Multi-Centre retrospective study of the long-term outcome following suspected traumatic elbow luxation in 32 cats

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Objectives: To describe reduction techniques and clinical outcome in a series of traumatic elbow luxations in cats.

Materials and Methods: Retrospective review of unilateral elbow luxations treated at five specialist referral centres. Data included signalment, aetiology, concurrent injuries, luxation direction, time to reduction, primary reduction technique, surgical procedure and complications. Cases were excluded if reduction technique was unknown. Telephone owner questionnaire follow-up was completed using a Feline Musculoskeletal Pain Index.

Results: Thirty-two cats were included. Lateral luxations were most common (n = 21). Time (hours) until attempted initial closed reduction was <24 (n = 12), 24–48 (n = 13), >48 (n = 3) or unrecorded (n = 4). Luxation was treated by closed reduction alone (n = 7) or by surgery (n = 25); 14 of 25 cases underwent primary surgical reduction and 11 of 25 were secondary procedures following failure of closed reduction. Transcondylar bone tunnels and circumferential suture (n = 19) was the most commonly used surgical technique. Catastrophic (n = 1), major (n = 11) and minor complications (n = 5) were recorded; reluxation occurred more frequently after closed reduction (n = 8) than after open reduction with fixation (n = 0). Feline Musculoskeletal Pain Index data were available for 12 cats; outcome was good-excellent in all 12, with a median function score of 64.5/68 (range: 55–68) and a median pain score of 0/15 (range: 0–5). Outcome was not associated with reduction technique.

Clinical Significance: Elbow reluxation occurred in 61% of cats following primary closed reduction but did not occur in any open reduction cases. Reluxation rate increased with duration from injury. Most cats had good-excellent owner-assessed outcome, regardless of reduction technique.

INTRODUCTION

Elbow luxation is an uncommon traumatic injury in cats, with indirect or direct force more commonly resulting in peri-articular or articular fractures (Billings et al. 1992, Farrell et al. 2007, Mitchell 2011). The elbow is an intrinsically stable compound joint, with uniaxial hinge-like movement (Andersson 2004) and comprising of humeroulnar, humeroradial and proximal
radioulnar articulations (Mitchell 2011). Pronation and supination are primarily achieved through carpal motion although movement within the elbow may increase the possible range of pronation-supination (Andersson 2004). The canine elbow is optimised for parasagittal movement (Andersson 2004), with deep humeral and ulnar trochlear notches and a prominent anconeal process affording greater congruence than in the feline elbow. In dogs, engagement of the anconal process with the olecranon fossa stabilises the elbow in extension (Bordelan et al. 2005, Mitchell 2011). The collateral ligaments (CLs), as primary stabilisers, limit medial and lateral elbow translation and pronation-supination (Bordelan et al. 2005, Mitchell 2011).

Compared with dogs, cats have increased thoracic limb dexterity, conferred by shallower trochlear furrows, larger and distally-projecting humeral trochleas and smaller anconal processes (Andersson 2004). Additionally, feline oblique and olecranon ligaments are relatively large compared to those of dogs, and act as important secondary stabilisers (Bordelan et al. 2005). The feline olecranon ligament is twice the width and one-third the length of the canine olecranon ligament (Engelke et al. 2005). Combined, these features provide extra stability within the feline elbow against forces acting in a non-parasagittal plane. Elbow luxations thus occur secondary to high-energy indirect rotational forces. Elbow luxation can occur with an intact radioulnar joint, with radioulnar joint disruption and humeroulnar luxation, or as a Monteggia-like lesion (radial head luxation with concurrent ulna fracture) (Voss et al. 2009).

Elbows with an intact radioulnar joint most commonly luxate laterally, with the larger medial humeral trochlea and its more acute distal articular slope minimising medial movement (Billings et al. 1992, O’Brien et al. 1992, Guzel et al. 2006, Sajik et al. 2016). Medial (Billings et al. 1992) and caudal elbow luxations (Scott & McLaughlin, 2006) have also been reported in cats. In feline cadavers, injury to both the medial collateral ligament (MCL) and lateral collateral ligament (LCL) were required to enable lateral luxation of the feline elbow (Farrell et al. 2007). In contrast, collateral ligament rupture is identified surgically in only 18–50% of traumatic canine elbow luxations (Sajik et al. 2016, Krotscheck & Böttcher 2018). Mid-substance collateral ligament tears are most commonly reported (Farrell et al. 2007, 2009) and have been treated by primary repair with or without augmentation, using bone tunnels or screws and washers (Farrell et al. 2007, 2009). Campbell’s test provides a non-invasive assessment of collateral ligament function by defining excessive antebrachium rotation in collateral ligament-insufficient joints. With the elbow and carpus flexed to 90° (Campbell 1969), Farrell et al. (2007) demonstrated a mean pronation angle of approximately 50° and a mean supination angle of approximately 125° in feline cadaveric elbows with intact collateral ligaments. Significantly increased angles of supination and pronation have been demonstrated in cadaveric feline and canine elbows following LCL and MCL transection, respectively (Farrell et al. 2007).

Closed reduction is recommended for initial treatment in acute traumatic elbow luxations in cats and dogs without concurrent articular or peri-articular fractures. Excellent outcomes are reported for elbows that remain stable following closed reduction, with no benefit of surgical stabilisation for such cases (Bordelan et al. 2005). The reported owner-perceived outcome for feline elbow luxation managed by closed reduction is excellent (Mitchell 2011). Chronic luxations, or those with significant concurrent intra-or peri-articular injuries are reported to have a poorer prognosis than luxations managed acutely (Bordelan et al. 2005).

Surgical stabilisation is undertaken in cases in which on-going instability renders closed reduction unsuccessful (as demonstrated by an abnormal Campbell’s test or recurrence of the luxation). Cases in which concurrent elbow fractures preclude successful joint alignment and articulation with closed reduction must be managed as articular fractures and surgically stabilised (Piermattei & Flo 1997, Johnson & Hulse 2002, Dassler & Vasseur 2003). Previously reported techniques for surgical stabilisation of feline elbow luxations include locking sutures (Billings et al. 1992, Scott & McLaughlin 2006), ligament prosthesis using screws (Voss et al. 2009), open reduction with circumferential sutures using bone tunnels (Farrell et al. 2009) and transarticular pins (Scott & McLaughlin 2006). Collateral ligament stabilisation is reported to reduce the risk of reluxation, and reduce instability-associated osteoarthritis (Voss et al. 2009). Transarticular external skeletal fixators have also been reported to augment closed reduction in elbows with continued instability (Kalff et al. 2013). External coaptation is recommended following closed reduction (Johnson & Hulse 2002, Mitchell 2011) and primary collateral ligament repair (Farrell et al. 2009), using spica splints, support bandages or Robert Jones bandages (De Camp 2003, Mitchell 2011). Post-operative re-examination of cats that underwent open reduction demonstrated resolution of lameness and no pain response on elbow manipulation (Billings et al. 1992, Farrell et al. 2009).

While a recent multi-centre case series has outlined the long-term outcome for closed and open management of traumatic canine elbow luxations (Sajik et al. 2016), the corresponding literature in cats is limited to a closed reduction series (11 cats, Mitchell 2011) and case reports of open reduction (Billings et al. 1992, Scott & McLaughlin 2006, Farrell et al. 2007, 2009, Voss et al. 2009). Here we report the clinical findings and outcome of a multi-centre series of traumatic intact radioulnar joint feline elbow luxations managed by closed reduction or surgical stabilisation.

**MATERIALS AND METHODS**

The ethical and welfare committee (URN 2016 1566) granted study approval. Clinical records for cats with suspected traumatic elbow luxation at six referral institutions were reviewed (2005–2016). Elbow luxation was diagnosed as a palpable medial, lateral or caudal displacement of the radius from the humeral capitulum and ulna from the humeral trochlea and anconeal process, with associated lameness. Orthogonal radiographs were obtained to confirm disarticulation of the elbow with an intact radioulnar joint and absence of concurrent articular elbow fractures or Monteggia-like lesions. Post-procedure elbow reduction was confirmed radiographically. Data collected included signalment, aetiology, direction of luxation, time to reduction (<24 hours, 24–48 hours, >48 hours), reduction method (closed/surgical stabilisation), lig-
Elbow luxation, cat, outcome

RESULTS

Thirty-two cats were included. Evaluation of cases was distributed between specialist referral institutions Queen Mother Hospital for Animals (Royal Veterinary College [RVC]) (n = 12), Fitzpatrick Referrals (n = 16), University of Glasgow Small Animal Hospital (n = 2) and 1 case each at Langford Veterinary Services Small Animal Hospital (University of Bristol) and Small Animal Specialist Hospital (Sydney). In three cases seen at the RVC, treatment was performed by a primary care practice (n = 2) or further referral service (n = 1) for financial reasons. Signalment data are shown in Table 1: most of the cases were male neutered domestic short hair cats (n = 23) and all elbow luxations were unilateral. Of the 13 cases with a witnessed traumatic luxation, falling from a height (n = 4) and road traffic accidents (n = 4) were the most common causes. The direction of luxation was recorded as lateral (n = 21), medial (n = 8), caudal (n = 2), or unrecorded (n = 1; cranio-caudal radiographic view unavailable). Time to reduction and primary reduction method are recorded in Table 2.

Concurrent orthopaedic injuries were reported in four of 32 cases (Table 3) which affected the ipsilateral pelvic limb (Case 31) or multiple limbs (Cases 3, 10, 15). These cases underwent treatment by primary closed elbow reduction (n = 1) or secondary surgical stabilisation following failed closed reduction (n = 3). One cat without concurrent injuries (case 6) had radiographically visible pre-existing elbow osteoarthritis identified at the time of luxation diagnosis.

Management of elbow luxations is outlined in Fig. 1. Following opioid analgesia and general anaesthesia, manual closed reduction (method according to De Camp et al. 2016) was performed as the primary management method in 18 cases. Of these, seven were successfully managed by closed reduction alone (Group 1). Six cases managed by closed reduction alone had additional coaptation, including spica splint (n = 4), palmar splint (n = 1) and spica splint following by dressing (n = 1). Duration of coaptation was known for five cases with a median application duration of 3.5 weeks. Results of Campbell’s testing of post-reduction stability are demonstrated in Fig. 2. In cats managed by primary closed reduction, Campbell’s testing was accurate in predicting stability in 10 of 13 cats. When time to primary closed reduction post-injury was considered, 50% of elbows reduced in <24 hours had recurrent luxation, compared to 67% reduced within 24–48 hours and 100% reduced in >48 hours (Table 2). After reduction, cats were discharged with meloxicam analgesia. Activity was restricted to cage rest with incremental periods of supervised floor exercise over 5–8 weeks. After clinical and radiographic reassessment, activity was gradually further increased to normal levels. Passive range of motion exercises were performed from discharge in cats without coaptation or following coaptation removal in cases in which coaptation was used.

In total, 25 cases underwent surgical management of elbow luxation under opioid analgesia and general anaesthesia (Group 2). Surgical stabilisation was the primary management method in 14 cases and as secondary stabilisation in 11 cases in which primary closed reduction had failed (Fig. 1). Campbell’s testing was performed in five of 14 cats that underwent primary surgical management, with all of the elbows assessed judged to be stable (Fig. 2). Campbell’s testing was performed in 13 of 18 cats that underwent primary closed reduction (Fig. 2). Following primary closed reduction, five cats had elbows judged as unstable on Campbell’s testing and underwent secondary surgical management (Fig. 2). Subsequent relaxation did not occur in any cases following primary or secondary surgical management. Table 4 details surgical techniques used and ligament injuries. Post-surgical coaptation (spica splint), of unknown duration, was used in two cases. After surgery, cats were discharged for home management under the same guidelines as the closed reduction cases.

Complications involving the affected limb were recorded in 17 of 32 cases (Table 5). Recurrent luxation (n = 8) was the

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Table 1. Signalment data of 32 cats with suspected traumatic elbow luxation

| Breed                        | Total (n) |
|------------------------------|-----------|
| Sex                          |           |
| Male neutered                | 23        |
| Male entire                  | 0         |
| Female neutered              | 9         |

| Breed                        | Total (n) |
|------------------------------|-----------|
| Domestic short hair           | 21        |
| Domestic long hair, British  | Two of each (4) |
| Domestic semi-long hair,     | One of each (7) |
| Maine coon, ragdoll, Asian,  |           |
| Siberian, Bengal, Burmese    |           |

| Median age (months) | 49 | Range 8–185 |
| Median weight (kg)  | 4.49 | 2.9–7.70 |
FIG 1. Flow diagram of management of 32 cats with traumatic elbow luxation

most common complication, but only occurred in cases that had undergone primary closed reduction. Closed reduction was deemed to have failed in a further three cases in which severe elbow instability persisted, requiring secondary surgical stabilisation. Overall, primary closed reduction failed in 11 of 18 cats. Of 18 cats that underwent primary closed reduction, four had concurrent injuries. Elbow reluxation occurred in three of the four cats with concurrent injuries, representing three of the 11 cats in which primary reduction failed. Of the 14 cats that underwent primary closed reduction that did not have concurrent injuries, reluxation occurred in eight of 14 cases. By comparison, of seven cats in which primary reduction did not fail, only one had concurrent orthopaedic injuries.

Median body weight of cats in which primary reduction failed was greater (4.63 kg [range: 3.6–6.6 kg]) than that of cats in which primary closed reduction did not fail (4.0 kg...
Elbow luxation, cat, outcome

While lateral luxation was the most common direction in cats both groups, a greater proportion of cats in which closed reduction failed had medial luxation (n = 3/11) compared to those in which it did not (n = 1/7). A greater proportion of cats in which closed reduction was successful had reduction performed in less than 24 hours of injury (four of seven cats in <24 hours), compared to cats in which reluxation occurred following closed reduction (four of 11 cats in <24 hours). Coaptation-related soft tissue complications occurred in one of eight cases in which coaptation was used. Surgical stabilisation was required in two of eight primary closed reduction cases in which adjunctive coaptation had been used.

Follow-up was available by telephone interview only (n = 2), clinical records only (n = 14) and by both methods (n = 10) for 26 of 32 cats. Subjective follow-up through clinical records was available at a median follow up time of 1.5 months after surgery.

[FIG 2. Flow diagram of post-reduction Campbell's test results in cats with traumatic elbow luxation]

**Table 4. Analysis of surgical techniques and ligament injuries in 32 cats with traumatic elbow luxation**

| Feature | Total number of cases | Categories |
|---------|-----------------------|------------|
| Surgical techniques | 25 | Bone tunnels and biaxial collateral ligament suture prostheses¹ | TESF | Prosthetic ligament and suture | Screw and washer collateral ligament attachment |
| n | 19 | 2 | 2 | 1 |
| Ligament injuries | 11 | LCL only | MCL only | MCL & LCL | LCL & annular | LCL, MCP & annular | Unrecorded |
| n | 5 | 0 | 4 | 1 | 1 | 14 |

Abbreviations: TESF Transarticular external skeletal fixator, LCL Lateral collateral ligament, MCL Medial collateral ligament

¹Farrell et al. 2007

**Table 5. Complications occurring in 32 cats managed for traumatic elbow luxation**

| Total complications |
|---------------------|
| Complication category (Cook et al. 2010) | Catastrophic | Major | Minor |
| Number of cases | Closed reduction | Severe¹ on-going lameness without radiographic osteoarthritis or elbow instability (n = 1) | Elbow luxation recurrence following initial closed reduction (n = 8)² | Inter-digital pyoderma secondary to the spica splint and restriction in elbow range of motion (n = 1) |
| Surgical reduction | Severe² on-going lameness without radiographic osteoarthritis or elbow instability (n = 1)³ | Elbow luxation recurrence following initial closed reduction (n = 8)² | Severe subluxation requiring surgery (n = 3) | Mild carpal hyperextension – no treatment required (n = 1)⁴ |
| | Mild lameness at 10 weeks post-operatively (n = 1) | Mild carpal hyperextension – no treatment required (n = 1)⁴ | Restriction in elbow range of motion following TESF (n = 1) | Seroma (n = 1)⁴ |

Abbreviation: TESF Transarticular external fixator

¹Lameness severity according to scheme by Voss & Steffen 2009
²One cat had repeated elbow luxation following closed reduction, resulting in severe on-going lameness, and categorisation as a catastrophic complication
³Cat had concurrent lateral collateral ligament injury, and had undergone open reduction with bone tunnels and biaxial collateral ligament prostheses (Farrell et al. 2007)
⁴Cat had concurrent lateral collateral ligament injury, and had undergone open reduction with bone tunnels and biaxial collateral ligament prostheses (Farrell et al. 2007)
intervention (range: 5 days to 30 months). Cases with clinical record follow-up had undergone closed reduction (n = 3), primary surgical stabilisation (n = 8) and secondary surgical stabilisation (n = 13). Post-operative survival was documented in 31 of 32 cases. One polytrauma case (cat 31) was euthanised 5 days post-operatively having systemically deteriorated secondary to a hypercoagulopathy and suspected cerebral vascular accident. For 23 surviving cats with clinical record follow-up, 10 cats were reported to not be lame, with a normal range of elbow motion. Six cats were judged mildly lame (Grade 1, Voss & Steffen 2009), and a further five cats were reported to have mild restriction to elbow range of motion without lameness. Two of the cats with mildly restricted range of elbow motion were assessed immediately following transarticular external skeletal fixator removal. One cat assessed at 6 weeks following primary closed reduction was reported to be moderately lame (Grade 2, Voss & Steffen 2009), with mild discomfort on elbow manipulation and range of motion reduced by approximately 20°. One cat assessed 8 months following secondary surgical stabilisation had persistent severe lameness on the affected leg (Grade 3, Voss & Steffen 2009). Elbow flexion was 90°, with no radiographic abnormalities detected. A meloxicam trial was undertaken. Further follow-up was unavailable for these two cats. Questionnaire follow-up was not available for cats in which lameness was reported within clinical records.

Modified Feline Musculoskeletal Pain Index (FMPI) and pain score follow-up was completed by telephone for 12 cats, which were managed with primary closed reduction (n = 3), or bone tunnels and biaxial collateral ligament suture prostheses (Farrell et al. 2007) as primary surgical stabilisation (n = 3) and secondary surgical stabilisation (n = 6). Median time to questionnaire follow up was 48 months (range: 4–109 months). Median FMPI function score was 64.5/68 (range: 55–68). The function of the injured leg was described as excellent (n = 4), very good (n = 3), good (n = 1) or fair (n = 1) for surgical cases. The function of the injured leg was described as excellent (n = 1) or very good (n = 2) for cases managed by primary closed reduction. Median pain score was 0/15 (range: 0–5). Median FMPI and pain scores are shown in Table 6; scores did not differ by management technique. Quality of life was graded as excellent (n = 10) or good (n = 2).

Ten cases had both short-term follow-up available (within 3.5 months post-management) through clinical records and longer term follow-up through questionnaire data (median 48 months after intervention). Two cases had been managed by primary closed reduction and eight had been managed surgically. Eight of these cases were reported to have normal limb use at short-term follow-up, with long-term limb use reported to be excellent (n = 5), very good (n = 2) and fair (n = 1, case 23). One cat (case 34) with mild lameness at short-term follow-up 3 months following primary secondary stabilisation with bone tunnels was reported to have a very good long term limb function at 20 months post-operatively. One cat (case 26) with mildly restricted range of motion at transarticular external skeletal fixator removal 4 weeks post-operatively was reported to have very good limb use at 109 months post-operatively.

### Table 6. Outcome parameters by elbow luxation management technique

| Outcome parameter | Elbow luxation management technique | Primary closed reduction | Primary surgical stabilisation | Secondary surgical stabilisation |
|-------------------|-------------------------------------|--------------------------|-------------------------------|----------------------------------|
| Number of cats    |                                     | 3                        | 3                             | 6                               |
| Median FMPI function score |                           | 66                       | 63                            | 65.5                             |
| Median pain score |                                     | 0                        | 1                             | 0                               |

**Abbreviation:** FMPI Feline Musculoskeletal Pain Index (Benito et al. 2013)

DISCUSSION

In this series, 32 cats with traumatic elbow luxations were treated at five specialist veterinary referral centres over an 11-year period, demonstrating that elbow luxation is a relatively rare injury. To our knowledge, this is the largest reported cohort of feline traumatic elbow luxations. The direction of luxation in this series was most commonly lateral (21 of 32 cats). While less frequently observed than lateral luxation, medial and caudal elbow luxations were also observed in this series, as previously reported in cats (Billings et al. 1992, Scott & McLaughlin 2006).

Recurrence of elbow luxation was the most frequent complication in this series, but only occurred following primary closed reduction. Additionally, luxation recurrence was associated with increased injury duration before initial closed reduction. Muscle contracture has been proposed to increase the difficulty in manual closed elbow reduction with injury chronicity (De Camp et al. 2016). Traction of contracted muscles on the reduced joint may result in a less stable joint after reduction and increase the risk of luxation recurrence. There was no recurrence in any cat that had undergone primary surgical reduction or secondary surgical reduction following failure of primary closed reduction. As none of the cats in this series were managed with repeated closed reduction following luxation recurrence, we cannot comment on the success of that alternative strategy.

Forced early loading of the affected limb because of concurrent orthopaedic injuries has been proposed to worsen outcome for patients with elbow luxation (Mitchell 2011, Sajik et al. 2016). Following initial primary closed reduction, relaxation occurred in three of four cats with concurrent injuries, compared with 11 of 14 cats without concurrent injuries. No cat with concurrent orthopaedic injuries was managed with initial surgical reduction, making comparison of this factor alone complicated. In Case 3, secondary surgical stabilisation of the luxated elbow was successful, but contralateral pancarpal arthrodesis infection and implant failure resulted in contralateral thoracic limb amputation. It would therefore seem appropriate that cats with elbow luxation and concurrent injuries are managed with primary surgical stabilisation rather than primary closed reduction to reduce the risk of complications affecting the luxated elbow or the concurrent injuries. Surgical management also appears favourable in cats without concurrent injuries when compared to a relaxation rate of more
Elbow luxation, cat, outcome

than 50% following primary closed reduction. Owners should be counselled that primary surgical stabilisation of feline elbow luxation is associated with a lower reluxation rate (zero in this series) than primary closed reduction (>60% in this series). However, in the event that surgical stabilisation is not undertaken, this series demonstrates that many cats with traumatic elbow luxation can be successfully managed with primary closed reduction.

In canine traumatic elbow luxation cases managed by primary closed reduction, reoccurrence of luxation was reported in 29% of dogs (Sajik et al. 2016). It is considered likely that the increased frequency of reluxation following primary closed reduction in the feline elbow compared to canine elbow reflects the relatively increased severity of damage to the collateral ligaments in the cats (Farrell et al. 2007). Cadaveric studies have demonstrated that 83% of canine elbows luxate following transection of the lateral collateral ligament alone, whereas feline elbow luxation requires transection of both the medial and the lateral collateral ligaments (Farrell et al. 2007). Ligament damage was inconsistently recorded in these surgically-managed cases and cannot be confirmed in cases undergoing closed reduction alone, preventing analysis of the severity of ligament damage as a risk factor for reluxation.

Our data demonstrate increased frequency of recurrent luxation in feline elbows undergoing primary closed reduction (~60%) compared to those managed by primary (0%) or secondary surgical reduction (0%). This would support surgical stabilisation as the initial management method for traumatic feline elbow luxation. While external coaptation has been advocated to increase support following closed reduction, the efficacy of these methods to prevent elbow luxation recurrence in dogs has been questioned (Sajik et al. 2016). In this series, two of 12 cats in which luxation reoccurred had external coaptation applied. Coaptation-related soft tissue injuries, which can cause significant morbidity and increased treatment costs (Meeson et al. 2011), occurred in one of eight cats in this series. Although the use of appendicular coaptation and spica splints are reported, it is widely accepted that their maintenance can be challenging in cats. We would suggest that this data does not support the use of coaptation methods for management of elbow luxation and that any elbow that is not demonstrably stable following closed reduction should be considered a candidate for surgical stabilisation.

Campbell’s test has been reported as a means of functionally assessing elbow stability after reduction (Farrell et al. 2007). Campbell’s test was performed in 13 of 18 cases that underwent primary closed reduction (Fig. 2). Of these, five were unstable and therefore failed primary closed reduction. Campbell’s test was not recorded in five primary closed reduction cases, with subsequent recurrence of luxation in three untested cases. Had elbow instability been demonstrated in these cases by an abnormal Campbell’s test, surgical stabilisation may have been performed under the same general anaesthetic, potentially decreasing patient morbidity and cost associated with secondary surgical stabilisation as a subsequent procedure. In the three elbows initially judged as stable by Campbell’s test that later luxated, luxation occurred within 72 hours of closed reduction in two cases, and at 6 weeks after closed reduction in one case. Recurrent luxation may therefore have occurred following reduction in soft tissue swelling that had initially masked the severity of elbow instability. Increased patient activity with soft tissue swelling reduction may also contribute to increased instability with time after injury. In humans, simple elbow dislocations are assessed fluoroscopically in varus and valgus stress following closed reduction to quantitatively gauge severity of joint instability (Schnertzke et al. 2015). Severely unstable elbows that dislocate during testing undergo primary open stabilisation (Schnertzke et al. 2015). Human elbows with moderate reduction instability (≥10°) after closed reduction have a significantly worse elbow extension range following non-surgical treatment and have significantly higher odds of complication and revision surgery rates, compared with people with <10° of elbow instability (Schnertzke et al. 2015). Fluoroscopy may be a useful tool for assessing the stability of grossly stable feline and canine elbows following closed reduction, with secondary surgical management chosen if instability is diagnosed.

Outcome following traumatic elbow luxation was assessed by clinical record review, and using a modified previously reported owner-questionnaire to assess patient function, and owner-perceived pain. Although follow-up was available for 26 of 32 cats (81% of cohort) when all follow-up methods were combined, it was not completed for all cases, nor conducted at standardised time points. Post-operative survival was documented in 31 of 32 cases, with the death of one of six cats with concurrent injuries. Analysis for factors such as polytrauma influencing the survival of cats with traumatic elbow luxations would have been under-powered in this cohort. Clinical records follow-up demonstrated that ~90% of surviving cats had a positive outcome following elbow luxation management, with normal limb use (n = 10/23), mild lameness (n = 6) or mildly restricted range of motion without lameness (n = 5). Both cases managed with a transarticular external skeletal fixator had mildly restricted range of motion when the device was removed, and physical rehabilitation was advised. Prolonged joint immobilisation, as achieved with transarticular external skeletal fixation, has a negative effect on joint mobility due to altered intra-articular physiology (Jaeger et al. 2005). Long-term follow-up was available in one of these cases (case 26), with limb use reported to be very good, suggesting an improvement in joint mobility with unrestricted limb use.

Overall, eight of 31 surviving cats were reported to be lame on clinical follow-up. Questionnaire follow-up was available for one of eight lame cats (case 34). Mild lameness was reported at 3 months clinical follow-up following primary surgical stabilisation with bone tunnels, with very good limb use at 20 months post-operatively on questionnaire follow-up, suggesting improvement. Removal of nylon prosthetic ligaments was considered to address the lameness at 3 months; it is uncertain from records whether this was performed. Two cats (cases 4 and 21, 9% of cohort) were reported to have severe lameness at 8 and 1.5 months follow up respectively. Both cases were lateral elbow luxations without concurrent orthopaedic injuries, and were judged to be stable with Campbell’s test following management. In Case 4, luxation recurred following closed management and the cat underwent secondary surgical stabilisation with bone tunnels. In Case 21,
closed reduction was performed within 48 hours after injury without recurrence of luxation. Additional follow-up not available for these cases, preventing evaluation of response to analgesia management or further treatment, or progression of lameness. Further work is required to assess risk factors for cases in which severe lameness persists.

Functional outcome was reported to be excellent or very good in 10 of 12 cases in which questionnaire follow-up was available, with no significant difference in modified FMPI scores between surgical and closed reduction management methods. Activities most frequently reported to be graded “moderately worse than normal” or worse were jumping to kitchen counter height (two of 12 cats unable to perform activity) and jumping down (three of 12 cats moderately worse). Jump height has previously been identified as a reduced functional activity in cats following pancarpal or partial carpal arthrodesis (Calvo et al. 2009) and femoral head and neck excision (Yap et al. 2015), and appears a sensitive performance parameter. The cat reported to have a “fair” outcome (case 23) at 81 months following primary surgical stabilisation (bone tunnels) had a modified FMPI score of 58/68 and a pain score of 2/15. Activities reported to be “moderately worse” were walking, running and tolerance of handling. The responses to questions regarding jumping ability being “moderately worse” and “normal” were conflicting. Quality of life was reported to be “good,” and analysis was not being administered. Overall questionnaire reported quality of life was reported as excellent (n = 10) or good (n = 2). While secondary osteoarthritis would be expected to have a deleterious effect on mobility with time after injury, median follow-up time at questionnaire response was >3-years post-injury, suggesting that elbow osteoarthritis within this time period did not have a negative effect on owner-perceived quality of life. Completion of serial questionnaires over a longer follow-up period, repeated veterinary clinical assessment and objective measures such as kinetic or kinematic analysis would potentially increase the accuracy of follow up, and decrease possible caregiver bias.

Limitations of this study are inherent to its retrospective, multicentre design, with incomplete records and variability introduced by veterinary surgeons at multiple primary care and referral centres. A bias for surgical management may have originated within a referral population, especially within cats in which closed reduction before referral had not been achieved or had failed. The cohort size, while larger than those previously reported is still small, and so conclusions regarding comparative efficacy of therapies must be tentative.

In conclusion, this series demonstrates that primary closed reduction of feline elbow luxations is associated with more frequent relaxation than in cases managed surgically. Recurrence appeared to occur in a greater proportion of cases in which the elbow was luxated for longer before initial closed reduction. Our data show that the relaxation rate following closed elbow reduction in cats is higher than previously reported. We conclude that primary surgical reduction should be considered in those cases in which elbow instability is identified on Campbell’s test and there are concurrent orthopaedic injuries. Furthermore, if primary closed reduction is performed, it should be performed promptly, and cases monitored closely for signs of luxation recurrence.

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Conflict of interests

The authors have no conflicts of interests to declare.

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Supporting Information
The following supporting information is available for this article:
Appendix S1: Owner Questionnaire results for 12 cats following elbow luxation reduction, by method of reduction (Q1-17, modified FMPI (Benito 2013)).