EQUINE VETERINARY EDUCATION
Equine vet. Educ. (2009) **21** (7) 352-357
doi: 10.2746/095777309X431294

Satellite Article

Fracture repair techniques for the equine mandible and maxilla

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Summary

The purpose of this article is to review the principles of fracture repair for the rostral mandible and maxilla and to demonstrate a variety of repair techniques. Because each fracture is unique, knowledge of the different repair techniques will allow the practitioner to choose a repair method best suited to the fracture configuration, equipment available, and the skill level and preferences of the surgeon.

Introduction

Fractures of the mandible and maxilla are common in horses (Henninger *et al.* 1999). The fractures vary in cause, location, configuration, degree of comminution and involvement of other structures. This article accompanies a Case Report describing the repair of an incisive bone fracture using an intraoral splint (Iacopetti *et al.* 2009). The repair method chosen in this horse was an excellent match for the fracture configuration; however, there are other methods that would have yielded equally satisfactory results.

Preoperative considerations

Fractures of the mandible and maxilla usually occur from blunt trauma such as a kick, or as an avulsion fracture that results when a horse is startled and pulls back abruptly while chewing on a fixed object (Henninger *et al.* 1999). The cause is usually apparent and important only in that recognition of the cause may give some insight into the repair method required. For example, avulsion injuries usually involve the incisors and a variable amount of the incisive bone and often may be successfully repaired with tension band wiring as the sole means of fixation (**Fig 1**). Fractures resulting from kicks may cause bone comminution resulting in a repair that will collapse with tension band wiring alone (**Fig 2**). In these cases some form of buttress is required to support the repair. Physical examination should be used to determine the fracture alignment, interdigitation of the fracture fragments and stability of the reconstruction. The horses are usually painful and resist efforts to perform a thorough examination of the fracture until they are anaesthetised. The surgeon should have a general idea of the method of repair based on knowledge of how the fracture occurred, radiographs, physical examination and available equipment. A decision on the repair method may not be finalised until a thorough examination can be performed under anaesthesia.

***Fig 1:** A transverse fracture through the mandibular symphysis resulting from an avulsion type injury.*

Interdental wiring of the incisors may be performed in the standing patient with sedation and a local anaesthetic deposited around either the mental or infraorbital nerves. More complicated repairs are best accomplished with the patient in dorsal recumbency with the poll flexed to provide good access to the oral cavity (Beard 1999). Nasotracheal intubation will improve visualisation and will be out of the surgeon's way. A properly inflated cuff is necessary to protect the trachea from accumulated blood in a horse thus positioned.

Fracture biomechanics and intraoperative considerations

The tension surface for both the mandible and maxilla is on the oral surface. Implants positioned on the tension surface will be at a biomechanical advantage by being loaded in tension. The biomechanical properties for several repair methods have been evaluated in an *in vitro*

Fig 2: Fracture of the premaxilla resulting from a kick. Note that the incisors are displaced caudally and will collapse further with wiring alone.

model of a bilateral fracture of the mandibles in the interdental space (Peavey *et al.* 2003). This study confirmed that dynamic compression plating was the most rigid repair and that intraoral wiring significantly increased the strength and rigidity of intraoral splints and external skeletal fixators. Although results of this study are informative, it should not follow that the strongest repair is always the best in the clinical patient. A bilateral transverse osteotomy model does not necessarily reflect the typical fracture seen in clinical practice. Open reduction and internal fixation require more surgical exposure along with the complications of sepsis and the likely need for implant removal. Also, all of the repair techniques described by Peavey *et al.* (2003) have been used successfully either alone or in combination.

Fractures communicate with the bacterial laden oral cavity and open surgical approaches will almost inevitably become infected. Therefore, minimal dissection is preferred and implants should be placed through stab incisions when appropriate. Open exposure of the fracture is not required to ensure reduction because the accuracy of reduction can be ascertained by the alignment of the teeth. Skull fractures may enter the alveolus and tooth roots may be fractured. In spite of tooth exposure and root fracture, tooth removal is seldom necessary. The practitioner is cautioned against attempting to remove any teeth other than those that are almost completely detached. Removal of a cheek tooth by extraction or via repulsion with a dental punch and mallet is very traumatic to an intact mandible and attempts to remove a tooth in a fractured mandible are likely to result in severe fragmentation of the mandible or maxilla. Devitalised teeth may be removed at a subsequent surgery if indicated by clinical and radiographic signs.

A variety of factors work in the surgeon's favour with these fractures. The bones have a well vascularised soft tissue covering. Unilateral fractures of the mandible are supported by the opposite mandible and the fractures are not subjected to nearly the same forces as weightbearing fractures of the extremities. The goals of repair are alignment and stability and the simplest fixation method that achieves these goals will probably be successful. For any fracture configuration, there will be several treatment options or combinations thereof that will be satisfactory. Choosing between the various procedures is based on the individual fracture configuration, availability of materials, cost of implants, familiarity of the surgeon with the instrumentation, and personal preference.

Repair techniques

Fractures of the incisors, incisive bone and mandibular symphysis

The following are depictions of common configurations of fractures involving the mandible and maxilla with suggestions for possible repair methods. For each type of fracture there are many available options and techniques can be easily combined or modified as necessary to achieve the goals of alignment and stability. There are no precise anatomical landmarks for implant attachment because there is no standard fracture configuration. The surgeon should be able to deduce by visual examination and manual manipulation the forces that a particular fracture will be subjected to and strategically place implants to neutralise those forces. The reader will be referred elsewhere for specifics of the surgical procedures, details of case management, success rates and complications.

Avulsion fractures of the incisors are easily amenable to repair by tension band wiring alone in the standing or anaesthetised patient (**Fig 3**). The incisors are manually reduced and one or two 14 gauge wires are passed through 14 gauge needles inserted between the teeth at the level of the gingiva to affix unstable teeth to the stable incisors (**Figs 4** and **5**) (Beard 1999). Fractures that involve a larger portion of the incisive bone or mandibular symphysis may have wires anchored more caudally in these bones by drilling with either a pneumatic drill or a Steinmann pin for insertion of wires (**Fig 6**). Another simple method of anchoring wires

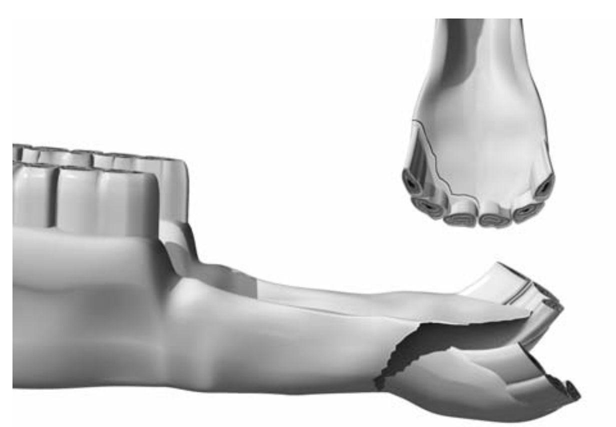

Fig 3: A typical configuration for an avulsion fracture of the mandible involving the central, intermediate and corner incisors.

caudal to the incisors is to anchor the wires to the canine teeth in horses in which they are present (**Fig 7**) (Beard 1999).

Oblique fractures of the mandibular symphysis are uncommon however, lag screw fixation is a simple method of repair (**Fig 8**) (DeBowes *et al.* 1981). This fracture would also be amenable to the interdental wiring techniques depicted in **Figure 5**. Wiring diagonally from the incisors in the fracture fragment to the opposite side of the symphysis or canine tooth, if present, would provide additional stability. This type of fracture would also be an excellent candidate for an intraoral splint made of polymethylmethacrylate (PMMA) (Colahan and Pascoe 1983; Dart and Pascoe 1987; Peavey *et al.* 2003; Iacopetti *et al.* 2009) (**Fig 9**). The PMMA splint is fixed to the mandible with cerclage wires after appropriate fitting and drilling and may be combined with tension band wiring as circumstances dictate.

Unilateral fractures of the horizontal ramus

Various options are available for repair of unilateral fractures of the horizontal ramus of the mandible. Transverse or short oblique fractures are the most common configurations. The fracture ends usually interdigitate well without the tendency to override when compressed; however, this is easily verified by manual manipulation of the fracture (**Fig 10**). The simplest method of repair is to compress the fracture with

Fig 4: A 14 gauge needle inserted between the central incisors for passing cerclage wire between the incisors.

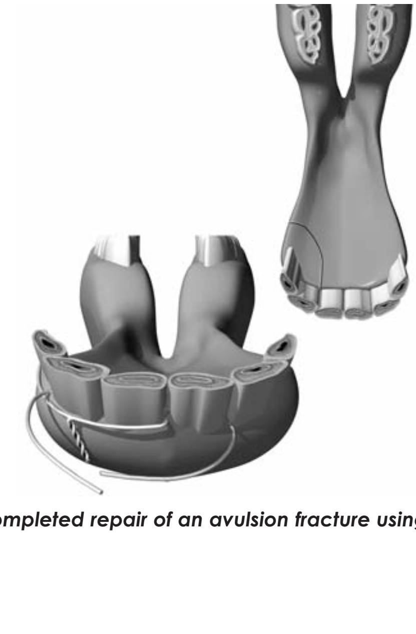

Fig 5: A completed repair of an avulsion fracture using 2 cerclage wires.

Fig 6: Drilling through the mandibular symphysis with a Jacob's chuck and Steinmann pin to anchor wires or an intraoral splint caudal to the incisors.

Fig 7: Cerclage wiring from the corner incisor to the canine tooth. The canine tooth must have a notch cut into it to prevent the wire from slipping.

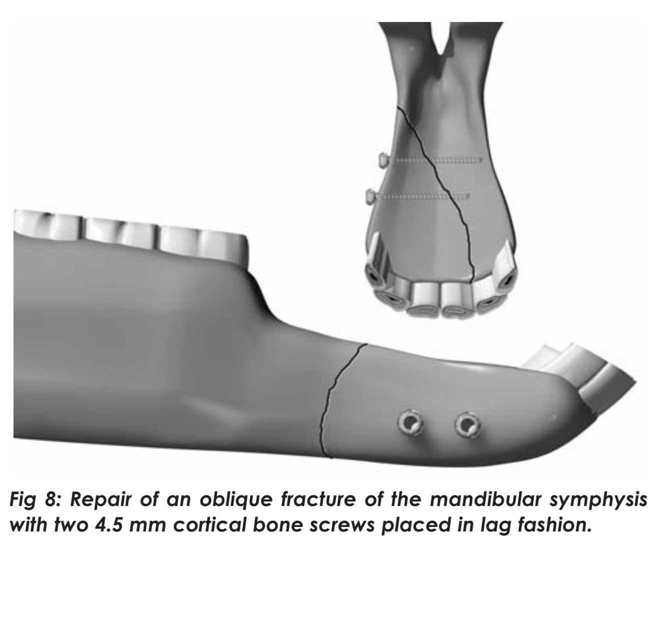

Fig 8: Repair of an oblique fracture of the mandibular symphysis with two 4.5 mm cortical bone screws placed in lag fashion.

tension band wiring from the incisors to the cheek teeth (Beard 1999; Auer 2000) (**Fig 11**). Added stability is provided by fixation on the ventral or dorsal cortex of the mandible when necessary (Beard 1999; Auer 2000). This would be indicated when the fracture is comminuted or physical manipulation reveals that the fracture ends do not interdigitate well when compressed. This is easily accomplished through a small incision on the ventral cortex of the mandible and figure 8 wiring across the fracture. The wires may be anchored by cortical screws placed in the mandible (**Fig 12**) or by simple cerclage wiring of the fracture ends through drill holes in the mandible (**Fig 13**). Long oblique fractures of the horizontal ramus of the mandible may be stabilised by cerclage or hemicerclage wiring, Steinmann pins, or lag screw fixation to compress the fracture fragments and prevent sliding of the fracture fragments (Beard 1999; Auer 2000). The success of these methods relies on support from the intact mandible and a fracture configuration that is stable when reduced.

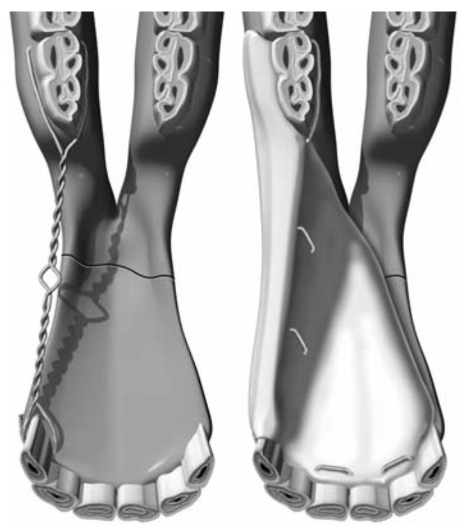

Fig 9: Tension band wiring accompanying an acrylic intraoral splint for repair of a fractured mandibular symphysis.

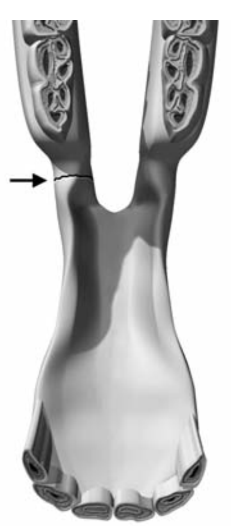

Fig 10: A unilateral fracture of the horizontal ramus of the mandible.

Bilateral fractures of the mandible or premaxilla

Bilateral fractures of the horizontal ramus are highly unstable and are accompanied by a variable amount of comminution (**Figs 14** and **15**). There is a tendency for these fractures to collapse or override when tension wiring

Fig 11: Tension band wiring from the corner incisor to premolar 2.

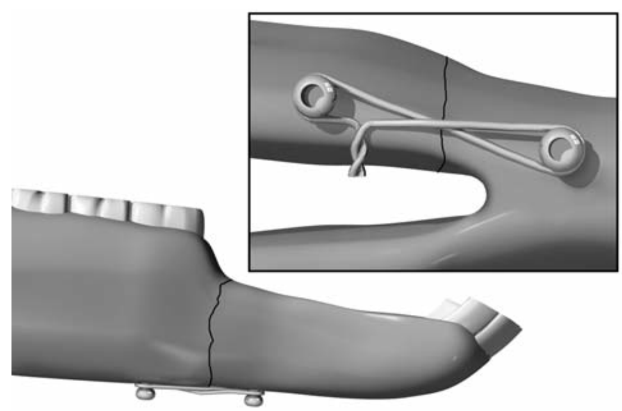

Fig 12: Figure 8 wiring across a fracture of the horizontal ramus of the mandible. Wires are held under the heads of 4.5 mm cortical bone screws.

Fig 13: A transverse fracture of the horizontal ramus of the mandible rostral to premolar 2 repaired by intraoral tension band wiring to the cheek teeth. Cerclage wiring across the fracture on the ventral cortex provides extra stability. The cerclage wire is threaded through 3.2 mm drill holes in the mandible.

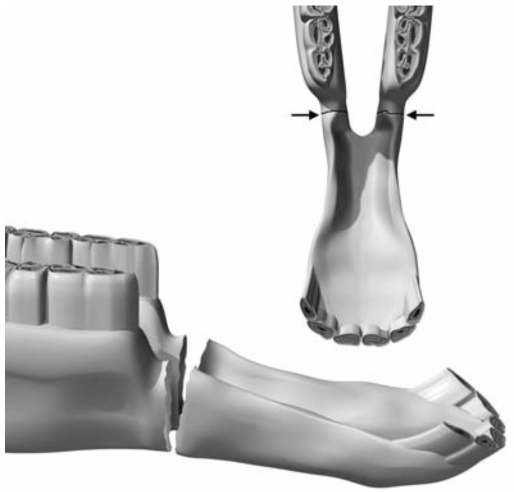

***Fig 14:** A ventrally displaced bilateral fracture of the mandibles.*

***Fig 15:** Ventrally displaced, highly unstable bilateral fracture of the horizontal ramus of the mandible.*

***Fig 16:** A properly fitted U-Bar fixation.*

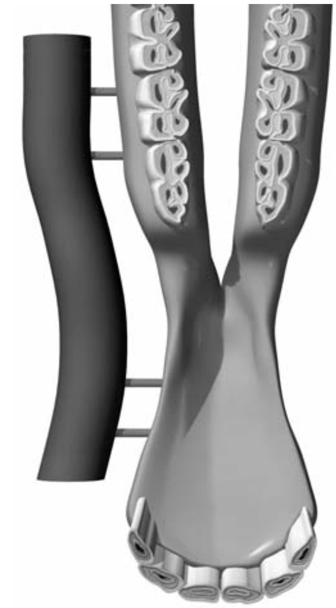

***Fig 17:** A* **Type I** *external skeletal fixators with an acrylic side bar.*

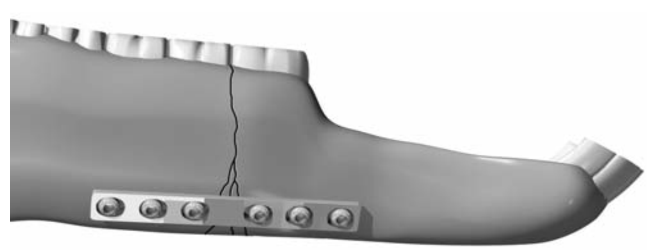

***Fig 18:** A transverse fracture of the horizontal ramus of the mandible repaired with a 6-hole dynamic compression plate.*

alone is used and this can be easily verified by manual manipulation of the fracture during anaesthesia. One solution that requires very little in the way of instrumentation is a U-Bar repair (Gabel 1969; Beard 1999) (**Fig 16**). This technique is conceptually simple but requires some practice to accomplish with efficiency. External skeletal fixators (ESF) are another repair technique that should be considered and may be combined with tension band wiring, intraoral splints and bone plating (Auer 2000; Belsito and Fischer 2001; Peavey *et al.* 2003) (**Fig 17**). ESF configurations that should be considered in the treatment of mandible fractures are *Type II*, bilateral *Type I*, and biplanar *Type I* fixators. Acrylic side bars are commonly used for these repairs in horses. Side bars have also been fashioned from a variety of readily commercially available 2-part epoxy putties (Roe and Keo 1997). Dynamic compression plating is a very stable method of repair that can be used alone or in combination with other methods (Auer 2000; Kuemmerle *et al.* 2009) (**Fig 18**). This method requires the most expensive instrumentation and requires more expertise although there are fractures for which plating would be the most appropriate choice.

Conclusions

There are many techniques as well as endless variations of those techniques for repair of fractures of the maxilla and mandible. Each repair method described here has been presented as a stand alone technique though they should not be considered as such. Tension band wiring, intraoral splints, external skeletal fixators and compression plating may be combined as circumstances dictate. It is easy to imagine a bilateral fracture in which dynamic compression plating is the preferred repair method for one mandible yet a bone defect in the contralateral mandible may make an ESF a better option for that side. Surgeons have a variety of techniques at their disposal to combine as necessary to achieve the goals of alignment and stability. Familiarity with a wide range of techniques gives the surgeon the ability to match the repair to each individual fracture.

References

Auer, J. (2000) Mandible, maxilla, and skull. In: *AO Principles of Equine Osteosynthesis*, Eds: G. Fackelman, J. Auer and D. Numamaker, Thieme, Stuttgart.

Beard, W. (1999) The skull, maxilla, and mandible. In: *Equine Surgery*, 2nd edn., Eds: J. Auer and J. Stick, W.B. Saunders, Philadelphia. pp 887-899.

Belsito, K. and Fischer, A. (2001) External skeletal fixation in the management of equine mandibular fractures: 16 cases (1988-1998). *Equine vet. J.* **33**, 176-183.

Colahan, P.T. and Pascoe, J.R. (1983) Stabilization of equine and bovine mandibular and maxillary fractures, using an acrylic splint. *J. Am. vet. med. Ass.* **182**, 1117-1119.

Dart, A.J. and Pascoe, R.R. (1987) Treatment of a bilateral mandibular fracture in a mare using an intraoral acrylic splint. *Aust. vet. J.* **64**, 382-384.

DeBowes, R.M., Cannon, J.H., Grant, B.D., Nickels, F.A. and Wagner, P.C. (1981) Lag screw fixation of rostral mandibular fractures in the horse. *Vet. Surg.* **10**, 153-158.

Gabel, A.A. (1969) A method of surgical repair of the fractured mandible in the horse. *J. Am. vet. med. Ass.* **155**, 1831-1834.

Henninger, R., Beard, W., Schneider, R., Bramlage, L. and Burkhardt, H. (1999) Fractures of the rostral portion of the mandible and maxilla in horses: 89 cases (1979-1997). *J. Am. vet. med. Ass.* **214**, 1648-1652.

Iacopetti, I., de Benedictis, G., Faughnan, M., Perazzi, A. and Busetto, R. (2009) Treatment of incisive bone fracture in a horse using an acrylic splint. *Equine vet. Educ.* **21**, 346-351.

Kuemmerle, J., Kummer, M., Auer, J., Nitzl, D. and Furst, A. (2009) Locking compression plate osteosynthesis of complicated mandibular fractures in six horses. *Vet. Comp. orthop. Traumatol.* **22**, 54-58.

Peavey, C., Edwards, R.I., Escarega, A., Vanderby, R.J. and Markel, M. (2003) Fixation technique influences the monotonic properties of equine mandibular fracture constructs. *Vet. Surg.* **32**, 350-358.

Roe, S. and Keo, T. (1997) Epoxy putty free-form external skeletal fixators. *Vet. Surg.* **26**, 472-477.