

# Outcomes of an all-suture anchor technique for the treatment of transverse olecranon fractures: a case series

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**Citation:** Qwanyaza W, O'Connor M, Haynes W, Pretorius JL. Outcomes of an all-suture anchor technique for the treatment of transverse olecranon fractures: a case series. *SA Orthop J*. 2026;25(1):33-38. <http://dx.doi.org/10.17159/2309-8309/2026/v25n1a5>

**Editor:** Dr Cameron Anley, Stellenbosch University, Cape Town, South Africa

**Received:** November 2024

**Accepted:** June 2025

**Published:** March 2026

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**Funding:** No funding was received for this study.

**Conflict of interest:** The authors declare they have no conflicts of interest that are directly or indirectly related to the research.

## Abstract

### Background

Mayo type IIa olecranon fractures are typically managed with plate osteosynthesis (PO) or tension band wire (TBW) fixation. Reoperation rates for the removal of prominent metalware are high following TBW. All-suture anchors (ASA) in a tension band configuration can potentially capitalise on tension band principles and reduce hardware irritation. This investigation aimed to review the outcomes of patients with Mayo IIa olecranon fractures managed with this technique.

### Methods

This retrospective chart review describes the ASA surgical technique and assesses the outcomes of adult patients with Mayo IIa olecranon fractures managed with the technique between 1 August 2017 and 31 October 2021. Patient charts were used to capture basic demographic details, injury characteristics, timing of surgery and surgical outcomes. The outcomes of interest included the union rate, functional outcomes, complications and reoperation rates.

### Results

Thirty patients met inclusion criteria; 60% were male, the majority of which (63%) were injured from a direct blow. Two injuries were compound. All but one fracture united, representing a union rate of 97%. The median postoperative total range of motion was 130°. The median Mayo Elbow Performance Score (MEPS) was 100 (excellent). Three cases complicated: two with superficial sepsis and exposed suture material, and one developed a fibrous non-union. No patients required reoperation.

### Conclusion

The adult patients with transverse olecranon (Mayo type IIa) fractures managed with the described all-suture anchor technique in this investigation had a union rate of 97%, with excellent functional results as measured by the MEPS. No reoperations were required.

**Level of evidence:** 4

**Keywords:** olecranon fracture, suture anchor, tension band suture, Mayo IIa olecranon fracture, adult, case series, orthopaedics

## Introduction

Olecranon fractures occur frequently in adults, accounting for 10% of all upper limb fractures.<sup>1</sup> Male patients exhibit a bimodal distribution pattern according to age, and the fractures occur from low- or high-energy mechanisms.<sup>2</sup> In women however, they occur more commonly from low-energy mechanisms around the sixth decade.<sup>2</sup> Originally described by Morrey, the Mayo classification of olecranon fracture stability (types I–III) is commonly applied to categorise these injuries, with type IIa accounting for the majority.<sup>2-4</sup> The classification is clinically useful, providing a treatment algorithm that includes nonoperative and operative indications.<sup>5</sup>

Various fixation methods have been described to treat olecranon fractures operatively. Tension band wiring (TBW) and plate osteosynthesis (PO) are the most commonly practised techniques.<sup>6,7</sup>

But, alternatives such as intramedullary screw fixation (IMS), external fixation (EF), combination wire and suture constructs, and suturing in a tension band configuration (TBS) have also been explored for various indications.<sup>4,6,8,9</sup> Importantly with the use of each technique is anatomic reconstruction of the trochlear notch and correction of alignment, to prevent postoperative stiffness and limitation of active elbow extension.<sup>4</sup> A 2024 systematic review and meta-analysis determined that for similar functional outcomes, PO required significantly fewer implant removals, reoperations, and had fewer complications than TBW.<sup>10</sup> For uncomminuted stable Mayo fractures (types Ia and IIa), a prospective randomised trial comparing TBW and PO has shown equivocal functional outcomes and patient satisfaction at one year postoperatively.<sup>11</sup> However, each modality reported complications.<sup>11</sup> Infections were exclusive

to the PO group, and symptomatic metalware requiring removal occurred predominantly in the TBW group.<sup>11</sup> Intuitively, then, to avoid infection, the TBW would be preferential if hardware irritation could be minimised.

The TBW construct overlies the superficial and prominent olecranon; this region's thin soft tissue envelope is easily compromised, resulting in wound breakdown.<sup>12</sup> Reoperation rates as high as 81% have been reported.<sup>13</sup> Despite these complications, TBW is considered the gold standard for the fixation of simple displaced olecranon fractures.<sup>14</sup> The technique employs the tension band principle, converting the posterior tensile force of the triceps to a compressive force across the articular fracture gap.<sup>15</sup> This generally allows for early motion of the joint to prevent stiffness without compromising union rates.<sup>11,16</sup>

Harnessing the tension band principle while limiting the hardware irritation would conceivably represent an ideal technique. TBS configuration represents an exploration of this ideal. TBS techniques employing sutures alone or in combination with anchors or interference screws are less prominent than wire constructs, potentially minimising the hardware irritation and need for removal.<sup>8</sup> Phadnis et al. performed a tension band technique utilising sutures alone through a transverse drill hole in the distal ulna fragment, and sutures passed through the triceps. Their 28 patients all achieved union in six weeks, and no patients required hardware removal.<sup>17</sup> McGee et al. described another TBS technique employing two suture anchors embedded in the distal ulna fragment within the medullary canal. The anchor's sutures are passed through parallel drill tunnels in the proximal ulna fragment. A secondary pair of anchors are embedded in the distal ulna fragment cortex; sutures are crossed over the fracture site and passed through a horizontal drill tunnel in the proximal fragment.<sup>8</sup> Carofino et al. compared a TBS technique utilising a high-strength polyester and polyethylene suture to standard TBW with an 18-gauge metal wire in cadaveric models. Under cyclic loading mimicking the elbow's physiological active range of motion, they found no difference in fracture displacement or biomechanical strength between the two fixation methods.<sup>18</sup> This does *not* remain true in cadaveric osteoporotic bone.<sup>19</sup> Von Keudell et al. compared the biomechanical properties of TBW to TBS with anchors or TBS with sutures alone.<sup>19</sup> The three groups were no different under the active range of motion conditions, but the TBS with sutures alone failed on all occasions when simulating a push-up. The TBW and TBS constructs with anchors were found to be no different with push-up simulation.<sup>19</sup>

This retrospective case series aimed to evaluate the outcomes of patients with transverse olecranon fractures (Mayo IIa) managed with an alternative TBS construct design, an all-suture anchor (ASA) technique. Specific objectives included determining the union rates, functional outcomes, complications and reoperation rates.

## Methods

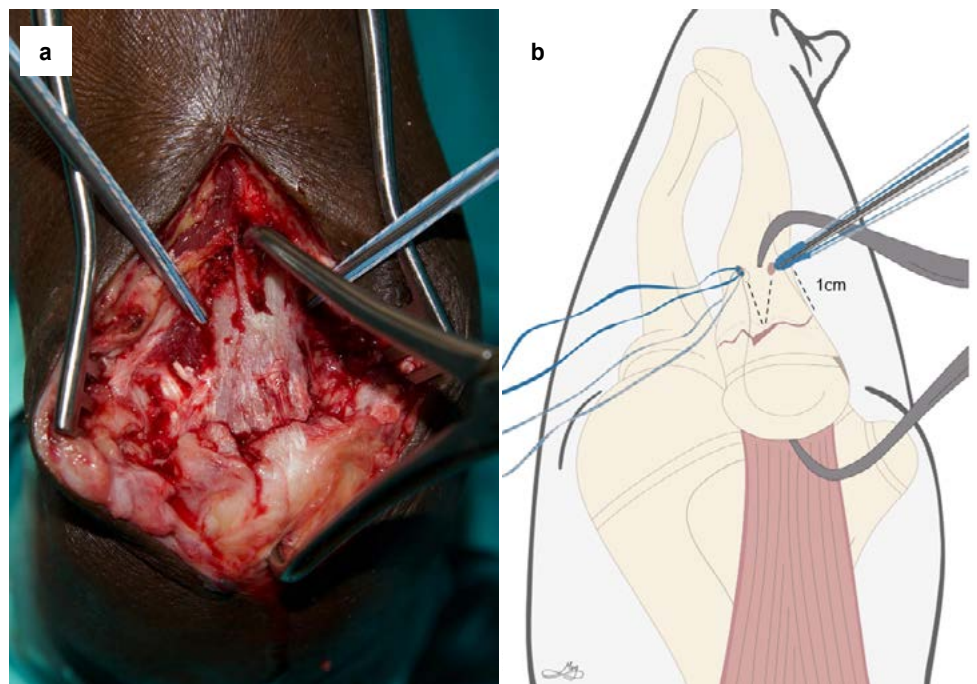
This retrospective case series investigated the outcomes of adult patients with displaced transverse olecranon fractures (Mayo IIa) who were managed with an ASA technique. It is reported according to the Preferred

Reporting of Case Series in Surgery (PROCESS) guidelines of 2023.<sup>20</sup> The requisite ethical approval was obtained from the institution's research ethics committee. Adult patients with Mayo type IIa olecranon fractures, treated surgically by the senior author (orthopaedic specialist) with the ASA technique from 1 August 2017 to 31 October 2021, were eligible for inclusion. Patients with incomplete records were excluded.

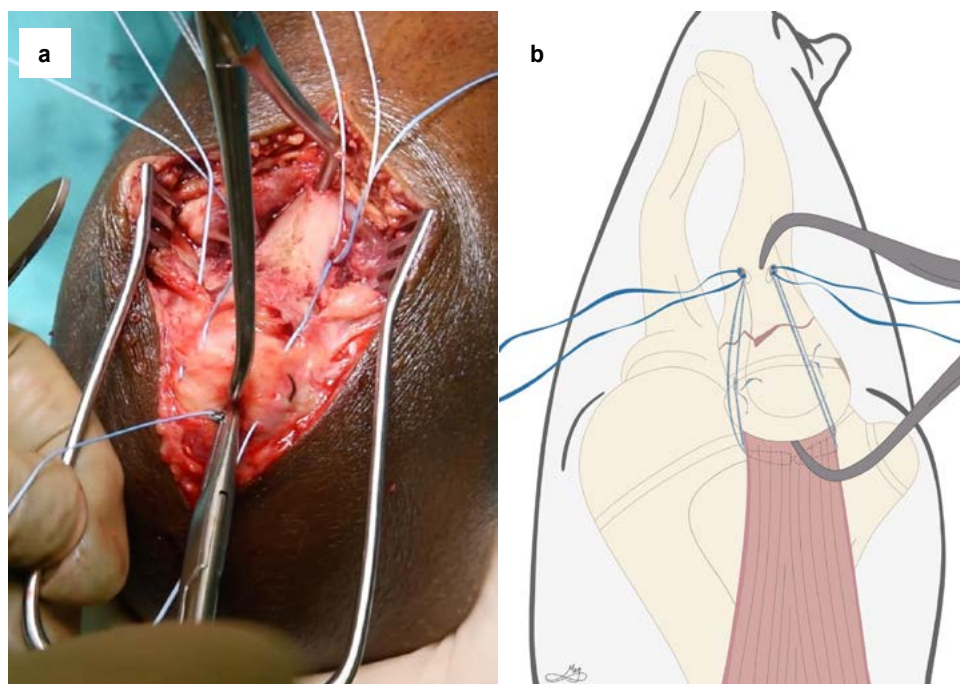
Patients' clinical records and radiographs were reviewed. Basic demographic details (age, sex and comorbidities) and injury characteristics (side of injury, mechanism of injury, whether the injury was compound or not, and time to surgery) were captured.

## Surgical technique

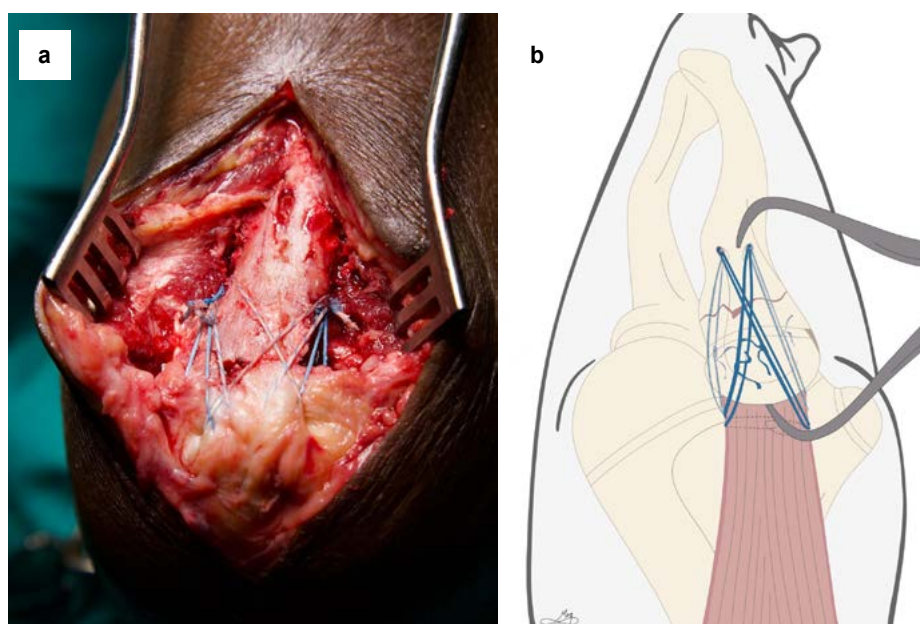
All cases were performed by a single surgeon, the senior author. Patients were positioned supine with the elbow flexed 90° over a padded bolster. A midline posterior approach was performed with subperiosteal exposure of the fracture site. The fracture site was debrided, and a Lewin bone clamp was used to reduce and maintain the fracture reduction. Two convergent anchor holes were drilled close to the medially and laterally exposed ulna edges. These holes were placed at least 1 cm distal to the fracture site, 1 cm volar to the dorsal cortex ridge, and aimed toward the coronoid process to provide the maximal depth for the anchor. Two 2.9 mm ASA (JuggerKnot® Zimmer Biomet) were then inserted, a modification of the technique described by Ravenscroft et al., who utilised metal bone anchors.<sup>21</sup> Figures 1a-c depict the steps for inserting and suturing after anchor placement. One suture from each anchor was carried vertically across the fracture site and passed horizontally (one limb to the opposite side of the ulna and one reversing back to the entry point) through the triceps as close as possible to its insertion. The suture material was carried back across the fracture site towards its corresponding suture limb from the originating anchor for tying. Both medial and lateral knots were tied simultaneously for even tension across the fracture. The knot stack was placed as close to the drill hole as possible so the periosteum could later be closed over the stack. The second suture



**Figure 1a.** a – photo and b – illustration, depicting insertion of two 2.9 mm all-suture anchors. Anchors were placed at least 1 cm distal to the fracture site, each were placed close to the medial and lateral cortices at least 1 cm volar to the dorsal ulna ridge, and both were aimed in a convergent fashion toward the coronoid process.



**Figure 1b.** a – photo and b – illustration, depicting placement of the initial suture set. One suture from each anchor was carried vertically across the fracture site and passed through the triceps insertion in a horizontal fashion (one limb to the opposite side of the ulna and one reversing back to the entry point). This suture was then tied to the corresponding suture limb from the same anchor.



**Figure 1c.** a - photo and b - illustration, depicting placement of the second set sutures. The second suture of each anchor was carried obliquely across the fracture site in a crossing fashion. As before, the sutures were passed forward and back through the triceps insertion, and then carried obliquely back toward the corresponding suture limb of the originating anchor and tied.

of each anchor was carried obliquely across the fracture site in a crossing fashion. These were horizontally sutured through the triceps as before and brought back toward their corresponding limb from the originating anchor, where they were also tied close to the drill holes. The sutures were then cut, and the elbow was taken through a range of motion to confirm no fracture gapping. Standard closure was performed. On day 1 postoperatively, patients were permitted to perform active range of motion of the elbow and discharged only when their hand could reach their mouth. Heavy

lifting or axial load was restricted in the first six weeks postoperatively.

## Outcomes

The outcomes of interest were union rate, functional outcome, complication and reoperation rates. Radiographs were used to assess union. Union for this investigation was defined as the presence of bridging callous on three or more cortices in two orthogonal radiographic views.<sup>22</sup> Functional outcome included measurement of the Mayo Elbow Performance Score (MEPS) and assessment of the elbow's range of motion at the most recent follow-up. The senior author measured the range of motion with a goniometer in all cases. Extension and flexion measurements were recorded using 5° increments; 0° denoted full extension and 130° full flexion. MEPS is a score out of 100, comprising individual scores for pain, motion, stability and function concerning activities of daily living.<sup>23</sup> The higher the score, the greater the functional result.<sup>23</sup> A score between 90 and 100 is considered excellent, 75–89 good, 60–74 fair and 59 or less is considered poor.<sup>23</sup> Complications included loss of reduction, prominent or symptomatic sutures or anchors, and infection (superficial or deep).<sup>24</sup> Reoperation could include any return to theatre for sepsis or hardware removal. Patients were discharged from the clinic once radiological union was confirmed and the patient had not developed complications.

All data was captured on an Excel spreadsheet (Microsoft © Excel version 16.84) to generate summary statistics. Categorical variables were summarised as counts and percentages. Continuous variables were represented as medians with an interquartile range (IQR) and range if non-parametric.

## Results

### Demographics

A total of 30 patients met inclusion criteria, and no patients were excluded. The median age of patients was 34 years (IQR 12, range 18–70), 60% were male (18 of 30), and only 7% (2 of 30)

reported a comorbidity, which was HIV infection in both cases. The mechanism of injury was a direct blow in 63% of cases (19 of 30) and a fall onto an outstretched hand in 37% of cases (11 of 30). Two patients had compound injuries (7%, 2 of 30). The left side was more frequently affected (83%, 25 of 30). *Table 1* summarises the patients' demographic and injury characteristics. The median number of days from injury to surgery was 9 (IQR 6, range 0–50). Patients followed up for a median of 11 weeks (IQR 7, range 6–114).

**Table I:** Descriptive statistics for the 30 included patients

	Counts (n)	% of total	Median	IQR	Range
<b>Demographics</b>					
Age (years)	30		34	12	18–70
<b>Sex</b>					
Female	12	40			
Male	18	60			
<b>Comorbidities</b>					
Yes (HIV)	2	7			
No	28	93			
<b>Injury detail</b>					
<b>Mechanism of injury</b>					
Direct blow	19	63			
Fall on an outstretched arm	11	37			
<b>Side of injury</b>					
Left	25	83			
Right	5	17			
<b>Compound</b>					
Yes	2	7			
No	28	93			
Time to surgery (days)			9	6	0–50
<b>Complications (n = 3)</b>					
Wound sepsis and protruding suture material	2	67			
Fibrous non-union	1	33			
Follow-up duration (weeks)			11	7	6–114
<b>Functional outcome</b>					
Total range of motion (degrees °)			130	5	120–130
Mayo Elbow Performance Score			100	0	90–100
Pain			45	0	45–45
Motion			20	0	20–20
Stability			10	0	10–10
Function			25	0	15–25

IQR: interquartile range, continuous variables expressed as medians with interquartile range (IQR) and range. Categorical variables expressed with counts and percentages of total.

### Outcomes

Twenty-nine patients (29 of 30) achieved union, representing a 97% union rate. *Figure 2* contains the lateral radiographs of a patient preoperatively, on day 1 postoperatively, and at union. One patient developed a fibrous non-union. No patients had pronation or supination loss following the procedure. The median postoperative flexion and extension total range of motion was 130° (IQR 5°, range 120–130). Of the patients that lost motion, the loss was at extreme extension; ten patients lost 5° of extension and one patient lost 10°. The median postoperative MEPS measured was 100 (IQR 0, range 90–100), considered an excellent functional result. Four patients did not score 100, all with loss in the MEPS function of activities of daily living category. Three cases complicated. There was a single fibrous non-union; the patient had no pain and minimal limitation in range of motion (a loss of 5°), and they did not require a reoperation. Two patients developed a



**Figure 2.** Lateral radiographs of a patient: a – preoperative; b – day 1 postoperative of open reduction and internal fixation with the all-suture anchor technique; c – at union six weeks postoperatively

superficial wound infection with suture material or knot protrusion through an area of dehiscence, noted at the six-week follow-up. In both cases, the visible suture was removed in the outpatient

clinic, the patients were given oral antibiotics to take home, and alternate-day dressings were requested from their local clinics. The infections both resolved by ten weeks postoperatively without further intervention. Two of the three patients that complicated had compound injuries. No patients required a return to theatre.

## Discussion

This investigation aimed to assess the outcomes of patients with transverse olecranon fractures managed with an ASA technique. In the present study, our cohort comprised predominantly male patients (60%) with a median age of 34 years, and we observed a 97% union rate.<sup>6,13,14,25</sup> Much like the findings in the present investigation, previous studies that employed sutures alone or suture anchors in a tension band configuration report high union rates.<sup>17,21,26</sup> These union rates have been consistent for olecranon fractures and osteotomies.<sup>17,21,26</sup> Particularly noteworthy is that these union rates were typically in cohorts comprising older patients.<sup>21,26</sup> Ravenscroft et al. obtained a 96% union rate in their cohort of 22 patients of age 54 years managed with the TBS technique employing metal bone anchors.<sup>21</sup> While our cohort was more than a decade younger than this and other investigations,<sup>17,26</sup> collectively they suggest that TBS for transverse olecranon fractures can reliably attain union across a spectrum of ages.

Union rates following transverse olecranon fractures are typically high irrespective of fixation method; however, complications and reoperation rates differ between strategies. Recently, comparative studies and systematic reviews have explored the pooled outcomes or comparative outcomes of TBS fixation alone or compared with TBW or PO.<sup>27-29</sup> A 2020 investigation comparing TBW, TBS and PO showed that the union rates of TBS were comparable to that of TBW and PO, but reoperation was significantly lower in the PO and TBS groups.<sup>27</sup> Of note, the TBS group had two cases complicate; one case required revision for failure of fixation, and the other developed a non-union.<sup>27</sup> These were both in patients who had fixation of an osteotomy.<sup>27</sup> There were no cases of infection in the 41 patients who had a TBS repair, in contrast to the present investigation.<sup>27</sup> These reports include small cohorts limiting the ability to analyse if the differences are spurious. The 2023 systematic review of Dogramatzis et al. further support that TBS union rates are comparable to that of TBW, with lower complication and reoperation rates, but caution that the studies included in the review were of poor quality.<sup>28</sup> The Bone and Joint Journal (Open) of 2023 saw the registration of the Simple Olecranon Fracture Fixation Trial (SOFFT), which proposes to compare the clinical results and cost-effectiveness of TBW and TBS.<sup>30</sup> This trial would improve the evidence base available for a conclusive understanding of the outcomes with TBS techniques.

Nazifi et al. have already performed a preliminary exploration of the cost-effectiveness of TBW as compared to TBS (including the use of implants), and concluded that TBS was more cost-effective.<sup>29</sup> TBS and TBW had equivalent costs at the time of operation; however, the high removal rates incurred additional costs, predominantly in the TBW group.<sup>29</sup> The reduction in the cost-effectiveness of TBW is an important consideration in the South African context of medical resource constraints.<sup>31</sup> Furthermore, previous investigation has reported that access to operating theatres in South Africa is almost half that of the global average.<sup>32</sup> A return to theatre for removal of prominent metalware following TBW, therefore, comes at great expense to the system. While three patients developed complications with the ASA technique employed, no patients required reoperation. Also interesting to note is that two of the three patients who developed complications had compound injuries. However, the authors caution against the assumption that the technique may be unsafe to fix injuries are compound. Only a large-scale prospective comparison

investigation would be able to determine if the complications (and cost-effectiveness) of the ASA technique are greater than the TBW method in a South African setting.

Principally, the union rates, limited number of complications, and lack of reoperations do not seem to come at the expense of the functional outcomes. All the patients in the present investigation had a functional range of motion and an excellent MEPS measured at the final follow-up. This finding has been echoed in previous works.<sup>17,28</sup> Ongoing research is essential to further evaluate the long-term outcomes and complications associated with the ASA technique.

The study was retrospective by design, which led to specific limitations for this dataset. There was a potential for patient selection bias. During the period under investigation, the senior author began incorporation of the surgical technique into his practice but did not do so exclusively. Regarding follow-up, the senior author's practice is to review patients at two weeks and then at six weeks postoperatively; thereafter, the timing of follow-up visits is based on the individual's progress. Patients are discharged if radiological union is established, and the wounds are healed. This practice led to variability in follow-up durations. Furthermore, the limited long-term follow-up reduced the conclusions we could draw regarding complications and reoperations. While a single surgeon conducting the procedure in a consistent manner is advantageous in the evaluation of outcomes of a new ASA technique, this limits the generalisability of the findings. Recognising these limitations, the study illustrates the potential efficacy of the ASA technique and the value it may offer in limiting adverse outcomes. Addressing these limitations in future prospective comparative studies would be necessary to truly assess its role in the management of transverse olecranon fractures.

## Conclusion

The adult patients with transverse olecranon (Mayo type IIa) fractures managed with the described ASA technique in this investigation had a union rate of 97%, with excellent functional results as measured by the MEPS. No reoperations were required. Comparative studies and long-term follow-up investigations will be necessary to determine superiority over alternative fixation methods.

### 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. The study complied with the South African Department of Health ethics guidelines (2015), and the University of KwaZulu Natal policy on research ethics. Prior to commencement of this research the appropriate ethical approval was obtained from the Biomedical Research Ethics Committee of University of KwaZulu-Natal (BREC/00003664/2021). For this study, formal consent was not required.

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.

### 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

WQ: study conceptualisation, data capture, data analysis, first draft preparation, manuscript revision

MoC: data analysis, manuscript preparation, illustrations, manuscript revision

WH: data collection, manuscript review

JLP: study design, data capture, data analysis, photographs, manuscript revision

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