Pre Operative MRI Diameter Measurement of Semitendinosus Tendon Using for Anterior Cruciate Ligament Reconstruction Compared with the Diameter of the At Surgery

Abstract

Background: The use of autograft hamstring tendons for ACL reconstruction has increased due to measurable outcomes such as decreased donor site morbidity and improved fixation methods. Final graft diameter is effective in reducing the chance of graft re-tearing. Anthropometric parameters such as age, gender, height, weight, Body Mass Index (BMI) and thigh circumference have been reported to be of predictive value in a variety of studies but there is poor consensus agreement. MRI based radiologic assessments also needs radiologic workstation and special software. This study investigated the relationship between pre-operative semitendinosus tendon diameter measured by MRI and intra-operative final graft construct diameter.

Methods: Adult patients confirmed to have anterior cruciate ligament (ACL) rupture by positive physical test and 1.5 Tesla quality magnetic resonance imaging (MRI), who were candidates for autograft ACL reconstruction entered the study. Those with previous history of ACL surgery or candidates for allograft or bone patellar bone graft reconstruction were excluded. The MRI images of the patients were uploaded into Infinitesoftware. Joint level was determined first in coronal plane and then by using cross linking option the axial joint level was defined. Using cursor and ruler tools the maximum diameters of semitendinosus tendon was measured at the joint line, and two spaces (SPs) proximal and distal to it. Semitendinosus and final graft construct diameters were measured intraoperatively. SPSS software was used to analyze the data to find possible correlations.

Results: The Semitendinosus tendon graft diameter over 3.4 millimeters at two spaces distal to joint line on axial MRI cut well correlated to intra-operative final graft construct diameter over 8 millimeters.

Conclusion: The proposed measurement technique is a reliable option to assist the surgeons for pre-operative prediction of graft size in hamstring autograft reconstruction.

Keywords: Anterior Cruciate Ligament Reconstruction–Autograft-Hamstring Tendon- Magnetic Resonance Imaging

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Introduction

The anterior cruciate ligament (ACL) is one of the most repaired ligaments in the body. The incidence of the ACL tear in adults is on the rise, a part of which is due to increased use of diagnostic imaging and a higher rate of adults’ participation in high-risk sports [1]. ACL reconstruction is the current standard of care for those involved in sports activities, which reduces the risk of a torn meniscus and cartilage damage in the future by stabilizing the knee. The use of tendon autograft has increased due to relatively favorable results of the process along with a low morbidity rate, a low risk of inflammatory reactions, a small chance of disease transmission, and improved fixation techniques. Hamstring tendons are known as reliable grafts [2]. A graft with a minimum diameter of eight mm has been suggested for ACL reconstruction to reduce the risk of re-rupture. While both semitendinosus and gracilis tendons are both used, the diameter and length of the former are the main components affecting the final graft diameter [3-7].
Preoperative parameters, such as age, gender, height, weight, body mass index (BMI), leg length, and thigh circumference, have been introduced as the determinants of the final diameters in some studies. Nevertheless, there is no strong consensus on the issue \(^{8-12}\). Radiological evaluation methods have also been used to predict the final diameter of the graft and have excellent capability in this area. A high number of these methods utilize MRI technique to measure the relationship between the cross-sectional area of the hamstring tendons at the maximum level of medial condyle diameter, which requires special software programs for observation \(^{1,13-15}\).

This study aimed to investigate the relationship between the pre-op diameter of semitendinosus tendon for the anterior cruciate ligament reconstruction (ACL reconstruction) with the diameter of the end product during surgery by MRI.

**Method**

This prospective cross-sectional study has evaluated the pre-op diameter of semitendinosus tendon in candidates for the ACL reconstruction by MRI and compared it with the final diameter of the graft during the operation. The protocol of this research has been designed by the World Medical Association (WMA) Declaration of Helsinki and was sanctioned by the Ethics Committee of Shiraz University of Medical Sciences (1396-01-01-14342). The confidentiality of patient information was guaranteed. Since there was no non-standard intervention and treatment procedure in this study, the patients had only given a surgical consent.

The study sample has consisted of patients referred to Motahhari Clinic of Shiraz University of Medical Sciences from May 2017 to September 2018, with an ACL rupture and was nominated for autograft surgery. The inclusion criteria were the skeletal maturity, positive clinical test results, a confirmed ACL rupture at least 1.5 Tesla MRIs, and different MRI radiology results on a CD.

The exclusion criteria of the study were previous ACL reconstruction surgery, previous allograft surgeries, previous reconstruction with a Bone-Patellar Tendon-Bone (BPTB) graft, and those patients whose MRIs’ quality is less than 1.5 Tesla or is not on a CD. The sampling was performed by a simple random method; according to the results of Bickel et al. study, with a minimum power of 80% and marginal error of 5% by MedCalc statistical software, the sample size was determined to be at least 20 cases \(^{(1)}\).

The MRI images of the knee were imported in the INFINITT software (version 3.0.11.4). The joint level was determined at the sagittal or coronal view by cross-linking them in the axial view; the joint level limit was calculated. The maximum diameter of the semitendinosus tendon is measured at the joint surface (Figure 1). Changing the axial cutting spaces in MRI will result in the re-measurement of proximal and distal surfaces of the joint; finally, the average diameter of the tendons was measured and recorded in five intervals.

![Figure 1 - Determining the maximum diameter of the semitendinosus tendon at the axial view by the joint level MRI - source: author.](image_url)
The measurements were performed and recorded twice by two individuals and in three weeks. Although the diameter of the end product was the dependent variable, the following variables were analyzed to investigate their correlation with the dependent variable.

- **P2**: (maximum diameter of ST tendon at two proximal distances to the joint level)
- **P1**: (maximum diameter of ST tendon at one proximal distance to the joint surface)
- **STJ**: (maximum diameter of the ST tendon at the joint level)
- **D1**: (maximum diameter of the ST tendon at one distal distance to the joint surface)
- **D2**: (maximum diameter of the ST tendon at two distal distances to the joint surface)

The first step of the surgery was removing the semitendinosus tendon. The diameter and length of the graft were calculated using the specified measuring instruments available in the ACL surgical set (Arthrex, USA). The grafts longer than 34 cm and less were prepared in four and three layers, respectively. Afterward, the diameter of these four or three-layered grafts was measured and recorded for ACL reconstruction. The gracilis tendon was separately removed and prepared in all cases of three-layered grafts; the diameter of the final graft was also measured and recorded.

Data were acquired and analyzed with SPSS software (version 22, Chicago, IL, USA). The linear regression model evaluated the relationship between pre-op and during surgery measurements (such as the diameter of the graft). The correlation coefficient of the study was obtained based on the number of samples for both of the Spearman and the Pearson models.

### Results

This prospective study has investigated 20 adult male patients with a mean age of 28 years old. There were four cases in which the length of semitendinosus grafts was more than 34 cm, and the diameters of four-layered grafts were equal or more than nine millimeters. In all of these cases, the diameter of semitendinosus grafts was more than 4.6 millimeters for two distances of distal to knee (cases 1,15,16,20 in Table 1). The gracilis tendon was removed from the patients' pelvis bone in the other 16 cases. Table 1 presents the diameter of the final grafts and semitendinosus tendon at five levels. Data analysis was performed with SPSS software, and the correlation of variables was presented in the tables.

The p-values are demonstrated in Tables 2 and 3.

Among the independent variables, D2 had the strongest correlation with the final product so that the minimum diameter of the semitendinosus tendon (3.4 mm) at the D2 level of MRI, provides a suitable graft during the surgery with a p-value less than 0.05.

### Discussion

The pre-op anticipation of a hamstring graft is beneficial for surgical procedures. This study aimed to devise an MRI-based measurement method for the determination of the diameter of the final graft to increase knee stability. There have been different methods for measuring the diameter of the final graft; anthropometric measurements have also been yielded different results. The studies of Bickel, Wernecce, and Grawe have measured cross-sectional surfaces at different levels by MRI and specified software.

First, each method needs to determine the appropriate level for measuring the cross-sectional surface of both semitendinosus and gracilis tendons. The cross-sectional surface of each tendon is calculated via a radiology workstation and finally establishing a safe value by summing up the results. This process demands enough time to calculate the values and define the limits of grafts; moreover, it is not accessible for the majority of orthopedic surgeons (1,14,15). The method of this study has suggested a minimum diameter value as the
### Table.1 - The diameter of the final product and the semitendinosus tendon in the five levels of axial view MRI

<table>
<thead>
<tr>
<th>Age (year)</th>
<th>Graft length (cm)</th>
<th>P1 mm</th>
<th>P2 mm</th>
<th>Joint mm</th>
<th>D1 mm</th>
<th>D2 mm</th>
<th>The final diameter (mm)</th>
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<td>9.00</td>
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<td>4.90</td>
<td>4.30</td>
<td>4.00</td>
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<tr>
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<td>4.55</td>
<td>4.44</td>
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<td>4.45</td>
<td>4.90</td>
<td>5.10</td>
<td>10.00</td>
</tr>
</tbody>
</table>

* The diameter of the semitendinosus tendon at two proximal distances of joint surface in the MRI
** The diameter of the semitendinosus tendon at one proximal distance of the joint surface in the MRI
*** The diameter of the semitendinosus tendon at the joint surface in the MRI
† The diameter of the semitendinosus tendon at two proximal distances of joint surface in the MRI

### Table.2 - Correlation between the final product and diameters of semitendinosus tendon at different levels according to the Pearson correlation coefficient

<table>
<thead>
<tr>
<th>Dimeters of semitendinosus tendon at different levels</th>
<th>P1</th>
<th>P1</th>
<th>Joint</th>
<th>D1</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of grafts</td>
<td>Pearson correlation coefficient</td>
<td>0.026</td>
<td>0.040</td>
<td>0.360</td>
<td>0.386</td>
</tr>
<tr>
<td>Significance level (p-value)</td>
<td>0.912</td>
<td>0.867</td>
<td>0.119</td>
<td>0.093</td>
<td>0.045</td>
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</table>
The diameter of the semitendinosus tendon at two distal spaces of the joint surface had a significant correlation coefficient with the diameter of the final graft at the axial view. This measurement technique can assist the surgeon in deciding the proper treatment procedure and a suitable type of graft.

**Conclusion**

**The limitations of the study**
Although determining the diameter of the semitendinosus tendon is more convenient easier than measuring the cross-sectional surface, but it demands the necessary skills of the toolbar in the observer software. The MRI measurements and surgery were performed by two individuals whose knowledge of the patients can lead to misdiagnosis; this issue is addressed by the employment of the ruler Arthrex’s ACL surgical set. The accuracy of the article can be improved by increasing the sample population or utilizing a single-blind or double-blind method of measurement.

**References**


168