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LONG-TERM SUCCESS RATE OF RESIN-BONDED METAL CROWNS ON THE CANINE TEETH OF WORKING DOGS

A.W. van Foreest¹, and F.J.M. Roeters²

SUMMARY
In this clinical study, 19 full metal crown restorations of canine teeth were placed in seven working dogs. Thirteen canine teeth were severely abraded with no involvement of the pulp cavities; six fractured canine teeth were endodontically treated. At least 1/3 of the coronal part of the canine tooth was available for a supragingivally performed, minimal tooth crown preparation. An adhesive technique to bond the electrolytically etched crown (an alloy of cobalt-chrome-molybdenum) to the tooth was used. The metal crowns, slightly shorter and with a rounder tip than the original tooth, were bonded to the enamel and dentine by using a resin luting cement. Posts or post-and-core techniques were not used. Mean follow-up period was 32 months (range 24 - 52 months), at which stage 17 crowns were found to be intact and functional. Two crowns were lost as a result of trauma resulting in a fracture of the tooth below the crown.

INTRODUCTION
Tooth fractures are frequently seen in dogs and most of the time direct trauma is the cause. In the dog dental fractures commonly involve the upper fourth premolar and the canine teeth. The percentage of fractured teeth in reports before 1980 varied between 3.42% and 10.7% (1,2,6,43,54). In two more recent surveys of dogs anaesthetized at a veterinary hospital for reasons other than dental disease the percentage of dogs with fractured teeth was 27% (1982, Golden et al, 63 dogs) and 8% (1992, Smeets and Rem, 99 dogs) (20,45). Dogs used for police or military work or for guarding, watching or hunting need their teeth and especially the canine teeth to catch and hold persons or prey. During the training activities of these dogs there are many potential traumatic causes for a tooth fracture: retrieval of stones and metal objects caught in the air, a too wild and not well coordinated attack on the padded subject, or becoming entangled in the leather armshields of the subject. If the dog does not take a full bite but only bites with its canines and incisors, the forces perpendicular to the long axis of these teeth can be sufficient to cause a fracture. If there is a fracture of one of the canine teeth, the biting grip can be out of balance and this can cause a fracture of the antagonist or contralateral canine.

There has always been a demand for treatment of fractured teeth but both veterinary interest and the chance of successful dental treatment have been minimal for a long time. During the last two decades new developments in dental treatments have offered the veterinarian techniques which might be more successful. When there is a good treatment option, owners of working dogs will be more interested because they have invested much time and money in training their dogs. Therefore, in these dogs it can be worthwhile to restore the loss of function due to dental fractures.

Owing to the enormous biting forces, only very strong restorative materials should be used (35). Full metal crowns will fulfil these demands. A crown is an extracoronal restoration that covers all or most of the coronal portion of a tooth, replaces the function and structure of a damaged tooth, and protects the portion of the tooth that remains. Its retention is normally derived from the preparation design and the cement. To facilitate placement of the crown, the prepared Owing to the enormous biting forces, only very strong restorative materials should be used (35). Full metal crowns will fulfil these demands. A crown is an extracoronal restoration that covers all or most of the coronal portion of a tooth, replaces the function and structure of a damaged tooth, and protects the portion of the tooth that remains. Its retention is normally derived from the preparation design and the cement. To facilitate placement of the crown, the prepared

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Figure 1. Four metal crowns on the canine teeth of a German shepherd dog still in place 40 months after placement.
tooth should have a configuration converging towards the occlusal plane.

Retention in conventional crowning procedures is largely dependent on the design of the preparation. The space between the tooth surface and the crown is filled with a cement which will provide some mechanical interlocking. As in humans, in dogs the loads are normally in axial direction, a good compressive strength of the cement is relatively unimportant. In human dentistry zinc phosphate and carbobonate cements have sufficient strength. According to a large number of case reports and other literature, these cements are frequently used in dogs, still work well, and are not very technique sensitive (4,5,7,9,13,14,15,19,23,24,26,28,29,31,43,55). However, there have been no reports on their long-term evaluation.

In working dogs the forces applied to canine teeth are a combination of compression, shear and tensile forces. If the resistance of the preparation is less than ideal, a high tensile strength of the cement will be more important. Conventional cements have a low tensile strength, which casts doubt on their suitability in working dogs. The resin composite cements combine a high tensile strength with good compressive strength (49). Furthermore these materials have the advantage that they can be combined with an adhesive technique.

Techniques such as sand blasting, tin plating, and electrolytic etching create a retentive surface on metal crowns. On such a surface a composite cement will provide micro-mechanical retention, and, in fact, retention can be so high that the bond strength surpasses the strength of the remaining tooth (21). However, to achieve this, the tooth itself (enamel and dentine) also has to be acid-etched to provide a retentive surface.

The purpose of this study was to evaluate the clinical performance and effectiveness of adhesively bonded metal crowns on damaged canine teeth of working dogs over a 2- to 4- year period (Figure 1).

Table 1. Description of cases.

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Name</th>
<th>Breed</th>
<th>Sex</th>
<th>Age in years</th>
<th>Indication</th>
<th>Total of crowns</th>
<th>Date of treatment</th>
<th>Months</th>
<th>Lost crowns</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dourak</td>
<td>MH</td>
<td>m</td>
<td>5.5</td>
<td>AB</td>
<td>3</td>
<td>8/90</td>
<td>52</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>AB (204)</td>
<td></td>
<td>8/90</td>
<td>4 (1/91)</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Foster</td>
<td>MH</td>
<td>m</td>
<td>6.5</td>
<td>FR</td>
<td>1</td>
<td>12/90</td>
<td>49</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Bas</td>
<td>CR</td>
<td>m</td>
<td>1.5</td>
<td>FR</td>
<td>1</td>
<td>2/90</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Eyk</td>
<td>DP</td>
<td>m</td>
<td>3.5</td>
<td>AB</td>
<td>4</td>
<td>8/92</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Erwin</td>
<td>DH</td>
<td>m</td>
<td>8</td>
<td>AB</td>
<td>4</td>
<td>1/93</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Arros</td>
<td>MH</td>
<td>m</td>
<td>7</td>
<td>AB</td>
<td>3</td>
<td>1/93</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Franky</td>
<td>DH</td>
<td>m</td>
<td>1.75</td>
<td>AB</td>
<td>1</td>
<td>1/93</td>
<td>11</td>
<td>1</td>
</tr>
</tbody>
</table>

MH = Mechelse herder = Malinois shepherd dog; DH = Duitse herdershond = German shepherd dog; CR = cross breed; DP = Dobermann Pinscher; FR = Fractured canine with pulp exposure; endodontically treated; AB = Abrasion with no pulp exposure; Months = number of months between date of treatment and date of lost crown or date of last evaluation interview (1/1995).

Dourak (Nr. 1) is still a winner with three crowns left.

Franky (Nr. 7) is still in function as a watchdog.

19 Crowns (2 lost) in 7 dogs total 559 months: mean 29.4 months. 17 Crowns in 6 dogs total 544 months: mean 32.0 months.
3. Preparation procedure
As a reduction of sound tooth material will only weaken the tooth a circumferential crown preparation was not made. Grinding was restricted to the elimination of undercuts and contacts with antagonistic teeth to create sufficient space for the crown. In 18 canine teeth the margin of the preparation was minimally 1-2 mm above the gingiva margin. In one dog (Franky) the gingiva was severely traumatized on the buccal side: the crown preparation in this case was 1-2 mm above the mucogingival line. During preparation an effort was made to stay in the enamel layer. A minimum of two longitudinal grooves on all teeth were ground using diamond tapered burs, on the buccal and lingual surfaces (Figure 4).

4. Impression and bite registration
Impressions were made of the upper and the lower archs (including incisors, canines, and first premolars) using impression trays (especially made for dogs). Fast-setting alginate material was used. The alginate impressions were kept moist and always poured in stone within a few hours in a dental laboratory. For a detailed reproduction a silicone impression was made of the jaw with the prepared teeth (47). A bite registration was obtained using wax. After the stone models were made, the design of the crown was discussed with the dental technician. During the period the crowns were cast and completed (2 days to 1 week) the prepared tooth was not protected with a temporary crown. The owner of the dog was advised not to work with the dog during that period and to prevent the dog from playing with hard objects.

5. Laboratory procedures
The metal crowns were cast in a cobalt-chrome-molybdenum alloy (R/Heranium: Cobalt 63.5 - Chromium 27.8 - Molybdenum 6.5). The metal crown was made slightly shorter and with a rounder tip than the original tooth (Figure 5). After the crown was finished, the internal surface was electrolytically etched.

6. Crown cementing
To provide adhesion to the enamel as well as the dentine, a resin luting cement with adhesive properties was used. In this study Panavia Ex* (Kuraray) composite cement was used. Before cementation the prepared tooth was polished, cleaned thoroughly with water, and air-dried. The inside of the metal crown was wetted with alcohol to prevent contamination of the etched surface during checking of the fit. The fit on the tooth was checked to ensure that the crown could be properly seated and did.

Figure 4. An example of a prepared canine tooth after etching and before the placement of a metal crown. The margin of the preparation is 1 - 2 mm above the gingiva margin. Longitudinal grooves are visible.

Figure 5. Stone models showing four metal crowns for four abraded canine teeth.
Two of the metal crowns were lost by injury. The first dog in this study lost one metal crown 4 months after placement during a training session. This metal crown did not cover the whole clinical crown and a fracture line went through the remaining tooth. Nevertheless, with three crowned canine teeth and one endodontically treated fractured canine tooth, the grip and biting capacities were sufficient and this dog still won competitions. Owing to repeated trauma the last dog in this study lost a treated canine tooth after 11 months, because of an oblique fracture of the root. This dog has been active as a working dog during these months but was now used as a watchdog.

DISCUSSION
Fractured teeth should be restored if they are important to the health and use of a working dog (15). In working dogs reduced crown height often leads to a diminished biting ability and to a functional handicap. Working dogs of all breeds need a strong restoration of a fractured canine tooth to withstand the forces exerted when the dog is "working". A canine tooth shorter than normal, however, does not always cause problems to a working dog. If the remaining coronal portion of the tooth is healthy and long enough, and the dog is functioning well during training, crowning is not essential. But there will always be a risk of repeated fracture of that canine tooth or fracture of one of the other canine teeth because the normal equilibrium/balance of the biting grip with four canine teeth has been lost. Furthermore, the exposed dentine will easily wear and the crown height will diminish.

The size of the coronal part of the tooth necessary for successful crown therapy by cementation is still unknown. No guidelines have been agreed upon in the recent veterinary dental literature. In 1978 Scheffler stated that at least 1/3 of the coronal part of the tooth should be available for successful crown therapy (43). In 1994 Coles stated that crown placement on canine teeth requires at least 2/3 of the coronal part of the tooth to be present if retention of the crown is to be maintained by cementation only (10). If less than 2/3 of the coronal part of the tooth is left, then a core build-up or a core build-up and a post should be used to add retention (10, 13, 44).

Very little information about the results of crowning teeth in working dogs has been reported. In 1966 Jirava et al. described clinical observations concerning six injured canine teeth.

RESULTS
Nineteen metal crowns were placed on the canine teeth of seven working dogs. In all dogs training activities were started a few days to one week after the crown therapy was performed. The first training was carried out with prudence to give time for the dogs to get accustomed to their "new bite". Because a thorough oral examination in these dogs, for example, to obtain information about the periodontal status, is not possible without sedation or anaesthesia, the follow-ups were made by telephone calls only. The first interview was undertaken one month after treatment when the dog was already working. Many telephone calls were made at irregular times to keep informed about the results. At the end of this study a telephone interview was made with the owners of the treated dogs. All owners of the patients were satisfied. The full biting capacity and the general suitability for service had returned to normal. The four dogs with metal crowns on all four severely abraded canine teeth were in full function and were winners in competitions. Two of the three dogs with only one metal crown were working as they had before the fracture had taken place. One dog was now used as a watchdog (Table 1).

Two years after the last of the 19 metal crowns was placed, 17 were still in place and all dogs were still in function (18).
(with no pulp exposure) in five dogs treated with a metal crown, the last control being made after about 12 months (28). It was not reported whether these dogs were working dogs. Since then there have been several reports of prosthetic metal crowns, most being case reports with no follow-up or long-term evaluations (3,8,11,12,23,28,31,3,6,39,40,42,48,49,53). Greck \ et al. described a case of enamel hypoplasia in a young Boxer in which four crowns were placed. These east crowns remained clinically adequate in this guard dog over a period of 12 years (22). Scheffler (1978) reported crown covering of 23 fractured canines in 14 service dogs. These fractures reduced the dogs' biting ability and general suitability for service. After treatment full biting ability returned and the dogs withstood tests for over 2 - 3 years (43). There was no follow-up report.

Reconstruction of a fractured canine tooth in combination with the acid-etching technique is indicated if enough enamel is present. As there is never too much retention, crown lengthening is sometimes indicated and can be achieved by gingivectomy, osteoplasty, or an endodontic post and core build-up.

The results of the present study indicate that crown therapy for fractured or abraded canine teeth in working dogs is successful if sufficient clinical crown length is available. In this study all owners of the seven working dogs, in which 19 metal crowns were placed, were satisfied with the result. The re-duction of biting and/or gripping ability before treatment disappeared after one or two training sessions after treatment. Full biting ability and general suitability for service were restored to normal. The fact that two teeth fractured and lost the metal crown with it shows that the coronal part of the treated teeth had been of sufficient length to keep the metal crown in place (Figure 8).

Some important facts should be taken into consideration before crown therapy is performed in working dogs:

- First of all, the owner of the dog should realize that the crown restoration of a canine tooth will be weaker when sound tooth structure is replaced by the crown. Therefore, preparation of sound tooth tissue should be kept to a minimum and the use of posts minimized. In human dentistry a circumferential crown preparation is standard. The crown preparation used in this study is different in that it was restricted to the elimination of undercuts and contacts with antagonistic teeth to create sufficient space for the crown. With the final crown the original contour of the crown will not be restored, but an overcontour will be present if there is space available. During preparation an effort should be made to stay in the enamel layer, as this provides a stronger bond for the adhesive technique than dentine does. In case of a more extensive preparation, the risk for fracture in the tooth will probably increase. The longitudinal grooves guide the metal crown into position and will provide better resistance and retention of the crown as they act as an anterotational lock.

Because aesthetic considerations are not important in working dogs, fracture-resistant metal crowns are the choice. The tip of the metal crown is rounded, as a sharp point might lead to overstress and loss of the crown, if the crown becomes entangled in leather armshields during training. The metal crown is always made slightly shorter as this will reduce the levering forces applied to the tip of the crown. With this shape, occlusal and lateral stress is minimized. The preferable length of the crown is discussed with the owner of the dog. In this study electrolytic etching of the internal surface provided sufficient retention to the resin based cement.

- Gingivectomy and/or osteoplasty can be considered to lengthen the clinical crown (34,37). If the length of the stump of the tooth is inadequate, crown therapy has a poor prognosis. More crown lengthening by osteoplasty or other alternatives may be necessary if there is not enough crown length for the crown therapy used in this study. Further research on minimal crownheight for successful attachment of metal crowns and the possibilities for crown lengthening should be undertaken.

- The choice of cement used to fix metal crowns on the canine teeth of working dogs is of importance. Glass ionomer and the resin composite cements have recently been developed; they have gained popularity because they have the capacity to bond to tooth structures. These cements have strong resistance to crushing, and work well for cementing crowns in working dogs (24,25,26,44,51). In comparison to other types of cements, the resin cement Panavia Ex* has the highest compressive and tensile strength (49). The use of Panavia Ex* cement in veterinary dentistry has been reported but details of the methods used and results obtained were not given (2,26,51). In this study Panavia Ex* was found effective and provided adequate retention. It is a composite of low viscosity and it is claimed to have very strong bonding to sand-blasted metals (52). Another advantage of Panavia Ex* is the absence of }

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**Figure 8.** This canine tooth fractured four months after placement of the metal crown. The metal crown did not cover the whole clinical crown and a fracture line went through the remaining tooth. It shows that the coronal part of the treated tooth had been of sufficient length to keep the metal crown in place. The used Panavia cement provided adequate retention.
mico leakage of the crown (46). Studies in monkeys showed good bio-compatibility of resin composite cements as these materials are well accepted by pulpal tissue. Studies to evaluate the pulpal responses to resin adhesive resins and composite have shown that there is no detrimental effect on the pulp (27,38). Transdental fixation was described by Küpper and Bienek (32). A successful method for attaching a cast crown to fractured non-vital canine teeth not only by cementing but also by transverse bolting was described by Fahrenkrug (15,16,17,44). In the case of failure such a technique will probably result in a fracture extending to the root.

CONCLUSION

From the present study it is concluded that abraded and fractured canine teeth with sufficient length can be effectively restored with metal crowns. A resin cement with adhesive properties in combination with a retentive surface on the tooth and crown provides a strong bond. When there were failures (2 out of 19), these were not due to adhesive failure but to a new fracture through the tooth.

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