Comparison of Kneelax and KT-1000 Knee Ligament Arthrometers

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Abstract:

Two commercially available knee ligament arthrometers (KT-1000, Kneelax) were used to measure anterior tibial translation. Ninety-one subjects with no history of knee pathology were tested using both devices. Both normal knees were tested and comparison of recorded anterior translation (mm) was performed. Absolute numbers at forces of 67N, 89N, 134N, and manual maximum displacements were recorded. Side-to-side differences were calculated and data were compared. There was a significant difference found between the absolute values of each device. The KT-1000 was found to record greater values in mm of translation. Although the absolute values were significantly different, the side to side differences were not significantly different between devices.

Introduction

The ability to document knee laxity has been an important advancement in measuring knee stability. Knee ligament arthrometers have been developed to measure millimeters of translation present after injury to the anterior cruciate ligament. The KT-1000 knee ligament arthrometer was developed by Dale Daniel in 1983. [1] (**figure 1)** Although other devices have been developed, Daniel is credited with presenting the orthopedic community with a device that was reproducible and easy to administer. The KT-1000 is considered the gold standard of testing devices. The KT-1000 has allowed clinicians to document the extent of knee injury by measuring in mm of the degree of side-to-side differences between normal and injured knees.[3,6] Daniel should be also credited with using the device to document post-operative results in large numbers of patients that had undergone ACL reconstructive procedures. The KT-1000 uses a visual manual recording method by the examiner as audible tones are reached. The tones correlate to 67N, 89N, 134N forces that are applied using a T shaped handle on top of the device. This was a very reproducible measurement tool, however there is some inherent error built into the device, up to 1.5mm.[3,6] Inter and intra-tester reliability was also proven to be acceptable. [4]

The Kneelax testing device is similar in size and shape to the KT-1000, but updates the recording procedure by use of computerized software integrated into the machine. (**figure 2)** This allows for digital recording of the mm of translation at the same forces or the original KT-1000. These forces are 67N, 89N, and 134N lbs. of force. A manual maximum displacement may also be performed using the Knee Lax. Instantaneous calculations are performed to display both absolute and side-to-side differences. Because of the quantity of published data using the KT-1000, a comparison study was performed to record and analyze the differences between the two devices.

Materials and Methods:

Subjects

Ninety-one normal subjects (mean age, 29 ±5 years, range 16 to 41) with no prior history of knee pathology were included in the study.

Measurement Technique

One examiner performed all testing on ninety-one subjects. The examiner has over 20 years experience using the KT-1000. Each subject was informed of the testing procedure and positioned supine on an examination table. For convention the right knee was described as the normal knee and the left, the involved. The testing procedure for the KT-1000 followed guidelines of the manufacturer. The subjects were positioned with the thigh support just above the joint line so that translation measurements will not be blocked. This positioned the knee in approximately 30 degrees of flexion. The KT-1000 was applied to the anterior tibia and oriented in line with the tibial shaft. The device is then rotated to be in-line with the natural rotation of the knee. If excessive external rotation of the tibia on the femur occurred, a thigh strap was applied to allow testing to be uniform. Quadriceps relaxation was monitored by palpating the patellar tendon as described by Paine. [10] If tension was felt in the patellar tendon, oscillations were performed to the calf to help dissipate any quadriceps tension. The force handle was used to apply a posterior force of 89N. The tibia was allowed to return to the starting position and the dial of the arthrometer was rotated and zeroed. This procedure was repeated until a consistent zero position was achieved. This served as a starting position of the tibia. A posterior push was then performed to 89N and the corresponding posterior translation was visually recorded. An anterior pull was then performed and an anterior translation measurement in millimeters was recorded at 67N, 89N, and 134N of force. A manual maximum displacement was then performed to replicate a lachman exam. Maximum displacement of the tibia on the femur during this maneuver was recorded. Three repeated measures were recorded. This testing was repeated on both knees for all subjects.

Testing for the Kneelax was performed in the exact sequence as described above. Placement of the device was performed according to manufacturers' instruction which is very similar to that of the KT-1000. Translations were automatically recorded when the successive 67N, 89N, 134N, and manual maximum forces were applied.

Results:

Paired student's t-test was used to analyze differences between these two devices. Table 1 presents absolute values for the kneelax device. The Kneelax side-to-side differences were less than 0.3mm (Table 1). Table 2 describes the absolute values for the KT-1000 device. The KT-1000 side-to-side differences were less than 0.4mm (Table 2). Table 3 provides a comparison of absolute numbers between the 2 devices. As seen in Table 3, the absolute values for the KT-1000 averaged 1.4mm greater than the kneelax. This was found to be significantly different at all forces ($P<0.05$). Table 4 presents the side-to-side values for each device. The side-to-side difference values were less than 0.5mm for both devices. There was no significant difference in the side-to-side measurements between devices.

Discussion:

Measuring knee translation has been attempted by several different devices. Instrumented testing began in 1971 by Kennedy and Fowler using radiograph stress testing.[8] This testing was performed at 90 degrees while patients sat in a machine. Markolf used a modified dental chair with potentiometers that measured anterior and posterior translation along with applied loads. Dale Daniel introduced the KT-1000 which became the gold standard for measurement of knee translations.[3] The device did not attempt to measure varus and valgus rotation, but the KT-1000 introduction helped us gain a better perspective on grading the degree of knee instability. Other instrumented testing devices included the Genucom knee analysis system. This device is no longer available, but used potentimeters to be able to measure all 6 degrees of freedom of the knee. The Genucom device had poor reliability of repeated testing, and intra and inter tester reliability was poor. [7] The next testing device was the CA4000/KSS. This device was designed to quantify four degrees of freedom of the knee and was introduced in 1986. Inter and intra tester reliability was much better with the CA4000/KSS [7] The KLT (Knee Laxity Tester) was another device similar to the KT-1000 and was introduced in 1985 [1].

The primary use of instrumented testing has been that of documentation of translation when reporting outcome studies of various ACL reconstruction procedures. The use of an accurate and reproducible instrumented testing device can be of great value when trying to determine if the ACL is torn in cases where there is no obvious instability on physical examination. As Daniel reported, 96% of subjects (N=144) with an arthroscopically confirmed ACL tear had involved minus normal anterior translations differences greater than 3mm. [3,4,5,6,7]Another interesting finding reported by Daniel was the determination of instability and function. He determined 44% of individuals who had side-to-side anterior translation differences greater than 3 mm (KT-1000 unstable) were able to return to an active sports level. This group was described as "copers". Of those that underwent ACL reconstruction (non-copers) 49% were able to resume pre-injury activity levels. [2] The ability to use measurements to help determine patient outcome and function is one of the advantages of implementing instrumented testing as a part of the clinical evaluation process.

Post-operative testing has been performed by many authors to determine the translation of the reconstructed knee to the normal knee. Although 3mm is a very good predictor of an ACL tear, the 3mm side-to-side value is not as good a predictor of knee post-op stability. Many patients have a 3mm side-to-side difference with no pivot shift. The senior author believes that the compliance index is the most telling measurement of post-operative ligament reconstruction success. The compliance index is the difference in anterior displacement found between 67N and 134N forces. Daniel et al found that 85% of the subjects (N=89) with ACL disruption had a compliance index greater that 0.5mm. In two studies, they concluded that a compliance index of 1.5mm or greater was considered positive for an ACL tear.[3,4] Daniel later reported that the compliance index is an important number in establishing pathologic laxity in individuals who have marginal side-to-side differences. [2] Post-operative side-to-side differences may approach 3-5mm in patients that present with no subjective giving way episodes. The compliance index measures how the graft reacts once it begins to receive an applied force (change in length with applied force).

Testing technique is an important factor when using knee ligament arthrometers. Markolf [9] and others have reported that lack of quadriceps relaxation may account for 25-50% reduction in anterior translation. This is due to the quad active translation of the tibia that occurs near the testing position of 30 degrees. As the quadriceps contracts, the tibia is pulled anterior, thus giving a false starting point for the testing procedure to begin. Daniel describes this as the quad active test [5] As stated earlier, quadriceps relaxation is best assessed by palpating the patellar tendon.

In our study, the absolute values recorded with the kneelax were 1.5mm less at 67N,89N, 134N, and manual maximum (Table 3). It is unknown why this occurred but the increase of 1.5mm recorded translation using the KT-1000 was very consistent (Table 3). The set-up and application of the device could have had an effect, but this was not addressed in our study. Visual documentation of the KT-1000 is not required using the Kneelax as the computer records each value instantaneously to the hundredth of mm translation. This may have had an effect on increased accuracy of recordings.

According to Daniel, normal knee side-to-side differences should be less than 1.0mm [3,4,5,6]. Our data reports that both devices recorded less than 1.0mm side to side differences (Tables 1, 2)

Conclusion:

The side-to-side difference numbers are the most important values when using instrumented testing for diagnosis of ACL tears. When comparing the KT-1000 and Kneelax there was no significant difference found between the side-to-side difference measurements at 67N, 89N, 134N, and manual maximum displacement. The KT-1000 produced significantly greater absolute values at 67N, 89N, 134N, and manual maximum displacements (mean = 1.4mm).

Acknowledgments

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Table 1: Kneelax Measurements

Force	Normal (R)	Involved (L)	I-N
67N	4.2(1.2)	4.0(1.7)	0.2
89N	5.0(1.4)	4.8(1.8)	0.2
134N	6.2(1.6)	6.1(2.3)	0.1
MMax	7.5(1.8)	7.2(2.6)	0.3

Expressed in mm translation

Table 2: KT-1000 Measurements

Force	Normal (R)	Involved (L)	I-N
67N	5.7(1.3)	5.3(1.6)	0.4
89N	6.4(1.6)	6.3(1.8)	0.1
134N	7.6(1.8)	7.5(2.3)	0.1
MMax	8.7(1.3)	8.7(2.9)	0.0

Expressed in mm translation

Table 3: Kneelax and KT-1000

Force	Kneelax	KT-1000	PValue	Difference
67N – R	4.2	5.7	0.004	1.5
67N – L	4.0	5.3	0.046	1.3
89N – R	5.0	6.4	0.009	1.4
89N – L	4.8	6.4	0.015	1.4
134N–R	6.2	7.6	0.019	1.4
134N-L	6.1	7.5	0.027	1.4
MMax-R	7.5	8.7	0.058	1.2
MMax-L	7.2	8.7	0.026	1.5

Expressed in mm translation

Table 4: I-N KT-1000, Knee Lax

KT-1000 (I-N)	Kneelax(I-N)	P-Value	Difference
67N = 0.8	67N = 1.1	0.385	0.3
89N = 1.2	89N = 0.9	0.320	0.3
134N =1.3	134N= 0.9	0.148	0.4
Mmax=1.4	Mmax=1.0	0.503	0.4

Expressed in mm translation

Figure 1. KT-1000 knee ligament arthometer

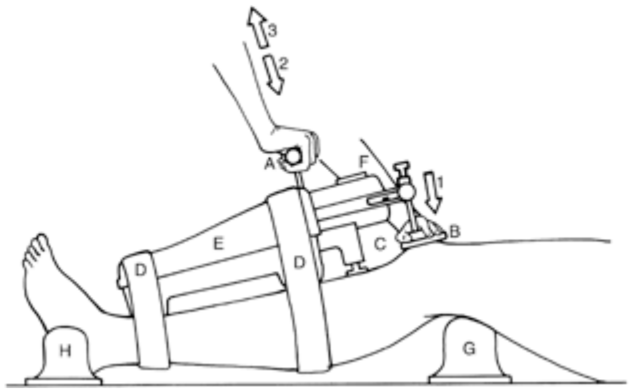

Figure 2. Kneelax