Functional and patient-reported outcomes of terrible triad elbow fracture-dislocations

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Abstract

Background

The elbow ranks second only to the shoulder as the most commonly dislocated large joint in the human body. Terrible triad elbow injuries, or simply terrible triad (TT), involve an elbow dislocation coupled with a radial head and coronoid fracture. This study aimed to assess functional and patient-reported outcomes for surgically managed TT patients.

Methods

An ambidirectional observational study included all adults who underwent surgical treatment for TT over a six-year period. Demographic data, elbow range of motion (ROM), and QuickDASH scores were collected. Elbow ROM data was used in a preferential order of a participation goniometer measurement followed by a photographic measurement and, lastly, recorded values within the patient's file.

Results

Of the 49 eligible patients (mean age 37.5 ± 12.3 years), 39 patients followed up postoperatively at a median of 18.0 (2.0–34.3) months. Thirty-six of the 39 patients followed up postoperatively and had relevant data pertaining to elbow ROM. Of these, 17 were successfully recruited to participate. The mean flexion and extension endpoints were 118.7° ± 19.4° and 39.9° ± 19.3° respectively, while mean flexion-extension arc (FEA) was 77.4° ± 28.5° (n = 36). Pronation and supination had mean endpoints of 58.4° ± 26.4° (n = 32) and 54.9° ± 32.5° (n = 30) respectively, with mean prosupination arc (PSA) at 111.2° ± 52.3° (n = 30). Median (interquartile range) QuickDASH score among participants was 31.8 (9.1–47.7), with seven participants scoring < 25 (9.1 [8.0–10.2]) and eight participants between 25 and 50 (40.9 [35.2–48.3]). Functional flexion-extension ROM, accepted as 130° flexion and 30° extension with a FEA of 100°, was not met, but prosupination functional ROM (50° prosupination and 100° PSA) was retained.

Conclusion

Discrepancies that exist between the measured ROM and the subjective patient outcomes suggest that further investigation is needed to understand the clinical impact on patient experience and functionality.

Level of evidence: 3

Keywords: terrible triad, functional outcome, patient-reported outcomes

Introduction

The elbow is the second most dislocated large joint in the body.[1,2] Elbow dislocations can be broadly classified as either simple or complex. A complex elbow dislocation is when the dislocated joint is associated with a fracture of any of the bony elements that comprise this complex hinge joint. In comparison, simple dislocations are pure soft-tissue injuries.

Hotchkiss, in 1966, identified a pattern of elbow fracture-dislocations that he dubbed as having a 'terrible triad' configuration, comprising a posterior elbow dislocation with an associated radial head and coronoid fracture, classically caused by a fall onto an outstretched hand coupled with an internal rotational force, which drives the forearm into supination.[3] Terrible triad elbow injuries (from here on simply referred to as 'terrible triad' or TT) have a reputation for being difficult to treat and are frequently associated with poor outcomes such as arthrosis, recurrent instability, and/or stiffness from prolonged immobilisation.[4,5]

The current gold standard of management, as described by Pugh et al.,[4] focuses on preserving radiocapitellar contact, reattaching the lateral collateral ligament (LCL) complex to the lateral epicondyle, and repairing the coronoid capsular complex (CCC). The aim of surgical management in TT elbow injuries is to achieve a concentric, stable elbow that will allow early mobilisation to prevent complications and maximise joint function.[6,7]

The universally accepted functional range of motion (ROM) required to perform activities of daily living (ADL) is a 100° arc of motion in both flexion-extension (30–130°) and pro/supination (50° equally distributed) planes.[8]

With a mean flexion-extension arc (FEA) of 113° (80–172°) and a QuickDASH score of 13 (4–21), Stambulic et al. reported in their

recent scoping review comparable results in terms of ROM and clinical outcome measures following the implementation of the gold standard protocol for managing TT injuries.[9]

There is, however, little available published literature regarding the numbers treated or the outcomes, both in terms of ROM as well as patient-reported outcomes, of TT in South Africa. Early, supervised and structured postoperative rehabilitation aims to improve functional outcomes and prevent complications, and forms an essential part in managing TT elbow injuries.[10,11] In a resource-constrained environment, such specialised services are often neither routinely nor timeously accessible.

This study aimed to determine the burden of TT and to report the functional and patient-reported outcomes of patients treated for TT, using standard methods, at two hospitals in the Western Cape, South Africa.

Materials and methods

This study followed a cross-sectional descriptive design including all adult patients (> 18 years) who were surgically treated for a TT between 1 January 2016 and 31 December 2021 at either of two hospitals in the Western Cape province of South Africa. Ethics and institutional approvals were obtained prior to the commencement of this study.

Specific exclusion criteria were applied, including ipsilateral upper limb polytrauma, previous major upper limb surgery/injury, and a lack of clinical records.

Surgical procedures

All surgeries were performed or supervised by an upper limb trained orthopaedic surgeon with a surgical technique closely resembling those published by Garrigues et al.[12] However, a lateral Kocher-based approach, utilising the internervous plane between extensor carpi ulnaris (ECU) and anconeus was used in all cases (*Figure 1*).[13]

The radial head was assessed first, and a final decision to either repair (open reduction internal fixation, 'ORIF' – if possible), resect fragments ('none' – if the bulk of the radial head was unaffected) or replace ('arthroplasty' – if the integrity and stability of the radial head was compromised) was made based on the structural integrity of the radial head.

If the radial head required replacement, resection of the radial head was followed by a digital examination of the anterior CCC. The surgeon attempted to pass a finger anteriorly over the elbow, clinically assessing the CCC. A complete avulsion of the anterior capsule was suggested when minimal or no resistance was encountered during this manoeuvre and the CCC was repaired using a Lasso suture technique with the two free limbs of the suture only being definitively tied once all lateral structures (radial head and LCL) have been addressed and the elbow deemed stable after performing the hanging arm test.[12] However, when resistance to a passing finger was encountered, this indicated an incomplete/partial anterior capsular injury. The CCC was only addressed if the elbow remained unstable after replacing the radial head and repairing the LCL. Data for the classification of coronoid and radial head fractures were not uniformly available.

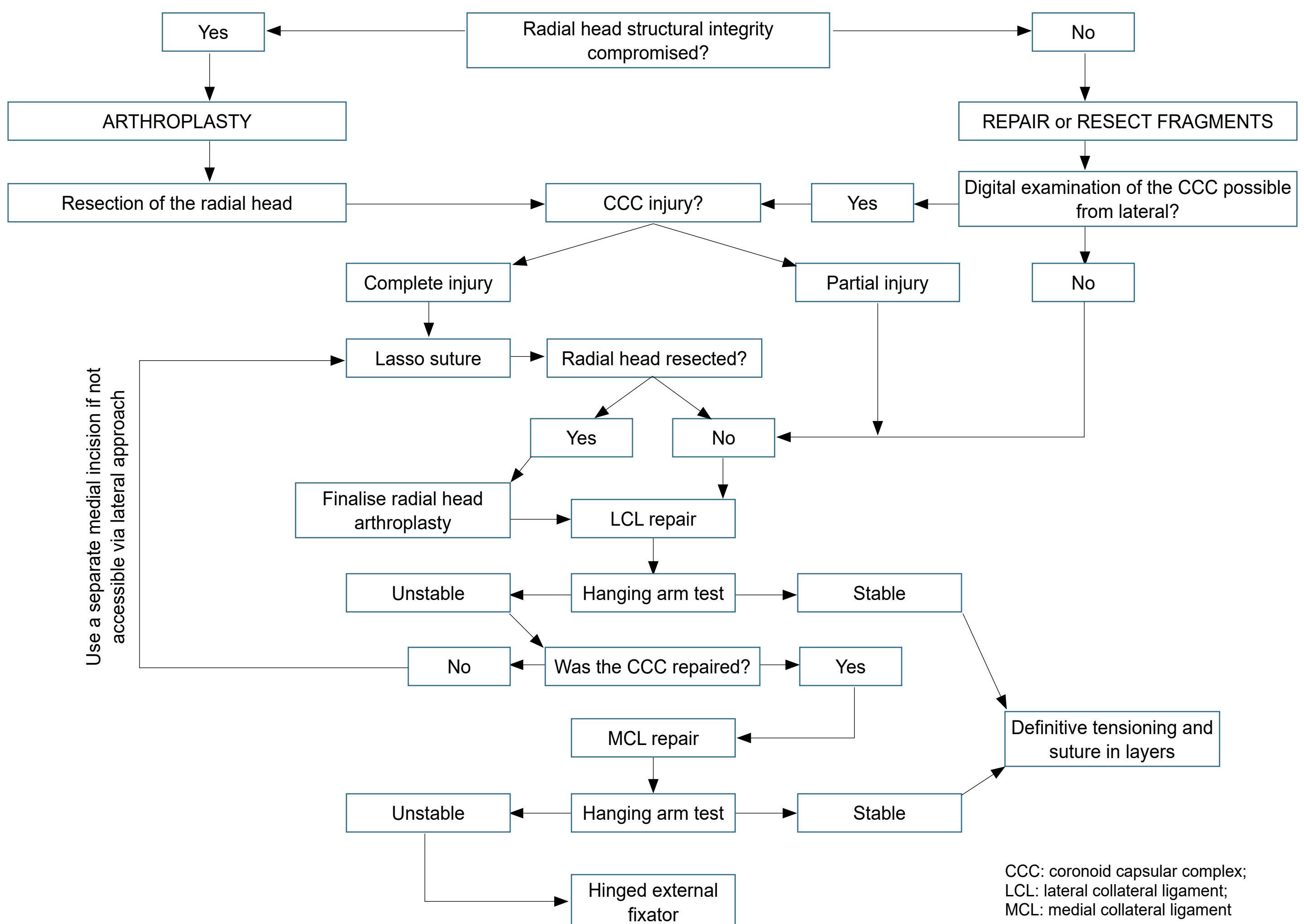

Figure 1. Algorithmic layout of the surgical flow in managing terrible triad elbow injuries

Following replacing the radial head with the correctly sized prosthesis, a metallic suture anchor was placed at the isometric centre of the capitellum, which is regarded as the origin of the LCL.[14] The LCL stump was subsequently sutured in a continuous and locked manner.

The LCL and lasso sutures were preliminarily tensioned, with the two limbs of each suture locked temporarily using a needle holder so as not to damage the suture material. Elbow stability was then assessed in its position of maximum instability by using the hanging arm test, where the upper arm was elevated and supported off the hand table, the elbow allowed to hang free in full extension, and the forearm in full supination.[12,15] If a concentric reduction of the elbow was maintained, the pre-tensioned LCL and lasso sutures were definitively knotted, and the surgical wound was sutured in layers.

However, if a concentric reduction was not maintained, then the medial collateral ligament (MCL) complex would require repair (with either a transosseous or metallic suture anchor) using a separate medial incision. The adjunctive use of an external fixator might be necessary should the elbow still be unstable.

In cases where the radial head was preserved (either by repair or fragment excision) and the LCL reattached, thus preventing digital evaluation of the CCC, and the elbow remained unstable, the CCC was assessed and repaired via a separate medial incision. The hanging arm test was subsequently repeated, the outcome of which dictated the repair of the MCL. The retrospective study design did not allow for accurate and controlled data collection regarding the treatment decision-making at the time of surgery. The assumption is made that the appropriate management was followed in each case as per Pugh's protocol.

Data collection procedures

The data collected from the electronic and radiographic records included basic patient demographics, date of injury and date of surgery, as well as final follow-up. Information-related elbow ROM measurements documented within the patients' files was also collected. Any additional and relevant documented information pertaining to the injury and/or surgery, for example, wound breakdown, heterotopic ossification or redislocation, was also noted.

The use of a goniometer remains a reliable and valid method of measuring elbow ROM,[16,17] while Meislin et al. previously concluded in a comparative study that measuring elbow ROM from photographs is comparable to goniometer measurements.[18] Therefore, all eligible patients were contacted telephonically and invited to participate remotely or in person. Elbow ROM was measured with a goniometer, and a QuickDASH questionnaire was completed for those who attended an in-person visit. Remote participants submitted four photographs with the elbow at the maximum endpoints of motion, and the QuickDASH questionnaire was completed telephonically.

The photographic ROM angles were measured using a cross-platform image editor called GIMP (GNU Image Manipulation Program 2.10.34 [revision 2]). A measuring tool was used to measure the angle of the elbow at each of the endpoints of motion. The angle for maximal flexion and extension was measured between a line connecting the lateral acromion and lateral epicondyle and a line connecting the lateral epicondyle and a point in the centre of the wrist (*Figure 2a*). For the pro- and supination angles, the participants were instructed to grip a straight object (like a pen or a stick) where the angle between a longitudinal line in the centre of the humerus and a line along the axis of the gripped object was measured (*Figure 2b*).

The sources of data were used in a hierarchal fashion, with a goniometer measurement being the top tier, followed by a photographic measurement and lastly the recorded data within the file (if available).

Range of motion (ROM) measurements

The elbow endpoints and arc of motions were compared to the accepted functional ROM, which is a flexion and extension endpoint of 130° and 30°, respectively, with a FEA of 100°. Similarly, pronation and supination of 50° with a pro/supination arc (PSA) of 100° was regarded as the functional elbow range.[8]

QuickDASH measurements

The patient-reported outcome measures were measured using a QuickDASH score, which was further categorised into one of four descriptive severity ranges, as 'none-to-mild', 'mild-to-moderate', 'moderate-to-severe' and 'severe-to-extreme' disability.

Each participant's score was then categorised into QuickDASH categories and associated grading to determine a patient's perceived disability grade.

Analysis

Data were analysed using Statistica v13 (TIBCO software) and continuous data are reported as mean ± standard deviation or median (interquartile range, [IQR]). Mean ROM measurements

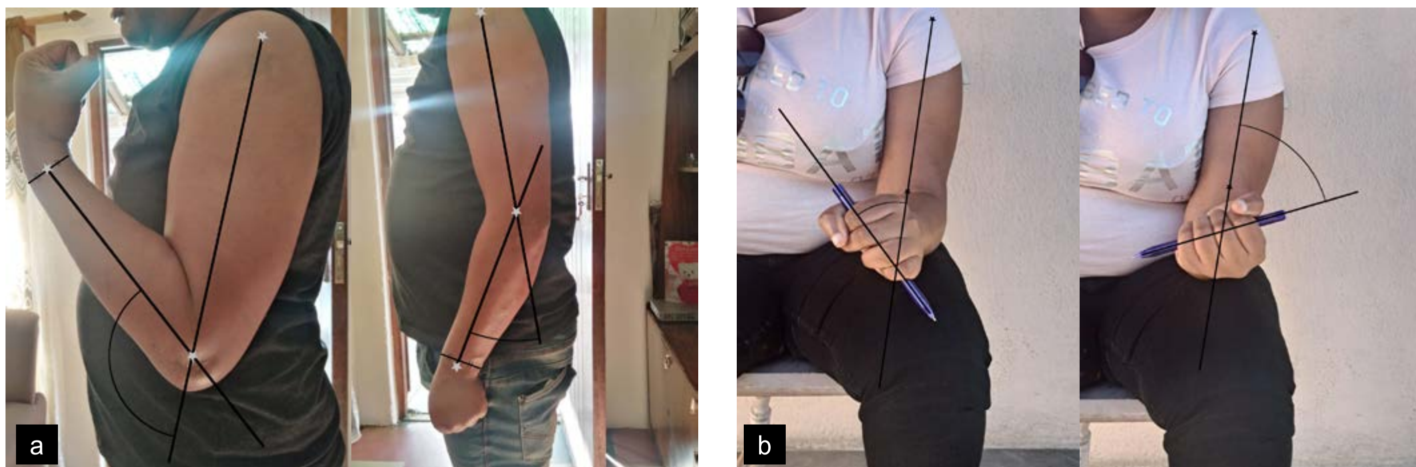

Figure 2. Examples of digital photographs and the measured angles: a) flexion and extension – the measured angle is between the axes of the upper arm and forearm (star – lateral acromion, lateral epicondyle and centre of the wrist); b) pronation and supination – the measured angle is between the axes of the upper arm and a gripped pen (star – centre of the proximal and distal humerus; centre edges of a pen)

were descriptively compared to a functional standard, as described by Morrey et al.[8] Categorical data are reported as frequencies (counts). While the entire cohorts' measurements were used to calculate the mean ranges of motion and to compare these to the functional standard, the recruited participants were also separately compared. Differences between ROM and QuickDASH categories were investigated by means of a one-way ANOVA, with a post-hoc Tukey's honest significant difference (HSD) to evaluate differences between groups. An alpha-level of 0.05 was considered the cut-off value to indicate significance.

Results

A total of 56 patients sustained TT; however, seven patients were excluded for either having accompanying ipsilateral upper limb injuries or not having any available intraoperative records. Overall, 49 patients (53% male, 47% female) with a mean age of 37.5 ± 12.3 years were therefore included, with 48% of the final cohort sustaining TT in 2020 and 2021 (*Figure 3*). Of the 49 patients, 39 followed up at a median of 18.0 (2.0–34.3) months post-surgery, while the remaining ten patients were recorded as 'lost to follow-up' (LTFU). The median time to surgery was 7 (4–10) days. The right side was affected in 45% of patients (22 of 49) versus 55% (27 of 49) of patients with the left elbow affected.

Radial head fractures underwent arthroplasty in 86% of patients (n = 42), with the LCL complex being repaired using a suture-anchor construct in 90% of cases (n = 44). The coronoid component was deemed stable and left untreated in 67% of cases (n = 33), whereas 14 patients (29%) had the coronoid secured with an all-suture lasso technique. The remaining two cases had the coronoid fixed using metallic suture anchors (*Table I*). No MCL repair or external fixation was needed in any of our cases.

Of the 49 patients with intraoperative data, only 36 (74%) had data relating to flexion and extension, including patients who had only file data (n = 19 of 36) as well as those who were recruited successfully (n = 17 of 36). Only 32 and 30 patients had pronation and supination data, respectively.

The mean maximum flexion and extension was 118.7° ± 19.3° and 39.7° ± 19.3° respectively, with a calculated FEA of 77.4° ± 28.5° (*Figure 4*). Regarding rotation, only 32 (89%) endpoint

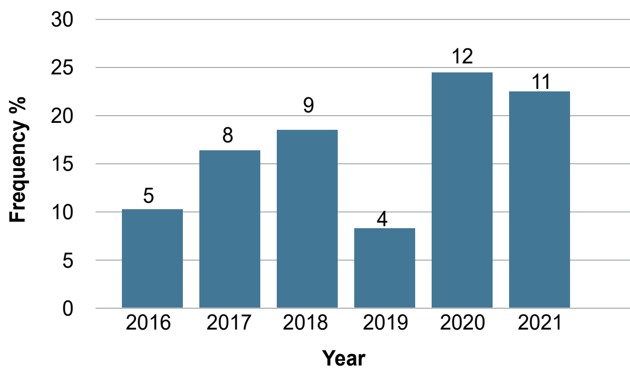

Figure 3. The rate of terrible triad elbow fracture-dislocations per year as a frequency of the total cohort. The absolute number of injuries is indicated above each bar.

Table I: Specific intraoperative procedures to address the radial head, coronoid and collateral ligaments in terrible triad elbow injury (TT)

Procedure	Radial head (%, n)
ORIF	10 (5)
Arthroplasty	86 (42)
Partial excision	2 (1)
None	2 (1)
	Coronoid
Suture anchor	4 (2)
Lasso suture	29 (14)
None	67 (33)
	LCL
Suture anchors	90 (44)
Suture repair	10 (5)

Data is described as frequency (count). ORIF: open reduction internal fixation; LCL: lateral collateral ligament

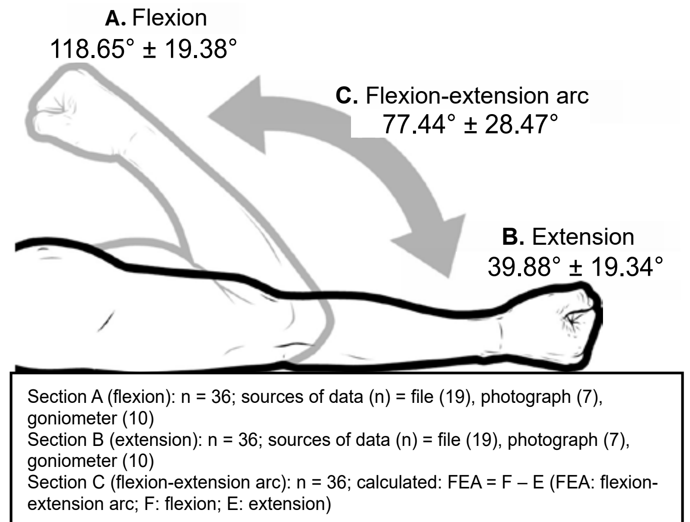

Image courtesy of The Rehab Lab (www.therehablab.com)

Figure 4. An illustration of the flexion, extension and flexion-extension arc of all patients (n = 36) using either file data (n = 19) or measured data from recruited participants (n = 17). A) mean flexion; B) mean extension; C) mean flexion-extension arc (FEA)

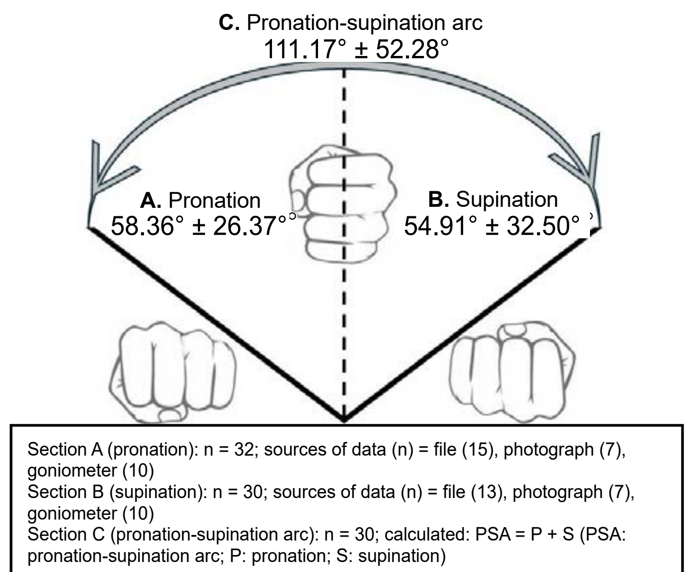

Image compiled by authors

Figure 5. An illustration of the pronation, supination and pronation-supination arc of all patients (n = 32) using either file data (n = 15) or measured data from recruited participants (n = 17). a) mean pronation; b) mean supination; c) mean pronation-supination arc (PSA)

Table II: Summary of the functional ranges of motion in the flexion-extension as well as pro/supination plane

Range of motion	n (%)
Flexion	**n = 36**
≥ 130°	18 (50)
< 130°	18 (50)
Extension	**n = 36**
≤ 30°	17 (47)
> 30°	19 (53)
FEA	**n = 36**
≥ 100°	12 (33)
< 100°	24 (68)
Pronation	**n = 32**
≥ 50°	22 (69)
< 50°	10 (31)
Supination	**n = 30**
≥ 50°	20 (67)
< 50°	10 (33)
PSA	**n = 30**
≥ 100°	21 (70)
< 100°	9 (30)

Data is reported as count (frequency) for each of the six parameters, as described by Morrey et al.,[8] as flexion ≥ 130°, extension < 30°, pronation and supination ≥ 50°, FEA ≥ 100° and PSA ≥ 100°. FEA: flexion-extension arc; PSA: pronation-supination arc

measurements for pronation and 30 (83%) for supination were available, thus only allowing 30 pronation-supination arcs (PSA) to be calculated. The mean pronation was 58.7° ± 26° and supination 54.9° ± 32.5°, with a mean PSA of 111.2° ± 52.3° (*Figure 5*).

A flexion endpoint greater than or equal to 130° was present in 18 participants (50%) and an extension endpoint less than or equal to 30° in 17 (47%), but a FEA greater than or equal to 100° was only found in 12 participants (33%) (*Table II*). Pronation and supination endpoints greater than or equal to 50° were achieved in 22 and 20 participants (69% and 67%), respectively, and a PSA greater than or equal to 100° in 21 patients (70%) (*Table II*).

Recruited participants

A total of 17 participants were successfully recruited at a median of 38.4 (27.6–49.6) months postoperatively, ten (59%) of which chose to participate in person, with the remaining seven (41%) being remote participants. ROM of the recruited participants was slightly higher compared to the cohort as a whole (*Table III*).

Table III: Summary of the elbow range of motion of the recruited participants

Elbow motion (n = 17)	Degrees
Flexion	125.7 ± 17.7
Extension	29.8 ± 10.9
FEA	95.9 ± 23.0
Pronation	64.6 ± 18.2
Supination	74.0 ± 18.4
PSA	138.5 ± 30.3

Data is reported as mean ± standard deviation (in degrees) for the four measured and two calculated elbow range of motion parameters. FEA: flexion-extension arc; PSA: pronation-supination arc

Table IV: A summary of the QuickDASH scores and proposed disability severity subdivisions

Disability category (n)	QuickDASH
All participants (17)	31.8 (9.1–47.7)
None-to-mild (7)	9.1 (8.0–10.2)
Mild-to-moderate (8)	40.9 (35.2–48.3)
Moderate-to-severe (2)	68.2 (62.5–73.8)
Severe-to-extreme (0)	Not applicable

QuickDASH score is presented per category as median (interquartile range)

Recruited participants had a median QuickDASH score of 31.8 (9.1–47.7), with 88% (n = 15) being categorised as either none-to-mild or mild-to-moderate disability (*Table IV*).

All ROM measurements were similarly distributed between the none-to-mild and mild-to-moderate groups (*Table V*). Significant differences were found between the none-to-mild and moderate-to-severe groups for flexion (p = 0.037) and the FEA (p = 0.005) with a significant difference between mild-to-moderate and moderate-to-severe groups for FEA (p = 0.025) (*Table V*).

There were three recorded complications, with two patients having suffered early postoperative wound complications, which were treated successfully without the need for further surgery. The third patient developed heterotopic ossification but declined any further surgery. These three patients were not contactable during our recruitment phase and thus did not form part of the recruited cohort of participants.

Discussion

Despite improved outcomes since the implementation of a standard surgical protocol, TTs remain challenging injuries to treat.

The prevalence of TT needs to be better reported within the literature, with one potential reason being that TTs are a

Table V: QuickDASH scores with corresponding elbow range of motion

Range of motion	Disability categories			
	None-to-mild (n = 7) Degrees (°)	Mild-to-moderate (n = 8) Degrees (°)	Moderate-to-severe (n = 2) Degrees (°)	p-value
Flexion	133.9 ± 7.2	124.9 ± 19.7 (8)	100.0 ± 14.1 (2)	0.046*
Extension	25.8 ± 11.1	29.4 ± 8.7	45.0 ± 7.1	0.080
FEA	108.1 ± 14.0	95.5 ± 20.3	55.0 ± 7.1	0.006**
Pronation	61.8 ± 16.7	64.4 ± 21.7	75.0 ± 7.1	0.692
Supination	78.0 ± 12.4	68.3 ± 23.4	82.5 ± 10.6	0.496
PSA	139.8 ± 19.6	132.7 ± 40.2	157.5 ± 3.5	0.608

Range of motion is reported as mean ± standard deviation. FEA: flexion-extension arc, PSA: pronation-supination arc
*p = 0.037 between none-to-mild and moderate-to-severe groups; **p = 0.005 between none-to-mild and moderate-to-severe groups; p = 0.025 between mild-to-moderate and moderate-to-severe groups

unique subtype of complex elbow dislocations. TT may also be 'misdiagnosed' as a radial head fracture with an elbow dislocation and not reported as a TT injury; similarly, a transolecranon elbow fracture-dislocation may be classified as a TT injury or a Monteggia-type fracture-dislocation. We report a total of 49 patients suffering from TT over six years with a similar sex and age distribution as what has previously been reported,[5,19-26] with a mean age of injury being around 40 years. The reason for the sudden increase in TT during 2020–2021 is unknown and future studies should investigate patterns of the subsequent years to try and identify possible reasons for this increase.

Range of motion and reported outcomes

While the cohort in the present study failed to meet the flexion-extension ROM, as accepted within the literature[8] to be regarded as functional, a functional pro/supination ROM was achieved. It should be noted that a relatively large standard deviation was present for all the present study's measurements, likely as a result of the differences in measurement modalities used. Similarly, the QuickDASH scores were also worse than the most recent reported literature.[9] However, the majority of participants were classified into mild and moderate disabilities, according to the QuickDASH categorisation. Interestingly, those participants who were categorised in the 'none-to-mild' and 'mild-to-moderate' disability categories both measured elbow ROM that is regarded as functional, whereas those in the worse disability tier did not.

However, the question remains whether a patient with a functional elbow should perceive themselves as experiencing any degree of disability at all.

Despite achieving a near-functional elbow ROM, most participants still regarded themselves as suffering from a mild-to-moderate disability. Studying the individual questions of the QuickDASH questionnaire may highlight the impact that psychosocial factors have on patient-reported outcome measures.[27]

While not an objective of this study, some interesting observations were made about the data collection processes. None of the participants who were successfully contacted declined participation, either as a remote or in-person participant. This is reassuring for future researchers attempting a similar data collection strategy. However, the biggest hurdle to overcome is to successfully make contact, as the recorded contact details were often recorded in error, if at all. Similarly, patients in our setting frequently change phone numbers, which leads to inaccurate contact details being available on file.[28] Another noteworthy observation pertaining to the patients participating remotely was that despite clear instructions, illustrative banners and questionnaires in multiple languages, many participants required assistance with the QuickDASH questionnaire and had to repeat attempts at adequate photography. While none of the recruited participants withdrew from the study despite these challenges, indicating a willingness to participate in research, it might indicate low health literacy in the patient cohort. These observations highlight foci for future research. Being in a resource-constrained environment where patients experience high levels of inequality, most do not have the means (financial, logistical, social, etc.) to schedule an interview reliably. The remote avenue for data collection was thus seen a viable alternative to the norm in collecting data, and it is believed to have promoted inclusivity and participation.

A relatively small sample with complete data (PI measurement and QuickDASH score) is an important limiting factor to consider. However, a strength of this review is that tangible data now exists, for the first time, on the epidemiology of TT injuries in South Africa. Similarly, this study, a pilot investigation in our specific setting for collecting data remotely to evaluate ROM measurements following an orthopaedic intervention, highlights that remote data collection is a viable methodology that can be utilised.

Conclusion

This retrospective review highlights a high burden of TT in our setting, and finds that patients narrowly missed achieving a functional flexion-extension ROM. This study further highlights that a small difference in functional range might be perceived to be much larger in terms of perceived disability by the patient. Clinicians treating TT in a resource-constrained environment are encouraged to discuss patients' expected outcomes upfront, as functional ROM does not always equate to patient satisfaction.

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Ethics statement

The authors declare that this submission is in accordance with the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010.

Prior to the commencement of the study ethical approval was obtained from the following ethical review board: Stellenbosch University Health Research Ethics Committee 1 (HREC 1) S22/06/103.

All procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed written consent was obtained from all patients for being included in the study. Consent was obtained from patients for the use of clinical photographs, and these images were adequately anonymised.

Declaration

The authors declare authorship of this article and that they have followed sound scientific research practice. This research is original and does not transgress plagiarism policies.

Author contributions

JPS: first author, research ideation, compiled research protocol, data collection, analysis and interpretation of results, preparation of the manuscript, final approval of the version to be published

HSP: last author, research ideation, compiled research protocol, interpretation of results, critical revision and editing of final manuscript

MCB: compiled research protocol, analysis and interpretation of results, editing approval of final manuscript

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