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Nonvital Pulp Therapy of Elongation of Roots of Mandibular Cheek Teeth in Pet Rabbits

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Abstract : Elongation of cheek teeth roots in pet rabbits is very common, and is associated with malocclusion followed by reduced appetite, salivation, periapical abscess, and epiphora. Conservative methods including medication, drainage, irrigation, tooth trimming, intraoral and extraoral extraction, surgical treatment of periapical abscessation, and diet control have been adapted as the only treatments to resolve elongation of teeth roots. However, remaining challenges include the long-term period of cure and recurrence. This study was performed to investigate the possibility of nonvital pulp therapy on elongation of the mandibular cheek teeth roots in pet rabbits. Thirty-one pet rabbits with dental problems due to root elongation were submitted. Ten pet rabbits among them were treated by nonvital pulp therapy procedures (group A), while the others were treated by conservative methods (group B). Appetite improved within 1–5 days after nonvital pulp therapy and the treatment was discontinued 1 month postoperatively in group A. Abscess occurred in another site not treated with nonvital pulp therapy in only two rabbits. Growth of the mandibular cheek teeth treated with nonvital pulp therapy stopped, resulting in malocclusion, intraoral inflammation from the enamel spur, and abscess of the teeth roots. In the group B rabbits treated with conservative therapy, partial drainage, long term medication, recurrent oral trimming and control of repeated oral inflammation occurred. Consequently, buccotomy or tooth extraction was performed in group B. Owners were satisfied with nonvital pulp therapy preventing dental root abscess and repeated troubles including inflammation and malocclusion and reduction of the treatment period. These results suggest that nonvital pulp therapy can be performed on pet rabbits with elongation of mandibular cheek teeth roots.

***Key words* :** Pet rabbits, Nonvital pulp therapy, Cheek teeth, Root elongation.

Introduction

Pet rabbits, which belong to the order Lagomorphs, have 28 teeth (2 × (I 2/1 C 0/0 PM 3/2 M3/3) = 28) including four upper incisors and two lower incisors. Their teeth have the same components as other animals and all grow continually throughout life (3,8). The characteristic symptom of acquired dental diseases and malocclusion is the elongation of the dental roots (18). Ectopic tooth roots due to the elongation of dental roots may penetrate the skull bone and form a cavity of abscess (5,13,11). This phenomenon occurs in both maxilla and mandible, and is consequently associated with malocclusion followed by reduced appetite, salivation, dacryocystitis, infection of dental roots induced by the loss of alveoli, and abscess (4,5,8,16). Dental problems of rabbits are not severe in grade 2 (8). However, after grade 3, anorexia, salivation, inflammation of alveolar bone and abscess of the teeth root occur. Treatment includes buccotomy, partial teeth extraction, long term post care, and, in some cases, repeat surgery. The progress from grade 2 to grade 3, in which abscess and degeneration of the alveolar bone occurs and which requires aggressive surgical debridement, is hard to predict (12). However, if the disease persists at least 2-3 months, treatment is required. In Japan, postoperative medication including Skin Care Ointment product consisted of olive oil, peppermint, spearmint, and thyme (Van Beek Global, IA, US) after buccotomy galenicals can provide relief of the inflammation and help in tissue repair. However, 2–3 months of treatment is required. Nonvital pulp therapy is performed in grade 3, before osteomyelitis and abscess of dental root appears, to prevent the mandible alveolar bone progression to grade 4 or 5. In addition, the purpose of this treatment is to reduce repeated teeth trimming due to overgrowth of premolars and molars that result in inflammation of the cheek and tongue, and surgery of the mandible alveolar bone.

For dental diseases that can lead to death with painful fibrous osteodystrophy, subcutaneous abscess (15), and dacryocystitis, nonvital pulp therapy can be used to alleviate the

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etiologic agent in a short time and prevent anorexia, gastrointestinal retention, diarrhea, and death caused by long-term medication use (1,3,12,19). Nonvital pulp therapy in canines and felines can be performed intraorally after anesthesia when there is irreversible pulpal pathology such as generalized pulp necrosis. However, nonvital pulp therapy in rabbits may prevent elongation of dental roots. It was due to concerns about the toxicity of medication, tissue damage, and operator skill (3). In this study, we report our experience with endodontic therapy to treat elongation of the mandibular cheek teeth root in pet rabbits.

Materials and Methods

Animals

Thirty-one pet rabbits with clinical signs including salivation, anorexia, reduced fecal size, abnormal growth of teeth, and swelling of the ventral mandible were admitted to our facility. Of these, 10 rabbits with elongation and inflammation of the mandibular cheek teeth roots were treated by endodontic procedures (group A). The other 21 rabbits were treated by conservative methods (group B).

Intra-oral dental examination

Dental conditions (2) including horizontal ridges formation of upper incisors, loss of vertical groove, and malocclusions of incisors were observed using a model F2100P imaging apparatus (EDK, Busan, Korea) and observations were recorded on the dental chart for each rabbit (Fig 1).

Radiography

The severity of dental diseases and postoperative prognosis were estimated by preoperative and postoperative oblique lateral and ventral views of the skull (Fig 2). The dental disease progression was graded into five stages: grade 1, normal condition of the tooth; grade 2, elongated dental roots and deterioration in tooth quality without clinical signs; grade 3, loss of the supporting bone, alterations in the position, shape, and structure of the teeth that change the direction of growth by causing malocclusion; grade 4, each outline of the tooth is irregular, the enamel fold disappears, the dental root is curled, and the lamina dura cannot be observed; grade 5, the end-stage, in which reduction of the entire bone density, damage of most of the dental crowns, and resorption of the roots occur (8).

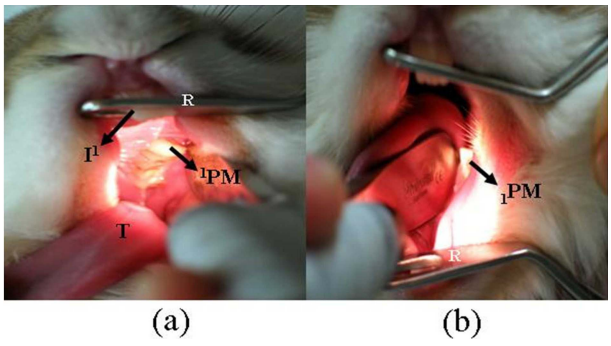

Fig 1. Examination of cheek teeth after administration of sedative. (a) Abnormal growth of maxillary cheek teeth toward buccal mucosa, (b) Ventrolateral portion of tongue injured by enamel spur. ^{1}PM: left maxillary first premolar, $_{1}$PM: left mandibular first premolar, T: tongue, R: rodent mouth gag.

Hematology and serum chemistry

For the measurement of alanine aminotransferase (AST), aspartate aminotransferase (ALT), blood urea nitrogen (BUN), creatinine, calcium (Ca), phosphorous (P), total protein (T-Protein), and albumin concentration, a PROCHEM-V automatic serum analyzer (Synbiotics, San Diego, CA, USA) was used to determine the compatibility of operation and the health of the animals.

Dental surgical instrument and equipment

The dental instruments and equipment included a Vet-care II animal dental unit (Dentalaire, Fountain Valley, CA, USA), several burrs, hand-file, barbed broaches, sterilized 200 absorbent paper points, hand-rolled 100 gutta percha points, gutta percha applicator, Temp-Bond root canal sealer (a zinc oxide-eugenol product; Kerr, Orange, CA, USA), intermediate restorative material (IRM), mixing paper, and mixing spatula.

Preoperative management

Atropine sulfate (0.1 mg/kg, intramuscularly (IM); Jeil Pharmaceutical, Daegu, Korea) was used as premedication. Anesthesia was induced with ketamine (50 mg/kg, IM; Korea United Pharm, Seoul, Korea), xylazine (5 mg/kg, IM; Bayer Korea, Gyeonggido, Korea), and butorphanol (0.1 mg/kg, IM; Myungmoon Pharm, Seoul, Korea), and was maintained with isoflurane in oxygen with endotracheal intubation. Antibiotic (Enrofloxacin, 10 mg/kg, IM; Bayer Korea) and an anti-inflammatory agent (dexamethasone, 0.5 mg/kg, IM; Sinil Pharm, Seoul, Korea) were administrated IM, and then normal saline was maintained during the operation.

Conservative treatment

Medication (ciprofloxacin, chloramphenicol, tetracycline), drainage, honey therapy, irrigation, teeth trimming, partial tooth extraction, diet management, and environmental improvement were performed as conservative treatments (20).

Nonvital pulp therapy (Apicoectomy and root canal treatment)

A median incision was made in the cutaneous and subcutaneous layers of the mandibular angles of the premolar and molar cheek teeth between the mandibular symphysis of the mandible. Once, to secure sufficient surgical region, platysma with subcutaneous fascia was pulled back and the mandibular diaphysis was exposed. In the case of elongated dental roots in the medial mandibular, the mylohyoid and geniohyoid muscles were detached from the mandible to secure the

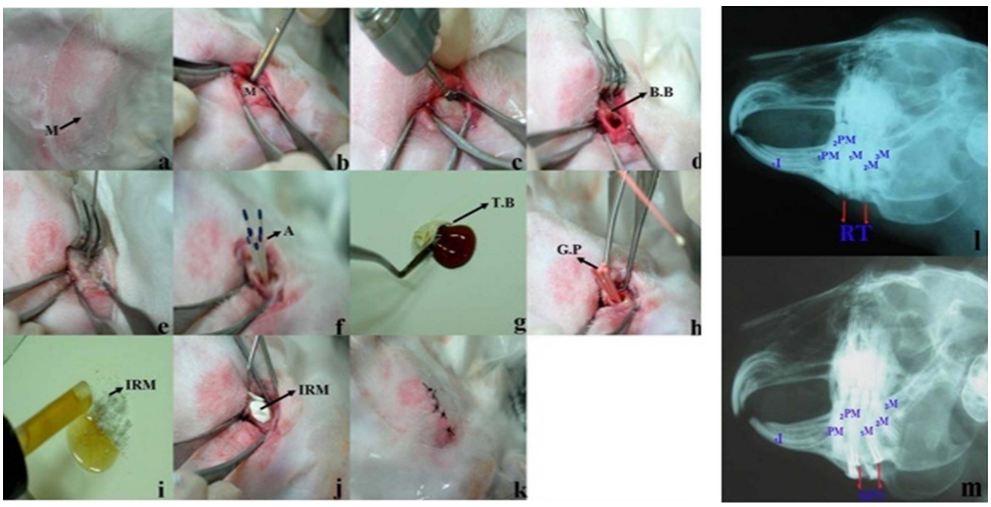

Fig 2. Procedure of nonvital pulp therapy (a-k) and radiography of skull of a rabbit before (I) and after (m) nonvital pulp therapy. M: Mandible, B.B: Barbed broach, A: Absorbent paper point, T.B: Temp bond, G.P: Gutta percha point, IRM: Intermediate restorative material; $_1$I: left maxillary incisor teeth, $_1$PM: left mandibular first premolar, $_2$PM: left mandibular second premolar, $_1$M: left mandibular first molar, $_2$M: left mandibular second molar, $_3$M: left mandibular third molar, RT: root elongation, NPT: nonvital pulp therapy.

surgical regions (Figs 2a and 2b). We were careful not to damage the lower labial artery, vein and submental vein, facial vein, and buccal gland. After that, the dental roots were accessed using an electric motor handpiece by the grinding of the mandibular penetrating the premolar and molar cheek teeth (Fig 2c). The barbed broaches were loosely put into the canal and pulp tissues were removed, rotated 360°, and then the blunt tipped needle was put into the canal and irrigated with hydrogen peroxide (Figs 2d and 2e). After irrigation with normal saline, the pulp cavity was dried with sterilized absorbent paper point to treat the pulp hemorrhage (Fig 2f). A gutta percha point master cone or an accessory cone covered with Temp-Bond was inserted into the canal (Figs 2g and 2h). Next, a hand file (root canal condenser) was pressed and the empty space was filled with gutta percha point master cone or accessory cone. Afterward, heating of the gutta percha point applicator using an alcohol lamp eliminated the remaining part outside of the canal. One spoon volume of IRM and three drops of solution were mixed on mixing paper and applied to the root apex, and the IRM was allowed to harden (Figs 2i and 2j). After the irrigation of the surgical region with normal saline, the platysma, fascia, and subcutaneous tissues were closed with a simple continuous suture using 4-0 polyglactin, whereas the skin was closed with a simple interrupted suture using 3-0/4-0 surgical nylon (Fig 2k).

Postoperative treatment

For 3-5 days post-surgery, each patient was hospitalized until appetite and digestion recovered. For the first 2 days, butorphanol was administered as an analgesic along with the administration of enrofloxacin (10 mg/kg, BID, IM) and prednisolone acetate (1 mg/kg, SID, IM; Komipharm International, Gyeonggido, Korea) was given for 4-5 days. Afterward, ciprofloxacin (10 mg/kg, BID, PO) was administered orally for 3-4 weeks.

Postoperative assessment

Respiration, heart rate, temperature, appetite, and vital signs were measured. Swelling of the surgical region was checked by palpation. Oral movement was observed during food intake. After surgery, medication was taken for one month and radiographic assessments were conducted to check the occurrence of inflammation at the mandibular and dental roots. Intra-oral dental examination and palpation of the mandible were performed to evaluate the existence of inflammation every month for 3-5 months.

Results

The rabbits were followed-up for 7 months through hospital visits. Group A included one 1-year-old, two 2-year-old, six 3-year-old, and one 4-year-old rabbit. The ratio of females to males was 3:7, and there were eight dwarfs, one lion, and one lop ear. In group B, there were three 1-year-old, seven 2-year-old, six 3-year-old, and five 4-year-old rabbits. The ratio of females to males was 4:17, and there were 16 dwarfs, four lions, and one lop ear. The chief clinical signs through history and physical examination of group A were anorexia (n = 7), epiphora (n = 3), weight loss (n = 3), elongated incisors (n = 2), mandibular abscess (n = 2), diarrhea (n = 2), nasal discharge (n = 2), and salivation (n = 1). Group B clinical signs were anorexia (n = 17), epiphora (n = 3), weight loss (n = 7), elongated incisors (n = 1), mandibular abscess (n = 7), salivation (n = 2), and torticollis (n = 2).

In group A, eight rabbits had mandibular swelling and five rabbits had lesions existing in the incisors, which were noticed upon gross examination. Enamel spur was present in 21 rabbits and 13 had supernumerary, which was found by dental

Table 1. Breed, sex, age, X-ray and skull observation on 10 rabbits with dental disease (Group A)

Rabbit clinical signs	Breed	Age	Sex	Clinical observation		EDK observation		X-ray observation	
				Visible incisior lesion	Palpable mandibular swellings	Enamel spur	Super numerary	Ectopic tooth roots	Ectopic orbital roots
Anorexia Lacrimal discharge Weight loss Mandibular abscess	[1]D	[4]3y	[6]♂	N	[8]Y	Y	Y	Y	Y
Nasal discharge Overgrown incisors Weight loss	D	3y	♂	Y	Y	Y	Y	Y	Y
Anorexia Diarrhea	D	[5]30 m	♂	[9]N	Y	Y	N	Y	N
Anorexia	D	3y	♂	Y	Y	Y	N	Y	N
Diarrhea Lacrimal discharge Nasal discharge	D	3y	[7]♀	N	Y	Y	Y	Y	Y
Anorexia Lacrimal discharge Mandibular abscess	D	4y	♀	Y	Y	Y	Y	Y	Y
Overgrown incisors	D	2y	♂	Y	N	N	Y	Y	N
Anorexia	[2]LO	1y	♀	N	Y	Y	Y	Y	N
Anorexia Weight loss	[3]L	2y	♂	N	N	Y	Y	Y	Y
Anorexia Salivation	D	3y	♂	Y	Y	N	Y	Y	N

※ [1]D:Dwarf, [2]LO:Lop ear, [3]L:Lion, [4]y:years, [5]m:month, [6] ♂ :Male, [7] ♀ :Female, [8]Y:Yes, [9]N:No

Table 2. Location of root elongation, inflammation, malocclusion in mandible teeth of pet rabbits of group A by radiographic findings (Group A)

Case No	Mandibular incisor teeth	$_1PM_1$	$_2PM_2$	$_1M_1$	$_2M_2$	$_3M_3$
1	R	I($_1PM_1$), R($_1PM_1$)	I($_2PM_2$), R($_2PM_2$)	R(M_1)	N	N
2	M, R	M($_1PM_1$), R($_1PM$)	R($_2PM_2$)	N	N	N
3	N	N	R($_2PM_2$)	R($_1M_1$)	N	N
4	M	N	R($_2PM_2$)	R($_1M_1$)	N	N
5	N	R($_1PM$)	R($_2PM_2$)	R($_1M$)	N	N
6	M, R	R($_1PM_1$)	I($_2PM_2$), R($_2PM_2$)	R($_1M$)	N	N
7	M	N	R(PM_2)	R($_1M_1$)	N	N
8	N	N	R($_2PM_2$)	R($_1M_1$)	N	N
9	R	M(PM_1)	R($_2PM$)	R($_1M$)	N	N
10	R	M($_1PM$)	R($_2PM_2$)	R($_1M_1$)	N	N

PM_1: right mandibular first premolar, $_1PM$: left mandibular first premolar, PM_2: right mandibular second premolar, $_2PM$: left mandibular second premolar
M_1: right mandibular first molar. $_1M$: left mandibular first molar, M_2: right mandibular second molar, $_2M$: left mandibular second molar
M_3: right mandibular third molar, $_3M$: left mandibular third molar, I: inflammation, M : malocclusion, N: normal, R: root elongation

examination. Radiographic findings of all 10 rabbits of group A showed the ectopic dental roots at mandible and five had ectopic dental roots in the orbit. In group B, 13 rabbits had ectopic dental roots at the mandible and three had orbital ectopic dental roots (Table 1). The hematology and serum chemistry of group A (mean ± standard deviation) showed that all categories were in the normal range except lymphocytes, T-Protein, and albumin concentration. In group A, all 10 rabbits showed the occurrence of elongated dental roots on mandibular cheek teeth at the second premolar through radiographic findings, and the elongation was also found to occur at the first premolar in nine rabbits. The bilateral elongation occurred, in particular, at the second premolar in nine rabbits and at the first premolar in five rabbits. Malocclusion existed at the incisor (n = 4) and at the first premolar (n = 3). Moreover, there was inflammation at the first premolar (n = 1) and at the second premolar (n = 2). The second and third molars seemed normal (Table 2). In group B, 14 rabbits were observed with the occurrence of elongation of dental roots by inclusion of 12 incisors, seven of the first premolars, 13 of the second premolars, and 11 of the first molars. Bilateral elongation occurred, especially at the first premolar in five rabbits and at the second premolar in 12 rabbits. Malocclusion was observed at the incisor (n = 6) and at the first premolar (n = 2). Moreover, there was inflammation at the first premolar (n = 2) and at the second premolar (n = 2) (Table 3). Dental examination including observation of the condition of occlusion of the premolar and molar, overgrowth of enamel spur, and laceration of the tongue and cheek due to enamel spur overgrowth was performed monthly, before inflammation of alveolar bone and infection of dental root occurred, and radiologic examination evaluated the condition of teeth and alveolar bone. If problems including anorexia, oral inflammation, and abnormal gastrointestinal motility occurred, the animals were cared for with teeth trimming, administration of prokinetic drugs (i.e. metoclopromide) and antibiotics (i.e. ciprofloxacin, sulfa drugs), diet improvement, and ultraviolet light irradiation after anesthesia. In the case of grade 3 with abscess of alveolar bone and dental roots and grade 4 and 5, teeth trimming, buccotomy, honey therapy, and administration of antibiotics were performed (Table 4). All rabbits treated by nonvital pulp therapy (all in group A), had normal respiration, heart rate, temperature, and appetite by post-operative day 5, except for two rabbits. The two rabbits showed

Table 3. Location of root elongation, inflammation, and malocclusion in mandible teeth of pet rabbits of group B by radiographic findings (Group B)

Case No	Mandibular incisor teeth	${}_1PM_1$	${}_2PM_2$	${}_1M_1$	${}_2M_2$	${}_3M_3$
1	M, R	I(${}_1PM_1$), R(${}_1PM_1$)	I(${}_2PM_2$), M, R(${}_2PM_2$)	R(${}_1M$)	N	N
2	M, R	M	R(${}_2PM_2$)	R(${}_1M_1$)	R($M_{2)}$	N
3	M, R	N	R(${}_2PM_2$)	R(${}_1M_1$)	N	N
4	M, R	R(${}_1PM_1$)	R(${}_2PM_2$)	R(M_1)	N	N
5	R	R(${}_1PM_1$)	I(PM_2), M, R(${}_2PM_2$)	I(M_1), R(${}_1M_1$)	N	N
6	M, R	N	I(${}_2PM$), M, R(${}_2PM_2$)	R(${}_1M$)	N	N
7	N	N	N	N	N	N
8	N	N	R(${}_2PM_2$), M	R(M_1)	N	N
9	R	R(PM_1)	I(${}_2PM$), M, R(${}_2PM_2$)	I(${}_1M$), R(${}_1M$)	N	N
10	R	I(PM_1), R(${}_1PM_1$)	I(PM_2), R(${}_2PM_2$)	R(M_1)	N	N
11	R	R(PM_1)	R(${}_2PM_2$)	N	N	N
12	N	N	R(${}_2PM_2$)	R(${}_1M_1$)	R(${}_2M$)	N
13	R	N	R(PM_2)	R(M_1)	N	N
14	R	R(${}_1PM_1$)	R(${}_2PM_2$)	N	N	N
15	R	N	N	N	N	N
16	N	N	N	N	N	N
17	M	M	N	N	N	N
18	N	N	N	N	N	N
19	N	N	N	N	N	N
20	N	N	N	N	N	N
21	N	N	N	N	N	N

PM_1: right mandibular first premolar, ${}_1PM$: left mandibular first premolar, PM_2: right mandibular second premolar, ${}_2PM$: left mandibular second premolar, M_1: right mandibular first molar. ${}_1M$: left mandibular first molar, M_2: right mandibular second molar, ${}_2M$: left mandibular second molar, M_3: right mandibular third molar, ${}_3M$: left mandibular third molar, I: inflammation, M: malocclusion, N: normal, R: root elongation

Table 4. History taking, clinical examination, and x-ray view of the rabbits without endodontic therapy (Group B)

Case No.	Breed	Age	Sex	Chief complaint	Physical examination view		EDK view		X-ray view		Grade	Treatment method	Period of treatment
					Visible incisor lesion	Palpable mandibular swellings	Enamel spur	Super numerary	Ectopic tooth roots	Ectopic orbital view			
1	D	2y	♂	Anorexia, Mandibular abscess, Weight loss	Y	Y	Y	Y	Y	N	G3	Dr/KM/TE/TT	5M
2	D	4y	♂	Anorexia, Salivation, Weight loss	Y	Y	Y	Y	Y	Y	G4	Dr/KM/TE/EX ing	7M
3	D	4y	♂	Anorexia, Overgrowth incisor, Weight loss	Y	Y	Y	Y	Y	N	G4	KM/EX/DA ing	6M
4	D	4y	♂	Anorexia, Mandibular abscess, Weight loss	Y	Y	Y	Y	Y	Y	G4	Dr/KM/TE/EX ing	4M
5	D	2y	♂	Anorexia, Mandibular abscess, Weight loss	N	Y	Y	Y	Y	N	G3	Dr/M/TT/EX ing	2M
6	D	1y	♂	Anorexia, Mandibular abscess, Salivation	N	Y	Y	Y	Y	N	G4	Dr/M/TE/EX ing	4M
7	L	3y6m	♀	Anorexia, Weight loss	N	N	Y	Y	N	N	G2	KM/TT/EX	2W
8	D	4y	♂	Lacrimal discharge, Headtilt	N	Y	Y	N	Y	N	G2	M/EX/DE	4M
9	D	3y	♂	Anorexia, Mandibular abscess	Y	Y	Y	Y	Y	N	G3	Dr/KM/EX	4M
10	D	3y	♂	Mandibular abscess	N	Y	Y	N	Y	N	G3	Dr/KM/TT/EX	4M
11	D	2y	♀	Anorexia, Mandibular abscess	N	Y	Y	Y	Y	N	G3	Dr/KM/TT/EX	6M
12	D	3y	♂	Salivation, Weight loss	N	Y	Y	N	Y	N	G3	KM/TT/EX/DA	3M
13	D	4y	♂	Anorexia	N	Y	Y	Y	Y	N	G3	KM/TT/EX	8M
14	L	2y	♀	Anorexia, Salivation	N	Y	Y	N	Y	N	G3	M/TT/G	
15	R	3y	♂	Head tilt, Lacrimal discharge	N	N	Y	Y	N	Y	G3	KM/EX ing	2M
16	D	1y6m	♂	Anorexia	N	N	Y	N	N	N	G2	KM/TT/EX/DA	2W
17	D	3y	♀	Anorexia, Lacrimal discharge	N	N	Y	Y	N	N	G2	KM/TT/EX/DA	3W
18	D	2y6m	♂	Anorexia	N	N	Y	N	N	N	G2	KM/TT/EX	3W
19	LO	2y	♂	Anorexia	N	N	Y	N	N	N	G2	KM/TT/EX	2W
20	L	1y	♂	Anorexia	N	N	Y	N	N	N	G2	KM/EX/DA	1W
21	D	2y	♂	Anorexia	N	N	Y	Y	N	N	G2	KM/TT/EX/DA	3W

※ D: Dwarf, L: Lion, LO: Lop ear, W: Week, M: month, y: years, ♂ : Male, ♀ : Female, Y: Yes, N: No, M: Medication, TE: Teeth extraction, Dr: Drainage, Euth: Euthanasia, TT: Teeth trimming, G: Give up of medication, DE: Death, EX: Exercise outside (UV), DA: Dietary advice, G1: Grade1, G2: Grade2, G3: Grade3, G4: Grade4, G5: Grade5

Table 5. Postoperative healing process in rabbits with nonvital pulp therapy

	Days after endodontic therapy									
	1	2	3	4	5	10	15	20	25	30
Swelling	2/10	3/10	3/10	1/10	1/10	0/10	0/10	0/10	2[a)]/10	2[a)]/10
Inflammation	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10	2[a)]/10	2[a)]/10
Anorexia	6/10	4/10	4/10	1/10	0/10	0/10	0/10	0/10	1/10	1/10
ABW[b)]	0/10	4/10	4/10	1/10	0/10	0/10	0/10	0/10	1/10	1/10
ARR[c)]	3/10	2/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
AHR[d)]	3/10	2/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10

a) Two cases had elongation of teeth roots at non-operated site, postoperative; b) ABW, Abnormal body weight; c) ARR, Abnormal respiratory rate (normal: 30-60 breaths/minute); d) AHR, Abnormal heart rate (normal: 180-300 beats/minute)

anorexia, swelling, and inflammation around post-operative day 25. In this case, other elongated and untreated dental roots were observed (Table 5).

The cure rate was 80% and 28.6% in group A and group B, respectively. In the second degree, the cure rates in group A and B were 100% and 75%, respectively. In group B, the third degree had a cure rate of 75%. Cure required 26.6 ± 3.0 days in group A and 121.5 ± 88 days of treatment. In the third degree, the treatment period was 26.6 ± 3.1 days for group A and 20.6 ± 16.5 days for group B.

Discussion

Dental disorders have been recognized as a cause of diseases in rabbits for many years. The excessive salivation due to the abnormal teeth was termed as 'slobbers' (14). This term is still used in many texts. Especially, the malocclusion with characteristic elongation of dental roots and acquired disease in pet rabbits is common (15). Harcourt-Brown recognized that the ectopic dental root could penetrate the skull bone and result in abscess formation (7). Many etiologies of dental disease in rabbits have been discussed. Until recently, it has been considered that the congenital factors are mainly related. However, it is now apparent that there are many other factors involved, although congenital malocclusion does occur. There is a high incidence of dental disease in rabbits in Korea, because the indoor breeding of rabbits is popular, but some owners lack basic dietary information.

In rabbits, dental disease occurs as a result of malocclusion due to the alteration of the mandible and maxilla, and elongated dental crown, since the upper teeth grow 0.5 cm every month, while the lower teeth grow 1 cm every month. The characteristic symptom of acquired dental diseases and malocclusion is the elongation of dental roots (5). Ectopic tooth roots due to the elongation of dental roots may penetrate the skull bone and form an abscess (5). These changes are the basis of symptoms such as facial swelling, and can develop into a life-threatening condition. Also, the etiology of dental diseases includes enamel projection of cheek teeth, due to loss of attrition or disuse atrophy, low calcium level in diet (the ideal level is 0.44%), indoor husbandry, vitamin D deficiency, vitamin A deficiency, and magnesium (Mg) deficiency (1,5,6,12,13). These etiologies worsen dentin and enamel formation, lead to secondary hyperparathyroidism, and lead to metabolic bone disease (6). Hematologically, an increase of albumin and neutrophils can occur because of inflammation (9). The reduced dental attrition due to the changes in diet and dietary habits, which is a common aspect of domestication, results in a high incidence of dental disease, especially in dwarfs (16). For this reason, anorexia is one of the first clinical signs, and is the major reason for the hospital visit.

Endodontic treatment can be divided into two categories: vital pulp therapy and nonvital pulp therapy (root canal therapy), in which all pulp tissues are removed. In addition, vital pulp therapy can be subdivided into pulp capping and vital pulpotomy (17). In this study, we used nonvital pulp therapy, whose purpose is the conservation of the teeth although the endodontic system is removed. Therefore, the normal function of the teeth can be continued due to the presence of the remaining teeth. Moreover, it is less painful and complicated than tooth extraction, which is one of the conservative methods (17). Endodontic therapy in canines and felines is performed when there is irreversible pulpal pathology such as generalized pulp necrosis. Similarly, this method has been used restrictively in endodontic disease for rabbits (16). However, we tried the nonvital pulp therapy as a treatment on elongated dental roots not associated with endodontic diseases. We could verify that the consequence of the treatment was more effective in the cure rate and treatment period than the regular method. There are several access sites in endodontic therapy. The most common access site in canines and felines is the intraoral access to the dental roots. Another approach performed in the case of periapical abscess is an access from the dental roots to the oral cavity using a gingival mucous patch plaque (10). In this study, the skin of the mandible was incised and after dissection of platysma muscle and subcutaneous fascia, the dental roots including roots apex were exposed using a burr and apicoectomy and nonvital pulp therapy were performed. This was different from the approach that is used in canines and felines. In rabbits, it is not practical to use the method applied in canines and felines due to abscess forma-

tion that results from mandibular swelling and ectopic dental roots. Moreover, the growth of the dental nerves should be prevented. The materials used in endodontic therapy were the same as used in treatment of canines and felines. However, the materials in rabbits did not induce foreign body reaction as occurs in canines and felines.

The prognosis of the nonvital pulp therapy performed in group A with clinical signs was satisfactory, whereas in group B the prognosis was not favorable owing to the long, expensive, and stressful environment during the treatment period. Therefore, the conventional method is not more effective than nonvital pulp therapy owing to the effect and duration of the treatment. Nonvital pulp therapy of mandibles, which was presently performed for the first time in rabbits, helped to maintain the teeth for a longer period than the existing methods including extraction of teeth, removal of abscess, and euthanasia, and prevented lower tooth disorders through the removal of ectopic dental root, abscess, pain, and inflammation (4). For this reason, the therapy restores the normal dietary and behavioral patterns of the rabbit.

In conclusion, nonvital pulp therapy can be applied in grade 2 or 3 elongations of dental root in pet rabbits, which represents an alternative therapeutic approach.

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애완토끼에서 과잉성장된 하악치아의치신경치료 연구

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요 약 : 애완 토끼의 치아는 정교하게 배열되고 정렬되어 서로 마모되면서 그 형태와 교합을 유지한다. 어떠한 요소이던 치아의 위치를 변화시키는 요소는 비록 작은 부분이라고 하더라도 부정교합을 일으키고 크라운의 과잉성장을 야기한다. 토끼의 후천적 치아질환과 부정교합은 치아 뿌리의 성장을 특징으로 한다. 이러한 현상은 애완토끼에게서 흔히 발생한다. 정상위치를 벗어난 치아 뿌리는 두개골을 관통하여 농양을 형성한다. 치아문제와 관련된 임상증상으로는 식욕저하, 유연, 치근농양, 과도한 눈물분비가 있다. 임상증상이 나타난 토끼들에게는 치신경 치료가 필요하다. 이 논문은 통증, 식욕부진, 유연, 과도한 눈물분비, 누낭염 증상으로 치신경 치료를 받은 토끼들의 외과적 절차와 수술후 회복과정을 간략하게 서술하였다. 31케이스 중 후천적 치아질환을 치료하기 위해 10마리의 토끼는 치신경 치료를 받았다. 치신경 치료는 치아 뿌리의 성장을 영구적으로 해결하기 위한 방법이다. Root canal 의 치수 조직을 제거한 후 식염수로 세척하였다. 이후 Guatta percha points와 IRM으로 치수강을 채웠다. 치신경 치료 후 10개중 8개의 케이스에서 예후가 좋았고, 토끼 보호자분들의 수술후 관리가 양호하였다. 본 결과를 통하여 하악 어금니의 치아 뿌리가 과잉성장한 케이스에서 치신경 치료가 수행될 수 있다는 것을 알 수 있었다.

주요어 : 애완토끼, 과잉성장치료, 하악치아, 치신경