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Clinicoradiological correlation between preoperative measurement of ACL footprint on MRI and intra operative semitendinosis graft diameter

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Abstract
Aims & Objectives: To assess the accuracy of preoperative measurement of Hamstring graft thickness using Magnetic Resonance Imaging (MRI) with intra-operative measurements.
Materials: The present prospective type of clinical study was conducted. A total of 50 patients operated for Anterior Cruciate Ligament (ACL) reconstruction were selected for the study. Informed consent was obtained from all study participants. Patients who fulfilled the inclusion criteria were studied and evaluated.
Results and Observations: It was observed that the maximum number of patients (56%) belonged to age group 21-30 years. The mean ± standard deviation of age was 31.04±6.58. It was observed that 72% of patients were males and 28% females, the mean ± standard deviation of anteroposterior (AP) and mediolateral (ML) diameter of semitendinosis on Magnetic Resonance Imaging at joint line was 6.34±0.88 and 6.57±0.71 respectively. The anteroposterior and mediolateral diameter of semitendinosis on Magnetic Resonance Imaging at physeal line was 6.71±0.61 and 6.99±0.39 respectively. It was observed that the measured values on Magnetic Resonance Imaging at joint level and physeal level correlated with the intraoperative values of semitendinosis graft and p value was significant. (p value<0.05).
Conclusion: A significant statistical correlation was found between the diameter of the 4-stranded semitendinosis autograft and mediolateral diameter and the anteroposterior diameter at both levels.

Keywords: Clinicoradiological correlation, preoperative measurement, intra operative

Introduction
The anterior cruciate ligament (ACL) provides almost 90% of the stability to the knee joint. More than 11.2 million visits are made to physicians' offices because of a knee problem. It is the most often treated anatomical site by orthopedic surgeons. Of the four major ligaments in the knee, the anterior cruciate ligament and the medial collateral ligament are most often injured in sports. ACL ruptures occur at a rate of 60 per 100,000 people per year. With society's increasing interest in physical fitness, primary care physicians are seeing more athletic injuries. Along with these injuries are the commonly experienced ACL ruptures in athletes and non-athletes. Anterior cruciate ligament (ACL) reconstruction is one of the most commonly performed sports medicine procedures in the United States, with approximately 100,000 procedures performed each year. The reconstruction can be performed with various techniques according to the preference and experience of the surgeon. Regarding the success of ACL reconstruction, the major factor for hamstring autograft is the graft size. [1, 2] As it is widely accepted opinion that hamstring tendon autograft should be at least 7 mm in diameter for a successful treatment. [2, 3] In recent studies, the authors have indicated that the diameter of tendon equal to or more than 8 mm decreases the risk of graft failure. [2, 4] However, the diameter of the hamstring graft can only be determined after folding the harvested autograft into 4-stranded. [5] This situation leads to interest in finding ways to predict graft diameter preoperatively. To predict the graft size, there are some studies about evaluation of the diameter of hamstring tendons preoperatively with magnetic resonance imaging (MRI), computed tomography (CT), and ultrasonography (USG). [1, 6-10]

In all studies about this subject, both gracilis tendon (GT) and semitendinosus tendon (ST) were used for ACL reconstruction. [1, 6-10]

Some authors prefer both ST and GT to obtain 4-stranded autograft, whereas some of them prefer only ST in single-bundle ACL reconstruction. [7, 11] This present study was designed for primary ACL reconstruction technique with 4-stranded ST autograft. The aim of the present study was to evaluate whether there is a correlation between the diameters of the ST on the preoperative MRI and the diameter of the 4-stranded ST autograft measured during the surgery.

Materials and methods

The present prospective type of clinical study was conducted. A total of 50 patients operated for ACL reconstruction were selected for the study.

Inclusion criteria

- Patients with clinical and radiological proven ACL tear with grade II or more.
- Patients between 25 to 40 years of age of both sexes.

Exclusion criteria

- Patients requiring revision ACL reconstruction.
- Patients older than 40 years of age with changes of osteoarthritis.
- Patients contraindicated for MRI.
- Patients with multi-ligament injury.

Patients who fulfilled the inclusion criteria were studied and evaluated.

Clinical

Subjective

A detailed questionnaire was completed with each patient to evaluate subjective factors such as pain, functional limitations and occupational considerations.

Objectives

Objective examination included inspection of the knee for deformity, tenderness, abnormal mobility of the knee joint, measurement of range of movements.

All patients underwent preoperative MRI scanning to assess the preoperative ACL footprint. During surgery, the semitendinosis autograft harvested was measured intra-operatively. Anthropometric data was recorded for all patients.

Results and Observation

A total of 50 patients operated for ACL reconstruction were selected for the study.

The following observations were noted: -

1. Age distribution.

Table 1: No of patients in different Age Groups.

Age (years)	N	%
21-30	28	56
31-40	16	32
41-45	6	12

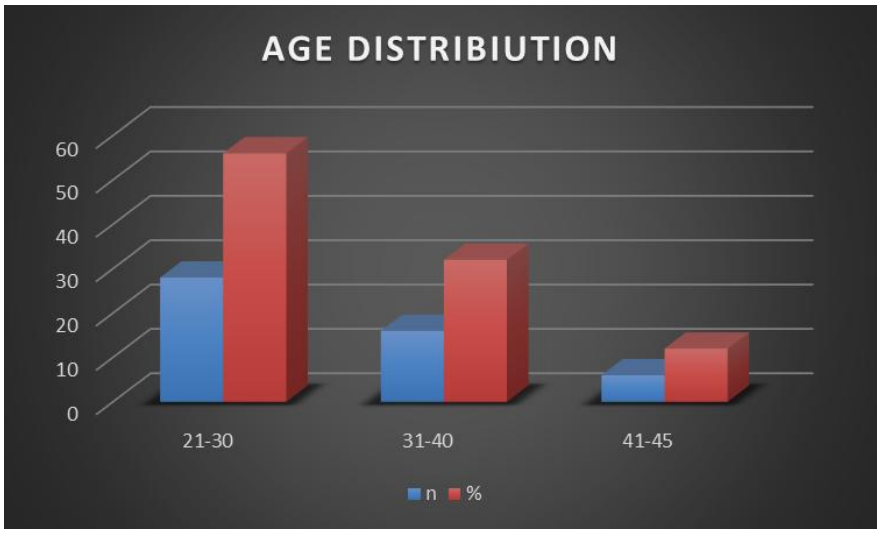

Fig 2.1: Graph depicting the number of Patients in Different Age Groups

It was observed that the maximum number of patients (56%) belonged to age group 21-30 years.

The mean ± standard deviation of age was 31.04±6.58.

2. Sex distribution

Table 2: Sex distribution

Sex	N	%
Males	36	72
Females	14	28

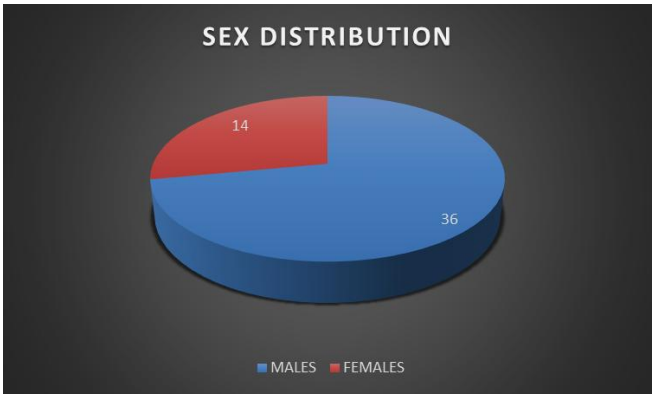

Fig 2.2: Pie chart depicting the Sex Distribution of patients.

It was observed that 72% of patients were males and 28% females.

3. MRI measurements of 4-stranded ST grafts

Table 3.1: MRI measurements of 4-stranded ST grafts at joint level (JL)

MRI Values	JL
AP (mm)	6.34±0.88
ML (mm)	6.57±0.71

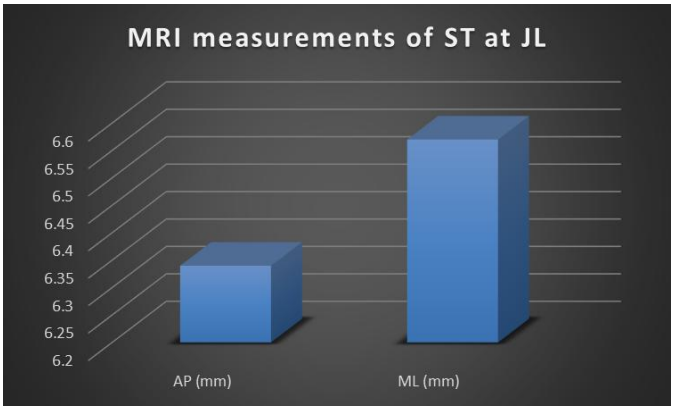

Fig 2.3.1: Graph depicting MRI measurements of 4-stranded ST grafts at joint level (JL).

Table 3.2: MRI measurements of 4-stranded ST grafts at physeal level (PL)

MRI Values	PL
AP (mm)	6.71±0.61
ML (mm)	6.99±0.39

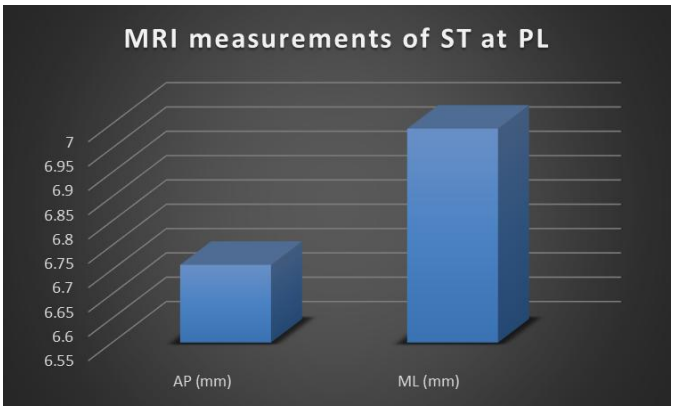

Fig 2.3.2: Graph depicting MRI measurements of 4-stranded ST grafts at physeal level (PL)

It was observed that the mean ± standard deviation of AP and ML diameter of ST on MRI at JL was 6.34±0.88 and 6.57±0.71 respectively and the AP and ML diameter of ST on MRI at PL was 6.71±0.61 and 6.99±0.39 respectively.

4. Intraoperative measurements of 4-stranded ST grafts.

Table 4: Intraoperative measurements of 4-stranded ST grafts

Intraoperative ST	Mean±SD
Diameter	**8.42±0.78**

It was observed that the Intraoperative ST diameter was 8.42±0.78.

5. P values

Table 5: P values

MRI Values	AP JL	ML JL	AP PL	ML PL
INTRAOP	<0.05	<0.05	<0.05	<0.05

It was observed that the measured values on MRI at Joint level and Physeal level correlated with the intraoperative values of ST graft and p value was significant.

Discussion

ACL injuries have increased in young individuals because of intensive sportive activities. The two primary ACL reconstruction procedures are the autologous bone – patella tendon – bone graft and the autologous four-strand hamstring graft, which is also known as the doubled semitendinosus and gracilis tendon graft. [13] The bone – patella tendon – bone graft is harvested by taking bone blocks from the patella and the tibial tubercle with the intervening central third of the patellar tendon. The second graft is composed of the distal semitendinosus and gracilis tendons, which are harvested from the musculotendinous junction to their tibial insertion. They are then sutured together and doubled back, giving four-strands. If the level of activity remains the same in cases who underwent ACL reconstructions, they will be more prone to graft failure. [13]

There are some studies that evaluated the graft thickness with the correlations of anthropometric characteristics of the patients. [3, 14-16] As an alternative method to anthropometric characteristics in preoperative evaluations, there are some studies based on quantitative analysis in the prediction of intraoperative graft size. And these studies focused on the correlation between CSA and diameter of hamstring tendon on preoperative MRI and intraoperative hamstring graft size. [1, 6-8] For this reason, standard sections were evaluated for the comparisons. Wernecke *et al*., [6] Bickel *et al*., [7] and Erquicia *et al*. [8] measured the ST diameter at the level of the largest region of the medial femoral condyle, and Beyzadeoglu *et al*. [1] measured at two different levels – distal to the musculotendinous junction and at the level of the JL. In this study, MRI measurements of diameters and CSA of STs were performed at the level of the JL and femoral PL.

Inadequate graft size is one of the major causes of the surgical failure. Based on recent studies, large graft diameter that is equal to or larger than 8 mm decreases the risk of graft failure. However, 7 mm was considered as the baseline threshold value in some MRI studies. [1, 6, 7]

Measurements were performed under × 10 magnification by an observer blinded to the intraoperative measurements of the autograft diameter. A significant statistical correlation was found between the diameter of the 4-stranded ST autograft and ML diameter and the AP diameter at both levels.

Erquicia *et al*. [8] predicted threshold values for combined ST and GT CSA for 4-stranded ST-GT graft with a minimum diameter of 8 mm as 25 mm^2 and 17 mm^2 under ×2 and ×4 magnifications, respectively. In their study, 17 mm^2 CSA measured under ×4 magnification had 96.2% sensitivity and 100% specificity. [8] The authors indicated that measurements with MRI under ×4 magnification were more accurate than those performed under ×2 magnification. [8] In this current study, measurements on MRI were performed under ×10 magnification. Other magnifications were not evaluated.

In daily practice, only ST autograft is used for ACL reconstruction in the institute in which this study was designed. For that reason, GT was not evaluated in this study. In other studies, combined CSA was used for 4-stranded

grafts and corresponding threshold values were provided. According to our result, it is believed that AP and ML diameter at the JL will provide more accurate prediction.

In a study that evaluated the length of ST and its CSA with MRI, it was expressed that preoperatively measured ST length was closely related to the intraoperatively measured length of ST, however, contrary to data obtained from MRI studies, an apparent correlation was not found between preoperatively determined CSA and that measured during operation. [9] Erquicia *et al*. compared preoperative USG and MRI measurements of tendon CSA and diameters, and measured during surgery and demonstrated reliability of USG in the preoperative evaluation of CSA which also comparable to MRI results obtained under ×2 magnification. [8] However, in clinical practice, for the diagnostic confirmation of ACL lesions, CT and USG are not routinely used.

It was believed that the advantages of this current study are: All surgical interventions were performed with a single tendon by the same operative team, and MRI evaluations were made from two levels under ×10 magnification.

The limitations of the current study are that all measurements were performed by a single observer, and cylindrical caliber gauges which were used to measure graft diameter intraoperatively could not determine the exact diameter of 4-stranded graft.

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