

Direct Measurements of the Tendon

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ABSTRACT

AIM: Tendon pathology, especially patellar, is relatively common. Studying the anatomy and taking measurements is often part of the diagnostic process. The accuracy of these measurements is essential for suitable diagnosis and performing appropriate follow-up. Direct

measurements are the gold standard and anatomical studies provide an interesting study of the pathology of tendons in this field. The digital caliper has proven its accuracy in experienced hands. Just as there are studies that have assessed the degree of experience in the use of ultrasound for the evaluation of these structures, there are no studies in this area regarding the use of the digital caliper for patellar tendon.

METHODS: Six donated knees were chosen for the present study. Seven observers performed the measurements, which were length, thickness and width of the patellar tendon; a skilled surgeon (gold standard), and six third-year medical student. An external participant collected all data and analyzed results.

RESULTS: No overall differences were observed in the direct measurements, however, specific measurements such as thickness or width of the patellar tendon showed significant differences in one case each.

CONCLUSIONS: Although some variations between patellar tendon measurements by less expert participants of an experienced surgeons, especially on thickness and width measurements have been shown, there is not significant differences between both of them.

Key words: Digital caliper; Tendon; Patellar

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INTRODUCTION

Patellar tendon pathology is especially common in the practice of certain sports such as athletics and soccer^[1]. Current studies describe a rate of 0.12 injuries per 1000 hours of sport, where 1.5% of all injuries are in sports like soccer^[1].

Correct diagnosis and treatment outcomes require evaluation systems that are reproducible, such as ultrasound imaging.

Fornage back in 1984 defended its usefulness in patellar tendon pathologies^[2-5]. This reproducibility is also supported by other series^[6] and evaluated in recent studies such as in Seijas *et al.*^[7].

Studies on interobserver variability with ultrasound in tendons have shown a very high concordance rate, specifically in knee a very high correlation rate has been shown^[8].

The gold standard for measurements of this type of structure is considered to be direct vision, like open surgery view and the digital caliper^[9-12]. Our experience in the clinical laboratory has allowed us to observe differences in calculations depending on the experience of the person who was doing the measures.

Ultrasound is used as a diagnostic tool for tendon pathology and different authors support its use even in hands of less experienced professionals, or at least defend that learning curves are relatively short^[13-15]. In the same manner we questioned whether there are sufficient differences between those taking measurements to consider specific training in direct measurement with the digital caliper as has been done with the use of ultrasonography.

Our study aims to evaluate differences in patellar tendon measurements using digital caliper with experienced and inexperienced evaluators.

MATERIAL AND METHODS

Six knees belonging to six different male donors from the donation service of the Laboratory of surgical and Functional anatomy of the International University of Catalunya, were included. Knees were not embalmed and cryopreserved.

The range of donors' age used for the present research was from 58 to 71 years old. The causes of death were cirrhosis, renal failure, coronary artery disease, cardiac arrest, metastatic adenocarcinoma, and pneumonia. Excluded knees were those with previous knee surgery. The samples were stored frozen at -20°C up to 12 hours before the test. The limbs were removed and placed in a refrigerator at 4°C for 10 hours and then completely thawed in the laboratory temperature 18°C. Specimens were placed in a 30°-flexion position over a support.

The University's Ethical Committee approved the present study.

The six knees were dissected to observe the patellar tendon. Consecutively and without displaying the rest of the participants, an expert on knee tendon pathology and orthopedic surgeon (RS) placed a needle on the tip of patella tendon insertion into the anterior tibial tuberosity. With a digital caliper [digital caliper (No. 500-191; Mitutoyo, Kawasaki, Japan) (accurate to 0.02 mm, resolution of 0.01 mm)], measurements were made between the two needles.

One member of the anatomy lab team (OA) was in charge of collecting the data from the different evaluators.

A needle is then placed at a distance of 15 mm from the patellar pole and at that point both the width of the patellar tendon and its thickness were measured. These three measurements were performed in quick succession and were repeated three times. The mean measure of the three measurements was the final recorded for each evaluator.

Consecutively, 6 graduate students of medicine without specific training in digital caliper measurement or cadaver management beyond their undergraduate practices performed the same measurements. All graduates were explained in a very basic way where the reference points were and where measurements were to be performed and data was recorded the same way as the primary surgeon. We chose 6 students and not more due a limited workspace in our lab and temporary disposition of the samples.

Each graduate student placed the needles in the origin and insertion points of the patellar tendon and positioning 15 mm from the tip of

the patella, from these points' measurements of thickness and width are done. Every measurement was performed three times. The final measure was the mean of all three, ruled out by a different student than those who had performed the measurements.

SPSS version 18.0 was used to perform all the statistical analysis.

RESULTS

The orthopedic surgeon was considered the gold standard (observer 1) with respect to tendon measurements and was compared with the rest of observers looking for differences in the three types of measurements (Table 1).

The constant systematic error was in all cases between 0.8 and 0.85 (Beta 1), implying that observers' measurements tend to be between 80% and 85% inferior than the gold standard. However, taking the confidence intervals into account we cannot conclude that there is statistically significant proportional systematic error (Table 2).

Regarding the constant systematic error, this appears in Width and Thickness where observers systematically gave measurements inferior to the Gold Standard. Student n- 5 showed a trend, however, no significant differences were observed..

Regarding the ANOVA analysis, differentiating the three measurements we found that thickness showed differences between different evaluators, with significant differences in three of six observers compared with the gold standard ($p < 0.05$) (Figure 1).

Regarding the length measurements, ANOVA analysis showed no significant differences in any of the evaluators (Figure 2).

Regarding the width measurement, significant differences also appear ($p < 0.05$) in only one student using ANOVA (Figure 3).

DISCUSSION

Globally, no significant differences between the gold standard measurement (an experienced orthopedic surgeon specialized in knee surgery) and the measurements performed by a group of inexperienced personal, in the present study undergraduate students.

Systematic error is observed in measurements of width and thickness, which could be explained by the type of method used to measure. When taking the measurement, the pressure that can be exerted to close the digital caliper can reduce the size of the tendon, explaining why observers tended to always take a measurement

Table 1 In the three types of measurements the gold standard (1) and the other observers (2 through 7; six students) are described. A mean measurement is also calculated for the non Gold Standard group.

	Observer	Mean	SD
Length	1 (GS)	366.83	51.69
	(2,3,4,5,6,7)	386.87	74.40
	Dif. [(2,3,4,5,6,7)-1]	20.03	70.32
Width	1	268.67	24.78
	(2,3,4,5,6,7)	247.47	27.16
	Dif. [(2,3,4,5,6,7)-1]	-21.19	20.27
Thickness	1	38.12	7.10
	(2,3,4,5,6,7)	32.98	10.85
	Dif. [(2,3,4,5,6,7)-1]	-5.14	9.33

Table 2 Based on data in Table 1 the types of errors are looked for as well as the interval at which they were measured.

	Beta 0	Beta 1	IC 95%		IC 95%		SD Dif.
Length	85.92	0.80	0.17	1.43	-19.50	42.66	88.40
Width	29.69	0.81	0.51	1.11	-28.42	-13.96	20.55
Thickness	0.45	0.85	0.36	1.35	-8.47	-1.81	9.47

inferior to that taken by the gold standard. This is not the case with the length where measurements were made on the needles placed at the reference points. The non-significant disparity in the longitudinal measurement can be explained by the variability in the placement points that are related to the anatomical training of observers.

Direct measurements are considered the gold standard in different anatomical studies^[9-11] and therefore we must ensure that the observer in these cases has experience in managing both the equipment and tissues under evaluation.

Although no significant differences were observed, the trend of obtaining measurements between 80 and 85% of the gold standard is important, for which basic measurement standards are recommended as performed with ultrasound training^[13,14].

Previous studies recommend basic training to avoid systematic errors when using US as a tool for measurement.

It has been reported that measurements collected with computerized or navigation systems tend to generate more accurate data than direct measurements, like with a digital caliper^[16], but even these measurements with navigation systems are not exempt from intra- and interobserver variability^[17].

With the non digital caliper, error of 0.5 mm is accepted^[18], but the digital measurement increases the digital caliper method precision to within hundredths of mm^[19]. This data can be important because the difference between digital caliper systems and non digital can make us perform measurement biases that would alter the outcomes^[11].

These data are important because the use of a technique instead of another can lead to small differences that can create a bias and thus generate different outcomes.

In previous articles, measurement capability with the gold standard systems have not shown significant different results compared to computerized methods^[11], thus giving equal validity without additional cost.

While significant differences in measurements of width and thickness were observed between the different observers and the gold standard in some of the measurements, it must be taken into account that these measurements are lower than 3 or 4 mm for the thickness, and a little compression when measuring the tendon can easily change the measurement by 1 mm, giving a measurement that can vary by more than 25%. In the case of the width, where we go to more than 25 mm, something similar occurs. When closing the digital caliper to take the measurement one can compress the tissue and reduce the measurement. The length can be measured based on the reference points given by the previously positioned needles and therefore there is less margin for error. Despite each participant placed the needles, the results are reproducible.

The study by Yang comparing measurements of a senior surgeon with a resident, showed very high correlation, indicating that not a high level of surgical training is required for reliable measurement^[20].

Our study leads us to believe that there are more “sensitive” measurements such as thickness as it is more dependent on experience with respect to more “objective” measurements of distance between two marked points.

LIMITATIONS

In our study, we could have obtained measurements from another expert knee surgeon, to add the possible inter-examiner variability. We decided not to because according to the literature there is no significant variation among experts^[17]. Another limitation may be the use of medical students as controls instead of doctors in training (residents), but decided to choose students with the same inexperience and identify the possible significant differences, if any.

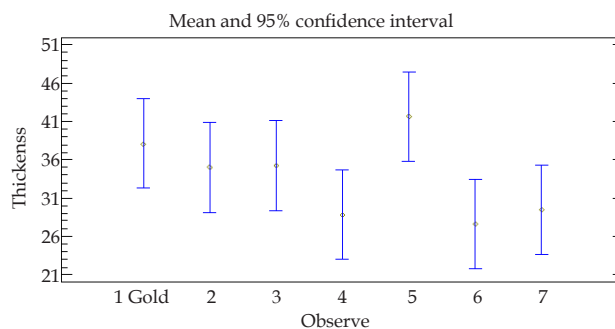


Figure 1 Thickness measurements of the gold standard (1) and the six students (2-7). Student n- 5 showed a trend, however, no significant differences were observed.

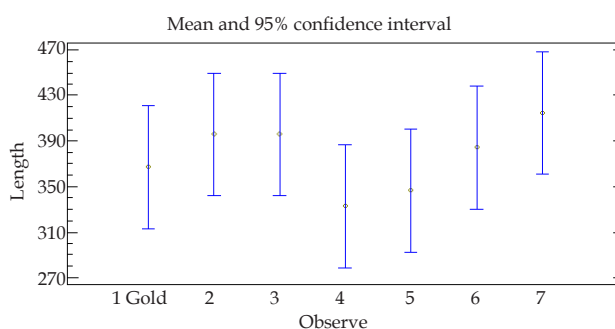


Figure 2 Representation of length measurements. The ranges of observers in this case do not show significant differences from the gold standard.

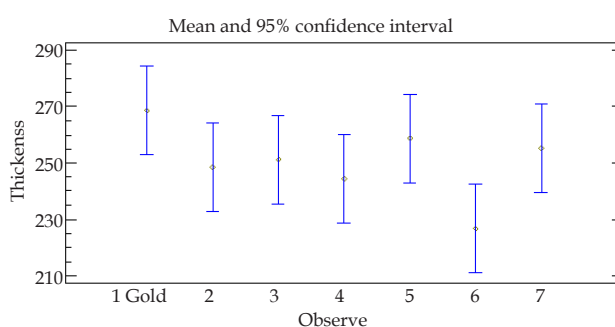


Figure 3 Representation of the width of the patellar tendon, where only one student showed significant differences with respect to the gold standard (6).

CONCLUSION

Although some variations between patellar tendon measurements by less expert participants of an experienced surgeons, especially on thickness and width measurements have been shown, there is not significant differences between both of them. The important similarity of the data makes us conclude that the design of future studies can be performed in collaboration with students and with non-surgical trained personal. Therefore, we are not limited to expert surgeons when measuring anatomical pieces.

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