



Original Article

Ultrasonography for evaluation of hamstring tendon diameter: is it possible to predict the size of the graft?☆



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ABSTRACT

Objective: Perform the preoperative measurement of the hamstring tendons using ultrasound imaging, validating and correlating the measured value with that found during surgical reconstruction of the ligament.

Methods: A cross-sectional study was carried out with 24 patients who underwent ultrasonographic measurement of the semitendinosus and gracilis muscle tendons and were subsequently submitted to surgical reconstruction of the ACL, with ipsilateral semitendinosus and gracilis tendon grafting.

Results: The patients' ages ranged from 16 to 43 years, with a mean of 24.8 years (SD=8.4 years), 79.2% were men, and the distribution by side was 41.7% right knees and 58.3% left knees. A non-significant correlation coefficient was found between the area calculated by ultrasound ($2 \times$ semitendinosus area + $2 \times$ gracilis area) and the intraoperative measurement ($r=0.16$; $p=0.443$). No evidence of a difference between intraoperative measurements <8 mm and ≥ 8 mm was found for the area calculated by the ultrasound ($p=0.746$). The difference observed between the groups was -0.01 (95% CI: -0.09 to 0.07).

Conclusion: Preoperative ultrasound imaging of the semitendinosus and gracilis tendons does not present a statistically significant correlation with the intraoperative measurement of the quadruple hamstring graft for ligament reconstruction.

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☆ Study conducted at Universidade Federal de São Paulo, Escola Paulista de Medicina, Centro de Ortopedia e Traumatologia do Esporte (CETE), São Paulo, SP, Brazil.

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Ultrassonografia para avaliação do diâmetro dos tendões flexores do joelho: é possível prever o tamanho do enxerto?

R E S U M O

Palavras-chave:

Ligamento cruzado anterior
Traumatismos do joelho
Ultrassonografia

Objetivo: Fazer a mensuração pré-operatória dos tendões flexores do joelho com o uso do exame de ultrassonografia, validar e correlacionar o valor medido com aquele encontrado durante a reconstrução cirúrgica do ligamento.

Métodos: Estudo transversal com 24 pacientes submetidos a mensuração ultrassonográfica dos tendões dos músculos semitendíneo e grácil e posteriormente submetidos a reconstrução cirúrgica do LCA, com enxerto ipsilateral dos tendões semitendíneo e grácil do próprio paciente.

Resultados: A idade dos pacientes variou entre 16 e 43 anos, com média de 24,8 (DP = 8,4), 79,2% eram homens e a distribuição quanto ao lado foi de 41,7% joelhos direitos e 58,3% joelhos esquerdos. Foi encontrado coeficiente de correlação não significante entre a área calculada a partir do ultrassom ($2 \times$ área do semitendíneo + $2 \times$ área do grácil) e a medida obtida intraoperatoriamente ($r = 0,16$, $p = 0,443$). Não foi encontrada evidência de diferença entre medidas intraoperatórias < 8 mm e ≥ 8 mm quanto à área calculada a partir do ultrassom ($p = 0,746$). A diferença observada entre os grupos foi de $-0,01$ (IC 95%: $-0,09$ a $0,07$).

Conclusão: A mensuração pré-operatória por método de imagem ultrassonográfico dos tendões dos músculos semitendíneo e grácil não apresenta correlação estatisticamente significativa com a mensuração intraoperatória do enxerto quádruplo de flexores para reconstrução ligamentar.

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Introduction

Anterior cruciate ligament (ACL) reconstruction is one of the most performed surgeries worldwide, with more than 120,000 procedures per year in the United States.¹ In order to restore the ACL function on knee stability, graft reconstruction is currently considered the gold standard. This graft may be autologous or from a tissue bank (allograft).^{2,3}

The choice of graft depends on the patient, the type of implant used, and the availability of a tissue bank.^{3,4} The following grafts are most commonly used: tendons of the knee flexor muscles (hamstring), semitendinosus and gracilis, patellar tendon, and quadriceps tendon. In Brazil, knee flexor grafting is the option used by 82.3% of the knee specialists who participated in research at a national conference.⁵ In addition to adequate technique, graft size is also extremely important for the success of the procedure.⁴

When using quadriceps or patellar grafts, it is possible to determine graft size.⁴ However, when the graft option is the hamstrings (knee flexor tendons), the literature does not describe a well-recognized and accurate method for predicting graft size preoperatively. Previous studies have used different methods of preoperative measurement to adequately predict flexor graft size, such as anthropometric data⁵⁻⁹ and imaging studies.¹⁰⁻¹⁵

The limitation in preoperative measurement in relation to flexor grafts is important, as there are reports in the literature that grafts smaller than 8 mm in diameter increase the chance of ACL reconstruction failure.^{4,16-19}

The present study is aimed at performing the preoperative measurement of the knee flexor tendons with ultrasound imaging, and to validate and correlate the measured value with that found during the surgical reconstruction of the ligament.

Material and methods

This is a cross-sectional study submitted and approved by the Research Ethics Committee of the institution in which the study was conducted. The inclusion criteria were patients with clinical and radiological diagnosis of ACL injury who underwent surgical reconstruction of this ligament using an autograft from the semitendinosus and gracilis tendons of the ipsilateral limb, who agreed to participate in the study and signed the Informed Consent Form. The non-inclusion criteria were patients in whom flexor grafts were used for a previous surgical procedure and patients with rheumatologic diseases. The exclusion criteria were patients who for any reason, despite having been scheduled to receive a semitendinosus-gracilis graft, received grafts other than the flexor graft during surgery, and patients who chose not to participate in the study.

Ultrasound evaluation

The diameter of the semitendinosus and gracilis tendons was measured one week before the surgical procedure by a preoperative ultrasound evaluation of the knee. The same radiologist performed all the exams using a GE Healthcare Logic P6 device (GE Healthcare, Little Chalfont, UK) with a

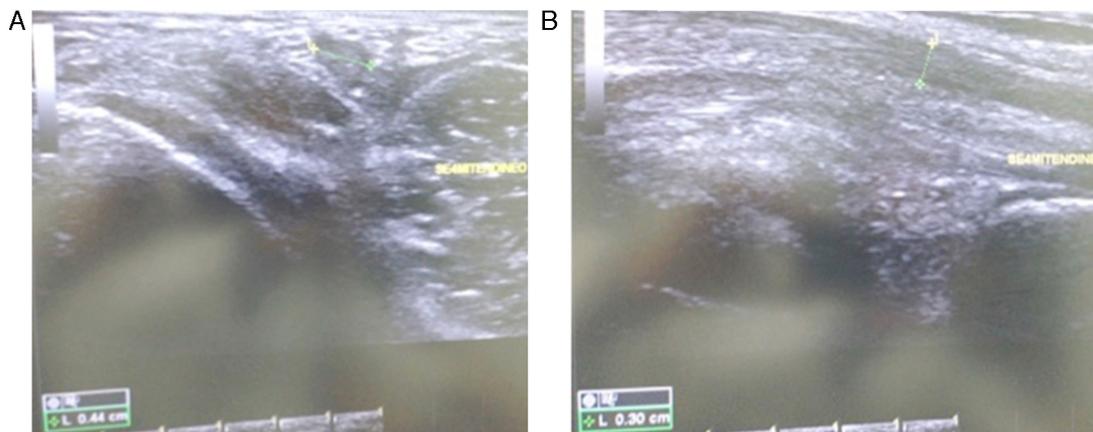


Fig. 1 – (A) Ultrasonographic measurement of the semitendinosus muscle tendon in a transverse plane; (B) ultrasonographic measurement of the semitendinosus muscle tendon in an anteroposterior plane.

7–11 MHz transducer. The patient was positioned in the ventral recumbent position, and the tendons were measured at the articular line; three values were obtained: anteroposterior (AP) diameter and transverse diameter in millimeters (mm), and cross-sectional area in square millimeters (mm^2 ; Fig. 1A and B).

Surgical procedure and intraoperative measurement

The patients then underwent ACL reconstruction, using a semitendinosus and gracilis flexor tendon graft, always removed by the same orthopedist using the following technique: 3 mm longitudinal incision in the anteromedial region of the leg, beginning 2 mm distal and medial to the tibial tuberosity. Then the semitendinosus and gracilis tendons were dissected and removed with a tendon stripper (Smith & Nephew, London, England). The graft was cleaned and prepared on a specific table for this purpose (Smith & Nephew, London, England). The tendons had their ends sutured and were folded in half together to form a quadruple graft, as routinely used in ligament reconstructions. The graft was then measured with a graft measurement block (Smith & Nephew, London, England), which has orifices for measurement in 0.5 mm increments. The measurements were always made in the central region of the graft to avoid differences in diameter at the extremities caused by sutures or irregularities of the tendons due to their extraction, and to the size of the block in which the graft presented a maximum filling of the measurement hole, without deformation of the graft and with free passage (Fig. 2).

Statistical analysis

Numerical variables were described as means and standard deviations (SD) and as minimum and maximum values, and categorical variables, as absolute and relative frequencies.

The correlation between the intraoperative measurements and the area calculated by the ultrasound ($2 \times$ area of the semitendinosus + $2 \times$ gracilis area) was assessed by Pearson's correlation coefficient (r).

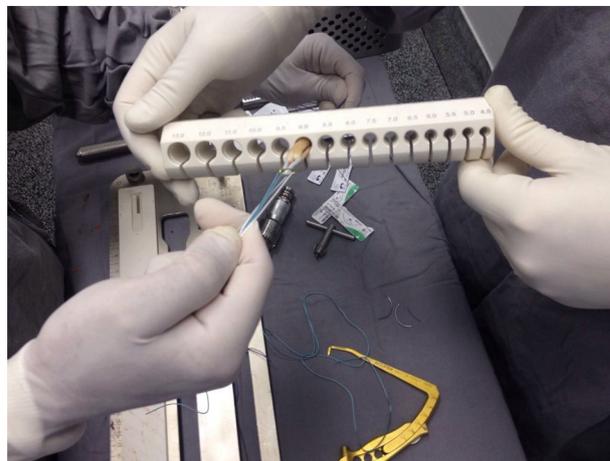


Fig. 2 – Intraoperative measurement of quadruple flexor graft size with the appropriate guide.

Student's t-test was applied to compare the intraoperative measurement groups (<8 mm and ≥ 8 mm) with the mean area measurements calculated by ultrasound.

The analyses were performed using SPSS[®] software version 18, and a significance level of 0.05 was adopted in all cases.

Results

This study included 24 patients with clinical and radiological diagnosis (magnetic resonance imaging) of ACL injury who underwent surgical ACL reconstruction, with ipsilateral autograft of the semitendinosus and gracilis tendons.

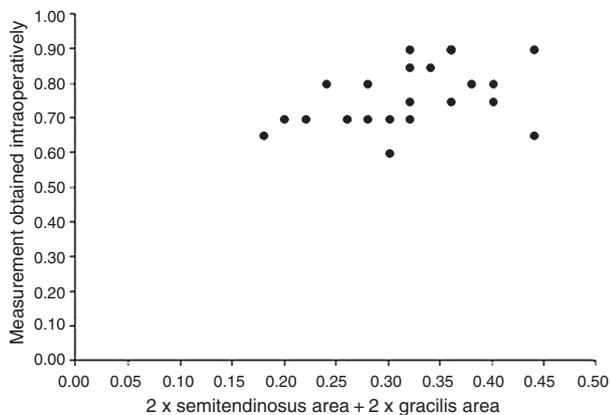
The patients' ages ranged from 16 to 43 years, with a mean of 24.8 (SD = 8.4); 79.2% were males and the side distribution was 41.7% right and 58.3% left knees.

Table 1 presents the descriptive analyses of the patients' data and the ultrasound and intraoperative measurements.

No statistically significant correlation was observed between the area calculated by ultrasound

Table 1 – Patient characteristics, and ultrasonographic and intraoperative measurements (n = 24).

Transverse ST	
Mean (SD)	0.50 (0.07)
Minimum–maximum	0.40–0.66
AP ST	
Mean (SD)	0.27 (0.05)
Minimum–maximum	0.18–0.36
ST area	
Mean (SD)	0.11 (0.03)
Minimum–maximum	0.05–0.19
Transverse gracilis	
Mean (SD)	0.40 (0.07)
Minimum–maximum	0.25–0.50
AP gracilis	
Mean (SD)	0.19 (0.04)
Minimum–maximum	0.11–0.26
Gracilis area	
Mean (SD)	0.06 (0.02)
Minimum–maximum	0.03–0.10
Intraoperative measurement	
Mean (SD)	0.76 (0.09)
Minimum–maximum	0.60–0.90
Intraoperative measurement	
<8 mm	14 (58.3)
≥8 mm	10 (41.7)
2 × semitendinosus area + 2 × gracilis area	
Mean (SD)	0.34 (0.09)
Minimum–maximum	0.18–0.54

**Fig. 3 – Correlation between the area calculated by ultrasound (2 × semitendinosus area + 2 × gracilis area) and the measurement obtained intraoperatively in a sample of 24 patients.**

(2 × semitendinosus area + 2 × gracilis area) and the measurement obtained intraoperatively (Fig. 3; $r=0.16$; $p=0.443$).

Furthermore, when categorizing the intraoperative measurements into two groups, <8 mm and ≥8 mm, no statistically significant difference was observed in the area calculated by ultrasound (Table 2; $p=0.746$). The differences observed between the groups was -0.01 (95% CI: -0.09 to 0.07).

Table 2 – Measurement of the area calculated by ultrasound (2 × semitendinosus + 2 × gracilis area) vs. intraoperative measurement.

Area calculated by ultrasound (2 × semitendinosus area + 2 × gracilis area)	Intraoperative measurement of knee flexor tendons	
	<8 mm (n = 14)	≥8 mm (n = 10)
Mean (SD)	0.33 (0.11)	0.34 (0.06)
Minimum–maximum	0.18–0.54	0.24–0.44
Student's t-test	$p=0.746$	

Discussion

The most important finding of the present study was that the preoperative ultrasonographic measurement of the semitendinosus and gracilis tendons does not present a statistically significant correlation with the intraoperative measurement of the quadruple flexor graft for ligament reconstruction.

Following the publication of studies showing the importance of flexor graft size and its association with a greater risk of ACL reconstruction failure, specifically when smaller than 8 mm,^{4,16–19} several studies have been conducted in an attempt to preoperatively measure the semitendinosus and gracilis tendons, and to correlate that measurement with the quadruple flexor graft size that would be obtained at the time of surgery.

Anthropometric data have been studied in different populations, but the obtained results are inconsistent, hindering an appropriate correlation between these data and the intraoperative measurement of the quadruple flexor graft.^{6–9,20,21}

Studies that used imaging tests for the preoperative measurement of the semitendinosus and gracilis tendons have presented a better correlation with the intraoperative measurement. In addition to several studies with magnetic resonance imaging,^{10–14,22,23} computed tomography with 3-D¹⁵ reconstruction and, more recently, ultrasonography have been used.¹⁴

In the study by Erquicia et al.,¹⁴ both magnetic resonance imaging (MRI; with magnifications of 2× and 4×) and ultrasound were used. Those authors concluded that the calculation of the cross-sectional area with the three methods was adequate to estimate the size of the quadruple graft flexors in the surgical procedure. While the results obtained with ultrasound were comparable to those of MRI with 2× magnification, 4× MRI presented much higher accuracy. Finally, they asserted that lower limit values with a cross-sectional area of 25 mm², 17 mm², and 14 mm², in relation to the 2× MRI, 4× MRI, and ultrasound, respectively, would be adequate to predict a flexor graft with at least 8 mm.

The present study contradicts the results obtained by Erquicia et al.¹⁴ in relation to the minimum value in ultrasound measurement of 14 mm² as an adequate value to predict the minimum value of 8 mm for the flexor graft. In the present study, some patients who presented values greater than 14 mm² by ultrasound had grafts smaller than 8 mm in the surgery. Regarding grafts obtained greater than 8 mm, the

smallest area obtained on ultrasonography was 24 mm². This difference may be due to the fact that the ultrasound imaging is operator-dependent and that, specifically in the case of tendon measurement by this radiological method, in which the tendons undergo spatial deformation according to the pressure applied with the transducer by the examiner, it is not possible to quantify and standardize it. Thus, this test was not reproducible in relation to previous studies.

The authors aimed studying the use of ultrasonography in the measurement of the semitendinosus and gracilis tendons preoperatively due to the accessibility and the low cost of this exam, aspects of relevant importance in Brazil, especially in public health service. MRI, although routinely done in cases of ligament injury, is not usually performed using the specific techniques proposed for semitendinosus and gracilis tendon measurements in published studies. Thus, for preoperative measurement, ultrasound would be a more practical and cheaper method in Brazil. However, the hypothesis that ultrasonography would be a suitable exam to predict quadruple flexor graft size was not confirmed.

One of the limitations of the present study is the fact that the semitendinosus and gracilis tendons were not measured in the intraoperative period and were not associated with the data obtained by ultrasound imaging. Perhaps in this way some correlation could have been found, rather than simply comparing with the measurement of the graft already in quadruple format, despite the actions implemented in the measurement to avoid discrepancies. Another limitation was the nonuse of another (more specific) method for intraoperative measurement, since the measurement guides present in the materials routinely used for reconstruction of the ACL show increments of only 0.5 mm, which in itself weakens the correlation with the ultrasound measurements, in which the values are accurate up to the second decimal place. Studies using an intraoperative tool with higher measurement accuracy may better assess the correlation between ultrasound and intraoperative measurement.

Conclusion

Preoperative ultrasound imaging of the semitendinosus and gracilis muscle tendons does not present a statistically significant correlation with the intraoperative measurement of the quadruple flexor graft for ligament reconstruction.

Conflicts of interest

The authors declare no conflicts of interest.

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