Clinical Measurement of Patellar Tendon: Accuracy and Relationship to Surgical Tendon Dimensions

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Abstract

Patellar tendon width and length are commonly used for preoperative planning for anterior cruciate ligament reconstruction (ACLR).

In the study reported here, we assessed the accuracy of preoperative measurements made by palpation through the skin, and correlated these measurements with the actual dimensions of the tendons at surgery. Before making incisions in 53 patients undergoing ACLR with patellar tendon autograft, we measured patellar tendon length with the knee in full extension and in 90° of flexion, and tendon width with the knee in 90° of flexion. The tendon was then exposed, and its width was measured with the knee in 90° of flexion. The length of the central third of the tendon was measured after the graft was prepared.

Mean patellar tendon length and width with the knee in 90° of flexion were 39 mm and 32 mm, respectively. No clinical difference was found between the estimated pre-incision and surgical widths. However, the estimated pre-incision length with the knee in full extension and in 90° of flexion was significantly shorter than the surgical length.

Skin measurements can be used to accurately determine patellar tendon width before surgery, but measurements of length are not as reliable.

Patellar tendon width and length are commonly measured in the clinical setting to determine the suitability of the tendon for grafting in reconstruction of the anterior cruciate ligament (ACL),[1-3] the posterior cruciate ligament,[4-6] the medial patellofemoral ligament,[7] and the contralateral patellar tendon.[8] This estimation is a preoperative attempt to ensure that the graft will have the appropriate width and also be neither too short nor too long.

ACL reconstruction (ACLR) with bone–patellar tendon–bone (BPTB) autograft requires preoperative assessment of patellar tendon length and width for several reasons. Patellar tendon rupture after ACLR with BPTB autograft is a rare complication, described in only a few case reports.[9-11] Having a preoperative evaluation of patellar tendon width is important. If a patient's original patellar tendon is too narrow, the tendon portion that remains after the central third is removed may be at higher risk for rupture when the patient resumes strenuous physical activity. In addition, evidence of patella alta or baja on preoperative radiograph may indicate that a patellar tendon is shorter or longer than normal. A patellar tendon that is too long or too short may contribute to graft-tunnel length mismatch.[12,13] In these settings, an alternative graft may be indicated for ACLR.

For these reasons, other investigators[14,15] have used magnetic resonance imaging (MRI) to measure patellar tendon length before ACLR. Measurements are easy to perform and more accurate with digital MRI; they are much less accurate with nondigital MRI, making surgical planning difficult for ACLR with patellar tendon autograft. A quicker, more accessible, and cost-effective preoperative method for determining patellar tendon length would certainly be valuable to orthopedic surgeons using patellar tendon autografts.

We conducted a study to assess the accuracy of preoperative measurements made by palpation through the skin, to correlate these measurements with the actual dimensions of the tendons at surgery, and to determine the correlation between patellar tendon length and patient height, weight, and body mass index (BMI). We hypothesized that there would be a considerable difference between preoperative skin measurements and surgical measurements and that there would be no correlation between patellar tendon length and patient height, weight, or BMI.

Materials and Methods

After obtaining institutional review board approval for this study, we prospectively identified 53 patients undergoing primary ACLR with a patellar tendon autograft. Surgery was

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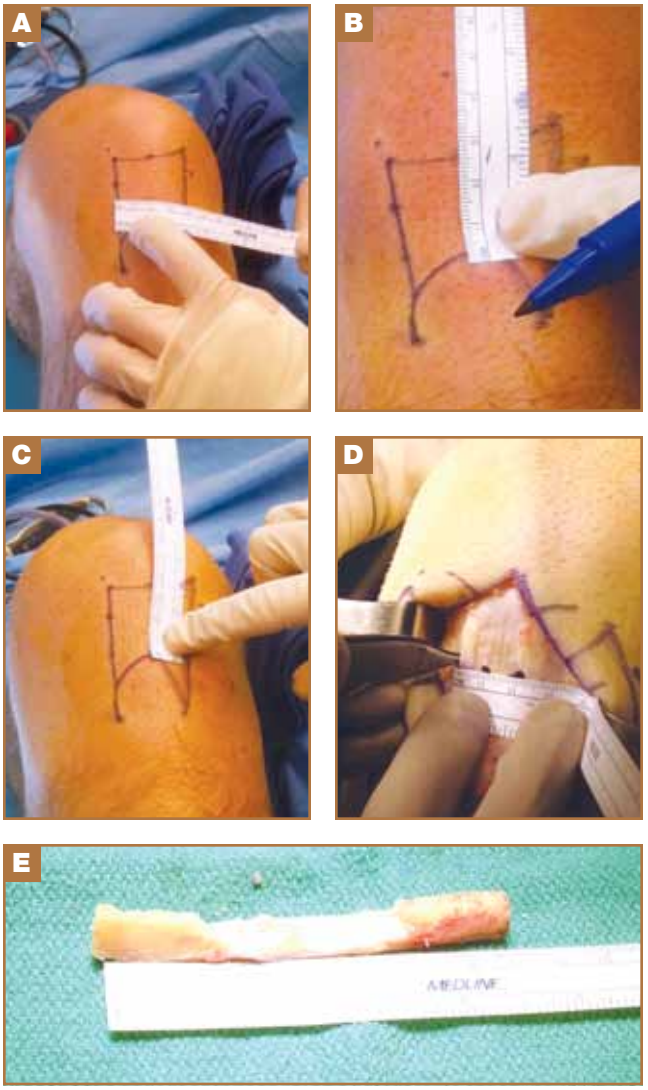

Figure. Patellar tendon measurements: (A) preoperative width with knee in 90° of flexion, (B) preoperative length, full extension, (C) preoperative length, 90° of flexion, (D) perioperative width, 90° of flexion, (E) length on back table after graft was prepared.

performed by 1 of 2 surgeons (SBC, PFD) between February 2010 and June 2011. During surgery, before an incision was made, the width of the patellar tendon was measured with the knee in 90° of flexion (**Figure A**), and the length was measured with the knee in full extension (**Figure B**) and in 90° of flexion (**Figure C**). For measurement standardization, the distal pole of the patella and the proximal edge of the tibial tubercle were used as landmarks. After the patellar tendon was exposed, its width was measured with the knee in 90° of flexion (**Figure D**). The actual length of the central third of the tendon was measured on the back table after graft preparation (**Figure E**). Tension was placed on the tendon during this measurement.

The Pearson correlation coefficient was used to determine the linear dependence of the surgical patellar tendon measurements on patient height, weight, and BMI. Paired Student t-tests were used to determine significant differences between clinical and surgical measurements. P<.05 was considered significant.

Results

Mean age at time of surgery was 19 years (range, 14-42 years). Of the 53 patients, 30 (57%) were male. Mean patellar tendon width as measured before excision was 32 mm (range, 25-40 mm). Mean tendon lengths with the knee in full extension and in 90° of flexion were 36 mm (range, 26-50 mm) and 39 mm (range, 30-52 mm), respectively (P<.001).

Mean patellar tendon width and length after excision (surgical measurements) were 33 mm (range, 26-40 mm) and 42 mm (range, 23-61 mm), respectively (**Table**). Surgical widths were statistically larger than pre-excision widths (P = .044), but we believe the mean difference (1.2 mm) was not clinically significant. Patellar tendon lengths with the knee in full extension (P<.001) and in 90° of flexion (P<.001) were significantly shorter than the surgical lengths.

The 2 surgeons did not differ significantly in terms of mean tendon width or length, either pre-excision or surgical (P>.05), or in terms of absolute differences between pre-excision and surgical widths (P = .80) or lengths (P = .33).

Mean patient height, weight, and BMI were 173 cm (range, 158-191 cm), 78 kg (range, 51-146 kg), and 25.6 kg/m^2 (range, 19.4-40.2 kg/m^2), respectively. Surgical patellar tendon width correlated weakly with patient height (R^2 = 0.27), weight (R^2= 0.13), and BMI (R^2 = 0.030). Surgical patellar tendon length also correlated weakly with patient height (R^2 = 0.066), weight (R^2 = 0.089), and BMI (R^2 = 0.065).

Discussion

A quick and cost-effective method for determining patellar tendon length would be valuable in performing ACLR with patellar tendon autografts. Other investigators have had successful results with MRI[14,15] and standard radiographs.[16] These techniques, though precise, are not practical from a logistical or cost perspective. We postulated that a more accessible method, such as using a ruler to measure over a patient's skin, would be extremely useful.

Patellar tendon width measured by palpation through the skin appears to be clinically similar to surgical width. However, length with the knee in flexion or extension can significantly underestimate the surgical length of the tendon. A possible reason for the palpation–postharvest difference in patellar tendon length is that tibial tubercle bone may emanate or overhang proximally. These are important considerations during planning for procedures that involve patellar tendon autograft. Physicians should be familiar with these relationships ahead of time so that they can make proper adjustments. Although patellar tendon width is not as important during preoperative measurements, it can be accurately assessed by palpation through the skin.

Patient height, weight, and BMI do not provide reliable estimates of patellar tendon length or width before surgery. Two previous studies[17,18] have also found poor correlations. Brown and colleagues[17] used MRI for tendon measurements

Table. **Patellar Tendon Measurements**

Skin Measurements, mm			Surgical Measurements, mm			
Length						
Flexion	Extension	Width	Length	Width	Skin Length (Flexion)—Surgical Length, mm	Skin Width—Surgical Width, mm
46	49	38	47	34	–1	4
45	41	31	45	33	0	–2
38	32	33	37	30	1	3
45	50	31	38	35	7	–4
39	44	34	40	34	–1	0
48	NM	28	54	33	–6	–5
43	45	31	45	33	–2	–2
34	32	35	44	33	–10	2
36	35	30	39	35	–3	–5
32	32	35	40	34	–8	1
34	31	30	41	34	–7	–4
40	30	29	NM	29	NA	0
42	35	30	49	32	–7	–2
38	37	37	50	26	–12	11
39	32	37	41	37	–2	0
40	36	32	44	36	–4	–4
34	30	30	40	32	–6	–2
40	30	29	47	31	–7	–2
43	35	39	39	32	4	7
41	48	35	40	29	1	6
45	45	33	40	35	5	–2
48	40	37	61	35	–13	2
40	45	37	39	39	1	–2
42	35	26	43	32	–1	–6
37	30	30	35	35	2	–5
40	40	39	50	35	–10	4
32	30	27	35	28	–3	–1
45	40	30	42	30	3	0
35	34	37	32	35	3	2
35	33	37	40	40	–5	–3
35	32	40	23	31	12	9
35	30	27	40	30	–5	–3
30	26	31	38	28	–8	3
36	35	29	31	35	5	–6
35	33	33	47	39	–12	–6
43	40	30	38	31	5	–1
35	40	25	40	29	–5	–4
40	32	29	44	32	–4	–3
40	33	33	36	35	4	–2
40	38	33	41	36	–1	–3
39	39	34	40	35	–1	–1
NM	NM	25	NM	29	NA	–4
36	32	28	39	32	–3	–4
33	29	30	47	29	–14	1
45	40	40	55	37	–10	3
40	35	30	48	38	–8	–8
52	50	35	53	40	–1	–5
30	26	28	39	30	–9	–2
35	30	29	30	35	5	–6
46	40	38	51	36	–5	2
42	34	35	42	40	0	–5
34	30	25	41	36	–7	–11
30	28	38	32	36	–2	2

Abbreviations: NA, not applicable; NM, not measured.

and noted a weak positive association between patient height and patellar tendon length as well as no correlation between patellar tendon length and intra-articular ACL length. Yoo and colleagues[18] used MRI to measure patellar tendon length and found no significant association between length and patient height, weight, or BMI; coefficient of determination (R^2) values for these relationships ranged from 0.015 to 0.061. On the other hand, Goldstein and colleagues[15] found correlation between patient height, sex, and patellar tendon length using MRI measurements; however, they grouped patient height into 4-inch increments instead of using a single height value for each patient.

Strengths of the present study include use of 2 experienced surgeons and inclusion of a wide range of body types. Study limitations include the fact that we did not collect MRIs and therefore could not compare the MRI measurements of patellar tendon length with the skin measurements of length.

Our study results showed that patellar tendon width can be accurately determined before surgery, but length measurements are not as reliable. In addition, patient height and weight do not provide reliable estimates of patellar tendon length before surgery. We recommend using clinical measurements for tendon width and, when possible, MRI measurements for length assessment.

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References

1. Hospodar SJ, Miller MD. Controversies in ACL reconstruction: bone–patellar tendon–bone anterior cruciate ligament reconstruction remains the gold standard. *Sports Med Arthrosc*. 2009;17(4):242-246.
2. Schoderbek RJ Jr, Treme GP, Miller MD. Bone–patella tendon–bone autograft anterior cruciate ligament reconstruction. *Clin Sports Med*. 2007;26(4):525-547.
3. Shelbourne KD, Vanadurongwan B, Gray T. Primary anterior cruciate ligament reconstruction using contralateral patellar tendon autograft. *Clin Sports Med*. 2007;26(4):549-565.
4. Hermans S, Corten K, Bellemans J. Long-term results of isolated antero-lateral bundle reconstructions of the posterior cruciate ligament: a 6- to 12-year follow-up study. *Am J Sports Med*. 2009;37(8):1499-1507.
5. MacGillivray JD, Stein BE, Park M, Allen AA, Wickiewicz TL, Warren RF. Comparison of tibial inlay versus transtibial techniques for isolated posterior cruciate ligament reconstruction: minimum 2-year follow-up. *Arthroscopy*. 2006;22(3):320-328.
6. Seon JK, Song EK. Reconstruction of isolated posterior cruciate ligament injuries: a clinical comparison of the transtibial and tibial inlay techniques. *Arthroscopy*. 2006;22(1):27-32.
7. Witoński D, Keska R, Bira M. Reconstruction of the medial patellofemoral ligament with patellar tendon autograft—preliminary report [in Polish]. *Chir Narzadow Ruchu Ortop Pol*. 2010;75(1):42-46.
8. Milankov MZ, Miljkovic N, Stankovic M. Reconstruction of chronic patellar tendon rupture with contralateral BTB autograft: a case report. *Knee Surg Sports Traumatol Arthrosc*. 2007;15(12):1445-1448.
9. Marumoto JM, Mitsunaga MM, Richardson AB, Medoff RJ, Mayfield GW. Late patellar tendon ruptures after removal of the central third for anterior cruciate ligament reconstruction. A report of two cases. *Am J Sports Med*. 1996;24(5):698-701.
10. Mickelson PL, Morgan SJ, Johnson WA, Ferrari JD. Patellar tendon rupture 3 years after anterior cruciate ligament reconstruction with a central one third bone–patellar tendon–bone graft. *Arthroscopy*. 2001;17(6):648-652.
11. Milankov Ziva M, Semnic R, Miljković N, Harhaji V. Reconstruction of patellar tendon rupture after anterior cruciate ligament reconstruction: a case report. *Knee*. 2008;15(5):419-422.
12. Augé WK 2nd, Yifan K. A technique for resolution of graft–tunnel length mismatch in central third bone–patellar tendon–bone anterior cruciate ligament reconstruction. *Arthroscopy*. 1999;15(8):877-881.
13. Shaffer B, Gow W, Tibone JE. Graft–tunnel mismatch in endoscopic anterior cruciate ligament reconstruction: a new technique of intraarticular measurement and modified graft harvesting. *Arthroscopy*. 1993;9(6):633-646.
14. Chang CB, Seong SC, Kim TK. Preoperative magnetic resonance assessment of patellar tendon dimensions for graft selection in anterior cruciate ligament reconstruction. *Am J Sports Med*. 2009;37(2):376-382.
15. Goldstein JL, Verma N, McNickle AG, Zelazny A, Ghodadra N, Bach BR Jr. Avoiding mismatch in allograft anterior cruciate ligament reconstruction: correlation between patient height and patellar tendon length. *Arthroscopy*. 2010;26(5):643-650.
16. McAllister DR, Bergfeld JA, Parker RD, Groof PN, Valdevit AD. A comparison of preoperative imaging techniques for predicting patellar tendon graft length before cruciate ligament reconstruction. *Am J Sports Med*. 2001;29(4):461-465.
17. Brown JA, Brophy RH, Franco J, et al. Avoiding allograft length mismatch during anterior cruciate ligament reconstruction: patient height as an indicator of appropriate graft length. *Am J Sports Med*. 2007;35(6):986-989.
18. Yoo JH, Yi SR, Kim JH. The geometry of patella and patellar tendon measured on knee MRI. *Surg Radiol Anat*. 2007;29(8):623-628.