

PERIODONTAL CHANGES INCIDENT TO PROLONGED OCCLUSAL OVERLOAD IN MONKEYS

by

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INTRODUCTION

"Traumatic articulation" and "traumatic occlusion" indicate conditions in which forces created by the masticatory muscles cause damage to the periodontal structures. The terms are extensively used in clinical phraseology, although the correlation between assumed clinical symptoms of disease and the histologic evidence of trauma is not established. In the majority of experiments no apical migration of the epithelial cuff was demonstrated (1, 3, 4, 5, 7, 9, 10). In a few cases histologic evidence of some pocket deepening was documented, although the influence of bacterial plaque and food impaction could not be excluded (2, 5, 8). Pocket deepening, apparently due to occlusal trauma alone, has been demonstrated in one case (10). The subject has been reviewed in a number of articles which should be consulted for further details (see references).

As most investigations have demonstrated that it is very difficult to induce pocket deepening around teeth by applying high crowns on them, the following experiment was designed with the aim at establishing to what extent prolonged and repeated occlusal overload would do so in the monkey.

MATERIAL AND METHOD

Five monkeys were used for the experiment. Their exact age was unknown, but all the permanent teeth had erupted and showed some abrasion, indicating that the animals were "adult"

or "middle age". Except for occasional attacks of common colds, the animals were reasonably healthy during the experiment. The clinical examination before initiation of the experiment revealed that two of the monkeys (no. 1 and no. 6) had marked gingivitis and the remaining three animals had slight gingivitis. Calculus was present in all of them. The calculus was removed just before the experiment started and the gingival condition improved.

The occlusal overload was produced by means of high gold crowns on the lower left first molar (experimental teeth). The crowns caused an opening of the bite of about five millimeters between the upper and lower incisors, and they created a combination of vertical and horizontal forces on the experimental teeth and their antagonists. They were cemented onto the teeth and additional retention was attained by using amalgam locks after a method described previously (10). The crowns were left on, until the experimental teeth and their antagonists were intruded and displaced to such an extent that normal occlusion reappeared on the remaining teeth. They were then removed and the experimental teeth were allowed to extrude until normal occlusal relationship was re-established. At this stage one animal (M 1) was sacrificed, whereas the same procedure was repeated in the remaining four animals. One monkey (M 2) had the gold crown re-cemented, even for the third time, and it was sacrificed with the crown in situ. (See table I).

Four of the monkeys had their teeth brushed every day; the fifth (M 1) could, for reasons to be explained later, not be treated in this way. The animals were decapitated in nembutal anesthe-

Table I
Number of days with (+) or without (—) a crown

Monkey no.	Observation periods
1	+ 61, — 72
4	+ 108, — 67, + 104, — 53
5	+ 110, — 59, + 110, — 51
6	+ 107, — 57, + 111, — 51
2	+ 54, — 52, + 111, — 89, + 52

sia. All the first molars were selected for sectioning. The specimens were fixed in formalin, decalcified in 5 % nitric acid, embedded in celloidin and cut in bucco-lingual direction. The sections were stained with hematoxylin and eosin. Care was taken to provide representative sections at regular intervals from the entire buccal and lingual surfaces of the experimental teeth and their antagonists, as well as from the control teeth on the opposite side. In each of the sections from the individual teeth the width of the epithelial downgrowth was measured. The figures were added and divided by the number of observations, and the average values are given in Table II.

RESULTS

Clinical observations

The animals obviously were irritated by the high crowns and they chewed nervously with a frequency of about four times per second. The gnashing of the teeth was clearly audible and consequently can be likened to bruxism in man. The teeth were gradually intruded and the monkeys apparently became accustomed to the new condition. The midline of the lower jaw was displaced to the right about 1 millimeter and the experimental teeth became very mobile.

The artificial crowns favoured retention of food and plaque along the gingival margin. However, in the four animals having daily toothbrushing, these accretions were removed and the clinical examination revealed no sign of inflammation associated with the experiment.

One animal (M I, female) had the teeth brushed for the first week at the end of which it gave birth to a baby monkey. Under these conditions the mother became ill and extremely restless and for the following five weeks it was feared that she would not survive. For that reason, further brushing and examination had to be discontinued. Eventually, the mother monkey recovered, calmed down and could be re-examined 61 days after insertion of the high crown. At that time, the lower left first molar was extremely mobile both in bucco-lingual and occlusal direction. Large amounts of sub- and supragingival calculus and plaque had ac-

cumulated, particularly on the lingual side. Adjacent to the deposits the gingiva was heavily inflamed and a 3 millimeter deep periodontal pocket had developed lingually (pressure side).

The crown was removed and a thorough scaling was undertaken; during this procedure ample amounts of subgingival calculus were removed. During the following 72 days the mother monkey was examined occasionally, but regular toothbrushing could not be carried out due to the restlessness and poor physical condition of the animal. However, it was observed that the tooth became firmer and the gingival inflammation improved, although some of it persisted to the conclusion of the experiment.

Histologic observations

Depending upon whether or not the high crowns were in situ at the time of death, the histologic picture varied. In the one case in which the crown was in situ, the reaction on the pressure side was characterized by necrosis of the periodontal membrane and the adjacent bone (Fig. 1 A and B). However, the necrotic bone was apparently quickly removed by osteoclastic resorption (Fig. 1 B), and when the damaged tissue had been resorbed, healing took place, as observed in the periodontal membrane apical to the necrotic area (Fig. 1 A). Thus, the tissue reaction adjacent to the necrotic area was not characterized by destructive inflammation but by constructive repair; there was no mentionable apical migration of the epithelial cuff (Fig. 1 B).

Fig. 1 A. Monkey no. 2. Observation period, see table 1.

High crowns in situ at conclusion of experiment. Necrotic bone in contact with resorption area in dentin. More apically necrotic bone resorbed and healing going on.

Fig. 1 B. Higher magnification from Fig. 1 A showing necrotic bone with numerous osteoclasts adjacent to it. Only slight apical migration of epithelial cuff.

Fig. 2 A. Monkey no. 2. Observation period, see table 1.

Antagonist to experimental tooth shown in Fig. 1. Root resorption on pressure side. Very little apical migration of epithelial cuff.

Fig. 2 B. Higher magnification from Fig. 2 A showing osteoclastic activity both on dentin and bone. In periodontal membrane cellular infiltration is slight and the picture characterized by healing.



Fig. 1 A.



Fig. 1 B.

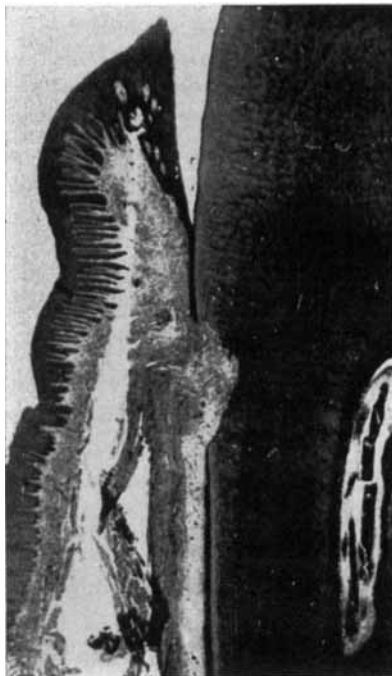


Fig. 2 A.



Fig. 2 B.

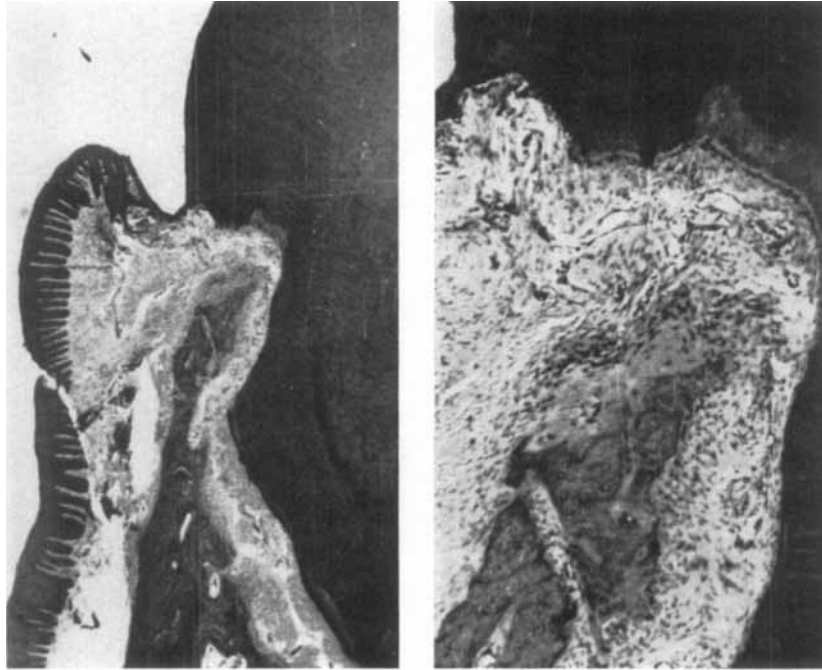


Fig. 3 A. Monkey no. 4. Observation period, see table 1.

Crown removed before conclusion of experiment. Extensive cementum and dentin resorption. New bone laid down to normal distance from tooth in resorption area and from C. E. J. No apical migration of epithelial cuff.

Fig. 3 B. Higher magnification from Fig. 3 A showing new formation of bone and cementum with fairly normal periodontal membrane in between.

The tissue reaction adjacent to the antagonist of the experimental tooth showed the same trend as described above, although necrotic tissue could not be observed (Fig. 2 A and B). There was evidence of bone and dentin resorption, but bone apposition and regeneration of the periodontal membrane were the dominating features.

In three of the four cases (M 4, M 5, M 6) in which the high crowns had been removed some time before the monkeys were sacrificed, the overall picture was characterized by repair (Fig. 3 A and B). The experimental teeth had extruded and adjusted to normal occlusion; the periodontal membrane (once or twice necrotic) had regenerated and bone had been laid down to build

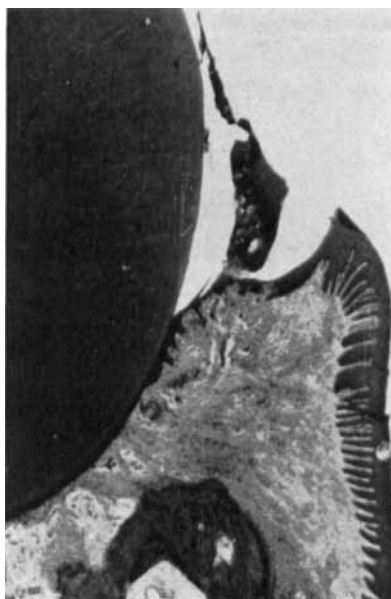


Fig. 4. Monkey no. 5. Observation period, see table 1.
Control tooth showing apical migration of epithelial cuff and related calculus and plaque formation.

up the alveolar crest to approximately normal height (Fig. 3 A). Normal width of the periodontal membrane had been re-established, even adjacent to very deep dentin resorptions.

Apical migration of the epithelial cuff was observed on the experimental teeth, both on the pressure side (Fig. 2 A) and the stretch side, but similar apical migration was observed also on the control teeth (Fig. 4 and Table II).

An unusual observation was made in one animal (M 5, LL 6, Fig. 5). Between areas of cementum and dentin resorptions there were areas of fairly intact cementum covered with epithelium which had no connection with the epithelial cuff. In the areas of cementum resorption there was no epithelial proliferation. This observation was limited to a narrow area (max. 1 mm) on the pressure side.

Obvious evidence of pocket deepening was seen on the lingual side of the experimental tooth of the mother monkey previously

Table II
Epithelial downgrowth (mm.) along the cementum

Monkey No.	Experimental teeth				Control teeth			
	LL 6		UL 6		LR 6		UR 6	
	Buccally Stretch	Lingually Pressure	Buccally Pressure	Lingually Stretch	Buccally Stretch	Lingually Pressure	Buccally Pressure	Lingually Stretch
1	0.1	2.4	0.3	0.1	0.1	0.1	0.5	0.1
4	0.3	0.1	0.3	0.3	0.3	0.1	0.5	0.2
5	0.4	0.3	0.6	0.2	0.3	0.4	0.5	0.2
6	0.6	0.3	0.7	0.3	0.5	0.3	0.7	0.2
2	0.4	0.2	0.5	0.1	0.4	0.3	*	*

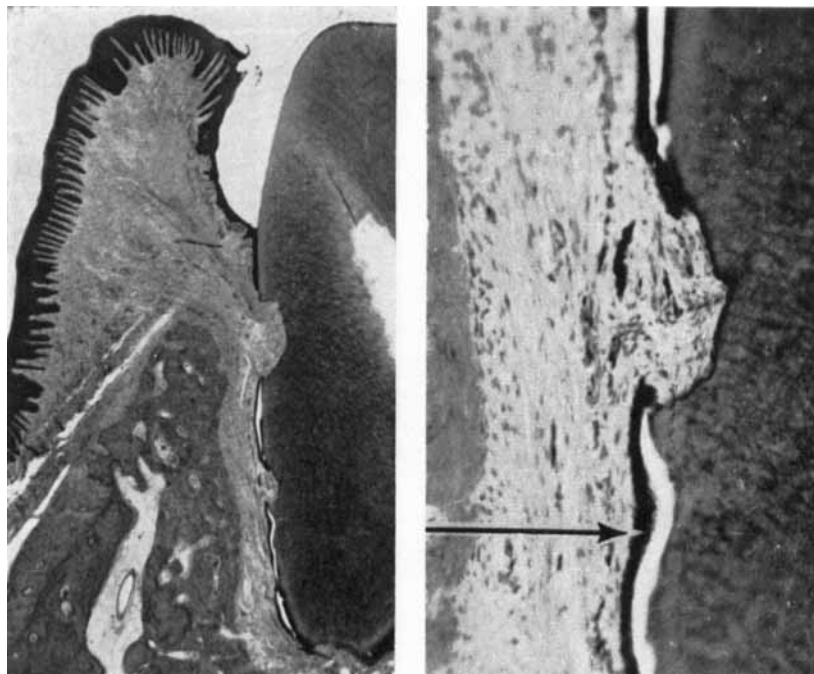


Fig. 5 A. Monkey no. 5. Observation period, see, table 1.

Pressure side. Between two areas of root resorption, and below the most apical one there is a sheath of epithelial cells which apparently has no connection with epithelial cuff.

Fig. 5 B. Higher magnification from Fig. A showing that the split between the epithelium (arrow) and the dentin is an artefact.

described in further details (Fig. 6 A). There was some marginal inflammation which can be related to the accumulation of bacterial plaque in this area. More apically, and close to the bottom of the pocket, the inflammation was minimal (Fig. 6 C). In some places the cementum is thinner, due to the root planing already mentioned (Fig. 6 B). There is no apical migration of the epithelial cuff on the buccal side of the same tooth (Fig. 7).

As documented in Table II, there was some apical migration of the epithelial cuff in some areas on most of the teeth. Except for the mother monkey (M1) there was no apparent difference

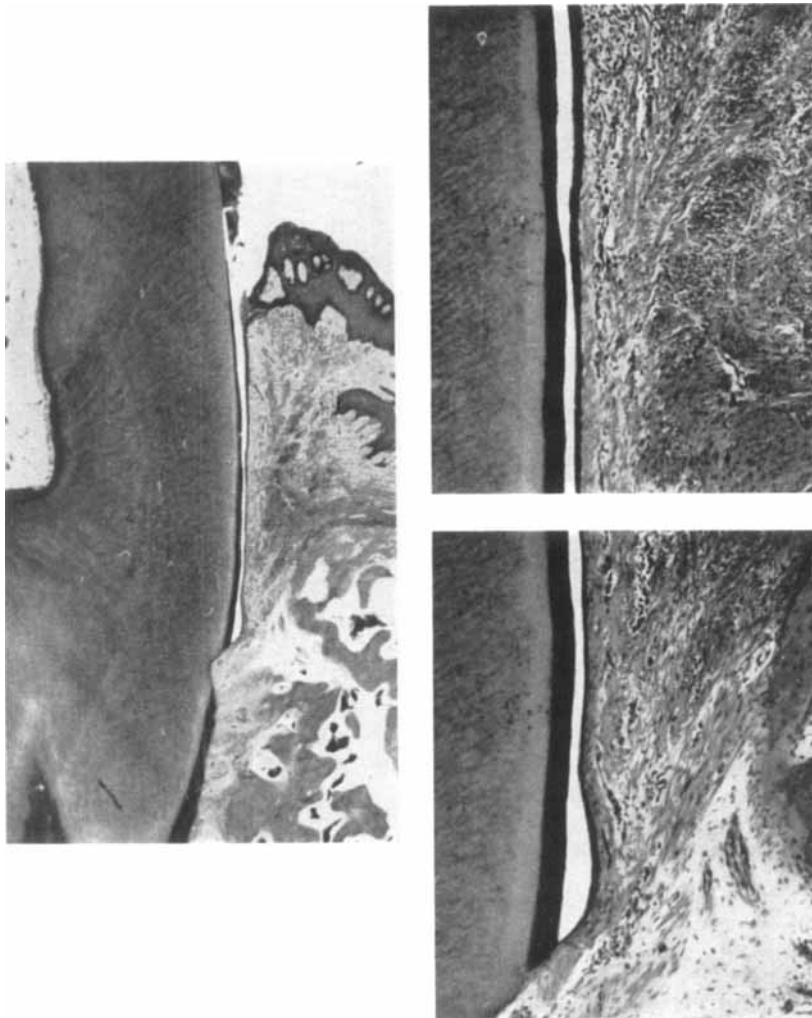


Fig. 6 A. Monkey no. 1. Tooth LL6. Observation period, see table 1. Pressure side. Downgrowth of epithelium to resorption area in cementum. Inflammatory reaction in marginal part opposite plaque.

Fig. 6 B. Higher magnification from Fig. 6 A. Split between epithelium and cementum is artefact. In upper part cementum is thinner due to subgingival curettage carried out in this pocket at time of removal of heigh crown. Inflammation slight.

Fig. 6 C. Higher magnification from Fig. 6 A showing deepest area of pocket. Minimal inflammation.

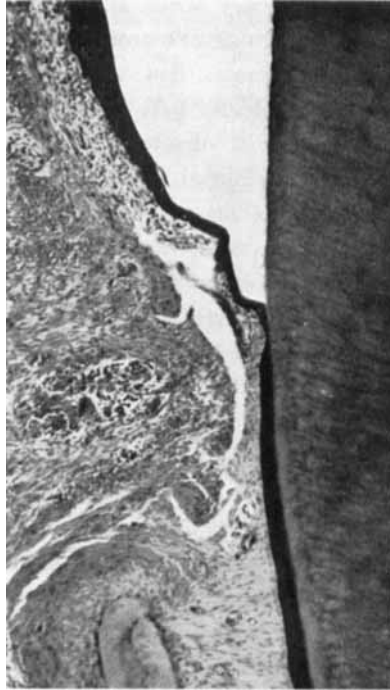


Fig. 7. Monkey no. 1. LL6 buccally (stretch side). No apical migration of the epithelial cuff and very little inflammation.

between the average values from corresponding root surfaces of the experimental teeth as compared with those from the control teeth in the same animal.

DISCUSSION

It is noteworthy that the apical migration of the epithelial cuff was not greater on the experimental teeth and their antagonists than on the control teeth in the four animals which had the crowns put on for a second and even a third time (Table II). This is in agreement with a number of earlier investigations which have shown that it is extremely difficult to create pathologic pockets by occlusal overload alone. The tissue damage, including necrosis (Fig. 1 B), which is the consequence of severe

occlusal overload heals quickly when the pressure is reduced or eliminated. Not even in cases of extreme trauma, as evidenced by extensive cementum resorptions, did an apical migration of the epithelial cuff take place (Figs. 1 A, B and 3 A, B). The slight pocket deepening, which was observed adjacent to the experimental teeth and their antagonist, can most likely be explained as the consequence of bacterial plaque, as the same amount of pocket deepening was observed around the control teeth (Fig. 4). This is in agreement with observations made by *McHugh* (6) who found that epithelial downgrowth over the cementum is common in monkey teeth which have been erupted two or more years. The animals in the present study were old enough to come into this category. The pathogenesis of the periodontal pocket observed adjacent to the experimental tooth of the mother monkey (Fig. 7) is obviously related to the occlusal overload, but the poor physical condition of this animal, which apparently reduced its resistance to infection, obviously was equally important. It is well known that the status of collagen is interfered with in pregnancy, particularly in its later stage. This, and related conditions, may have reduced the tissue resistance and interfered with repair. As the high crowns were not particularly well finished, they favoured retention of plaque. In the other four animals the teeth were brushed daily, thus preventing the plaque from causing damage. In the mother monkey toothbrushing could not be done. Therefore, the plaque could grow in apical direction, undisturbed by this preventive measure. Besides, in this particular case the plaque did not meet the mechanical resistance due to the flabbiness of gingivae. This may explain the rapid apical growth of the plaque with the subsequent calculus formation which was observed after 61 days. Thus, the apical growth of the plaque was the immediate cause of the pocket deepening. The trauma, the pregnancy, the lactation period and the poor physical condition of this animal were the predisposing factors. This is the only way to explain why a pathologic pocket developed in this particular animal and not in the remaining four of them.

The observations made in Fig. 5 A and B suggest that the epithelial rests of Malassez may be the source of epithelial proliferation when the periodontal membrane has been destroyed by

trauma. It should be emphasized that this suggestion is only a working hypothesis.

SUMMARY

In five monkeys occlusal overload was created by placing high crowns onto the lower left first molars, opening the bite about five millimeters between the front teeth. After some months the experimental teeth and their antagonists had been intruded to such an extent that normal occlusion re-appeared on the remaining teeth. The crowns were then removed, allowing the teeth to extrude to normal articulation before they were re-cemented for a second time. In one animal the high crown was re-cemented even for a third time and in another one it was cemented only once (Table II).

The procedure led to necrosis of the bone and periodontal membrane and extensive cementum and dentin resorptions. When the high crowns were removed, the usual sequence of events was that the necrotic tissue of the periodontal membrane was resorbed and replaced by normal periodontal membrane. The alveolar bone was rebuilt to normal distance from the deepest point of the epithelial cuff and from the tooth surface. In four of the animals downgrowth of the epithelium was not more extensive on the experimental teeth than on the control teeth. In one animal, in which systemic and local conditions were highly unfavourable a periodontal pocket developed on the pressure side. This observation suggests that extreme occlusal overload in combination with highly unfavourable systemic conditions may reduce the resistance to local bacterial factors and also ease the progress of these constituents.

RÉSUMÉ

ALTÉRATIONS DU PARODONTE DE SINGES SOUMIS DE FAÇON PROLONGÉE À UNE OCCLUSION TRAUMATISANTE

Chez cinq singes, une occlusion traumatique a été déterminée en posant une couronne de surélévation sur le première molaire inférieure gauche, ce qui provoquait un béance d'environ

cinq millimètres au niveau des incisives. Au bout de quelques mois, les dents de l'expérience et leurs antagonistes avaient subi une ingression d'un degré tel qu'une occlusion normale s'était rétablie au niveau des autres dents. Les couronnes ont alors été enlevées, ce qui a permis aux dents de subir une extrusion déterminant à leur niveau une articulation normale, jusqu'à ce que les couronnes soient de nouveau scellées sur ces dents. Chez un des animaux, la couronne de surélévation a été scellée ultérieurement une troisième fois, et chez un autre, la couronne n'a été scellée qu'une fois en tout (tableau II). On a obtenu de cette manière une nécrose de l'os et du desmodonte, et des résorptions étendues du cément et de la dentine. Lorsque les couronnes de surélévation étaient enlevées, il se produisait d'ordinaire une résorption des tissus desmodontaux nécrosés qui étaient ensuite remplacés par un desmodonte normal. L'os alvéolaire se trouvait régénéré à une distance normale du point le plus profond de la manchette épithéliale et de la surface de la dent. Chez quatre des animaux, la prolifération de l'épithélium en profondeur n'était pas plus étendue pour les dents de l'expérience que pour les dents témoins. Chez un des animaux, qui présentait un état général et local des plus défavorable, un cul-de-sac gingivo-dentaire s'est formé du côté où s'exerçait la pression.

ZUSAMMENFASSUNG

DIE VERÄNDERUNGEN DER PARODONTALEN GEWEBE BEI LANGWIERIGER, ÜBERMÄSSIGER ÜBERLASTUNG DER ZÄHNE

Fünf Affen wurden mit zu hohen Kronen auf den ersten linken unteren Molaren versorgt, um die Zähne dadurch stärker zu belasten. Einige Monate später waren die überkronten Zähne und ihre Antagonisten so weit intrudiert, dass die normale Okklusion auf der rechten Seite wiederhergestellt war. Um eine nochmalige Eruption zu ermöglichen, wurden die Kronen entfernt, später rezementiert und noch einmal entfernt, (Tab. 1). Nekrose von Alveolarknochen und Wurzelhaut, sowie ausgedehnte Zement- und Dentinresorptionen waren das Ergebnis. Nach Entfernung der Kronen stellte man folgendes fest: Das nekrotische Gewebe war resorbiert und mit normalem Gewebe ersetzt. Der Alveolarknochen war wiederaufgebaut und hatte

seinen normalen Abstand zum Epitelansatz und zur Zahnoberfläche erreicht. Bei vier Affen wurde kein Unterschied zwischen den Epithelansätzen der Experimentalzähne und der Kontrollzähne festgestellt. Ein Tier mit schlechten Lokal- und Allgemeinzustand entwickelte eine tiefe Zahnfleischtasche an der Druckseite.

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