# Reliability of the VDO Clip-based Goniometry Method for Measuring Range of Motion of the Elbow

**Pinkawas Kongmalai, MD, Arunwong Thepchatree, MD, Cholawish Chanlalit, MD**

*MSMC Hospital, Department of Orthopedics, Faculty of Medicine, Srinakarinwirot University, Nakonnayok, Thailand*

***Purpose:*** *Telemedicine is an adaptation of internet-based communication for remote patients. The video (VDO) clip-based goniometry method is a type of telemedicine that would be useful for patients who need periodic assessment. A previous report showed the validation of this technique but it did not verify the generalizability or reproducibility of the technique. The purpose of this study was to determine the generalizability and reproducibility of the VDO clip-based goniometry method for measuring the range of motion of the elbow.*

***Methods:*** *Both elbow flexion and extension, and forearm pronation and supination were measured by the specialist in elbow surgery using standard goniometer. On the same day, VDO records of 30 subjects were performed. One week later, the VDO clips were displayed and their range of motion (ROM) was measured using free download software (PicPick, 3.1.0) by an orthopaedic resident (to determine inter-rater/intra-method reliability). One month later, measurements were taken again by the same specialist (to determine intra-rater/intra-method reliability).*

***Results:*** *The intraclass correlation coefficient and the Bland-Altman analysis showed the capability of VDO-clip based goniometry and clinical goniometry by the specialist in elbow surgery and orthopaedic resident especially in elbow extension and forearm supination. For elbow flexion and forearm pronation, the data showed that there was some degree of correlation but not as strong as flexion and extension. The results were reproducible by the specialist in elbow surgery even when the measurements were taken again 1 month later.*

***Conclusion:*** *The VDO clip-based goniometry method for measuring the range of motion of the elbow was reproducible by a specialist in elbow surgery. It was also shown to be possible even if the measurement was obtained by an orthopaedic resident. This offers a great opportunity to follow the outcome assessment of patients for whom transportation to a tertiary care center is a significant barrier.*

***Keywords:*** *Elbow range of motion, measurement, telemedicine, VDO clip-based goniometry*

***The Thai Journal of Orthopaedic Surgery: 37 No.2-4: 23-28***
***Full text. e journal:*** *http://www.rcost.or.th, http://thailand.digitaljournals.org/index.php/JRCOST*

## Introduction

With advancements in internet-based communication, adaption to the technology for the use in clinical assessments of patients is proving interesting. Telemedicine, a service delivered at a distance using this technology, has been experiencing rapid growth with new clinical applications and new products appearing frequently. These services include evaluation and treatment, as well as education, consultation, and coordination of care. They have shown beneficial results in neurology, psychiatry, and rehabilitation [1-4]. To date, few studies have investigated standard assessment tests applied to telemedicine in orthopaedics. Blonna et al. used photography-based goniometry to show the accuracy and reliability of elbow flexion and extension[5]. If one photograph was reliable to indicate the range of motion of the elbow, the video (VDO) clip with the subject in motion should be more reliable because the observer can choose the proper angle to measure from any point of movement.

Reliability in the new measurement technique could include the parameters of validation, generalizability and reproducibility. Chanlalit and Kongmalai have shown that the VDO-clip based goniometry method is technically feasible for measuring the range of motion of the elbow, especially for flexion and extension[6]. But they did not show the inter-rater, intra-method and intra-rater, intra-methods' reliability. This study was designed to investigate the inter-rater, intra-method and intra-rater, intra-methods' reliability to show the generalizability and reproducibility of the VDO-clip based goniometry method.

*Correspondence to: Chanlalit C, Department of Orthopaedics, Faculty of Medicine, Srinakarinwirot University, Ongkarak, Nakonnayok 26120, Thailand.*
*E-mail: chanlalit@hotmail.com*

## Materials and Methods

### *Subjects*

Sample size calculations (by PASS 2008) indicated that 30 subjects were necessary to detect greater than moderate reliability (alpha = 0.05 and beta = 0.1)[7]. Fifteen women and fifteen men were recruited from the hospital's staff.

An exclusion criterion was that subjects with an obvious deformity of the elbow that precluded the use of standard goniometer.

### *Methods*

The ranges of motion of the elbow from VDO-clips, including flexion, extension, forearm pronation and supination, were measured by free download software (PicPick, 3.1.0, NTe works) by the same landmarks as Chanlalit[6] (Fig. 1). For part 1, we compared the results from a specialist in elbow surgery and an orthopaedic resident to evaluate the generalizability (inter-rater/intra-method reliability).

For part 2, measurements were taken again by the specialist in elbow surgery one month later. This result was compared with the earlier result by the same rater to evaluate the reproducibility (intra-rater/intra-method reliability).

### Statistical analysis

The data were analyzed using Bland-Altman analysis that defines the "limits of agreement". This system is based on the mean and standard deviation of the difference between ratings of the same subject[8-10]. The dash line represents the upper limit of agreement for each motion (|average| + 1.96*SD). For discussion later, an upper limit of agreement at 10 degrees is used to accept or refuse the VDO clip-based technique because if we used the upper limit of agreement at 15 degrees, the percentage of measurement within this limit would be very high. In clinical practice, 5 degrees difference might not be significant.

The intra-class correlation coefficient (ICC) two-way mixed model on absolute agreement was used to analyze measurement reliability[11]. The values of the ICC can range from 0 to 1, with a higher value indicating better reliability. An ICC of less than 0.40 was considered as poor; 0.40 to 0.59 as fair; 0.60 to 0.74 as good, and 0.75 to 1.00 as excellent. In addition, the lower and upper limit of 95% confidence interval of ICC was calculated to provide an estimate of the magnitude of the measurement error. Statistical analysis was performed using the statistical package for social sciences (SPSS) software, version 17.0 for Window.

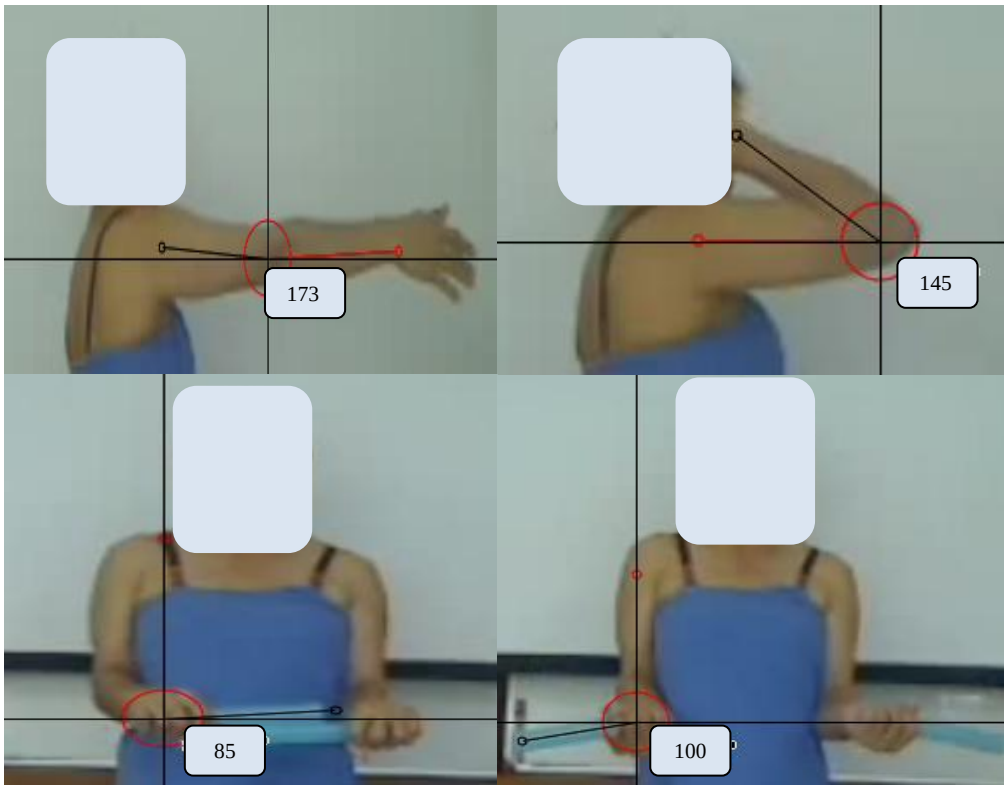
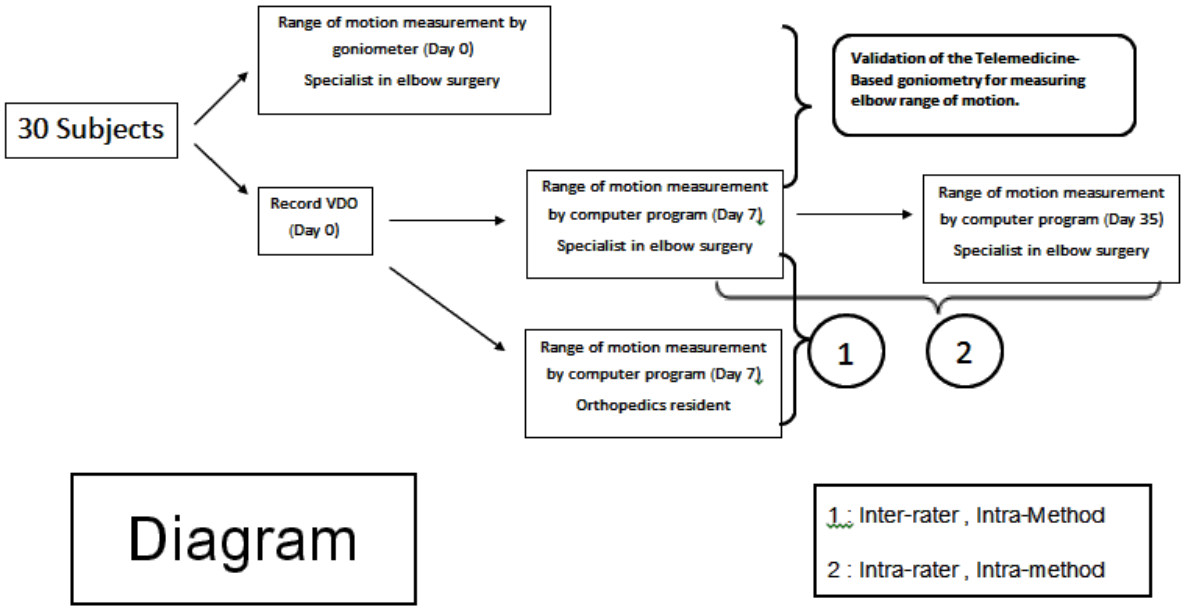



**Fig. 1** Range of motion of elbow measurement by computer program




## Results

Sixty elbows in 30 subjects were included in the study. The average age of subjects was 42 years old. The average weight, height and body mass index of subjects were illustrated in table 1.

**Table 1** Demographics data

| Variables | Average | | |
|---|---|---|---|
| | Male | Female | Overall |
| Age (years) | 41 | 43 | 42 |
| Weight (kg) | 73 | 57 | 65 |
| Height (cm) | 176 | 152 | 164 |
| BMI (kg/m$^2$) | 23.6 | 24.7 | 24.2 |

**Table 2** The ICC between measurements obtained by VDO-based goniometry from the specialist elbow surgeon and orthopaedic resident

| Motion | ICC | 95% Confidence interval | |
|---|---|---|---|
| | | Lower limit | Upper limit |
| **Flexion** | 0.517 | 0.304 | 0.680 |
| **Extension** | 0.719 | 0.570 | 0.822 |
| **Pronation** | 0.535 | 0.326 | 0.693 |
| **Supination** | 0.659 | 0.488 | 0.781 |

The ICC between measurements obtained by VDO clip-based goniometry from the specialist in elbow surgery and an orthopaedic resident showed elbow extension and forearm supination as good, fair in elbow flexion and forearm pronation (Table 2). The percentage of range of motions within the upper limit of agreement at 10° were 83% for elbow flexion, 95% for elbow extension and 68-78 % for forearm rotation (Fig. 2 and Table 4).

The ICC between measurements obtained by VDO clip-based goniometry from the specialist in elbow surgery in a separate session showed excellent in elbow extension and forearm supination and good in elbow flexion and forearm pronation (Table 3). The percentage of range of motions within the upper limit of agreement at 10 degrees was 95% for elbow flexion, 100% for elbow extension and 82-93% in forearm rotation (Fig. 3 and Table 4).

**Table 3** The ICC between measurements obtained by VDO-based goniometry from a specialist elbow surgeon in a separate session

| Motion | ICC | 95% Confidence interval | |
|---|---|---|---|
| | | Lower limit | Upper limit |
| **Flexion** | 0.638 | 0.4604 | 0.767 |
| **Extension** | 0.879 | 0.806 | 0.926 |
| **Pronation** | 0.645 | 0.469 | 0.772 |
| **Supination** | 0.762 | 0.631 | 0.851 |

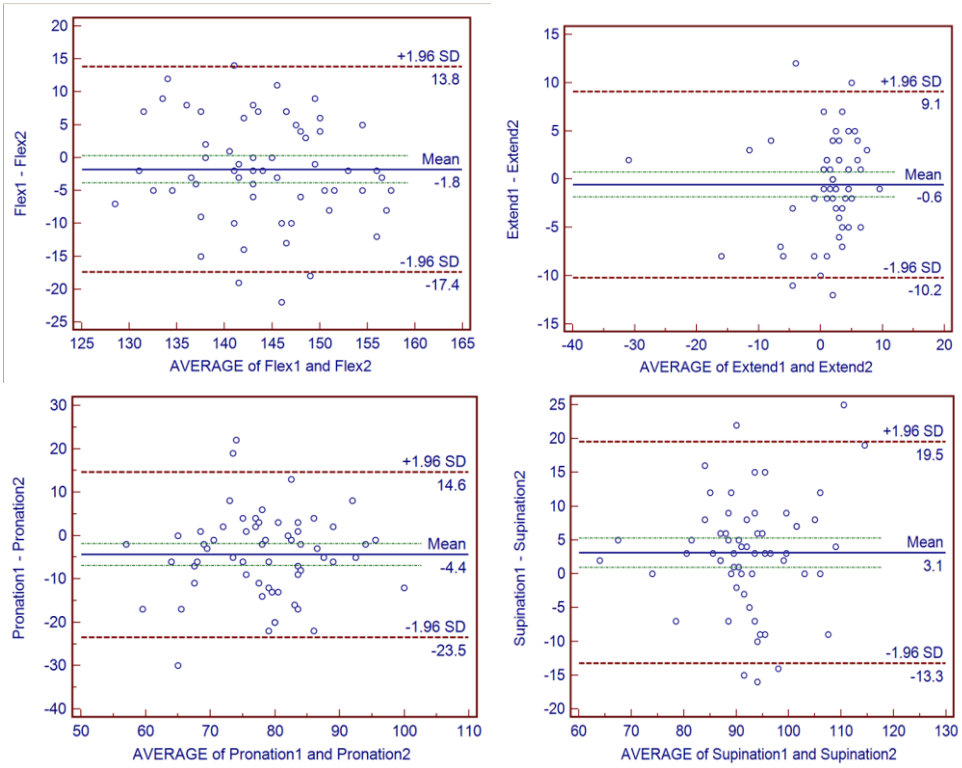



**Fig. 2** Part 1 Bland-Altman analysis of inter-rater, intra-method reliability

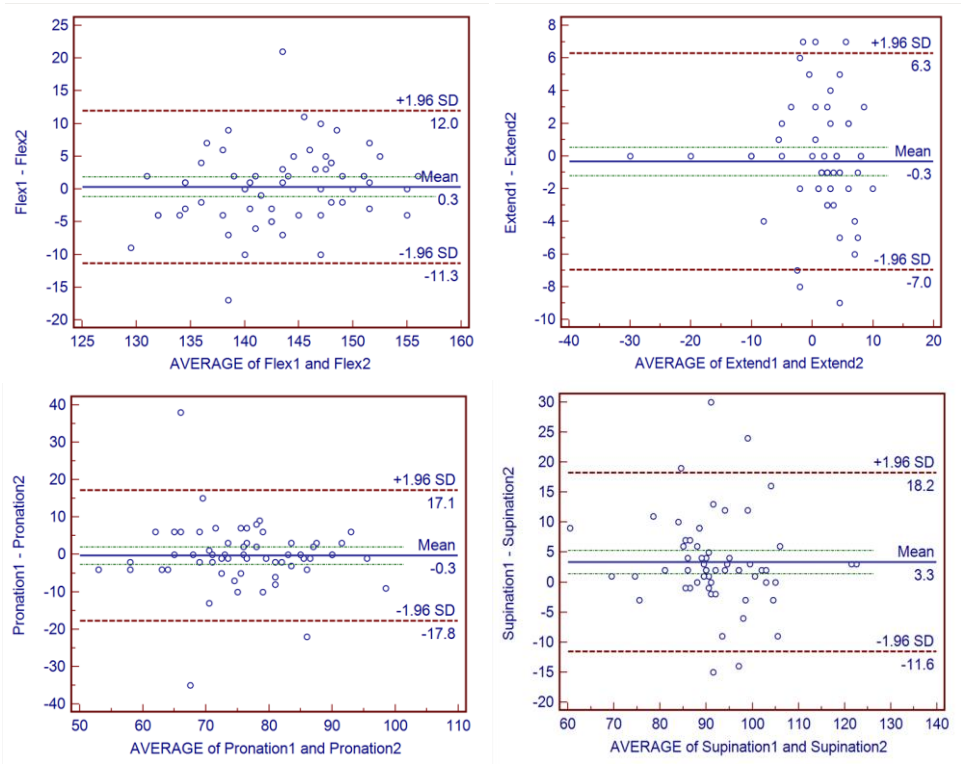



**Fig. 3** Part 2 Bland-Altman analysis of intra-rater, intra-method reliability

**Table 4** The percentage of range of motions within the upper limit of agreement at 10 degrees

| **Motion** | **Part 1** Inter-rater , Intra-method | **Part 2** Intra-rater , Intra-method |
|---|---|---|
| Flexion | 83% | 95% |
| Extension | 95% | 100% |
| Pronation | 68% | 82% |
| Supination | 78% | 93% |

## Discussion

Part 1 is a comparison of inter-rater, intra-method reliability that determines the generalizability. It showed a good correlation in elbow extension and forearm supination. Although the others showed only fair correlation, the percentage of range of motion within the upper limit of 10 degrees was high. Although we could not conclude that this technique is generalizable, it might be possible if we could eliminate the cause of forearm rotation measurements error as described below.

Part 2 is a comparison of intra-rater, intra-method reliability by a specialist in elbow surgery in separate session. We could conclude that this technique was reproducible because it still showed a good to excellent outcome.

In addition, the interpretation of the measurement angle for each motion is different. The difference in the angle of elbow extension is less than that of the flexion or forearm rotation. From our results, the lower to upper limit of variation interval for a measurement of elbow extension was lower than elbow flexion and forearm rotation. This would suggest the error component of extension measurements was the lowest and the most reliable.

The forearm rotation measurement error could be due to many reasons. First, the measurement error might be the position of the camera because we used a camera in a constant position for subjects of different heights. We should adjust the height to be suitable with patient's height to correct the angle of recording for all subjects. The second possible explanation is likely to be the patient positioning. We did not control the shoulder level of the subject to be the same; therefore measurements of forearm rotation might be influenced by external or internal rotation of the shoulder. Patients should be positioned with their backs against a wall; this could eliminate the problem of shoulder rotation. These changes might reduce the error component of forearm rotation results.

## Conclusion

The VDO clip-based goniometry method for measuring the range of motion of the elbow was reliable, generalizable and reproducible. This offers a great opportunity to follow-up the outcome assessments of patients for whom transportation to a tertiary care center is a significant barrier.

## Acknowledgements

This research has financial support from Faculty of Medicine, Srinakarinwirot University.

## References

1. Dhurjaty S. The economics of telerehabilitation. Telemed J E Health 2004; 10: 196-9.
2. Shafqat S, Kvedar JC, Guanci MM, Chang Y, Schwamm LH. Role for telemedicine in acute stroke. Feasibility and reliability of remote administration of the NIH stroke scale. Stroke 1999; 30: 2141-5.
3. Engbers L, Bloo H, Kleissen R, Spoelstra J, Vollenbroek-Hutten M. Development of a teleconsultation system for communication between physiotherapists concerning children with complex movement and postural disorders. J Telemed Telecare 2003; 9: 339-43.
4. Mielonen ML, Ohinmaa A, Moring J, Isohanni M. Psychiatric inpatient care planning via telemedicine. J Telemed Telecare 2000; 6: 152-7.
5. Blonna D, Zarkadas PC, Fitzsimmons JS, O'Driscoll SW. Validation of photograph-based goniometric measuring joint range of motion. J Shoulder Elbow Surg 2012; 21: 29-35.
6. Chanlalit C, Kongmalai P. Validation of the Telemedicine-Based goniometry for measuring elbow range of motion. J Med Assoc Thai 2012; 95 Suppl 12: S113-7.
7. Donner A, Elraszrw M. Sample size requirements for reliability studies. Stat Med 1987; 6: 441-8.
8. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res 1999; 8: 135-60.
9. Bland JM, Altman DG. Comparing methods of measurement: why plotting difference against 247 standard method is misleading. Lancet 1995; 346: 1085-7.
10. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of 249 clinical measurement. Lancet 1986; 1: 307-10.
11. Shrout PE, Fleiss JL. Intraclass correlations: uses in assessing rater reliability. Psychol Bull 1979; 86: 420-8.

## *ความน่าเชื่อถือของการวัดพิสัยการเคลื่อนไหวข้อศอกด้วยภาพจากวีดิโอคลิป*

***พิงควรรศ คงมาลัย, พบ, อรุณวงศ์ เทพชาตรี, พบ, ชลวิช จันทร์ลลิต, พบ***

***วัตถุประสงค์:*** *เพื่อเปรียบเทียบความน่าเชื่อถือของการใช้ภาพจากวีดิโอคลิป (VDO-clip) ในการวัดพิสัยการเคลื่อนไหวข้อศอก*

***วิธีการศึกษา:*** *เป็นการศึกษาตัดขวาง (cross-sectional) โดยวัดพิสัยการเคลื่อนไหวข้อศอก คือการงอ เหยียด และพลิกคว่ำหงาย ของกลุ่มตัวอย่าง 30 ราย ทำต่อเนื่องจากการวิจัยเดิมที่พบว่าการวัดพิสัยโดยแพทย์ผู้เชี่ยวชาญทางข้อศอกจากการตรวจร่างกายเปรียบเทียบกับการวัดจาก VDO-clip (intra-rater/inter-method reliability) มีความถูกต้องเพียงพอ โดยงานวิจัยนี้ศึกษาในเรื่องของการวัดพิสัยการเคลื่อนไหวข้อศอกโดยเปรียบเทียบระหว่างแพทย์ผู้เชี่ยวชาญทางข้อศอกจากการตรวจร่างกายกับแพทย์ประจำบ้านออร์โธปิดิกส์จาก VDO-clip (inter-rater/intra-method reliability) และโดยแพทย์ผู้เชี่ยวชาญทางข้อศอกจาก VDO-clip ที่เวลาแตกต่างกัน (intra-rater/intra-method reliability)*

***ผลการศึกษา:*** *ผล intraclass correlation coefficient และ Bland-Altman analysis แสดงความเป็นไปได้ในการวัดพิสัยการเคลื่อนไหวข้อศอกโดยใช้ภาพจาก VDO clip แม้ผู้วัดจะมีประสบการณ์ที่แตกต่างกันและการศึกษาสามารถวัดซ้ำที่ระยะเวลาต่างกันโดยแพทย์ผู้เชี่ยวชาญทางข้อศอกได้โดยไม่เปลี่ยนแปลงผลการศึกษา*

***สรุป:*** *การประเมินพิสัยการเคลื่อนไหวข้อศอกด้วยภาพจาก VDO-clip โดยแพทย์ผู้เชี่ยวชาญทางข้อศอกมีความน่าเชื่อถือเพียงพอ ถึงแม้ทำซ้ำที่ระยะเวลาแตกต่างกัน ซึ่งน่าจะเป็นประโยชน์สำหรับการติดตามการรักษาของผู้ป่วยอย่างต่อเนื่อง โดยเฉพาะอย่างยิ่งผู้ป่วยที่ประสบปัญหาในการเดินทางมาโรงพยาบาล*