Treatment of type 2 and 4 olecranon fractures with locking compression plate (LCP) osteosynthesis in horses: a prospective study (2002-2008)

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Abstract

This prospective study describes a series of 18 olecranon fractures in 16 horses that were treated with locking compression plates (LCP). Twelve of the 18 fractures were simple (type 2), whereas six were comminuted (type 4). Six fractures were open and 12 were closed. Each horse underwent LCP osteosynthesis consisting of open reduction and application of one or two LCP. Complete fracture healing was achieved in 13 horses. Three horses had to be euthanatized: two because of severe infection and one because of a comminuted radial fracture 11 days after fixation of the olecranon fracture. Complications encountered after discharge of the horses from the Equine Hospital at the Vetsuisse Faculty (University of Zurich) included implant infection (n = 2) and lameness (n = 3), which were successfully treated with implant removal. Despite being easier to use, LCP osteosynthesis resulted in a clinical outcome similar to DCP osteosynthesis.
Clinical Communication


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Keywords
Horse, ulnar fracture, locking compression plate, osteosynthesis

Summary
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Introduction
Ulnar fractures are common in horses of all ages and occur mainly after kick injuries or other external trauma (1). These fractures are classified as type 1a, 1b, 2, 3, 4, or 5, depending on their configuration, which is determined radiographically (1–4). The most common configuration in immature horses is type 1b, with involvement of the growth plate (1, 5). In adult horses, type 2 fractures (simple oblique mid-body fractures with articicular involvement) are the most prevalent; type 4 (comminuted fractures involving the articular surface and the olecranon body) and type 5 fractures (oblique fractures of the distal ulna involving the elbow joint) are seen less frequently (3, 4). The treatment of choice for repair of ulnar fractures is open reduction and internal fixation using the tension-band principle (1, 3, 6). A narrow dynamic compression plate (DCP) or a limited-contact dynamic compression plate (LC-DCP) is usually applied to the caudal aspect of the ulna (2, 6). For comminuted fractures, the application of two plates, one caudal and one lateral, may improve the stability of the fixation (1, 2, 7). The prognosis for ulnar fractures after internal fixation is good based on reported healing rates (bony union) of 68%, 76%, and 87% (3, 4, 6). The prognosis is better in juvenile horses with a reported healing rate of 92%, whereas it is poorer in cases with comminuted fractures where healing was reported in only 63% of the patients (7, 8). Non-surgical treatment has been described for type 5 ulnar fractures, which had a reported healing rate of 70%, although the convalescent time was longer than that of internal fixation (9).

The locking compression plate (LCP), which is relatively new to orthopaedic surgery, follows the principle of ‘biologic fixation’ by combining the benefits of internal and external fixators (10). Numerous in vitro studies have demonstrated the superior biomechanical properties of the LCP system compared with the DCP (11–14). In humans, the LCP is especially valuable for complex fractures, revision fixations after other implants have failed, and for fractures of osteoporotic bones (15). The first clinical studies in horses where a LCP was used for the treatment of various fractures as well as for arthrodesis showed good results (16, 17). In one report, two comminuted ulnar fractures treated with LCP osteosynthesis healed without complications (16). A recent study reported complete fracture healing and excellent cosmetic results after LCP osteosynthesis of complicated mandibular fractures (18). Since 2002, all olecranon fractures undergoing surgery in our hospital (Equine Hospital, Vetsuisse Faculty, University of Zurich, Switzerland), have been stabilised using the LCP system. The aim of this report was to describe our experience with olecranon fractures stabilised with the LCP system, focusing on complications and outcomes.
Material and methods

The medical records of all horses with olecranon fractures presented to the Equine Department at the Vetsuisse Faculty (University of Zurich, Switzerland), and treated with LCP between 2002 and 2008 were reviewed. For each horse, the history, breed, sex and age were recorded and the affected limb was determined. Additional data retrieved for each case included weight (0–199 kg, 200–299 kg, 300–399 kg, 400–499 kg, and greater than 500 kg), cause of the fracture (kick from another horse, unknown aetiology, refracture during recovery), duration between injury and surgery (1–2 days, 3–6 days, 7–20 days, and greater than 20 days), severity of the lameness at initial examination (non-weight bearing or lameness at walk), presence of a skin wound (open or closed fracture), radiographic findings (classification of fracture type), type of surgery (single narrow LCP applied on the caudal aspect of the olecranon, an additional narrow LCP applied laterally, or two broad LCP: one caudal and one lateral), surgery time (under 2 hours, between 2 and 3 hours, between 3 and 4 hours, or more than 4 hours), recovery (pool or assisted), complications with resolution (incisional and implant infections, plate removal, olecranon refracture and second fixation), complications leading to euthanasia (laminitis, osteomyelitis, radius fracture) and outcome (no complications: horse returned to full athletic function, complications with resolution: horse returned to full athletic function after resolution of the complications, or complications leading to the horse being euthanatized). All cases had clinical and radiographic follow-up examinations performed at our hospital at two, four and eight months after surgery; in two cases, follow-up examinations were also performed three years after the first surgery. All radiographs were evaluated by two of the authors (MJ, RH).

Cases

Between January 2002 and January 2008, 16 horses with a total of 18 ulnar fractures were treated with a LCP. Two horses underwent a second surgery one day and one year after the first surgery, respectively. There were eight female and eight male horses, with a mean age of 11.4 years (range: 9 months to 20 years). The breeds included 11 warmblood horses, one Arabian horse, one Friesian horse and one Shetland pony.

History

Nine fractures were the result of a kick from another horse, and in four cases the cause of fracture could not be determined, although a kick injury was suspected. In three cases, the cause of the fracture was not recorded. Two horses suffered refracture of the olecranon during recovery from anaesthesia: case 1 had a failure of the internal fixation (bending of the caudal plate) during assisted recovery, and case 9 fell on the elbow in the recovery room after removal of the two plates, which resulted in refracture of the olecranon through a screw hole. The fracture was one- to two-days-old in the majority of cases (9 cases), three- to six-days-old in six cases, seven to 20 days in one case, and in two cases the fracture was more than three-weeks-old. On presentation, 10 of the horses could not bear weight on the affected limb and had a ‘dropped elbow’ appearance, and six horses could bear weight but were lame at a walk (11).

Fracture configuration

Twelve cases had a simple oblique type 2 fracture with a transverse fracture line entering the trochlear notch near its midpoint. Six fractures were staggered comminuted (type 4), and there was separation of a rectangular- or trapezoid-shaped fragment in the caudal cortex of the ulna in two cases (Fig. 1). Six fractures were open and 12 were closed. There was dislocation of the proximal fragment in 15 cases. Two fractures were more than three weeks old, one of which showed proliferative callus.

Results

The case details can be reviewed in Supplementary Tables 1 and 2, both of which are available online at http://www.vcott-online.com.
screws to ensure good plate-bone contact. The time from the first skin incision until the end of the surgery was less than two hours in one case, between two and three hours in nine cases, between three and four hours in six cases, and more than four hours in two cases.

A pool recovery system was introduced in our clinic in 2002 and was successfully used for 13 horses (14 ulnar fractures in total). In four cases, the horses recovered without using the pool; the foal and pony underwent assisted recovery due to their smaller size, whereas one adult horse (case 1) had assisted recovery because the pool had not yet been installed. This horse refractured the olecranon during recovery and underwent a second surgery and assisted recovery from anaesthesia.

**Outcome and complications**

Of the 16 horses, eight were discharged from the hospital three weeks after surgery without complications. Follow-up examinations performed at two, four and eight months postoperatively in all eight patients showed that the fractures had healed radiographically at eight months, and it was determined that the horses could return to their intended use without further complications. The nine-month-old foal showed good healing of the fracture after four months, and, although the screws were not penetrating the radius, a decision was made to remove the plate to allow normal growth of the ulna. Five horses could return to their intended use after resolution of their complications. Two horses developed implant infection which required removal of the plates after four and six months, respectively. Both horses recovered and were completely sound four months after removal of the implants. In three other adult horses, the plates had to be removed after healing of the fracture because of lameness, but without signs of infection (case 7 after 9 months, case 9 after 1 year, and case 12 after 32 months). In two of the three horses (case 7 and case 12), the lameness resolved after removal of the implants. Case 9, which had suffered from a comminuted ulnar fracture in the previous year (Fig. 1), fell in the recovery room after removal of the two plates and refractured the elbow (Fig. 4). The new fracture line ran caudally through the initial fracture line and followed the hole of the fourth proximal cortex screw. The horse was immediately re-anaesthetised and the simple fracture was stabilised with a single LCP placed caudally. Nine months after the second surgery the horse was sound and the fracture appeared healed radiographically (Fig. 3). Three horses suffered from complications leading to euthanasia. Failure of internal fixation due to bending of the caudal plate during assisted recovery (without pool) occurred in case 1 with an open comminuted fracture. The fracture was then stabilised with two broad LCP. The horse developed implant infection and was euthanatized eight weeks later due to laminitis in the contralateral limb. Case 14 with an open comminuted fracture developed septic arthritis of the elbow after surgery. The joint was lavaged and the infection in the joint resolved. Nevertheless, the horse remained severely lame and was euthanatized 10 weeks after surgery due to septic osteitis at the fracture site. Case 13

**Surgical management**

All horses were treated by open reduction and internal fixation (2). One narrow LCP was applied as a tension band to the caudal aspect of the olecranon process in 15 cases (Fig. 2) as described previously (2). Two narrow LCP were used in two cases (Fig. 3), and two broad LCP (one caudal and the other lateral) were used in one case. In 17 cases a 4.5/5.0 mm LCP were used, and in one Shetland pony a 3.5 LCP was used. A combination of locking screws and conventional cortex screws were used in most of the repairs. The decision to use locking or standard screws in a particular hole was made by the surgeon and was based on the fracture configuration at the level of the screw hole and on the position of the plate caudal to the olecranon. The most frequent reason for inserting cortex screws was that they could be angled, which is not possible with locking screws. The cortex screws were placed prior to insertion of the locking

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**Fig. 3** Immediate postoperative lateromedial radiographic view of the repair of case 9, showing one single narrow 4.5/5.0 LCP applied to the caudal aspect of the olecranon and ulna and an other shorter such plate applied to the lateral aspect of the bone.

**Fig. 4** Refracture of the ulna due to a fall in the recovery room after plate removal in case 9. The new fracture line ran caudally through the initial fracture line and followed the hole of the fourth proximal cortex screw.
acquired a comminuted radius fracture 11 days after fixation of a simple open olecranon fracture. The fracture line of the radius ran through the screw of the 11th LCP hole (Fig. 6) which had been inserted in the lateral cortex of the radius (Fig. 7).

Discussion

The LCP system represents a relatively new internal fixation concept and allows the insertion of conventional cortex screws and locking head screws; the conventional cortex screws can be axially loaded to provide fracture compression, and the locking head screws have complementary threads on the screw head and plate hole which provide axial and angular stability (10, 15, 16, 18–20). Because the LCP functions as an internal fixator and does not have to be contoured perfectly to the bone surface the periosteum can be left in place, which facilitates blood supply to the bone (10, 11, 16, 18–20). Biomechanically, LCP constructs have a significantly longer survival time under cyclic loading than DCP constructs (12). However, little is known about the mechanical properties of LCP implants when a combination of locking and non-locking screws are used (19). In our patients, the choice of a cortex or locking screw was based on the fracture configuration at the level of the screw hole and on the position of the plate caudal to the olecranon: the most frequent reason for inserting cortex screws was that they could be angled, which was not possible with locking screws. A recent study showed that the addition of a single locking screw to a non-locking construct increases the torque to the offset failure point by 17%, and the authors of the study concluded that one locking screw is able to provide an angle-stable construct (19). Thus, we considered all our implants LCP constructs, independently from the number of locking screws used.

Locking compression plate osteosynthesis resulted in an excellent functional outcome in eight horses with olecranon fractures (50%), and another five horses (31.2%) returned to their intended use after resolution of their complications. The complications for these five horses were infection in two cases and persistent lameness in three. Infection is the most common complication after internal fixation, particularly in olecranon fractures (1, 4). Locking compression plate osteosynthesis provided sufficient mechanical stability to allow fracture healing in both cases and removal of the implant after resolution of the infection. However, this has also been reported after stable internal fixation using other implants like DCP, probably due to the limited weight bearing of the olecranon (3–6). Three horses were lame after healing of the fracture but had no signs of infection. Persistent pain in the region of the implants following fracture fixation is common in humans and one study reported an overall improvement in pain relief and function after implant removal (21). Similarly, we thought that the metallic implants could interfere with athletic function and thus cause the lameness. Therefore the plates were removed. The lameness resolved in two of the horses; however, the third one refractured the olecranon during recovery after removal of two plates. Refracture is the most significant complication after removal of all types of plates (22). A staged removal, in which only one plate is removed followed by the other at a later date after the bone has had time to remodel, may have reduced the risk of refracture and allowed the bone to heal completely. Usually plates on the ulna are not removed unless there is infection or if it is absolutely necessary because of the associated risks and expense (22).

Three horses incurred complications necessitating euthanasia. In two cases of implant infection, it was not possible to continue treatment because of laminitis in one and septic osteitis in the other, although the fractures appeared radiographically stable. The third horse suffered from a comminuted radial fracture 11 days after fixation of the olecranon fracture. The new fracture line ran through the hole of the 11th locking head screw, which had been inserted in the lateral cortex of the radius. In this case the distal plate was positioned too laterally, so that the distal locking.
screws could only be inserted into the lateral cortex of the radius, weakening the bone. The fact that the locking screws must be inserted perpendicular to the plate can be considered a disadvantage, especially in ulnar fractures (16). Proper anatomic placement of the plate on the caudal aspect of the ulna is of paramount importance, and even a wide or a narrow DCP implant can be challenging to place correctly. Proximally, the screws must avoid penetrating the concave medial cortex of the olecranon, whereas distally they should not be inserted in the lateral cortex of the radius (1, 4). Perhaps the use of an angled cortex screw or a short locking screw at this site would have prevented this catastrophic event.

In conclusion, internal fixation of olecranon fractures using a LCP construct was successful in 81.2% of our patients. This was comparable to the results of internal fixation using other implants like DCP, which had a successful outcome in adult and juvenile horses (3, 4, 6, 8). In our patients, the main complication was implant infection, which occurred in open as well as closed fractures. However, in all cases LCP osteosynthesis provided a stable fixation. A possible disadvantage of the system is that the locking head screws must be inserted in a fixed perpendicular angle through the plate; therefore a careful placement of the implant is critical for the prevention of complications. However, the ease of application of LCP makes the system desirable in challenging and complicated olecranon fractures, which carry a poorer prognosis (7). Further studies using a larger population are necessary to substantiate these findings.

References

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