

## Prediction Model for Toothache Occurrence in College Students by using Oral Hygiene Habits and the CART Model

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### 대학생의 구강건강관리실태와 CART모델을 이용한 치통발생예측

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**Abstract** The occurrence of toothache signals the malfunction in oral health, which allows the detection of any abnormal condition in the oral cavity at an early stage to prevent the condition from worsening, and thus can act as a preventive measure. This study has looked into the status of oral health management in relation to toothache through the structured survey administered to 235 college students. Based on the survey results, this study aimed at comparing the toothache occurrence prediction between regression analysis and CART model in order to clarify the relationship between the factors of oral health management habits that contribute to toothache occurrence. According to the result, there was a difference between the present health status and the health status of the past year depending on the presence or non-presence of toothache occurrence ( $p < 0.05$ ). There was a difference in the regularity of meal time depending on the presence or non-presence of toothache occurrence from the dietary habits of the research subjects ( $p < 0.05$ ). As for the presence or non-presence of toothache occurrence from the oral hygiene habits of the research subject, there was a difference between the occurrence and nonoccurrence of bleeding during brushing or flossing ( $p < 0.05$ ). According to the results of regression analysis, no factors were significant in the relationship with the presence or non-presence of toothache occurrence from the status of life habits and oral hygiene habits. 70% of the researched group was randomly selected as the sample for generating an analytical model and the remaining 30% was used as the sample for generating an evaluation model. According to the results of CART model, the occurrence of toothache was higher in the case of irregular meal time and poor current health condition than the case of average or satisfactory health condition. The above results imply that CART model is a very useful technique in predicting toothache occurrence compared to regression analysis, and suggests that CART model could be very useful in predicting other oral diseases including toothache.

**Key words** toothache, oral hygiene habits, CART

### Introduction

Oral disorders or diseases deteriorate the quality of physical life by complicating the nutrition supply to the body. However, oral diseases have been dealt with lightly under the presumption that oral diseases have little relevance to life. The oral cavity is an organ that is responsible for the intake of food, the most fundamental factor in maintaining and improving health, and therefore, the presence of toothache alone could complicate the intake of food<sup>1-2)</sup>.

Toothache may be caused by dental caries or have nothing to do with dental caries. The toothache caused by dental caries may be accompanied by one or more symptoms, which include cold pain felt from cold water and cold wind breeze, hot pain felt from warm water and food, spontaneous pain, occlusion pain and masticatory pain. Toothache may also be caused by dentin hypersensitivity, periodontal disease, and tooth fracture, which are not associated with caries<sup>3)</sup>.

The presence of one or more symptoms of toothache often indicates latent problems in teeth or gum, and thus toothache is mostly caused by dental caries and periodontal diseases<sup>4-5)</sup>.

In the field of dentistry and public oral health, numer-

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ous studies have been conducted on the relationship between oral health and general health<sup>1,6-10</sup> using the caries prediction of bacteriologic caries activity test, tree structured classification model for high risk dental caries, and CART (classification and regression tree, hereafter indicated as CART). Analytical techniques for predicting toothache occurrence are still insufficient but logistic regression analysis has been used to determine the relationship between general health and oral health. Nevertheless, some studies have reported that logistic regression analysis has lower prediction accuracy than CART model or neural network<sup>11-13</sup>.

Decision tree is a method of analysis that classifies groups or performs prediction by mapping decision rules<sup>14</sup>. The analytic processes are expressed in a tree structure that, compared to other methods such as discriminant analysis and regression analysis, allows the researchers to easily understand and explain the analytic processes. Tree generating algorithm of decision tree analysis varies but the most commonly used are CART and CHAID (chi-squared automatic interaction detection) with the newest algorithm, C4.5. Decision tree may be used in any studies that aim to classify or predict but is more useful in explaining the analytical processes rather than the accuracy of analysis.

Therefore, to encourage the maintenance and improvement of oral health and to detect toothache, which signals abnormalities in oral health, at an early stage, this study will predict the possibility of toothache occurrence in advance by using CART model based on the dietary habits and oral hygiene habits of college students.

## Subjects and Methods

### 2.1. Research Subjects and Data Collection

During the period between March 1, 2008 and March 31, 2008, a total number of 243 students at two universities were surveyed and excluding 8 students, who answered insincerely, the remaining 235 students (78 males and 157 females) became the research subjects.

The present toothache referred to the presence or non-presence of pure toothache, excluding toothache caused by external wound, in the past month from the time of survey. Students with three or more days of toothache pain were classified into the group with the presence of toothache.

### 2.2. Research Tools

The survey was given by two interviewers who had been

trained by the researcher to provide descriptive explanation on the research purpose and contents to the respondents of self-administered survey. General characteristics such as gender, age, weight and height have been surveyed. As for the dietary habits by gender, number of meals, regularity of meal time, snack intake and subjective awareness of one's own dietary habits were surveyed. Also, sleep time, amount of exercise, type of exercise, smoking status and alcohol intake were asked to survey the life habits of the subjects. As for the oral hygiene habits, presence or non-presence of toothache, scaling experience, number of brushing, education experience in oral care, type of toothbrush, frequency of toothbrush replacement, and the use of dental floss have been surveyed. Cronbach's  $\alpha$ , the reliability of the survey on toothache was 0.887.

### 2.3. Analysis Method

The data collected through the survey was analyzed using SPSS (ver. 12.0). Chi-square test was used to compare the dietary habits, life habits and oral hygiene habits based on the presence or non-presence of toothache in the research subjects. Prior to generating the toothache occurrence prediction model using the data mining technique, logistic regression analysis was performed with the variables greatly related to toothache occurrence, where toothache is the clan variable. Next, the toothache occurrence prediction model was generated using SPSS Clementine (ver. 10.0) with the application of CART model.

## Result

### 3.1. Relationship between the presence or non-presence of toothache occurrence and the dietary habits

The difference of the presence or non-presence of toothache occurrence in the research subjects and their dietary habits is shown in Table 1. The occurrence of toothache varied depending on the regularity of meal time ( $p < 0.05$ ) but showed no relationship with the number of meals, snack intake, taste preference and balanced meal status.

### 3.2. Relationship between the presence or non-presence of toothache occurrence and the life habits

The relationship between the presence or non-presence of toothache occurrence in the research subjects and their life habits is shown in Table 2. The occurrence of toothache showed no significant relationship with sleep time, amount of exercise, alcohol consumption, smoking status, amount of smoking intake and anamnesis.

**Table 1. Relationship between the presence or non-presence of toothache occurrence and the dietary habits** N(%)

		Pain	No pain	Total	p
The number of meals	1 time/day	10(4.3)	20(8.5)	30(12.8)	0.622
	2 times/day	22(9.5)	61(26.0)	83(35.3)	
	3 times/day	30(12.8)	92(39.1)	122(51.9)	
Time to eat	Regular	19(8.1)	86(36.6)	105(44.7)	0.032*
	Normal	32(13.7)	70(29.8)	102(43.4)	
	Irregular	11(4.7)	17(7.2)	28(11.9)	
Snack intake	Nothing	11(4.7)	27(11.5)	38(16.2)	0.914
	1-2 times/week	23(9.8)	73(31.1)	96(40.9)	
	3-4 times/week	16(6.8)	41(17.4)	57(24.3)	
	5 times/week	12(5.1)	32(13.6)	44(18.7)	
Taste preference	Salty taste	23(9.8)	50(21.3)	73(31.1)	0.399
	Normal	35(14.9)	117(49.8)	152(64.7)	
	Sour	1(0.4)	1(0.4)	2(0.9)	
	Sweet	3(1.3)	5(2.1)	8(3.4)	
Balanced meal	Yes	19(8.1)	74(31.5)	93(39.6)	0.094
	No	43(18.3)	99(42.1)	142(60.4)	
Total		62(26.4)	173(73.7)	235(100.0)	

The data were analyzed by  $\chi^2$ -test.

**Table 2. Relationship between the presence or non-presence of toothache occurrence and the life habits** N(%)

		Pain	No pain	Total	p
Sleep Time (hours/day)	< 5	6(2.6)	8(3.4)	14(6.0)	0.532
	5 - 7	36(15.3)	104(44.3)	140(59.6)	
	8 <	17(7.2)	50(21.3)	67(28.5)	
	Irregular	3(1.3)	11(4.7)	14(6.0)	
Amount of exercise (hours/week)	1 <	25(10.6)	69(29.4)	94(40.0)	0.789
	1 - 4	15(6.4)	48(20.4)	63(26.8)	
	8 - 12	5(2.1)	18(7.7)	23(9.8)	
	Nothing	17(7.2)	38(16.2)	55(23.4)	
Consumption of alcohol (per week)	Nothing	23(9.8)	70(29.8)	93(39.6)	0.799
	1 - 3	35(14.9)	130(55.3)	130(55.3)	
	3 <	4(1.7)	12(5.1)	12(5.1)	
Smoking status	Nothing	42(17.9)	124(52.8)	166(70.6)	0.842
	Stop smoking	6(2.6)	15(6.4)	21(8.9)	
	Smoking	14(6.0)	34(14.5)	48(20.4)	
Total		62(26.4)	173(73.7)	235(100.0)	

The data were analyzed by  $\chi^2$ -test.

### 3.3. Relationship between the presence or non-presence of toothache occurrence and the oral hygiene habits

The occurrence of toothache showed relevance with bleeding at the time of brushing or flossing ( $p < 0.05$ ) but showed no relevance with other factors of oral hygiene habits such as the number of brushing and prior visit to a dentist (Table 3).

### 3.4. Result of toothache prediction through logistic regression analysis

Major variables that are closely related to the occurrence of toothache have been selected by examining the survey items used in this study. To make the toothache occurrence prediction model, variables for neural network

have been selected based on the variables that have been analyzed with basic statistics and shown to be significant. The variables that have been verified to have relation with the toothache occurrence in the  $\chi^2$ -test were present health status, health status of the past year, regularity of meal time, and bleeding during brushing or flossing. The result of logistic regression analysis is shown in Table 4. Odds ratio for all variables were not significant.

### 3.5. Decision tree model by CART

To develop the toothache occurrence prediction model using CART model that considers toothache as the clan variable using SPSS Clementine (ver. 10.0), input variables have been selected in this study based on the variables that were proven to be significant through the basic

**Table 3. Relationship between the presence or non-presence of toothache occurrence and the oral hygiene habits** N(%)

		Pain	No pain	Total	p
Prior seen a dentist	Yes	30(12.8)	73(31.1)	103(43.8)	0.476
	No	32(13.6)	100(42.6)	132(56.2)	
Prior experience with scaling	Yes	44(18.7)	121(51.5)	165(70.2)	0.880
	No	18(7.7)	52(22.1)	70(29.8)	
Gum treatment (except for scaling)	Yes	6(2.6)	14(6.0)	20(8.5)	0.701
	No	56(23.8)	159(67.7)	215(91.5)	
The number of toothbrush	1 time	4(1.7)	10(4.3)	14(6.0)	0.746
	2 times	22(8.5)	45(19.1)	65(27.7)	
	3 times	32(13.6)	103(43.8)	135(57.4)	
	4 times over	6(2.6)	15(6.4)	21(8.9)	
Toothbrush time	After eating	50(21.3)	154(65.5)	204(86.8)	0.225
	After morning meal	6(2.6)	11(4.7)	17(7.2)	
	Before morning meal	5(2.1)	4(1.7)	9(3.8)	
	Before sleep	1(0.4)	4(1.7)	5(2.1)	
Toothbrush education	Yes	39(16.6)	108(46.0)	147(62.6)	0.537
	No	23(9.8)	65(27.7)	88(37.4)	
Type of toothbrush	Soft wool	29(12.3)	96(40.9)	125(53.2)	0.471
	Normal wool	27(11.5)	62(26.4)	89(37.9)	
	Hard wool	5(2.1)	9(3.8)	14(6.0)	
	Irregular wool	1(0.4)	6(2.6)	7(3.0)	
Frequency of toothbrush replacement	2-3 week	4(1.7)	14(6.0)	18(7.7)	0.917
	2-3 month	47(20.0)	129(54.9)	176(74.9)	
	6 month	11(4.7)	30(12.8)	41(17.4)	
Using dental floss	Yes	26(11.1)	81(34.5)	107(45.5)	0.507
	No	36(15.3)	92(39.1)	128(54.5)	
Bleeding (brushing and flossing)	Yes	43(18.3)	91(38.7)	134(57.0)	0.022*
	No	19(8.1)	82(34.9)	101(43.0)	
Total		62(26.4)	173(73.7)	235(100.0)	

The data were analyzed by  $\chi^2$ -test.

**Table 4. Result of toothache prediction through logistic regression analysis**

Variable	OR	95% CI
Present history	0.664	0.198-2.230
Past history(1 year)	1.668	0.733-3.793
Time to eat	0.621	0.216-1.789
Bleeding (brushing & flossing)	1.707	0.887-3.282

OR: odds ratio, CI: confidence interval.

statistical analysis. All the variables, except for the independent variables that relatively have high significance including the present health status (0.156), the health status for the past year (0.032), the regularity of meal time (0.246), bleeding during brushing or flossing (0.042), have been eliminated. A group of samples, that takes up 70% of the surveyed group, was randomly drawn to generate an analytical model, and the remaining 30% was used for generating an evaluation model.

The results on the data for analysis of decision tree model by CART are shown in Figure 1 and the results of

the evaluation data are shown in Figure 2. 41 people (25.62%) out of 160 people in the analysis answered to have toothache. Among this group, 32.22% of 90 people who have irregular meals had toothache where as 17.43% of people who have regular meals had toothache. Among the people who have irregular meal time, there was a higher occurrence of toothache in people with average or poor health conditions (20 people, 41.66%) than in people with good health condition (9 people, 21.42%). Also, in the case of irregular meal time and poor health conditions, 100% answered to have toothache, which is significantly higher than those with average health condition (41.66%) (Figure 5).

Looking at the evaluation data, toothache in people with changes in health condition in the past year was 58.33%, which is higher than toothache in people with no change in health condition in the past year (22.22%) (Figure 6). Also, 100% of people with poor health condition at the present answered to have toothache where as only 50% of the people with good or average health condition answered to have toothache. In the case of irregular meal

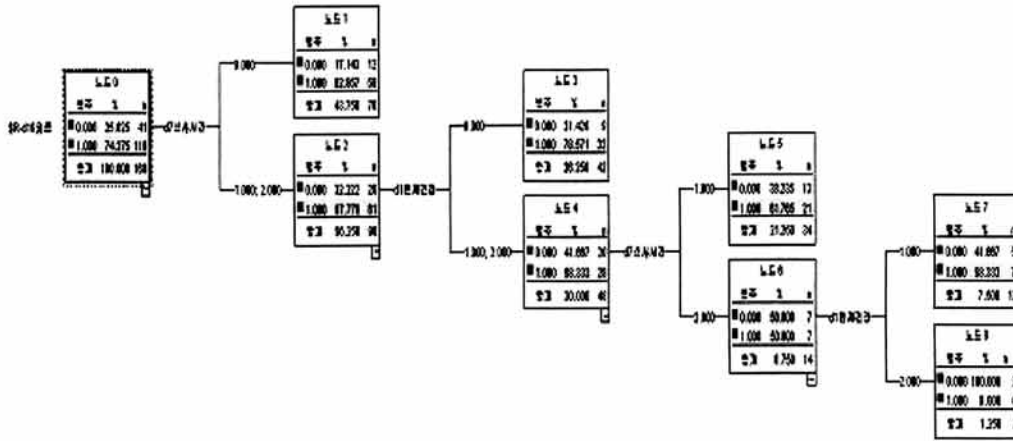


Fig. 1. Decision tree in CART model (train).

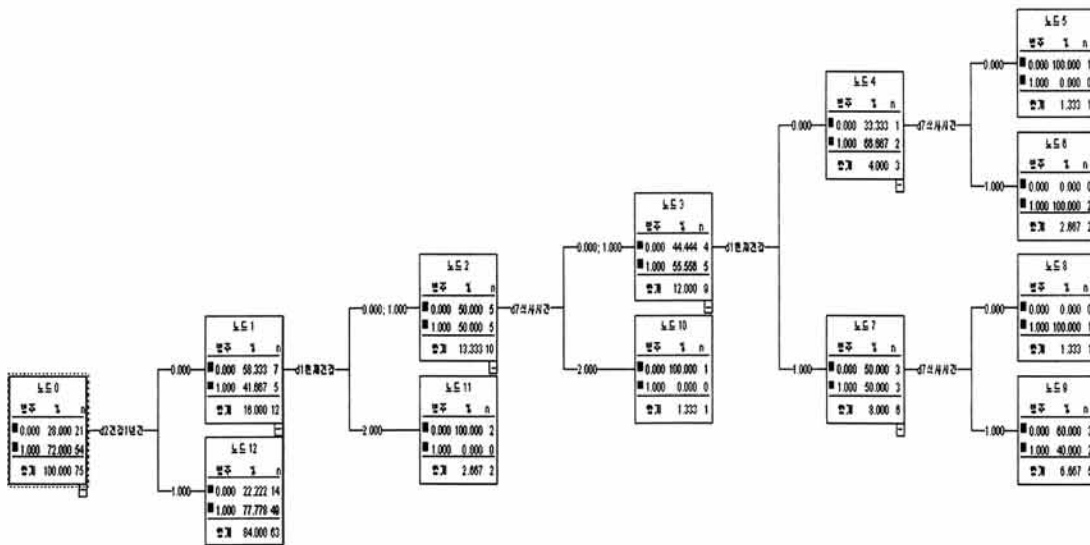


Fig. 2. Decision tree in CART model (validation).

time with the current health condition being either satisfactory or average, the occurrence of toothache is 100%, which is higher than the tooth occurrence (44.4%) in the case of average or regular meal time. Also, in the case of average health condition at the present, the toothache occurrence in those with regular meals reported to be 9% where as those with somewhat regular meals was 60%.

### Discussion

Teeth and oral cavity, organs that intake and digest food, eat, drink and masticate to survive. Moreover, they have the pronunciation function and cosmetic function which allow natural communication of opinions with one another for sustaining social life. Likely, in order to sustain a healthy social life and to avoid the contraction of diseases, oral health must be managed logically. Dental car-

ies and periodontal diseases are known as the major causes that hinder oral functions<sup>15</sup>.

The symptoms of dental caries and periodontal diseases are very minor at the initial stage that except in the cases of severe discomfort and pain, many people tend to overlook and neglect the occurrence of minor toothache. Minor toothache is the initial signal that indicates malfunction of oral cavity and thus understanding the causes of toothache is reported to be very helpful in oral health management and general health maintenance. The causes of toothache known up to now are reported in the following studies: relationship between the number of toothbrush strokes, the number of caries and the percentage of caries experience, study on the number of visits to dentist<sup>16</sup>, study on the relationship between oral health improving behaviors, recognized oral health and the oral health of daily life<sup>4</sup>, and study on the relationship between

age, gender, marital status, education level, economic status, social position and the recognized oral health status and oral health improving behaviors.

In this study, the present health status, health status of the past year, regularity of meal time, and bleeding during brushing or flossing have been found to be the important factors causing toothache occurrence, which coincides with the results of precedent studies<sup>11,17</sup>.

In the study related to oral health status, oral health improving behaviors and oral health awareness of daily life in adult subjects, people who recognize their present oral health status to be satisfactory and people who recognize their oral health status of the past year to be satisfactory are reported to engage in more activities for improving oral health<sup>4</sup>. In the study on the relationship between the social demographic factors and the factors affecting the oral health status, unfavorable social economic conditions tend to deteriorate oral health conditions, and the oral health behaviors such as visit to the dentist, number of toothbrushing, method of brushing and dietary habits in the past year have reported to reduce the occurrence of oral diseases<sup>18</sup>. In the research study on the use of oral hygiene products in Korea, the close examination of the patient health including the oral health conditions and the appropriate use of oral hygiene aids such as floss and interdental brush are reported to have improve oral health by eliminating the causes of oral diseases<sup>19</sup>. The above results are emphasized by the important factors such as the present health status, health status of the past year, regularity of meal time, and bleeding during the use of toothbrush or floss.

Regression analysis has been used as an analytical technique for predicting toothache occurrence, but has been reported to have lower prediction accuracy and discrimination compared to CART model. Medical fields have already attempted the use of CART model, which is one of the data mining techniques, as well as analyzing the patterns of diseases for determining the influential factors that affect treatment results and diseases. In predicting the nursing needs for hospitalized cancer patients using data mining techniques, neural network analysis, besides two other analysis models including logistic regression analysis and decision tree analysis, has been verified to have the highest sensitivity, specificity and accuracy<sup>20</sup>. Also in the study on the characteristic exploration of low-weight adolescents and the method of health improvement, CART model was verified to be the most appropriate model in terms of correct classification rate and specificity when

evaluating safety and prediction accuracy through the use of various techniques including multi-logistic regression analysis, CART, model, CHAID model and C4.5 model, for constructing the most optimal classification model of low-weight adolescents<sup>12</sup>. In the study on the relationship between oral health and general health using CART algorithm, the prediction accuracy of CART algorithm model was higher than logistic model<sup>6</sup>.

As shown in the results of the above-mentioned precedent studies, CART model was verified to have a higher prediction accuracy than the logistic regression analysis in this study as well. The factors related to toothache occurrence are expressed into a tree structure using CART model, and thus ease the understanding and explanation of the prediction processes. The prediction accuracy of toothache occurrence was very similar to the results of other studies.

Such results are expected to be used in predicting not only toothache occurrence but also in predicting the causes of dental caries and periodontal diseases by revealing new meaningful correlations and trends that have not been discovered in the previous researches and studies and by systemizing relatively accurate analysis and information by using the new techniques of CART model. Prediction of toothache occurrence in advance could improve individual health by understanding the dietary and oral hygiene habits and stress level at the time of prediction to present solutions for maintaining healthy lifestyle.

The limitations of this study include the insufficient number of research subjects, and the survey to a specific group, thus may be inappropriate to apply to the entire population. Related factors of toothache occurrence such as dietary habits, oral hygiene habits, happiness index, and stress related index on other age range besides the college students must be examined, and research studies on predicting various oral diseases such as dental caries and periodontal diseases must be performed and sustaining models with a higher prediction accuracy must be developed in the future.

## Conclusion

The occurrence of toothache signals the malfunction in oral health, which allows the detection of any abnormal condition in the oral cavity at an early stage to prevent the condition from worsening, and thus can act as a preventive measure. This study has looked into the status of oral health management in relation to toothache through the

structured survey administered to 235 college students. Based on the survey results, this study aimed at comparing the toothache occurrence prediction between regression analysis and CART model in order to clarify the relationship between the factors of oral health management habits that contribute to toothache occurrence.

According to the result, there was a difference between the present health status and the health status of the past year depending on the presence or non-presence of toothache occurrence ( $p < 0.05$ ). There was a difference in the regularity of meal time depending on the presence or non-presence of toothache occurrence from the dietary habits of the research subjects ( $p < 0.05$ ). As for the presence or non-presence of toothache occurrence from the oral hygiene habits of the research subject, there was a difference between the occurrence and nonoccurrence of bleeding during brushing or flossing ( $p < 0.05$ ). According to the results of regression analysis, no factors were significant in the relationship with the presence or non-presence of toothache occurrence from the status of life habits and oral hygiene habits.

70% of the researched group was randomly selected as the sample for generating an analytical model and the remaining 30% was used as the sample for generating an evaluation model.

According to the results of CART model, the occurrence of toothache was higher in the case of irregular meal time and poor current health condition than the case of average or satisfactory health condition.

The above results imply that CART model is a very useful technique in predicting toothache occurrence compared to regression analysis, and suggests that CART model could be very useful in predicting other oral diseases including toothache.

## Summary

치통의 발생은 구강 건강의 이상을 알리는 신호로 발생 초기에 구강의 이상 유무를 파악하게 하여 조기에 질병의 악화를 차단할 수 있게 함으로써 사전에 예방이 가능할 것으로 사료되어, 대학생 235명을 대상으로 구조화된 설문을 통하여 치통과 관련된 구강건강관리실태를 조사 분석하였다. 이를 토대로 치통 발생에 관여하는 구강건강관리습관 요인과의 관계를 규명하고자 회귀분석, CART 모델 간의 치통 발생 예측을 비교하고자 한다.

연구결과 대상자의 치통 발생 유무에 따른 현재 건강상태, 지난 1년간의 건강상태는 차이가 있었다( $p < 0.05$ ). 대상자의 식생활 습관에 따른 치통 발생 유무에서 규칙적인 식사

여부와 차이가 있었다( $p < 0.05$ ). 대상자의 구강건강 관리습관에 따른 치통발생 유무에서는 칫솔질이나 치실 사용시 잇몸 출혈 여부에서 차이가 있었다( $p < 0.05$ ). 회귀분석 결과 건강생활습관 및 구강건강관리실태에 따른 치통발생 유무와의 관계에서는 어느 요인도 유의하지 않았다.

연구 조사된 집단에서 70.0%의 샘플을 무작위 추출하여 분석용 모형을 생성하였고, 나머지 30%의 샘플로 평가용 모형을 생성하였다.

CART 모델 결과 식사 시간이 불규칙하면서 현재 건강상태가 나쁜 경우 치통 발생이 건강상태가 좋거나 보통인 경우보다 높게 나타났다.

이상의 결과는 치통의 발생을 예측하는데 회귀분석에 비하여 CART모델이 매우 유용한 기법임을 시사하며, 향후 치통을 포함한 다른 구강 질환을 예측하는데 매우 도움이 될 것으로 기대된다.

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