

MANDIBULAR FRACTURE REPAIR IN CATS USING NYLON LOOPS – A RETROSPECTIVE STUDY ON 19 CASES (2001-2012)

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Abstract

Fractures of the mandible are common in cats. The goal of treatment for mandibular fractures is normal function of the jaw, with perfect dental occlusion. At the Medisch Centrum voor Dieren (MCD) in Amsterdam the orthopedic surgeons have been looking for a practical way to stabilize different types of mandibular fractures. They have used an interarcuate wiring technique, the nylon loop method, to stabilize mandibular fractures and temporomandibular junction (TMJ) luxations. A retrospective study on 19 cats treated at the MCD, in the period between 2001 and 2012, was performed. The patients in this study had at least one mandibular fracture, and were all treated with the nylon loop method. In 10 of the patients an additional fixation method was used. The nylon loop method, a technique which stabilizes the fracture in occlusion was evaluated in this study, as well as the fractures types treated with this method. The consequence of fixation in occlusion was the necessity to place an esophageal feeding tube. In 3 patients minor complications occurred, like weight loss and vomiting without serious consequences. In 18 out of the 19 cases the fixation using the nylon loops led to healing of the fractures with fair to good occlusion, in one of the cats the stabilization failed and another fixation technique had to be used. Nylon loop fixation was a successful method in stabilizing mandibular fractures in cats.

Mandibular fractures are common in cats and comprise 11.4 - 23.1 % of all the fractures seen in this species. Mandibular fractures in cats are often associated with traffic accidents². Local pain, asymmetry of the face and jaws, and malocclusion are symptoms seen in these fractures⁸. Symphyseal separations were most commonly seen (73.3%), followed by fractures of the body (16%), condyle (6.7%), and coronoid process (4%)¹⁸. The goal of treatment in a mandibular fracture is a normal function of the jaw, accompanied by perfect occlusion of the teeth. Proper occlusion of the teeth is important in cats because of the presence of carnassials. For a functional dentition the occlusion has to be perfect. Specific problems that can occur with an imperfect occlusion are having difficulty eating, tooth wear, pain, osteoarthritis of the temporomandibular joint (TMJ), oral ulceration and/or fistula¹⁵. In order to achieve functional occlusion, several methods have been developed to stabilize the mandibular fractures. Stabilization techniques that have been described earlier are the 'tape muzzle', interarcuate wiring, interdental wiring, interfragmentary wiring, intraoral splints, circumferential wiring, mini stainless steel and titanium plates and screws, dental composite, epoxy resin and poly methyl methacrylate external fixation of the skull, maxillo-mandibular external fixation' and the 'Bi-gnathic encircling and retaining device (BEARD)'¹⁻¹³.

At the Medical Center for Animals (MCD) in Amsterdam the veterinarians have been looking for a practical way to stabilize different types of mandibular fractures. In particular the caudal mandibular fractures

formed a challenge in the stabilization, because the bone is often too thin to be able to stabilize by means of plates and screws. To work with dental composite resin specialist tools are required, and, as also described in literature, the orthopedic surgeons at the MCD also encountered practical problems, such as separation of the composite bridges¹⁵.

For the fixation of caudal mandibular fractures the maxillo-mandibular fixation methods have proven to be suitable⁹. Maxillo-mandibular fixation can be achieved with an open mouth, or in occlusion. Both of these methods have their own advantages and disadvantages. Whilst a cat with its mouth fixated in occlusion cannot eat independently, and therefore needs a feeding tube, this might not be necessary in an open mouth fixation. In this case the cat is able to eat, but might be reluctant to eat enough because it is difficult^{15,16}. At the MCD the veterinarians have chosen to work with an interarcuate fixation technique in occlusion. As the veterinarians find nylon thread easier to work with than orthopedic wire, they have chosen to work with this material. Another advantage of using nylon thread is that the removal of the wire is easy and quick, so cats don't need to be brought under anesthesia to remove the fixation.

This study will describe the nylon loop fixation method as used at the MCD in Amsterdam. It will also describe the different fractures that can be stabilized with this technique. In addition, the results and complications of this technique will be evaluated.

CASE INFORMATION

This retrospective study looked at all cats with mandibular fractures, treated at the MCD in Amsterdam between 2001 and 2012, in which the fractures were stabilized using the nylon loop method. The orthopedic surgeon at the MCD determined, particularly on the basis of the type and location of the fracture, but also on the basis of further injuries, whether the nylon loop method was the only stabilization technique to be used, or if an additional method would be necessary. The data collection consisted of the identification of the patients, the etiology of the fracture(s), the exact location of the fracture(s), additional injuries, fixation methods used, placement of an esophageal feeding tube, duration of treatment and complications such as dyspnea or vomiting.

19 cats met the inclusion criteria; they had at least one mandibular fracture, and these fractures were (amongst others) stabilized using the nylon loop technique. In 10 cases an additional fixation method was used in conjunction with the nylon loops.

RESEARCH METHOD

First, the files of the 19 cats included in the study were examined and their radiographs

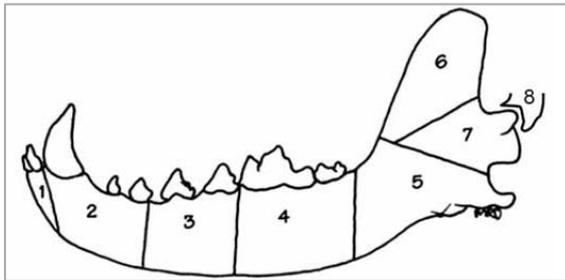


Figure 1. Eight regions of the mandible (after Weigel, Wallace-Bennet et al, and Owen et al.) 1: Symphysis to canine teeth, 2: Canine to third premolar, 3: Third premolar to first molar, 4: First molar to angle of the mandible, 5: Angle of the mandible, 6: Coronoid process, 7: Condyloid process, 8: Mandibular fossa and retroarticular process of temporal bone

were evaluated by the orthopedic surgeon at the MCD. On the basis of the classification

method of *I. Nicolson et al (2010, figure 1)* the fractures were classified according to their localization in the different zones. This was done to create an overview of the different fractures and their locations that were stabilized using nylon loops.

THE NYLON LOOP METHOD

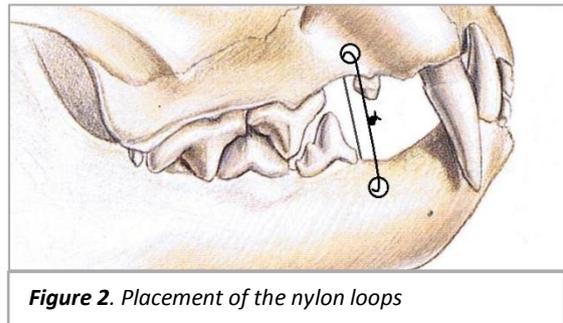


Figure 2. Placement of the nylon loops

Before the fixation method was applied, a percutaneous esophageal feeding tube was placed, preferably on the left side of the neck, according to van Noort¹⁷. Then, in the maxilla and mandible, caudal to the canines, holes are drilled with a diameter of 1.1 mm using Kirschner wire (Figure 2). A 0.5 mm thick nylon thread was passed through the hole in the maxilla, from the buccal to the lingual side, and then through the mandible from the lingual to the buccal side. The process was repeated on the contralateral side. Before the loops are drawn and tightened by tightening the knots, the pharynx was cleared of fluids, and the cat was extubated.

POST-OPERATIVE CARE

The first 24-48 hours post-operatively, the cats are hospitalized and closely monitored, especially to monitor the animals breathing. Dyspnea can be an important risk in cats when the mandibular fractures are stabilized in occlusion. In these first couple of days the feeding through the esophageal tube was also started up and closely monitored. A risk of tube feeding was choking due to vomiting, which in the case of fixation in occlusion can be fatal. Also,

the cats salivated a lot after the placement of the esophageal tube and the nylon loops. Postoperatively a Fentanyl patch was placed for pain relief. Once postoperative comfort and tube-feeding were established the cats were discharged from the clinic and nursed at home with the feeding tube and the nylon loops in place.

FOLLOW-UP

Of the nineteen cats in this study, three of the patients have had a checkup 6 weeks postoperatively, including an X-ray. After a complete physical and pre-anesthetic exam, the animals were brought under anesthesia. Two X-rays of the skull were made; one in lateral and one in dorsoventral direction. The X-rays were evaluated by the orthopedic surgeon at the MCD. In the physical exam extra attention was paid to the mobility of the jaw, the occlusion and the outline of the jaw.

Sixteen of the cats have been back for checkups on the occlusion and for changes of the bandages around the neck covering the percutaneous esophageal tube. These sixteen cases haven't, however, been back for an X-ray 6 weeks postoperatively. There were various reasons for the owners not to do so, such as lack of time or money. Also, many of the owners were satisfied with the results, because the cats ate well and seemed to have returned to their usual selves. In these sixteen cases, the absence of 6 week postoperative X-rays means it will be difficult to assess the healing of the fracture, as there are no radiographic results. Conclusions will be drawn on the function of the jaw, and the physical exam at the checkups, by the orthopedics at the MCD.

Results

CASE INFORMATION

In the period from 2001 to 2012, twenty-one cats were treated at the MCD Amsterdam, using the nylon loop fixation technique. Two of these cats were excluded from this study, because they did not have mandibular fractures and therefore did not meet the requirements of this study. In one of the remaining 19 cases there was no sufficient follow-up information, but the case was included anyway, because of the describing character of this study.

The average age of the cats included in this study was 43 months (range 5 to 135, Table 1). Thirteen (68%) of the cats were male. Amongst these nine (47%) had been castrated and four (21%) had not. Six (32%) cats were female, all of them had been spayed. The ratio Female : Male = 1:2.

The cause of the fractures was a hit by a car (n=4, 21%), fall from great height (n=7, 37%), or unknown (n=8, 42%).

ADDITIONAL INJURIES

Three (16%) of the patients in this study also had serious other injuries, which had an effect on the time of placement of the nylon loops. In one of the cats the surgeons had to wait for 4 days before placing the loops, because the cat had a pneumothorax. Fixation in occlusion would have caused dyspnea. In cases 2 and 17 there was so much swelling of the nasal mucosa that fixating the jaw in occlusion would also have meant serious dyspnea in these cats. For this reason the surgeons waited 7 and 16 days respectively before placing the loops. In case 19, a cat who had fallen from great height, there had also been a nose bleeding. The swelling was however not too serious, and the loops could be placed on day 1.

Four (21%) of the patients (no. 9, 13, 17 & 19) had a palatoschisis. In case 9 the wound edges already touched, and no sutures are put in. In cases 13, 17 and 19 the wound edges were pulled towards each other by soft tissue sutures.

LOCATION OF FRACTURES

In fifteen (79%) of the cats in this study, there was a fracture in the caudal part of the mandibular (Zone 5,6 or 7, Fig 1). Four of these cats (21%) had one or multiple concurrent rostral mandibular fractures, without the presence of symphyseal separation. Four (21%) cats in this study had a fracture in the cranial part of the mandible (Zone 2 or 3, Fig. 1) without the presence of a fracture in the caudal mandibular. Nine (47%) of the cats had a separation of the mandibular symphysis. Six (32%) of these cats with a separation of the mandibular symphysis, had a concurrent caudal mandibular fracture (Fig.3).

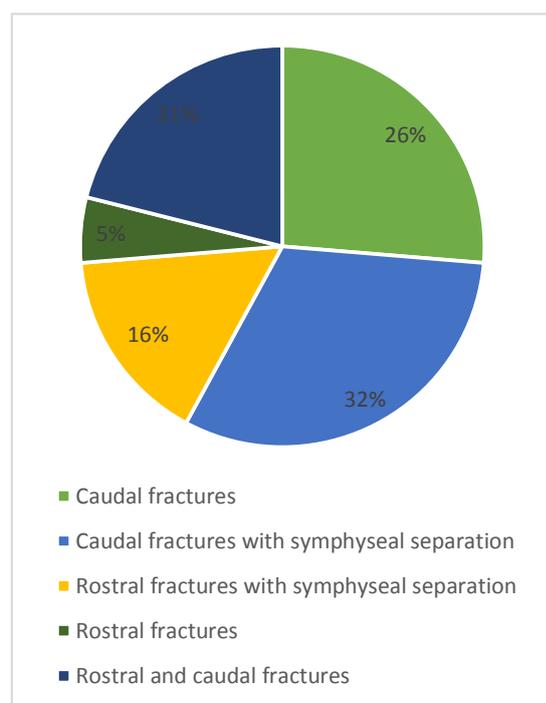


Figure 3. Localization of the fractures treated with the nylon loop method

In two cats (Cases 2 and 4, 11%) there was an open fracture in the mandible. In case 2

the fracture was in zone L2 (Fig.1), and stabilization using the nylon loop method wasn't sufficient. In case 4 the fracture was in zone R3 (Fig.1).

In case 6 the nylon loops were placed because the first method of fixation, interfragmentary wiring to stabilize the fracture in region R2 (Fig.1), didn't work sufficiently.

ADDITIONAL FIXATION METHODS

In 10 (53%) cases, in addition to the maxillo-mandibular fixation, another stabilization technique was also applied. Examples are a PDS suture around the symphysis of the mandible in order to stabilize a separation of the symphysis (n = 9, 47%), interfragmentary stabilization (n = 1) or pins (n = 1). In one cat fixation, using the nylon loop method, did not lead to healing of the fracture. In this case, there was an open fracture in the rostral part of the mandible (L2, according to Weighel, fig.1), which had not healed after a fixation period of 21 days. The loops were removed after these 21 days and a pin was placed in the mandible to stabilize the fracture.

FOLLOW UP

All cats in this study were equipped with a percutaneous esophageal tube and were fed through this tube throughout the whole period of fixation, until they could eat by themselves. In one of the cats the percutaneous esophageal tube was in place shorter than the maxillo-mandibular fixation, because this patient ate enough alongside the tube to be able to remove it. The mean duration of tube feeding was 24.7 days (n = 18, in one of the cats the duration of maxillo-mandibular fixation is unknown), with a range of 13 to 42 days.

The nylon loops were removed after an average of 23.7 days (n = 18, in one of the cats the duration of maxillo-mandibular fixation is unknown), with a range of 13 to

Case	Sex	Age	Cause	L : R	Symp hfx	Fx - OK	Fixation days	Tube	Other fixation techniques	Details
1.	M	20w	Fall from great height	0 : 7	-	4	40	16	-	Good occlusion, normal ROM
2.	VG	2y	Traffic accident	2 : 0	yes	7	21	28	PDS 0 suture. Pins in the mandible from day 27	C304 iets te nauw, schaaft niet mooi
3.	MG	9m	Unknown	7 : 7	-	5	22	29	-	Good occlusion. X-ray: no bone fragments anymore
4.	MG	1y1m	Fall from great height	3 : 0	yes	1	18	21	PDS0 suture around the symphysis	Functional occlusion. C304 is spearing. The cat has lost weight.
5.	MG	8y3m	Unknown	6+7 : 6+7	-	?	23	23	-	Functional occlusion
6.	MG	2y	Unknown	0 : 2+7	-	10	13	13	Cerclage and 2 U-shaped PDS 3-0 loops on the fracture in zone R2	Functional occlusion
7.	MG	6y	Unknown	7 : 6+7	-	?	20	20	-	Functional occlusion. Slight impingement of C304 with C204
8.	VG	5m	Unknown	7 : 2	-	?	?	?	-	No follow-up
9.	MG	10m	Fall from great height	2 : 2	-	0	25	25	-	Functional occlusion
10.	VG	11y	Unknown	5,6+7 : 2,5,6+7	-	?	25	25	-	Good occlusion.
11.	MG	1y10m	Unknown	5,6+7 : 6+7	yes	?	15	18	PDS 0 suture	X-ray: no excess callus formation. Good occlusion.
12.	M	2y3m	Traffic accident	0 : 7	yes	1	35	42	PDS1 suture	Functional occlusion
13.	VG	5y	Fall from great height	2 : 0	yes		37	42	PDS 0 suture	C304 points forward a bit. Functional occlusion
14.	MG	5y6m	Traffic accident	6+7 : 0	-	2	21	23	-	Functional occlusion
15.	VG	2y5m	Unknown	0 : 7	yes	?	21	21	2 PDS sutures	Functional occlusion
16.	VG	3y3m	Fall from great height	0 : 6	yes	22	13	15	On day 18 the cerclage placed by the own vet was removed. A PDS suture was placed.	Functional occlusion
17.	M	3y1m	Traffic accident	7 : 0	yes	16	28	28	PDS1 suture . 2 crosspins in the maxilla	Functional occlusion
18.	MG	11y3m	Fall from great height	7 : 7	yes	4	36	36	PDS 1 suture .	X-ray: nice healing of the fracture. Functional occlusion
19.	M	9m	Fall from great height	2+7 : 2	-	1	14	13	-	Functional occlusion

Table 1. Case information

40 days. The exact duration of proper maxillo-mandibular fixation is however, in most cases, unknown. In the six (32%) cats with symphyseal separation as well as a caudal mandibular fracture, the loops were removed after an average of 24.7 days, with a range of 13 to 36 days.

Of the nineteen cats in this study, three (16%) have been back at the MCD six weeks post-operatively for follow-up, including radiographs of the jaw (one VD, and one SD). In these three cats there was proper healing of the fractures, the fracture lines were closed, there was no excessive callus formation and there were no more splinters. There was clinical and radiological union.

In four (21%) cats the occlusion is perfect. In 13 (68%) cases, there is functional occlusion, with proper function of the jaw, despite of the fact that the occlusion is not perfectly straight. In one case, the occlusion is poor, although it is unknown whether the cat can eat properly. In this cat C304 does not stand well with the upper canine. In one cat there is no follow-up available, in this case the occlusion is unknown.

The recovery of these patients is time-consuming. The owners need to revisit the clinic every week to have the bandage around the neck changed and the entry wound for the esophageal tube inspected. Also, the cats need to be fed 4 times daily, which in most cases needs some adapting from both the cat and the owner.

COMPLICATIONS

Despite the percutaneous feeding through the esophageal tube two (11%) of the cats did lose weight during the time of maxillo-mandibular fixation.

One cat (case 12) was presented to the clinic 4 days after the operation, because of complaints of vomiting and pain in the abdominal region. While hospitalized the cat didn't vomit anymore, but was salivating a lot. One day later the cat was allowed to go home again and no further problems occurred.

Hyperthermia was not documented in any case.

Discussion

Fracture healing depends on many factors, like the age of the animal, the type of fracture, the age of the fracture, the condition of the surrounding soft tissue and any systemic or local bone disorders²⁰. Jaw bone does not bear any weight, so compression isn't required for fracture healing. A proper alignment of the fracture lines is enough to secure recovery⁹.

According to Lewis et al (1991) maxillo-mandibular fixation (n=2), using orthopedic wire, for 7 days is sufficient to stabilize the

fracture and maintain proper occlusion. In this study both patients suffered from a symphyseal separation as well as one or multiple fractures in the caudal part of the mandible. These are similar patients to 6 (32%) of the cases we looked at in this study. The average time that the fixation lasted in the whole patient group treated at the MCD was 23.7 days, the average time of fixation in the six patients with symphyseal separation as well as a caudal mandibular fracture was 24.7 days. If 7 days of stabilization is sufficient to stabilize the

fracture and maintain proper occlusion, one could wonder why the orthopedics choose to leave the fixation for so much longer, in some cases up to 42 days. Especially, because fixation in occlusion also brings with it the risk of some serious complications. On the other hand, in the study done by Lewis et al. (1991), only two patients were assessed which might not be a large enough amount of patients to draw conclusions about a required fixation period. It is unknown what the optimal length of stabilization is. Instead, an educated assessment was made as to when the fracture was stable enough to be able to remove the loops.

Maxillo-mandibular fixation is particularly indicated for the treatment of caudal mandibular fracture and unstable TMJ dislocations, in which cases a different way of fixation has proven to be difficult^{5,14,16}. These interarcuate techniques are examples of indirect stabilization, and offer the advantage of not disturbing the fracture site and preservation of the blood supply⁵. Maxillo-mandibular fixation can be divided into open mouth fixation or fixation in occlusion. Both forms of maxillo-mandibular fixation have their pros and cons.

The orthopedic surgeons at the MCD have chosen to work with the nylon loop method, a fixation in occlusion, in cases where there were fractures of the caudal mandible (n = 15), in one case combined with a TMJ luxation. Also, the technique was used to stabilize fractures rostral to region 5 (Fig.1) in four cats. In one of these cats there was also a TMJ luxation. In 9 cases there was also separation of the mandibular symphysis. In this study, we looked at the functionality and possible complications of fixation using nylon loops, a way of fixation in occlusion. In 18 of the 19 cases examined, this type of stabilization led to union with functional (n=14, 74%) or perfect (n=4, 21%) occlusion. In one case, the nylon loop method did not lead to

healing of the fracture and a different fixation method was required to stabilize the fracture.

The nylon loop method does not require the use of specialist equipment, just a drill to make the holes in the mandible and maxilla. By using nylon thread instead of orthopedic wire, the application of the loops is much easier. Also, it can easily be determined how tight the loops are applied. The removal of the loops is fast and simple, little space or equipment is required for the removal of the nylon loops, so cats don't need to be put under anesthesia to remove them. This also means that in case of emergency, for example when the cat would be vomiting, the loops can be removed instantaneously by cutting the sutures. Whether or not this will be in time is questionable though. Although the loops can loosen, or may be broken by the cat, this has not happened in this study described before the required 7 days for proper stabilization of the fracture¹⁴.

An important disadvantage of fixation in occlusion is that the cats cannot eat independently and need to be fed through a percutaneous esophageal tube throughout the fixation period. However, the esophageal tube was well tolerated by both the cats and their owners in this study. The owners indicated that they did need time to get used to this way of feeding, but after several feedings the cats tolerated it well. A risk of tube feeding is that the cats might not take in enough calories. In this study, two of the cats (11%) lost weight during the period of mandibulo-maxillary fixation.

Disadvantages of other fixation methods in occlusion, like the tape muzzle include poor toleration of the muzzle by cats and the risk of developing a dermatitis underneath the material. Also, in all techniques stabilizing the mandible in occlusion, there is the risk of hyperthermia and aspiration pneumonia or the asphyxiation hazard due to vomiting.

In this study, 15% of the patients developed complications. In 11% (n=2), cats lost weight even though they were fed by their owners, multiple times daily. One of the cats was reported to vomit, and was hospitalized for 24 hours to be monitored. Although vomiting wasn't seen while being monitored at the clinic this cat did salivate a lot. In another study with fixation in occlusion, using the BEARD, complications which were seen consisted of dislodgement (n=2/9, 22%) or blockage (n=1/9, 11%) of the esophageal feeding tube⁵. In this particular study the percentage of complications is higher than in our study. According to L.M. Ireland et al.(2013), the most common complications reported with esophageal feeding tubes were vomiting, scratching at the tube and bandage, patient removal of the tube, mechanical difficulties (i.e., tube obstruction, tube nozzle dislodgement), and tube vomition. These findings are consistent with the results in our study, and with the complications seen in the study done by Nicholson et al.(2010). Other complications seen when using the BEARD are swelling and discharge from the needle hole in the dorsal nasal skin, which occurred in 40%⁵. These type of complications are not seen in the nylon loop method, because the sutures are only pulled through the mandible and maxilla.

IMPROVEMENT OF FUTURE DATA COLLECTION

The retrospective nature of this study, and the relatively small amount of cases treated, limits the strength of any conclusions that can be made. Also, patient files have not

been filled in completely, which means a lot of useful information is missing.

Owners seem to miss control consultations for various reasons. As a result, radiographic documentation of bone healing 6 weeks post operatively was not done routinely in this study in most (n=16) of these animals. In only 3 of the cases 6 week post-operative radiographs were taken. Also, some of the radiographs (before and after operation) were made with analog devices, in which the contours of the mandible are more difficult to follow. There is a lot of superimposition of other structures of the skull, which makes it hard to give a precise description of some of these fractures. A CT-scan would be a more accurate diagnostic imaging method for the caudal mandibular fractures and TMJ dislocations, but was not available at the for 6 week post-operative radiographs for many of these patients.

MEDICAL RECORDS

The administration in the medical records of the patients needs to be more extensive and more accurate in the future. When an animal comes in for a control consultation, or for the removal of the loops, findings on the physical examination and fracture healing should be reported clearly and completely by the veterinarians. In this study a lot of information is missing in the medical records of the patients, which means that in many of the cases there isn't any more information on the occlusion, other than that it is functional.

Conclusion

Nylon loops, as an alternative to already described maxillo-mandibular fixation methods in occlusion, seem to work well. In eight-teen of the nineteen cases in this study, there were satisfactory results with

functional or even perfect occlusion. Despite the possibility of early loosening of the loops, in 17 cats the fixation held long enough for fracture healing. In one case however, another fixation method was

necessary in order to stabilize the fracture of the mandible, because fixation using the nylon loops lead to non-union. In one case the occlusion and healing of the fracture is unknown, due to lack of follow up information.

Although animals cannot eat independently while their jaws are fixed in occlusion, the esophageal tube was well tolerated by the animals as-well as by the owners, and only two of the cats in this study have lost weight during the period of maxillo-mandibular fixation. Frequent monitoring of the esophageal tube and a change of the protecting bandage is necessary in order to prevent infection of the skin around the tube. The advantage of having the animals regularly come in for control consultations, is that there is also frequent contact with the veterinarian, which means failure of fixation or occlusion will be noticed as early as possible.

Even though it is necessary to drill in the jaws to apply the nylon loops, further specialist tools, necessary for the

application of composite splints for example, are not needed. And while for the removal of the composite splints or external fixation the cat needs to be put under anesthesia, this is not necessary for the quick and easy removal of these nylon loops.

Complications like vomiting and weight loss are seen in 15% of the patients (n=3) in this study. Only one of the complications was a potential risk to the patient though, as vomiting could cause an aspiration pneumonia or an asphyxiation hazard.

All in all, the nylon loop method according to the MCD in Amsterdam seems to be a readily applicable technique in caudal mandibular fractures and TMJ luxations, with satisfactory results. It has also been successfully used to stabilize rostral mandibular fractures, either with or without symphyseal separation.

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