Journal of Hand Surgery Global Online 5 (2023) 48–54

Contents lists available at ScienceDirect

Journal of Hand Surgery Global Online

journal homepage: www.JHSGO.org

Original Research

Clinical Utility of Patient-Reported Outcome Measures Used for Tendon and Nerve Transfers for Tetraplegia in New Zealand

K. Anne Sinnott Jerram, PhD, [*,†] Jennifer Ann Dunn, PhD, [‡] Richard Peter Smaill, PhD, [†] James Walter Middleton, MBBS, PhD [*,§]

[*] John Walsh Centre for Rehabilitation Research, The Kolling Institute, Northern Sydney Local Health District, NSW, Australia., Australia
[†] Burwood Academy Trust, Burwood Hospital, Christchurch, New Zealand
[‡] Department of Orthopedic Surgery & Musculoskeletal Medicine, University of Otago, Christchurch, New Zealand
[§] Translational Research Collective, Faculty of Medicine and Health, The University of Sydney, NSW, Australia

ARTICLE INFO

Article history:
Received for publication June 9, 2022
Accepted in revised form October 4, 2022
Available online November 16, 2022

Key words:
Patient-reported outcomes
Tetraplegia
Upper extremity reconstructive surgery

Purpose: This study determines the clinical utility of patient-reported outcome measures used to measure outcomes of upper extremity (UE) reconstructive procedures in individuals with tetraplegia. The patient-reported outcome measures are the Canadian Occupational Performance Measure, the Capabilities of Upper Extremity Questionnaire (CUE-Q), and the Personal Wellbeing Index.
Methods: Retrospective data of 43 individuals with spinal cord injury (SCI) levels C4-C7 tetraplegia, and American Spinal Injury Association Impairment Scale grades A-D who had upper limb reconstructive surgery were reviewed. Participants were grouped according to their SCI level and resultant surgical procedures into higher SCI severity and lower SCI severity groups.
Results: The mean age of participants was 26.3 years (SD 13.4; range 13–64 years). The higher-severity SCI group required elbow and hand reconstruction surgery, whereas the lower-severity group only required hand reconstruction surgery. Important differences in Canadian Occupational Performance Measure priorities were identified between the higher and lower SCI severity groups. Question redundancy was evident with the CUE-Q. The self-report Personal Wellbeing Index captures the possible impacts of improved UE function on an individual's perceived sense of personal wellbeing.
Conclusions: In this patient-reported outcome measure analysis, we found that the level of impairment influences patient priorities. Functional measures ought to consider UE impairment and personal wellbeing as a construct in this population, given the demands of surgery.
Type of Study/Level of Evidence: Prognostic II

Measuring the outcomes following upper extremity (UE) reconstructive surgery for tetraplegia is increasingly important considering the advent of nerve transfer (NT) procedures that are now offered at a much earlier stage following spinal cord injury (SCI) to augment traditional tendon transfer (TT) procedures.[1] For TT surgery, proposals dating back as far as 2007 have included recommendations for the collective use of the Canadian Occupational Performance Measure (COPM) in all upper limb surgery centers worldwide to capture and document individuals' self-identification of problems.[2] In keeping with self-identification, 2 patient-reported outcome measures (PROMs), the Capabilities of Upper Extremity Questionnaire (CUE-Q) and the Personal Wellbeing Index (PWI), were added to the battery of measures within the International Upper Limb Surgery registry.[3–5] Although the CUE-Q was designed to measure functional limitation of the UE in individuals with tetraplegia, it had previously been recommended as being useful in the upper extremity (UE) reconstructive surgery population.[6,7] However, robust studies that report the use of the CUE-Q in this population are lacking. The PWI was validated for SCI.[8] However, we are not aware of any studies that report changes in individuals'

Declaration of interests: No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

Corresponding author: K. Anne Sinnott Jerram, University of Sydney, John Walsh Centre for Rehabilitation Research, Kolling Institute, 10 Westbourne Street St Leonards, Sydney, NSW 2065, Australia.
E-mail address: anne.sinnottjerram@sydney.edu.au (K.A. Sinnott Jerram).

https://doi.org/10.1016/j.jhsg.2022.10.005

perception of their personal wellbeing, specific to UE reconstructive surgery.

We aimed to explore the clinical utility of these PROMs because self-report measures are time-consuming and demanding, so it is important to understand their clinical usefulness. Clinical utility is a term used to "describe the relevance and usefulness of an intervention in patient care."[9] Although extensive research demonstrates good clinical utility for the COPM in this population, the clinical utility of the CUE-Q and PWI has yet to be established.[10–14] We postulated that the clinical utility of all 3 PROMs differs according to the suite of surgical interventions offered and the likelihood of achievable functional improvements with the activities of daily living.

There are many contributors to clinical utility, including analytic validity, clinical validity, test setting and purpose, societal legitimacy, efficacy and effectiveness, the balance of outcomes, patient and family acceptability, economic measures, and equity.[15] For this study, we reviewed the clinical validity and explored further the test setting, purpose, and effectiveness. Clinical validity determines the potential clinical uses of the measures, whereas test setting and purpose determine the outcomes sought from the testing. Notably, effectiveness determines the potential for the test to describe the health outcomes sought.[15] The aims of this paper are to review outcomes data from the 3 PROMs used to report changes over time for individuals with tetraplegia in New Zealand. The primary outcome was to determine whether the COPM, CUE-Q, and PWI demonstrated clinically meaningful changes in scores after UE surgery. This study is part of a larger series where we hypothesized that the functional priorities, activities of daily living, and contextual factors are not measured adequately by the current clinician-directed PROMs.[16,17]

Materials and Methods

Inclusion criteria for the international registry were: (i) a cervical SCI between C4–C7 levels and American Spinal Injury Association Impairment Scale (AIS) grades A, B, C, or D, (ii) assessed clinically as suitable for surgical reconstruction requiring TT on one or both arms, (iii) 16 years or older at time of the first surgery. Inclusion criteria for this study were: i) TT surgery performed to restore elbow extension and/or pinch grip and/or grasp at least 6 months previously (+/− a single NT procedure); and ii) completion of both preoperative and postoperative clinical outcome measures. The exclusion criteria for this study were: i) revision surgery, ii) NT for finger extension only, and iii) tendon lengthening procedures without any TT reconstruction. The surgery cohort was divided by their clinically determined SCI severity into 2 main groups: 1) lower-severity SCI group (who required pinch and/or grip reconstruction only) and 2) higher-severity SCI group (who required elbow extension and pinch and or/grip reconstruction +/ NT). It is routine clinical practice at the Burwood Spinal Unit for bilateral and simultaneous surgery, where first elbow reconstruction and then pinch and/or grip reconstruction are performed. Thus, the analysis of the CUE-Q was ordered first by elbow reconstruction procedures and then the pinch and/or grip reconstructions. Elbow reconstructions used posterior deltoid to triceps TT , and hand reconstructions comprised forearm TT for pinch and/or grasp. The split distal flexor pollicis longus tenodesis was used as an alternative to thumb interphalangeal joint arthrodesis to prevent excessive flexion of the thumb during key pinch.[18] All NT procedures were the nerve to supinator being transferred to the posterior interosseous nerve (SPIN) and were performed at least 6 months prior to any TT procedures.

Sociodemographic and clinical details and reconstruction type are reported using descriptive statistics. The information included date of birth, date and cause of SCI, ethnicity, geographic location, surgical procedures and complications, impairment categorization using International Standards of Neurological Classification of Spinal Cord Injury (ISNCSCI) and International Classification for Surgery of the Hand in Tetraplegia.[19,20] The COPM, CUE-Q, and PWI were completed prior to each TT procedure. The COPM, CUE-Q, and PWI were completed between 6 and 12 months following surgery. The COPM is an instrument that uses interviews to enable individuals to identify, prioritize, and score their satisfaction and performance of self-selected activities over time. Individuals then prioritize the 5 most important activity limitations they identified during the interview and rate their current level of performance and satisfaction. Performance and satisfaction are scored separately on a 1–10 scale, where 10 indicates very good performance and high satisfaction.[2] When looking at clinically meaningful changes to the COPM, the summed score of performance and satisfaction are each divided by the number of problems identified (in this case, 5 for each individual) to provide an average score for each identified problem. A change of more than 2 points in the average COPM score has been identified as clinically meaningful.[21] The CUE-Q is a 17-item questionnaire (15 items assessed separately for right and left sides, and 2 bimanual activities) in which individuals rate their ability to perform functional tasks with their upper limbs on a 5-point scale (0 = unable/complete difficulty, 1 = severe difficulty, 2 = moderate difficulty, 3 = mild difficulty, and 4 = no difficulty).[3] Scores of the CUE-Q range between 0 and 128; the higher the score, the less difficulty the individual has performing the activity. The PWI consists of 8 items gauging satisfaction with specific life domains (living, standard, health, achievement, relationships, safety, community, religion/spirituality, and future security) and one optional question about overall life satisfaction. Responses are provided on a 0–10 rating scale. The lower the rating, the less the satisfaction.[22] The psychometric properties of these 3 measures are provided in Appendix 1 (available on the *Journal's* website at www.jhsgo.org).

For the COPM, CUE-Q, and PWI, summed score changes from preoperative to postoperative (6–12 months) assessment were determined for the full cohort first and then for the lower and higher SCI severity groups. Changes from preoperative to postoperative assessment were determined for single-item scores for the CUE-Q and PWI. Using SPSS24, the data met the criteria for the use of the Wilcoxon test, which is recommended to test for differences between groups when the dependent variable being measured is ordinal.[23] For the single-item analyses, two-way ranked analysis is reported with median score change provided to determine frequencies of score changes for the full surgery group and then the 2 SCI severity groups. In all cases, the median scores and interquartile ranges are reported. Again, this was calculated for the full surgery group with completed preoperative and postoperative scores and then for the higher and lower SCI severity groups for each measure. Additionally, the higher SCI severity group was analyzed separately in relation to the CUE-Q score changes for the questions specific to elbow function. This was repeated for the lower SCI severity group. This distinction was repeated for the COPM for performance and satisfaction and the PWI. In addition, the CUE-Q single-item score change over time was calculated for preoperative and postoperative for the full sample (n = 43). The threshold for significance was set at $P < .05$. Frequency analysis provided median score changes that give a better idea of which results are clinically meaningful. The minimal clinically meaningful difference for the PWI is that a 1-point median score difference is detectable.[7,24]

Ethical approval for this study phase was obtained from the Canterbury District Health Board Ethics Committee (RO 14063-A1). Informed consent was sought at the time of clinical assessment as

Table 1
Demographics and SCI Characteristics

	Group 1: Lower SCI severity	Group 2: Higher SCI Severity	chi-square $P < .05$
Number of people (arms)	23 (44 arms)	20 (40 arms)	.07
Mean age at injury years, (SD) range	29.8 (14.6) 16–64	22.8 (14) 13-56	.38
<30	16 (69.6%)	16 (69.6%)	
31–45	2 (8.7%)	3 (15%)	
46–65	5 (21.7%)	1 (5%)	
Women:Men	4:19	7:13	.59
Men %	82.6%	65%	
Time from injury to surgery years, (SD) range	10.3 (2.24) 1.2-34.1	10.9 (1.4) 0.3-16.6	**.001***
<6 months	0	4 (20%)	
6–12 months	0	4 (20%)	
1–2 years	5 (21.7%)	5 (25%)	
2–5 years	4 (17.4%)	4 (20%)	
5–10 years	3 (13.0%)	1 (5%)	
>10 years	11 (47.8%)	2 (10%)	
Ethnicity			.59
NZ European	17 (73.9%)	13 (65%)	
Māori	4 (17.4%)	3 (15%)	
Pacific	0	1 (5%)	
Other	2 (8.7%)	3 (15%)	
Cause of Injury			.26
Sports	14 (60.9%)	7 (35%)	
Transportation	6 (26.1%)	10 (50%)	
Fall	3 (13%)	3 (15%)	
Other traumatic event	0	0	
ISNCSCI level			**.008***
C4	0	3 (15%)	
C5	5 (21.7%)	10 (50%)	
C6	7 (30.4%)	6 (30%)	
C7	11 (47.8%)	1 (5%)	
AIS severity score			.67
A	14 (60.9%)	13 (65%)	
B	7 (30.4%)	4 (25%)	
C	1 (4.3%)	3 (15%)	
D	1 (4.3%)	0	
Reconstructions (limbs)			
NT - SPIN	0	18 (90%)	<.001*
Key pinch	44 (95.6%)	16 (40%)	<.001*
Grasp	42 (95.2%)	12 (30%)	<.001*
Elbow	0	40 (100%)	<.001*
Other joint fusions	20 (43.5%)	14 (35%)	.96
Surgeries			
Bilateral simultaneous	21 (91.3%)	18 (90%)	
Bilateral staged	0	1 (5%)	
Unilateral	2 (8.7%)	1 (5%)	
ICSHT	R/L	R/L	R.47
O0	1/1	0/1	L.80
O1/OCu1	6/8	8/8	
OCu2	2/1	3/1	
OCu3	4/3	4/5	
OCu4	7/4	2/1	
OCu5	1/3	3/5	
OCu6	1/0	0/0	
OCu7	1/1	0/0	
X	0/1	0/0	
not classified	1/1	1/	

ISNCSCI - International Standards for Neurological Classification of SCI; ICSHT International Classification for Surgery of the Hand in Tetraplegia

per the ethics committee approval from the New Zealand Health and Disability Ethics Committee for the development of the International Upper Limb Surgery registry (URA/11/EXP/026).

Results

Of the 99 individuals clinically assessed as suitable for UE surgery between 2010 and 2019, 62 had surgery, and 33 declined the offer. Forty-three (69%) individuals met the inclusion criteria for this cohort study, whereas 19 (30.6%) exclusions included revision surgery, NT for finger extension only, or tendon lengthening procedures without any TT reconstruction. Of the 43 individuals who had surgery and met the inclusion criteria, 39 had completed all PROMs with preoperative and postoperative scores. The dataset for 4 individuals was incomplete, but they were included in the analysis where possible. Sociodemographic details and injury-related characteristics for the 2 SCI severity groups are shown in Table 1. Group 1 was the lower SCI severity (n = 23), comprising only hand reconstructions, and group 2 was the higher SCI severity (n = 20). In group 1, 2 individuals had unilateral procedures only but were included in the analysis. In group 2, all individuals had received elbow reconstruction, 40% had key pinch reconstruction, and 30% had grasp reconstruction. As stated previously, it is routine clinical practice for the individual to receive elbow reconstruction surgery

Table 2
Differences in COPM Based on SCI Severity

Prioritized problem identification per COPM category	Lower SCI Severity Group (N = 23)	Higher SCI Severity Group (N = 20)	chi-square $P < .05$
Problem 1			**<.001***
Self-care	23 (100%)	11 (55%)	
Productivity	0	9 (45%)	
Leisure	0	0	
Problem 2			**<.001***
Self-care	22% (95.7%)	9 (45%)	
Productivity	1 (4.3%)	11 (55%)	
Leisure	0	0	
Problem 3			**.009***
Self-care	16 (69.6%)	7 (35%)	
Productivity	7 (30.4%)	7 (35%)	
Leisure	0	6 (30%)	
Problem 4			**<.001***
Self-care	16 (69.6%)	3 15%)	
Productivity	6 (26.1%)	6 (30%)	
Leisure	1 (4.3%)	11 (55%)	
Problem 5			**<.001***
Self-care	16 (69.6%)	1 (5%)	
Productivity	6 (26.1%)	8 (40%)	
Leisure	1 (4.3%)	11 (55%)	

first and then subsequent surgery for reconstruction of pinch and or grasp reconstruction. One individual had staged procedures, and one had unilateral procedures only. Nine individuals in group 2 also had a single NT procedure (SPIN), and no individuals in group 1 had NT procedures. All elbow reconstruction procedures were posterior deltoid–triceps TT. Key pinch reconstructions were either brachioradialis or extensor carpi radialis longus to flexor pollicus longus TT, and grip reconstructions were either brachioradialis, extensor carpi radialis longus, or pronator teres to flexor digitorum profundus TT.

Canadian Occupational Performance Measure

The COPM goals for the 2 SCI severity groups were analyzed according to the category in which they corresponded (ie, self-care, productivity, or leisure) and the individual's ranking of importance of the goal (Table 2). Individuals in the lower-severity SCI group identified and prioritized more goals in the self-care category. In contrast, individuals in the higher-severity SCI group were more likely to rank productivity goals higher.

Preoperative and postoperative scores for all 3 PROMs

The preoperative and postoperative results for all 3 PROMs are displayed in Table 3. We reported the results of each of the PROMs for the full cohort as well as the lower- and higher-severity SCI groups.

Canadian Occupational Performance Measure

The summed scores are reported for performance and satisfaction. Score changes for COPM satisfaction reached significance for all groups on the Wilcoxon signed-rank test. However, for COPM performance, the higher-severity SCI group did not report a significant improvement ($P = .12$). Clinically meaningful changes (change in more than 2 points in the average score) were seen for performance and satisfaction for the whole cohort and the higher and lower SCI severity groups.

Capabilities of UE Questionnaire

The summed CUE-Q scores for each group showed a significant change before and after surgery. Given the lack of psychometric testing for the CUE-Q, we are unable to determine if this is a clinically meaningful change. When the CUE-Q questions were considered in relation to function following surgery, Questions 1–9 directly related to the ability to reach or lift (Q1–4) and pull and push (Q5–9). Therefore, it was hypothesized that these questions should show changes in scores following elbow reconstruction surgery in the higher-severity SCI group. Similarly, it was hypothesized that there should be no changes in question responses for those who only received hand reconstruction surgery (ie, the lower-severity group). Questions 10–17 relate to moving and positioning your arm and wrist (Q10,11) and using your hands and fingers (Q12–17). Thus, it was hypothesized that there should be changes in these questions' responses following hand reconstruction surgery but not elbow reconstruction surgery. Table 4 displays the change over time in CUE-Q single-item scores calculated for preoperative and postoperative for the full cohort (n = 43). For Q1–9 (relating to elbow reconstruction surgery), only 4 out of the 9 questions showed a significant change between pre and postoperative. These were Q2 (raising the arm above the head), Q3 (reaching down to touch the floor and sitting back up), Q7 (pushing a can of soda away from you), Q8 (pushing a heavy object away from you), and Q9 (pushing down with both arms to lift buttocks out of seat). Of the questions that did not show a change in score, 3 questions (Q2 reach out in front of you; Q5 pull light object; Q7 push light object) all showed that the maximum response had been attained prior to surgery, and, therefore, no further change in score was available.

Similarly, one question (Q3 reach down to the floor); indicated that this task was too difficult/impossible to perform prior to surgery, and there was no change after surgery. Thus, for those who had elbow reconstruction surgery there appeared to be a number of tasks that were able to be performed prior to surgery and some that were impossible to perform either before or after surgery, suggesting redundancy in the questions for this group. In addition, for those who only had pinch and grip reconstruction, there was no change in score in any of these questions, again suggesting question redundancy.

For questions, 10–17 (relating to grip/pinch reconstruction surgery), only one question Q13 (picking up a small object with the tips of the thumb and the first 2 fingers) out of the 8 questions that would be expected to show changes showed a significant change. Again, there were 2 questions that participants had scored the maximum value prior to surgery (Q10 wrist up; Q11 palm down), so no further changes could occur. There were also 3 questions (Q12 grasp a hammer; Q16 manipulate a coin; Q17 push with a finger) that scored extremely difficult/impossible before and after surgery. While there was not a significant change in score for the remaining 2 questions, Q14 key pinch and Q15 wide grasp, changes in responses were seen. This could be because not all individuals had both their key pinch and grasp reconstructed, and, as such, there would be no change in score for Q15 (wide grasp) for those who only had pinch reconstructed and vice versa. Median score changes of further frequency analysis[24] showed a clinically meaningful difference score change for 6 out of the 17 questions. These were (Q2 raising your arm above your head, Q8 pushing a heavy object away from you, Q9 pushing down with both arms to lift your buttocks off the seat, Q13 picking up an object with the tips of thumb and the first 2 fingers, Q14 pinching and holding an object between the thumb and the index finger, Q15 grasping large object with the tips of the fingers enough to pick it up). Overall, the analysis of the questions of the CUE-Q indicates that only 6 out of the 17 (35%) questions showed a clinically meaningful change in score after surgery. When broken down into the type of surgery, only 3 questions out of 9 (33%) related to elbow reconstruction surgery, and 3 questions out of 8 (38%) related to pinch/grip reconstruction.

Table 3
Preoperative and Postoperative Scores for All Measures

Group/Measure	Preoperative	Postoperative	*P* value
Full Cohort – All surgery participants			
COPM (n = 215 goals)			**<.001***
Median summed score (IQR) COPM performance	10 (7–14)	27 (11–36)	
Median averaged score COPM performance	2 (1.4–2.8)	5.4 (2.2–7.2)	**<.001***
Median summed score (IQR) COPM satisfaction	9 (7–21)	29 (23–40)	
Median averaged score COPM satisfaction	1.8 (1.4–4.2)	5.8 (4.6–8)	
CUE-Q (n = 43)	62 (45–76)	76 (65–86)	**.008***
Median (IQR) summed score			
PWI (n = 43)			.07
Part 1 Q1- Life as a whole	7 (4–8)	7 (6–8)	
Part 2			.23
Q1 Living standard	8 (6–8)	8 (7–9)	**.006***
Q2 Health	7 (6–8)	8 (7–9)	.5
Q3 Life achievement	6 (5–7)	6 (5–7)	.38
Q4 Relationships	6 (5–7)	6 (5–7)	.37
Q5 Safety	7 (6–8)	7 (6–8)	**.002***
Q6 Community feeling	7 (5–8)	8 (7–9)	**<.001***
Q7 Future security	6 (5–8)	8 (7–8)	.86
Q8 Spirituality	8 (7–10)	8 (5–10)	
Part 2 Summed Score			
Median (IQR)			**.001***
Summed score	57 (43–62)	60 (53–67)	>5%
PWI % preoperativepost score change			
Group 1: Lower SCI severity (hand reconstruction only)			
COPM (n = 110 goals)			
Median summed score (IQR) performance	10 (6–14)	29 (25–36)	**<.001***
Median summed score (IQR) satisfaction	2 (1.2–2.8)	5.8 (5–7.2)	**<.001***
Median averaged score performance	9 (7–13)	30 (25–40)	
Median summed score satisfaction	1.8(1.4–2.6)	6 (5–8)	
CUE-Q (n = 21)			
Median (IQR) summed score	57 (45–76)	76 (64–88)	**.001***
Q1- 9 Median (IQR) summed score	24 (14–31)	28 (24–32)	**.012***
Q10-17 Median (IQR) summed score	11 (8–14)	17 (11–19)	**.008***
PWI (n = 21)			
Median (IQR)	55 (47–61)	60 (51–67)	**.013***
Summed Scores	1261	1367	
PWI % preoperativepost score change			7.8%
Group 2: Higher SCI severity (elbow and hand reconstruction)			
COPM (n = 100 goals)			
Median summed score (IQR) performance	10 (5–20)	13 (7–46)	
Median summed score (IQR) satisfaction	2 (1.2–2.8)	5.4 (2.2–7.2)	**.006***
CUE-Q (n = 20)			**.006***
Median (IQR) summed score	1.8 (1.4–2.6)	5.8 (4.6–8)	**<.001***
Q1- 9 Median (IQR) summed score	11 (8–14)	17 (11–19)	**.01***
Q10-17 Median (IQR) summed score	10 (8–14)	14 (11–20)	**.01***
PWI (n = 20)			
Median (IQR)	50 (40–61)	60 (53–66.2)	**.046***
Summed Scores	1788	1930	
PWI % preoperativepost score change			7.4%

IQR, interquartile ranges
* $P < .05$ Nonparametric Wilcoxon Test.

Personal Wellbeing Index

In Part 1 of the PWI, the change in score for Q1 about *satisfaction with life as a whole* did not reach significance ($P = .07$). In Part 2 of the PWI, the scores for 3 questions changed significantly over time. These were: Q2 about *satisfaction with health* ($P = .006$), which showed a score change of 1, Q5 about *satisfaction with feeling part of the community* ($P = .002$), with a score change of 2, and Q6 about *satisfaction with a feeling of future security* ($P = .000$), with a score change of 2. The overall summed score for the Part 2 change reached statistical significance ($P = .001$), with a median score difference of 3.

Discussion

This study is part of a larger series exploring the functional priorities, activities of daily living, and contextual factors associated with UE surgery for individuals with tetraplegia.[16,17] The primary outcome of this study phase was to determine whether the COPM, CUE-Q, and PWI demonstrate clinically meaningful score changes following UE surgery. In the first instance, our findings reinforce the recommendation that the COPM is appropriate for this population. The individual's priorities and goals are satisfactorily met by UE reconstructive surgery. However, by dividing our cohort into 2 groups according to SCI severity, we raise the possibility that differences in priorities need to be considered in relation to impairment. While the analysis of the CUE-Q scores showed significant changes between the preoperative and postoperative scores for the full surgery group when each question was analyzed separately, only 6 of 17 questions showed a clinically meaningful change for one or the other hand. These were: Q2 raising the arm above the head, Q8 pushing a heavy object away, Q9 pushing down with both arms to lift the buttocks out of a seat, Q13 picking up a small object between the tips of the thumb and the first 2 fingers, Q14 pinching and holding an object between the thumb and the side of the index finger; and Q15 grasping a large object with the tips of the fingers enough to pick it up. This suggests substantial redundancy in the

Table 4
Full Cohort CUE-Q Single-Item Score Changes preoperative to 6–12 months post-Surgery

N = 43	Preoperative Median (IQR)	Postoperative Median (IQR)	*P value	Median Likert score change	Clinically detectable score change
REACH AND LIFT					
Q1 R	4 (3–4)	4 (4–4)	.09	n/a	n/a
Q1 L	4 (2–4)	4 (4–4)	**.01***	0	no
Q2 R	2 (0–4)	4 (3–4)	**<.001***	2	yes
Q2 L	3 (0–4)	4 (4–4)	**<.001***	1	yes
Q3 R	0 (0–2)	0 (0–3)	**.016***	0	no
Q3 L	0 (0–2)	0 (0–3)	**.037***	0	no
Q4	3 (1–4)	4 (2–4)	.071	n/a	n/a
PULL/PUSH					
Q5 R	4 (4–4)	4 (4–4)	.21	n/a	n/a
Q5 L	4 (4–4)	4 (4–4)	.12	n/a	n/a
Q6 R	4 (4–4)	4 (4–4)	.38	n/a	n/a
Q6 L	4 (4–4)	4 (4–4)	.19	n/a	n/a
Q7 R	4 (3–4)	4 (4–4)	**.001***	0	no
Q7 L	4 (2–4)	4 (4–4)	**<.001***	0	no
Q8 R	3 (1–4)	4 (3–4)	**.01***	1	yes
Q8 L	3 (1–4)	4 (2–4)	**.003***	1	yes
Q9	0 (0–4)	1 (0–4)	**.03***	1	yes
MOVING/POSITIONING					
Q10 R	4 (3–4)	4 (3–4)	.49	n/a	n/a
Q10 L	4 (3–4)	4 (3–4)	.75	n/a	n/a
Q11 R	4 (3–4)	4 (3–4)	.16	n/a	n/a
Q11 L	4 (3–4)	4 (3–4)	.28	n/a	n/a
USING FINGERS/HANDS					
Q12 R	0 (0–1)	0 (0–3)	**.04***	0	no
Q12 L	0 (0–1)	0 (0–2)	.12	0	no
Q13 R	0 (0–2)	1 (0–2)	**.01***	1	yes
Q13 L	0 (0–2)	1 (0–2)	**.03***	1	yes
Q14 R	1 (0–2)	1 (0–3)	**.04***	1	yes
Q14 L	1 (0–2)	1 (0–2)	.09	n/a	n/a
Q15 R	0 (0–0)	1 (1–3)	**<.001***	1	yes
Q15 L	0 (0–1)	0 (0–2)	**.01***	0	no
Q16 R	0 (0–0)	0 (0–0)	.22	n/a	n/a
Q16 L	0 (0–0)	0 (0–1)	**.04***	0	no
Q17 R	0 (0–0)	0 (0–0)	.85	n/a	n/a
Q17 L	0 (0–0)	0 (0–0)	.14	n/a	n/a

* $P < .05$ Nonparametric Wilcoxon Test

questions of the CUE-Q for this population, as some tasks may be impossible for an individual with tetraplegia to perform. In terms of the clinical utility of the CUE-Q in this population, we wanted to determine whether the tasks were relevant for UE surgery for tetraplegia. To do this, we looked at what questions in the CUE-Q showed clinically meaningful change after surgery. We found that for people who had elbow reconstruction surgery, only 3 of the 9 questions about shoulder/upper arm function showed a change.

Additionally, for those who had hand reconstruction, only 3 of the 8 questions about the wrist, finger, and thumb function showed a change. Some questions in both sections show ceiling and floor effects (ie, could already be performed prior to surgery or were extremely difficult to perform even after surgery). Thus, the identified redundancy of over 50% of questions in the tool challenges the clinical validity, efficacy, and effectiveness of this measure. If we use a tool to measure the outcome of surgery, we expect the majority of tasks tested to be capable of demonstrating change.

When looking at the clinical utility of the PWI, and in the absence of a quality-of-life measure for this population, the results provide the impetus for ongoing use of the PWI. As with the CUE-Q, the PWI pre - post operative percentage score differed when the groups were divided by SCI severity. This is notable in terms of the demands of surgeries offered to the higher-severity group and the relatively lower percentage scores. Given that the higher-severity group included the NT procedures undertaken far earlier post-SCI, the psychosocial readiness for elective surgery demands closer scrutiny. Understanding wellbeing in this field forms the basis of this broader study series.[16]

Regarding the specific PROMs, there appear to be important differences in COPM-identified priorities for individuals with different levels of SCI severity. There is a specific concern in terms of question redundancy raised for the CUE-Q. It is clear from this analysis that alternative measures should be explored. Finally, the self-report PWI captures possible impacts of improved UE function on perceived personal wellbeing. All phases of this research received ethical approval from the Canterbury District Health Board Human Ethics Committee. Although not required by either of the ethics committees, consultation in terms of the 'lived experience' of SCI was undertaken by the Burwood Academy Consultation committee. This thesis project was funded by the University of Sydney Clinical Training scheme, the Burwood Upper Limb Surgery Governance group, and the New Zealand Spinal Trust.

Acknowledgments

Our heartfelt thanks are extended to the study participants from New Zealand. We are grateful to the travel funds contributed by the Upper Limb Surgery Endowment Fund, Burwood Hospital, Christchurch New Zealand.

References

1. Fox IK. Nerve transfers in tetraplegia. *Hand Clin*. 2016;32(2):227–242.
2. Law M, Baptiste S, McColl MA, Opzoomer A, Polatajko H, Pollock N. The Canadian Occupational Performance Measure: an outcome measure for Occupational Therapy. *Can J Occup Ther*. 1990;57(2):82–87.

3. Marino RJ, Shea JA, Stineman MG. The capabilities of upper extremity instrument: reliability and validity of a measure of functional limitation in tetraplegia. *Arch Phys Med Rehabil*. 1998;79(12):1512–1521.
4. Cummins R. *Personal Wellbeing Index*. Australia: Australian Centre on Quality of Life, Deakin University; 2010.
5. Sinnott KA, Dunn JA, Rothwell AG, Hall AS, Post MW. The development of the NZ upper limb surgery registry for tetraplegia. *Spinal Cord*. 2014;52(8):611–615.
6. Bryden A, Sinnott A, Mulcahey MJ. Innovative strategies for improving upper extremity function in persons with tetraplegia and considerations in measuring functional outcomes. *Top Spinal Cord Inj Rehabil*. 2005;10(4):75–93.
7. Mulcahey MJ, Hutchinson D, Kozin S. Assessment of upper limb in tetraplegia: considerations in evaluation and outcomes research. *J Rehabil Res Dev*. 2007;44(1):91–102.
8. Geyh S, Fellinghauer BA, Kirchberger I, Post MW. Cross-cultural validity of four quality of life scales in persons with spinal cord injury. *Health Qual Life Outcomes*. 2010;8:94.
9. Lesko LJ, Zineh I, Huang SM. What is clinical utility and why should we care? *Clin Pharmacol Ther*. 2010;88(6):729–733.
10. Wangdell J, Friden J. Performance of prioritized activities is not correlated with functional factors after grip strength reconstruction in tetraplegia. *J Rehabil Med*. 2011;43(7):626–630.
11. Wangdell J, Friden J. Activity gains after reconstruction of elbow extension in patients with tetraplegia. *J Hand Surg Am*. 2012;37(5):1003–1010.
12. Wangdell J, Fridén J. Satisfaction and performance in patient selected goals after grip reconstruction in tetraplegia. *J Hand Surg Eur Vol*. 2010;35(7):563–568.
13. Wangdell J, Carlsson G, Fridén J. Enhanced independence: experiences after regaining grip function in people with tetraplegia. *Disabil Rehabil*. 2013;35(23):1968–1974.
14. Wangdell J, Carlsson G, Friden J. From regained function to daily use: experiences of surgical reconstruction of grip in people with tetraplegia Orthop Rheumatol. *Disabil Rehabil*. 2014;36(8):678–684.
15. Burke W, Laberge AM, Press N. Debating clinical utility. *Public Health Genomics*. 2010;13(4):215–223.
16. Sinnott Jerram KA, Dunn JA, Smaill RP, Middleton JW. Using mixed methods to better appreciate the life impact of upper limb reconstruction surgeries for tetraplegia in New Zealand. *JSM Orthop Rheumatol*. 2019;5(7):1–7.
17. Sinnott Jerram K, et al. ICF word mapping to determine the human functioning associated with arm/hand surgery for tetraplegia. *J Inj Funct Rehabil*. 2022. Under review.
18. Mohammed KD, Rothwell AG, Sinclair SW, Willems SM, Bean AR. Upper limb surgery in tetraplegia. *J Bone Joint Surg Br*. 1992;74(6):873–879.
19. Kirshblum SC, Burns SP, Biering-Sorensen F, et al. International standards for neurological classification of spinal cord injury (Revised 2011). *J Spinal Cord Med*. 2011;34(6):535–546.
20. McDowell CL, Moberg EA, House JH. The Second International Conference on Surgical Rehabilitation of the Upper Limb in Tetraplegia (Quadriplegia). *J Hand Surg*. 1986;11(A):604–608.
21. McColl MA, Paterson M, Davies D, Doubt L, Law M. Validity and community utility of the Canadian Occupational Performance Measure. *Can J Occup Ther*. 2000;67(1):22–30.
22. Lau AL, Cummins RA, McPherson W. An investigation into the cross-cultural equivalence of the Personal Wellbeing Index. *Social Indicators Research*. 2005;72(3):403–430.
23. Derrick B, White P. Comparing two samples from an individual Likert question. *Int J Math Stat*. 2017;18(3):1–13.
24. Research Optimus. What is Frequency Analysis? History and Definition of Frequency Analysis. Research Optimus. Accessed May 19, 2022. https://www.researchoptimus.com/article/frequency-analysis