Short-term results of combined anterior cruciate ligament and anterolateral ligament reconstruction using a novel hamstrings graft construct in obese patients: a pilot study

Ahmed M. F. ElGuindy[a,b], Ibrahim Mohsen[b]

[a]Department of Orthopedic Surgery, Doctor Soliman Fakeeh Hospital, AlHamra, Jeddah, Kingdom of Saudi Arabia, [b]Department of Orthopedic Surgery, Faculty of Medicine, Fayoum University, El Fayoum, Egypt

Correspondence to Ibrahim M. Mohsen, MD, Street 79, Building 2, Maadi, Cairo 11431, Egypt Tel: +002 010 23 054 054; Fax: 084 6330 587; e-mail: imm00@fayoum.edu.eg

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Background

Elevated body mass index (BMI) was associated with increased complication rates including failures in arthroscopic anterior cruciate ligament (ACL) reconstruction surgery.

We present our short-term results of our technique used for ACL reconstruction in obese patients with the aim to reduce chances for graft failure and improve outcomes.

Patients and methods

We present our case series of obese patients (BMI > 30) operated for ACL reconstruction during the period from January 2017 to January 2022 using a dedicated technique for ACL reconstruction. We are using hamstring tendons prepared in a single construct to reconstruct both the intra-articular ACL and the anterolateral ligament. All patients received the same surgical technique and associated injuries were operated on according to their indications and guidelines. All patients completed the subjective knee evaluation form of the International Knee Documentation Committee at the time of the procedure and at the last follow-up visit and assessment of knee laxity was performed using a KT-1000 arthrometer before the surgery and at the last follow-up.

Results

Twenty patients underwent anterior cruciate ligament reconstruction (ACLR) using this technique during the study period, with average follow-up period of 1 year. All cases were males, mean BMI was 32.2 (30.4–36.2), 18 cases were operated on using ipsilateral Semitendinosus and Gracilis grafts, 2 cases were operated on using contralateral knee hamstrings. All cases were instructed nonweight bearing for 6 weeks after surgery and received the same standard accelerated rehabilitation protocol. Two cases developed postoperative superficial wound infection at the graft harvest site that resolved with conservative treatment of oral antibiotics and wound care. The mean postoperative International Knee Documentation Committee score improved from 45.195 to 79.245 (P<0.001), and the mean KT-1000 arthrometer differential improved from 11.8 to 2.77 (P<0.001) and pivot shift tests were negative in the postoperative exam for all the cases.

Conclusion

ACLR in obese patients should be approached with care, our technique can offer a feasible solution to obtain an acceptable outcome, Further work is required to provide insight on the long-term outcome of ACLR in obese patients.

Keywords:
anterior cruciate ligament, anterolateral, cruciate, obese, reconstruction

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Introduction

The World Health Organization defined excessive body weight as the condition associated with the accumulation of body fats that can endanger the health of an individual. Obesity is the extreme form of weight excess and is defined as body mass index (BMI) equal or more than 30 [1]. Obesity is a worldwide epidemic, with countries like Egypt, Saudi Arabia and the United states of America showing a prevalence among adults 18 years and older, exceeding 30% of the population [1].

Anterior cruciate ligament (ACL) injuries are among the most common knee ligament injuries, according to work by Sanders and colleagues the incidence of ACL tears can reach 68.6/100 000 person-years [2].

Obesity and ACL were found combined in literature in many instances. Many studies showed that Obesity is associated with elevated risk for surgical complications in arthroscopic procedures [3–6]. Cooper *et al.* [3] indicated that obesity is associated with longer operative time and higher rate for hospital readmission in the first postoperative month [3]. Burns *et al.* [7] found a high statistical correlation between high BMI and requiring revision in ACL reconstruction [7]. This can be explained that in obese patients the knee ligaments are under excessive stress as demonstrated by high rates of noncontact ACL injury was documented in obese population [7]. In another study, obesity if associated with a higher lateral tibial slope was found to show an increased risk for ACL tears [8].

In ACL surgery, the graft is vulnerable during the immediate postoperative period, until graft integration occurs. This vulnerability is exacerbated by modern rehabilitation techniques involving early weight bearing and rapid restoration of knee range of motion [9].

In the literature we could not find studies that describe special techniques to use in this increasing population of patients. In this work, we aim at describing our dedicated technique in the surgical treatment of ACL injuries in obese patients and its short-term results.

Patients and methods

We present our case series of obese patients (BMI > 30) operated for anterior cruciate ligament reconstruction (ACLR) during the period from January 2017 to January 2022. The inclusion criteria were anterior cruciate ligament injury, age above 18 years old, BMI above 30 at the time of surgery and completion of more than 1 year of postoperative follow-up. The exclusion criteria were patients aged 18 years or less, BMI less than 30 at the time for surgery, multi-ligament knee injury and follow-up less than 1 year. During this period, we operated 750 patients for ACLR, 20 patients fulfilled the inclusion criteria and were included in the results. Preoperative informed consents about operation and possible risks were obtained from all patients. The study was approved by the institutional review board in our hospital (Decision No. 128/M-IRB/2022 and R-503).

All patients were clinically assessed by the first author and they completed the subjective knee evaluation form of the international knee documentation committee (IKDC) [10] at the time of the procedure and at the last follow-up visit and assessment of knee laxity was performed using a KT-1000 arthrometer before the surgery and at the last follow-up.

All patients received the same surgical technique, associated injuries were operated according to their own indications and guidelines.

Technique

After anesthesia, the patient was placed supine, prophylactic antibiotic was given after performance of hypersensitivity test. Examination under anesthesia was done and documented, tourniquet was placed at the root of the thigh. Preparation, and draping in the standard technique was performed. The lower limb was exsanguinated using a sterile Esmarch bandage, and tourniquet was inflated to 350 mm Hg.

Our technique involved combining the anterior cruciate reconstruction with the anterolateral ligament of the knee (ALL) using a novel preparation of the Semitendinosus and the Gracilis tendons.

Graft harvest and preparation

Both the Semitendinosus and Gracilis were harvested by the standard technique using a 4 cm vertical incision, incision size was increased as dictated by the amount of the subcutaneous fat. The graft was prepared in a U shaped with unequal strands as shown in (Fig. 1a-c), ending with a graft composed of a main quadruple part 9–10 cm long and with a diameter of 8.5 mm or 9 mm and the remainder part was usually enough to form two strands with a length not less than 5 cm (Fig. 1d).

Arthroscopy

Knee arthroscopy was performed through standard viewing and working portals and the knee was examined using the standardized technique. Associated meniscus and cartilage lesions were documented and managed as indicated. Preparation of the notch was done with cleaning of the remnants that interfere with proper viewing of the anatomical landmarks.

Tunnels creation

Femoral tunnel was created with an outside-in C-guide Arthrex Inc. Naples, Florida, USA. A trans-patellar tendon portal was created to allow passage of the intraarticular portion of the C-guide. The intraarticular point was adjusted at the anatomical location of the ACL footprint [11]. The outside point was located at the femoral ALL footprint as described by Claes *et al.* and Vincent *et al.* [12,13] (Fig. 2a). The tunnel was drilled at the same size of the graft. A traction suture was passed into the joint through the tunnel and pulled through the anteromedial portal.

The tibial tunnel was created in the standard technique with a tibial C-guide (Arthrex Inc, Naples, Florida, USA) fixed at 55°. The traction suture was pulled into

Figure 1

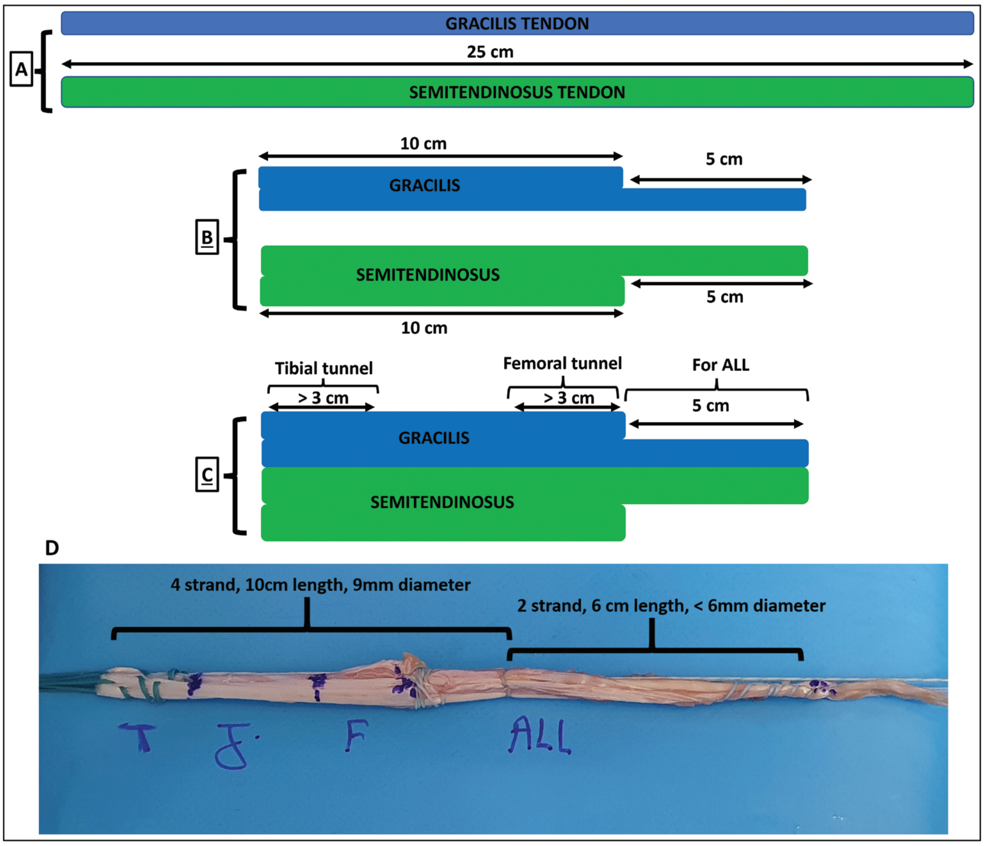


Illustration on the process of graft preparation: A: representing the harvested tendons after cleaning from muscle tissue. B: the tendons are prepared in the shape of a U with unequal limbs, one is 10 cm long and the remaining part is whipstitches at its end. C: the graft is prepared as a 10 cm four strand hamstring tendon and the remaining is a two-strand extending from one end. Stitches are shown as black arrows. D: Picture of the prepared graft: T= tibia, J= joint, F= Femur, ALL= Anterolateral ligament. Shows the intended distribution of the graft segments.

the tibial tunnel and delivered at the tibial metaphysis opening of the tunnel.

The tibial insertion of the ALL was identified at 1 cm below the joint line and midway between the head of Fibula and the Gerdy tubercle [12–14] (Fig. 2b). A guide pin with an eyelet was drilled from lateral to medial in a direction away from the tibial tunnel, meanwhile a drill bit was left inside the tibial tunnel to ensure that the tunnels did not cross. The lateral end of the tunnel was drilled with a drill bit 6 mm for a depth of 30 mm. A traction filament was pulled through this tract and delivered at the medial side of the tibia.

Graft passage

The graft was pulled from the femoral side, into the joint and then into the tibial tunnel. Adjustment was made according to the preapplied ink marks to avoid excessive pulling of the graft into the joint bringing the ALL piece inside the femoral tunnel.

Femoral fixation was done with an interference screw of the same size of the tunnel while maintaining tension to avoid graft rotation or entangling.

Graft tensioning

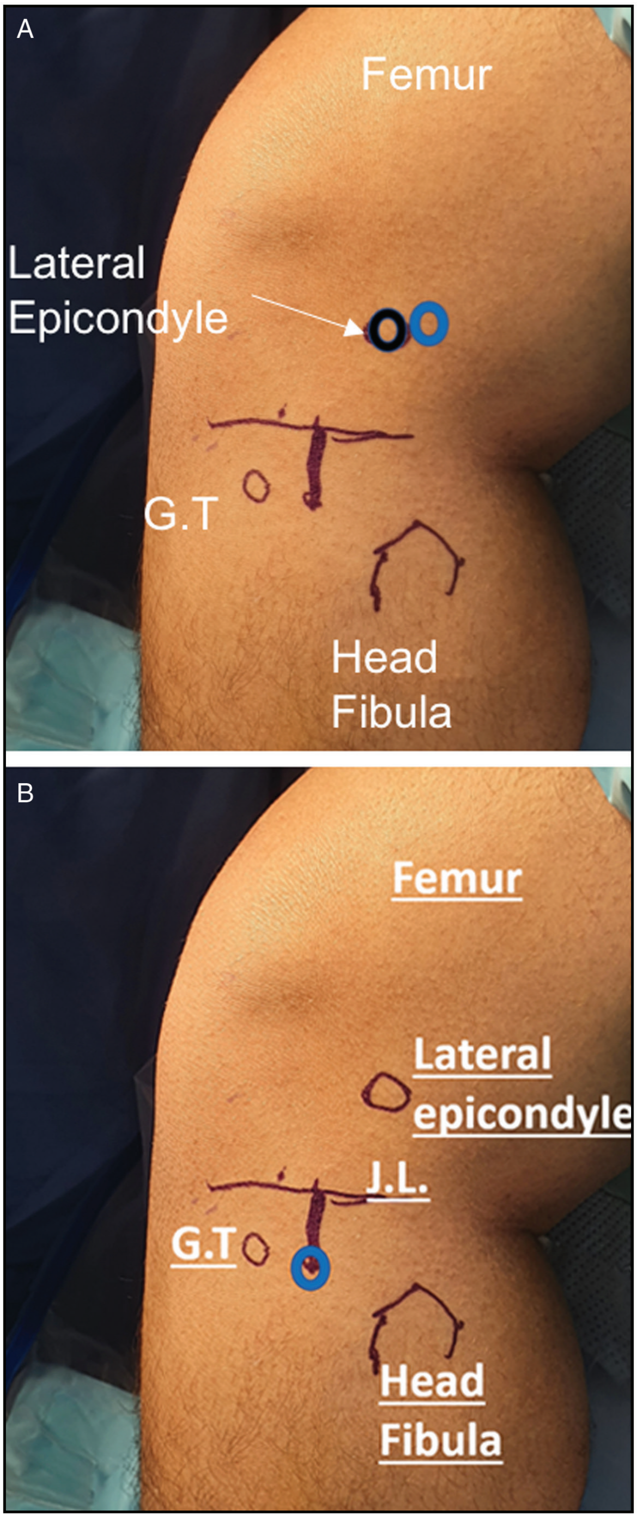
Graft cycling was performed to protect against creep and stress relaxation.

Tibial side fixation: tibial side main graft fixation was done with the knee in 30º flexion and neutral rotation with a posterior drawer force applied on the proximal tibia. Tibial fixation was done with an interference screw and complemented with a ligament staple. The interference screw size was +1 the size of the tunnel.

A curved forceps was passed deep to the iliotibial band and superficial to the Lateral Collateral Ligament from distal to proximal, pulling the strands of the ALL down to tibial tunnel wound. The graft was pulled into the tunnel and held temporarily while the assistant cycles the knee into flexion/extension to pretension the graft. Fixation was done using an interference screw 7 mm with the knee in 30º flexion and in neutral rotation.

Verification of the graft tension was performed under direct visualization of the arthroscope with the probe at 30º flexion and deemed satisfactory when no yield on pulling is observed.

Figure 2



Landmarks on the lateral aspect of the knee: GT= Gerdy Tubercle, JL= Joint line. A: The blue circle on the picture identifies landmark of the femoral attachment of the Anterolateral ligament of the femur in relation to the lateral epicondyle. B: The blue circle on the picture identifies landmark of the tibial attachment of the Anterolateral ligament located 1 cm below the joint line midway between the Gerdy tubercle and the fibular head.

Closure of the graft harvest wound, the lateral femoral wound and the portals and drains were inserted inside the joint through the anteromedial portal, and in the graft harvest wound.

Postoperatively

A knee immobilizer in 30° flexion was applied to the patient, antibiotics and pain medications were provided. In bed, the knee immobilizer was removed and continuous passive motion machine was applied from 0 to 60°. Closed chain knee exercises were initiated immediately under supervision of physiotherapist three times/day during hospital stay to instruct the patient how to deal during the early postoperative period. The drain was removed when it collected less than 50cc/24 h and the patient was discharged home for follow-up in the clinic. Surgical wounds were followed at 1 week postoperatively and sutures removed at 2 weeks, and patient was referred to physiotherapy to follow the standardized accelerated rehabilitation protocols [15]. Weight bearing was delayed for 6 weeks, then progressed from partial weight bearing to full weight bearing along the course of 4 weeks. Knee immobilizer was removed after 4–6 weeks according to patient's progression in physiotherapy. Follow-up visits were scheduled every week for the first 2 weeks then on monthly basis to assess range of motion and muscle strength. Final assessment was performed using the international knee documentation committee and KT-1000 arthrometer, results were documented to be compared with preoperative values.

Data entry and master sheet were carried out using Microsoft Office Excel 2010. Statistical analysis was conducted using SPSS Statistical package for social science v.16. The analysis included descriptive analysis (frequency and percentage for categorical data mean and standard deviation for scale data) and comparative analysis (paired sample *t*-test, $P<0.05$).

Results

Twenty patients underwent ACLR using this technique during the period of study, average follow-up was 17 month (average of 17 ± 3 months), all cases were males, mean age was 28 years (20–40 years), mean weight was 102.5 (89–127) kg, mean BMI was 32.2 (30.4–36.2), the right side was the index side in 70% of cases, eleven cases had a noncontact injury during sporting activity, 7 had contact injury and 2 cases had their knees injured in activities of daily living. The mean time between injury and operative intervention was 7 months (3–16). We had 18 primary ACL injuries, and 2 cases were undergoing a first revision surgery, the latter received their autograft from the contralateral side. The average Semitendinosus tendon graft length was 25 cm (±2.6) and the average Gracilis tendon graft length was 24 cm (±3.2). The average quadruple construct length was 9.5 cm (±1.8), and the double strand portion average length was 5.6 cm (±1.2). The diameter of the intraarticular portion was 8.5 mm in eleven cases and

Table 1 Type of injury in cases and additional procedures

Type of injury	Number of cases	Procedures in addition to anterior cruciate ligament reconstruction	
Isolated ACL injury	5	None	
Associated medial meniscus injury	7	Partial menisectomy in 5 cases	Body repair (1 case) Root repair (1 case)
Associated lateral meniscus injury	3	Partial meniscetomy	
Associated both menisci injury	2	Repair	
Associated medial femoral condyle chondral lesion	2	Chondroplasty and Drilling	
Associated Trochlear chondral lesion	1	Chondroplasty	

Table 2 Comparative analysis for key indicators in results

	Preoperative	Postoperative	Significance
Pivot shift Test	Glide: 8 Clunk: 20	Negative test: 20	$P< 0.001$
*IKDC Subjective Score	Mean= 45.195 (34.2–57.5)	Mean= 79.245 (69.5–86.2)	$P< 0.001$
KT-1000 Arthrometer Differential	Mean = 11.8 (9–14)	Mean= 2.775 (2–6)	$P< 0.001$

*International Knee Documentation Committee

was 9 mm in nine cases. In our study, five patients had isolated ACL injury, 7 cases had associated medial meniscus injury, 3 cases had associated lateral meniscus injury, 2 cases had associated both menisci injury, and three patients had associated chondral surface lesions. Associated injuries were treated as follows, 5 cases by partial medial meniscectomy, 3 cases by medial meniscal repair, 3 cases by partial lateral meniscectomy, 2 cases by lateral meniscal repair, 2 cases by chondroplasty and drilling using 1.2 mmk wire, 1 case chondroplasty and 1 case by root avulsion repair. (Table 1)

Comparative IKDC and KT-1000 arthrometer results showed that the mean postoperative IKDC score improved from 45.195 to 79.245 ($P<0.001$), and the mean KT-1000 arthrometer differential improved from 11.8 to 2.77 ($P<0.001$) and pivot shift tests were negative in the postoperative exam for all the cases. (Table 2).

The range of motion ROM of patients were assessed according to the IKDC knee examination form, no significant difference between preoperative and postoperative range of motion with ($P=0.4642$) for the flexion loss and ($P=0.2836$) for extension loss. (Table 3)

A clinical case is presented in (Fig. 3).

Two patients developed superficial wound infection noted during the first postoperative visit presenting with angry edge of the graft harvest wound, and mild fever. Synovial fluid aspirate was done, no signs of interarticular infection was noted (white blood cell less than 40 000, and negative cultures). They resolved with wound care, oral amoxicillin/clavulanic 625 mg BID for 7 days.

Table 3 Range of motion of motion of patients according to the International Knee Documentation Committee knee examination form

Range of motion affected	No of cases Preoperative	No of cases Postoperative
Flexion deficit 0 to 5°	6	8
Flexion deficit 6 to 15°	14	12
Extension deficit <3°	10	13
Extension deficit 3 to 5°	10	7

In this pilot study, no retears happened for these cases during the reported duration.

Discussion

We present our technique and the early results of ACLR in obese patients, we operated twenty patients, the postoperative results showed improved stability and functional results. We could not find a series describing ACLR in obese patients in the literature, and we had to compare with the available ACLR literature. Our series demonstrated comparable improvement in the different stability testing, and KT-1000 arthrometer results. However, the small number of patients in our series and the short term follow-up makes the comparison not informative.

In our technique we aim to provide protection of the graft against high stresses during the early phases of graft integration and reduce stresses on the graft-fixation-device/bone interface. Before graft integration,

Figure 3

Male patient with anterior cruciate ligament injury left knee: A: showing anatomical landmarks and planned course of antero-lateral ligament reconstruction. B: guide wire exit in anterior cruciate ligament footprint. C: intra-articular graft in place. D: lateral skin wounds at the end of procedure. E and F: Radiography postoperative. G and H: Range of motion at final follow-up.

if the construct is exposed to excessive stresses, the fixation device can fail and the graft may slip in the bone tunnel causing laxity and hence failure of the surgery [9]. The amount of stress and load on the knee structures in obese patient is explained by the work of Azar *et al* [16]. They described a series of obese patients suffering knee dislocations while performing activities of daily living, like stepping of a stair, stepping of a curb, or simply falling during walking and they named these injuries 'Ultra-low velocity knee dislocations' [16]. This is indicative of the amount of stress the ACL graft/fixation device construct is exposed to during activities of daily living in obese patients in the early phases after ACLR surgery. We added an ALL reconstruction in our patients because recent research showed that the addition of a lateral extra-articular augmentation would lower stresses on the intraarticular graft thus protecting it [17–19]. The ALL of the knee was shown to play an important role in the sagittal plane and rotational stability of the knee, its anatomy was described and biomechanical studies showed the benefit of its concomitant reconstruction during ACL surgery [13,14,20,21].

In addition to adding the ALL reconstruction, we have elected to fix the tibial side of the main ACL graft with an interference screw and a ligament staple because research has shown that the bone density of tibial metaphyseal bone is less than that of the femoral metaphyseal bone within the same individual [9]. The significance of this is debated, but it has been postulated that decreased bone density negatively affects the biomechanical properties of interference screw fixation for soft tissue grafts [22]. Additionally, the orientation of the femoral and tibial tunnels is different. During weight-bearing work, the tibial tunnel and graft are co-linear, potentially transmitting greater direct forces to the tibial bone-graft interface. These issues have led some to refer to tibial fixation as the 'weak link' in ACL reconstruction [9]. We believe that using two fixation devices at the tibial side greatly increases stiffness of the construct and helps its capacity to resist high stresses and failure before graft integration occurs [23].

In our series, we chose to use the hamstring graft in ACLR and not the gold standard Bone Patellar Tendon

Bone (BPTB) graft. In obese patients the quality of the extensor mechanism tissue is questionable with fatty degeneration of the tendon microstructure predisposing it to rupture when excessively stressed [24]. This finding suggests a poor Bone Patellar Tendon Bone graft quality and weakens the extensor mechanism rendering it susceptible to rupture.

Graft diameter was an important point in our graft preparation technique, the diameter of the intraarticular portion of the ACL graft was not less than 8.5 mm in all cases. We believe that the size of the graft is an important factor against failure. Although we did not face this situation in this study, but in case we face that the intra-articular portion of the graft is less than 8.5 mm, we would add the part dedicated for reconstruction of the ALL ligament to the intra-articular graft to reach the desired diameter and we would use a 4 mm polyester tape to percutaneously reconstruct the ALL [21] using the same anatomical landmarks described in our work and we would exclude this case from the study.

Reviewing of 4029 patients in the Norwegian registry for ACL reconstruction, Inderhaug *et al* [25]. found that graft size was not an independent risk factor for revision of ACL reconstruction and that graft 8 mm or more did not have better outcome than smaller ones. However, these results contradict a systematic review published recently [26], it demonstrated that graft thickness less than 8 mm was associated with a higher rate of revision. This systemic review analyzed the work of Magnussen *et al*. [27] and concluded that graft 8.5 mm or more were associated with less revision rates. At the same time, the Multicenter Orthopedic Outcomes Network cohort study showed similar findings [28].

Our study has low number of patients and short term follow-up, we cannot assess the long-term performance of the technique on knee stability and function. Knee stability was assessed clinically using KT-1000 arthrometer, Lachman test and pivot shift test. However, postoperative MRI may be used for radiological assessment of integrity of the graft after incorporation in future studies. We could not study the effect of the associated intra-articular injuries on the results due to the small number of this case series. However, this work should attract attention to this group of patients, that we face increasingly in practice, and we believe that a dedicated approach should be applied to improve the outcome of their procedures. Our study did not include female patients, in our practice obese female patients were reluctant to undergo the surgery due to the long ambulatory restriction, and the required lengthy rehabilitation protocol.

ACLR in obese patients should be approached with care, every attempt to improve the graft safety during the initial period of graft healing is essential for adequate result. Our technique can offer a feasible solution to obtain an acceptable outcome. Further work is required to provide insight on the long-term outcome of ACLR in obese patients.

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Bioethics Committee of Doctor Soliman Fakeeh Hospital, Jeddah, Kingdom Saudi Arabia (Decision No. 128/M-IRB/2022)

Authors' contribution

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by A EG and I M. The first draft of the manuscript was written by A EG and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.
Informed consent: was obtained from all patients.

Conflicts of interest

There are no conflicts of interest.

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