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Predicting quadruple graft size preoperatively using MRI

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Abstract

ACL is one of the most injured ligaments of the knee in contact sports, ACL reconstruction is one of the most performed procedures. The aim of this study is to assess correlation of intraoperative hamstring quadruple graft diameter with preoperative (MRI) hamstring tendon's diameter measurements, and demographic characteristics. A total of 32 male patients who were treated with primary ACL reconstruction between 2019 and 2020 in Al-Sadr Medical City in Najaf and al Kafeel hospital in Karbala were included in this study. We collected patients' demographic data (height, weight, BMI, age), and measurements of gracilis CSA, semitendinosus CSA, and combined semitendinosus and gracilis CSA from the MRI scan, and intraoperative graft diameter for all patients.

Keywords: ACL; MR; Injured ligaments

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Introduction

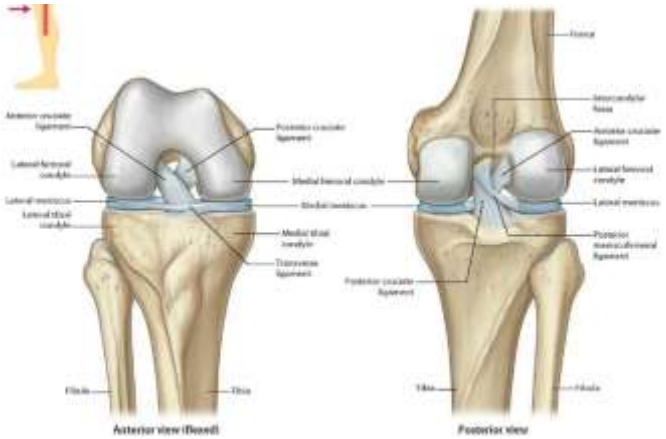
The anterior cruciate is an intracapsular, extrasynovial ligament of dense collagen that connects the distal femur and proximal tibia. It consists of two main bundles, anteromedial and posterolateral. ACL is one of the most commonly injured ligaments of the knee in contact sports, and the reconstruction of a torn ACL is one of the most commonly performed procedures. Several predisposing factors for ACL injury were mentioned in the literature, including neuromuscular and biomechanical abnormalities, mutations within COL5A1 and COL1A1 genes, female sex hormones, abnormal joint laxity, and primary structural influences of the knee. The ACL is a band-like structure of dense connective tissues.

The femoral bony attachment is located at the posterior part of the inner surface of the lateral femoral condylei. The ACL is lateral to the midline and occupies the superior 66% of the lateral aspect of the notch on an anterior view of the flexed knee joint. The size of the bony attachment can vary from 11 to 24 mm across.

From its femoral attachment, the ACL runs anteriorly, medially, and distally to the tibia. Its length ranges from 22 to 41 mm (mean, 32 mm) and its width from 7 to 12 mm. The ACL fibers fan out as they approach their tibial attachment. They attach to a fossa located anterior and lateral

to the medial tibial spine. The tibial attachment is known to be wider and stronger than the femoral attachment.

The cross-sectional area increases from the femur to the tibia, as it measures 33 mm2 proximally, 35 mm^2 at mid-substance level, and 42 mm2 distally.



Patient and Methods

A total of 32 male patients who were treated with primary ACL reconstruction between 2019 and 2020 in Al-Sadr Medical City in Najaf and al Kafeel hospital in Karbala were included in this study. We collected patients' demographic data (height, weight, BMI, age), and measurements of gracilis CSA, semitendinosus CSA, and combined semitendinosus and gracilis CSA from the MRI scan, and intraoperative graft diameter for all patients.

Inclusion Criteria

Patients with diagnosis of ACL rupture and were planned for primary ACL reconstruction surgery.

Exclusion criteria

Patient who had previous failed ACL reconstruction surgery.

Patient with multiple ligament injury.

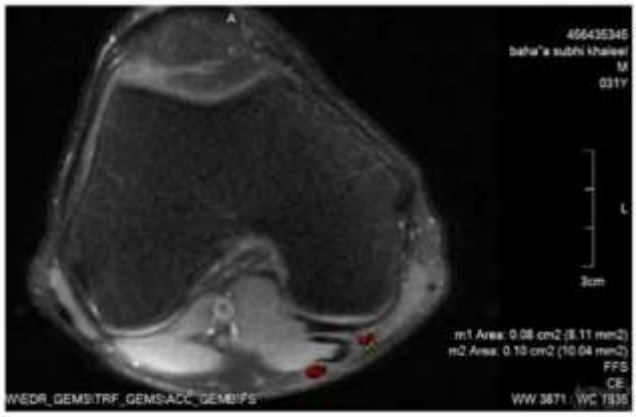


Figure 2.1 axial MRI at level of maximum diameter of patella

Figure 2.2 skin incision showing graft harvest technique

Figure 2.3 using stripper to release tendons from their insertions]

Figure 2.4 cleaning graft from soft tissue and muscles

Figure 2.5 Four strand graft preparation

Figure 2.6 Measuring graft size

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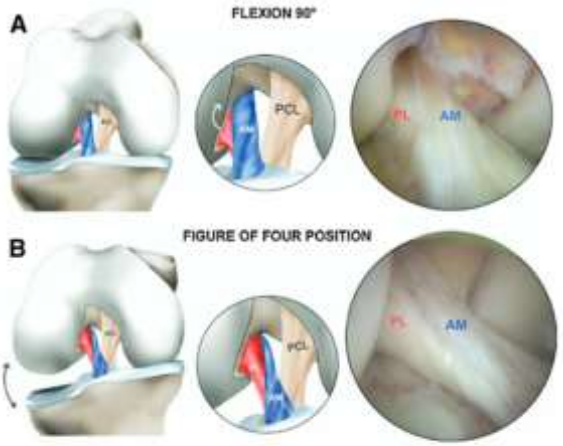


Figure 1.1 showing ACL bundles (anteromedial and posterolateral) in flexion position and in figure of four position.

The ACL is considered:

Primary restraint ..... anterior translation of the tibia relative to the femur

major secondary restraint ..... internal rotation, particularly when the joint is near full extension

minor secondary restraint.....external rotation and varus–valgus angulation, particularly under weightbearing conditions.

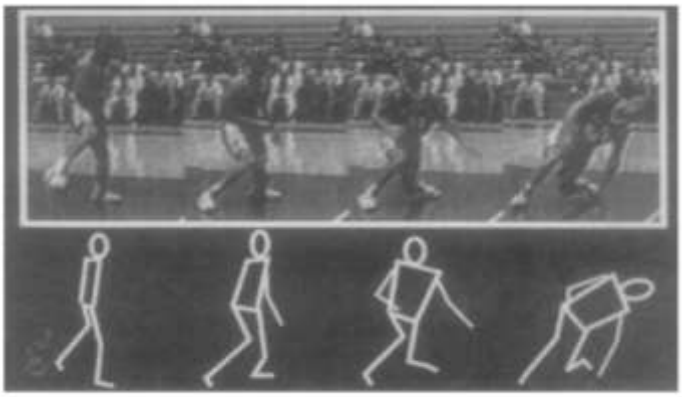


Figure 1.2. position of no return as described by Ireland

ACLR is preferred to be done within 1 year of injury to avoid further meniscal and cartilage damage. Early (3 weeks after injury) ACLR is considered more advantageous and gives excellent clinical outcomes.

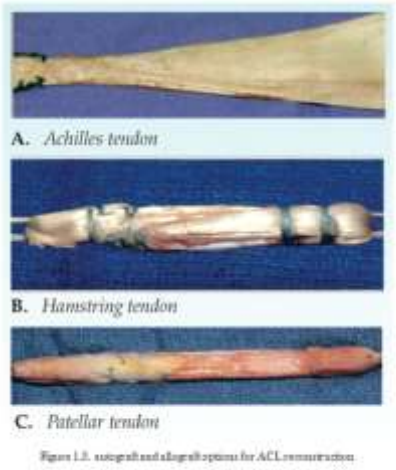
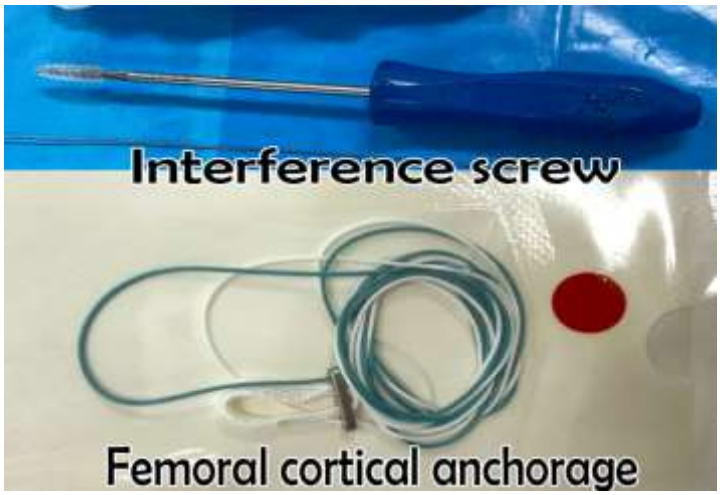


Figure 1.4 synthetic graft for ACL reconstruction

A BPTB graft has the disadvantage of donor site morbidity but the advantage of better graft stability. A hamstring graft is an attractive, good all-around graft choice with easier harvesting, fewer donor site complications, and good results. Allograft remains valuable in cases where the availability of an autograft is a concern, Allografts are expensive, but save time and remove one of the more technically demanding stages of ACLR.



Rehabilitation is of almost importance after ACLR for achieving good functional outcomes. Accelerated rehabilitation protocol is now being considered the protocol of choice for ACLR.

Statistical methods

All statistical analyses were performed using SPSS statistical software, version 25 (IBM Corporation, USA). Variables were presented as mean ± SD as well as range. Correlations between intraoperative graft diameter other variables were performed with two-tailed Pearson's correlation analysis. Receiver operating characteristic (ROC) curve analyses was used to evaluate the value of combined MRI cross sectional area and height in predicting the intraoperative graft diameter. Through this test the area under the curve (AUC), sensitivity and

specificity of each parameter were calculated. For all tests, a significant level of statistics was considered when $p<0.05$.

Results

Demographic and Graft Characteristics

the overall data of the patients including age, height, weight, BMI, gracilis tendon cross-sectional area, semitendinosus tendon cross-sectional area, combined cross-sectional area and operative diameter of gracilis and semitendinosus tendon. The mean age of the patients was 26.69± 4.64 years (range 18-35 years). Those patients had a mean height, weight and BMI of 169.94±8.51 cm, 69.03± 9.35 kg and 23.8± 1.56 kg/m^2, respectively. According to MRI, the mean cross-sectional area (CSA) of gracilis and semitendinosus tendons were 8.28±1.57 mm^2 and 13.0± 2.47 mm^2, respectively, while the combined CSA of both tendons was 21.27±4.04 mm^2. Mean intraoperative graft diameter was 7.95±0.45 mm (Table 3-1).

Table 1.

Patients' characteristics and demographic data (*n*=32)

Variables	Values
Age, years Mean±SD Range	26.69± 4.64 18-35
Height, cm Mean±SD Range	169.94±8.51 155-182
Weight, kg Mean±SD Range	69.03± 9.35 65-87
Body mass index, kg/m^2 Mean±SD Range	23.8± 1.56 21.08-27.15
MRI gracilis CSA, mm^2 Mean±SD Range	8.28±1.57 5.02-12.06
MRI semitendinosus CSA, mm^2 Mean±SD Range	13.0± 2.47 7.88-18.94
MRI Combined CSA, mm^2 Mean±SD Range	21.27±4.04 19.9-31
Intraoperative graft diameter Mean±SD Range	7.95±0.45 7.0-9.0

Table 2.

Pearson's correlation between intraoperative graft diameter and other variables

Variable	Coefficient	p-value
Age	0.195	0.285
Height	**0.381**	**0.038**
Weight	0.309	0.085
Body mass index	0.06	0.742
MRI combined CSA	**0.432**	**0.014**
MRI gracilis tendon CSA	**0.440**	**0.012**
MRI semitendinosus tendon CSA	**0.437**	**0.012**

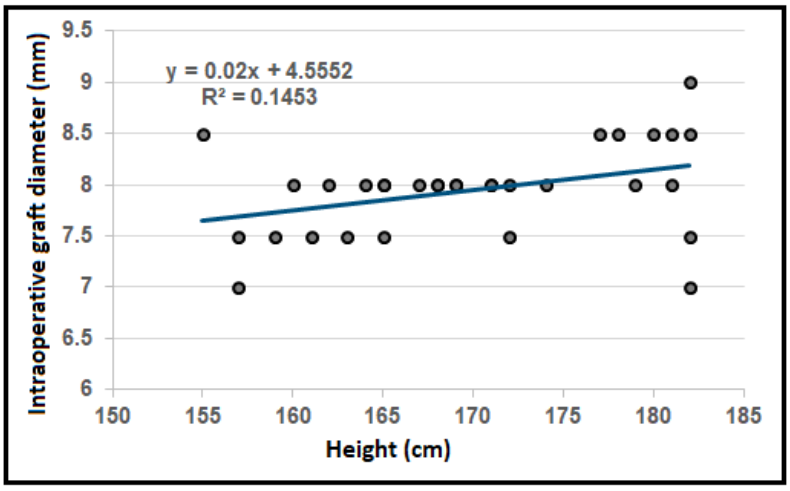


Figure 1.

Scatter plot and regression of intraoperative graft diameter with height

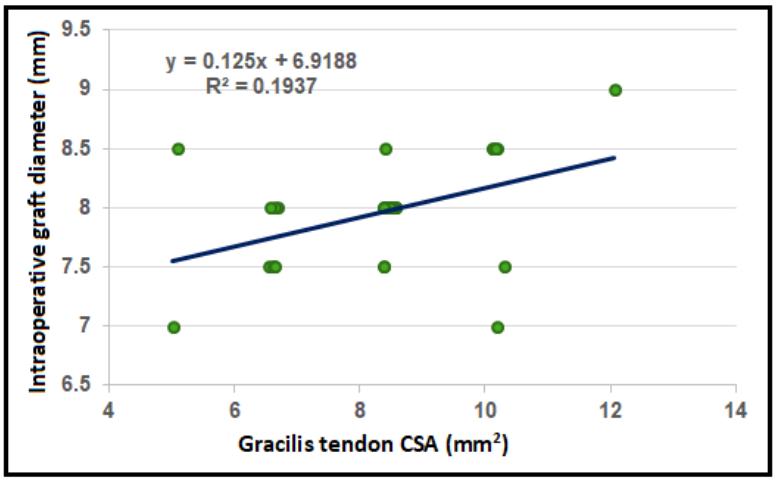


Figure 2.

Scatter plot and regression of intraoperative graft diameter with gracilis tendon CSA

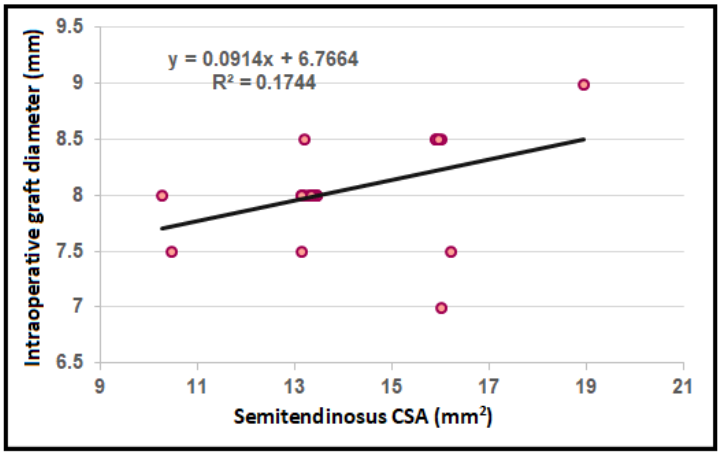


Figure 3.

Scatter plot and regression of intraoperative graft diameter with semitendinosus tendon CSA

Predictive value of MRI Combined CSA

Receiver operating curve (ROC) was used to evaluate the value of combined CSA obtained by MRI as well as the height of the patients in prediction of graft diameter in relation to intraoperative graft diameter. The area under the curve (AUC) was 0.807 [95%CI 0.587 to 1.0], p= 0.047. The sensitivity and specificity of the test at cut off values of MRI combined CSA = 17 mm^2, which is corresponding to 8 mm IOD, was 92% and 72% respectively (Figure 4).

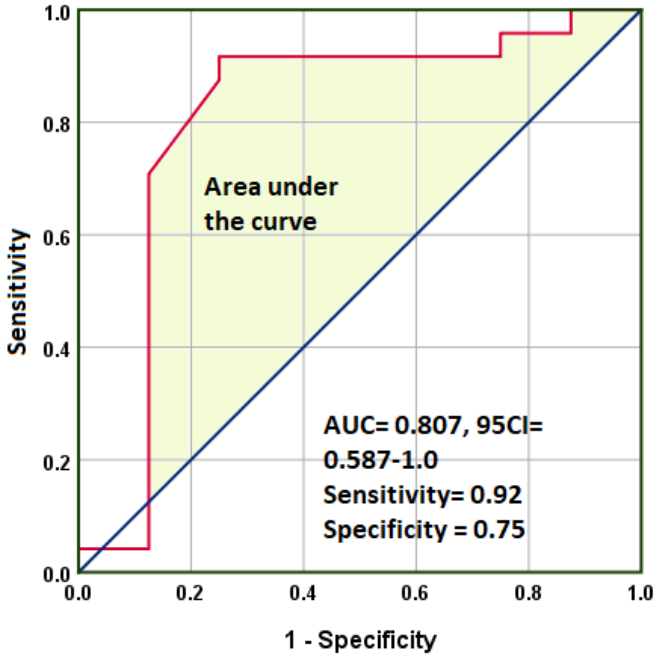


Figure 4.

Receiver operating characteristic curve for MRI combined CSA for predicating intraoperative graft diameter.

For height, the AUC was 0.745 [95%CI 0.515 to 0.974], p= 0.041. The sensitivity and specificity of the test at cut off values of height = 166 cm, which is corresponding to 8 mm IOD, was 75% for each (Figure 5).

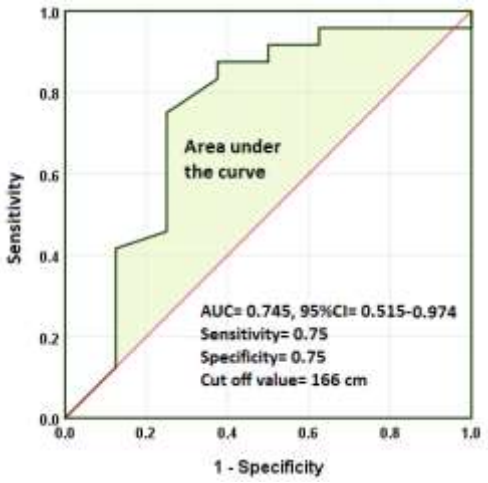


Figure 5.

Receiver operating characteristic curve for height of the patient in predicating intraoperative graft diameter

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Discussion

In the present study, the mean MRI combined CSA was 21.27±4.04 mm^2, while the intraoperative graft diameter was 7.95±0.45 mm [37]. Compared with other international studies, The mean STGT CSA ranges in the literature between 18.8 and 28.1 mm^2. Why it is difficult to compare results between studies? differences in sample size ethnicities gender ratio lack of standardization with imaging protocols CSA measurement techniques variations the equipment used to calculate CSA different landmark levels [38]. For demographic characteristic only height of the patients was found to be significantly correlated with intraoperative graft diameter. Tuman et al also reported that height is the best predictor and concluded that patients whose height was less than 147 cm have insufficient graft. The sensitivity and specificity of MRI combined CSA at cut off = 17 mm2, which is corresponding to 8 mm IOD, was found to be 0.92 and 0.72 respectively, indicating a very good predicting value [39]. The cut off value of hamstring graft diameter in this study was assigned at 8 mm. That was based on a systematic review which demonstrated that a hamstring graft size of 8mm or larger greatly reduced the failure rate of ACL reconstruction surgery. Leiter et al. found the sensitivity and specificity to be 79% and 78% Erquicia et al. reported sensitivity was 76.9% and a specificity of 85.7% [40]. Therefore, the data from the current study are generally in line with previously published work, which further confirm the predictability of variable studies to predict intraoperative graft diameter. However, although there was variability between studies due to differences in cut off calculation methods and individual and institutional MRI protocol differences, as well as differences in sample size and sex ratios.

Conclusion

The height of the patients was the only demographic factor that had a significant correlation intraoperative graft diameter. Pre-operative measures of ST-CSA, GT-CSA and combined CSA via MRI are significantly correlated with intraoperative graft size. The MRI combined CSA of 17mm^2 or greater could be a reliable measure in prediction of 8 mm intraoperative graft diameter for ACL reconstruction with high sensitivity and good specificity.

Recommendation

Surgeons can use The MRI combined CSA in combination with patient's height to predict the intraoperative graft diameter for ACL reconstruction. This assists the surgical planning to determine the most appropriate graft choice. Further studies with larger sample size are required for more reliable results.

Competing interests

The authors declare no conflict of interest.

Ethics Statement

This study has been approved by the Ethical Review Committee of the Kufa University. The publication of any potentially identifiable images or data contained in the article requires personal written informed consent. The research team will provide consultations for all subjects and their families to answer any research questions. Before signing the informed consent form, after the patients and their families fully understand the research process, our team members will organize the patients to sign the informed consent form or withdraw from the research. All subjects or their guardians will sign informed consent. Authors tend to submit research results to peer-reviewed journals or academic conferences for publication.

Authors' contributions

All authors shared in the conception and design and interpretation of data, drafting of the manuscript and critical revision of the case study for intellectual content and final approval of the version to be published. All authors read and approved the final manuscript.

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