were presented as frequency and percentage (%). P values below 0.05 were considered significant.

RESULTS

Table 1 displays that the average age of the cases under study was 27.6±5.9 years, with a range of 20–40 years. Also, the mean BMI was 26.4±5.1 (kg/m^2). About (46.7%) of patients were smokers and (23.3%) were students.

Table (1): Sociodemographic data of studied group

	Socio-demographic characteristics	Distribution (n= 30)
Age/ years	− Mean ± SD − Range	27.6±5.9 20-40
Male Sex		30 (100%)
BMI/ (kg/m^2)	− Mean ± SD − Range	26.4±5.1 19-35
Smoking	− Yes − No	14 (46.7%) 16 (53.3%)
Occupation:	− Student − Teacher − Manual Worker − Employee − Farmer − Footballer	7 (23.3%) 3 (10%) 9 (30%) 2 (6.7%) 4 (13.3%) 5 (16.7%)

BMI: Body mass index, **SD**: Standard deviation.

Table (2) shows that, preoperatively, the mean static and dynamic ATT was 2.6 ± 3.7 and 7.9 ± 3.9, respectively. Intraoperatively, (46.7%) of the studied patients had isolated medial meniscal lesions. Also, (33.33% and 10%) had resected medial and lateral meniscal treatment, correspondingly. The mean Tegner score was 6.5±1.26. Also, the mean net change of Lysholm and IKDC subjective score postoperatively were 25.4 ± 11.93 and 26.77 ± 13.25, respectively.

Table (2): Preoperative, intraoperative and postsurgical data of the studied patients.

		Lemaire group, n = 30 knees	
		Mean ± SD	**Range**
	Static ATT	2.6 ± 3.7	(5–10)
	Dynamic ATT	7.9 ± 3.9	(0–17)
Intraoperative data		**No.**	**(%)**
Meniscal lesions	None	11	36.67
	Isolated medial	14	46.7
	Isolated lateral	5	9
Medial meniscal treatment	No lesion	16	53.33
	Untreated	0	0.00
	Resected	10	33.33
	Sutured	4	13.34
Lateral meniscal treatment	No lesion	25	83.33
	Untreated	0	0.00
	Resected	3	10.0
	Sutured	2	6.67
Postoperative data		Mean ± SD	Range
	Tegner score	6.5±1.26	(6–8)
Net change	Lysholm	25.4 ± 11.93	(30–60)
	IKDC subjective score	26.77 ± 13.25	(24–72)

ATT: Anterior Tibial Translation, **IKDC:** The International Knee Documentation Committee.

Table (3) shows that, hard endpoint and delayed hard endpoint Lachman and Glide Pivot Shift were significantly increased postoperatively than preoperatively; whereas, soft endpoint Lachman, Clunk and Gross PS, anterior drawer test and McMurray test were significantly diminished postoperatively than preoperatively.

Table (3): Comparison between pre- and postoperative data of the studied patients.

	Presurgical N=30		Postoperative N=30		P value
	No.	**%**	**No.**	**%**	
Lachman					
Hard endpoint	0	0.00	27	90.0	<0.001*
Delayed hard endpoint	0	0.00	3	10.0	<0.001*
Soft endpoint	30	100.0	0	0.00	<0.001*
Pivot Shift					
None	0	0.00	28	93.33	<0.001*
Glide	0	0.00	2	66.67	<0.001*
Clunk	27	0.00	0	0.00	<0.001*
Gross	3	0.00	0	0.00	<0.001*
Anterior drawer test (ADT)					
Positive	30	100	3	10.0	>0.001**
Negative	0	0.00	27	90.0	
McMurray test					
Positive	17	57	4	13.33	
Negative	13	43	26	86.67	

***P-value >0.05:** significant.

Table (4) shows that, Lysholm and IKDC subjective scores were significantly increased postoperatively than preoperatively; while, extension deficit and flexion range were significantly decreased postoperatively than presurgically.

Table (4): Comparison between pre and postoperative data of the studied patients.

	Pre-operative		postoperative		Paired t-test	P value
	Mean ± SD	**Range**	**Mean ± SD**	**Range**		
Lysholm score	64.12 ± 18.02	35–100	89.9 ± 7.17	34–100		
IKDC subjective score	60.83 ± 15.0	(23–95)	87.6 ± 8.12	39–100	15.807	>0.001**
	No.	**%**	**No.**	**%**		
Extension deficit	1	3%	0	0.00		
Flexion range	135.4 ± 13.7	60–140	130.5 ± 4.90	130–140		

IKDC: The International Knee Documentation Committee, ***P-value >0.05:** significant.

Table (5) shows that age was significantly correlated with post-IKDC, while, BMI didn't show any significant correlation with it.

Table (5): Correlation between age, BMI and post-IKDC

	post-IKDC	
	r	**P-value**
Age	-0.412	0.024*
BMI	-0.253	0.177

BMI: Body Mass Index, **r:** Pearson correlation coefficient, ***P-value >0.05:** significant.

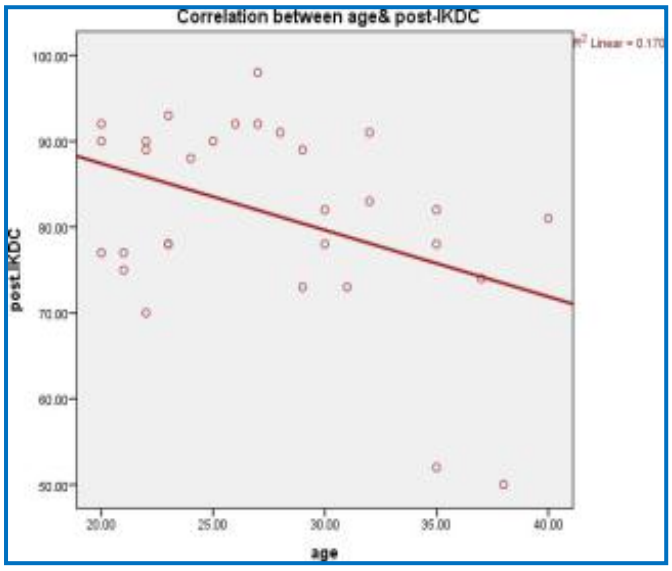

Figure (1): Correlation between age and post-IKDC.

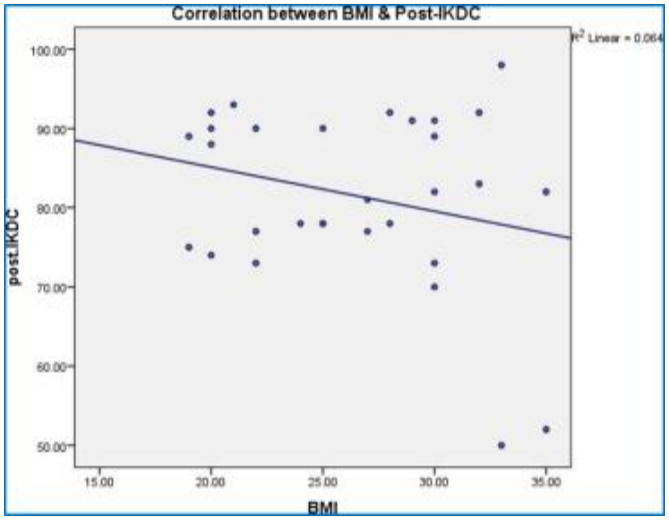

Figure (2): Correlation between BMI and post-IKDC.

DISCUSSION

We found that intraoperatively, (46%) of the studied patients had isolated medial meniscal lesions. Also, (33.33% and 10%) had resected medial and lateral meniscal treatment, respectively.

Other findings were reported by **Joseph *et al.*** [10], because isolated medial meniscal lesions were discovered in 29% of patients, the groups also varied in terms of meniscal lesions and therapies. About (40% and 6%) had sutured medial and lateral meniscal treatment, respectively.

Farthing *et al.* [11] have displayed that prompt ACL restoration lowers the likelihood of medial meniscal ruptures. Because of the disease's inflammatory and locally damaging characteristics, PVNS offered a contraindication for ACL repair in this instance. It's possible that the pro-inflammatory joint milieu that PVNS maintained hampered graft recovery and raised the possibility of graft failure.

Additionally, in the **Williams *et al.*** [6] research, the group that underwent solitary ACL restoration experienced one graft rupture at 8 months, but the group that underwent combination surgeries experienced none. They demonstrated unequivocally that there was a substantial failure rate when the extra-articular treatment was performed alone to alleviate instability after an ACL tear.

The present study showed also that, postoperatively, most of the studied patients (90%) had hard endpoint Lachman and negative anterior drawer test. Also, (93.33%) of them had no pivot shift. Almost (86.67%) of the studied patients had a negative McMurray test. The mean Tegner and Lysholm scores were 6.5 and 89.9 ± 7.17, respectively. No cases had an extension deficit. The mean flexion range was 130.5 ± 4.90. The mean net change of Lysholm and IKDC subjective score postoperatively were 25.4 ± 11.93 and 26.77 ± 13.25, respectively.

These results were consistent with a research by **Yoo *et al.*** [12], which displayed that the mean Lysholm score for the ALL-injured group was 93.2 ± 2.2 and for the ALL-intact group it was 93.3 ± 2.1. Preoperation and postoperative measurements of ATT were 4.8 ± 1.4 and 1.4 ± 0.9 mm for the ALL-intact group and 4.7±1.7 and 1.4±1.0 mm for the ALL-injured group. The two groups' postsurgical results were better than their preoperative state, in contrast, there was no

insignificant difference between the presurgical and terminal follow-up periods (P=0.759 and 0.833, correspondingly). Similar to the PS test (P>0.05), the Lachman test displayed insignificant difference between the groups (P=0.18) and negative findings in both groups at the most recent follow-up.

Furthermore, the present results were consistent with those of **Dodds *et al.*** [13]**,** which demonstrated that the Lemaire procedure has demonstrated advantages in cases with high retear risks or those who play pivoting sports by reducing PS, limiting ATT within the lateral compartment, and protecting the graft and meniscus with negligible or no adverse effects [14].

Additionally, **Joseph *et al.*** [10] found that the Lemaire and reference groups' Lysholm, IKDC, and ACL-RSI were comparable. Although the Lemaire group's Tegner scores were greater than those of the reference group (P<0.05), the two groups' net Tegner score declines were equal (median, 1.0 vs. 1.0). There were no extension deficiencies in either group (P>0.05), and the two groups' flexion ranges were comparable (p=0.174). Additionally, eight months following ACLR, none of the cases had high-grade PS, and just one knee (3%) in the Lemaire group had low-grade residual PS.

This supports the results of a comprehensive study by **Joseph *et al.*** [10] and **Song *et al.*** [15]**,** which discovered that LET techniques increase rotational stability by reducing PS. Additionally, the Lemaire group experienced no graft failures in this series, whereas the reference group experienced one.

Tashiro *et al.* [16] also discovered a quadriceps deficit of 20% at 60°/s and 10% at 180°/s utilizing lower rotational velocities. The hamstrings showed a deficit of 21.3% at 60°/s and 9.6% at 180°/s, whereas the quadriceps showed a deficit of 18.3% at 60°/s and 15.3% at 180°/s, according to **Yosmaoglu *et al.*** [17]**.** Using semitendinosus and gracilis graft, **Kyung *et al.*** [18] discovered defects in the quadriceps of 29.9% at 60°/s and 18.5% at 180°/s, as well as in the hamstrings of 24.6% at 60°/s and 10.5% at 180°/s. In order to confirm RTP and as part of the rehabilitation regimen, athletes must undergo isokinetic examination [19]**.** Numerous study have examined the biomechanical properties and advantages of LET, showing that it protects the graft and meniscus, minimizes PS, and limits ATT within the lateral compartment with few or no adverse consequences. According to several authors, LET enhances therapeutic results [20].

In this study, age was significantly correlated with post-IKDC, while BMI didn't show any significant correlation with it. This is consistent with **Magnitskaya *et al.*** [21] who discovered that age was the primary determinant of the IKDC 2000 score, which rose at every time point throughout the initial year following ACL-R. Prior to and throughout the first year following surgery, younger patients (less than 30) had steadily greater IKDC 2000 median score values (six–nine points) than those over 30. In healthy participants, **Anderson *et al.*** [22] have previously observed a negative relationship between the IKDC 2000 score and age, with subjects over 35 years old having considerably lower score values. These results imply that age, instead of the kind of ACL-R or other specific patient data, may be the reason for the lower IKDC 2000 score values shown in cases over 30 in the current investigation. Since it has been proposed that BMI wasn't a reliable indicator of IKDC 2000, mush research is required to detect the significance of these findings [23].

In contrast to our results, a study conducted by **Fabio *et al.*** [24] on 88 patients who underwent STGR surgery between 2002 and 2010 found insignificant differences in the mean IKDC 2000 score at a mean follow-up of three to five years between patients under 30, those between thirty and forty, and those over forty at the onset of the ACLR.

Additionally, **Pietrosimone *et al.*** [23] anticipated that their patients would be less likely to contribute to competitive and level I sports, have a BMI greater than 25 kg/cm^2, and have grade 2–4 cartilage injuries. At one or more time periods following surgery, BMI, pre-injury participation in competitive athletics, and graft type had an impact on the IKDC 2000 score. Future research may thus take these aspects into account to determine even more accurate patient reference values.

Presurgical BMI and postoperative IKDC 2000 score were shown to be somewhat correlated in earlier research by **Kowalchuk *et al.*** [25] **and Spindler *et al.*** [26]. IKDC 2000 score values were lower before, three, six, and twelve months after surgery for those with a BMI more than 25 kg/cm^2.

Interestingly, it was shown that cases with a presurgical BMI of less than 25 kg/m^2 already had noticeably higher IKDC 2000 scores. In the same line, presurgical ratings were higher (median 6–8 points) for patients who participated in competitive athletics [21]. Although the exact causes are unknown, it seems that these two factors raise the chance of greater scores following an injury, indicating that postsurgical changes were not always connected to the ACL-R.

CONCLUSION

Laboratory investigations of the constraint offered by the lateral anatomic structures and the assessment of the decrease of rotational laxity have accumulated data in favor of the inclusion of a lateral extra-articular surgery to an intra-articular ACL restoration. For knees with rotational instability, ACLR combined with a modified Lemaire method has been demonstrated to be associated with isokinetic muscle recovery that is comparable to that of stand-alone ACLR for knees without rotational instability. At the time of return to play, a modified Lemaire treatment improves rotational stability for ACL-deficient knees with high-grade PS without sacrificing isokinetic muscle recovery.

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