INTRODUCTION

Major lower extremity amputation (MLEA) is often the best option for risk modification and overall health outcomes following severe trauma. Although many advances have been made in the surgical management of MLEA following trauma, most research in this field focuses on medical outcomes, such as surgical complications, re-amputation rates, and resulting health issues. Recently, there has been a push across all fields of medicine to incorporate patient-centered outcomes (PCO) into clinical research to augment medical decision making. PCO are defined as outcomes important to patient decision making, often describing functional status, satisfaction, and quality of life (QOL). In 2010, the Patient-Centered Outcome Research Institute was approved by congress as part of the Affordable Care Act to fund research for increased patient-centered endpoints.

Despite this emphasis on improving patient-centered care, there is insufficient research that evaluates PCO after MLEA, including functional capabilities, QOL, mental health status, and chronic pain. Further, the PCO research that does exist lacks cohesiveness and standardization of instruments to assess function, QOL, and other patient-focused measures.

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standardization, with few measures specific to lower extremity trauma and amputation.\textsuperscript{7,8} Validated patient-reported outcome measures (PROMs) that assess multiple aspects of treatment outcomes, such as the Short Form Survey-36 and the Sickness Impact Profile (SIP), are frequently used in this patient population\textsuperscript{5,6}; however, QOL PROM scales specific to patients after traumatic MLEA are rare, prohibiting assessment of the success of treatment options to meet specific needs, values, and expectations of the traumatic amputation patient.\textsuperscript{11}

Standardized collection and reporting of patient-centered functional and QOL outcomes following amputation is critical for advancing surgical techniques, comprehensively assessing outcomes, and improving patient expectations and joint medical decision making.\textsuperscript{5,11,12} To better understand the prevalence and methods of PCO reported following traumatic MLEA, this study performs a systematic review of articles published between 2000 and 2020 and applies a meta-analysis to assess trends. Improved understanding of PCO research in this population will contribute to the overarching objective in healthcare to incorporate patient-centered data into shared decision making, accounting for patient values and goals and improving outcomes.

**METHODS**

**Search Strategy**

A systematic review and meta-analysis were performed, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, with the goal of identifying all peer-reviewed studies of traumatic-origin MLEA published between January 2000 and November 2020. An electronic database search using Ovid MEDLINE was performed to identify relevant articles. Medical Subject Headings terms and keywords included in this search were limb salvage, leg injuries, lower extremity trauma, wounds and injuries, trauma, traumatic; traumatic amputation, major lower extremity amputation, below knee amputation, through knee amputation, above knee amputation, transfemoral amputation, transfibular amputation, lower extremity amputation.

**Study Identification**

Abstracts and titles from this search were initially screened independently for relevance by two reviewers (ART, WR). If the decision to include an article was not unanimous, a third reviewer (KGG) was consulted until consensus was determined. Included studies then underwent full-text review. Studies that met all inclusion criteria were included in the review and meta-analysis.

Articles were included in this study that reported data on lower extremity amputations if more than 80% of the amputations were “major,” defined as above knee- (AKA), below-knee (BKA), or through-knee (TKA) amputation. Similarly, more than 80% of amputations in each study had traumatic etiology; studies were excluded if they reported more than 20% oncologic resections or chronic wound-associated amputations, or if they included upper extremity amputations. Studies could report any outcome, including complication rates, biomechanical data, QOL measures, or functional results. Case reports describing two or more patients were included if they met other inclusion criteria. All articles in the final analysis were in English language and published in peer-reviewed journals.

**Study Quality Assessment**

The Newcastle-Ottawa Scale for cohort studies was applied to assess the quality and possible biases of each article by a single reviewer (ART). The “most important” factor for assessment of comparability between groups in our review was the level of amputation. An additional star for comparability was awarded to any study design that controlled for at least one confounding factor.

**Data Extraction and Statistical Analysis**

Article information, including study design, publication year, military population, amputation level and laterality, and cohort size, was collected. All outcomes were recorded, and when data were available, weighted means and SDs were calculated. The inclusion of PCO was analyzed qualitatively and quantitatively by four categories: (1) physical function and mobility, (2) QOL and satisfaction, (3) psychosocial, and (4) pain outcomes. Temporal trends in the reporting of PCO were assessed. Univariate analyses with Pearson’s chi-squared test compared the inclusion of PCO between study categories of patient populations, amputation levels, and amputation laterality. Bivariate analysis with one-way analysis of variance compared PCO by studies in 5-year time intervals. Statistical analysis was performed using STATA, v.15 (StataCorp, College Station, Tex.) with significance defined as a $P$ value less than 0.05.

**RESULTS**

The literature search initially yielded 7001 articles. After the title and abstract screen, 370 articles remained to undergo full-text review, with 136 articles meeting inclusion criteria for data synthesis (Fig. 1). Assessment of study quality using the Newcastle-Ottawa Scale found all studies met a minimum score of six out of nine stars, designating study quality as “good” or higher as defined by the Agency for Healthcare Research and Quality standards.

Among all 156 studies included in the final review, data from 12,486 patients who underwent MLEA were collected. Study characteristics are outlined in Supplemental Digital Content 1. (See table, Supplemental Digital Content 1, which displays the studies included. \textsuperscript{http://links.lww.com/PRSGO/B832}.) An estimated 140 studies (89.7%) were retrospective, and the average cohort size was 80 patients. In total, 123 studies reported only unilateral amputations, six studies reported bilateral amputations, and 27 studies reported data on both. Most studies reported data on only BKA or AKA patients, 62 and 26 studies respectively; the remaining 68 reported a mix of data from individuals who underwent BKA, TKA, or AKA. Further, 58 articles analyzed military patient populations, whereas the rest focused on civilian amputees.
Analysis of all outcomes in the included articles revealed that 129 (82.7%) studies reported clinical-centered outcomes, including surgical outcomes, complication rates, long-term health outcomes, and biomechanical assessments. In contrast, only 94 (60.3%) studies report PCO. Figure 2 displays the categories of PCO reported among articles; 83 (53.2%) report physical function and mobility outcomes, 33 (21.2%) report QOL and satisfaction measures, 38 (24.4%) report psychosocial effects, and 43 (27.6%) report pain outcomes.

Clinical-centered Outcomes
Of the 129 studies that reported clinical-centered outcomes, 58 (37.2%) reported biomechanical assessments, including kinematic and temporospatial measures, 44 (28.2%) described surgical outcomes or complication rates, 36 (23.1%) reported long-term health outcomes, 33 (21.2%) reported physiologic and metabolic changes, nine (5.8%) reported neurological changes, and only three (1.9%) reported mortality rates after amputation.

The most commonly reported complication after major amputation was infection or abscess by 23 studies, with a weighted rate of 24.4% (Table 1). Other frequently described complication rates were neuroma (20.0%), heterotopic ossification (16.4%), and ulceration (8.7%) (Table 1). The average reoperation rate after amputation was 48.8%, as reported by 14 studies. An estimated 58 studies described kinematic and temporospatial assessments of amputees, often with prosthesis use. These metrics included gait speed, step length, muscle forces, and joint angles. The long-term health outcomes described by 33 studies included chronic back pain and arthritis that developed after amputation.

PCO: Physical Function and Mobility
A total of 83 studies reported outcomes related to physical function and mobility; 38 (24.4%) described measures of functional status, 57 (36.5%) reported ambulatory rates, and 30 (19.2%) described prosthesis use (Fig. 2).

Functional status reported was measured through ability to participate in sports, activity and functional scales, and activities of daily living (ADLs) (Table 2). Sports involvement was described by three studies with an average rate of 48.62% of amputees. The Day Activity Scale was used by three studies, with an average score of 29.98 corresponding to high physical activity level. The Medicare Functional Classification Level, used in four studies, classified most amputees at a K3 level
indicating unlimited community ambulation with ability to use a prosthesis. ADLs, reported in two studies, displayed an average of 40.4% of amputees able to independently complete basic ADLs. Likewise, various sub-scores of multidimensional scales, including the 36-Item Short Form Survey (SF-36), Patient-Reported Outcomes Measurement Information System-29 (PROMIS-29), and SIP, were used by 20 studies to describe functional status.

Ambulation and mobility are described in Table 2. An estimated 20 studies reported ambulatory rate, with an average rate of 90.97%. The average time to ambulation was 3.68 months among 187 patients. A general Ambulation Level was reported by two studies that scored patients from 1 to 7, corresponding to “cannot walk” and “high impact activities,” respectively; 64.9% scored at or below a Level 4. The Special Interest Group in Amputee Medicine Mobility Grade was also used by two studies, with over half of patients scoring a grade E or F corresponding to occasional walking aid use. Other studies included the Harold Wood Stanmore Ambulation Assessment, the Lower Extremity Functional Scale, and the Ambulation Grade. More than 20 articles included physical tests, such as the 6 Minute Walk Test and the Timed Up and Go, to measure mobility status.

Prosthesis use was commonly reported as a means of assessing mobility. Average daily prosthesis use, from 20 articles, was 12.24 hours/day. Eleven studies also described time from amputation to prosthesis use as an

Table 1. Amputation Complication Rates

| Complication                  | No. Studies (No. Patients) | Weighted Complication Rate |
|------------------------------|----------------------------|---------------------------|
| Infection or abscess         | 23 (1883)                  | 24.4%                     |
| Neuroma                      | 16 (1475)                  | 20.0%                     |
| Heterotopic ossification     | 11 (1084)                  | 16.4%                     |
| Ulceration                   | 11 (1229)                  | 8.7%                      |
| Stump skin issues            | 7 (397)                    | 26.2%                     |
| Delayed healing              | 4 (171)                    | 39.2%                     |
| Flap necrosis                | 4 (69)                     | 4.3%                      |
| Flap loss or failure         | 4 (55)                     | 10.9%                     |
| Osteomyelitis                | 2 (57)                     | 5.3%                      |
| Bleeding or hemorrhage       | 2 (54)                     | 5.6%                      |
| Skin graft loss              | 1 (6)                      | 16.7%                     |

Fig. 2. Flowchart of studies that report PCO, divided into categories and subcategories of physical function and mobility, QOL and satisfaction, psychosocial, and pain.
average of 4.23 months. Patient prosthesis use was reported by two studies,37,38 and Li et al used the Houghton Scale to assess patient perspective of their own prosthesis usage.21

PCO: QOL and Satisfaction
QOL and satisfaction after major amputation was investigated by 33 (21.2%) studies, with the majority of these articles reporting satisfaction with prosthesis (21 studies, 13.5%); 11 (7.1%) studies examined overall QOL, two (1.3%) reported general satisfaction, and three (1.9%) reported other measures of QOL and satisfaction (Fig. 2).

Various questionnaires and surveys were used to assess overall QOL (Table 3). The Questionnaire for Persons with a Transfemoral Amputation was used by three studies, with an average QOL score of 76.71 out of 100,35,59 Two studies reported a QOL rating, and more than half of patients reported their QOL to be good, fair, or poor; only 42.5% reported their QOL to be excellent or very good.20,27,40 QOL was also reported by studies in the SIP and EuroQol Questionnaire (EQ-5D).10,41–45

Satisfaction with prosthesis was the most commonly reported QOL or satisfaction metric (Table 3). Various scales were used, including the Trinity Amputation and Prosthesis Experience Scales (TAPES) by three studies,23,41,42 and Prosthesis Evaluation Questionnaire (PEQ) by eight.20,35,47–52 Average overall prosthesis satisfaction score was found to be 7.3 on a scale of 10.10,46 Eight studies had patients rate their prosthesis satisfaction; 86.5% of patients reported that they were satisfied.17,19,25,28–30,37,40,53,54

General satisfaction was described by two studies in sub-scales of the PROMIS-29 and AAOS LLQ.31,32 Additional QOL and satisfaction reports were in the forms of sexual satisfaction and satisfaction with body image. Em et al reported an overall satisfaction with sexual performance after amputation to be 5.6 out of 10.36 Gozaydinoglu et al implemented the Amputee Body Image Scale, and Poljak-Guberina et al described overall satisfaction rates with cosmetic outcomes,46,54

Table 2. Physical Function and Mobility Outcomes

| Outcome | No. Studies (No. Patients) | Weighted Outcome |
|---------|---------------------------|------------------|
| Activity and functional status | | |
| Physical activity level | | |
| Sports participation | 3 (399) | 194 (48.62%) |
| Day Activity Scale (mean ± SD) | 3 (27) | 28.98 ± 2.86 |
| Functional status | | |
| Medicare Functional Classification Level | | |
| K0 | 3 (363) | 0 (0%) |
| K1 | 3 (363) | 0 (0%) |
| K2 | 3 (363) | 77 (21.21%) |
| K3 | 3 (363) | 292 (63.91%) |
| K4 | 3 (363) | 54 (14.88%) |
| Mean K score (mean ± SD) | 1 (17) | 2.89 ± 0.93 |
| ADLs, % independent | 2 (256) | 103 (40.38%) |
| Ambulation and mobility | | |
| Ambulation assistance devices | | |
| % Requiring assistive device | 11 (803) | 489 (60.90%) |
| Mobility & ambulatory scales | | |
| Ambulation level | | |
| Level 1-2 (cannot walk) | 2 (57) | 18 (31.58%) |
| Level 5 (household walker) | 2 (57) | 6 (10.33%) |
| Level 4 (community walker) | 2 (57) | 13 (22.81%) |
| Level 5 (can walk with varying speeds) | 2 (57) | 9 (15.79%) |
| Level 6 (low impact activities) | 2 (57) | 5 (8.77%) |
| Level 7 (high impact activities) | 2 (57) | 6 (10.53%) |
| Harold Wood Stanmore | | |
| Ambulation Assessment | | |
| Nonambulatory | 2 (277) | 3 (1.08%) |
| Household ambulatory | 2 (277) | 8 (2.89%) |
| Community ambulatory | 2 (277) | 263 (94.95%) |
| SIGAM Mobility Grade | | |
| A (not using limb) | 2 (137) | 3 (2.19%) |
| B (transfers/short distances) | 2 (137) | 8 (5.84%) |
| C (walks indoor with aid) | 2 (137) | 17 (12.41%) |
| D (walks outdoors with aid) | 2 (137) | 37 (27.01%) |
| E (occasional walking aid use) | 2 (137) | 13 (9.49%) |
| F (walk anywhere without aid) | 2 (137) | 59 (43.07%) |
| Ambulation rate | | |
| Ambulation rate | 20 (1164) | 1059 (90.97%) |
| Time to ambulation, mo (mean ± SD) | 2 (187) | 3.68 ± 0.73 |
| Prosthesis use | | |
| Daily prosthesis use, h/d (mean ± SD) | 20 (1877) | 12.24 ± 1.90 |
| Time to prosthesis use, mo (mean ± SD) | 11 (341) | 4.23 ± 1.74 |

SIGAM, Special Interest Group in Amputee Medicine

Table 3. QOL and Satisfaction Outcomes

| Outcome | No. Studies (No. Patients) | Weighted Outcome |
|---------|---------------------------|------------------|
| Overall QOL | | |
| Questionnaire for Persons with a Transfemoral Amputation | 2 (59) | 76.71 ± 10.66 |
| QOL rating | | |
| Excellent or very good | 3 (407) | 173 (42.51%) |
| Good, fair, or poor | 3 (407) | 253 (57.49%) |
| Satisfaction with prosthesis | | |
| Satisfaction score (0-10) | 2 (593) | 7.33 ± 0.55 |
| Satisfaction rating | | |
| Dissatisfied | 8 (911) | 88 (9.66%) |
| Neither satisfied nor dissatisfied | 8 (911) | 21 (2.31%) |
| Satisfied | 8 (911) | 788 (86.50%) |

Table 4. Psychosocial Outcomes

| Psychiatric disorders | No. Studies (No. Patients) | Weighted Outcome |
|-----------------------|---------------------------|------------------|
| Depression | 7 (1048) | 280 (19.08%) |
| PTSD | 9 (1212) | 377 (31.11%) |
| Anxiety | 2 (196) | 26 (13.27%) |
| Substance use disorder | 3 (552) | 22 (3.99%) |
| Any diagnosis | 4 (583) | 261 (44.77%) |
| Employment status | | |
| Employment rate | 17 (2948) | 1257 (61.38%) |

PTSD, post-traumatic stress disorder.
Employment rate was reported by 17 studies, with an average of 61.4% of amputees returning to work (Table 4). Ebrahimzadeh et al reported whether amputees had to change their occupation,62 and two studies reported whether patients returned to active military duty.60,61 Adjustment and social function after major extremity amputation was reported by 14 articles, predominately using social subscales of multidimensional surveys. In total, 10 studies used the SF-36,9,10,15,13,35,51,56,64–67 one used the TAPES,46 and four used the SIP.10,42,43,68

PCO: Pain

Less than one third of studies assessed pain in amputees (Fig. 2). A total of 12 (7.7%) studies reported general body pain, 34 (21.8%) reported residual limb pain, and 15 (9.6%) reported phantom limb pain (PLP) measures. General body pain scores were reported through sub-scales of the PROMIS-29 and SF-36 surveys by 12 studies.

Reports of RLP and PLP consisted of prevalence rates and intensity scores (Table 5). Based on data from 21 studies, 44.2% of amputees experienced RLP. The average intensity score of RLP was determined to be 3.27 out of 10.21,57,64,69 Likewise, 12 studies reported the prevalence of PLP to be 50.6%, and four of these articles reported an average intensity score of 5.13 out of 10.21,57,64,69

Patient-reported Outcome Measures

Multidimensional PROMs that assess numerous classifications of PCO were used by 27 articles (Table 6). Used most frequently, the SF-36 was implemented in 14 studies to assess outcomes within the Physical Component Scale (PCS) and the Mental Component Scale and eight sub-scores.9 The average PCS score as reported by seven studies was 46.63 out of 100, where scores higher than 50 indicated better QOL.10,33,35,56,66,70,71 The average physical functioning sub-score was 60.45, social functioning sub-score was 78.36, and mental health sub-score was 65.84.9,10,33,35,51,56,64,65,67

Other frequently used PROMs included the PEQ, SIP, and TAPES (Table 6). The PEQ was used in eight studies to assess prosthesis function, mobility, psychosocial experiences, and general well-being (Table 6).20,35,47–55 Overall usefulness of prosthesis was rated to be an average of 73.9 out of 100.35,48–51 Mobility was rated an average score of 75.1, and overall well-being scored a mean of 83.1.35,48–51 Four studies integrated the SIP in the domains of physical, psychosocial, and independence outcomes, where a score of 0 indicated no dysfunction and 100 indicated complete dysfunction.10,41–43 Average physical and psychosocial domain scores were 11.63 and 8.84, respectively.35,41–43 TAPES focused on psychosocial adaptation, activity, and prosthesis satisfaction in three studies.52,54

Average psychosocial score was 58.0 on a scale of 7–75, activity restriction score was 16.2 on a scale of 12–36, and prosthesis satisfaction was 39.8 on a scale of 10–50.52,54 Less commonly included PROMs were the PROMIS-29, AAOS LLQ, and EQ-5D measures (Table 6). The EQ-5D self-reported measures of mobility, self-care, pain, and mental health.44,45

### Table 5. Pain Outcomes

|                | No. Studies (No. Patients) | Weighted Outcome |
|----------------|----------------------------|------------------|
| Residual limb pain |                             |                  |
| RLP prevalence  | 21 (1615)                  | 713 (44.15%)     |
| Pain score (0–10)| 17 (1144)                  | 3.27 ± 1.37      |
| PLP            |                            |                  |
| PLP prevalence  | 12 (1264)                  | 639 (50.55%)     |
| Pain score (0–10)| 4 (101)                    | 5.13 ± 1.33      |

### Table 6. Patient-reported Outcome Measures

| PROM Scale            | No. Studies (No. Patients) | Weighted Score |
|-----------------------|----------------------------|----------------|
| SF-36                 |                            |                |
| General health        | 9 (623)                    | 64.53 ± 7.27   |
| Physical functioning  | 10 (701)                   | 60.45 ± 10.19  |
| Role limitations due to physical function | 9 (623) | 50.09 ± 9.91 |
| Social functioning    | 9 (623)                    | 78.36 ± 4.31   |
| Vitality/energy       | 9 (623)                    | 62.11 ± 6.59   |
| Bodily pain           | 11 (739)                   | 63.10 ± 8.93   |
| Mental health         | 9 (623)                    | 65.84 ± 8.08   |
| Role limitations due to emotional health | 9 (623) | 60.27 ± 11.06 |
| PCS                   | 7 (332)                    | 46.63 ± 5.63   |
| Mental Component Scale| 5 (196)                    | 47.92 ± 6.29   |
| Total score           | 1 (271)                    | 59.00 ± 5.00   |
| Sickness Impact Profile |                         |                |
| Overall score         | 4 (177)                    | 13.20 ± 4.81   |
| Physical domain       | 4 (177)                    | 16.55 ± 5.01   |
| Body care and movement| 2 (58)                     | 11.38 ± 6.30   |
| Ambulation            | 2 (58)                     | 33.78 ± 11.23  |
| Mobility              | 2 (58)                     | 13.72 ± 6.78   |
| Sleep and rest        | 2 (58)                     | 22.28 ± 10.16  |
| Psychosocial domain   | 4 (177)                    | 8.84 ± 3.85    |
| Emotional behavior    | 2 (58)                     | 10.27 ± 2.92   |
| Social interaction    | 2 (58)                     | 12.17 ± 7.64   |
| Alertness behavior    | 2 (58)                     | 8.43 ± 6.88    |
| Communication         | 2 (58)                     | 1.77 ± 1.79    |
| Independent dimension |                          |                |
| Household management  | 2 (58)                     | 21.25 ± 8.77   |
| Work                  | 2 (58)                     | 50.88 ± 15.96  |
| Eating                | 2 (58)                     | 2.35 ± 2.28    |
| PEQ                   |                            |                |
| Prosthesis function   | 5 (179)                    | 73.89 ± 3.20   |
| Residual limb health  | 4 (168)                    | 61.30 ± 9.06   |
| Appearance            | 3 (101)                    | 73.77 ± 5.23   |
| Sounds                | 4 (112)                    | 61.33 ± 5.76   |
| Mobility              | 5 (179)                    | 75.07 ± 6.45   |
| Psychosocial experience|                         |                |
| Perceived responses   | 4 (112)                    | 90.10 ± 2.86   |
| Social burden         | 2 (73)                     | 83.42 ± 7.05   |
| Frustration           | 5 (179)                    | 70.67 ± 8.26   |
| Well-being            | 5 (179)                    | 83.09 ± 6.20   |
| TAPES                 |                            |                |
| Psychosocial adjustment|                         |                |
| Activity restriction  | 3 (107)                    | 50.00 ± 3.28   |
| Prosthetic satisfaction| 3 (107)                   | 39.82 ± 3.71   |
| PROMIS-29             |                            |                |
| Physical function     | 1 (604)                    | 44.53          |
| Satisfaction with social roles | 1 (604) | 49.9 |
| Pain interference     | 1 (604)                    | 54.1           |
| Depression            | 1 (604)                    | 48.4           |
| Fatigue               | 1 (604)                    | 47.5           |
| Sleep disturbance     | 1 (604)                    | 49.1           |
| Anxiety               | 1 (604)                    | 48.6           |
| American Academy of Orthopaedic Surgeons Lower Limb Questionnaire Score | 1 (28) | 88.25 ± 1.62 |
Trends in Reporting PCO

Univariate statistical analysis compared the prevalence of PCO reporting based on study characteristics (Table 7). Studies that included data from military amputee populations reported PCO at a higher frequency than studies on nonmilitary amputees, trending toward significance (70.7% versus 55.1%, \( P = 0.054 \)). There was no difference in the frequency of PCO reporting between studies that reported outcomes of all BKA patients or all AKA patients (50.0% versus 59.7%, \( P = 0.403 \)). Studies that reported data on all bilateral amputees reported PCO at a significantly higher rate of 100.0% when compared with only 56.9% in studies that reported all unilateral amputees (\( P = 0.036 \)).

To compare the reporting of PCO over time, bivariate analysis was performed between 5-year time intervals of articles published between 2000 and 2020 (Table 8). The frequency of studies that reported PCO during each 5-year interval ranged between 59.2% and 66.7%; no significant difference was found between each time interval (\( P = 0.557 \)). Figure 3 depicts patterns in the overall reporting of PCO and among subcategories of PCO between 2000 and 2020. There was no discernible trend in changes of PCO reporting during this 20-year time period.

**DISCUSSION**

This study demonstrates a significant paucity in research between clinical-centered outcomes and PCO; in the last two decades only 60% of articles that report outcomes of traumatic MLEA include any form of PCO in their analysis. This gap is widened further when taking into account specific patient-reported outcomes, such as functional capabilities, QOL, and psychosocial measures, which are only reported in 53%, 21%, and 24% of articles, respectively. Although previous reviews have explored PCO reporting after MLEA, this study is the first to highlight the prevalence and details of the discrepancy in PCO documentation in this patient population.

The extensive variety and inconsistency of approaches to measure PCO revealed by this meta-analysis made it difficult to compare traumatic amputee populations by etiology. More than 45 unique measurements, ratings, and scales were implemented by the included studies to assess physical function and mobility of amputees alone. Nearly 40 other measurements were used to reflect the impact of traumatic amputations on QOL, psychosocial, and pain outcomes. Despite the useful data provided by each PCO metric, comparing surgical strategies or recovery methods using these disparate measurements is a challenge. Further, we revealed that despite global pushes in healthcare research to incorporate and emphasize PROMs, there has been no trend in PCO inclusion in the last 20 years to suggest improvement. Though many factors may contribute to this finding, the lack of a standardized tool to measure PCO among traumatic amputees likely plays a significant role.

The traumatic amputee population has higher rates of anxiety and depression than the general population, warranting a closer assessment of overall well-being and daily function. Studies have shown that patient satisfaction after lower extremity amputation is highly correlated with physical function in combination with psychological distress factors, such as depression and ability to return to work. O’Toole et al found that these factors were more predictive of satisfaction than injury severity or specific treatment itself. Unfortunately, postamputation care does not often focus on psychosocial or QOL interventions. Archer et al found that 85% of individuals after traumatic lower extremity injury reported an unmet need for at least one service, including vocational and mental health services. Engaging these highly comorbid patients with patient-centered surgical and recovery plans specifically adapted for traumatic amputees may address these health disparities and care limitations, leading to improved long-term outcomes.

A standardized set of PROMs individualized to the needs of the traumatic MLEA population is critical for clinical and patient-centered improvement. Presently, no traumatic amputee-specific QOL metric has been used that allows us to analyze the experiences distinct to this patient population. Many functional scales and instruments used in these studies are not designed for the traumatic amputation population and thus may not elucidate small changes in outcomes reliably. Measurements overly specific to patients, such as military or amputation level-specific metrics, included in some articles lacks generalizability to larger populations of traumatic amputees. On the contrary, the use of standardized scales and PROMs intended for the general population such as the SF-36, or nontraumatic amputees such as the PEQ is not tailored to the specific needs and values of this patient population. Although some provide some reliable data, such as associations of higher phantom pain severity with SF-36 scores for physical function and PCS, others may not reflect true differences from baseline function and QOL.

Multiple scales specific to lower extremity surgical outcomes exist, such as the Lower Extremity Functional Scale and the Locomotor Capabilities Index. Instruments specific to traumatic injury, such as the Toronto Extremity

### Table 7. PCO by Categories

| Patient Population | Total Articles | Studies with PCO | \( P \) |
|--------------------|---------------|-----------------|------|
| Military           | 58            | 41 (70.69%)     | 0.054|
| Nonmilitary        | 98            | 54 (55.10%)     |      |
| Amputation Level   |               |                 |      |
| All BKA            | 26            | 13 (50.00%)     | 0.403|
| All AKA            | 62            | 37 (59.68%)     |      |
| Laterality         |               |                 |      |
| All unilateral     | 123           | 70 (56.91%)     | 0.036|
| All bilateral      | 6             | 6 (100.00%)     |      |

Bold indicates significance level. Significance is defined as \( p > 0.05 \).

### Table 8. PCO by 5-year Intervals

| 5-Year Interval | No. Studies | Studies with PCO | \( P \) |
|-----------------|-------------|-----------------|------|
| 2000–2005       | 21          | 14 (66.70%)     | 0.557|
| 2006–2010       | 36          | 22 (61.11%)     |      |
| 2011–2015       | 50          | 30 (60.00%)     |      |
| 2016–2020       | 49          | 29 (59.18%)     |      |
Salvage Score and to lower extremity amputations, such as the TAPES and the Prosthetic Mobility Questionnaire, have also been developed. However, instruments targeting the unique intersect of traumatic MLEA populations have yet to be implemented. Our meta-analysis calls for the creation of more PCO instruments, such as the LIMB-Q currently under development, customized to both lower extremity and traumatic amputees to guide management.

This meta-analysis and systematic review is limited in several ways. Many articles included for analysis were retrospective in nature, which has inherent biases. This study investigated the general reporting rates of PCOs; the individual significance of specific variables regarding patient well-being and patient-defined amputation success was not determined due to the heterogeneity of patient populations and means of data reporting. The subjective nature of PCO data is a large limiting factor in its analysis, considering the personalized responses and long-term follow up of subjects. Further research will be necessary into the relative significance of each PCO on amputation and patient success, advantageous mechanism of collecting and reporting this data, and suitable methods to include PCO in medical decision-making for traumatic amputations.

**CONCLUSIONS**

Despite an emphasis on patient QOL and functional capabilities as important factors to assess after traumatic lower extremity amputation, only 60% of studies in the past two decades report PCO, with no trends in increasing prevalence over time. The inconsistency of measures and scales used to examine PCO precludes providers and patients from having a comprehensive understanding of outcomes after MLEA. As healthcare continues to progress toward patient-centered care, our study calls for improved inclusion and standardization of measures to assess functional capabilities, QOL, satisfaction, and other patient-valued measures among traumatic lower extremity amputees.

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