Repair of thirty-six fractures in dogs using the Mennen clamp-on plate: preliminary results

W. T. McCartney1; C. B. Garvan2; K. Kiss1
1Marie Louise Veterinary Hospital, Baldoyle, Dublin, Ireland; 2Dublin Institute of Technology, Dublin, Ireland

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Summary
Objective: To report the use of a human fixation device, the Mennen clamp-on plate (MCOP), for fracture repair in dogs as the sole method of fixation, or in combination with another fixation method such as an intramedullary pin.

Methods: The study, which was performed to evaluate the use of the MCOP in fracture repair in dogs, included 36 cases that were selected between 2004 and 2008. The selected cases were all closed diaphyseal fractures, in which sufficient plate prongs could engage the bone on either side of the fracture.

Results: Of the 36 cases, 32 had excellent outcomes, and four had complications; these were two cases of fixation failure, one case of osteomyelitis, and one with mild sciatic nerve deficits.

Discussion: The MCOP is a promising method for fracture repair on its own for young puppies (six months or less), and in conjunction with other fixation methods in older dogs. It is quick to apply, as no screw holes are created and it achieved a successful outcome in 95% of the cases, provided the cases were appropriately selected for this method.

Conclusions: Using the MCOP has produced promising preliminary results in this study and warrants further evaluation.

Methods and materials
Case selection

A study was conducted between 2004 and 2008 to evaluate use of the MCOP in canine diaphyseal fracture repair, either as the sole form of fixation in dogs younger than six- to eight-months old, or in combination with other fixation devices such as an intramedullary pin in dogs older than six- to eight-months old, as well as in a group of miscellaneous fractures. Fracture configuration (Supplementary Table 1 - available online at http://www.VCOT-online.com) was classified as comminuted (C-1, C-2, C-3), oblique (O), transverse (T), and butterfly (B). The basic criteria used for selecting fracture cases for this method of repair were diaphyseal fractures that would permit the application of a sufficient number of MCOP prongs on either side of the fracture, and those with a bone diameter that matched the size of the MCOP. These basic criteria resulted in the elimination of a large number of cases from the study. Additional exclusion criteria were cases of gunshot or infected fractures, dogs over 50 kg bodyweight, polytrauma cases, cases not suitable for intramedullary pinning, chronic fractures, dogs over 10-years-old, and dogs with intercurrent illness. Cases that had any other problem that may have increased the incidence of complications were also excluded. Other standard techniques such as plating, interlocking nail and external fixation were employed in these cases. Initially, fractures of the tibia and radius were selected, but this selection was then halted due to con-

Introduction

Methods and instrumentation for diaphyseal fracture repair in dogs are diverse, and as long as the chosen method aims to satisfy the principles of fracture repair (1, 2), surgeon preference can be accommodated using pins, external skeletal fixation, interlocking nails and plates (3–9). More recent developments of fixation devices have expanded the options available and include such implants as the locking compression plate (10), clamp rod internal fixator (11), Perno system plate (12) and rod-through-plate (13). Mennen (14) reported the use of a clamp-on plate in 282 forearm fractures in man, and later for metacarpal fractures (15). Problems encountered with human fracture repair in dealing with osteoporotic bone and periprosthetic fractures of total hip replacement, or shoulder arthroplasty have been solved by using the Mennen clamp-on plate (MCOP) (16–21). However a review of cases revealed that the case types that were successful represented only a small subgroup (22). Difficulty with application of the plate, the exposure required, healing complications and implant failure were problems that were encountered with the MCOP (22, 23). A different type of clamp-on plate has been successfully used by Coetzee to repair canine tibial osteotomies (24), and diaphyseal fractures of the humerus, tibia, and femur in 21 dogs (25). However, that plate had a different shape and prong configuration; the MCOP has prongs along its whole length while the plate used by Coetzee did not have any prongs in the middle of the plate, directly near the fracture zone.
cerns over the placement of the MCOP on the bone. The specific criteria used to decide what fixation combination would be used divided the cases into three groups as follows:

In dogs younger than six- to eight-months-old, an MCOP was used alone, or in some cases a single cerclage wire was applied to aid reduction during the application of the MCOP.

In dogs older than six- to eight-months-old, an adjunctive fixation method such as an intramedullary pin, cerclage wiring, plate or external fixator was used in combination with the MCOP.

In the third group, the MCOP was used on its own for miscellaneous fractures such as periprosthetic femoral fractures and metacarpal fractures, irrespective of the age of the animal.

**Implants and instruments**

The MCOP is made from 316L stainless steel and is available in 15 sizes which differ in diameter, number of prongs, length, and whether there is tapering. The range of implants is divided into five main size sets of micro, mini, small, medium and large. The diameter of the prongs ranges from 7 mm in the micro set to 25 mm in the large taper, and the length ranges from 29 mm to 89 mm. The number of prongs per MCOP range from five to 11 per side. The taper effect is useful for fractures nearer to the metaphysis where there is a disparity between bone diameters. There are two instruments required to apply the MCOP and a distractor (Fig. 1).

**Surgical technique**

All dogs were given cephalexin (30mg/kg, IM) 30–40 minutes prior to surgery or cefuroxime (15mg/kg, IV) 10 minutes prior to surgery as well as meloxicam (0.2 mg/kg). The dogs were premedicated with 10 μg/kg medetomidine and butorphanol (0.2 mg/kg) or buprenorphine (20 μg/kg). Anaesthesia was induced and maintained with isoflurane.

Eighteen dogs had only a MCOP applied. In these dogs, the fracture fragments were reduced and the MCOP was slid over the bone and clamped in place ensuring that the fixation was secure. In some cases, additional fixation of one cerclage wire was used solely to aid reduction before MCOP application (Figures 2 and 3). The authors decided that it was not necessary to apply three prongs to either side of the fracture in small dogs younger than six- to eight-months-old, and that two prongs were sufficient. In the second group, eighteen dogs had a MCOP with additional fixation such as pin, external skeletal fixation, multiple cerclage wiring or plating of a neighbouring bone (Figures 4, 5, 6, and 7). Intramedullary fixation with a threaded Steinman pin was applied using the normograde technique. Temporary fixation of fragments with a small arthrodesis wire could be used before the MCOP was slid onto the bone and clamped in position. Once the plate had been clamped, the arthrodesis wire was removed. In the miscellaneous group the MCOP was slid onto the bone without the use of any wire and clamped in position.

The MCOP was then checked to ensure it was securely fixed to the bone by moving the leg, and by manipulation of the plate. Routine closure was performed.

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a CHMedical Ltd, Devon, UK  
b Ceporex: Schering Plough, Welwyn Garden City, UK  
c Zinacef: Glaxo, Dublin, Ireland  
d Metacam: Boerhinger, Ingelheim, Germany  
e Domitor: Pfizer, Ringaskiddy, Ireland  
f Torbugesic: Fort Dodge, Sligo, Ireland  
g Temgesic: Schering Plough, Welwyn Garden City, UK  
h Forane: Abbott laboratories, Sligo, Ireland
Postoperative management

All dogs were maintained on the analgesia protocol of butorphanol (0.25–0.3 mg/kg every three to six hours pro re nata) or buprenorphine (20 μg/kg every six hours pro re nata) for up to five to seven days with meloxicam (0.1 mg/kg every 24 hours) for four days postoperatively. Passive flexion and extension of nearby joints began on the fifth postoperative day. Postoperative re-evaluations occurred at one, two, three, and eight weeks. The last evaluation was performed after six months to one year by the original surgeon, except in the cases where plate removal was planned in young puppies. Postoperative radiographs were taken between eight and 12 weeks (except in young puppies) and at the last evaluation.

Outcome assessment

The outcome of the fracture treatment was assessed by the original surgeon in each case on the basis of clinical recovery and radiographic monitoring. The following criteria were used to judge outcome: excellent—no lameness or stiffness and return to normal function; unsatisfactory—abnormal limb use, lameness, or stiffness of any frequency or duration; and failure that required revision surgery. Fractures were deemed to be healed once there was bone union evident on the radiographs.

Results

Thirty-six dogs were treated using the MCOP, of which 22 cases were over 10 kg bodyweight. The predominant breeds were Collies, Labrador Retrievers and Terriers. The age range was from one month to nine years, with 20 dogs one-year-old or younger (Supplementary Table 1 - online). An intramedullary pin (n = 16), external skeletal fixation (N = 1), and plating of the ulna (N = 1) were used as additional fixation. In dogs less than six- to eight-months-old, the proportions were comminuted 22%, oblique 44%, transverse 28%, butterfly 6%. In dogs over six- to eight-months-old, the proportions were comminuted 61%, oblique 11%, transverse 22%, butterfly 6%. Healing times, as measured radiographically, ranged from three weeks in the youngest puppies to 12 weeks in the older dogs, with a mean of four weeks for dogs under six-months-old, six weeks for dogs between six- to 12-months-old, and nine weeks for those over one year of age. Postoperative clinical examinations of the limb were unremarkable, except that the MCOP could be palpated in some cases under the skin and muscle. Complications were found in 13 cases, of which nine were not considered serious, and consisted of pin loosening, pin tip seroma (5 out of 8 humeri), and plate loosening. Case two had plate loosening and had no adjunctive fixation, but still had an excellent outcome. Four cases had serious complications that adversely affected their outcome. The authors chose to remove the MCOP in young dogs if possible. In those cases that did not have the plate removed, there was bone in-growth and coverage of the MCOP around the prongs. In
the cases with fractured radius or tibia, the case selection was halted as it was felt that the MCOP do not grip the bone correctly due to the bone shape, and had a tendency to encircle the bone rather than grip it.

Of the 36 cases, 32 had excellent outcomes, two were unsatisfactory and two were failures. Case 18 had an unsatisfactory outcome as it had developed sciatic nerve deficits due to intramedullary pin migration and had a mild proprioceptive deficit at the last check-up. Case 34 had a low grade chronic discharge sinus consistent with osteomyelitis, however use of the limb was normal and the sinus cleared up after implant removal. Of the two cases that had failures, one case (case 22) fractured the MCOP one year later at a site distal to the original periprosthetic fracture, and in the other (case 16), the MCOP had slipped off the bone and was replaced with an interlocking nail. In case 16, the MCOP slipped off the distal femoral fragment, due to either insufficient width, grip, or length of the plate. The dog was at the upper limit of the specific criteria for using the MCOP on its own at 10kg in weight and eight-months-old, and had two prongs either side of the fracture.

Discussion

This case series study was initiated to investigate in part the use of the MCOP in combination with an intramedullary pin as an alternative to the standard plate and rod fixation (26). One of the difficulties with the plate rod technique is the drilling and tapping in preparation for the screw insertion adjacent to the pin. To avoid this difficulty the screws may have to be angled or changed to monocortical screws; there needs to be a minimum of three monocortical and one bicortical either side of the fracture (27). Another difficulty is the damage to drills and taps through contact with the pin during insertion, and the possibility of damage to the soft tissues by the drill or tap. There may also be significant damage to the bone by drilling and tapping, although its clinical relevance is unknown. Applying the plate rod principle using the MCOP instead of a plate and an intramedullary pin allows for a greater pin diameter if needed, increasing the overall stiffness and avoiding problems associated with screw insertion. All of the dogs over six- to eight-months-old had additional fixation, such as an intramedullary pin, except case 6 and 22. The initial results of this small case study provide support that the MCOP can be used with an intramedullary pin successfully as an alternative to the standard plate rod fixation. These findings are in agreement with the findings in a previous report on canine fracture repair using a different type of clamp-on plate (25).

The use of an MCOP as the primary and sole form of fixation in puppies was in contrast to the technique used by Coetzee (25), where all cases had an intramedullary pin inserted, and only transverse or oblique fractures were repaired using a different type of clamp-on plate. In our study, 28% of the dogs aged six- to eight-months-old or younger had comminuted fractures. Treatment of these fractures is complicated by the presence of growth plates and thin cortices. Intramedullary pinning of femoral fractures was previously reported to be unsatisfactory (28) as growth plate damage and pin loosening were complications. Standard plating was also unsatisfactory due to screw pull-out (29). Use of an intramedullary pin with tie-in external skeletal fixation can be successfully used in humeral and femoral fractures of puppies, but there were complications associated with the distal pin of the external skeletal fixator (30). External skeletal fixation of fractures of the tibia, radius and ulna in puppies is an accepted treatment method, and there is no reason to indicate that the MCOP has any advantages (31). Elastic plate osteosynthesis
avoids excess strain on the screws by increasing the elasticity of the plate, and has been successfully used to treat long-bone fractures in puppies (32, 33); with good callus formation the bones healed quickly because of micro-movement (34). The MCOP successfully treated 17 out of 18 of these fractures, and in the authors’ opinion, provides a very useful technique for femoral and humeral fracture repair in young puppies. Also, in comparison to elastic plate osteosynthesis, the MCOP requires a smaller exposure as it is not applied across as much of the diaphysis, is quicker to apply, and is less traumatic to bone (no drilling).

The complications encountered in this case series were mostly minor and did not affect the outcome. Seroma of the tip of the pin occurred in five out of eight cases of fractured humerus. Migration of the pin occurred in one case which led to sciatic nerve damage; this is a recognised complication of intramedullary pin insertion. Pin loosening at the time of pin removal was recognised in three cases. Pin loosening and migration may be avoided by altering the pin size, and by cutting the pin below the level of the greater trochanter. The failure of the MCOP in case 16 may have been because the length or width of the MCOP was too short to resist the distal femur movement. As the femur was relatively thin and long, the plate chosen to match the width and length of the bone was not correct. The authors did not apply the manufacturer’s recommendation of having a minimum of three prongs either side of the fracture in small (less than 10kg) puppies as it was felt unnecessary. The other case of plate failure was case 22, and one can only assume that there had been repetitive loading damage to the plate leading to metal fatigue. The experience in repair of periprosthetic femoral fractures in man using the Mennen clamp-on plate has not been altogether satisfactory with implant failure being one of the problems (18).

Bone healing when using the MCOP either on its own, or with additional fixation, is by callus formation (14). The healing times observed in our study were consistent with the healing times seen with cases treated by other methods of fracture stabilisation (31). As the MCOP does not lie flush with the bone surface there is less disruption to bone blood supply, as the MCOP only contacts the bone at the grip points of the prongs on each side (Fig. 8). The ideal or required size of intramedullary pin in combination with a MCOP is not known, and along with the effect of the MCOP on the blood supply to the bone, these would be areas of recommended further study.

As there is no drilling or tapping required to apply the MCOP, we assume that the MCOP technique is less traumatic to the bone than plate screw fixation and avoids screw-hole stress risers. The MCOP does not lie flush against the bone like a standard plate, so there is minimum contact with bone, hence preserving the periosteum and blood supply. However the difference between the damage to the bone blood supply between the plate rod technique and the MCOP rod technique would need further investigation. Other potential advantages of the MCOP are that it requires simple instrumentation to apply, has the option to place bone graft under the plate, and its application has possibly a reduced operating time, although this was not measured in this study. The authors experience in this case study indicate that the MCOP is a choice for mid-diaphyseal fractures in dogs under six- to eight-months-old as the sole method of fixation, and in dogs over six to eight-months-old, the MCOP could be used to treat diaphyseal fractures of the humerus and femur in combination with an intramedullary pin. The fracture configurations particularly suited to the use of the MCOP are oblique and comminuted fractures with large fragments. This case series study has several significant limitations regarding the possible conclusions, and can therefore only be classified as a preliminary study. The limitations in this study were small case numbers, observer bias with no independent evaluation of cases or radiographic outcome, no randomised comparisons and insufficient conclusions on why two cases failed. The selection process in this case series may in itself have introduced some bias to the results. Only through a proper prospective study using controls and comparative studies with independent outcome evaluation could the full potential of the MCOP be evaluated.

In conclusion the results of this preliminary small case series indicate good potential for MCOP as a fracture fixation device in dogs.

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References


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