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Measurement of Accessory Motion of the Glenohumeral and Radiocarpal Joints: Intra-Rater Reliability of the Mobil-Aider® Device for Measurement of Linear Translation

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Abstract

Background: Within a joint, linear translation is a key component of arthrokinematic, or accessory, motion that is required for normal osteokinematic motion. A reduction in accessory motion, due to injury or dysfunction, can result in hypomobility and a loss of function. Limitations in posterior glide may result in a loss of Glenohumeral Joint (GHJ) rotation and limitations in volar glide may result in a loss of Radiocarpal Joint (RCJ) extension. Quantifying accessory motion is challenging, even for the experienced clinician. Objective quantification of joint linear translation is necessary during assessment of accessory motion, in directing patient care, and when developing psychomotor performance of joint mobilization procedures. The Mobil-Aider® is a newly-developed device designed to measure linear translation that can be adapted for assessment of multiple joints. The reliability of the Mobil-Aider® for measurement of linear translation of the GHJ and RCJ has not yet been established.

Aim: To investigate the intra-rater reliability of the Mobil-Aider® for assessment of end-range (Grade IV) linear translation of posterior glide and volar glide for the GHJ and RCJ, respectively.

Methods: The intra-rater reliability of a single, blinded investigator experienced in manual interventions was explored using the Mobil-Aider® device to assess GHJ posterior glide and RCJ volar glide in 21 and 24 participants, respectively.

Results: Intra-rater reliability (ICC3, K) for posterior glide of the GHJ was 0.771 and for volar glide of the RCJ was 0.904, indicating good and excellent reliability, respectively.

Discussion: The results of this study suggest that the Mobil-Aider® has clinical utility for assessment of linear translation of the GHJ and RCJ. Further evidence is needed to establish inter-rater reliability and the effectiveness of this device in improving patient outcomes and enhancing the development and performance of joint mobilization procedures.

Keywords: Joint Mobilization; Manual Therapy; Accessory Motion

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Introduction

Assessment of accessory motion

Linear translation is a key component of joint arthrokinematics, which is defined as the relative motion that occurs between joint surfaces [1]. These motions, often referred to as accessory or component movements, accompany the gross physiologic motions of a joint that are typically measured through goniometry [1,2]. Within a diarthrodial joint, articular surfaces roll and glide for the purpose of facilitating normal motion, while maintaining proper alignment to ensure joint stability [3]. Loss of accessory motion due to injury or dysfunction can lead to a reduction in motion of the joint and subsequent loss of function [4-7].

The relatively small amount of accessory motion that takes place at a joint poses difficulty in quantification for even the experienced clinician. The method of determining restrictions in joint glide includes the use of passive translatory glides in all planes. During performance of these procedures, the therapist ascertains the relationship between tissue resistance and an individual's report of pain, as well as the quality of tissue resistance at end range, or end feel, in each direction [8-11]. Due to the paucity of evidence supporting the reliability of accessory motion testing, clinicians and researchers are limited in their ability to effectively utilize these procedures to quantify motion and assess change in response to intervention.

Accessory motion of the glenohumeral and radiocarpal joint

Within the shoulder joint complex, the sternoclavicular, acromioclavicular, scapulothoracic, and glenohumeral joints compose a system of interdependent joints that serve a preeminent role in the function of the upper extremity. Of these four joints, the joint with the most mobility and susceptibility to impairment is the Glenohumeral Joint (GHJ). Approximately 25% of the humeral head is engulfed by the glenoid fossa, thus allowing greater mobility at the expense of stability. The majority of accessory motion that predominates at the GHJ is angular motion with less significant linear translation [12-14]. There has been much debate in regard to the direction in which translation occurs at this joint and exceptions to the convex/concave theory are common. The point of contact on the humerus and glenoid varies depending on the type of motion taking place [15-17]. Despite varying opinions, evidence suggests that external rotation produces an increase in tension of the anterior Capsuloligamentous Complex (CLC), which results in posterior translation, not anterior translation as the convex/concave theory would suggest (Figure 1)[18,19].

The Radiocarpal Joint (RCJ) is the articulation between the radius and the proximal row of carpal bones. However, only the scaphoid and lunate directly articulate with the radius. The average inclination of the distal radius is 23 degrees, resulting from the radius demonstrating greater length than its corresponding ulna. The distal radius is tilted volarly 11 degrees as a result of the dorsal aspect of the radius being slightly longer than its volar counterpart [20]. Within the RCJ, the contact area increases when the joint is loaded, and the congruency between the scaphoid and radius is greater than that which is between the lunate and radius [21]. Similar to the GHJ, the RCJ requires accessory glide to achieve full range of motion. As the convex proximal row of carpal bones moves upon the concave radius during wrist flexion and extension, it is generally considered that the direction of joint glide within the proximal row of carpal bones is opposite to the direction of hand motion and that the distal row of carpal bones glide in the same direction as hand motion (Figure 2) [22].

Kirby et al. [23] explored the variables that physical therapists viewed as important for clinical decision-making in the management of shoulder conditions. Responses from 660 American-trained therapists revealed that there was excellent agreement among clinicians on the use of translational motion of the GHJ in making clinical decisions regarding care. This suggests that despite evidence that challenges the validity of these procedures, therapists continue to rely on this data to direct patient care.

Intra-rater reliability was found to be moderate-good for assessing GHJ inferior glide on 18 subjects with and without a history of dysfunction between three experienced therapists [ICC (3,1): 0.88, 0.56, 0.53]. Inter-rater reliability was moderate [ICC (2,1): 0.52] [24]. These findings, however, cannot be applied to novice practitioners. To address the role of experience in ascertaining these measures, Rathi [25] investigated the intra- and inter-rater reliability of a therapist with minimal training and an ultrasonographer in quantifying anterior and post glides of the GHJ of 12 healthy participants in two positions at rest. Both raters demonstrated good intra-rater reliability (PT ICC: 0.86-0.98, US ICC: 0.85-0.96). For posterior glide, the inter-rater reliability was moderate-good (ICC: 0.50-0.75) and poor-moderate for anterior glide (0.31-0.53).

For the purpose of determining the reliability of accessory motion testing within the carpal joint, Staes et al. [26] tested the intra- and inter-rater reliability of two skilled therapists in assessing the available motion and end-feel of carpal joints in 30 students and 15 patients at two-time intervals. In students and patients 67% to 97% and 60% to 100% agreement was obtained for motion testing, respectively. Overall, reliability of accessory motion testing was acceptable; however, intra-rater was better than inter-rater reliability in both groups. Since these results were demonstrated in experienced therapists, they cannot be completely applied to those with less experience.

Efficacy of joint mobilization

Restoration of normal arthrokinematics through joint mobilization is an important part of the orthopedic manual physical therapist's treatment approach [27]. Joint mobilization involves the manual application of localized stretching to restore joint glides and rolls to improve the osteokinematics, or visible motion, of a joint [5,6,28,29]. Maitland defines mobilization as passive movement that is performed with a rhythm and a grade in a manner in which the patient is able to prevent the technique from being performed [10,11]. Grieve distinguishes the term manipulation from mobilization by defining manipulation as "an accurately localized, single, quick, and decisive movement of small amplitude following careful positioning of the patient [30]." He further notes that the manipulation may have a regional or more localized effect [30]. Paris contends that the terms mobilization and manipulation are identical in meaning and thus can be used interchangeably; they are described as the "skilled passive movement to a joint" [1].

Motion limitations within the GHJ are common. Cyriax defined the term capsular pattern as a characteristic loss of motion that is specific to each joint and attributed to restrictions within the CLC of a joint [31]. Despite the fact that insufficient evidence exists to support its clinical use, the capsular pattern for the GHJ is generally believed to consist of a loss of External Rotation (ER) that is more significant than a loss of abduction, that is more significant than a loss of Internal Rotation (IR) (ER>Abduction>IR) [32-34]. Given the propensity of the GHJ to exhibit a loss of ER, intervention strategies to improve posterior glide are commonly employed. Unlike the GHJ, the RCJ does not have a clear capsular pattern. Restrictions within the CLC often produce a reduction in motion in all directions. Within the RCJ, a loss of flexion suggests the need for joint mobilization to restore dorsal glide and for a loss of extension, a volar glide is warranted.

In 40 individuals with adhesive capsulitis, Shetty et al. [35] revealed significant improvement in flexion, abduction, IR, and ER mobility, as well as significant changes in self-reported pain and disability in response to posterior glides and muscle energy techniques for the subscapularis. Hsu et al. [28] found improved abduction range of motion in response to posterior glides performed at end range of abduction. Harsimran et al. [36] found that posterior glides improved both ER, as well as IR mobility, without a significant difference between the groups in 15 individuals with adhesive capsulitis. Biradi et al. [37] identified comparable changes in pain from end range anterior and posterior glides in 56 individuals with stage II adhesive capsulitis. In contrast to these studies that reveal non-preferential improvement in both ER and IR in response to posterior glides, Johnson et al. [6] revealed a significantly greater increase in ER in response to posterior glides in 20 participants with adhesive capsulitis. A significant difference in mobility between the two groups was noted after just three intervention sessions. Biradi et al. [38] concurs with these results by identifying a significantly greater increase in ER compared to IR range of motion following end range posterior glides compared to anterior glides.

Kamal et al. [39] revealed that joint mobilization of the wrist was more effective in improving wrist range of motion compared to closed kinetic chain exercises following a stable Colle's fracture in 30 participants. However, these techniques were no more effective than exercise in improving function, grip strength, and proprioception.

In summary, the current best evidence supports the use of joint mobilization techniques to improve linear translation and overall joint mobility of the GHJ and RCJ. However, the development of skilled performance of these procedures may be challenging and standardization of linear translation during their performance is difficult to quantify.

Novice practitioners and students who are seeking to develop proficiency in the performance of accessory motion testing and joint mobilization procedures are often challenged in accurate assessment of joint translation and in replicating the grades that are used during the application of joint mobilization procedures. It is clear from the existing evidence that new strategies for assessment of accessory motion and application of joint mobilization procedures are needed. A device that is capable of accurately identifying small degrees of joint translation would enhance assessment reliability, serve to standardize joint mobilization procedures, and enhance skill development in student and novice practitioners.

The Mobil-Aider® device for measurement of linear translation

There are a number of devices which seek to measure linear translation within a joint, however, most are cumbersome to use and quite expensive [40]. Diagnostic accuracy is often called into question, with these devices often eliciting false-positive or false-negative results [40,41]. Many of these devices, such as the KT-1000/2000, have a limited scope of use, having been designed primarily for testing of the knee, with one study validating its use on the shoulder [42]. The Mobil-Aider® (Therapeutic Articulations, LLC, Spring City, PA) is a new FDA-cleared device (Figure 3). Complete with a variety of interchangeable attachments, this device is easily adapted for testing on most joints throughout the body. The Mobil-Aider® has a stationary side and a mobile side, which enables precise measurement of linear translation in millimeters. A proof-of-concept study by Gulick [43], which compared translation measurements of the knee obtained using the device to radiography, demonstrated a strong correlation during performance of a Lachman's test. Additionally, reliability and concurrent validity was found between the Mobil-Aider® and the Zeiss Smartzoom 5 Microscope. Pearson correlation coefficients for this laboratory research were near-perfect (0.986 to 0.997) [44]. Based on these findings, the Mobil-Aider® holds promise as an examination tool for the assessment of joint linear translation, as well as a teaching aid in the academic setting for instruction in the performance of joint mobilization. The aim of the present study is to explore the intra-rater reliability of the Mobil-Aider® in assessment of posterior glides of the GHJ and volar glides of the RCJ.

Materials and Methods

Following informed consent, a normal and healthy sample of convenience was admitted consisting of doctor of physical therapy students and faculty. To ensure that the study was sufficiently powered a sample size calculation was conducted. When the rater was allowed three chances of rating each mobilization, a minimum sample size of 11 participants would be required to be assessed to achieve the statistical significance for an alpha-value set at 0.05 and with the minimum power of at least 80.0%. Exceeding the number needed to ensure sufficient power, 21 participants for assessment of posterior glide for the GHJ and 24 participants for assessment of volar glide for the RCJ were admitted into the study.

Accessory glide testing was performed on each joint during one session by a single, blinded physical therapist with 32 years of experience in the specialization of orthopedic manual physical therapy but a novice in the use of the Mobil-Aider® device. A co-

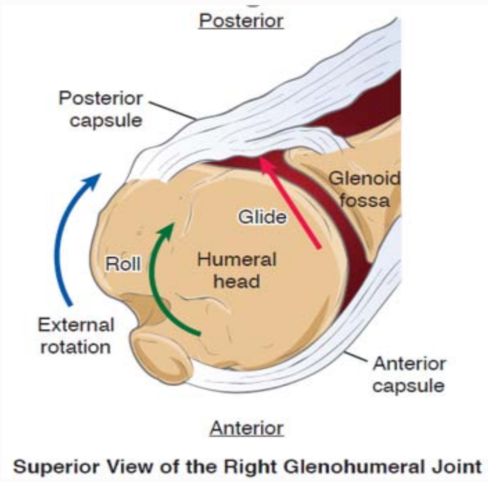

Figure 1: Posterior translation of the glenohumeral joint during external rotation. (From: Wise CH. *Orthopaedic Manual Physical Therapy: From Art to Evidence*. Figure 22-16, page 507 Philadelphia, PA: F.A. Davis Company; 2015, with permission.)

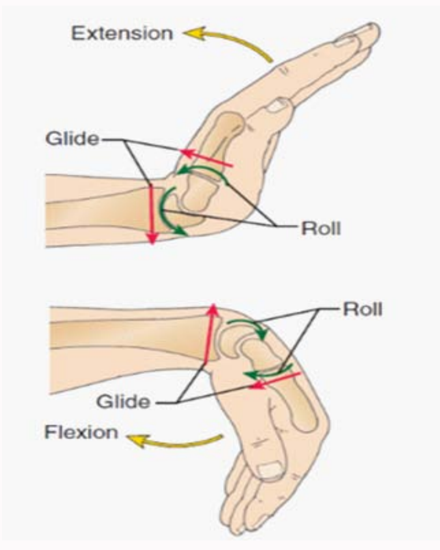

Figure 2: Volar and dorsal translation of the radiocarpal joint during extension and lexion, respectively (From: Wise CH. *Orthopaedic Manual Physical Therapy: From Art to Evidence*. Figure 24-3, page 572 Philadelphia, PA: F.A. Davis Company; 2015, with permission.)

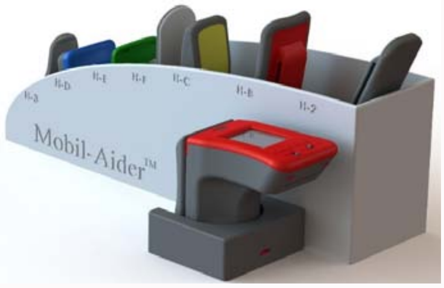

Figure 3: Mobil-aider device.

Figure 4: Glenohumeral posterior glide with the Mobil-aider.

Figure 5: Radiocarpal volar glide with the Mobil-Aider.

investigator palpated and marked the joint line and recorded all measures from the device.

For the GHJ, participants were placed in supine with a mobilizing wedge stabilizing the scapula, posteriorly. The glenohumeral joint was positioned in the plane of the scapula. The investigator then aligned the stationary arm of the device over the clavicular region (Figure 4). Following several lower-grade trials to confirm alignment, the investigator performed a series of three Grade IV accessory glides with 30 sec rest between trials moving the head of the humerus and mobile arm of the device in a posterolateral direction.

For the RCJ, participants were placed in sitting with the forearm in pronation and supported on a table with the distal forearm additionally supported on dense foam (Figure 5). The investigator then aligned the device over the radiocarpal joint line. Following several lower grade trials to confirm alignment, the investigator performed a series of three Grade IV accessory glides with 30 sec rest between trials moving the proximal row of carpal bones with the mobile arm of the device in a volar direction. The investigator was blinded to the digital display on the Mobil-Aider for all measures. A lab assistant viewed and recorded all measures on a data sheet.

Results

For posterior glide of the GHJ, there were 21 participants (5 male; 16 female) with a mean age of 28.09 years. Using a two-way mixed effects consistency model (ICC3, k) for intrarater reliability, the means are provided in Table 1 [45]. The mean of measure #2 was higher than that of #1 and #3. This was confirmed by the fact that measures #1 and #3 had a higher correlation with each other than either of them with measure #2. The correlation matrix is displayed in Table 2. The overall intra-rater reliability (ICC3, k) was 0.771. This indicates there was good reliability [46].

For volar glide of the RCJ, there were 24 participants (6 male, 18 female) with a mean age of 29.16 years. The mean values for the wrist are displayed on Table 3. In the wrist data, the mean of measure #3 was lower than that of #1 and #2. This was confirmed by the fact that measures #1 and #2 had a higher correlation with each other than either of them with measure #2. The correlation matrix is displayed in Table 4. The overall intra-rater reliability (ICC3, k) was 0.904. This indicates there was excellent, near perfect, reliability [46].

Discussion

Although good and excellent intra-rater reliability was demonstrated in the GHJ and RCJ, respectively, the less substantial agreement in the GHJ may be attributed to the greater degree of soft tissue that is present in the shoulder. These initial results indicate good clinical utility through the use of a device that can be easily applied for use with various joints. Measurement of joint translation has implications for the application of joint mobilization techniques and can be used to objectify improvement in response to these techniques. Lin et al. [29] demonstrated a connection between improved joint

Table 1: Means and standard deviations for glenohumeral posterior glide.

GHJ	Mean	Standard Deviation
Measure #1	11.99	1.95
Measure #2	12.36	1.92
Measure #3	11.19	1.69

Table 2: Correlation matrix for glenohumeral posterior glide.

GHJ	Correlation Matrix		
	Measure #1	**Measure #2**	**Measure #3**
Measure #1	1.00	0.76	0.83
Measure #2	0.76	1.00	0.74
Measure #3	0.83	0.74	1.00

Table 3: Means and standard deviations for radiocarpal volar glide.

RCJ	Mean	Standard Deviation
Measure #1	7.62	2.54
Measure #2	7.42	2.57
Measure #3	7.03	2.54

Table 4: Means and standard deviations for radiocarpal volar glide.

RCJ	Correlation Matrix		
	Measure #1	**Measure #2**	**Measure #3**
Measure #1	1.00	0.93	0.88
Measure #2	0.93	1.00	0.9
Measure #3	0.88	0.9	1.00

translation and improved osteokinematic motion in participants with adhesive capsulitis of the shoulder.

These results have implications for assessment of joint mobility by establishing the reliability of a device designed to quantify joint translation. This device may be useful during examination in providing objective data that can be used to identify mobility deficits and changes in mobility in response to joint mobilization. Further, these results may also provide important data used to guide the application of joint mobilization by serving to standardize the quantity of joint translation associated with a specific mobilization grade. This will improve the consistency with which joint mobilization is performed. Lastly, the results of this study may also facilitate psychomotor development in the performance of accessory motion testing and joint mobilization procedures. During instruction of these procedures, this device may be used to replicate joint translation that is associated with a specific grade.

Conclusion

When used by an experienced therapist, the Mobil-Aider® device demonstrates good and excellent intra-rater reliability of Grade IV posterior glides of the GHJ and volar glides of the RCJ, respectively, in healthy, unimpaired participants. Therefore, its clinical utility in quantifying end range joint translation of the GHJ and RCJ during the performance of accessory motion testing and joint mobilization and when teaching these psychomotor skills to student and novice practitioners is supported and should be considered.

Limitation and Future Research

Since this study was performed on young, unimpaired individuals, these results cannot be generalized to individuals with shoulder or wrist dysfunction. A single investigator with over 30 years of experience in performing these techniques obtained all measures. Therefore, the reliability that was demonstrated cannot be applied to therapists with varying levels of experience. Although quantification of joint translation is able to enhance teaching and learning these procedures, the manner in which these procedures were performed varied slightly from how they may be performed in general practice. Although the use of the device was valuable to quantify measures, there was a slight reduction in the perception of joint end feel with the device interfaced between the therapist hands and the joint.

All measures were obtained during a single session. The blinded nature of this study and randomization of participants served to control for recall bias, however, obtaining measures across multiple sessions may have provided a more valid determination of reliability thus reducing any threats to internal validity. Additional evidence is needed to determine its inter-rater reliability, explore the reliability of this device in individuals with impairments and within other joints.

Future research may explore the impact of joint mobilization directed by the use of the device that demonstrates an association between the quantity of change in accessory glide with improvement in the degree of osteokinematic mobility. The Mobil-Aider may also play a role in the reproducibility and development of skill in the performance of Grades I-III joint mobilization. The impact of this data on patient-centered outcomes has not been established and future work should explore the role of these measures on guiding clinical care that leads to optimal patient outcomes.

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