TECHNOLOGICAL ADVANCES

Use of Mobile Phones in Measurement of Knee Range of Motion – An Innovative and Practical Approach.

Qaed Dhariwal[1,2], Roby John, Ashok K Shyam[2,3]

Introduction: Measurement of knee range of motion is important to assess the severity of the knee lesion and is also of prognostic significance to assess the effectiveness of intervention.[1,2] Especially in cases of joint replacement where accurate measurement of knee range directly affects various clinical and functional scores like knee society score.[3] There are three methods used by most of the clinicians to judge the range of motion, visual estimation, manual goniometer and electronic goniometer. Visual estimation is an estimate recorded by the clinician by roughly judging the angle. On an average this is the most commonly used technique by all the clinicians, as it is simple, fast and is easy to use in the outpatient department. Few studies have found it comparable with the goniometer measurements.[4] However it does depend on the experience of the examiner. Others have reported inaccuracy to be in mean range of 25% with high intra and inter observer variability.[5] Few have commented on the extreme variability of these methods and commented on them as valueless for scientific studies.[6] Manual goniometers are the most commonly used device and are portable and economical.[6] Major disadvantage of goniometer is that while measuring both hand have to be used to hold the goniometer hence the body part cannot be stabilized.[7] Also these are difficult to use in obese patients and are known to over-estimate the measurements.[8] The interobserver and intraobserver variability is also reported to be quite high with use of these devices and repeated measurements need to be taken to improve the accuracy of the device.[9,10] Electrogoniometers are found to be more precise and are independent of the drawback of inter and intraobserver variations. They are however quite expensive, cumbersome to use, not very portable. The accuracy of these devices is also questioned with increased error at the extremes of motion.[11,12]

Thus all these methods have their advantages and disadvantages and a need for a portable but accurate instrument was felt in our practice. Two of the authors (QD and RJ) came out with an innovative idea of measurement using the mobile phone application. They developed the software which is based on the modern smartphone accelerometer technology and developed the Digital Goniometer Software (DGS). This software enables us to use the mobile phone as a goniometer and measure the angle flexion extension.

[1]Inamdar Hospital, Pune
[2]Department of Orthopaedics, Sancheti Institute for Orthopaedics and rehabilitation, Pune Maharashtra, India.
[3]Indian Orthopaedic Research Group, Maharashtra, India.

Address of Correspondence: Dr Qaed Dhariwal
H 19/20, Konark Pooram, Kondhwa, Khurd, Pune. Maharashtra, India.
Email: qaedjohar@gmail.com

MEASUREMENT TECHNIQUE.

The measuring surface of the phone is placed on the anterior surface of the thigh and the initial reading is taken (fig 1a). The screenshot shows the virtual goniometer, one arm of it then freezes with respect to the anterior surface of the thigh (Figure 1b). The phone is then placed on the anterior surface of the shin of the tibia and the final angle measurement is calculated by the phone (fig1c). The screenshot now shows the other arm of the goniometer that measures the inclination of this surface with respect to the previously freezed first arm (Figure 1d). Thus the phone measures the angle of the joint flexion in a two dimensional space making it more accurate. The definition of exact site to place the phones to accurately measure the angles is under investigation currently, however we presume that the placement points similar of standard goniometer will be useful for routine use.

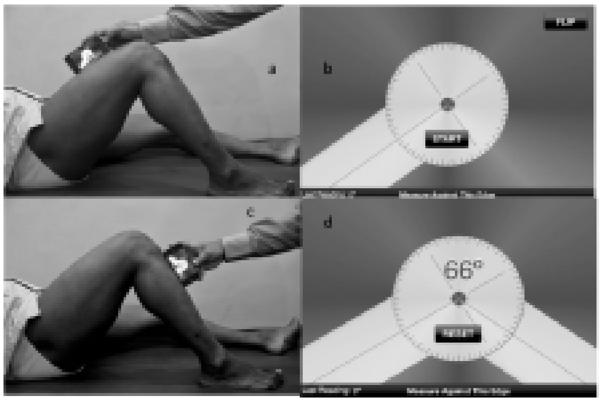

Fig 4: TW2 weighted coronal cut showing involvement extending to lesser and greater trochanter.

The most important advantage is the availability and ease of measurement. Everyone in today's world carries a mobile smartphone and it is readily available when needed. The technique of measurement is very simple to use and does not require any technical knowledge. Also if the points of placing the phone are same, the inter-observer and intra-observer variability will also be negated. The only disadvantage is that the starting point of measurements is to be assessed visually. This may add some interobserver error; however the ease and availability of this technology will definitely make it a success.

A detailed study on measurement of validity, reliability, accuracy and precision of this device has been undertaken at multiple centers across India and soon the results will be published. Use of this technology in measurement of complex motions such as supination pronation and inversion eversion is still investigational and we should shortly be able to improve the applicability and accuracy of the device further. However we feel in current form it is very useful in measurements of single plane range of motion especially at joints like knee, ankle, elbow wrist, shoulder and spine.

The software currently works on the Apple iPhone and is available on the ITunes store. The authors are also in the final stages of developing software which will enable surgeons to maintain their patient records and data using the cell phone. This will again be a revolutionary event in area of data collection, management and retrieval in particular and improved clinical research in general.

Note: this software has been patented and copyrighted by Dr Qaedjohar Dhariwal and Mr Roby John and is available on ITunes.

REFERENCES

1. Franklin PD, Li W, Ayers DC The Chitranjan Ranawat Award: functional outcome after total knee replacement varies with patient attributes. Clin Orthop Relat Res. 2008 Nov;466(11):2597-604.
2. Kotani A, Yonekura A, Bourne RB. Factors affecting range of motion after contemporary total knee arthroplasty. J Arthroplasty 2005; 7: 850-56.
3. Ewald FC. The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. Clin Orthop Relat Res 1989;(248):9-12.
4. Allington NJ, Leroy N, Doneux C. Ankle joint range of motion measurements in spastic cerebral palsy children: intraobserver and interobserver reliability and reproducibility of goniometry and visual estimation. J Pediatr Orthop B. 2002 Jul;11(3):236-9.
5. Rose V, Nduka CC, Pereira JA, Pickford MA, Belcher HJ. Visual estimation of finger angles: do we need goniometers? J Hand Surg Br. 2002 Aug;27(4):382-4.
6. Lea RD, Gerhardt JJ. Range-of-motion measurements. J Bone Joint Surg Am. 1995;77(5):784–798.
7. Allard P, Stokes IAF, Blanchi J-P. Three-dimensional analysis of human movement. Champaign: Human Kinetics; 1994.
8. Nussbaumer S, Leunig M, Glatthorn JF, Stauffacher S, Gerber H, Maffiuletti NA. Validity and test-retest reliability of manual goniometers for measuring passive hip range of motion in femoroacetabular impingement patients. BMC Musculoskelet Disord. 2010 Aug 31;11:194.
9. Watkins MA, Riddle DL, Lamb RL, Personius WJ. Reliability of goniometric measurements and visual estimates of knee range of motion obtained in a clinical setting. Phys Ther. 1991 Feb;71(2):90-6
10. Gogia PP, Braatz JH, Rose SJ, Norton BJ (1987). Reliability and validity of goniometric measurements at the knee. Phys Ther. Feb;67(2):192-5.
11. Shiratsu, A. and Coury, H.J.C.G., 2003, Reliability and accuracy of different sensors of a flexible electrogoniometer. Clinical Biomechanics, 18, 682–684.
12. Bronner S, Agraharasamakulam S, Ojofeitimi S. Reliability and validity of electrogoniometry measurement of lower extremity movement. J Med Eng Technol. 2010 Apr;34(3):232-42.

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