수의학석사 학위논문

Determination of Age by Pulp Cavity/Tooth Width Ratio Using Dental Radiography in Cats

고양이에서 치수공간과 치아너비 비율을 이용한 나이 추산 연구

2014 년 8 월

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이 논문을 수의학석사학위논문으로 제출함

2014 년 4 월

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박 경 선

박경선의 석사학위논문을 인준함.

2014 년 6 월

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Determination of Age by Pulp Cavity/Tooth Width Ratio Using Dental Radiography in Cats

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Abstract

The purpose of this study was to identify the effect of age on the ratio of pulp cavity/tooth width (P/T ratio) in healthy cats. The dental radiographs of 32 cats (16 males, 16 females) were generated with a digital dental X-ray unit under general anesthesia. Standardized measurement of the canine teeth was achieved by drawing a line on the radiograph perpendicular to the cemento-enamel junction (CEJ) of the tooth.

There was an inversely proportional correlation between the chronological age and the P/T ratio. Moreover, a strong squared Pearson correlation ($\gamma^2 = 0.92$) was revealed in the curved regression model. In terms of the cats' sex and breeds, no significant difference in the P/T ratio was found. These results suggest that determination of age by P/T ratio could be clinically useful in estimating the chronological age of unknown-aged cats.

Keywords: Age determination, Pulp cavity, Cats, Dental radiograph, Age estimation

Student Number: 2011 – 23710

CONTENTS

I. Introduction

Dental age estimation has been useful in human forensic medicine and wildlife animal research. Age estimation is an important aspect of the postmortem examination and it has been used in human forensic medicine to determine the age of humans who were killed during large scale disasters. Hard tissue, such as teeth and bones is preserved for a long time after the decay of soft tissue and it is utilized as useful evidence for personal identification (Sakuma et al., 2013). The pulp cavity volume of teeth is gradually decreased with advancing years and this is known to be associated with the aging deposition of dentin (Star et al., 2011). In veterinary medicine, the studies related to unknown-aged wildlife (grey foxes, coyotes, moose, and other species) have investigated the correlation between chronological age and teeth (Knowlton and Whittemore, 2001; Linhart and Knowlton, 1967; Sergeant and Pimlott, 1959; Tumlison and McDaniel, 1984). However, few studies have investigated domestic cats. The chronological age of abandoned cats is commonly unidentified. Therefore, it is not possible for some cat owners to know the chronological age of the abandoned cats they have adopted.

The dental age estimation method is beneficial because teeth are highly resistant to

mechanical, chemical, or physical impacts (Bass, 1979; Kringsholm et al., 2001; Liang et al., 2009; Thevissen et al., 2006). Teeth are less affected by hormones, nutrition and environmental factors as compared to other skeletal markers (Saunders et al., 1993). Although many methods have been evaluated, dental radiography has been generally used to analyze changes in the size of the pulp cavity in human forensic medicine and wildlife animal research (Kershaw et al., 2005; Knowlton and Whittemore, 2001; Kvaal et al., 1995; Tumlison and McDaniel, 1984). The dental radiograph method is simple, non-invasive, and suitable for age estimation (Karkhanis et al. 2013).

The purpose of this study was to evaluate the correlation of age and pulp cavity/tooth width in healthy cats. Additionally, the correlation between P/T ratio and sex and breeds was evaluated.

II. Materials and Methods

1. Animals

Thirty-two clinically healthy, client-owned cats (16 males, 16 females) were evaluated in this study. The age of all the cats was known and the age range was 6 to 108 months. The clients volunteered for this clinical study and signed a consent form were evaluated. The breeds of the participating cats were: Domestic Short Hair (DSH) (n=17), Persian (n=9), Turkish Angora (n=4), and Siamese (n=2). All the cats underwent physical examination and blood testing to rule out any systemic disease. Cats that had received dental treatment in the past were excluded from this study.

The entire sample (n=32) was used to evaluate the correlation of age and pulp cavity/tooth width in healthy cats. However, to study P/T ratio based on sex and breeds, the sample list was reclassified according to the subgroup of age. The following 18 cats were selected and evaluated based on their sex (9 males, 9 females) and breeds (9 DSH, 9 Persian). The each subgroup (n=9) was devided as like less than 1 year old group (n=2), 1~3 year old group (n=4), 3~6 year old group (n=3). To reducing the statistical error, the breeds that were deficient in number (Turkish Angora and Siamese cats) were excluded from the corresponding investigation (Table 1).

Table 1. Distribution of data (sex and breeds) and subgroup according to age

Breeds	Sex	Age group (years)				Subtotal	Total
		< 1	1-3	3-6	> 6		
DSH	M	1	3	2	2	8	17
	F	2	4	2	1	9	
Persian	M	2	2	1		5	9
	F		2	2		4	
Turkish Angora	M			2		2	4
	F		1	1		2	
Siam	M			1		1	2
	F				1	1	
Total		5	12	11	4		32

*DSH : Domestic Shorthair, M : Male, F : Female

2. Anesthesia

All the cats were anesthetized with medetomidine hydrochloride (Domitor®; Orion Pharma, Espoo, Finland, 40 μg/kg, IM) and tiletamine-zolazepam (Zoletil®; Virbac Laboratories, Carros, France, 5mg/kg, IM). A half-dose of tiletamine-zolazepam was additionally administrated when the symptoms of waking from anesthesia were identified.

3. Radiography

The cats were positioned in sternal recumbency for radiography of the maxillary canine teeth. The maxillary canine teeth were chosen because of convenience of application and obdurability by deep roots in comparison with other teeth. The digital sensor pad was inserted into the mouth to obtain a rostral maxillary view. The sensor pad was placed between the tongue and the maxilla and beneath the canine tooth root. The cat's head was adjusted so that the digital sensor pad can be level with the position indicating device (PID). The PID was positioned perpendicular to the bisecting angle (sensor and long axis of the tooth) and placed as close as possible to the cat's maxilla, and over the nose (Lommer et al., 2000). All dental radiographic images were generated with a digital dental X-ray unit (Dentix®, Ardet Buccinasco, Italy). The standard exposure setting was 8 mA at 60 kVp for 0.1 sec, and the setting of kVp was

slightly adjusted according to the radiographic outcome (Fig. 1).

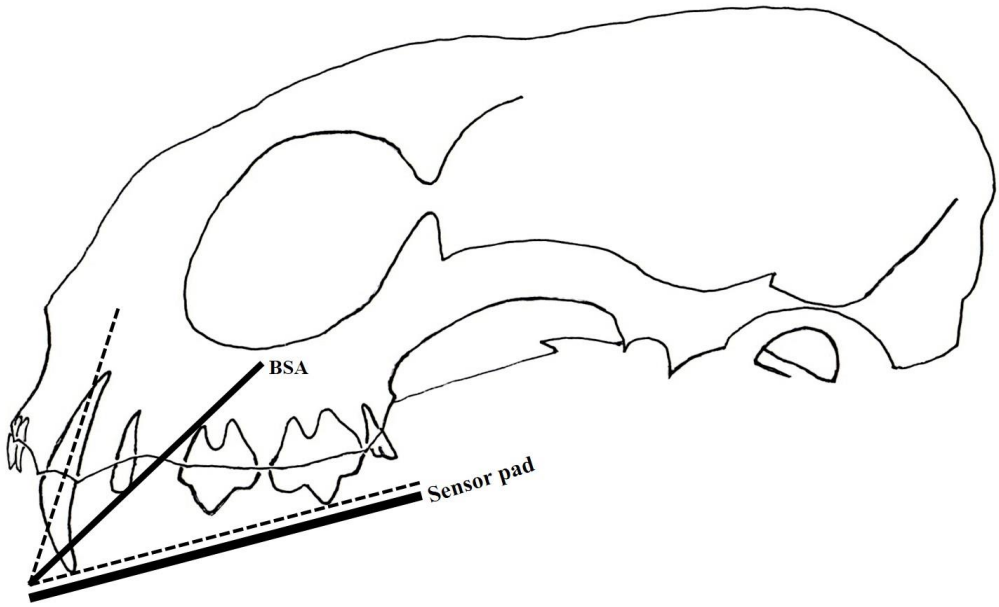

Fig. 1. Occlusal view of the maxillary canine teeth in the cat (BSA : bisecting angle).

4. Measurements

The radiographic images were converted into JPEG files and processed using the Adobe Photoshop CS6 image editing software program (Adobe Systems Incorporated, San Jose, CA, USA). Standardized measurement of the canine teeth was achieved by drawing a line on the radiograph perpendicular to the cemento-enamel junction (CEJ) of the tooth (Fig. 2). The program automatically calculated the pixel volume of the pulp cavity and the tooth width using a ruler tool.

Each image file was numbered consecutively from 1 to 32 as part of a blind setup. While analyzing the radiographs, the investigator did not know about the chronological age of the cats. To test the reproducibility, all measurements were performed by the same experienced investigator and re-examined after an interval of two weeks.

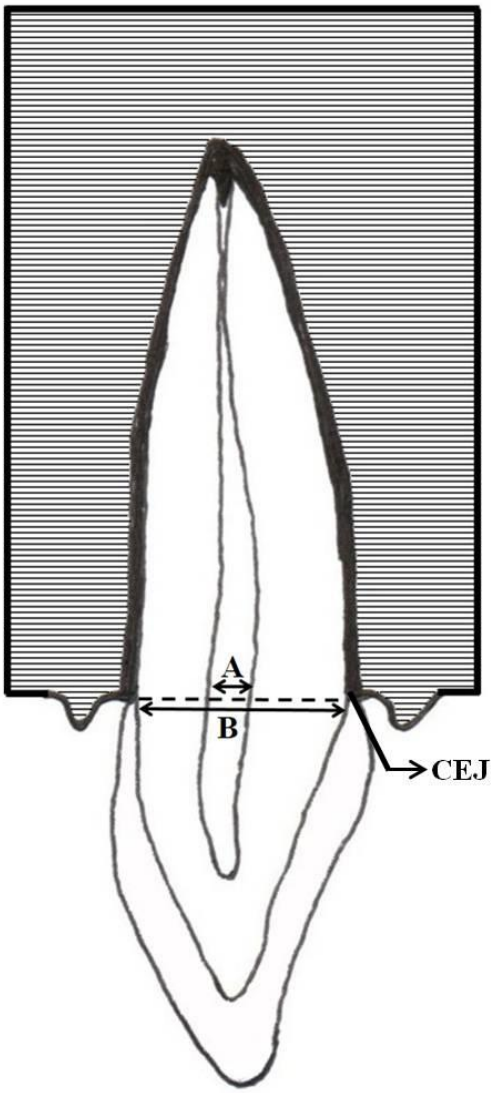

Fig. 2. Pulp cavity (A) and tooth width (B). Standardized measurement of the canines was achieved by drawing a line on the radiograph perpendicular to the cemento-enamel junction (CEJ) of the tooth.

9. Statistical Analysis

Statistical analysis was performed using SPSS Statistics 21.0 software (SPSS, Inc., Chicago, IL, USA). To quantify the proportion of variance explained in age by the pulp cavity/tooth width ratio, squared Pearson correlation coefficients were calculated. Linear and curved regression analyses were utilized to determine a correlation between age and P/T ratio. The best fit regression equation was determined by calculating the correlation coefficient (γ^2). The Mann-Whitney test was used to compare the mean values of the P/T ratio between the male and female cats. The same statistical method was used to compare the mean values of P/T ratio between two breeds (DSH and Persian cats). A P-value less than 0.05 was considered to be statistically significant.

III. Results

1. Reduction in the P/T ratio associated with increasing age

The P/T ratio associated with aging was shown to have a marked reduction. The P/T ratio was 0.56, 0.27, 0.18, and 0.15 for the cats aged 6 months, 12 months, 32 months, and 60 months, respectively. The calculated P/T ratio of the entire sample ranged from 0.13 to 0.56, with a mean (± SD) value of 0.21 ± 0.11 and a median of 0.18 (Fig. 3).

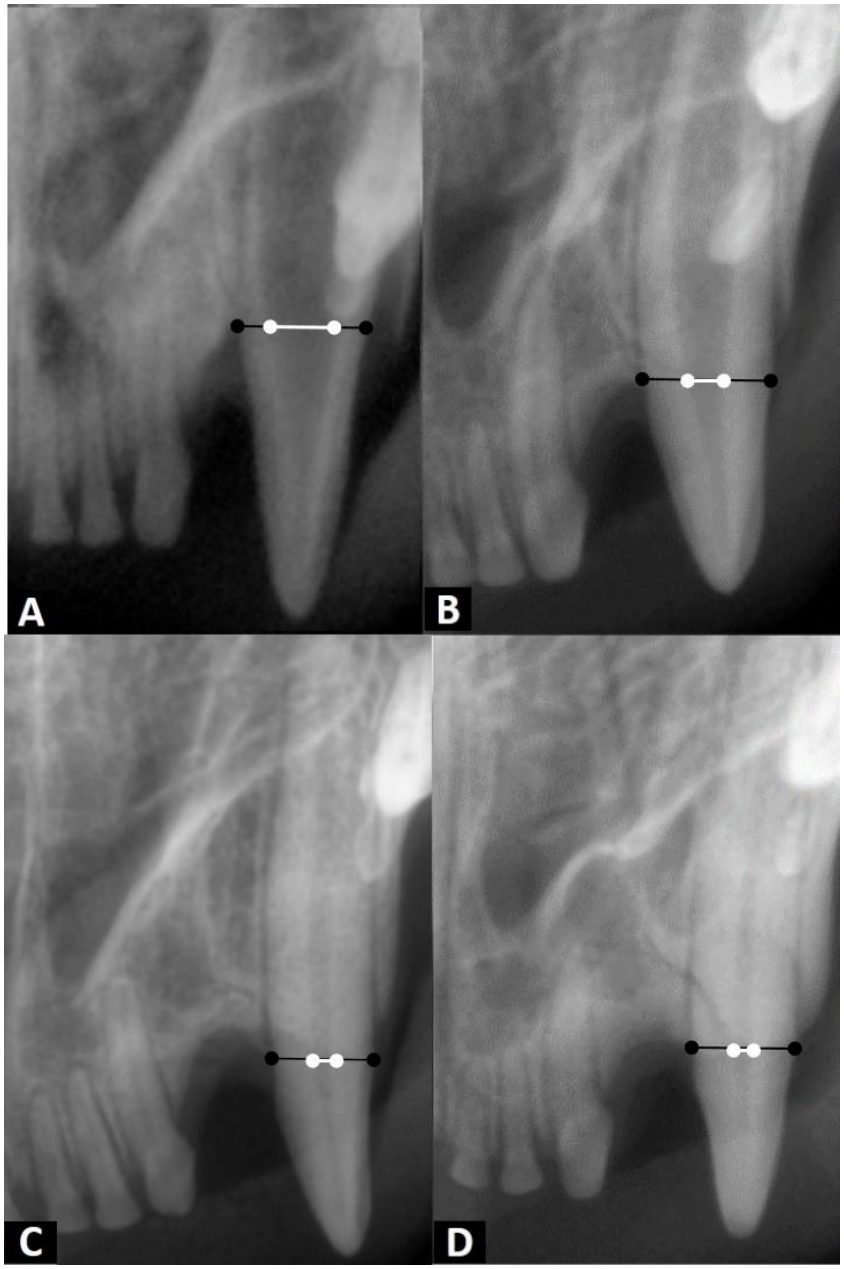

Fig. 3. Radiographic images of feline canine teeth. Marked reduction in the pulp cavity (white line)/tooth width (black line) ratio associated with increasing age (A: 6 months old; B: 12 months old; C: 32 months old; D: 60 months old).

2. Correlation between the chronological age and the P/T ratio

There was good correlation between age and P/T ratio (linear regression model: y = 0.294 – 0.002x, γ^2 = 34; curved regression model: y = 0.094 + 2.463/x, γ^2 = 92, p < 0.01, x: month, y: P/T ratio). An inversely proportional correlation was observed in the plot. The curved regression model was definitely more suitable than the linear regression model in this study (Fig. 4).

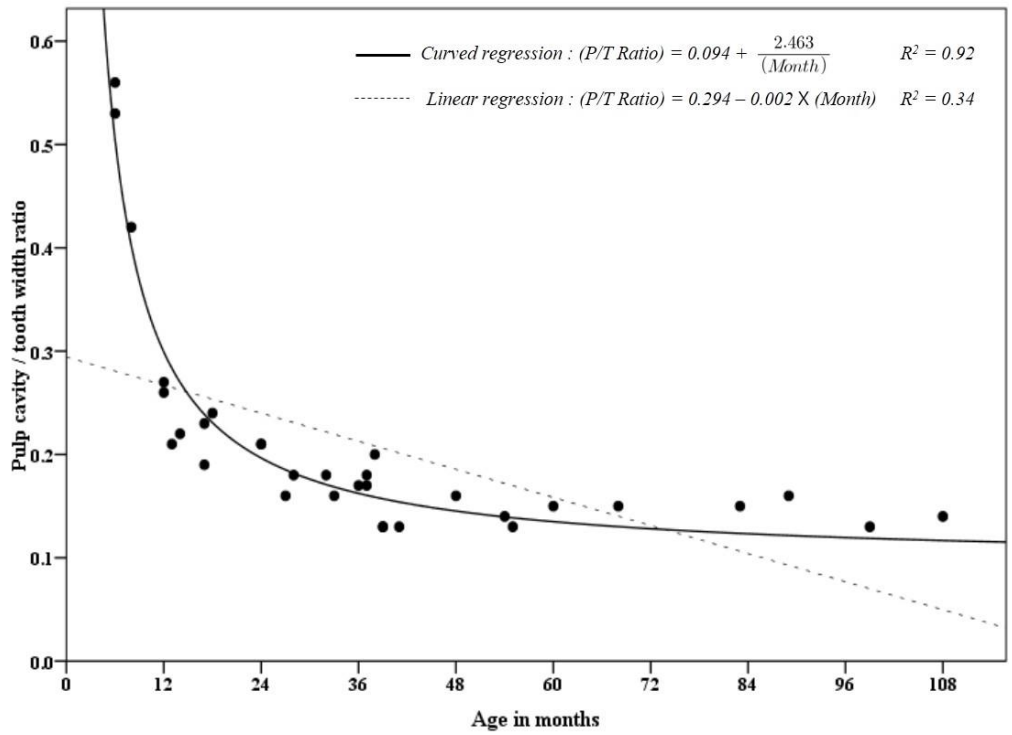

Fig. 4. Plot between chronological age and pulp cavity/tooth width ratio (P/T ratio).

3. Comparison of P/T ration between males and females

The mean value (± SD) for the male cats was 0.40 ± 0.19 (less than 1 year old group), 0.19 ± 0.03 (1~3 year old group), and 0.15 ± 0.02 (3~6 year old group). The mean value (± SD) for the female cats was 0.42 ± 0.21 (less than 1 year old group), 0.20 ± 0.02 (1~3 year old group), and 0.15 ± 0.03 (3~6 year old group). The value of entire sample (n=9) was 0.22 ± 0.12 in males and 0.23 ± 0.13 in the females, respectively. The differences between the males and females were not statistically significant (p = 0.66, Fig. 5).

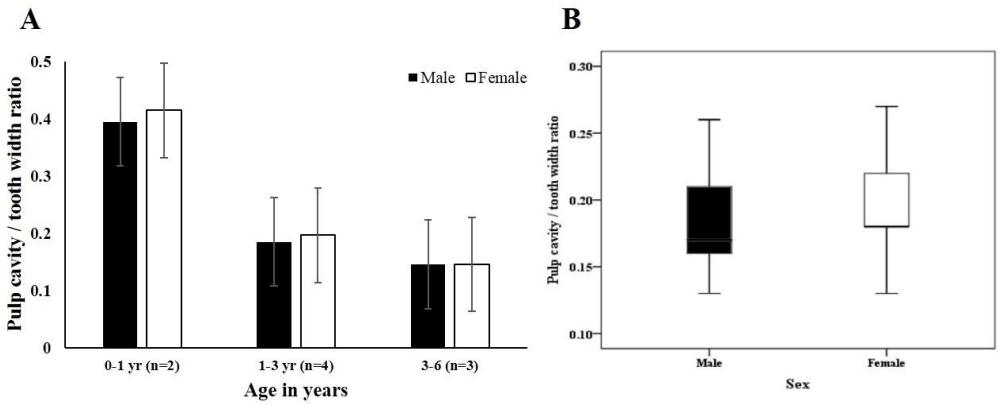

Fig. 5. Mean value of P/T ratio between males and females. Subgroup of age (A) and entire sample (B).

4. Comparison of P/T ration between the DSH and Persian cats

In terms of breeds, the mean value (± SD) of the DSH cats was 0.41 ± 0.21 (less than 1 year old group), 0.21 ± 0.03 (1~3 year old group), 0.16 ± 0.04 (3~6 year old group). The mean value (± SD) for Persian cats was 0.40 ± 0.19 (less than 1 year old group), 0.21 ± 0.03 (1~3 year old group), and 0.15 ± 0.01 (3~6 year old group). The value of entire sample (n=9) was 0.24 ± 0.13 (DSH) and 0.23 ± 0.13 (Persian), respectively. The differences between the DSH and Persian cats were not statistically significant (p = 0.80, Fig. 6).

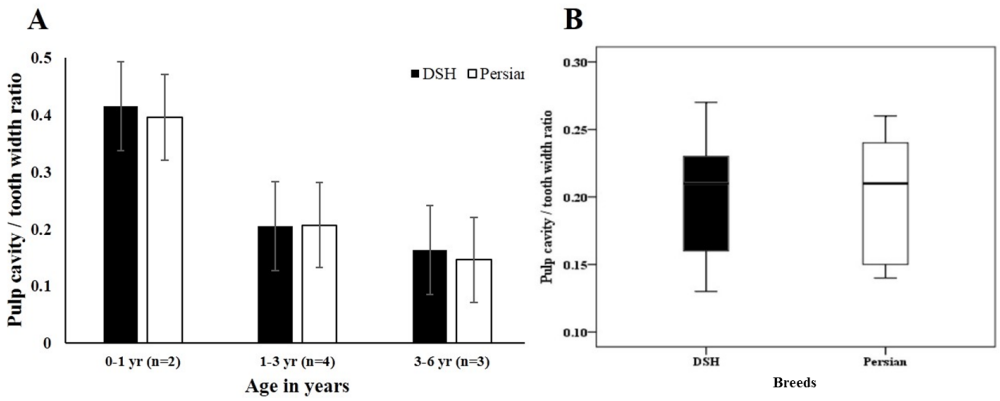

Fig. 6. Mean value of P/T ratio between the DSH and Persian cats. Subgroup by age (A) and entire sample (B).

IV. Discussion

In this study, the pulp cavity volume measured with maxillary canine teeth was evaluated to estimate the chronological age of cats. The change of pulp cavity volume is associated with secondary dentin deposition. Secondary dentin deposition is a normal morphological alteration of aging (Star et al., 2011). The formation of secondary dentin may be caused by the following impacts: attrition, abrasion, erosion, change in osmotic pressure throughout the pulp cavity, or aging (Philippas, 1961; Solheim, 1992). Among these, aging is the main reason for secondary dentin deposition in intact teeth. As a result, the volume of the pulp cavity progressively decreased. Therefore, the volume reduction of the pulp cavity in intact teeth can be recognized as a dental age predictor (Star et al., 2011).

In human forensic medicine, many studies have reported on the correlation between age and P/T ratio by radiograph. Furthermore, three-dimensional analysis using computed tomography has been used in recent years (Sakuma et al., 2013; Star et al., 2011). Overall, the result of regression analysis in humans indicated a general inverse relationship that was similar to the findings in this study. However, there are slight differences between humans and other animals, including cats. In humans, a rapid

reduction in the P/T ratio during the juvenile period was not revealed (Cameriere et al., 2012; Karkhanis et al., 2013; Sakuma et al., 2013; Star et al., 2011). However, the previous study in coyotes indicated a rapid reduction in the P/T ratio during the first year of life, with a marked reduction as the years go by (Knowlton and Whittemore, 2001). These features were also satisfied equally in this study. The supposed reason for these features is that humans and animals have a different whole-body growth rate during their respective juvenile periods.

In cats, the difference between males and females was not a dominant affecting factor, and this finding is similar to the findings in studies on humans and other animals (Cameriere et al., 2012; Knowlton and Whittemore, 2001; Sakuma et al., 2013; Star et al., 2011). Moreover, the differences between breeds (DSH and Persian cats) were not found to be dominant affecting factor in cats.

Further studies about more diverse types of teeth (incisors, canines, premolars) were evaluated in previous studies. There were slight difference in the correlation coefficients among the different types of teeth, but the overall relation between age and P/T ratio was not found to be widely different (Karkhanis et al., 2013; Knowlton and Whittemore, 2001; Star et al., 2011). In this study, other types of teeth (incisors, premolars) were not evaluated, so a comparison between cats and other animals was

not investigated.

In summary, our findings demonstrated that P/T ratio has a good correlation with age. Based on the results of our study, determination of age by P/T ratio could be clinically useful in estimating the chronological age of unknown-aged cats.

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VI. 국문초록

고양이에서 치수공간과 치아너비 비율을 이용한 나이 추산 연구

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본 연구에서는 건강한 고양이에서 치수공간과 치아 너비 비율 (P/T ratio)을 이용하여 나이를 추산하는 것이 효과가 있는지 조사하였다. 디지털 치과 엑스레이 장비를 이용하여 총 32 마리 고양이 (수컷 16마리, 암컷 16

마리)의 치과 방사선을 전신 마취하에 촬영하였다. 송곳니 (canine teeth)의 시멘트사기질이음 (cement–enamel junction, CEJ) 에서 수직으로 가상의 선을 그린 지점을 기준으로 하여 일정하게 비율 측정을 실시하였다. 실제 나이와 P/T ratio 사이에 반비례 관계가 있는 것으로 확인되었다. 이와 더불어, 통계적으로 곡선 회귀 분석 모델에서 매우 유의적인 결과 (squared Pearson correlation, $\gamma^2 = 0.92$)를 나타내었다. 성별과 품종간 차이는 확인되지 않았다. 이를 토대로 나이를 모르는 고양이의 실제 나이를 P/T ratio를 이용하여 추산하는 것이 임상적으로 도움을 줄 수 있을 것이라 생각된다.

주요어 : 나이 측정, 치수공간, 고양이, 치과 방사선, 나이 추산

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