Radiological, histological and clinical side effects of incisor trimming in rabbits

L. Gentsch-Baumberger[1], P. Roux[2], D. Bosshardt[3], P. Kircher[4]

[1]University of Zürich, Switzerland; [2]Dentovet Sàrl, Lausanne, Switzerland; [3]Robert K. Schenk Laboratory of Oral Histology, University of Berne, Switzerland; [4]Clinic for Diagnostic Imaging, University of Zürich, Switzerland

https://doi.org/10.17236/sat00421

Eingereicht: 14.07.2023
Angenommen: 07.02.2024

Radiologische, histologische und klinische Auswirkungen des Kürzens der Schneidezähne bei Kaninchen

Eine Malokklusion der Schneidezähne bei Kaninchen (*Oryctolagus cuniculus*) ist ein häufiges klinisches Problem in der Tierarztpraxis. Eine ungenügende Abnutzung führt bei einem durchnittlichen Längenwachstum von 2 mm/Woche schnell zu Ernährungsschwierigkeiten und Schleimhautverletzungen. Deshalb müssen zu lange Schneidezähne alle drei bis sechs Wochen gekürzt werden. Das Ziel dieser Studie bestand darin, die möglichen pathologischen Auswirkungen auf Zahn- und Parodontalgewebe zu bewerten, die mit den drei am häufigsten verwendeten Kürzungsmethoden verbunden sind: Nagelschneider, diamantbeschichtete Trennscheibe und Diamantbohrer.

Der linke Unterkieferschneidezahn von 28 gesunden Neuseeländer Kaninchen wurde viermal mit einer der drei Schnittmethoden gekürzt. Nach der Mastperiode wurden die Unterkiefer und beide Unterkieferschneidezähne anhand von Zahnröntgenaufnahmen, Mikrocomputertomographie-Scans und histologischen Schnitten untersucht. Zahn- und parodontale Gewebeveränderungen wurden bewertet.

Diese Studie ermöglichte eine genauere Aussage über die möglichen kurzfristigen Nebenwirkungen der drei Methoden zur Kürzung von Incisivi bei Kaninchen. Auf klinischer Ebene verursachte der Nagelschneider die Bildung einer unregelmäßigen Kaufläche mit scharfen Kanten. Beide maschinenbetrieben Methoden ermöglichten die Erzielung einer glatten Oberfläche, wobei die Trennscheibe unpräziser war als der Diamantbohrer. Die histologische Auswertung ergab, dass bei der Kürzung mittels Nagelschneider primäre Veränderungen, darunter koronale Frakturen, Verbreiterung und Entzündung im Bereich der parodontalen Fasern, reparatives Osteodentin, Paracementosis und Biofilmansammlung auftraten.

Schlüsselwörter: Diamantbohrer, Kegelstrahl-Computertomographie, Trennscheibe, Nagelschneider, Zahnerkrankung, *Oryctolagus cuniculus*

Summary

Incisor malocclusion in rabbits (*Oryctolagus cuniculus*) is a common clinical problem seen in general practice. Given that the growth rate is about 2 mm per week, a lack of wear quickly leads to feeding difficulties and soft tissue injuries. Therefore, pathologically elongated incisors must be shortened every three to six weeks. The goal of this study was to assess the potential adverse effects on dental and periodontal tissues associated with the three most commonly used trimming methods: nail cutter, diamond-coated cutting disc and diamond burr.

The left mandibular incisor of 28 healthy New Zealand rabbits was subjected to four trimmings with one of the three cutting methods. After the fattening period, the mandibles were collected and both mandibular incisors were investigated on dental radiographs, micro-computed tomography scans and histological sections. Dental and periodontal tissue changes were evaluated.

This study allowed a more accurate statement of the potential short-term adverse effects of the three trimming methods. At the clinical level, the nail cutter caused the formation of an irregular occlusal surface with sharp edges. Both engine-drive methods allowed the attainment of a smooth surface but the disc was less accurate. Histological evaluation revealed that the primary modifications, including coronal fractures, periodontal ligament widening and inflammation, reparative osteodentine, paracementosis and biofilm accumulation, were found in the nail cutter group.

Keywords: burr, cone beam computed tomography, disc, nail cutter, dental disease, *Oryctolagus cuniculus*

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Introduction

Rabbits (*Oryctolagus cuniculus*), like other herbivore mammals, have a specific dentition, which is specially adapted to a high fibre diet. All teeth have a long anatomical crown with an open apex (aradicular hypsodont) with germinative tissue enabling continuous tooth growth (elodont) to balance attrition. In practice, the tooth is divided into two parts: the clinical crown and the reserve crown. The dental formula of the permanent dentition is as follow: $I^{2/1}$; $C^{0/0}$; $P^{3/2}$; $M^{3/3}$ = 28.[18,21,32] The mandibular and maxillary first incisors have enamel on the vestibular and lateral side only, to enable constant sharpening of the occlusal surface. The second maxillary incisors, occluding with the mandibular incisors, are known as peg teeth and are distinctive of the *lagomorpha* order.

In the last few decades, rabbits have become increasingly popular pets and are now the third most common companion mammal in many countries in Europe and in the United States.[36] The owners are better informed about the physiological needs of those animals and are concerned about their wellbeing. As dental disease affects between 25 % and 40 % of domestic pet rabbits, it is the leading cause of veterinary consultations[23,29,35] and veterinarians need to be familiar with their causative factors and treatments. Incisor malocclusion is a common problem, particularly in young dwarf rabbits.[22] The most frequent cause is a genetically-induced maxillary brachygnathism, leading to a Class 3 malocclusion.[14,22] In older animals, it has also been stated that this condition could be secondary to an acquired cheek teeth malocclusion[46,19] but a new study suggests that these two types of malocclusions are not associated.[37] Other possible causes are trauma, abscess and neoplasia. The eruption rate of incisor teeth is 1,6 to 2,2 mm per week,[34,47] therefore insufficient dental wear can quickly lead to overgrowth. Maxillary incisors, which are more curved, may curl into the mouth, sometimes causing injury to the palate. The mandibular incisors have a less pronounced radius of curvature. In the absence of wear, they grow towards the nose, inflicting trauma on soft tissues and sometimes even bones. Affected animals display feeding difficulties, ptyalism, pain, weight loss and anorexia. Various management options are described in the literature. The surgical approach, which is the only way to achieve a long-term alleviation,[4,19,25,38,31] involves removal of the 6 incisors. The second, more conservative option, consists in tooth height reduction every three to six weeks.[3,4,18,20,46] Normal clinical crown length for maxillary and mandibular incisors is around 6 mm.[39] Great care has to be taken to avoid pulp exposure as the pulp cavity often extends above the gingival margin in rabbits with incisor malocclusion.[9,10] If the pulp is exposed, it is recommended to perform a partial pulpectomy and a pulp capping to minimise the risk of pulpitis, pulp necrosis and abscess formation[4,31] To ensure the quality of life for these rabbits, treatment must be carried out on a regular basis.[3,28] Frequent follow-up may be restrictive for owners,[38] sometimes resulting in abandonment or premature euthanasia.

Clipping the incisor teeth with nail clippers is the traditional approach to shortening overgrown incisors[18] and this method is still used by some owners and breeders. Within the European and American College of Veterinary Dentistry (EVDC/AVDC), this treatment is linked with great risks and is strongly disapproved for multiple reasons.[3,4,6,19,25,28]

- Risk of longitudinal fractures or fissures, possibly involving the pulp chamber
- Pain due to the tension on the highly innervated periodontal ligament
- Damage caused by forces applied on the germinal tissues
- Non-return to a physiological chisel shape of the teeth
- Creation of spikes and sharp edges that lead to lip injuries

Dental specialists recommend the use of a diamond burr with a high-speed turbine to cut owergrown incisors. A cutting disk mounted on a straight handpiece or a Dremel tool can also be used, but this technique may inflict soft tissue injury.[46] In both cases, water cooling is required to prevent thermal damage to the pulp cavity.[18] Until now, there is no evidence-based study comparing these different trimming methods. The goal of this publication was to evaluate the possible dental and periodontal tissue changes when using nail cutter, diamond-coated cutting disc or diamond burr for rabbit incisor crown reduction.

Material and methods

Experimental protocol

Twenty-eight healthy rabbits (males and females) were used (bred for meat, New Zealand White Rabbit) from the age of weaning (4–5 weeks) to the end of fattening (51 days later). In agreement with the Swiss cantonal committee on animal experimentation, we chose to use rabbits intended for meat industry. As only the skulls had to be collected, the rest of the carcasses remained suitable for human consumption, thus avoiding the unnecessary sacrifice of several individuals. All rabbits were housed with other rabbits in the same type of box and received the same nutrition: hay, pellets (Pellets UFA 856, UFA SA, Herzogenbuchsee, Switzerland) and water. Each rabbit was individually identified with a colour mark on the croup and a number marking on the ear. The rabbits were randomly assigned to 4 groups (NC, DI, BU, CO) (Table 1).

In the groups NC, DI and BU, the left mandibular incisor was cut 2 mm apical to the incisal edge with the method according to the group. This treatment protocol was repeated 4 times, at day 0, day 21, day 37 and day 49. The last shortening was made 2 days before slaughter (at day 51 after the start of the procedure). At each step, the rabbits were weighed, their mandible was palpated and photographs were taken after the trimming.

Although recent publications recommend performing incisor shaping under anaesthesia,[25] we chose to perform the treatments on non-sedated rabbits, to be as consistent as possible with what is done in practice. At the end of the fattening period, the rabbits were stunned with electricity and bled (normal slaughtering procedure for meat) and the heads were collected. The mandibles were directly removed from the skull and both halves separated with a scalpel blade. Thereafter, both right and left mandibles including the lower incisors with surrounding periodontal and soft tissues and the cheek teeth, were placed in 4% buffered formaldehyde solution.

Radiographic processing and analysis

We used a dentistry image plate (CR7 Vet Size 2, iM3, Duleek, Ireland) with a distance object-film of 40cm. The X-Rays source (Acteon X-Mind DC, Acteon, Mérignac, France) was set at 60kV and 10mAs. Each mandible was separately radiographed in lateral and posterior-anterior position. The digital radiographs were examined for dental (fractures, reserve crown elongation, pulp alteration, heterogenous aspect) and periodontal changes (delineation by the lamina dura, sclerosis, heterogenous or radiolucent bone area) as described by Van Caelenberg[43] with the software Horos (Horos Project, Annapolis, MD, USA).

Tomographic processing and analysis

All scans were made by a µCT 40 (Scanco Medical AG, Wangen-Brüttisellen, Switzerland), a desktop Cone-Beam micro-scanner with the following parameters: the X-Ray source (E) was set at 70 kVp, with 114 mA at high resolution

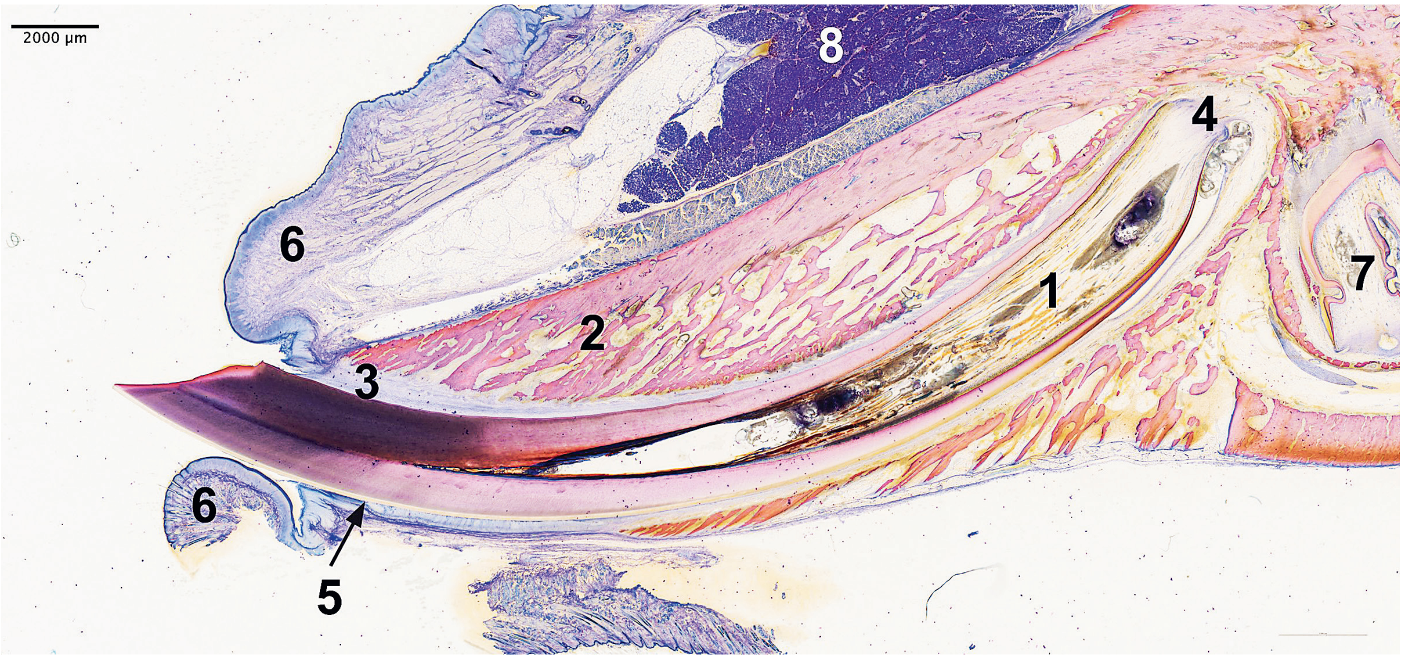


Figure 1: Tissues of a central histologic section of a mandibular incisor a rabbit (*Oryctolagus cuniculus*). Toluidine blue and basic fuchsin staining. 1. pulp, 2. alveolar process, 3. periodontal ligament, 4. germinative tissues, 5. junctional epithelium, 6. upper and lower lips, 7. first ventral mandibular premolar, 8. glandular tissues.

Table 1: Distribution of rabbits (*Oryctolagus cuniculus*) in the different groups according to the trimming method used.

Group NC	8 animals	left mandibular incisor trimmed with a **nail cutter**
Group DI	8 animals	left mandibular incisor cut with a **diamond cutting disc** mounted on a straight low-speed handpiece coupled to a micromotor
Group BU	8 animals	left mandibular incisor cut with a **diamond burr** mounted on a high-speed handpiece coupled to a micromotor
Group CO	4 animals	**Control,** no treatment

(1000 projections/180°), which showed an image matrix of 2048 x 2048 pixels; the diameter of the sample holder was 36 mm which allowed an Increment (Resolution) of 18 µm (= voxel size); Integration time was set on 300 ms. DICOM-Files were converted after measurements. The DICOM studies from all rabbits were retrieved and analyzed with the software Horos. Criteria identical to those used for conventional radiographs were evaluated. The goals with the µCT examination was to highlight more subtle modifications (ligament space widening, teeth resorption).[37]

Histological Processing

The chemically fixed jaw segments were dehydrated in an ascending ethanol series and embedded in methylmethacrylate. Non-decalcified sections of approximately 500 micron-thick slices were cut in a bucco-lingual direction using a low-speed diamond saw with coolant (Varicut® VC-50, Leco, Munich, Germany). After mounting the sections onto acrylic glass slabs, they were ground and polished to a final thickness of about 100µm (Knuth-Rotor-3, Struers, Rodovre/Copenhagen, Denmark). The sections were then stained with toluidine blue and basic fuchsin and the two most central ground sections were used for qualitative and semi-quantitative analyses. Digital photography was performed using a ProgRes® C5 digital camera (Jenoptik Laser, Optik Systeme GmbH, Jena, Germany) connected to a Zeiss Axioplan microscope (Carl Zeiss, Göttingen, Germany). Qualitative histological analysis of each section (Figure 1) was performed in order to characterize dental (pulpitis, fracture, dentin or enamel modification) and periodontal (biofilm, gingivitis, periodontitis, periapical abscess) lesions.

Ethics Approval

The study was approved by the ethical committees of the canton of Berne (permit BE69/13), and all experiments were performed in accordance with relevant institutional, national, and international guidelines and regulations.

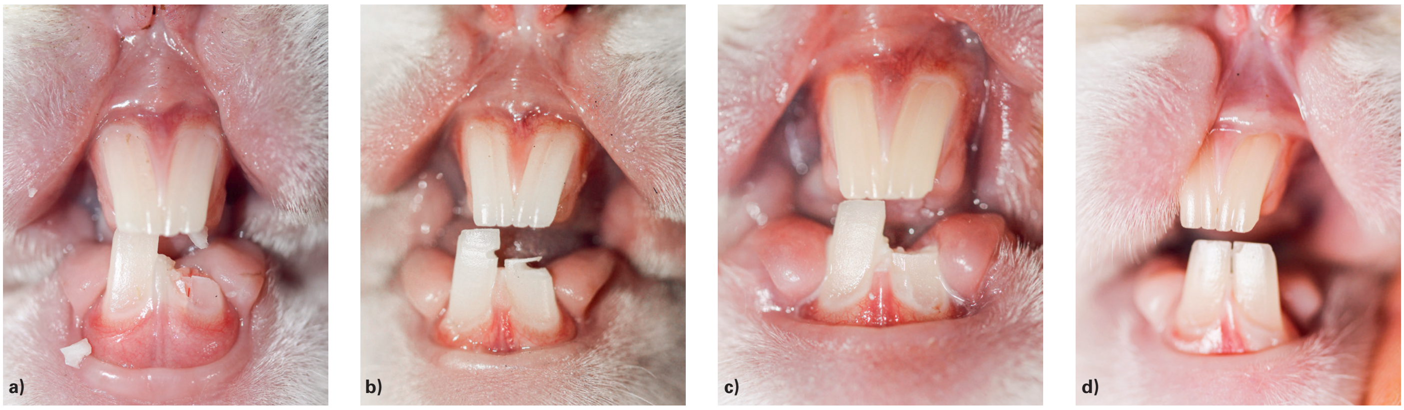
Results

Clinical findings

Two rabbits died during the experiment, one in the DI-group and one in the BU-group. The cause of death was not linked to any dental problems (signs of pneumonia). No difference in weight gain was observed between the groups. Representative images of the three trimming methods are grouped in the Figure 2. In the majority of cases, the result of the cut with the nail cutter created an irregular incisal surface with small sharp fragments. In contrast, both engine-drive methods were more accurate and the incisal edge was smooth. In 8 out of 24 cases of shortenings with the cutting disc, the neighbouring right incisor was also partially cut (Fig. 2). Treatment was easily performed without anaesthesia, provided that the rabbit was adequately restrained by an experienced helper.

Radiographic analysis

Radiographs did not reveal the presence of severe periodontal lesions such as radiolucent areas or bone sclerosis.[1] Reserve crown elongation was also absent. The table 2 shows the distribution of the changes listed in each group, as well as examples to illustrate them.

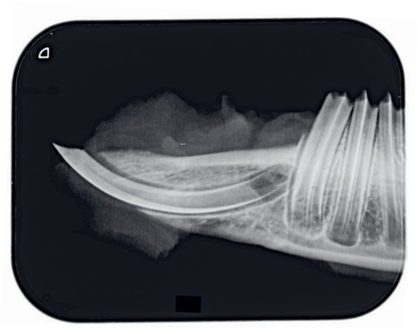
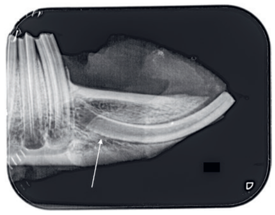


Figures 2: Illustrations of the incisors of 4 rabbits (*Oryctolagus cuniculus*) just after the trimming with the different techniques (**a:** nail cutter (NC), **b:** cutting disc (DI), **c:** diamond burr (BU), **d:** Control (CO))

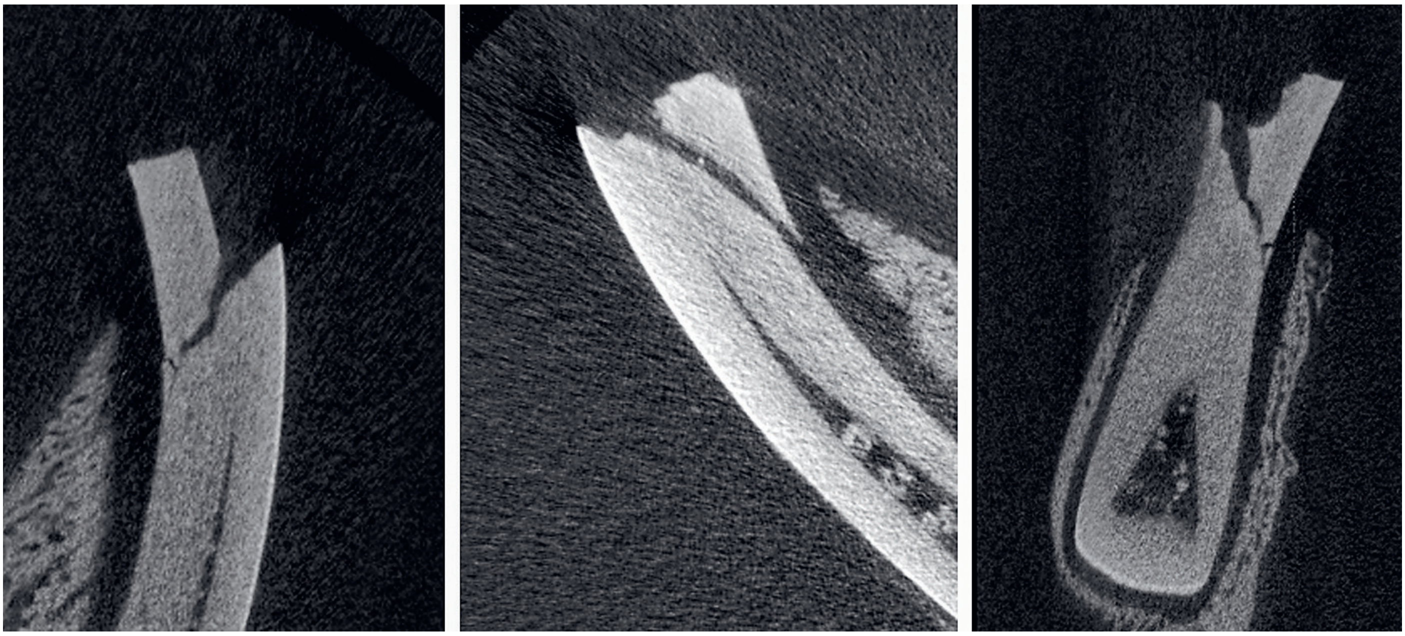
Tomographic analysis

Coronal tooth fractures were only found in the group treated with the nail cutter (Figure 3). The damage was limited to the occlusal end of the tooth, no longitudinal fractures were observed. However, an enlargement of the periodontal ligament space was noticeable at the level of the fracture zones. We did not find signs of osteolysis or sclerosis. The pulp cavity was apparent throughout the whole tooth length, and appeared to be open in most teeth, with a fine portion of the cavity discernible until the incisal edge. Pulp calcification was also present in many teeth (16/28), equally spread over all groups (Table 3).

Table 2: Frequency of occurrence and illustrations of radiographic dental changes, observed in the different treatment groups of 28 rabbits (*Oryctolagus cuniculus*).

Group	Treatment	Coronal Fracture	Heterogenous aspect of the pulp cavity	Unsharp delineation by the lamina dura
NC	Nail Cutter	3/7*	5/7	5/7
DI	Disc	0/7	5/7	4/7
BU	Burr	0/7	4/7	7/7
CO	Control	0/4	2/4	2/4
Normal teeth 				

*One radiograph of the NC-group couldn't be used for the interpretation because of superposition artifacts.



Figures 3: Example of different coronal fractures of incisors in rabbits (*Oryctolagus cuniculus*) after nail cutter trimming highlighted by dental cone beam computed tomography (CBCT).

Table 3: Frequency of occurrence of tomographic changes observed in the different treatment groups of 28 rabbits (*Oryctolagus cuniculus*).

Group	Coronal Fracture	Pulp cavity open to occlusal edge	Calcification in the pulp cavity
NC	6/8	8/8	5/8
DI	0/7	7/7	4/7
BU	0/7	5/7	4/7
CO	0/4	3/4	3/4

NC: Nail Cutter, DI: Disc, BU: Burr, CO: Control

Histological evaluation

Except for superficial fissures seen on one burr-trimmed incisor, all fractures were seen in the NC-group and were localised exclusively on the clinical crown (Table 4).

If a fracture line extended to the periodontal tissues, it was always associated with a local inflammatory reaction and widening of the periodontal ligament space on the lingual side (Figure 4). Inflammation was characterised by the presence of polymorphonuclear cells located in the region of the fracture line. No bone alterations were present opposite to the lesions. No gingivitis was found in any rabbit. We additionally noticed that the vestibular junctional epithelium was detached from the tooth surface in some specimens, independently of the group, and without being associated with other changes of the periodontium.

In one case in the NC-group, we observed the presence of irregular cementum deposits on the vestibular enamel layer (Figure 5). This phenomenon was associated with the loss of attachment of the coronal junctional epithelium and important accumulation of organic material and polymorphonuclear cells in this periodontal pocket.

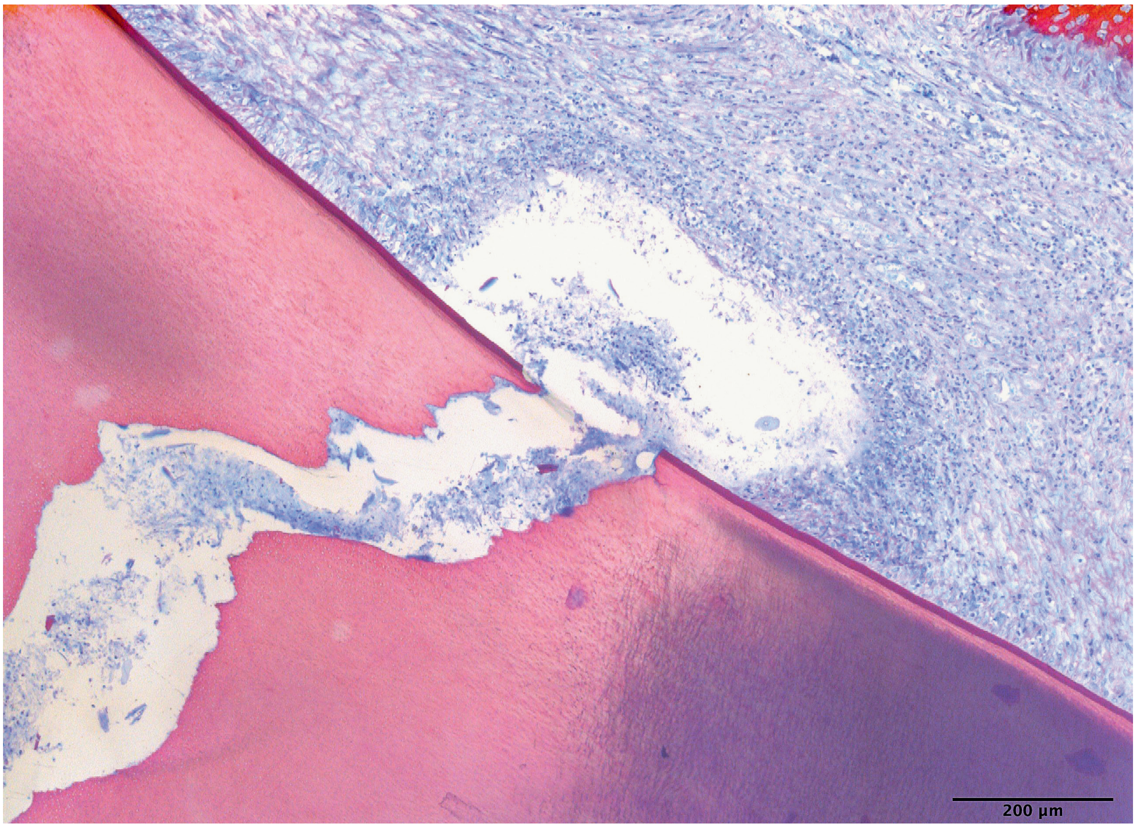


Figure 4: Dental fracture, local inflammation and enlargement of the periodontal ligament space of an incisor in a rabbit (*Oryctolagus cuniculus*) of the nail cutter (NC)-group. Toluidine blue and basic fuchsin staining.

In two cases (both in NC-group), the normal tubular dentin at the coronal edge of the incisor, was replaced by a bone-like structure (Figure 6). This occurrence was correlated with the presence of coronal fracture.

Biofilm was present only on the unregular occlusal surface created by shortening. The quantity of this deposit was more pronounced in the NC-group but also present in the BU-group. No biofilm formation was observed on the vestibular or lingual tooth surfaces, in any of the groups.

In the pulp cavity, many artefacts (detachment of pulp tissues coronally) and calcifications hampered a more detailed analysis. No signs of inflammation were found in the pulp cavity itself. Only a mild pulpitis was noticed apically in one burr-trimmed tooth.

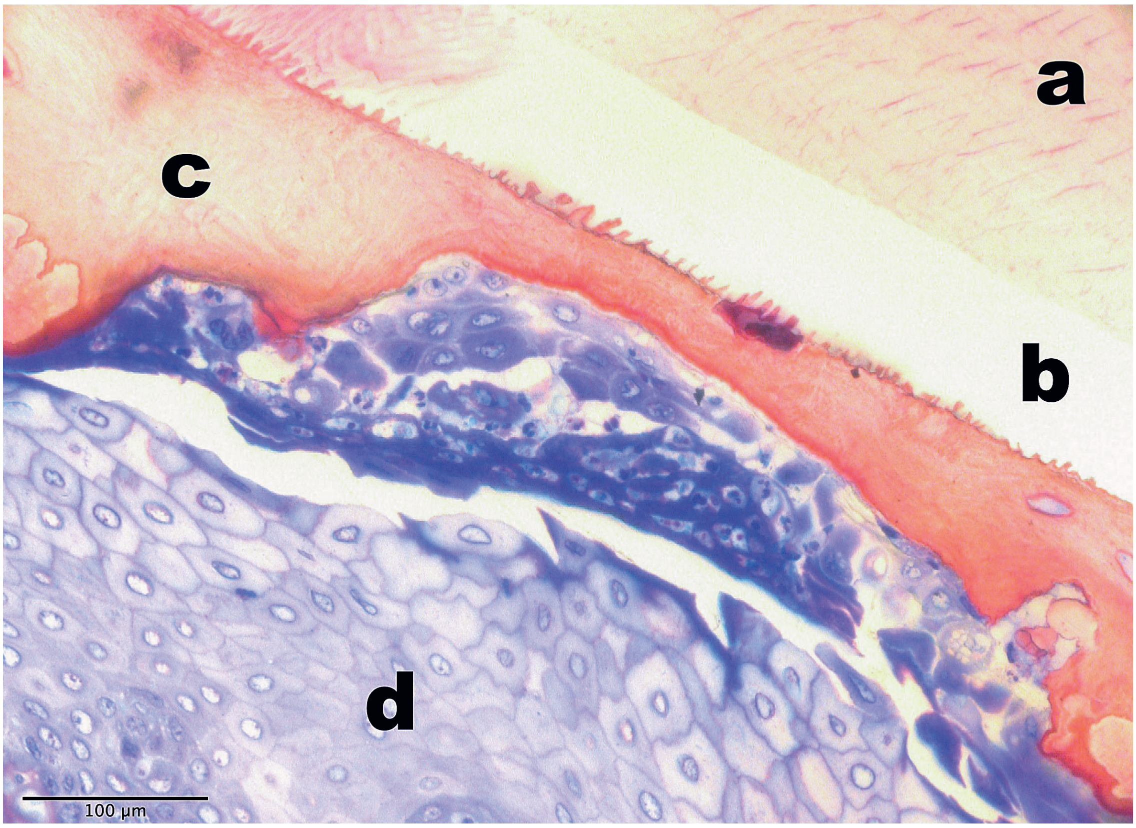


Figure 5: Histology picture of an incisor, trimmed with a nail cutter (NC), in a rabbit (*Oryctolagus cuniculus*). Zones of cementum deposits, presence of many neutrophils on the enamel of the vestibular side of the incisor and detachment of the junctional epithelium. Toluidine blue and basic fuchsin staining. **a)** Dentin **b)** Enamel **c)** Cementum deposit **d)** Junctional epithelium (detached)

Table 4: : Criteria observed on the histological sections of dental and periodontal tissue in 28 rabbits (*Oryctolagus cuniculus*) after 4 dental trimmings.

	GROUP	NC	DI	BU	CO
Coronal fracture	Fracture	5/8	0/7	0/7	0/4
	Superficial fissure	2/8	0/7	1/7	0/4
Biofilm accumulation	Mild	3/8	0/7	3/7	0/4
	Moderate	4/8	0/7	1/7	0/4
Osteodentine		2/8	0/7	0/7	0/4
Cementum deposit		1/8	0/8	0/7	0/4
Inflammation in the perdiodontal ligament		5/8	0/8	0/7	0/4
Pulpitis		0/8	0/7	1/7	0/4

NC: Nail Cutter, DI: Disc, BU: Burr, CO: Control

Discussion

Clinical considerations

The mortality rate (7,1 %) during the fattening period in our groups aligns with the 8,5–13,9 % reported in French meat rabbit breeding.[24]

Regarding the teeth, we observed uneven incisal edges with multiple splits after trimming with a nail cutter, representing a considerable risk of soft tissue injury. The incisal surface was generally smooth and regular when using engine-driven cutting systems. However, with the diamond disc, the cut was less precise, occasionally resulting in partial cutting of the neighbouring right incisor as well. This observation needs to be put into perspective, as in practice both mandibular incisors are shortened. While not utilized in our study, a protective cover can be added to the handpiece around the disc to prevent soft tissue and operator injuries should the animal move. The treatment interval was approximately 14 days. After this period, no differences in form and in length were observed between treated and untreated teeth. These observations correlate with the growth rate of the mandibular incisors (2,2 mm a week) published by Wyss et al..[47]

Dental alterations

We hypothesized that we would encounter the primary conditions described in the literature, such as longitudinal crown fractures, pulpitis and abscesses. However, the observed alterations were more subtle.

Fractures

All fractures were situated in the clinical crown, approximately at the level of the gingival margin (Figure 3). Their incidence was notably high in the nail-cutter group, with only one out of eight incisors in this group displaying an intact clinical crown. In comparison, we found only superficial fissures in one burr-trimmed tooth. Contrary to previous publications,[3,10,19,46] we did not identify any longitudinal fractures.

Pulpitis

Trimming with any the three methods did not result in visible signs of pulpitis, contrary to what is commonly observed after pulpal exposure in horses[11,44] and dogs.[16] We attribute this result to our decision of trimming only two millimetres of the coronal tip of the incisor, for animal welfare reasons. Consequently, the inflammatory reaction provoked by the procedure was not strong enough to cause

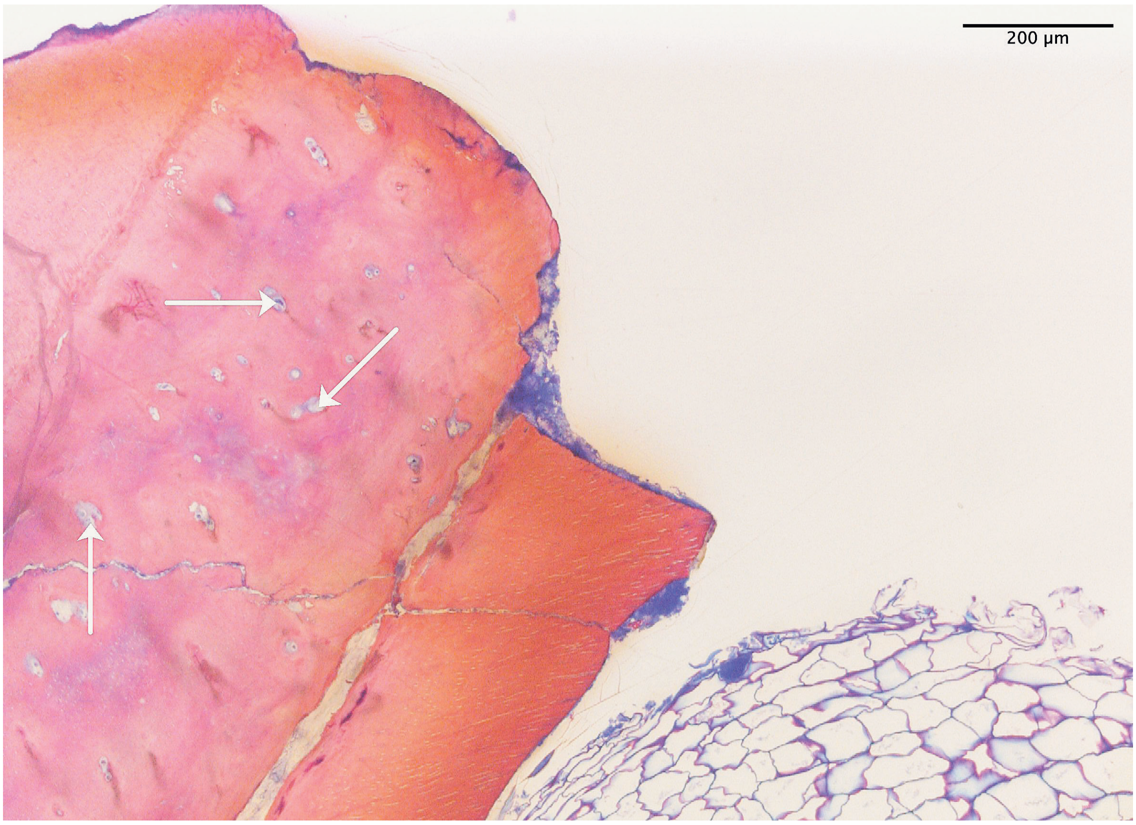
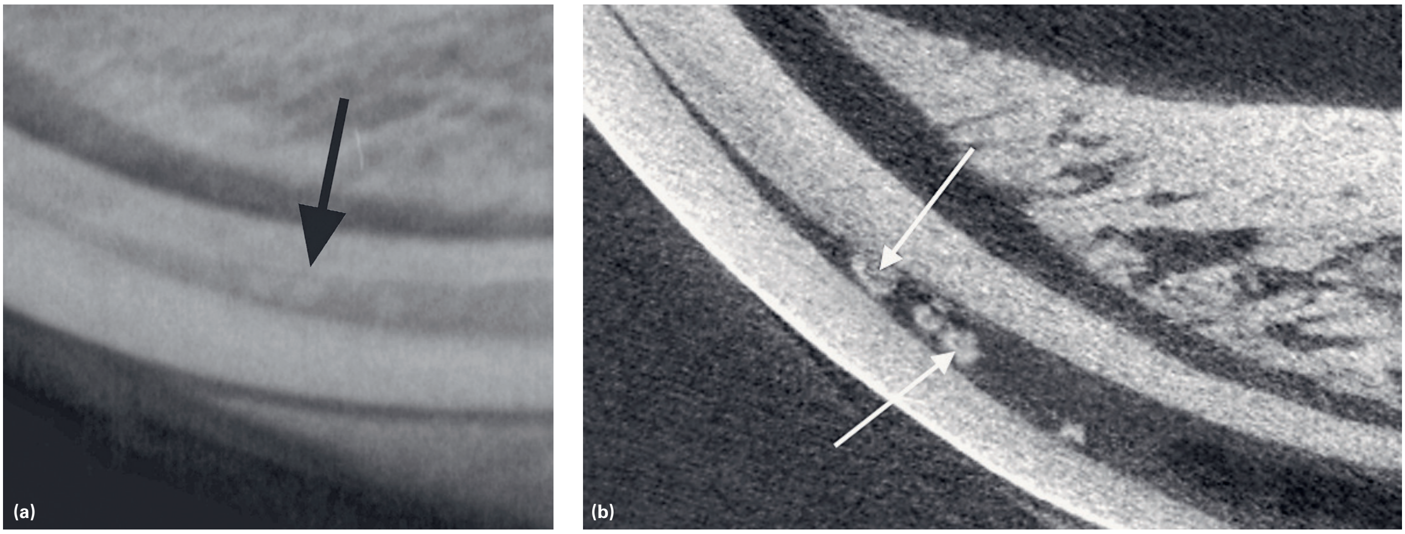


Figure 6: Dentin with an osteoid-like structure (arrows) at incisal edge of one incisor in a rabbit (*Oryctolagus cuniculus*) of the nail cutter (NC) group. Toluidine blue and basic fuchsin staining.

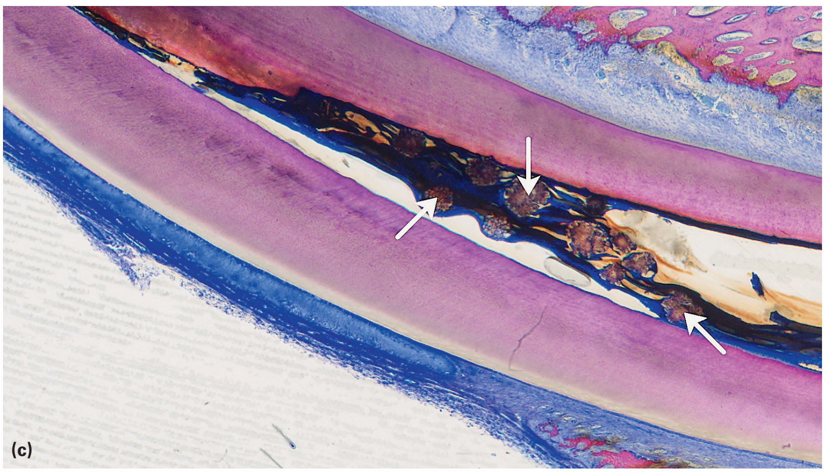
pulpitis. In rabbits with a normal occlusion, the pulp ends at the level of the gingival margin. However, in the absence of attrition, the tooth tends to elongate, causing the pulp to extend beyond the gingival margin, up to 5,7 mm in the mandibular incisor and 4,2 mm in the maxillary incisor.[9,19] In practice, the teeth are cut as short as possible, near the gingiva, with the aim to extend the interval between the treatments. Given the frequent need for crown reduction in these rabbits, the likelihood of pulp exposure and inflammation could be increased in this population.

Pulp calcifications

Pulp calcifications were present in many teeth across all groups. We observed these radio-dense manifestations on radiographs, µCT-scans and histological preparations in all three treatments groups (Figure 7). These calcifications show similarities to pulp stones found in horses[7] and humans,[15,45] although they have not been described in rabbits until now. We observed some differences in their morphological appearance: in humans and horses, the external layers consist of concentric lamellae of regular calcified material, whereas in the rabbit teeth examined in this study, these structures were composed of an amorphous mass of irregular calcification. Pulp calcifications have been found in cases of advanced periodontal disease in humans[40] and in case of pulpitis in horses,[7] among other conditions. Conversely, they also have been reported from unerupted and clinically healthy teeth, the cause for their development is mostly unknown, not necessarily associated with systemic or pulpal disturbance.[15,45] In our study, they were not correlated with periodontitis or pulpitis. Unfortunately, these alterations also affected the assessment of the pulp, making fine details such as pulpal oedema and hyperaemia less reliably detectable. These calcifications may also be linked to histological preparation artefacts, as they were often associated with pulp rupture. To determine whether the histological processing contributed to this phenomenon, pulp fixation could be improved by cutting transversal tooth slices, enabling faster fixation of the pulp tissue, or by using other histological techniques.[12,48]



Figures 7: Calcifications (arrows) in the pulp of rabbit (*Oryctolagus cuniculus*) incisors were observable with radiography **(a)**, cone beam computed tomography (µCBCT) **(b)** and histology **(c)** (Toluidine blue and basic fuchsin staining) in all groups.



Osteodentine / Reactionary dentine

Dentine with an osteoid structure was found in two cases in the nail cutter group, located at the coronal end (Figure 6). In rodents,[41] osteodentine (a form of tertiary or reactionary dentin) is present during tooth development in neonates but normally absent in adults. In young rabbits (up to 3 months of age), osteodentine formation was already observed at the occlusal end of the pulp cavity and along the pulp in healthy subjects.[48] This dentine type was also observed in one study on apical cheek tooth infection in horses and the authors suggested a correlation with a chronic inflammatory pulp response.[7] Osteodentine is also recognised in humans to be the result of some sort of insult. As these observations in the present study were associated with fractures, we assume that the process is probably a sign of endodontic disturbance.

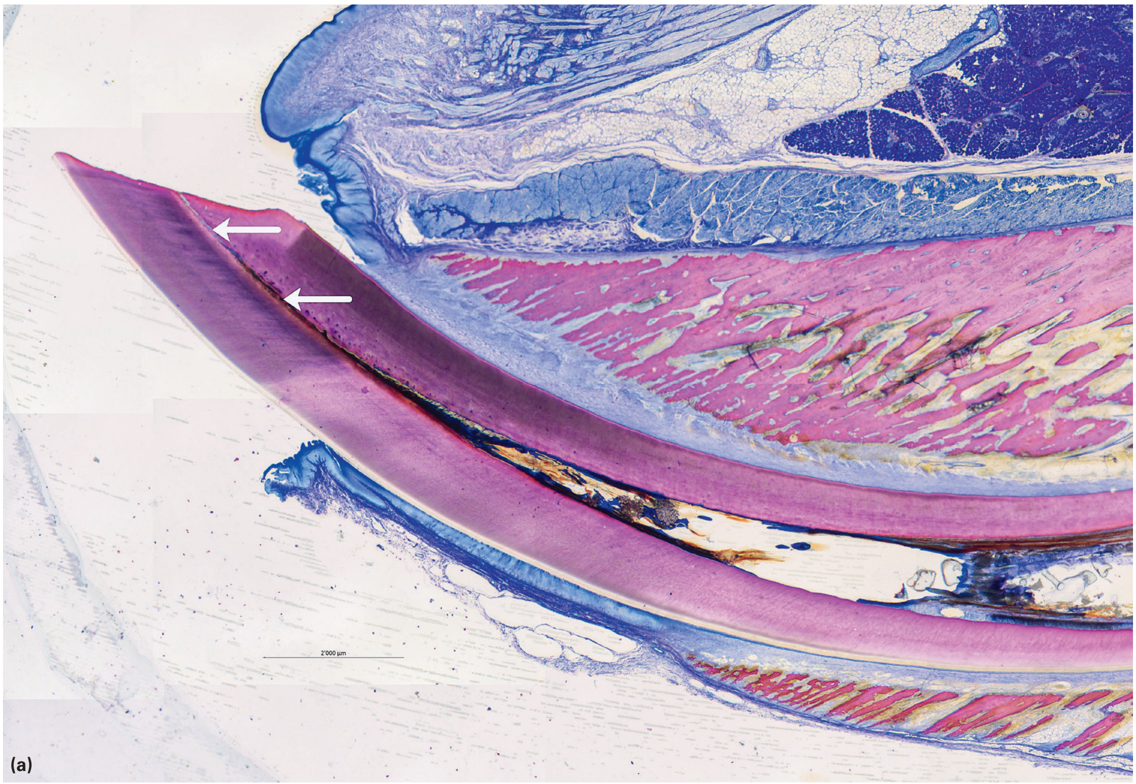
Communication between pulp chamber and attritional surfaces

The occlusal end of the pulp chamber was difficult to determine with accuracy. Indeed, in both treated and untreated teeth, the most coronal part of the pulp cavity appears not to be hermetically closed on the CT-images and histological preparations (Figure 8). In most cases, a thin canal remains unsealed toward the incisal edge. This contradicts other studies that have observed obliteration of the pulp cavity by deposition of osteodentine.[48] This particular and seemingly physiological opening of the pulp chamber, could be explained by the dentinogenesis mechanism in elodont teeth. The circumferential odontoblastic cell layer covering the cylindrical pulp chamber will progressively narrow up to a point where cells will face back-to-back. The continuous dentin secretion will increase the pressure, inducing morphological change (from tall columnar to low cuboidal cell shape), leading to the death of the odontoblasts and consequently halting dentin secretion. The absence of correlation between the observed pulp chamber opening and pulpitis leads us to speculate that constant tooth growth and attrition may prevent bacterial secondary infections.

Periodontal alterations

Cementum deposits on the enamel surface

In one case, histology revealed irregular cementum deposits on the vestibular enamel surface at an area where the junctional epithelium had detached, and there was a severe accumulation of polymorphonuclear cells in the gingival



Figures 8: A very thin open pulp cavity (arrows) in a rabbit (*Oryctolagus cuniculus*) incisor extended up to the attritional surface is visible in histology (Toluidine blue and basic fuchsin staining) **(a)** and cone beam computed tomography (µCBCT) **(b)** in most of the teeth studied.

pocket (Figure 4). It is surprising to find some cementum in an anatomical region where it is supposed to be absent (paracementosis). In human teeth, acellular afibrillar cementum is sometimes observed in form of islands on the coronal enamel as a result of focal degeneration of the reduced enamel epithelium. Coronal cementum (usually of the acellular type) is also found in many herbivorous species. In guinea pigs, pearls (or plaques) of cementum on the enamel are typically seen in molar teeth,[27] whereas sheep and rabbits[26] exhibit a more complete coverage of the molars' enamel surface by cementum. To the best of our knowledge, coronal cementum has never been described before in incisors of rabbits.

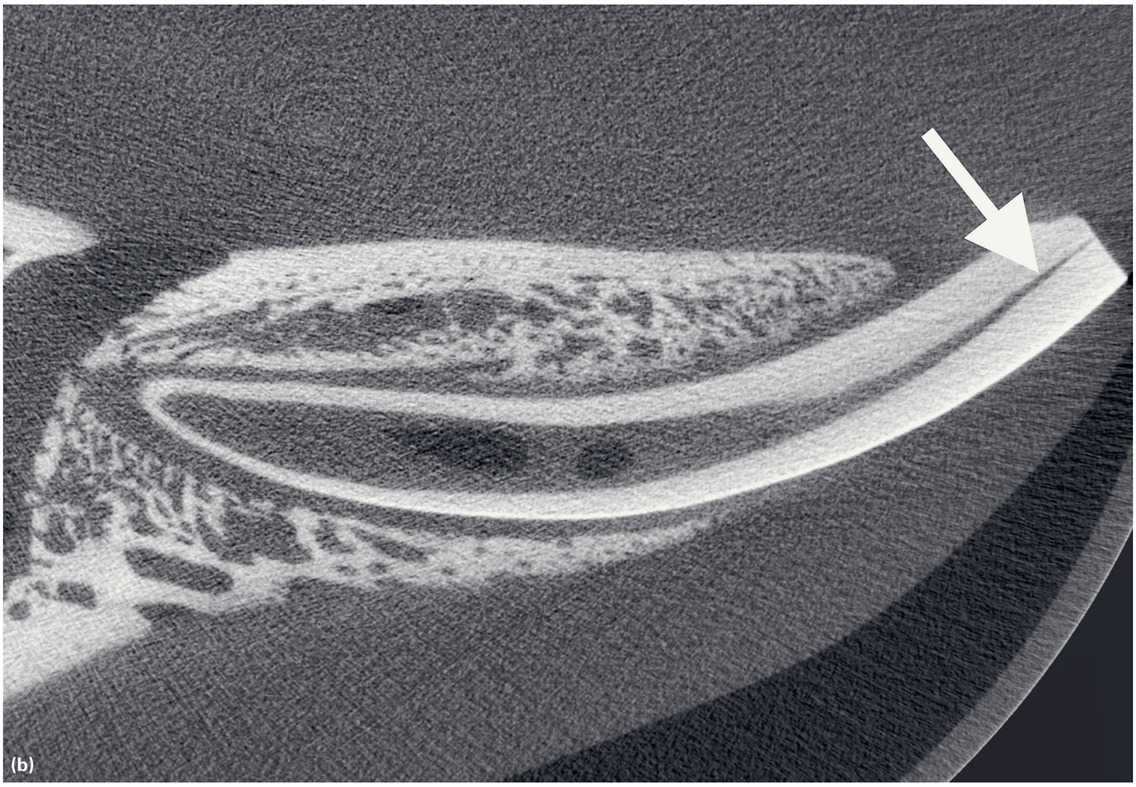
In the present study, cementum deposits were found in an inflammatory location, likely attributed to a loose junctional epithelium. A parallel can be drawn with the enamel anomaly named *enamel hypoplasia*. This developmental disturbance results in horizontal ridges or grooves on the vestibular surface of rabbits' incisors, giving the teeth a ribbed or 'washboard' appearance.[4] This hypothesis should be validated through a histological study of teeth exhibiting these visual defects on their surface.

Biofilm

In clinically healthy rabbits, incisor teeth with a normal wear-pattern and a smooth occlusal surface, have a complete absence of biofilm. Yet, we observed some biofilm deposits on the coronal sharp edges created by the nail cutter after treatment. Interestingly, we also found more biofilm in the burr-trimmed compared to the disc-trimmed group. Referring to studies that have compared the correlation between surface roughness and biofilm adhesion,[2,42] this could suggest that the surface is smoother after disc reduction. In general, lack of attrition will enhance biofilm deposition and retention. In horses, biofilm accumulation is known as a predisposing factor for periodontal disease and caries.[8,13] However, we conclude that the low amount of biofilm observed in our study have no detrimental effect, as no signs of gingivitis were observed.

Periodontal ligament space widening and inflammation

At the proximity of a fracture line, the periodontal ligament space was enlarged and infiltrated with polymorphonuclear cells. This inflammation was limited to the place where the fracture line encountered the soft tissues. Widening of the



periodontal ligament space around human teeth is one of the first visible signs of periodontal disease.[33] In rabbits, periodontitis also starts with enlargement of the periodontal ligament and loss of the adjacent alveolar bone.[37] We assume that a more pronounced or repeated mechanical insult may weaken the periodontal ligament, potentially serving as a risk factor for periodontitis. In certain incisors, across all groups, a detachment of the junctional epithelium and an accumulation of polymorphonuclear cells were visible on the vestibular side, deep in the gingival sulcus. The destruction of the integrity of this structure is a common finding in the initial stages of periodontal pocket formation, leading to periodontitis.[5] However, we were unable to establish a clear association with trimming and therefore, cannot make a definite assumption about the evolution of this modification.

Critique of research methodology

The tissue alterations and inflammation associated with the three treatment methods are relatively mild and less widely spread than expected. Young and growing rabbits were used for this study (about 3 months of age at the end of the fattening period). This could explain a higher capacity for adaptation and rate of regeneration when a lesion appeared, compared to older individuals. Secondly, the incisors in our study were healthy, without signs of malocclusion. We can speculate that these teeth were more resistant and less prone to fracture than elongated ones.[3,9] Moreover, we observed that the trimmed teeth returned to a macroscopically normal state after two weeks. Finally, for animal welfare reasons, we limited the trimming to 2 millimetres from the incisal edge of only one mandibular incisor to avoid painful pulp exposure and maintain normal food intake. The vital part of the pulp typically ends at the height of the gingival margin,[3] thus ensuring we did not cause pulp exposure during the trimmings. Additionally, the contralateral incisor, that was kept intact could protect the treated tooth and consequently reduce the extent of lesions.

To improve the study design, extending the experimental period (up to 6 or even 12 months) would likely provide more information about the long-term effects of regular incisor trimming in rabbits. It would also be useful to investigate crown shortening in rabbits with incisor malocclusion to determine if this condition also influence tissue morphology and consequently the array of lesions encountered.

In regards of the tools used to identify secondary effects, it is evident that conventional radiographs, even with the definition of a dental film, are not sufficiently reliable. Many coronal fractures were not detected and subtle changes such as periodontal ligament space widening were not recognized. The cone beam computed tomography (CBCT) holds the advantage of standardizing views and enabling necessary measurements. Finally, histology allows the evaluation of very fine and early processes but the production of standardized histological sections poses a challenge and would require the development of specific technical assistance (tomography, robotics).

Conclusion

This study provides a more accurate overview of the potential short-term side effects associated with the three most widely used trimming methods to shorten incisors in rabbits, namely nail cutter, diamond disc and diamond burr. The observed alterations predominantly affected periodontal tissues and, to a lesser degree, dental tissues. Trimming with a nail cutter clearly had the most detrimental dental and periodontal effects. We observed an increased incidence of coronal fractures, periodontal ligament space widening and inflammation, dentine structure modification (osteodentine), paracementosis and biofilm accumulation. These alterations may all represent predisposing factors for future endo- and periodontal diseases in case of repeated crown shortenings. Further studies are required to elucidate the long-term effects of trimming methods. Our observations confirm the current recommendations to use an engine-drive method when surgical incisor extraction is not considered.

Acknowlegments

The Authors would like to thank the team of the Robert K. Schenk Laboratory of Oral Histology (Bern) for their assistance in processing the samples, especially Mr. David Reist and Ms. Silvia Owusu for assistance in tissue processing and taking microscopic images, as well as Mr. Mark Siegrist from the Department for BioMedical Research (DBMR) of the University of Bern for his expertise in the field of computer tomography.

Declaration of Conflicting Interests

The Authors declare that there is no conflict of interest.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article. This work was supported by the Swiss Society of Veterinary Dentistry (SSVD) and the Swiss Veterinary Society (SVS).

Effets secondaires radiologiques, histologiques et cliniques de la taille des incisives chez le lapin

La malocclusion des incisives chez le lapin (Oryctolagus cuniculus) est un problème clinique courant en médecine générale. Étant donné que le taux de croissance est d'environ 2 mm par semaine, un manque d'usure entraîne rapidement des difficultés d'alimentation et des lésions des tissus mous. Par conséquent, les incisives pathologiquement trop longues doivent être raccourcies toutes les trois à six semaines. L'objectif de cette étude était d'évaluer les effets négatifs potentiels sur les tissus dentaires et parodontaux associés aux trois méthodes de taille les plus couramment utilisées : le coupe-ongles, le disque de coupe diamanté et la fraise diamantée. L'incisive mandibulaire gauche de 28 lapins néo-zélandais en bonne santé a été soumise à quatre tailles avec l'une des trois méthodes de coupe. Après la période d'engraissement, les mandibules ont été prélevées et les deux incisives mandibulaires ont été examinées sur des radiographies dentaires, des examens micro-tomodensitométriques et des coupes histologiques. Les modifications des tissus dentaires et parodontaux ont été évaluées.

Cette étude a permis de mieux cerner les effets indésirables potentiels à court terme des trois méthodes de coupe. Au niveau clinique, le coupe-ongles a entraîné la formation d'une surface occlusale irrégulière avec des bords tranchants. Les deux autres méthodes de taille permettent d'obtenir une surface lisse, mais le disque est moins précis. L'évaluation histologique a révélé que les modifications primaires, y compris les fractures coronaires, l'élargissement et l'inflammation du ligament parodontal, l'ostéodentine réparatrice, la paracémentose et l'accumulation de biofilm, ont été trouvées dans le groupe coupe-ongles.

Mots clés: fraise, tomographie assistée par ordinateur à faisceau conique, disque, coupe-ongles, maladie dentaire, Oryctolagus cuniculus

Effetti collaterali radiologici, istologici e clinici del taglio degli incisivi nei conigli

La malocclusione degli incisivi nei conigli (Oryctolagus cuniculus) è un problema clinico comune osservato nella pratica generale. Considerando che il tasso di crescita è di circa 2 mm a settimana, una mancanza di usura porta rapidamente a difficoltà alimentari e lesioni dei tessuti molli. Pertanto, gli incisivi patologicamente allungati devono essere accorciati ogni tre o sei settimane. Lo scopo di questo studio è di valutare gli effetti avversi potenziali sui tessuti dentali e parodontali associati ai tre metodi di rifilatura più comunemente utilizzati: tagliaunghie, disco diamantato e fresa diamantata.

Il primo incisivo mandibolare sinistro di 28 conigli neozelandesi sani è stato sottoposto a quattro rifilature con uno dei tre metodi di taglio. Dopo il periodo di ingrassamento, le mandibole sono state raccolte e sia gli incisivi mandibolari che le mandibole sono stati indagati su radiografie dentali, scansioni tomografiche micro-computerizzate e sezioni istologiche. Sono stati valutati i cambiamenti nei tessuti dentali e parodontali.

Questo studio ha consentito una descrizione più accurata degli effetti collaterali potenziali a breve termine dei tre metodi di rifilatura. A livello clinico, il tagliaunghie ha causato la formazione di una superficie occlusale irregolare con bordi affilati. Entrambi i metodi motorizzati hanno permesso di ottenere una superficie liscia, ma il disco era meno preciso della fresa. La valutazione istologica ha rivelato che durante l'accorciamento con il tagliaunghie sono apparse modifiche principali, tra cui fratture coronali, allargamento del legamento parodontale e infiammazione, osteodentina riparativa, paracementosi e accumulo di biofilm.

Parole chiave: fresa, tomografia computerizzata a fascio conico, disco, tagliaunghie, malattia dentale, Oryctolagus cuniculus

Radiological, histological and clinical side effects of incisor trimming in rabbits

L. Gentsch-Baumberger, P. Roux, D. Bosshardt, P. Kircher

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Korrespondenzadresse

Line Gentsch-Baumberger
Amivet Sàrl
Rue de l'Ecluse 12
CH-2000 Neuchâtel
Telefon: 41 32 725 50 77
E-Mail: line.gentsch@amivet.ch