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Long-Term Results of Bovine Mandibular Fractures Involving the Molar Teeth

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Objective—To evaluate postoperative complications and long-term outcome of simple mandibular fractures involving the molar teeth in cattle.
Animal Population—Seventeen cattle with mandibular fractures involving the molar teeth with disruption of the occlusal surface.
Methods—Treatment consisted of application of AO/ASIF-Pinless External Fixators (Synthes, Paoli, PA) in 14 cows, interdental wire stabilization in 1 cow, and conservative treatment in 2 cows. Long-term outcome was determined by telephone contact with the owners, and whenever possible, cows were reevaluated by physical, intraoral, and radiographic examination of the fracture site.
Results—Loosening of the fixation device (4 cattle) and bone sequestration (11 cattle) were the most commonly encountered complications. Oral incontinence during rumination was a minor complication in 1 cow. The mean (± SD) time the cattle were in production was 26 (± 14) months, with 10 cows still alive at follow-up examination; 9 cows were reevaluated. On intraoral examination there was a step in the occlusal surface at the level of the healed fracture site in 3 cows, wave and shear mouth formation in 3 cows, and enamel point formation in 1 cow. Radiographically, all the reevaluated fractures had healed, and there were no signs of tooth root infection.
Conclusions—Complications during healing were bone sequestration and loosening of the fixator. None of the cows was removed from production because of fracture-associated complications, but decreased milk yield occurred in 2 cows. Tooth abnormalities developed in 6 cows, but function of the mandible was not altered.
Clinical Relevance—Mandible fractures involving the molar teeth carry a good prognosis for return to normal function. Radiographic follow-up is necessary to detect bone sequestration.

TREATMENT OF mandibular fractures involving the molar teeth is challenging because outcome depends on stable bony union and functional integrity of the molar occlusal surface. Various techniques have been described for treatment of mandibular fractures involving the molar teeth[1-3]; however, suboptimal alignment of the molar teeth is common and results in an uneven occlusal surface.[4-6] Malocclusion may lead to dental abnormalities such as enamel points and wave and shear mouth formation, resulting in discomfort and dysfunction.[7] The purpose of the study reported here was to evaluate complications occurring during healing of bovine mandibular fractures involving the molar teeth and to assess long-term outcome and occlusal conformation.

MATERIALS AND METHODS

Medical records of 42 cattle with mandibular fractures examined at the Veterinary Teaching Hospitals of the

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Universities of Zurich and Bern between 1993 and 1998 were reviewed. Mandibular fracture types were categorized by 6 anatomic regions: symphysis, incisors, diastema, occlusal surface, vertical ramus, and temporomandibular joint.[5] Fracture types were subclassified as (1) simple, (2) presence of a reducible fragment, and (3) presence of multiple fragments. Only cattle with fractures involving the molar teeth were selected for further study. Depending on fracture stability, cattle were treated conservatively or by application of an AO/ASIF-Pinless External Fixator (PEF; Synthes, Paoli, PA). One cow was treated by an intraoral wire technique. All cattle were administered antibiotics during initial healing. To reduce jaw movement and to prevent food from penetrating the fracture site, feed was withheld for 1 to 2 days after fracture stabilization. If there was persistent inappetence, transfaunation and gastric administration of linseed and grass pellets were used during the initial 2 weeks after repair.

Long-term outcome (more than 6 months after treatment) was determined by telephone questionnaire and, when possible, by patient examination. Outcome after healing was based on milk yield, feeding habits, and problems associated with the mandible or molar teeth. For slaughtered cows, the time from hospital admission to slaughter, as well as the reason for slaughter, were recorded. Clinical follow-up included physical examination and external and intraoral examination of the mandible. Information recorded included nutritional status, swelling or skin lesions at the fracture site, and tooth irregularities (missing or loose teeth, enamel points, and irregularities of the occlusal surface including steps, shear, and wave mouth formation). Radiographic examination was based on a ventromedial to dorsolateral oblique projection of the mandible. Fracture healing, bone conformation, and tooth root morphology were evaluated for signs of infection, abscess formation, and other abnormalities. Numerical results were reported as median and range or mean ± standard deviation as appropriate for the data.

RESULTS

Of the 42 cattle with mandibular fractures, 9 had fractures of 2 or more anatomic regions, whereas 33 had only 1 region affected. Of these, 6 cows had fractured the symphyseal region, 2 through the incisors, 5 through the diastema, 18 through the molar region with disruption of the occlusal surface, 2 through the vertical ramus, and none involving the temporomandibular joint. One animal with molar involvement was slaughtered immediately after the diagnosis whereas 17 were treated conservatively or surgically (Table 1).

Breeds of the 17 were Brown Swiss (14), Red Holstein (2), and Eringer (1). The median age at admission was 30 months (range, 0.3 to 96 months). There were 2 males and 15 females. The most common cause of mandibular fracture was an accident at pasture. All animals were anorectic at admission except for cow 8, which was admitted 21 days after the fracture occurred. The mean fracture duration was 4.5 days (range, 1 to 21 days). All fractures were open to the oral cavity except animals 8 and 9 in which the gingival mucosa had healed. These fractures were 21 and 10 days old, respectively, and required no fixation because they were stable and callus formation was noted on radiographs. Skin perforation at the fracture site occurred in cow 7. Fractures were classified as simple transverse to oblique (12 animals), with an additional bone fragment visible in 5 cows.

Treatment consisted of application of a PEF in 14 cows, interdental wire stabilization in 1 cow, and conservative treatment in 2 cows. Three bone clamps on a single connecting bar were used for fixation in 2 cows (cows 3, 14), whereas at least 4 clamps on a single connecting bar were used in the other 12 animals. One fracture was repaired by an interdental wire technique (cow 1). Orthopedic wire was passed through a hole drilled into the 4th premolar tooth caudal to the fracture site and anchored around the premolar teeth cranial to the fracture site and to the incisors. Both techniques used in the cattle in this report have been described previously.[3,9] Antibiotics were administered for 8 ± 3 days. Four cattle had persisting inappetence after fracture stabilization and were transfaunated (3 to 7 times during the first 2 weeks) with normal ruminal contents combined with linseed and grass pellets. The appetite of the remaining 13 cows gradually improved. Mean hospitalization was 20 ± 14 days.

Loosening of the fixator clamps occurred during the first week after surgery in 4 cattle (animals 3, 14-16); clamps were retightened after sedation. Immediately after hospital discharge 14 days after surgery, cow 11 removed the fixation device, which was replaced under general anesthesia. No problems related to the fixation devices occurred in the other cattle.

The PEF was removed between 4 and 6 weeks (mean, 5 weeks) after initial stabilization. Masticatory difficulty occurred in 11 cattle including all 5 cattle with a bony fragment evident on initial radiographs. Radiographs showed bone sequestration in 11 cattle (Fig 1); sequestra were removed surgically between 5 and 8 weeks (mean, 6.6 weeks) after initial stabiliza-

Table 1. Signalment, Fracture Description, Treatment, Outcome, and Complications of 17 Bovine Mandible Fractures Involving Molar Teeth

No.	Breed	Age (mo)	Fracture Type	Open/ Closed	Fracture Age (d)	Fixation	Outcome	Follow-up Time (mo)	Complications During Healing	Complications After Healing	Milk Yield	Mandibular Examination	Intraoral Examination
1	BS	48	Simple	O, M	3	IOW	Alive	55	Sequestrum	None	G	Normal	Wave, shear
2	BS	24	Simple	O, M	1	PEF	Alive	41	Sequestrum	Asymmetry	G	Bony swelling	Normal
3	BS	30	Fragment	O, M	—	PEF	Alive	40	Sequestrum PEF loose	Slight swelling	P	2-cm × 3-cm nodule	PM3 missing
4	BS	30	Simple	O, M	1	PEF	Alive	39	Sequestrum	Oral incontinence	G	Normal	Wave, shear
5	Eringer	7	Simple	O, M	4	PEF	Alive	37	None	Slight swelling	G	Normal	Step
6	BS	60	Simple	O, M	7	PEF	Slaughtered (fertility)	30	Sequestrum Tooth extraction	None	G	ND	ND
7	BS	19	Simple	O, S	2	PEF	Slaughtered (milk yield)	30	Sequestrum Tooth extraction	None	P	ND	ND
8	BS	7	Fragment	C	21	None	Alive	29	None	Skin fold	G	Skin fold	Step, wave, shear, enamel points
9	BS	0.3	Simple	C	10	None	Slaughtered (meat)	24	None	None	Male	ND	ND
10	BS	96	Simple	O, M	3	PEF	Mastitis	24	None	None	G	ND	ND
11	RH	78	Simple	O, M	1	PEF	Alive	23	Sequestrum PEF pulled out	None	D	ND	ND
12	BS	30	Fragment	O, M	1	PEF	Alive	13	Sequestrum	Asymmetry	G	Normal	Step
13	BS	30	Fragment	O, M	7	PEF	Alive	13	Sequestrum	None	D	Multiple nodules	Normal
14	BS	12	Simple	O, M	2	PEF	Sold	12	Sequestrum PEF loose	Slight swelling	G	ND	ND
15	BS	12	Fragment	O, M	2	PEF	Slaughtered (claws)	12	Sequestrum	None	G	ND	ND
16	BS	18	Simple	O, M	5	PEF	Slaughtered (fertility)	7	PEF loose PEF loose	Slight swelling	Male	ND	ND
17	RH	30	Simple	O, M	5	PEF	Alive	6	None	None	G	Multiple nodules, bony swelling	Normal

Abbreviations: BS, Brown Swiss; RH, Red Holstein; O, open; M, mucosal perforation; S, skin perforation; C, closed; IOW, Intraoral wire technique; G, good; P, poor; D, dry; ND, not done.

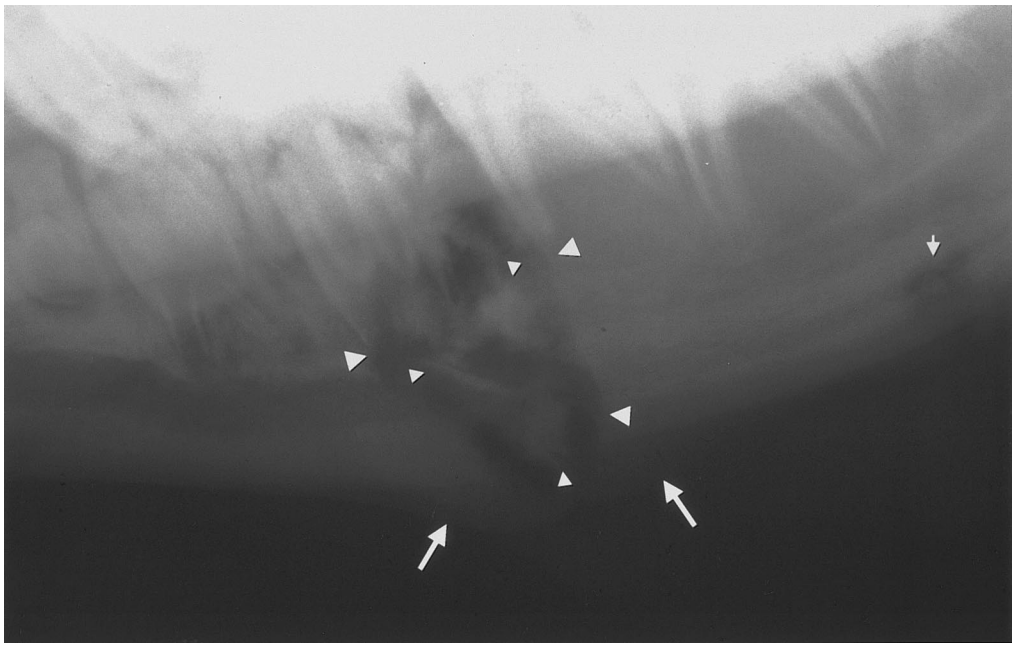

Fig. 1. Mediolateral oblique radiograph of the mandible of cow 15 at 7 weeks after injury, immediately after PEF removal. Note the bony sequestrum (small arrowheads) surrounded by an involucrum (large arrowheads) at the previous fracture site. Callus formation is evident on the ventral aspect of the mandible (large arrows). A radiolucent zone marks the insertion location of 1 PEF clamp (small arrow).

tion. Tooth root fragments were removed in 3 cows. In cow 3, the third premolar was removed completely because of looseness. Cow 1 had sequestrum removal 7 weeks after stabilization, and the interdental wire was removed at 5 months. Clinical improvement was seen in all cows after sequestrum removal. No mastication problems occurred in the other 6 cattle.

After injury, the 17 cattle remained in production for 26 ± 14 months; 10 cattle were still alive at the time of this study. According to the owners, 6 cows were slaughtered for reasons unrelated to the mandibular fracture; 1 male was slaughtered at the end of fattening (cow 9) and 5 females were slaughtered because of decreased fertility (cows 6, 16), mastitis (cow 10), inadequate milk yield (cow 7), and claw problems (cow 15). These 6 cattle had been in production for 21 ± 10 months. One cow was sold in good condition 12 months after the fracture had healed and was lost to further follow-up. Cow 1 was slaughtered because of decreased fertility at an age of 8.5 years after follow-up examination of the oral cavity (Fig 2, 3).

No long-term treatment for tooth problems was necessary. No change in feeding habit was observed in 16 cattle. Oral incontinence was noted during rumination in cow 4. Milk yield was considered adequate in 10 of 15 females at follow-up; 3 cows were dry because of advanced pregnancy. A drop in milk yield was noted in cow 3 immediately after the fracture occurred. The expected level of production was not regained and was mostly attributed to the mandibular fracture, but the cow remained in production. Milk yield in cow 7 was also less than anticipated, but there was no previous lactation to compare with; this cow was slaughtered 30 months after injury.

Of the 10 cattle alive at follow-up, cow 11, which was 8 months pregnant, was unavailable for examination because the owner was concerned about the risk of abortion from transportation. The other 9 cattle were reexamined and found healthy and well nourished. Small subcutaneous nodules corresponding to the position of the PEF clamps were noted along the ventrolateral margin of the mandible in 3 cows. A skin fold marked the fracture site at the ventral margin of the mandible in cow 8. On intraoral examination, a palpable step in the occlusal surface at the level of the previous fracture site was noted in 3 cows (cows 5, 8, 12), with the rostral teeth being lower than the caudal teeth. Wave mouth and shear mouth formation with sloping of the surface accentuated on the fracture side was seen in 3 cattle (cows 1, 4, 8). In cow 8, enamel points were noted on the labial side of the upper molar teeth and were removed by a tooth rasp with the animal sedated. Cow 3 was missing the third lower premolar. Gingival and buccal mucosa were intact in all cattle including the cow with enamel points. Maxillary and mandibular occlusal surfaces opposite the fractured side were normal in all cattle. Normal conformation of the occlusal surface on the fractured side was seen in only 3 cattle.

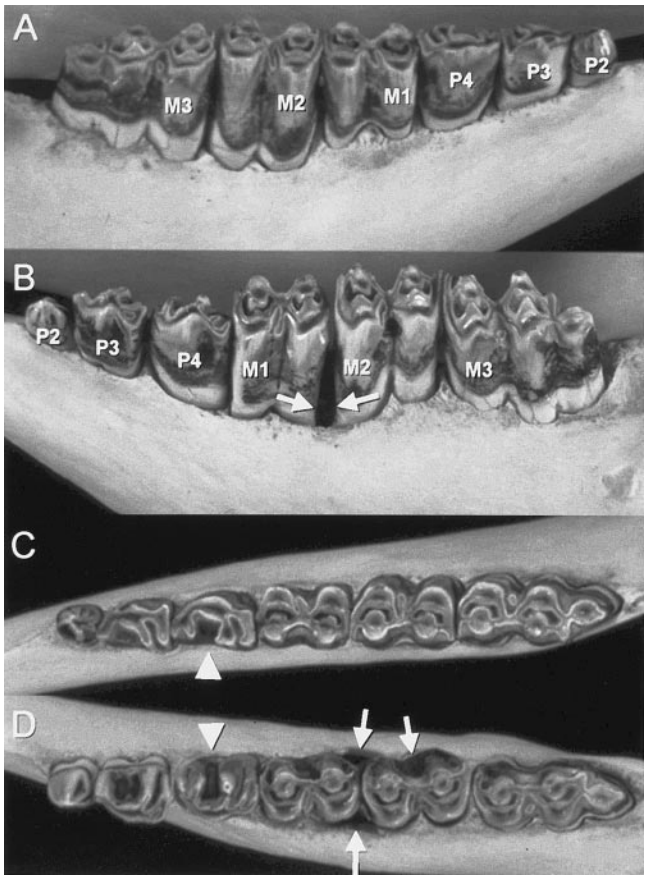

Fig. 2. Mandibular specimens from cow 1 at 4½ years after fracture healing. (A) Oblique view of the right mandible. (B) Oblique view of left mandible. (C) Dorsal view of the right occlusal surface. (D) Dorsal view of the left occlusal surface. Note the completely healed and remodeled bone of the left mandible (B, D). A space between M1 and M2 and bone resorption around the tooth roots marks the healed fracture site (arrows in D). Compare the flat and even table surface of the right mandible (A) with the uneven wave and shear mouth of the left mandible (B). The uneven wear of the dorsal surface of the left-sided teeth can be best appreciated by comparing the fourth premolar (P4) on each side (arrowheads in C and D).

All fractures were healed at follow-up. Various stages of callus resorption and bone remodeling were noted. Radiographic signs included radiolucent zones at the level of the fracture site, thickening or roughening of the cortex, or both. None of the tooth roots had signs of infection. Loss of the lamina dura surrounding the tooth roots adjacent to the fracture site was a common finding.

DISCUSSION

PEF was the treatment of choice in most cattle. Stability of the fixation device is influenced by the configuration, the number of clamps, and the implant to bone interface.[8,10] Loosening of the bone clamps was a common complication, mainly because of improper clamp application, which resulted in insufficient contact between implant and bone. The subcutaneous nodules and the bony swelling seen in 3 cattle were considered to be sequelae to bone clamp application and of no clinical relevance. The skin fold at the ventral margin of the mandible in cow 8 was probably a late trauma complication.

Bone or tooth fragments at the fracture site were identified in 5 cattle, and sequestrum formation occurred during healing in each of these animals. Sequestra developed in 6 other cattle despite no initial evidence of bone or tooth fragmentation. The high frequency of sequestrum formation differs from previous studies in which this complication is not mentioned.[5,6] Osteomyelitis, a far more common postoperative complication in previous reports,[5,6,11] did not occur in our cattle. Tooth or bone fragments in combination with bacteria from the oral cavity or an open skin wound can form sequestra and lead to

Fig. 3. Photograph of the left first molar and second molar between which the fracture occurred in cow 1. The caudal tooth root of M1 is partially missing (arrowhead). It had been removed with a bony sequestrum during the healing phase. Signs of lysis (arrows) are seen at the cranial part of the tooth root of M2, probably caused by erosion secondary to a fistulous tract running in between.

osteomyelitis.[12] Radiographic follow-up is necessary to confirm sequestrum formation. Surgery should be performed when the fracture is stable enough to tolerate sequestrum removal but the callus has not yet ossified. In our cattle, sequestrum removal was performed 6.6 weeks after fracture occurrence and 1.6 weeks after fixator removal.

Radiographic examination showed loss of the lamina dura surrounding the tooth roots adjacent to the fracture; however, no instability or tooth loosening was noted on intraoral examination. Enamel points occurred only in cow 8 in association with step, wave, and shear mouth formation. Upon admission, this fracture was 21 days old, and no surgical reduction of the fracture was attempted. Malocclusion in this cow was more pronounced than in the surgically reduced fractures and, therefore, likely led to enamel point formation.

Even though 6 cows had abnormalities of the occlusal surface, excellent functional outcome was reported by all but 1 owner. This apparent discrepancy might be explained by the specific manner in which trituration of food is accomplished. During central occlusion, only a small part of the buccal surface of the lower molars contact the upper molars because of the dissimilar width of the maxilla and mandible.[12] Because of the lateral excursion of the mandible, the occlusal surfaces are superimposed on one side and without contact on the opposite side.[13] Most likely, these cattle initially chewed mainly on the unaffected side of the mandible and retained this masticatory behavior after fracture healing. One reason for unilateral shear mouth formation in horses is behavioral chewing on 1 side of the mouth only[7]; this behavior might have been partly responsible for the wave and shear mouth formation that occurred in some of our cattle.

CONCLUSION

Based on our experience, close clinical and radiographic follow-up during the healing period is warranted to detect sequestrum formation. Sequestra should be removed surgically to prevent formation of osteomyelitis. After complete fracture healing, abnormalities of the molar occlusal surface developed in 6 cows available for reevaluation. However, except for 1 cow that had oral incontinence, no masticatory problems were seen. Therefore, when adequately stabilized, simple mandibular fractures involving the molar teeth have a good prognosis for recovery.

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