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치의학석사 학위논문

Time series analysis of patients
seeking orthodontic treatment
at Seoul National University
Dental Hospital over the past
decade

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orthodontic treatment at Seoul National
University Dental Hospital over the past
decade

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이 논문을 치의학석사 학위논문으로 제출함
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Abstract

Time series analysis of patients seeking orthodontic treatment at Seoul National University Dental Hospital over the past decade

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Introduction: This paper describes changes in the patients seeking orthodontic treatment over the past decade and the treatment they received to identify any seasonal variation or trend.

Material and methods: This single-center retrospective cohort study included all patients who presented to the Seoul National University Dental Hospital for orthodontic diagnosis and treatment from January 1, 2005, to December 31, 2015. The study variables included a set of heterogeneous variables in the following categories: demographic (age, gender, and address); clinical (Angle's classification, anomaly, mode of orthodontic treatment, removable appliances for Phase 1 treatment, fixed appliances for Phase 2 treatment, orthognathic surgery, extraction, mini-plate, mini-implant, and patient transfer); and time related (date of first visit and orthodontic treatment time). Time series analysis was applied to each variable.

Results: The sample included 14,510 patients with a median age of 19.5 years. The number of patients and their ages demonstrated clear seasonal variation, with peaks in summer and winter. Increasing trends were observed for the proportion of male patients, the use of non-extraction treatment methods, the use of ceramic brackets, patients from provinces outside the Seoul region at large, patients transferred from private practitioners, and patients who underwent orthognathic surgery by the university surgeons. Decreasing trends included the use of metal brackets and orthodontic treatment time.

Conclusions: Time series analysis revealed seasonal variation in some characteristics, and several variables showed changing trends over the past decade.

Keywords : Time series analysis, Orthodontics, Trend, Seasonal variation

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CONTENTS

I . INTRODUCTION	1
II . MATERIALS AND METHODS	3
1. STUDY DESIGN AND SAMPLE	3
2. STUDY VARIABLES	3
3. STUDY ANALYSIS	4
III . RESULT	6
1. ALL ORTHODONTIC PATIENTS REVIEWED	6
2. PATIENTS WHO UNDERWENT ACTIVE ORTHODONTIC TREATMENT	6
3. RESULTS OF THE TIME SERIES ANALYSIS AND VARIABLES THAT DEMONSTRATED A SEASONAL VARIATION OR TREND	7
IV . DISCUSSION	9
V . CONCLUSION	13
VI . REFERENCE	14
국문초록	25

표 목 차

[Table 1]	17
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그 림 목 차

[Figure. 1]	19
[Figure. 2]	20
[Figure. 3]	21
[Figure. 4]	22
[Figure. 5]	23
[Figure. 6]	24

I . INTRODUCTION

Orthodontic treatment is the treatment of choice for the correction of malocclusions and improvement of facial aesthetics. With recent socioeconomic development, orthodontic treatment has become a common clinical procedure. In addition, significant improvements have been made in orthodontic biomechanics, techniques, and appliances. In this respect, in the United States and in Europe, frequent nationwide surveys have helped us to understand the changing trends in the characteristics of patients seeking orthodontic treatment and in the orthodontic treatment procedures they receive.¹⁻⁵

However, formal reports on the changing trends in orthodontics seem insufficient.^{6,7} Graphic presentation of time-related variables may help us to understand changes in the trends. Time series analysis has been popular in describing changes over time. However, as of early October 2016, an internet search of Pub-Med and Web of Science revealed only one paper that applied the time series method to orthodontics.⁸ Time series analysis is a sophisticated statistical method that can reveal greater information than a cursory observation of data. The substantial advantage of time series analysis is the decomposition that eliminates noise and amplifies the signal within the time series data. Decomposing a time series separates the data

into a trend component and a seasonal component, if one exists.⁸⁻¹¹

The study's purpose was to determine whether the trends in orthodontic treatment changed over the past decade (from 2005 to 2015) among all patients seeking orthodontic treatment at Seoul National University Dental Hospital. The specific aim of this study was to identify any seasonal variations or trends using time series analysis.

II. MATERIALS AND METHODS

1. STUDY DESIGN AND SAMPLE

The study population of this single-center retrospective cohort study was composed of all patients who presented to the Department of Orthodontics at Seoul National University Dental Hospital for orthodontic diagnosis and treatment from January 1, 2005, to December 31, 2015. Patients who had only a simple consultation and no diagnostic studies (i.e., radiographic, photographic, and dental cast examination) were excluded. The institutional review board of Seoul National University School of Dentistry for the protection of human subjects reviewed and approved the research protocol (number S-D 20140025).

2. STUDY VARIABLES (Table 1)

The data collected from each patient record included a set of heterogeneous variables that can be categorized as follows.

1) Demographic variables

Age, gender, and address

2) Clinical variables

Angle's classification

Anomaly

Mode of orthodontic treatment: Phase 1, Phase 2, or both

Removable appliances for Phase 1 treatment: headgear, chin-cap, facemask, Bionator

Fixed appliances for Phase 2 treatment: metal, ceramic, lingual, or Aligner appliances

Orthognathic surgery (yes/no) and the place where the surgery was performed (at the same institution or in a private practice)

Extraction treatment method (yes/no)

Mini-plate (yes/no)

Mini-implant (yes/no)

Patients treated by residents or by faculty members

Patients transferred from private office (yes/no)

3) Time-related variables

Date that orthodontic treatment commenced and the orthodontic treatment time. The treatment time was defined as the time elapsed from the placement of the first active orthodontic component to the day of debonding/debanding.

3. STUDY ANALYSIS

Descriptive statistics were computed for each variable. For age and time-related variables, the median rather than the mean was

calculated because the median is less influenced by extreme values.¹⁸
The R programming language (R Foundation for Statistical
Computing, Vienna, Austria) was used for the time series analysis.¹¹

III. Result

1. ALL ORTHODONTIC PATIENTS REVIEWED

From 2005 to 2015, 14,510 patients presented to the Department of Orthodontics at Seoul National University Dental Hospital and were evaluated for orthodontic diagnosis, including radiographic, photographic, and dental cast examination. The patients' median age was 19.5 years, and 42% were male, who were slightly younger than the female patients. Most patients (88%) came from the greater Seoul region, including the Gyeonggi province and metropolitan Incheon. Seven percent of patients received a diagnosis of cleft lip and palate, craniofacial syndromes, or other anomalies (**Table 1**).

Class III malocclusion was present in 40% of the patients reviewed, followed by Class II (32%) and Class I (28%) malocclusion. After the initial diagnosis and consultation, more than half of the patients (53%) received no further orthodontic treatment.

2. PATIENTS WHO UNDERWENT ACTIVE ORTHODONTIC TREATMENT

Of the patients who underwent orthodontic treatment, 31% underwent orthognathic surgery, 45% had orthodontic treatment with extraction and 14% with mini-implants or mini-plates; 25% were treated by faculty members, and 8% had been transferred from private practitioners. The median duration of orthodontic treatment was 1 year 6 months in non-extraction cases; in cases that involved extraction the duration was 2 years 2 months.

3. RESULTS OF THE TIME SERIES ANALYSIS AND VARIABLES THAT DEMONSTRATED A SEASONAL VARIATION OR TREND

1) Number of patients seeking orthodontic treatment

From 2005 to 2015, the number of patients showed a fluctuating pattern. The trend was also variable and did not have a clear pattern. However, a clear seasonal variation was found that included peaks every winter and summer (**Figure 1**).

2) Patient age

A slightly decreasing trend was observed in the median age over time. In addition, age showed a distinct seasonal variation in a

pattern opposite to that of the number of patients (**Figure 2**).

3) Other variables that demonstrated a changing trend over the past decade

The proportions of male patients and non-extraction treatment methods showed increasing trends (**Figure 3, top**). The percentage of patients who underwent orthognathic surgery at the same institution also increased (**Figure 3, bottom**). The proportion of patients whose addresses were in Seoul decreased over the decade, and that of patients from Gyeonggi or other provinces increased (**Figure 4**). For active orthodontic treatment, the use of ceramic brackets has increased over the years while the proportion of metal brackets has decreased ($P < 0.0001$, **Figure 5**). The orthodontic treatment time varied significantly among patients (**Figure 6**). Treatment with extraction took 8 months longer than treatment without extraction ($P = 0.0053$). The median time for orthodontic treatment decreased by an average of 2 months per year ($P < 0.0001$). The proportion of patients who underwent orthognathic surgery by surgeons at the same institution showed an increasing trend. The number of patients who were transferred from private practitioners also increased.

IV. DISCUSSION

The study's purpose was to determine whether trends in orthodontic treatment changed over the decade from 2005 to 2015 among all patients seeking orthodontic treatment at Seoul National University Dental Hospital. The specific aim of this study was to identify any seasonal variations and/or trends using time series analysis.

To the author's knowledge, this is the first study to examine the current trends in orthodontic management using time series analysis. As expected, a seasonal variation was evident in the numbers of patients and their ages. The heights of the peaks coincided with the summer and winter breaks at schools nationwide, which implies that younger patients, who were likely students, sought orthodontic treatment during their summer and winter breaks. The same phenomenon has also been shown with orthognathic surgery patients.⁸

During the decade, increasing trends were observed in the following aspects: the proportion of male patients, non-extraction treatment methods, the use of ceramic brackets, patients from provinces outside the Seoul region at large, transferred patients from private practitioners, and the percentage of patients who underwent orthognathic surgery by the university surgeons. Decreasing trends

were observed in the use of metal brackets and in the orthodontic treatment time. In contrast, the distribution of Angle's classification among other variables did not show any obvious change in seasonal variation.

Among the general population, 19% had Class III malocclusions¹²⁻¹⁴ and 20% had Class II malocclusions. However, among patients who were seeking orthodontic treatment, those with Class III malocclusions were the most prevalent (40%). The predominant proportion of patients with Class III malocclusions did not change.^{6,7} Several studies have shown that patients with Class III malocclusions might be more inclined to opt for orthodontic treatment than those with Class II malocclusions, who are more inclined towards dental compensation treatment.^{8,12,14,15}

An increasing trend was seen in the proportion of male patients. Socioeconomic development in our society might have affected this trend, or it might be related to the decreasing population, with many families having no child or only one. The increasing number of patients from provinces outside the Seoul region at large might be related to the improved infrastructure nationwide, such as the express railway system and newly built highways. The use of ceramic brackets also increased greatly over the decade, but the proportion of lingual appliances and aligner treatment did not increase, in contrast

to a previous report from the United States.¹

The orthodontic treatment time varied significantly among the patients (**Figure 6**). In clinical orthodontics, it is possible that a few patients could for some reason experience unexpectedly long periods of orthodontic treatment; however, in general, the orthodontic treatment time has been decreasing. Advances in orthodontic techniques, such as orthodontic mini-implants and mini-plates, reduce the time required for correction of malocclusion.¹⁶ An article published in early 1980s reported that “the treatment time showed a steady decrease over the 15 year period.”⁵ With new techniques, the decreasing trend in orthodontic treatment time might continue into the future.

Although orthodontists and treatment techniques primarily affect the duration, further investigation will be necessary, because the treatment duration may merely reflect variation in other factors such as the severity of the patient’s condition and patient compliance.⁸ However, because these orthodontic treatments were performed in a university setting, the treatment time may also be a reflection of the university environment. Operator changes could influence orthodontic treatment times in a teaching environment. A patient’s orthodontic treatment may be directed by a number of faculty members and

multiple residents, who may have differing ideas concerning the best management of an individual orthodontic problem.¹⁷

This study has several limitations. The sample frame was limited to a single university institution in downtown Seoul. Therefore, no definitive conclusion could be drawn regarding how many orthodontic patients require orthodontic treatment in the general population nationwide. This could affect the interpretation of the results. It may be desirable for the time series analysis to be performed again in the future. Further expansion of the subjects would be desirable, as would a multicenter, multi-ethnicity design that can include a larger number of subjects.

V. CONCLUSIONS

This was a retrospective cohort study of all patients who sought orthodontic treatment at Seoul National University Dental Hospital from 2005 to 2015.

1. Time series analysis revealed increasing trends in the following variables: male patients, non-extraction techniques, ceramic brackets, patients from provinces outside the Seoul area, and patients transferred from private practitioners.
2. The number of patients and their ages showed distinct seasonal variation.
3. Patient age and orthodontic treatment time have been decreasing over the decade 2005–2015.
4. The distribution of Angle's classification remained unchanged over the years.

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Table 1. Summary of patients seeking orthodontic treatment from Jan 2005 to Dec 2015

Variables		Descriptive	statistics
Sample size		14,510	100%
Female gender		8,474	58.4%
Age (years)	Female	20.1 ±	11.7
	Male	18.8 ±	10.3
Patients address	Seoul	8,989	62.0%
	Gyeonggi	3,726	25.7%
	Other provinces	1,795	12.4%
Patients with anomalies	None	13,426	92.5%
	Patients with cleft	681	4.7%
	Other anomalies	352	2.4%
	Data not available	51	0.4%
Classification	Class I malocclusion	3,690	27.5%
	Class II malocclusion	4,340	32.3%
	Division 1	3,731	27.8%
	Division 2	609	4.5%
	Class III malocclusion	5,397	40.2%
Mode of orthodontic treatment	None, consultation only	7,118	53.0%
	Phase 1 treatment	557	4.1%
	Phase 2 treatment	4,865	36.2%
	Phase 1 plus Phase 2	406	3.0%
	Limited treatment	438	3.3%
	Relapse retreatment	42	0.3%
Removable appliances for Phase 1 treatment	Headgear	238	36.1%
	Chin-cap	188	28.5%
	Facemask	160	24.3%
	Bionator	73	11.1%
Fixed appliances for Phase 2 treatment	Metal brackets	2,770	48.2%
	Ceramic brackets	2,734	47.5%
	Clear aligners	74	1.3%
	Lingual brackets	53	0.9%
			30.7%
Orthognathic surgery patients (yes)		1,766	*

	By surgeons at the same institution	1,613	91.3%
	By private practice surgeons	153	8.7%
Extraction versus non-extraction treatment			
	Non-extraction	3,185	55.4% *
	Extraction	2,567	44.6% *
Phase 2 orthodontic treatment time (months)			
	Non-extraction		18.0 ± 10.9*
	Extraction		26.0 ± 10.3*
Mini-implants (yes)		1,885	13.0% *
Mini-plates (yes)		108	0.7% *
Patients treated by faculty members (yes, otherwise treated by residents)		3,394	25.3%
Patients transferred from private office (yes)		1,091	7.5%

Data presented as n (%) or median ± interquartile range. *Proportion calculated among patients who had undergone Phase 2 treatment.

FIGURES

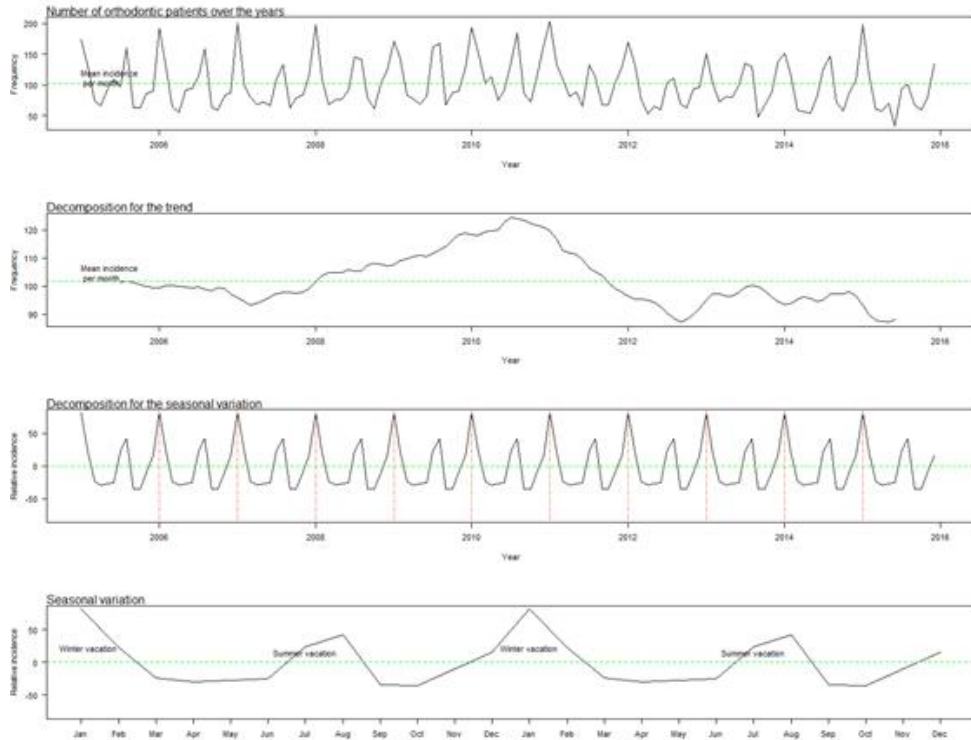


Figure 1. Between 2005 and 2015, the number of patients seeking orthodontic treatment at the Department of Orthodontics, Seoul National University Hospital showed a fluctuating pattern (*top*). The trend was also variable and did not have a clear pattern (*second from top*). However, a clear seasonal variation was found (*second from bottom*). A magnified view of the seasonal variation demonstrated peaks every winter and summer. The peaks coincided with the summer and winter breaks at schools in Korea (*bottom*).

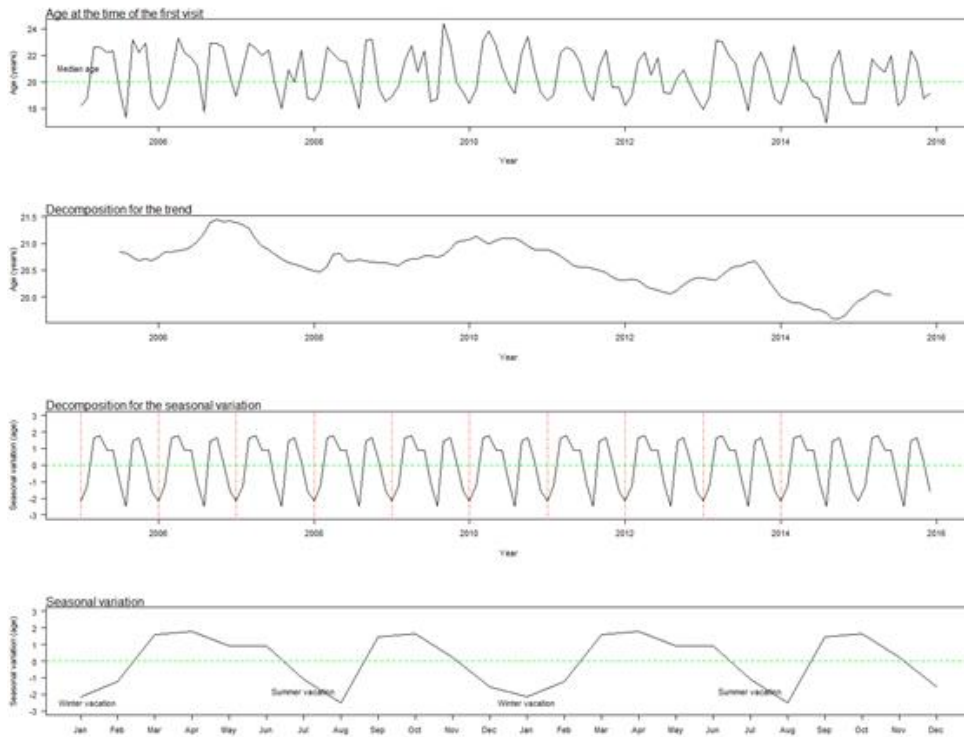


Figure 2. The patients' median age was 19.5 years (*top*). Time series analysis showed a slightly decreasing trend in the median age over time (*second from top*). It also demonstrated a distinct seasonal variation (*second from bottom*). A large-scale view of the seasonal variation (*bottom*) showed a pattern opposite to that of the number of patients, which implies that younger patients were likely students who sought to receive orthodontic treatment during their summer and winter breaks.

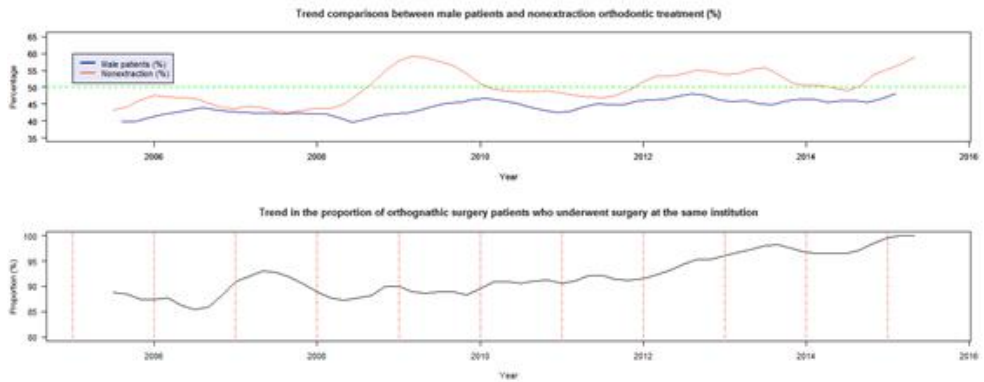


Figure 3. The proportion of male patients and non-extraction treatment methods showed increasing trends and had roughly similar patterns (*top*). The percentage of patients who underwent orthognathic surgery at the same institution also increased (*bottom*).

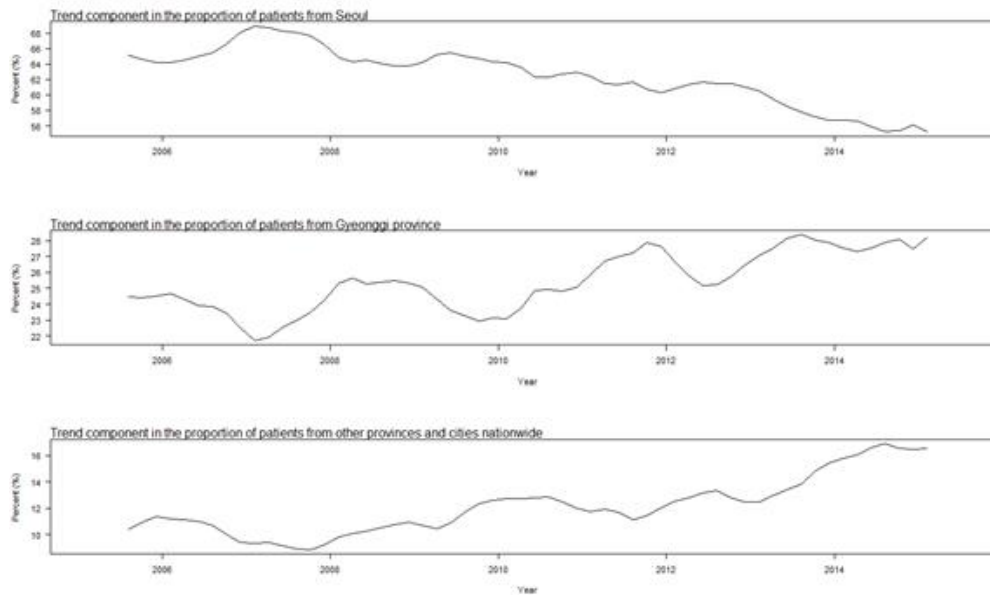


Figure 4. The proportion of patients whose address was in Seoul decreased over the decade while that of patients from Gyeonggi or other provinces increased.

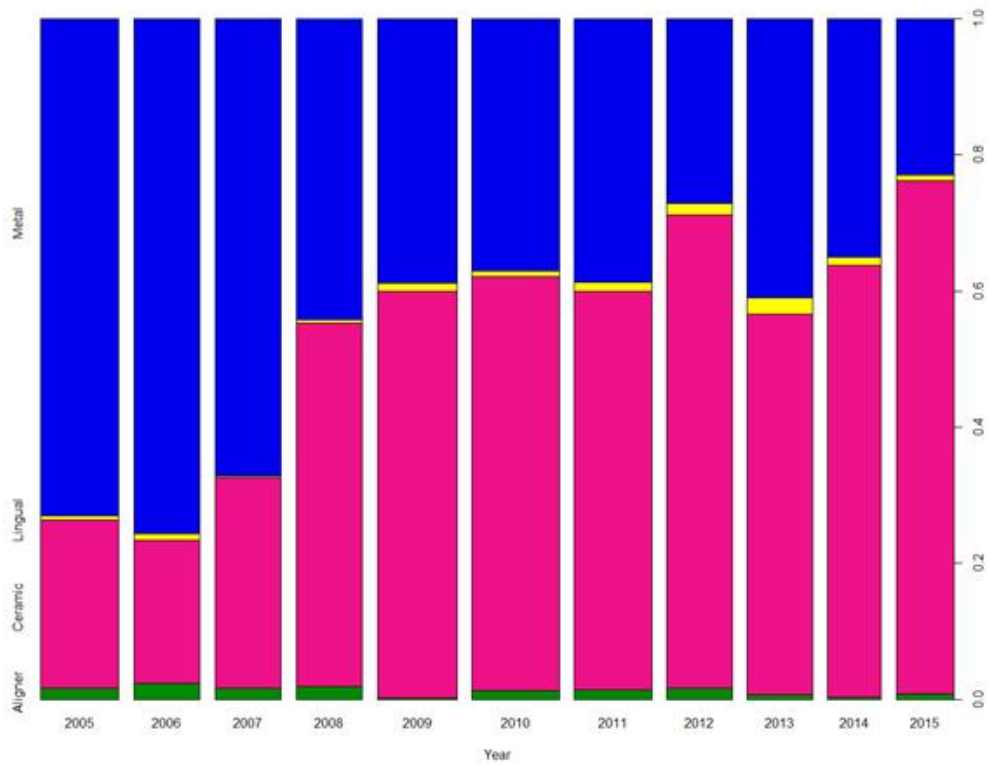


Figure 5. The use of ceramic brackets has increased over the years, while the proportion of metal brackets has decreased.

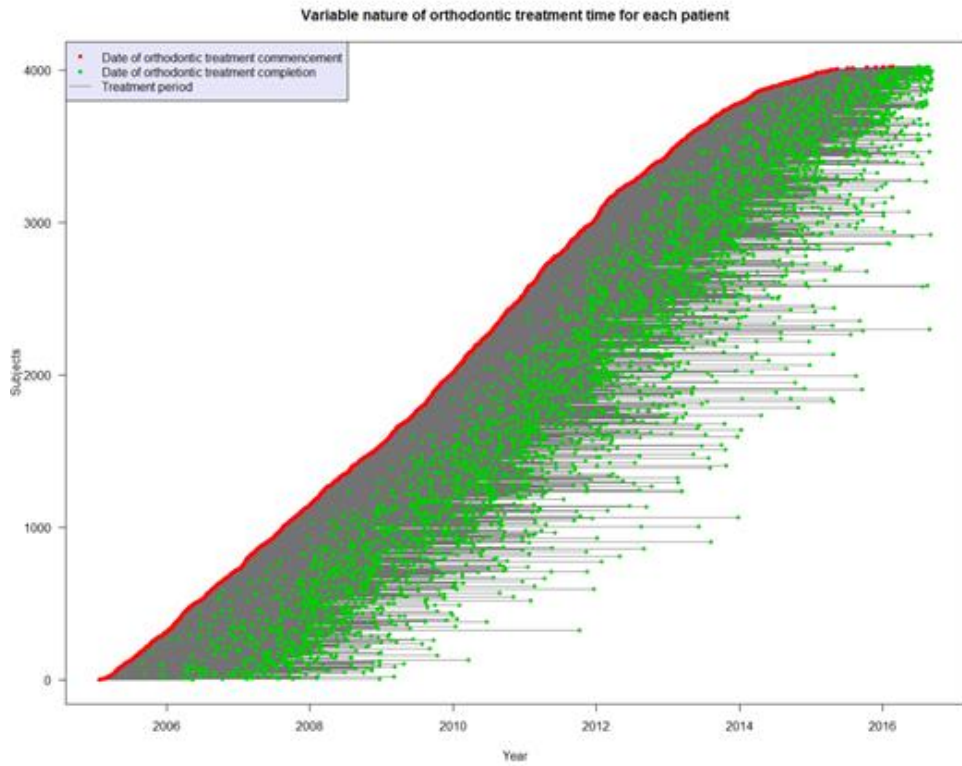


Figure 6. Orthodontic treatment time varied significantly among

국문초록

연구목적: 본 논문은 지난 10년간 교정치료를 원하는 환자의 추세 변화를 보고하고자 한다. 연구의 목적은 시계열 분석을 이용하여 교정치료를 원하는 환자들의 계절성 변동이나 추세 변화가 존재하는지 밝히는 것이다.

재료 및 방법: 본 연구는 단일 기관에서 시행된 후향적 추적 조사 연구로, 2005 년 1 월 1 일부터 2015 년 12 월 31 일까지 서울대학교치과병원 교정과에 내원하여 교정 진단과 치료를 받은 모든 환자를 대상으로 하였다. 활용된 변수는 다음과 같이 분류된 다양한 성질의 변수들로 구성되어 있다.

1) 인구통계학적 변수

연령, 성별, 주소;

2) 임상적 변수

Angle 분류, 기형, 교정치료 방법, 1 단계 교정치료에 사용된 가철성 교정장치, bracket 종류, 악교정 수술, 발치, mini-plate, mini-implant, 의뢰 여부;

3) 시간 관련 변수

첫 내원일, 교정치료 기간

위에 열거한 각각의 변수에 대해 시계열 분석을 시행하였다.

결과: 표본은 14,510 명의 환자가 내원하여 교정 진단을 받았으며,

연령의 중앙값은 19.5 세였다. 환자 수와 연령은 명확한 계절간 변동을 나타냈다. 남성 환자의 비율, 비발치 교정치료, ceramic bracket 의 사용, 서울 지역 밖의 지방에서 내원하는 환자의 수, 개인 의원에서 의뢰된 환자, 대학 병원의 외과의에게 악교정 수술을 시행 받은 환자의 비율은 증가하는 추세를 나타냈다. Metal bracket 의 사용과 교정치료 기간은 감소하는 추세를 나타냈다. 한편, Angle 분류의 분포를 비롯한 다른 변수들은 계절간 변동이나 뚜렷한 추세를 나타내지 않았다.

결론: 시계열 분석을 통해 지난 10 년간 교정치료를 원하는 환자의 특성 중 일부가 계절적 변동을 보였고, 몇 가지 변수가 추세 변화를 보였음을 확인할 수 있었다.

주요어 : 시계열 분석, 치과교정학, 추세, 계절성 변동

학 번 : 2013-22144