Research Article

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A Systematic Review of Outcome Measures Assessing Disability Following Upper Extremity Trauma

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Abstract

Objectives: To define upper extremity outcome measures focusing on trauma and level of initial psychometric evaluation and to assess methodological quality of relevant patient-reported outcome (PRO) measures.

Data Sources: A broad search strategy using PubMed, OVID, CINAHL, and PsycINFO was deployed and reported using PRISMA (PROSPERO: CRD42016046243).

Study Selection, Extraction, Synthesis: PRO measures involving orthopedic trauma in their original development were selected and original publications assessed, including psychometric evaluations. Extraction, synthesis, and quality assessment were performed using COSMIN.

Results: Of 144 upper extremity outcome measures, the majority were designed for the shoulder, wrist, and hand; 20% (n = 29/144) involved trauma conditions in their initial development, PRO measurements, and psychometric evaluation on introduction. Methodological quality was highly variable.

Conclusion: A few PRO measures were originally designed for use in upper extremity trauma. Methodological quality and psychometric evaluation need to improve. This review aims to highlight strengths and weaknesses and guide decision making in this field.

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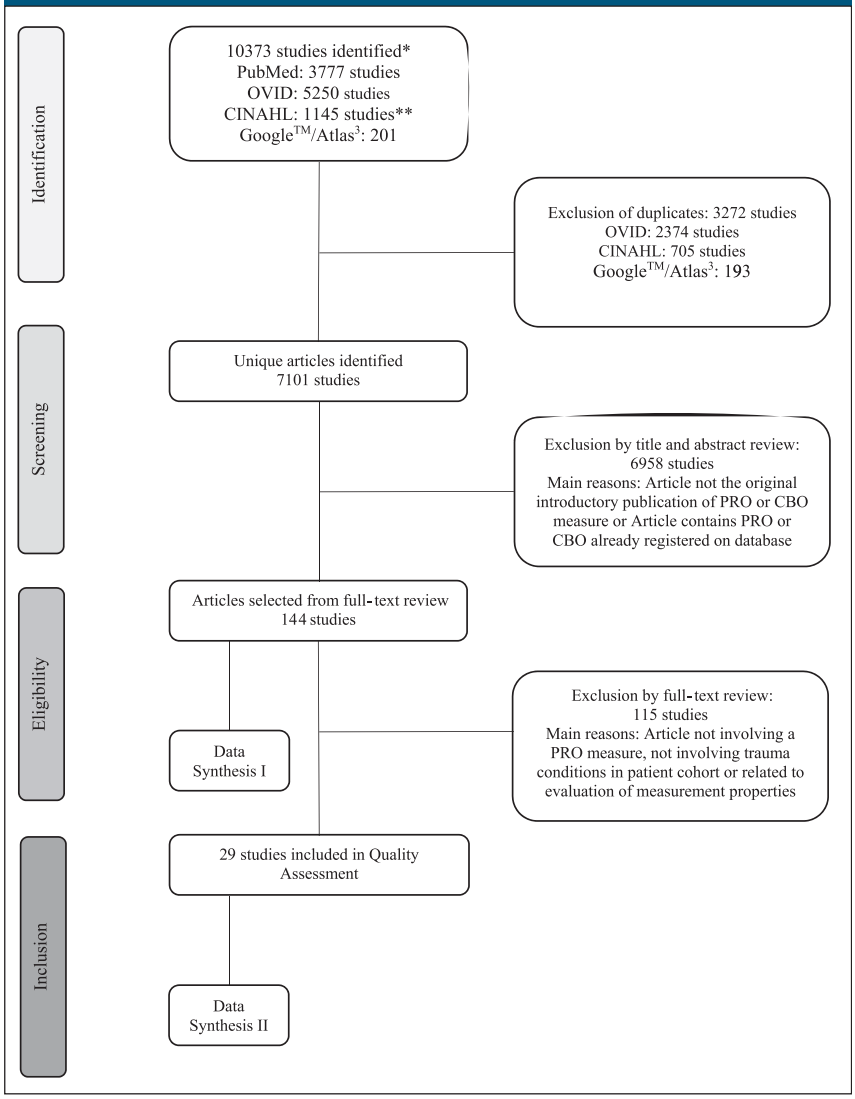
Outcome measurement in orthopaedics has evolved rapidly over the past 20 years, and there are many patient-reported or clinician-based outcome measures.[1,2] The popularity of patient-reported outcome (PRO) measurement, in particular, has grown in response to the perception that clinicians have an incomplete understanding of the true impact of disease on a patient's life and the complexity of the human illness experience.[2,3] PRO measures, by definition, focus on quantifying the subjective impact of health from the patient's perspective, commonly referred to as "disability" in contrast to "impairment" (objective pathophysiology). Common orthopaedic outcomes such as range of motion and fracture union represent the biomedical paradigm. PRO measures represent the biopsychosocial paradigm (including the influence of thoughts, emotions, behaviors, and circumstances) on symptoms and limitation.

The International Classification of Functioning, Disability and Health defines disability as a multidimensional concept related to the dynamic interaction between body functions

Figure 1



Search strategy and selection of articles. *July 1, 2016. **CINAHL search includes PsychINFO database. Data Synthesis I (Table 1); Data Synthesis II Quality Assessment (Table 2). CBO - clinician-based outcome, PRO = patient-reported outcome

and structures, activity limitations, and participation restrictions alongside environmental and personal factors.[3] These components are influenced by impairment (ie, problems with structure and function of the body leading to significant deviation and loss), psychosocial factors, and symptom experience.[3] The alleviation of disability, in this wider context, is the primary aim of most orthopaedic interventions.

Orthopaedic trauma is often associated with a significant impact on the magnitude of disability and the factors influencing it, which can affect an individual's quality of life in several health domains.[4,5] There is increasing evidence that disability is less associated with measures of impairment and objective pathophysiology than the subjective psychosocial aspects of illness.[6,7] Factors likely to mediate these interactions include anxiety, depression, ineffective coping, pain catastrophizing, and kinesiophobia, as well as social status, support, financial loss, and secondary gain.[4–8] This has an influence on recovery following musculoskeletal trauma, which is shown to have a stronger association with pain intensity and disability than biomedical factors, such as fracture type.[8–10] Furthermore, studies such as those conducted by Bhandari et al[4] reported on a significant number of patients experiencing orthopaedic trauma breach thresholds for psychological distress.

Upper limb injuries demonstrate reduced health-related quality of life indices compared with trauma involving other regions.[11] The inability to feed, clothe, and care for oneself following injury, particularly involving a dominant arm, can be extremely debilitating.[11] A study involving proximal humerus fractures demonstrated that measures of impairment, such as range of motion

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Table 1

Outcome Measures for Upper Extremity Conditions Classified by Conditions, Instrument, and Initial Psychometric Evaluation

			Clinical Conditions in Index Evaluation Study		Instrument Classification		Psychometric Evaluation	
Region	Outcome Measure	Short Title	Condition Type	Conditions	Coverage	Type	Level	Evaluation
Arm	Disabilities of the Arm, Shoulder, and Hand (1996)	DASH	Combo	Colles fracture; humerus fracture; thumb CMCJ arthritis; CTS; rotator cuff tendinopathy; lateral epicondylitis; de Quervain tenosynovitis; OA; RhA; nonspecific; other	Multiregion	PRO	P	Staged psychometric evaluation
	QuickDASH (2005)	QuickDASH	Combo	Colles fracture; humerus fracture; thumb CMCJ arthritis; CTS; rotator cuff tendinopathy; lateral epicondylitis; de Quervain tenosynovitis; OA; RhA; nonspecific; other	Multiregion	PRO	P	Psychometric evaluation and validation versus DASH; VAS ability to function in daily activities, rating of problem, pain severity, ability to work.
	Upper Extremity Function Test (1965)	UEFT	Combo	Upper extremities with traumatic, neurological and arthritic impairments; amputations	Multiregion	PRO	P	Psychometric evaluation and validation versus hand activities of daily living
	Upper Extremity Functional Index (2001)	UEFI	nos	Upper extremity dysfunction nos	Multiregion	PRO	P	Psychometric evaluation and validation versus UEFS
	Upper Extremity Functional Limitation Scale (2001)	UEFLS	nos	Elderly women with difficulty performing upper extremity tasks	Multiregion	PRO	P	Psychometric evaluation and validation versus fingers to grasp or handle, lifting and carrying 10 lbs, raising arms over head
	Upper Extremity Functional Scale (1997)	UEFS	Nontrauma	Chronic work-related upper extremity disorders; CTS	Multiregion	PRO	P	Psychometric evaluation and validation versus work status; physical findings (grip. pinch, Phalen test); duration of symptoms
	Upper Limb Functional Index (2006)	ULFI	Combo	Upper limb symptoms inc postoperative, acute postfracture, ligament sprain patients nos	Multiregion	PRO	P	Psychometric evaluation and validation versus DASH, UEFS
Shoulder	American Shoulder and Elbow Surgeons Assessment (1994)	ASES-S	Combo	[a]Impingement syndrome; instability/dislocation; RCT; adhesive capsulitis; hemiarthroplasty; shoulder weakness; humeral fracture; rotator cuff and adhesive capsulitis; status—postsurgery	Multiregion	[a]PRO	P	[a]Psychometric evaluation and validation versus UPenn Shoulder Score; SF-36
	Athletic Shoulder Outcome Scoring System (1993)		Trauma	Athletic shoulder injuries	Region specific	CBO	NE; NV	
	Bostrom Shoulder Impairment Scale (1991)		Nontrauma	RhA	Condition specific	CBO	NE	

(*continued*)

ACJ, acromioclavicular joint; AIMS2, Arthritis Impact Measurement Scale 2; CBO, clinician-based outcome measure; CMCJ, carpometacarpal joint; Combo, combination of traumatic and nontraumatic conditions; CTS, carpal tunnel syndrome; DRF, distal radius fracture; EPS, elbow plica syndrome; GHJ, glenohumeral joint; GROC, Global Rating of Change; IRGL, Impact of Rheumatic diseases on General health and Lifestyle; LCL, lateral collateral ligament; MCPJ, metacarpophalangeal joint; MEPS, Mayo Elbow Performance Score; MUA, manipulation under anesthetic; NE, no initial empirical psychometric evaluation; NHP, Nottingham Health Profile; nos, nonspecified or nonspecific; NV, no validation studies; OA, osteoarthritis; OCD, osteochondritis dissecans; P, confirmed psychometric evaluation; PHF, proximal humerus fracture; PRO, patient-reported outcome measure; RCT, rotator cuff tear; RhA, rheumatoid arthritis; ROM, range of motion; SCJ, sternoclavicular joint; SF-36, 36-Item Short Form Survey, SIP, sickness impact profile; SLAP, superior labral AP tear; TER, total elbow replacement, US, ultrasound; UTS, ulnar tunnel syndrome; VAS, visual analogue scale.

[a] ASES patient-reported component only—selected as clinician based measure rarely used.

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	Constant-Murley Shoulder Score (1985)	CMS	Combo	Rotator cuff repair; shoulder arthroplasty; adhesive capsulitis; PHF	Region specific	CBO	NE	
	Darrow Score for acromioclavicular joint separation (1980)		Trauma	Type III ACJ Separation	Condition specific	PRO	NE; NV	
	Flexilevel Scale of Shoulder Function (2003)	FLEX-SF	nos	nos	Region specific	PRO	P	Psychometric evaluation and validation versus ASES, SF-12
	Harryman rotator cuff functional assessment (1991)		Nontrauma	Chronic RCT	Condition specific	PRO	NE; NV	
	Herscovici Shoulder Scale (1992)		Trauma	Ipsilateral clavicle and scapular neck fractures	Condition specific	CBO	NE; NV	
	Hospital for Special Surgery Shoulder Assessment (1982)	HSS Shoulder Assessment	nos	Shoulder arthroplasty—etiology nos	Region specific	CBO	NE; NV	
	Hospital for Special Surgery Shoulder Rating Score (1990)	HSS Shoulder Rating	Nontrauma	Subacromial decompression for impingement; partial/full thickness RCT	Region specific	CBO	NE; NV	
	Hospital of the University of Pennsylvania Shoulder Score (1994)		Nontrauma	Open or arthroscopic acromioplasty; chronic impingement syndrome	Condition specific	CBO	NE; NV	
	Imatani Acromioclavicular Separation Evaluation System (1975)		Trauma	Acute ACJ separation	Condition specific	CBO	NE; NV	
	Japanese Orthopaedic Association Shoulder Score (2004)		Combo	Shoulder stiffness; primary idiopathic, traumatic (proximal humerus, clavicle, glenoid fracture, and contusion), prolonged immobilization (post-Colles fracture), patients with diabetes	Region specific	CBO	NE; NV	
	Kerlan Jobe Orthopaedic Clinic Score (2010)	KJOC	Trauma	Athletic shoulder and elbow injury	Multiregion	PRO	P	Psychometric evaluation and validation versus DASH
	Korean Shoulder Scoring System (2009)	KSS	Combo	Complete or partial RCT; impingement syndrome; rotator cuff tendinitis	Region specific	CBO	P	Psychometric evaluation and validation versus UCLA; ASES; CMS; SF-36
	McGinnis and Denton Rating Scale for Scapular Fractures (1989)		Trauma	Scapular fractures	Condition specific	CBO	NE; NV	
	Melbourne Instability Shoulder Scale (2005)	MISS	Combo	Shoulder instability; GHJ dislocation or subluxation	Condition specific	PRO	P	Psychometric evaluation and validation versus SRQ; Patient Subjective Rating Scale

(*continued*)

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	Modified Rowe Shoulder Score (2005)		Combo	Type II SLAP lesion	Condition specific	CBO	NE	
	Munich Shoulder Questionnaire (2012)	MSQ	Combo	ACJ/GHJ dislocation; OA; pain/contusion; biceps tendon tear; RCT; impingement; humerus bone cyst; clavicle/scapular/humeral fractures; brachial plexus damage; arthroplasty	Region specific	PRO	P	Psychometric evaluation and validation versus CMS, SPADI, DASH
	Neer Shoulder Score (1970)		Trauma	PHF	Condition specific	CBO	NE; NV	
	Nottingham Clavicle Score (2013)	NCS	Trauma	SCJ/ACJ injuries; clavicle fractures	Condition specific	PRO	P	Psychometric evaluation and validation versus CMS, OSS, Imatani, EQ5D
	Oxford Instability Score (1999)	OIS	Combo	Shoulder instability	Condition specific	PRO	P	Psychometric evaluation and validation versus CMS, Rowe, SF-36
	Oxford Shoulder Score (1996)	OSS	Nontrauma	Degenerative/inflammatory conditions; impingement ±RCT; calcified rotator cuff deposits; primary or secondary OA; inflammatory arthritis; adhesive capsulitis	Region specific	PRO	P	Psychometric evaluation and validation versus SF-36; HAQ; CMS
	Penn Shoulder Score (2003)	PSS	Combo	Impingement; tendonitis; RCT; instability; adhesive capsulitis; PHF; ACJ/GHJ OA	Region specific	PRO	P	Psychometric evaluation and validation versus ROM; muscle Force
	Postfunctional rating for long-head biceps tendinitis (1989)		Nontrauma	Primary bicipital tendinitis	Condition specific	CBO	NE; NV	
	Rockwood Score for Sternoclavicular Joint Arthritis (1997)		Nontrauma	SCJ OA	Condition specific	CBO	NE; NV	
	Rotator Cuff Quality-of-Life Measure (2000)	RC-QOL	Combo	RCT (all causes)	Condition specific	PRO	P	Psychometric evaluation and validation versus Functional Shoulder Elevation Test; SF-36; ASES
	Rowe Shoulder Score (1978)		Trauma	Shoulder dislocation; Bankart procedures for shoulder instability	Condition specific	CBO	NE	
	Shoulder Activity Level—Rating Scale (2005)		Combo	RCT; shoulder pain; instability; impingement; adhesive capsulitis; other	Region specific	PRO	P	Psychometric evaluation and validation versus SST; age; knee activity rating scale; self-reported shoulder activity

(*continued*)

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	Shoulder Disability Questionnaire (Dutch) (2000)	SDQ-NL	Combo	Shoulder soft tissue disorders (all causes)—electrotherapy/US plus exercise therapy for RCT	Region specific	PRO	P	Psychometric evaluation for responsiveness
	Shoulder Disability Questionnaire (United Kingdom) (1994)	SDQ-UK	nos	Community and primary care subjects with shoulder pain	Region specific	PRO	P	Psychometric evaluation and validation versus ROM; shoulder power
	Shoulder Function Assessment Scale (1996)	SFAS	Nontrauma	RhA	Condition specific	CBO	P	Psychometric evaluation and validation versus VAS; subjective shoulder function; objective shoulder function in 7 daily activities; radiological shoulder destruction
	Shoulder Function Index (2015)	SFInX	Trauma	PHF	Condition specific	CBO	P	Psychometric evaluation and validation inc Rasch analysis
	Shoulder Pain and Disability Index (1991)	SPADI	nos	Shoulder pain	Region specific	PRO	P	Psychometric evaluation and validation versus ROM
	Shoulder Rating Questionnaire (1994)	SRQ	Nontrauma	Impingement syndrome; glenohumeral instability; complete RCT; GHJ OA; adhesive capsulitis; ACJ OA	Region specific	PRO	P	Psychometric evaluation and validation versus AIMS-2; single Q assessing satisfaction in each domain
	Shoulder Severity Index (1987)	SSI	Nontrauma	Shoulder pain; chronic shoulder disability nos	Region specific	PRO	NE	
	Simple Shoulder Test (1993)	SST	nos	nos	Region specific	PRO	NE	
	Single Assessment Numeric Evaluation Rating (1999)	SANE	Combo	Postoperative following shoulder dislocation; chronic recurrent subluxations; ACJ separations	Region specific	PRO	P	Psychometric evaluation and validation versus Rowe, ASES
	Stanmore Percentage of Normal Shoulder Assessment (2012)	SPONSA	Combo	Shoulder OA/RhA; revision arthroplasty; subacromial impingement; instability; RCT; nonunion of fracture; adhesive capsulitis	Region specific	PRO	P	Psychometric evaluation and validation versus CMS, OSS
	Subjective Shoulder Rating Scale (1997)	SSRS	Combo	Anterior shoulder reconstructions; subacromial decompressions open and arthropscopic; MUA	Region specific	PRO	P	Psychometric evaluation and validation versus CMS; four-point verbal rating scale
	Subjective Shoulder Value (2007)	SSV	Combo	Rotator cuff repair; shoulder arthroplasty; stabilization for recurrent anterior instability	Region specific	PRO	P	Psychometric evaluation and validation versus CMS

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	Swanson Shoulder Score (1989)		Combo	RhA; OA; posttraumatic lesions	Region specific	CBO	NE; NV	
	Thorling Subjective Rating for Subacromial Decompression (1985)		Nontrauma	Subacromial decompression (acromioplasty) for shoulder impingement	Condition specific	CBO	NE; NV	
	UCLA End-Result Score (1986)		Combo	RCT	Condition specific	CBO	NE; NV	
	UCLA Shoulder Score (1981)	UCLA Shoulder	Combo	OA; osteonecrosis posttrauma; pseudarthrosis posttrauma; RhA; trauma	Region specific	CBO	NE; NV	
	Walch-Duplay Shoulder Instability Score (1987)		Combo	Anterior shoulder instability	Condition specific	CBO	NE	
	Watson Shoulder Score (1985)		Nontrauma	Chronic RCT	Condition specific	CBO	NE; NV	
	Western Ontario Osteoarthritis of the Shoulder Index (2001)	WOOS	Nontrauma	Shoulder OA undergoing hemiarthroplasty or total shoulder arthroplasty	Condition specific	PRO	P	Psychometric evaluation and validation versus CMS; UCLA; ASES; SF-12; McGill pain, VAS; GROC; ROM
	Western Ontario Rotator Cuff Index (1998)	WORCI	Combo	RCT	Condition specific	PRO	P	Psychometric evaluation and validation versus UCLA, SF-36, CMS, ASES, DASH, SIP, ROM
	Western Ontario Shoulder Instability Index (1998)	WOSI	Combo	Shoulder instability	Condition specific	PRO	P	Psychometric evaluation and validation versus DASH, ASES, UCLA, Rowe, CMS, SF-12, Global change, ROM
	Wolfgang Criteria for rating results of rotator cuff surgical repair (1974)		Combo	RCT	Condition specific	CBO	NE; NV	
Elbow	American Shoulder and Elbow Surgeons Assessment-Elbow (1999)	ASES-E	nos	nos	Multiregion	CBO	NE	
	Bishop Rating System (1989)		Combo	Cubital tunnel syndrome—anterior intermuscular transfer of ulnar nerve	Condition specific	CBO	NE; NV	
	Broberg and Morrey Elbow Scale (1986)	BMS	Trauma	Radial head fracture; elbow dislocation; ulnar fracture	Region specific	CBO	NE; NV	
	Conway Scoring System (1992)		Trauma	Medial instability (ulnar collateral ligament reconstruction)	Condition specific	CBO	NE; NV	
	Elbow Function Scale (1984)		Trauma	Olecranon fracture—displaced—tension band wiring	Condition specific	CBO	NE; NV	

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	Elbow Functional Assessment Scale (1999)	EFAS	Nontrauma	RhA	Condition specific	CBO	P	Psychometric evaluation and validation versus HSS assessment scale; HSS total elbow scoring system; MEPI
	Elbow Self-Assessment Score (2015)	ESAS	Combo	Fracture distal humerus, olecranon, proximal forearm, radial head; dislocation; bursitis; distal biceps rupture; TER; OA; OC; EPS; LCL lesion, reconstruction; epicondylitis; nerve lesion; UTS	Region specific	CBO	P	Psychometric testing and validation versus BMS, PREE, MEPS, OES, QuickDASH
	Ewald Elbow Scale (1975)		nos	nos	Region specific	CBO	NE	
	Flynn Criteria (1974)		Trauma	Supracondylar fracture (displaced)—pinning	Condition specific	CBO	NE	
	Hospital for Special Surgery Assessment Scale (1980)	HSS Assessment Scale	Combo	Total elbow replacement; RhA; posttraumatic OA; juvenile RhA	Region specific	CBO	NE	
	Hospital for Special Surgery Total Elbow Scoring System (1990)	HSS2 Total Elbow Scoring System	Combo	Failed total elbow arthroplasty—infection, periprosthetic fracture, recurrent dislocation	Region specific	PRO	NE	
	Japanese Orthopaedic Association Elbow Evaluation Score (1992)		nos	Elbow conditions nos	Region specific	PRO	NE; NV	
	Jupiter Functional Rating (1985)		Trauma	Distal humerus fractures—intercondylar fractures	Condition specific	PRO	NE; NV	
	Khalfayan Score (1992)		Trauma	Radial head fractures	Condition specific	CBO	NE; NV	
	Liverpool Elbow Score (2004)	LES	Combo	RhA; OA; posttraumatic OA; TER Inc revisions; tennis, Golfer elbow; loose body; OCD; posterior impingement; synovial chondromatosis; ulnar nerve problems	Region specific	CBO	P	Psychometric evaluation and validation versus DASH, NHP, SF-12
	Mayo Elbow Performance Index and modifications (1992)	MEPI	Combo	RhA—semiconstrained elbow arthroplasty; elbow fracture-dislocation; coronoid process fracture	Region specific	CBO	NE	
	Modified Bishop Scale (1997)		Combo	Ulnar nerve decompression—transposition —Z lengthening flexor pronator mass	Condition specific	CBO	NE; NV	
	Neviaser Criteria (1977)		Trauma	Elbow dislocation	Condition specific	CBO	NE	

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	Nirschl Tennis Elbow Scoring System (1992)		Nontrauma	Tennis elbow	Condition specific	CBO	NE	
	Oxford Elbow Score (2008)	OES	Combo	Primary OA; secondary OA; RhA; posttraumatic stiffness; epicondylitis	Region specific	PRO	P	Psychometric evaluation and validation versus MEPS, Score, DASH, SF-36
	Patient-Rated Elbow Evaluation (2001)	PREE	Combo	Radial head, humeral, olecranon fracture; TER; RHR; OA; RhA; biceps repair; contracture; bursitis; implant complications; inflammation; chronic pain; loose body; lateral epicondylitis	Region specific	PRO	P	Psychometric evaluation and validation versus ASES; SF-36; DASH
	Patient-Rated Tennis Elbow Evaluation (1999)	PRTEE	Nontrauma	Lateral epicondylitis	Condition specific	PRO	P	Psychometric evaluation and validation versus pain-free grip strength
	Patient-Rated Ulnar Nerve Evaluation (2013)	PRUNE	Nontrauma	Ulnar neuropathy—ulnar nerve decompression	Condition specific	PRO	P	Psychometric evaluation and validation versus SF-36; Bishop Scale
	Pritchard Scoring System (1977)		nos	Total elbow arthroplasty	Region specific	CBO	NE	
	Roles and Maudsley Outcome Score (1972)		Combo	Radial tunnel syndrome—Resistant tennis elbow	Condition specific	CBO	NE; NV	
	Timmerman and Andrews Score (1994)		Trauma	Posttraumatic elbow pain and stiffness; elbow injury in throwing athletes	Region specific	CBO	NE; NV	
	Verhaar Tennis Elbow Scoring System (1993)		Nontrauma	Tennis elbow	Condition specific	CBO	NE	
Wrist/ hand	6-item Carpal Tunnel Syndrome Symptom Scale (2009)		Nontrauma	CTS	Condition specific	PRO	P	Psychometric evaluation and validation versus QuickDASH; 11-item CTS Symptom Severity Scale
	ABILHAND Manual Ability Measure (1998)	ABILHAND	Nontrauma	RhA—wrist arthrodesis	Condition specific	PRO	P	Psychometric evaluation and validation inc Rasch analysis
	Alderson-McGall Hand Function Questionnaire (1999)	AMHFQ	Nontrauma	CTS	Condition specific	PRO	P	Psychometric evaluation and validation versus VAS for pain and function; grip and pinch strength; static and dynamic 2-point discrimination; Valpar ROM
	Arab Hand Function Index (2004)	AHFI	Nontrauma	RhA	Condition specific	PRO	P	Psychometric evaluation and validation versus Revel functional index; Lee functional index

(*continued*)

ACJ, acromioclavicular joint; AIMS2, Arthritis Impact Measurement Scale 2; CBO, clinician-based outcome measure; CMCJ, carpometacarpal joint; Combo, combination of traumatic and nontraumatic conditions; CTS, carpal tunnel syndrome; DRF, distal radius fracture; EPS, elbow plica syndrome; GHJ, glenohumeral joint; GROC, Global Rating of Change; IRGL, Impact of Rheumatic diseases on General health and Lifestyle; LCL, lateral collateral ligament; MCPJ, metacarpophalangeal joint; MEPS, Mayo Elbow Performance Score; MUA, manipulation under anesthetic; NE, no initial empirical psychometric evaluation; NHP, Nottingham Health Profile; nos, nonspecified or nonspecific; NV, no validation studies; OA, osteoarthritis; OCD, osteochondritis dissecans; P, confirmed psychometric evaluation; PHF, proximal humerus fracture; PRO, patient-reported outcome measure; RCT, rotator cuff tear; RhA, rheumatoid arthritis; ROM, range of motion; SCJ, sternoclavicular joint; SF-36, 36-Item Short Form Survey, SIP, sickness impact profile; SLAP, superior labral AP tear; TER, total elbow replacement, US, ultrasound; UTS, ulnar tunnel syndrome; VAS, visual analogue scale.

[a] ASES patient-reported component only—selected as clinician based measure rarely used.

Table 1 (*continued*)

Outcome Measures for Upper Extremity Conditions Classified by Conditions, Instrument, and Initial Psychometric Evaluation

			Clinical Conditions in Index Evaluation Study		Instrument Classification		Psychometric Evaluation	
Region	Outcome Measure	Short Title	Condition Type	Conditions	Coverage	Type	Level	Evaluation
	Arthritis Hand Function Test (1991)	AHFT	Nontrauma	RhA	Condition specific	CBO	P	Psychometric evaluation and validation versus Jebsen Hand Function Test; AIMS
	Australian/Canadian Osteoarthritis Hand Index (2002)	AUSCAN	Nontrauma	OA	Condition specific	PRO	NE	
	Boston Carpal Tunnel Questionnaire (1993)	BCTQ	Nontrauma	CTS	Condition specific	PRO	P	Psychometric evaluation and validation versus grip and pinch strength; 2-point discrimination; Semmes-Weinstein monofilament test
	Buck-Gramcko and Lohman Evaluation for Total Wrist Function (1985)		nos	Compression wrist arthrodesis	Region specific	CBO	NE; NV	
	Castaing Score (1964)		Trauma	DRF	Condition specific	CBO	NE; NV	
	Clawson Functional Index (1971)		Nontrauma	RhA	Condition specific	CBO	NE; NV	
	Colville Quality of Life Hand Questionnaire (1999)		Nontrauma	OA—trapeziectomy; RhA—Swanson MCPJ arthroplasty	Region specific	PRO	NE; NV	
	Crawford Classification (1984)		Trauma	Mallet finger	Condition specific	CBO	NE	
	Fernandez Point-Score System (1988)		Trauma	DRF—malunion—radial osteotomy/Bower arthroplasty	Condition specific	CBO	NE; NV	
	Fernandez Scale (1982)		Trauma	DRF: Posttraumatic correction wrist deformity inc osteotomy, bone grafting, internal fixation	Condition specific	CBO	NE; NV	
	Forearm Symptom Severity Scale (1998)		Trauma	DRF	Condition specific	PRO	NE; NV	
	Functional Index (1984)		Trauma	DRF	Condition specific	CBO	P	Psychometric evaluation and validation versus Gartland-Werley Scoring system; patient's and investigator's subjective characterization of function
	Functional Index for Arthropathies of the Hand (1995)	FIHOA	Nontrauma	Hand OA—digital or trapeziometacarpal OA—inactive hand OA	Condition specific	PRO	P	Psychometric evaluation and validation versus pain severity
	Gartland and Werley Scoring System (1951)		Trauma	DRF	Condition specific	CBO	NE	

(*continued*)

ACJ, acromioclavicular joint; AIMS2, Arthritis Impact Measurement Scale 2; CBO, clinician-based outcome measure; CMCJ, carpometacarpal joint; Combo, combination of traumatic and nontraumatic conditions; CTS, carpal tunnel syndrome; DRF, distal radius fracture; EPS, elbow plica syndrome; GHJ, glenohumeral joint; GROC, Global Rating of Change; IRGL, Impact of Rheumatic diseases on General health and Lifestyle; LCL, lateral collateral ligament; MCPJ, metacarpophalangeal joint; MEPS, Mayo Elbow Performance Score; MUA, manipulation under anesthetic; NE, no initial empirical psychometric evaluation; NHP, Nottingham Health Profile; nos, nonspecified or nonspecific; NV, no validation studies; OA, osteoarthritis; OCD, osteochondritis dissecans; P, confirmed psychometric evaluation; PHF, proximal humerus fracture; PRO, patient-reported outcome measure; RCT, rotator cuff tear; RhA, rheumatoid arthritis; ROM, range of motion; SCJ, sternoclavicular joint; SF-36, 36-Item Short Form Survey, SIP, sickness impact profile; SLAP, superior labral AP tear; TER, total elbow replacement, US, ultrasound; UTS, ulnar tunnel syndrome; VAS, visual analogue scale.

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Outcome Measures for Upper Extremity Conditions Classified by Conditions, Instrument, and Initial Psychometric Evaluation

			Clinical Conditions in Index Evaluation Study		Instrument Classification		Psychometric Evaluation	
Region	Outcome Measure	Short Title	Condition Type	Conditions	Coverage	Type	Level	Evaluation
	Glickel Clinical Grading system (1984)		Nontrauma	Chronic carpal instability	Condition specific	CBO	NE	
	Grace and Eversmann Rating (1980)		Trauma	Forearm fractures	Condition specific	CBO	NE	
	Green and O'Brien Scoring System (1978)		Trauma	Carpal dislocation—open	Condition specific	CBO	NE; NV	
	Hand Function Score (1998)	HFS	Trauma	Hand trauma—rehabilitation nos	Region specific	PRO	NE	
	Hand Function Sort (1996)		nos	nos	Region specific	PRO	NE	
	Hand Functional Index (1971)	HFI	Nontrauma	RhA	Condition specific	CBO	NE	
	Hand Injury Severity Score (1996)	HISS	Trauma	Hand injuries nos	Region specific	CBO	P	Psychometric evaluation and validation versus return to work
	Hospital for Special Surgery Wrist Scoring System (1990)	HSS Wrist	Non-Trauma	RhA—wrist—total wrist arthroplasty	Condition specific	CBO	NE; NV	
	Jebsen-Taylor Hand Function Test (1969)		nos	nos	Region specific	CBO	NE	
	Kapandji Index (1987)		Non-Trauma	RhA	Condition specific	CBO	NE	
	Lambert and Clayton Wrist Score (1980)		Non-Trauma	RhA—wrist —total wrist arthroplasty	Condition specific	CBO	NE; NV	
	MacBain Hand Function Test (1970)		Nontrauma	RhA	Condition specific	CBO	NE; NV	
	Manual Ability Measure-16; -36 (2005)	MAM-16; MAM-36	Combo	RhA; OA; CTS; median nerve neuritis; tenosynovitis; traumatic injuries inc fractures; open wounds; crush	Region specific	PRO	P	Psychometric testing and validation versus LIFEware Musculoskeletal Form; SF-12 health status
	Martini Score (1999)		Trauma	DRF	Condition specific	CBO	NE; NV	
	Measure of Activity Performance of the Hand (2010)	MAP-HAND	Nontrauma	RhA	Condition specific	PRO	P	Psychometric testing and validation versus AIMS2 arm, hand and finger function subscales; joint pain/fatigue/global disease and activity scales
	Michigan Hand Outcomes Questionnaire (1998)	MHQ	Combo	Hand disorders—hand injuries; RhA; CTS	Region specific	PRO	P	Psychometric evaluation and validation versus SF-12
	Milliken Activities of Daily Living Scale and modifications (1988)		Trauma	Simple and complex upper limb fractures; soft tissue injuries (tendon/nerve lacerations/repairs); crush; amputations; replantation	Region specific	PRO	P	Psychometric evaluation and validation versus HFS

(*continued*)

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Outcome Measures for Upper Extremity Conditions Classified by Conditions, Instrument, and Initial Psychometric Evaluation

			Clinical Conditions in Index Evaluation Study		Instrument Classification		Psychometric Evaluation	
Region	Outcome Measure	Short Title	Condition Type	Conditions	Coverage	Type	Level	Evaluation
	Modern Activity Subjective Survey of 2007 (2008)	MASS07	nos	nos	Region specific	PRO	P	Psychometric evaluation and validation versus DASH; PRWE
	Modified Gartland and Werley Scoring System (1975)		Trauma	Colles fracture	Condition specific	CBO	NE	
	Modified Green and O'Brien Scoring System (1987)		Trauma	Wrist fractures—perilunate fracture dislocations	Region specific	CBO	NE; NV	
	Modified Martini Score (2004)		Trauma	DRF	Condition specific	CBO	NE; NV	
	Modified Score for Assessment and quantification of Chronic Rheumatic Affections of Hands (2004)	M-SACRAH	Nontrauma	RhA; OA	Condition specific	PRO	P	Psychometric evaluation and validation versus SACRAH; patient global assessment; physician global assessment; C-reactive protein concentration; ESR
	Munich Wrist Questionnaire (2016)	MWQ	Combo	DRF; metacarpal, scaphoid, other carpal fractures; TFCC tear; synovitis; SL ligament tear; wrist OA; traumatic nerve injury; wrist contusion	Region specific	PRO	P	Psychometric evaluation and validation versus PRWE; DASH; MMWS; CBS
	New York Orthopedic Hospital Wrist Rating Scale (1991)	NYOH	Trauma	DRF—external fixation	Condition specific	CBO	NE; NV	
	Patient Evaluation Measure (1995)	PEM	nos	Hand surgery nos	Region specific	PRO	NE	
	Patient-Focused Wrist Outcome (2003)	PFWO	Combo	Wrist disorder/injury nos	Region specific	PRO	P	Psychometric evaluation and validation nos
	Patient Outcomes of Surgery-Hand/Arm (2004)	POS Hand/Arm	Nontrauma	CTS; Dupuytren fasciectomy; joint surgery; tendon surgery; mass excision—pre- and post-surgery	Region specific	PRO	P	Psychometric evaluation and validation versus DASH; MHQ Pain scale
	Patient-Rated Wrist/ Hand Evaluation (2004)	PRWHE	Trauma	Wrist/hand fractures; carpal instabilities; OA hand; tendon lacerations; palmar fasciectomies; finger joint arthroplasty (MCPJ/PIPJ)	Region specific	PRO	P	Psychometric evaluation and validation versus DASH
	Patient-Rated Wrist Evaluation (1996)	PRWE	Trauma	Scaphoid nonunion; Colles fracture	Region specific	PRO	P	Psychometric evaluation and validation versus SF-36 and impairment score (wrist ROM, grip strength; dexterity testing, expected changes in pain and disability)

(*continued*)

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Table 1 (*continued*)

Outcome Measures for Upper Extremity Conditions Classified by Conditions, Instrument, and Initial Psychometric Evaluation

			Clinical Conditions in Index Evaluation Study		Instrument Classification		Psychometric Evaluation	
Region	Outcome Measure	Short Title	Condition Type	Conditions	Coverage	Type	Level	Evaluation
	Revel Functional Index (1989)	RFI	Nontrauma	RhA	Condition specific	PRO	NE	
	Rheumatoid Hand Functional Disability Scale (1996)		Nontrauma	RhA	Condition specific	PRO	P	Psychometric evaluation and validation versus VAS for functional handicap; Hand Functional Index
	Score for Assessment and quantification of Chronic Rheumatic Affections of the Hands (2003)	SACRAH	Nontrauma	RhA; OA	Condition specific	PRO	P	Psychometric evaluation and validation versus patient global assessment; physician global assessment; C-reactive protein concentration; ESR
	Sequential Occupational Dexterity Assessment (1996)	SODA	Nontrauma	RhA—Hand surgery: CTS—release; resection ulnar head; tenosynovectomy; articular synovectomy; wrist prosthesis.	Region specific	CBO	P	Psychometric evaluation and validation versus wrist ROM; mobility of fingers; grip strength; self-reported dexterity; pain
	Short Version of the Sequential Occupational Dexterity Assessment (1999)	S-SODA	Nontrauma	RhA	Condition specific	CBO	P	Psychometric evaluation and validation versus SODA; VAS for pain; IRGL; grip strength; Larsen Score; wrist and finger ROM; disease duration and activity
	Solgaard Functional Score System (1988)		Trauma	DRF	Condition specific	CBO	NE; NV	
	Sollerman Hand Function Test (1995)		Combo	RhA; finger amputations; nerve injuries; Dupuytren contracture; shoulder-hand-finger syndromes; posttraumatic hand conditions	Region specific	CBO	P	Psychometric evaluation and validation versus subjective estimation of hand function; Disability Rating Scale
	Southampton Dupuytren Scoring System (2014)	SDSS	Nontrauma	Dupuytren contracture	Condition specific	PRO	P	Psychometric evaluation and validation versus QuickDASH
	Stewart Scores (1984)		Trauma	DRF—functional cast bracing	Condition specific	CBO	NE; NV	
	Unité Rhumatologique des Affections de la Main scale (2011)	URAM	Nontrauma	Dupuytren disease	Condition specific	PRO	P	Psychometric evaluation and validation versus Tubiana scale
	Wrightington Wrist Function Score (1998)		Combo	Scapholunate instability—Brunelli procedure	Condition specific	CBO	NE; NV	
	Wrist Outcome Measure (2002)	WOM	Trauma	DRF	Condition specific	CBO	NE; NV	

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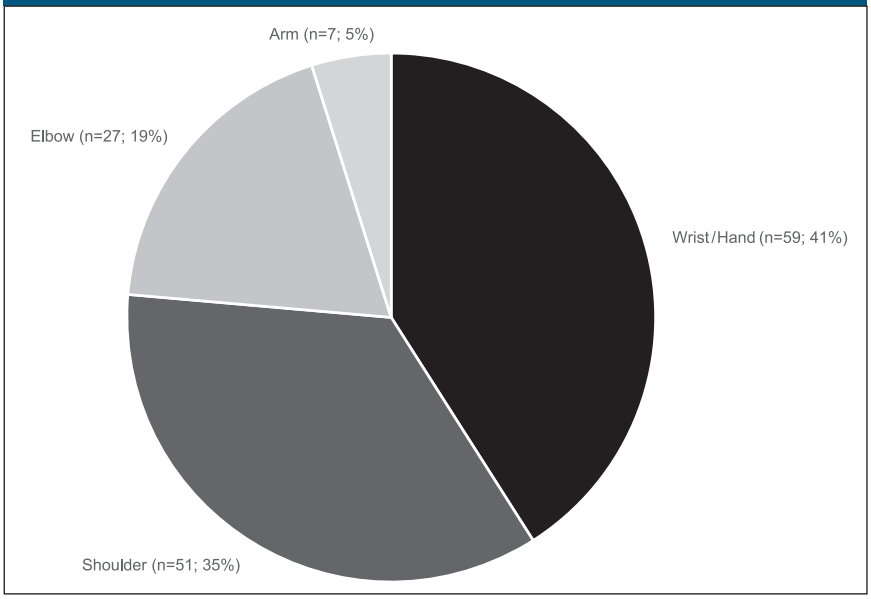
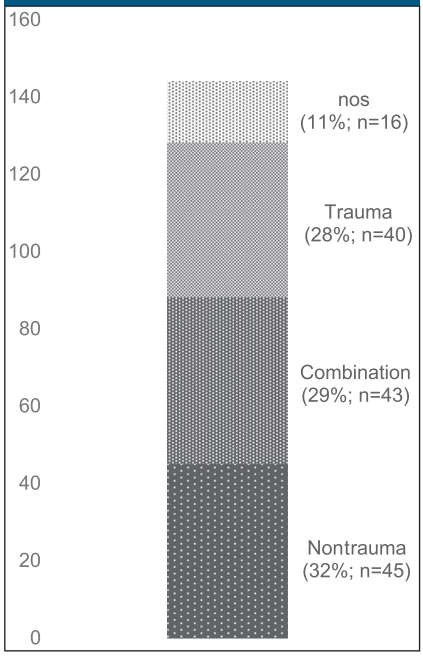
Figure 2



Outcome measures for upper extremity conditions by anatomic region.

Figure 3



Outcome measures for upper extremity conditions by clinical conditions in index evaluation studies. nos = nonspecific or not specified

and arm strength, did not correlate with PRO measures of disability.[12] Factors such as social independence appeared to more accurately predict PROs than physician based assessments and even mortality in these patients.[12,13] Similarly, studies involving distal radius fractures demonstrate depression, anxiety, kinesiophobia, and catastrophic thinking as the most important factors influencing disability and rate of recovery.[9,14,15] Despite this growing evidence and the rising demand for robust PRO measurement, there remains a lack of clarity regarding the original development, testing, and quality of PRO measures in the context of upper extremity trauma and disability in this region.

Objectives

The primary objective was to identify outcome measures developed for upper extremity conditions, focusing on traumatic injuries, and to classify them by anatomic region, condition type, instrument type, and the psychometric evaluation used in their original development. Secondarily, we aimed to assess the methodological quality of original studies, introducing a PRO measure that incorporated trauma patients in their development. We conclude by highlighting the challenges and solutions encountered in measuring outcomes and disability in this population.

Methods

Data Sources

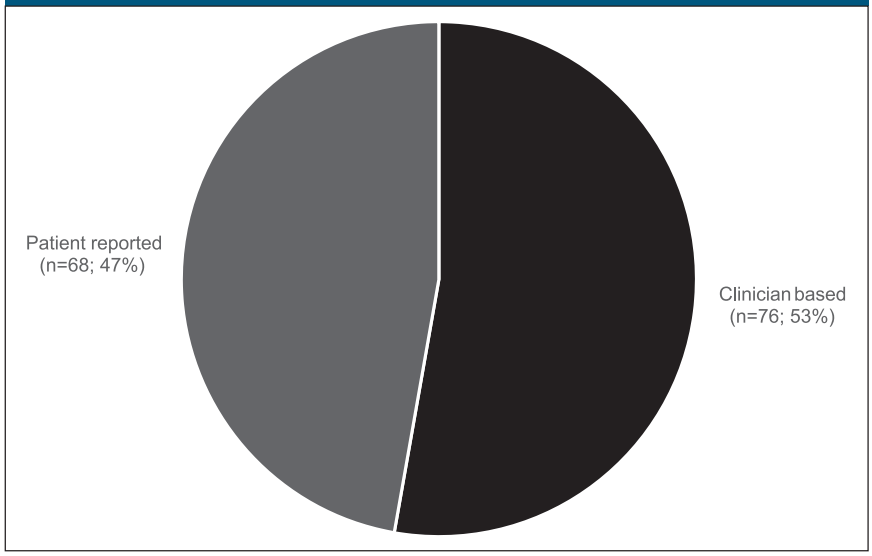
A broad search strategy was applied to PubMED (MEDLINE from 1946 to 2016), OVIDSP (EMBASE from 1974 to 2016), CINAHL (from 2006 to 2016), and PsycINFO (from 1806 to 2016) electronic databases on July 1, 2016. Search terms related to "upper limb anatomy," "outcome measurement," and demographic parameters were combined with the operator AND (Supplemental Digital Content 1, http://links.lww.com/JG9/A2). No restrictions were set in the search fields, and terms were identified in the title and/or abstract without any limits. Further identification was conducted through an internet search engine (Google) and a contemporary atlas of outcome measures.[3] The review is reported according to the PRISMA statement and registered on the PROSPERO system (No. CRD42016046243) (Appendix 1).

Study Selection

Studies involving adult patients experiencing any orthopaedic upper extremity condition involving outcome measurement systems were identified. Abstracts were screened by the lead investigator (P.J.) to (1) generate a comprehensive set of outcome measures and (2) track down the original article introducing the measure plus or minus any development and psychometric evaluation

studies, if available. Psychometric evaluations of PRO measures were taken to include assessments of validity, reliability, responsiveness, interpretability, and acceptability.[16] Eligibility assessment selected only the original publications of PRO measures for qualitative and quantitative synthesis. Measures not recognized as multidomain outcome measurement systems, such as those focusing on clinimetric features alone (eg, range of motion, pathoanatomic or radiological grading and classification, and clinical examination tests), single health components (eg, pain, depression, and return to activity), broad diagnostic groups (eg, osteoarthritis and tumor classifications), and health behavior scales, were excluded along with articles not published in English.

Figure 4



Instruments classified by clinician-based or patient-reported outcome measurement.

Data Extraction and Data Synthesis

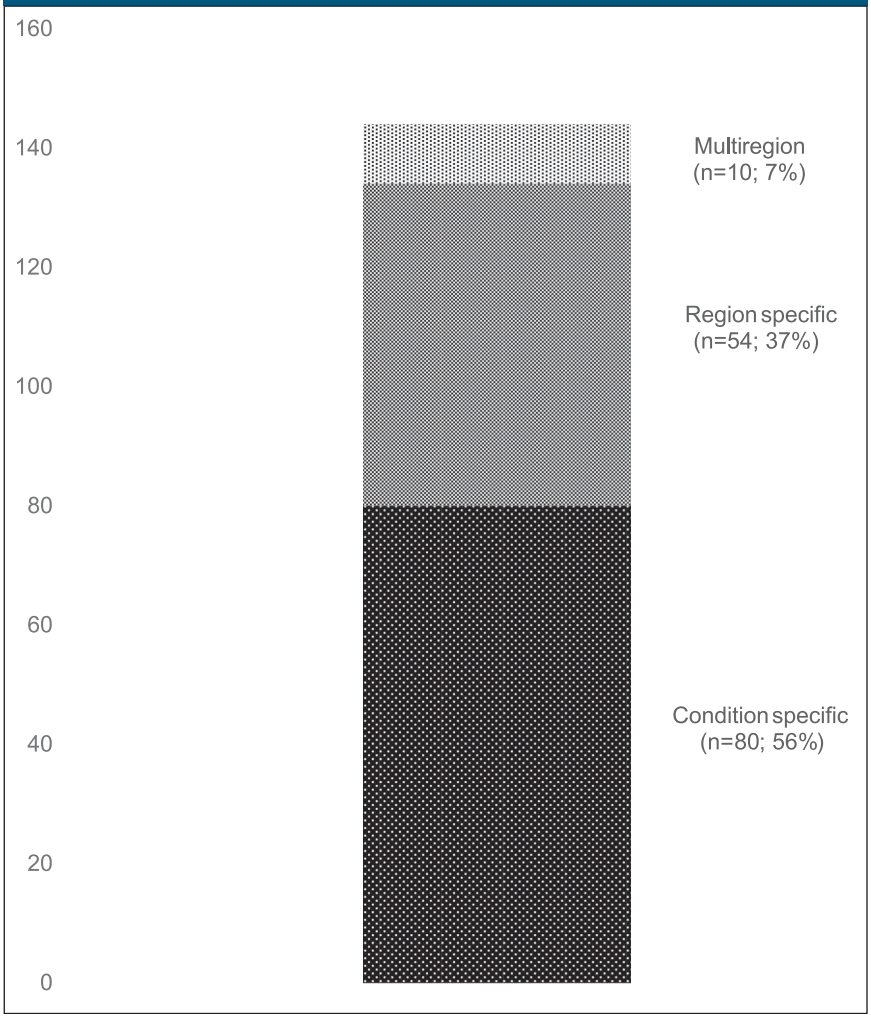
Data were extracted, synthesized, and recorded using an electronic database (Microsoft Excel, v15.33). Outcome measures were classified by anatomic region, conditions assessed (ie, broad etiology and specific diagnoses), instrument characteristics (ie, coverage and type), and initial level of psychometric evaluation. Measures combining patient-reported and clinician-based components were classified as the latter by default, unless one or the other was more popularly used in the literature. Initial characterization of psychometric evaluation was based on details of validation (construct validity). If none existed, measures were classified with "no initial empirical psychometric evaluation" or "no initial empirical psychometric evaluation and no validation studies identifiable."

Quality assessment was conducted using the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) criteria and 4-point checklist.[17] This is a well-established standard for evaluating methodological quality, design requirements, and preferred statistical analysis of measurement properties of health-related PRO measures. Only original studies involving patients with trauma conditions in the development and psychometric evaluation of instruments were assessed. Contact with authors was made for clarification of conditions when these were nonspecific. Properties were assessed with the lowest rating within a category taken as the score for the section. In addition, data were extracted for generalizability (ie, population characteristics and sampling procedure) and interpretability but were not rated. The items within PRO measures were also categorized as "best fit" into one of the five health domains by three investigators (P.J., D.R., and S.G.) to calculate the proportion (percentage) of each domain as part of the full score, including any instrument weightings. Discordant judgments were resolved through discussions coordinated by the lead author (P.J.) to reach a consensus between the three investigators. Synthesized data were reported using descriptive statistics and discordant judgments resolved by a discussion among all the authors.

Results

A total of 144 outcome measures targeting the upper extremity were identified (Figure 1 and Table 1). The majority focused on the shoulder, wrist, and hand (Figure 2). Fifty-eight percent (n = 83/144) included patients with trauma problems either in combination with other conditions or alone (Figure 3). Seven percent (n = 10/144) required corresponding authors to be contacted to determine conditions investigated because these could not be otherwise identified. Conditions included fractures, dislocations, and soft-tissue injuries (Table 1). Instrument classification revealed the majority as completely or partially clinician based (53%; n = 76/144) (Figure 4) and predominantly condition specific (56%; n = 80/144)

Figure 5



Instruments classified by the level of coverage.

(Figure 5), with trends in instrument type and coverage mapped over time (Figures 6 and 7).

Quality assessment was conducted on 29 original studies (20%; n = 29/144) that included some form of psychometric evaluation of PRO measures when they were first published and involved upper limb trauma patients in their study cohort (Table 2). The majority of studies included in quality assessment were prospective cohort studies. "Test-retest" reliability was assessed more frequently than internal consistency and measurement error, and rating was "poor" to "good" when assessed. Content (face) validity ratings were "good" to "excellent" for almost all measures. Construct validity assessed through testing of hypotheses rated "good to excellent" in two thirds of studies and "poor to fair" in the rest, while structural validity was "poor" in 71% of studies (n = 17/24) when it was assessed. This was primarily due to few studies undertaking factor analysis or item response theory (IRT) analysis, a requisite for higher ratings. The lack of gold-standard measures in this field meant that criterion validity was rarely assessed. Responsiveness was highly variable; although most studies allowed some interpretability through score distribution and change, few conducted analysis of floor-ceiling effects, minimal clinical important difference, or minimal detectable change. Characterization of health domains revealed that the majority of items were related to physical function and symptoms, whereas the relative proportion represented by social (median 14%; range 3%–35%) and psychological aspects (median 14%; range 3%–16.5%) was low. Generalizability assessment revealed low levels of reporting patient consent, percentage of missing items, and study limitations.

Discussion

The selection of outcome measures is of paramount importance in conducting high-quality orthopaedic research.[48] Arriving at this choice, particularly among the current assortment of PRO measures, may benefit from an understanding of the methodological quality of their development and relevance to study populations.[49] Over 140 different outcome measures targeted at upper extremity problems were identified, with a substantial number involving trauma conditions in their original cohorts, many of which included distal radius fractures, rotator cuff tears, and shoulder instability. The majority were clinician-based, injury-specific, or procedure-specific instruments and lacked empirical psychometric evaluation in initial development or any identifiable validation studies since introduction. One in five was a PRO measure, involving trauma patients who had undergone initial psychometric evaluation. Methodological quality was deemed acceptable in terms of test-retest reliability, content, and construct validity through hypothesis testing, but was of variable quality and/or lacking in others such

Table 2

Characterization and Quality Assessment of PRO Measures Involving Patients With Upper Extremity Trauma in the Original Study Cohort

		Outcome Measures—Health Domains as Proportion (%) of Total Score[a]					Study Characteristics and Psychometric Evaluation		
Outcome Measure	Instrument Items (Score Range)	Physical Function (Activities of Daily Life-Related), %	Psychological, %	Social, %	Pain/ Symptoms, %	Other	Level of Evidence of Index Study(s)	Psychometric Analysis: Property (n)	Outcome Measures
DASH[18]	30 (0–100)	77	3	3	17		1b	Reliability (407); validity (407); interpretability	VAS for overall problem; VAS for overall pain; VAS of ability to function; VAS of ability to work
QuickDASH[19]	11 (0–100)	64		18	18		1b	Reliability (407); validity (407); interpretability	VAS for overall problem; VAS for overall pain; VAS of ability to function; VAS of ability to work
UEFT[20]	33 (0–99)	100					3b	Reliability (30); validity (79); interpretability	Hand activities of daily living
ULFI[21]	25 (0–100)	76	4	12	8		1b	Reliability (64, 32); validity (64); responsiveness (24); interpretability	DASH; UEFS
ASES-S[22]	11 (0–100)	45		5	50		1b	Reliability (63); validity (63); responsiveness (63); interpretability	UPenn; SF-36
KJOC[23]	10 (0–100)	50		20	30		3	Reliability (21); validity (282); responsiveness (55); interpretability	DASH; DASH sports/ performing arts module
MISS[24]	21 (0–100)	57		18	25		1b	Reliability (22); validity (64); interpretability	SRQ; Patient Subjective Rating Scale
MSQ[25]	30 (0–314)	62		19	19		3	Validity (56); interpretability	CMS; DASH; SPADI
NCS[26]	10 (20–100)	20			70	10% (Cosmetic satisfaction)	2b	Reliability (70, 50); validity (70); interpretability	CMS; OSS; Imatani; EQ5D
OIS[27]	12 (12–60)	41	17	25	17		1b	Reliability (34, 92); validity (92); responsiveness (15); interpretability	CMS; Rowe; SF-36
PSS[28]	24 (0–100)	54		6	30	10% (Functional satisfaction)	3b	Reliability (109, 40); validity (40); responsiveness (109); Interpretability	ASES; CMS
RC-QOL[29]	34 (0–100)	35	15	35	15		1b	Reliability (30); validity (86); interpretability	Functional shoulder elevation test; SF-36; ASES
SAS[30]	5 + 2 (0–20)	100					1b	Reliability (40); validity (42); interpretability	SST; age; knee activity rating scale; self-reported shoulder activity

(*continued*)

IRT = item response theory; MCID = minimal clinical important difference; MDC = minimal detectable change; PRO = patient-reported outcome; SAS = Shoulder Activity Scale.

[a] Including instrument weighting.

[b] COSMIN Box G (Cross-cultural validity) was excluded—translations and cultural adaptations out of scope.

Table 2 (*continued*)

Characterization and Quality Assessment of PRO Measures Involving Patients With Upper Extremity Trauma in the Original Study Cohort

		Outcome Measures—Health Domains as Proportion (%) of Total Score[a]					Study Characteristics and Psychometric Evaluation		
Outcome Measure	Instrument Items (Score Range)	Physical Function (Activities of Daily Life-Related), %	Psychological, %	Social, %	Pain/ Symptoms, %	Other	Level of Evidence of Index Study(s)	Psychometric Analysis: Property (n)	Outcome Measures
SDQ-NL[31]	16 (0–100)	94 (88 Linked to pain)	6		88 (Linked to physical function—daily activities)		1b	Reliability (180); responsiveness (180); interpretability	Patient-rated VAS for severity of shoulder pain and VAS chief complaint; 8-point Likert Scale for overall change since baseline; clinical rating VAS symptom severity and VAS mobility restriction
SANE[32]	1 (0–100)					100% (Global general rating)	1b	Reliability (163); validity (163); interpretability	Rowe; ASES
SPONSA[33]	1 (0–100)					100% (Global general rating inc pain and physical function)	1b	Reliability (61); validity (61); responsiveness (61); interpretability	CMS; OSS
SSRS[34]	5 (0–100)	35		15	50		1b	Reliability (200); validity (200); interpretability	CMS; four-point verbal rating scale
SSV[35]	1 (0–100)					100% (Global general rating)	3b	Reliability (441); validity (441); interpretability	CMS
WORCI[36]	21 (0–2,100)	47	14	10	29		3b	Reliability (100); validity (97); responsiveness (100); interpretability	UCLA; SF-36; CMS; ASES; DASH; SIP; ROM
WOSI[37]	21 (0–2,100)	24	14	24	38		3b	Reliability (51); validity (47); responsiveness (47); interpretability	DASH; ASES; UCLA; Rowe; CMS; SF-12; global change; ROM
OES[38]	12 (0–48)	33	16.5	16.5	33		1b	Reliability (104, 52); validity (104); responsiveness (104); interpretability	MEPS; DASH; SF-36
PREE[39]	20 (0–100)	54		13	33		1b	Reliability (70); validity (70); interpretability	ASES; SF-36; DASH
MAM-16; MAM-36[40]	16 (0–100)	100					1b	Reliability (115); validity (115)	LIFEware Musculoskeletal Form; SF-12 health status
MHQ[41]	37 (0–100)	46		14	14	10% (Appearance); 16% (satisfaction in relation to physical function, pain, sensation)	1b	Reliability (22); validity (200); interpretability	SF-12

(*continued*)

IRT = item response theory; MCID = minimal clinical important difference; MDC = minimal detectable change; PRO = patient-reported outcome; SAS = Shoulder Activity Scale.

[a] Including instrument weighting.

[b] COSMIN Box G (Cross-cultural validity) was excluded—translations and cultural adaptations out of scope.

Table 2 (*continued*)

Characterization and Quality Assessment of PRO Measures Involving Patients With Upper Extremity Trauma in the Original Study Cohort

		Outcome Measures—Health Domains as Proportion (%) of Total Score[a]					Study Characteristics and Psychometric Evaluation		
Outcome Measure	Instrument Items (Score Range)	Physical Function (Activities of Daily Life-Related), %	Psychological, %	Social, %	Pain/ Symptoms, %	Other	Level of Evidence of Index Study(s)	Psychometric Analysis: Property (n)	Outcome Measures
MAS[42]	47 (47–235)	100					1b	Reliability (45); validity (37); interpretability	HFS
MWQ[43]	16 (0–100)	63		6	25	6% (Satisfaction)	1b	Reliability (100); validity (100); responsiveness (100)	DASH; PRWE; MWS; CBS
PFWO[44,45]	52 (Variable)	95 (Approx)		5 (Approx)			1b	Reliability (50); validity (50, 26); responsiveness (26); interpretability	ADLs
PRWHE[46]	15 + 1 (0–100)	54		13	33	Plus 10 pts (Appearance)	1b	Validity (60); responsiveness (60); interpretability	DASH
PRWE[47]	15 (0–100)	54		13	33		3b	Reliability (38); validity (53)	SF-36; impairment score (wrist ROM, grip strength; checkers subset)

		COSMIN Checklist and Four-Point Rating System[b]								
		Reliability			Validity				Responsiveness	Interpretability
					Content Validity	Construct Validity		Criterion Validity		
Outcome Measure	IRT Box	A. Internal Consistency	B. Reliability (Test-Retest, Interrater, Intrarater)	C. Measurement Error (Test-Retest, Interrater, Intrarater)	D. Content (Face) Validity	E. Structural Validity	F. Hypothesis Testing	G. Criterion Validity (Concurrent Validity, Predictive Validity)	H. Responsiveness	I. Interpretability
DASH[18]	0	Excellent	Excellent	0	Excellent	Excellent	Excellent	0	Excellent	Score distribution; score change
QuickDASH[19]	0	Excellent	Excellent	0	Excellent	Excellent	Excellent	0	Excellent	Score distribution; score change
UEFT[20]	0	Poor	Poor	0	Poor	Poor	Poor	0	0	Score distribution; score change
ULFI[21]	0	Good	Good	Good	Excellent	Poor	Good	Good	Good	Missing item handling; score distribution; score change; floor-ceiling effect; MDC
ASES-S[22]	0	Good	Good	Good	Excellent	Poor	Good	0	Good	Score distribution; score change; MDC, MCID

(*continued*)

IRT = item response theory; MCID = minimal clinical important difference; MDC = minimal detectable change; PRO = patient-reported outcome; SAS = Shoulder Activity Scale.

[a] Including instrument weighting.

[b] COSMIN Box G (Cross-cultural validity) was excluded—translations and cultural adaptations out of scope.

Table 2 (*continued*)

Characterization and Quality Assessment of PRO Measures Involving Patients With Upper Extremity Trauma in the Original Study Cohort

	COSMIN Checklist and Four-Point Rating System[b]									
		Reliability			Validity					
					Content Validity	Construct Validity		Criterion Validity	Responsiveness	Interpretability
Outcome Measure	IRT Box	A. Internal Consistency	B. Reliability (Test-Retest, Interrater, Intrarater)	C. Measurement Error (Test-Retest, Interrater, Intrarater)	D. Content (Face) Validity	E. Structural Validity	F. Hypothesis Testing	G. Criterion Validity (Concurrent Validity, Predictive Validity)	H. Responsiveness	I. Interpretability
KJOC[23]	0	Poor	Poor	Poor	Excellent	Good	Fair	0	Good	Score distribution; score change
MISS[24]	0	0	Poor	Poor	Good	Poor	Fair	0	0	Score distribution; score change; MDC
MSQ[25]	0	0	0	0	Good	Poor	Good	0	0	Score distribution; floor-ceiling effects
NCS[26]	0	Fair	Poor	0	Good	Poor	Good	0	0	Score distribution; score change
OIS[27]	0	Fair	Good	0	Excellent	Poor	Good	0	Good	Score distribution; score change
PSS[28]	0	Good	Fair	Fair	Excellent	Poor	Fair	0	Good	Score distribution; floor-ceiling effects; score change; MDC, MCID
RC-QOL[29]	0	0	Fair	0	Excellent	Poor	Good	0	0	Score distribution; score change
SAS[30]	0	0	Fair	0	Excellent	Poor	Fair	0	0	Score distribution
SDQ-NL[31]	0	0	0	Good	0	0	0	0	Fair	Score distribution; floor-ceiling effects; score change
SANE[32]	0	0	0	0	Good	0	Good	0	0	Score distribution; score change
SPONSA[33]	0	0	Fair	0	Good	0	Good	0	Good	Score distribution; score change
SSRS[34]	0	0	Fair	0	Good	0	Fair	0	0	Score distribution; score change
SSV[35]	0	0	Fair	0	Good	Poor	Good	0	Good	Score distribution; score change
WORCI[36]	0	0	Good	0	Excellent	Poor	Good	0	Good	Score change
WOSI[37]	0	0	Good	0	Excellent	Poor	Fair	0	Fair	Score change

(*continued*)

IRT = item response theory; MCID = minimal clinical important difference; MDC = minimal detectable change; PRO = patient-reported outcome; SAS = Shoulder Activity Scale.

[a] Including instrument weighting.

[b] COSMIN Box G (Cross-cultural validity) was excluded—translations and cultural adaptations out of scope.

Table 2 (*continued*)

Characterization and Quality Assessment of PRO Measures Involving Patients With Upper Extremity Trauma in the Original Study Cohort

	COSMIN Checklist and Four-Point Rating System[b]									
		Reliability			Validity					
					Content Validity	Construct Validity		Criterion Validity	Responsiveness	Interpretability
Outcome Measure	IRT Box	A. Internal Consistency	B. Reliability (Test-Retest, Interrater, Intrarater)	C. Measurement Error (Test-Retest, Interrater, Intrarater)	D. Content (Face) Validity	E. Structural Validity	F. Hypothesis Testing	G. Criterion Validity (Concurrent Validity, Predictive Validity)	H. Responsiveness	I. Interpretability
OES[38]	Good	Excellent	Good	Good	Excellent	Excellent	Good	0	Excellent	Score distribution; floor-ceiling effects; score change
PREE[39]	0	0	Good	0	Excellent	Poor	Good	0	0	
MAM-16; MAM-36[40]	Good	0	Good	Good	Excellent	Good	Good	0	0	
MHQ[41]	0	Poor	Poor	0	Excellent	Good	Good	0	0	
MAS[42]	0	0	Fair	0	Excellent	Poor	Fair	Fair	0	Score distribution
MWQ[43]	0	Good	Good	0	Excellent	Poor	Good	0	Good	Score distribution; score change; floor-ceiling effect
PFWO[44,45]	0	0	Good	0	Good	Poor	Poor	0	Poor	Floor-ceiling effect
PRWHE[46]	0	0	0	0	Excellent	0	0	0	Good	Score change
PRWE[47]	0	0	Fair	0	Excellent	Good	Good	0	0	

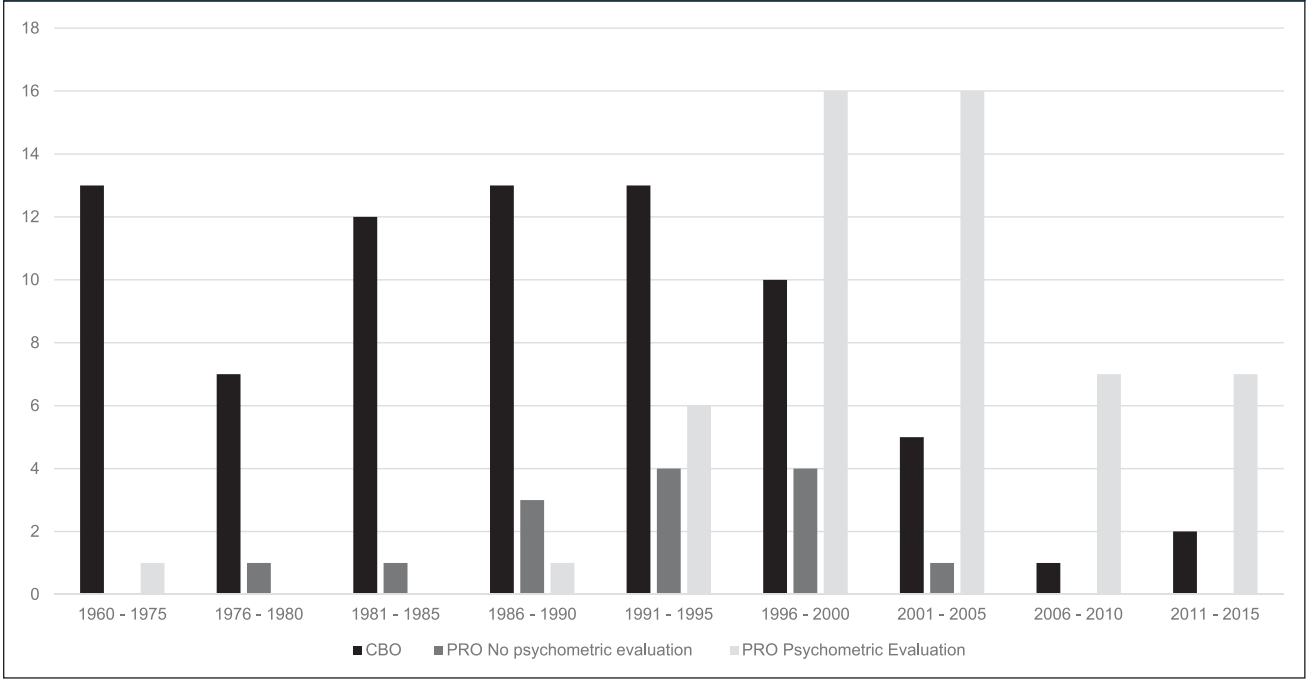
IRT = item response theory; MCID = minimal clinical important difference; MDC = minimal detectable change; PRO = patient-reported outcome; SAS = Shoulder Activity Scale.
[a] Including instrument weighting.
[b] COSMIN Box G (Cross-cultural validity) was excluded—translations and cultural adaptations out of scope.

as internal consistency, measurement error, responsiveness, and interpretability. This work also demonstrated a transition from pure clinician-based measures to nonvalidated PRO measures to those with some form of validation before introduction (Figure 6). A further trend toward an increase in the development of region-specific instruments over condition-specific measures is observed (Figure 7). This may reflect the importance placed on PRO measurement in modern orthopaedic practice as well as a possible trend toward more general outcome measurements of disability impact at the regional level. Despite these findings, relatively low rates of patient-reported assessment have been observed in the orthopaedic trauma literature, and the drive to develop these instruments does not appear to correlate with their level of utilization in clinical practice.[50]

Limitations

There are some limitations to this work. First, only the original index articles relevant to each outcome measure were within scope. We were interested in understanding the nature of the original developmental work by the investigators and the methodological quality of these measures. Although we located the studies for each instrument, it is recognized that more than one early investigation could lay claim to being part of the initial psychometric evaluation. Furthermore, subsequent studies may have superseded these index evaluations, performing further assessments, including specific trauma populations. Second, although the proportion of psychosocial components within our selection of PRO measurements was judged to be low, it is appreciated that investigators may incorporate other measures to account for psychological and social well being. Third, the identified outcome measurement set is unlikely to be exhaustive, but intuitively any instruments "missed" are more likely clinician-based than

Figure 6



Number of clinician-based and patient-reported outcome measurements, including the level of psychometric validation from 1960 to date. CBO = clinician-based outcome, PRO = patient-reported outcome

patient-reported. In this regard, there is an issue of publication bias and its impact on the internal validity of this work.[51] Unpublished studies reporting negative, unfavorable outcomes following instrument testing may exist. The lack of reporting limitations in many of the studies may also reflect a level of reporting bias where there has been a vested interest in instrument promotion. Fourth, we recognize that "all upper extremity trauma conditions" were included as the target category, and findings around methodological quality of measures may vary if the evaluations were performed around specific injuries. Finally, in 7% of authors contacted, inquiries were limited to diagnostic clarification, and no further information was gathered around methodological quality. Thus, it was unclear whether low ratings were down to lack of reporting or actual lack of quality according to COSMIN.

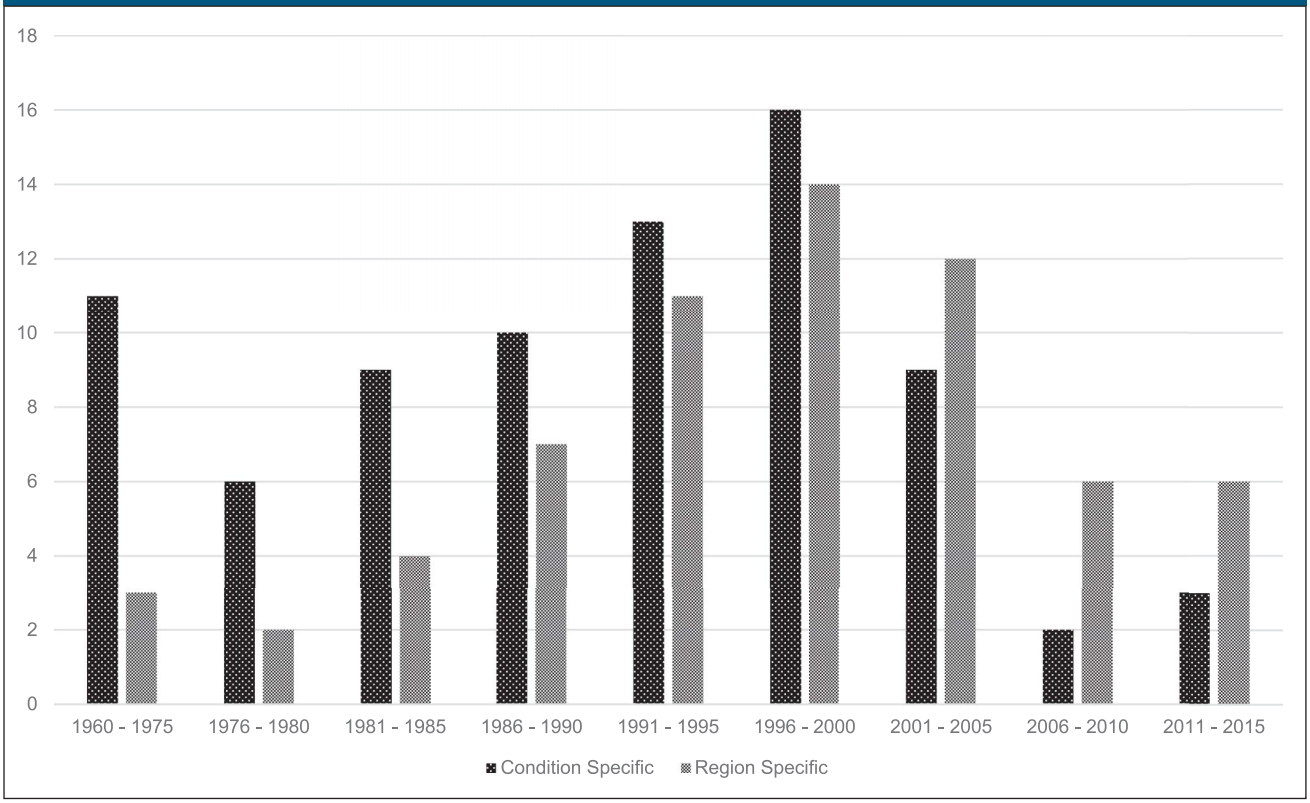
The findings of this review can be considered in light of some of the challenges and solutions in this field.

Timing and recruitment of orthopaedic trauma patients for instrument development, testing, and outcome assessment may be logistically difficult because of a variety of clinical and environmental stressors. Measurement should occur at a time when patients are "stable" enough to perform evaluations while being close enough to the date of injury to fully capture the health-related impact. This can be challenging when considering the effects of symptoms (eg, fracture-related pain) and clinical circumstances (eg, fracture immobilization). These issues may be unavoidable but managed best by improved patient and staff education as outcome measurement becomes part of everyday orthopaedic practice.

Responder burden plus inefficient and irrelevant testing are further issues, especially when full and lengthy fixed-length outcome measures are administered in these populations. The risks of incomplete scoring, poor patient experience, "gaming" of the assessment for perceived reward, and difficulties in estimating performance while being "out of action," alongside the tendency to overestimate one's level of ability in these situations, are apparent.[52]

Functionality and psychometric properties of instruments primarily developed in chronic conditions may lack adequate coverage and incorporate a set of items too narrow and limited in assessing health impact outside this context.[53] This tendency may be reflected by high floor-ceiling effects during applications in trauma.[3,53] Furthermore, instruments or groups of instruments

Figure 7



Outcome measurement type by original publication year from 1960 to date

should adequately cover all relevant health-related domains, including psychosocial factors which are shown to have a dominant influence on disability.

Tailored assessment of patients is an ongoing challenge within outcome measurement in general. It is particularly relevant in orthopaedic trauma where population characteristics are wide ranging. One component involves the assessment of a patient's baseline status, a particular challenge in trauma situations. Other aspects include the capture of patient experience and emerging concept of patient activation, an individual's level of involvement in his or her care and the propensity to engage in adaptive health behaviors.[28,29,54]

One or more of these challenges can be met by the introduction and/or mode of application of established and contemporary outcome measurement systems. First, combinations of region-specific and generic measures with instruments measuring specific factors of relevance, such as depression and pain interference, could be applied to more comprehensively assess patient-focused, health-related outcomes. Instrument choice should depend on the psychometric attributes of the measure, methodological quality in development, and evidence of validation in the target population.[49] Generic PRO measures have gained popularity in trauma as they provide a more holistic measurement of health-related outcomes in the multiply injured and medically complex patient, while allowing comparisons between interventions.[3] Collaborative efforts are underway to develop standardized outcome sets through a consensus-based selection of generic and specific outcome measures.[55]

Second, abbreviated versions of well-established scales (eg, Quick-DASH) have been developed to improve efficiency and performance while maintaining validity against their full-version counterparts.[19] Another contemporary solution involves computerized adaptive tests (CATs). CATs are dynamic tests using computers to administer test items based on the IRT mathematical model.[56–58] An IRT-based algorithm allows adaptation to the patient's last response and administration of relevant subsequent items from a large question bank.[58] The Patient-Reported Outcome Measurement Information System (PROMIS) developed by the US National Institute of Health is one of the most commonly used CAT systems.[56–58]

PROMIS CAT scores range from 0 to 100, with 50 points as US general population mean. They enable capture of physical (eg, physical function and pain interference), mental (eg, anxiety, and depression), and social (eg, social isolation) health domains through modules that can be tailored to the study and population being assessed.[56] Customization, avoiding redundancy, minimizing floor-ceiling effects, and maximizing scoring efficiency and measurement precision are clearly advantageous in the trauma setting.[56–58] Studies have demonstrated the correlation of CATs with popular fixed-length scales.[59]

In general, computer-based outcome assessment represents a positive paradigm shift, with instruments such as PROMIS CATs being incorporated in outcome measurement software by well-established organizations such as the AO Foundation.[60] It is important to note that PROMIS CATs were originally developed for chronic conditions, and their development as regional measures (eg, PROMIS Upper Extremity Physical Function CAT) and evaluation in traumatic conditions is ongoing.[56,61] Other outcome measures with adaptive capabilities, but delivered through a paper-based format, include the FLEX-SF shoulder instrument and short-form PROMIS measures.[56,62]

Some fixed-length scales have also been designed to provide a more relevant, patient-specific assessment by factoring in patient-reported "levels of ability" and "levels of necessity" in relation to various activities.[42] Other instruments have focused on accurate measurement of functional progress and minimizing the discrepancy between what patients report and what they actually do, by clinician-observed grading of enacted activities of daily life in real time.[63] PRO measures such as the PFWO and ULFI are designed to capture recall of preinjury performance and baseline function.[21,44,45] The former includes a component that accounts for compensatory mechanisms in performing daily activities.[44,45] Another strategy in establishing a baseline involves the use of patient proxies, such as family and friends, to aid in recall of preinjury function during the early postinjury phase.[64] In terms of patient satisfaction with various health domains, the MHQ includes a component measuring satisfaction with appearance, physical function, and symptoms.[41] Patient experience, including satisfaction with care, is often assessed through separate scales, although instruments such as the SRI and MWQ evaluate this aspect in musculoskeletal trauma and wrist/hand injuries, respectively.[43,65] Early work on patient activation measures has demonstrated a direct correlation with satisfaction among upper extremity conditions and musculoskeletal trauma patients, as well as improved pain relief, mental health, and reduced disability.[66,67] Further research is necessary to assess correlation with PROs.

This work has systematically reviewed the methodological quality of studies involving PRO measurements in upper extremity trauma on a broad scale. Focused evaluations, using the COSMIN checklist, have been conducted in distal radius fractures; however, the literature in this area is lacking overall.[49] Instrument properties should be defined for the population being tested and not for the PRO instrument itself.[3,13] In reality, PRO measures have been used throughout orthopaedics in patient groups for which the instrument was not initially developed or psychometrically evaluated.[3,13] It is unclear whether commonly used instruments can measure all the health-related aspects surrounding upper limb trauma important to the individual. These measures are commonly selected by intuition, clinical culture, and familiarity, with the belief that they are "fit for purpose" and capable of capturing the substantive components of disability experienced by these patients. Ultimately, PRO measurement selection requires careful consideration of the methodological quality, and further research is required to evaluate their psychometric properties in these populations. Reaching a consensus on outcome measurement sets in trauma that are delivered in a standardized fashion will form a more complete, comparable, and interpretable assessment of disability in these populations.[68]

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Appendix 1. PRISMA 2009 Checklist

Section/Topic	No.	Checklist Item	Reported on Page No.
Title			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
Abstract			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
Introduction			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3, 4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
Methods			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (eg, Web address), and, if available, provide registration information including registration number.	5
Eligibility criteria	6	Specify study characteristics (eg, PICOS and length of follow-up) and report characteristics (eg, years considered, language, and publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (eg, databases with dates of coverage and contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supplemental Digital Content 1 (http://links.lww.com/JG9/A2)
Study selection	9	State the process for selecting studies (ie, screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Figure 1
Data collection process	10	Describe method of data extraction from reports (eg, piloted forms, independently, and in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (eg, PICOS and funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (eg, risk ratio and difference in mean).	n/a
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (eg, I^2) for each meta-analysis.	6
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (eg, publication bias, selective reporting within studies).	6

(*continued*)

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Appendix 1 (*continued*)

Section/Topic	No.	Checklist Item	Reported on Page No.
Additional analyses	16	Describe methods of additional analyses (eg, sensitivity or subgroup analyses and meta-regression), if done, indicating which were prespecified.	n/a
Results			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	7
Study characteristics	18	For each study, present characteristics for which data were extracted (eg, study size, PICOS, and follow-up period) and provide the citations.	7
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Table 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (1) simple summary data for each intervention group (2) effect estimates and confidence intervals, ideally with a forest plot.	n/a
Synthesis of results	21	Present the main results of the review. If meta-analyses are done, include for each, confidence intervals and measures of consistency.	7
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see item 15).	Table 2
Additional analysis	23	Give results of additional analyses, if done (eg, sensitivity or subgroup analyses, meta-regression [see item 16]).	n/a
Discussion			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (eg, healthcare providers, users, and policy makers).	8
Limitations	25	Discuss limitations at study and outcome level (eg, risk of bias) and at review-level (eg, incomplete retrieval of identified research and reporting bias).	9
Conclusions	26	Provide a general interpretation of the results in the context of other evidence and implications for future research.	8, 13
Funding			
Funding	27	Describe sources of funding for the systematic review and other support (eg, supply of data); role of funders for the systematic review.	n/a

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