Arthrometers Contribute to Accuracy in Orthopedic Assessment

Orthopedics is about precision. We use a variety of devices to collect objective data on/from patients. These include goniometers, hand-held dynamometers, isokinetic machines, pulse-oximeters, and blood pressure cuffs, to name a few. These data contribute to other clinical techniques to assist the practitioner in the identification of pathology. A lesser utilized device to quantify joint mobility is an arthrometer. Unlike a goniometer which measures angles in degrees of motion, i.e., flexion or extension (osteokinematic motion), arthrometers measure linear translation of a joint in millimeters of motion (arthrokinematics/accessory motion). This accessory (gliding/sliding) motion that occurs between two joint surfaces contributes to the osteokinematic motion. Without this accessory motion, joint surfaces would fail to maintain optimal contact as concave and convex surfaces move on each other.

TYPES OF ARTHROMETERS

In the 1980's, Med Metrics Corporation developed a knee arthrometer called the KT1000. For the first time, injury to the anterior cruciate ligament (ACL) could be quantified. The device paved the way for a plethora of research studies and enhanced understanding of the magnitude of translation that defined pathology. Around 1990, the Rolimeter was developed and brought to market (Aircast Europe). Currently, neither of these devices are commercially available. However, several other arthrometers such as the KLT (Karl Storz, Tuttlingen, Germany), KiRA (I+, Italy), and GNRB (Genourob, France) entered the market. In 2020, the Automatic Knee Arthrometer (Peking University) was developed and reported to be able to successfully determine the degree of knee laxity in ACL injuries.[1] Yet, this device is not commercially available. In 2021, the Mobil-Aider arthrometer (Therapeutic Articulations, LLC) entered the market and has begun to populate the literature with several studies.[2-8] The Mobil-Aider and Telos are the only arthrometers that can be used on multiple joints, including the upper extremity. However, the Telos is used for positioning in conjunction with stress radiographs, so it is not truly a stand alone nor a portable device.

KNEE ARTHROMETER DATA

Magnetic resonance imaging (MRI) has been the gold standard for ACL diagnosis, but MRI's are expensive and are static images. Arthrometers can provide dynamic data. There have been numerous studies to evaluate the data obtained from arthrometers to assess anterior translation of the tibia on the femur (Lachman test). A study by Bach[9] using the KT1000 reported a 0.2 ± 1.6 mm difference between normal knees but 4.8 ± 3.7 mm for acute ACL injuries and 5.5 ± 4.5 mm in chronic ACL injuries. However, Barcellona et al[10] found the KT1000 to over-estimate sagittal knee joint laxity. Other studies[11-14] suggested less than 3 mm difference between knee translations was normal but more than 3 mm implied instability.

Klasan et al[15] compared the KT1000 and the GNRB. Maximal anterior translation of healthy knees measured 5.7 mm with the KT1000 and 4.4 mm with the GNRB with an increase of 3 mm or more indicating laxity. Whereas, Michel et al[16] reported a 4 mm difference was consistent with laxity using the GNRB. Runer et al[17] reported maximal anterior tibial translation as 5.8 mm for the Rolimeter, 6.0 mm for KLT, 12.3 mm for KiRA, and 7.7 mm for the KT1000. ICC (intra-rater) ranged from 0.7 to 0.9. Side-to-side differences in healthy knees were also reported with the Rolimeter, KLT, KiRA, and KT1000 as 0.8 mm, 1.1 mm, 2.4 mm, and 1.1 mm, respectively. The authors set equivalence boundaries to ± 1 mm and thus determined results were equivalent for the Rolimeter, KLT, and KT1000 but not for the KiRA. Murgier et al[18] also compared four arthrometers. However, they reported the threshold for side-to-side differences of sagittal knee laxity were 4.28 ± 2.25 mm for the GNRB, 6.05 ± 3.81 mm for the Telos, 4.15 ± 1.76 mm for the KT1000, and 2.82 ± 1.40 mm for the Rolimeter.

As one can see, most of the studies performed on these different arthrometer are comparing them to one another. If a device has not been validated, why would it be used as a comparison? Why aren't devices being compared (validated) to a gold standard? This validation process was performed on the Mobil-Aider arthrometer via bench research using the Zeis Smartzoom (ICC = 0.997).[2,3] In addition, a clinical study compared healthy knees to those with partial and complete ACL tears as confirmed by an MRI.[4] The double-blinded data revealed side-to-side differences in sagittal translation (Lachman test) of ± 0.18 mm in the healthy knees, 2.05 mm in partial ACL tears, and more than 3.38 mm in complete ACL tears with the Mobil-Aider.

ANKLE ARTHROMETER DATA

For the ankle, there are only three arthrometers available: Instrumented Ankle Arthrometer (Blue Bay), Telos SD900 (Telos Medical) and the Mobil-Aider (Therapeutic Articulations). A study validating the Instrumented Ankle Arthrometer reported approximately 2 mm differences between the control and ankle laxity group.[19] This was consistent with the work of Kerkhoff[20] and Kovaleski.[21] Kerkhoff[20] reported sectioning the anterior talofibular ligament in cadavers resulted in an increase of 2 mm of anterior laxity. Further, sectioning the calcaneal fibular ligament added another 2 mm of laxity.

A study performed with the Mobil-Aider arthrometer compared healthy ankles to those with first degree (1°) and second degree (2°) lateral ankle sprains.[5] When testing the anterior talofibular ligament with the Mobil-Aider using an anterior drawer technique, a 1.11 mm side-to-side difference was consistent with a 1° sprain and 2.16 mm difference indicated a 2° sprain. These ratios correspond with a study by Lee et al[14] using stress radiographs. When a ratio of ATFL stress to resting was 1.1, 1.3, and 1.4, the sprain was classified as a 1°, 2°, and 3°, respectively. The ability to have objective values of anterior laxity and the corresponding ratios can significantly impact the treatment decision.

UPPER EXTREMITY ARTHROMETER DATA

The Mobil-Aider is the only arthrometer available for upper extremity testing. When analyzing shoulder posterior glides, the Mobil-Aider arthrometer was found to have a 0.83 correlation with electro-magnetic motion analysis.[8] Two studies were also performed on shoulder and wrist accessory motions.[6,7] Intra-rater reliability was reported to be 0.691, 0.771, and 0.789 for posterior shoulder glides and 0.904, 0.917, and 0.932 for wrist volar glides. Whereas, inter-rater reliability for shoulder posterior glides were 0.546 and wrist volar glides were 0.462.

CLINICAL APPLICATION

Testing with arthrometers provide objective data . By placing a numeric value on the magnitude of motion, one can objectively compare right to left joints. While developing normative values may not be practical, data on differences between injured and uninjured joints can be clinically significant. As in other manual techniques, intra-rater reliability has been found to be good to excellent but inter-rater reliability is poor to fair with or without an arthrometer. There are many factors that contribute to this issue. Maximal manual force application has shown low agreement with dependency on investigator gender.[22] Because linear translation can be influenced by the force applied during excursion, side-to-side differences are recommended for clinical assessment.[17,23] Furthermore, many studies describe clinician testers as novice or experienced. Although years of clinical experience may be important, familiarity with the arthrometer is much more important.[17] Easy to operate arthrometers used in a way that is consistent with standard testing techniques can reduce the learning curve and enhance reliability.

In summary, there is technology available to provide objective data on joint laxity that fills the void between subjective assessment and expensive imaging. Clinicians should consider incorporating the use of arthrometers into practice to provide objective data to drive clinical decisions and to populate the literature about the efficacy of manual techniques.

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