Accuracy of patient-reported range of elbow motion

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Abstract

Background: Patient-reported outcome measures (PROMs) not only provide valuable insights into subjective indices of joint health, but also may provide limited objective information about range of motion (ROM). We sought to evaluate the accuracy of patient-reported range of elbow motion compared to measured ROM.

Methods: Sixty clinic patients were recruited, of whom 26 had elbow pathologies and 34 had pathologies other than at the elbow joint. Each patient independently estimated ROM for extension, flexion, pronation and supination before this was measured by a clinician using a universal goniometer, with the mean being the gold standard.

Results: We found that patients' ROM estimates were significantly different from measured ROM ($p < 0.00001$ at 95% confidence interval). There was no statistically significant difference between elbow pathology and non-elbow pathology patients' estimated ROM.

Conclusions: There was great disparity between patient-estimated and measured ROM, although estimates of patients with known elbow pathology did not demonstrate any significant difference from their healthy counterparts. These differences may be too great for patient-estimated range of motion to be used as a reliable tool for assessing outcomes.

Keywords

elbow, goniometer, patient-reported outcome measure, range of motion

Date received: 27th July 2015; accepted: 7th December 2015

Introduction

There is an increasing trend to employing subjective patient-reported outcome measures (PROMs) as a means of monitoring disease activity and postoperative recovery.¹ PROMs such as the Disabilities of Arm, Shoulder and Hand (DASH)² score are limited by their subjectivity, as well as their wide interpatient variation, and do not provide complete information regarding operative potential or functionality. Furthermore, none of the many scoring systems has been adopted as the standard score. This becomes relevant when attempting to compare clinical outcomes measured using different scoring systems because their parameters, as well as the differing emphasis that each system places upon them, vary.

Range-of-motion (ROM) indices yield an objective and complementary parameter for gauging severity of pathology, post-intervention outcome and functionality,³ yet they remain largely estimated by clinicians and not patients. Although the Liverpool Elbow Score⁴ attempts to reconcile PROMs with elbow ROM, the

latter is consultant-led. To our knowledge, no comparative studies have been conducted into the accuracy of patient ROM estimation.

We aimed to quantify and compare patient estimates and actual measurement of elbow ROM across trauma and orthopaedic patients with and without elbow pathology. In addition, we aimed to compare clinician estimates with actual measurements.

Materials and methods

Between September 2013 and March 2014, sixty trauma and orthopaedic outpatients consented and were

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recruited, of whom 26 (a total of 34 elbows) had elbow pathology such as fractures or arthritis with limited ROM, and seven had limited ROM as a result of forearm and/or wrist involvement such as distal radial or scaphoid fractures. The remaining 27 had no history of elbow, forearm or wrist pathology or injury and an assumed normal ROM. A statistician-agreed minimum of 50 participants (25 per subgroup) was recommended to validate the statistical analyses. Patient demographics including date of birth, sex, hand dominance and underlying pathology were noted.

Exclusion criteria included any patient aged less than 18 years, patients wearing devices restricting movement such as casts and patients with neurological disorder or intense pain. Because of the complexity of the instructions, patients considered unable to comprehend the protocol were also excluded. Otherwise, a wide variety of demographics was encouraged to best reflect the heterogeneity of British patients.

Participants were instructed to hold both elbows at their waist throughout to negate shoulder contributions

to forearm rotation. First, they were encouraged to perform flexion, extension, pronation and supination to their maximal extent, but not to strain their elbow in such a way that this did not reflect their everyday usage and that reproducibility of elbow movements could not be achieved.

Participants were then shown Figures 1a and 1b and explained that these represented arcs of motion. They were asked to plot the maximal extent of each of the four movements on the arc without any time pressure, assistance or influence from the investigator or any companions. They were first directed to the flexion–extension illustration but had to plot their estimates independently without any orientation from the investigator. The same was repeated for pronation–supination. The investigator measured and documented their plotted estimates to the nearest degree using a goniometer. Great care was taken to standardize instructions across all participants to prevent bias.

The investigator took the measurements three times and the mean was taken as the gold standard. In flexion

Figures 1a and 1b. Participants plotted their estimates of all four elbow motions on the arcs, knowing that the numbers along the arc served only as a guide, not as a suggestion. Written instructions were 'Standing with your arm by your side, please mark anywhere along the arc on the diagram below with two crosses to show how far you can straighten your elbow (extension)'. Identical instructions for elbow bending (flexion), palm to face the floor (pronation) and to face the ceiling (supination) were also printed as appropriate.

and extension, the stationary arm of the goniometer was positioned on the mid-humeral line, the axis on the lateral epicondyle, and the mobile arm of the goniometer was positioned on the mid-forearm line. In pronation and supination, the stationary arm of the goniometer was hung perpendicular to the floor, whereas the mobile arm was laid to rest on the mid-point of a line drawn 2 cm proximal to the proximal wrist skin crease.

Statistical analysis was performed using Instat software (Graphpad Software, La Jolla, California, USA) and was supported by a hospital statistician. Differences between estimates and measured angles were collected, summed and divided by the total number of elbows, giving the mean difference. Paired one-tailed Student's *t*-tests using the mean difference enabled formal comparison. Summing and subtracting two times the SD from the mean difference yielded the limits of agreement. Finally, data were separated into the four cardinal elbow movements, as well as into elbow pathology versus non-elbow pathology patients, and the above statistical analyses were repeated.

Results

The study group consisted of 29 females and 31 males; 53 were right-handed and seven were left-handed. The mean age was 50.1 years (range 24 years to 88 years).

The pathologies consisted principally of distal humerus or radial head fractures, osteoarthritis and rheumatoid arthritis.

Limits of agreement at 95% confidence interval, when combining flexion, extension, pronation and supination, were substantial for patients (-42.0° to 70.8°) (Table 1).

Paired one-tailed *t*-tests revealed a statistically significant difference between patient-estimated and actual ROM combining all four movements ($p < 0.00001$; 95% confidence interval). This was not apparent in the clinician *t*-test ($p = 0.95$).

Taken apart, estimates of flexion showed a markedly wider limit of agreement (patient -44.69° to 128.95°) compared to other movements (Table 2).

Table 1. 95% limits of agreement for combined patient-estimated flexion, extension, pronation and supination.

	Patients
Aggregated mean difference	14.35°
Aggregated SD	28.20°
Limits of agreement	-42.05° to 70.76°

Excluding the eight participants with forearm and/or wrist involvement, comparison of controls and participants with elbow pathology revealed no statistically significant difference in ROM estimation ($p = 0.1766$) by a two-tailed *t*-test.

The differences between estimated and measured ROM for the two populations are shown in Figures 2a to 2d.

F-tests demonstrated that between-patient, extension and supination variances were statistically higher in non-elbow pathology patients than their pathological counterparts, with flexion and pronation not being statistically different.

Table 2. 95% limits of agreement for patients with and without elbow or forearm/wrist pathology, separated into flexion, extension, pronation and supination.

	All patients	Control patients	Elbow patients
Extension			
Mean difference	-3.08	-6.67*	1.62
SD	20.41	13.87	26.80
Limits of agreement	-43.89 to 37.74	-34.41 to 21.08	-52.38 to 55.61
Flexion			
Mean difference	42.13*	35.72*	50.53*
SD	43.41	39.85	48.48
Limits of agreement	-44.69 to 128.95	-43.99 to 115.42	-46.44 to 147.49
Pronation			
Mean difference	8.89*	6.60	11.90*
SD	24.27	24.13	24.92
Limits of agreement	-39.64 to 57.43	-41.67 to 54.86	-37.94 to 61.74
Supination			
Mean difference	9.46*	7.59*	11.90*
SD	18.22	14.06	22.86
Limits of agreement	-26.99 to 45.91	-20.54 to 35.71	-33.83 to 57.63

*Statistical significance on a one-sample *t*-test.

Figures 2a–2d. Scatter plots compare the estimated and measured ROM for all four elbow movements. Estimates by patients with elbow pathology are contrasted with those without. There was no overall significant difference between the two populations.

Figures 2a–2d. Continued.

Discussion

The key finding of the present study is that, overall, patients estimate ROM with insufficient reliability. Errors of flexion estimation were most apparent, with 20 patients estimating flexion as 180°. This may be attributed to the higher numbers involved in estimating flexion; this error contributed substantially to the higher errors incurred by participants. It appears that, despite being more abstract, pronation and supination estimates were not substantially less accurate than extension and flexion.

Our results echo findings reported by Blonna et al.⁵ In their diagnostic study, systematic errors of elbow ROM estimation amongst clinicians of many years' experience, clinical fellows and physician assistants were low compared to errors of the inexperienced study coordinator.

We acknowledge that a variety of heterogeneous conditions, such as rheumatoid arthritis, hypermobility and fractures, are combined on the assumption that, regardless of pathology, perception of ROM remains similar across different conditions. It is clear that patients with chronic conditions may be more accustomed to predictions than acute fracture patients. Moreover, we assumed that patients perceived extension, flexion, pronation and supination equally when combining movements as indicated in Table 1. These were separated into their individual components in Table 2.

The universal goniometer was selected to objectively measure angles based upon its widespread use in clinics. Although associated with sound intra-tester reliability, it is limited by its reasonably low inter-tester reliability^{6,7} compared to radiological estimation, and a reliance on bony landmarks,⁸ which may be difficult to accurately palpate in obese individuals or those with severe joint involvement. Ranges of error of up to 14° have been observed in universal goniometers.

Overall, there is a significant discrepancy for patient-estimated elbow ROM compared to the actual elbow ROM. Requesting patient-assessed ROM in surveys and other correspondence may not be reliable and this is probably best left to clinicians.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethical Review and Patient Consent

Every participant verbally consented to the study. No ethical difficulties arose.

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