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Tooth size relationship for ideal occlusion of lateral segment teeth

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Tooth size relationship for ideal occlusion of lateral segment teeth

A Master's Thesis

Submitted to the Department of Medicine

and the Graduate School of Yonsei University

in partial fulfillment of the

requirements for the degree of

Master of Medical Science

Jungwoong Yang

December 2021

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This certifies that the Master's Thesis

of Jungwoong Yang is approved.

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감사의 글

본 논문의 시작부터 완성까지 세심한 지도와 가르침으로 이끌어 주시고, 교정학에 대한 학문적 기반을 만들어 주신 이정섭 교수님께 진심으로 감사드리며 존경을 전합니다. 귀중한 시간 내주시어 논문 작성과 심사에 많은 관심과 조언을 해주신 김지훈 교수님, 이천의 교수님께도 감사드립니다. 항상 따듯한 조언과 격려를 해주셨던 김인달 교수님, 김범수 교수님, 최병호 교수님, 정승미 교수님, 임재형 교수님, 최성현 교수님, 정승욱 교수님께도 감사드립니다.

교정과에서 수련한 3년 동안 교정학에 대한 많은 가르침을 주신 황충주 교수님, 김경호 교수님, 유형석 교수님, 이기준 교수님, 이지연 교수님, 차정열 교수님, 정주령 교수님, 최윤정 교수님, 최성환 교수님, 김정훈 교수님께도 감사의 마음을 전합니다.

의국 생활 중 항상 아껴 주시고 많은 도움을 주신 교정과 의국 선배님들께 늘 감사드립니다. 또한 논문을 진행하면서 많은 격려와 응원을 보내준 손은영 선생님, 백수인 선생님을 비롯한 교정과 식구들과 수련 생활 중 곁에서 큰 힘이 되어준 의국 선생님들께도 고마움을 전합니다.

마지막으로 저를 응원하고 격려해준 많은 친구와 지금의 저를 있게 해주시고 항상 무한한 사랑과 신뢰를 주시는 부모님과 형에게 진심으로 감사의 마음을 전합니다.

2021년 12월 저자 씀

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Abstract

Tooth size relationship for ideal occlusion of lateral segment teeth

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(Directed by Prof. Jeong Sub Lee, D.D.S., M.S.D., Ph.D.)

The purpose of this study was to investigate the tooth size relationship between maxillary and mandibular lateral segment teeth for ideal occlusion.

Sixty two patients who had Class I molar and Class I canine relationship in post-orthodontic treatment were divided into 2 groups according to the 4 premolars extraction during orthodontic treatment: extraction group(n=22; male 7, female 15) and non-extraction group(n=40; male 13, female 27). After measuring the tooth size of all teeth up to the first molar on the post-treatment stone models, the ratio and difference of several combination groups from lateral segment teeth were calculated and analyzed statistically.

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As a result of the study, the ratio of mandibular against maxillary premolar in the extraction group(104.11%) was larger than that in the non-extraction group(102.39%). Premolar size discrepancy showed no difference between the 2 groups. The size of mandibular premolars was larger than that of maxillary premolars (Mean 0.32mm SD 0.44).

By using the ratio and difference of the premolars and lateral segment teeth presented in this study along with the conventional methods to analyze tooth size discrepancy, it will be helpful to achieve ideal lateral segment occlusion.

Keywords: Class I relationship, lateral segment teeth, tooth size relationship, tooth size discrepancy

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Tooth size relationship for ideal occlusion of lateral segment teeth

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I. Introduction

Unlike incisors where aesthetics are important, the lateral segment teeth, from canine to molars, are important in the functional aspect of occlusion. Maxillary first molars play a key role in functional occlusion and mesiobuccal cusps of maxillary molars should be positioned on the buccal grooves of mandibular molars [1]. Canine guidance is also important in functional occlusion because canine can protect the other teeth by separating them during eccentric movement [2-7]. For canine guidance occlusion, the relative position of upper and lower canine is important and it is desirable to form a Class I canine relationship. Therefore, it is important to achieve Class I molar and Class I canine key simultaneously for functional occlusion [8].

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When tooth size discrepancy exists, it acts as an obstacle to achieving an ideal occlusion [9-16]. But clinically, because of crowding or malocclusion, tooth size discrepancy is often found at the end of orthodontic treatment and unexpected tooth size discrepancy can affect treatment outcomes adversely [17, 18]. For this reason, analysis methods had been developed to identify potential tooth size discrepancies in the dentition before orthodontic treatment [19, 20].

Bolton tooth size discrepancy analysis is widely used to analyze and control potential tooth size discrepancies that may occur in achieving a patient's final occlusion [21]. Bolton defined specific interarch relationships by creating the following ratios. The anterior ratio was defined as the ratio of the mesiodistal width between the 6 anterior mandibular teeth and the 6 anterior maxillary teeth. The overall ratio was defined as the ratio of the mesiodistal width between the 12 mandibular teeth up to the first molar and the 12 maxillary teeth up to the first molar.

Anterior ratio helped to form the proper anterior overjet and overbite, but to establish the Class I canine key along with the anterior occlusion, a more detailed anterior tooth size analysis was needed. The sum of incisors, a formula to calculate the mesiodistal width of the four maxillary incisors using the width of mandibular incisors was developed and widely used in clinical practice [22]. Just like calculating the size of incisors located between two canines for bilateral Class I canine key, the size relationship of premolars would be needed to achieve Class I molar and Class I canine key simultaneously. However, premolar size discrepancy had not been investigated yet.

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The purpose of this study was to investigate the tooth size relationship between maxillary and mandibular lateral segment teeth for ideal occlusion.

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II. Material and methods

Subjects

Post-treatment stone models of 62 patients who had received orthodontic treatment between 2009 and 2021 in the department of orthodontics at Yonsei Wonju Severance Christian Hospital were selected based on the following criteria: (1) permanent dentition (2) all teeth up to the first molar erupted completely except for the premolars extracted for orthodontic purpose (2) Class I molar and canine relationship, (3) no tooth anomalies, (4) no obvious loss of tooth material mesiodistally from caries, fractures, congenital defects, and restorations (Table I).

Table I. Patient characteristics

Factor	
Mean age (Range)	19.37 (11.9-41.4)
Female / Male	42 / 20
Extraction / Non-extraction	22 / 40

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Model analysis

A digital caliper(Jaintek, Ansan, Korea) was used to measure the mesiodistal width from the right to the left first molar to the nearest 0.01mm in each model. The mesiodistal width of each tooth was measured at the greatest distance between contact points on a line parallel to the tooth axis. All measurements were done by 1 investigator (J. Yang). The absolute measurements were recorded for each tooth and each patient.

After the teeth of all 62 patients had been measured, overall ratio, premolar ratio, premolar to molar ratio, lateral segment ratio, premolar difference, premolar to molar difference, and lateral segment difference were calculated on each model. In the extraction group, extracted teeth were excluded from each calculation (Figure 1, 2).

(1) Overall ratio: $\frac{\text{sum of mandibular } 1,2,3,4,5,6}{\text{sum of maxillary } 1,2,3,4,5,6} \times 100\ (\%)$

(2) Premolar ratio: $\frac{\text{sum of mandibular } 4,5}{\text{sum of maxillary } 4,5} \times 100\ (\%)$

(3) Premolar to molar ratio: $\frac{\text{sum of mandibular } 4,5,6}{\text{sum of maxillary } 4,5,6} \times 100\ (\%)$

(4) Lateral segment ratio: $\frac{\text{sum of mandibular } 3,4,5,6}{\text{sum of maxillary } 3,4,5,6} \times 100\ (\%)$

(5) Premolar difference: sum of mandibular 4,5 − sum of maxillary 4,5 (mm)

(6) Premolar to molar difference: sum of mandibular 4,5,6 − sum of maxillary 4,5,6 (mm)

(7) Lateral segment difference: sum of mandibular 3,4,5,6 − sum of maxillary 3,4,5,6 (mm)

※ 1: central incisor, 2: lateral incisor, 3: canine, 4: first premolar, 5: second premolar, 6: first molar

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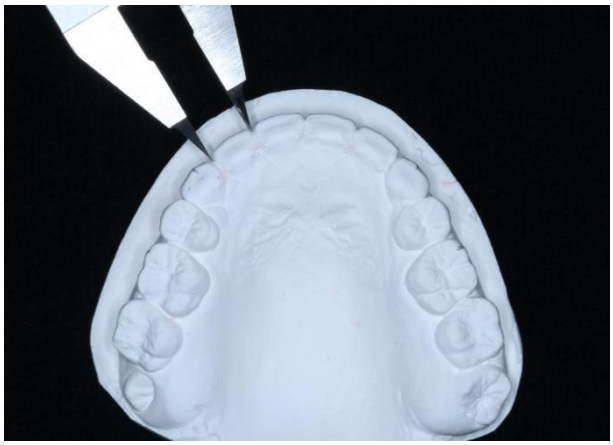

Figure 1. Tooth size measurement in stone model

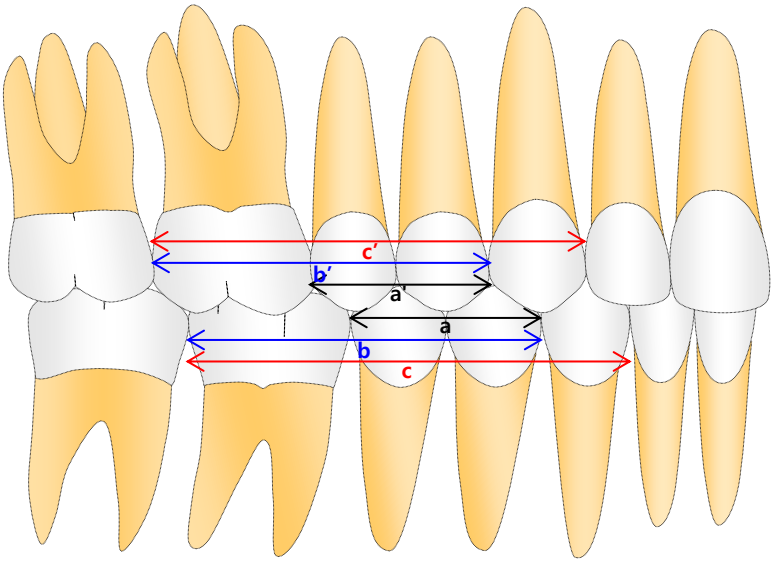

Figure 2. The schematic view of calculated values: premolar ratio, a/a'; premolar to molar ratio, b/b'; lateral segment ratio, c/c'; premolar difference, a-a'; premolar to molar difference, b-b'; lateral segment difference, c-c'. Extracted premolars were excluded from each calculation in the extraction group.

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Statistical analysis

Statistical analysis was performed with IBM SPSS software (version 26.0; SPSS, Chicago, Ill). The paired t-test was conducted to verify there was a statistically significant difference in the right and left sides. Since the paired t-test showed no statistically significant difference between both sides, all ratios were calculated by the sum of both sides. Means, minimum-maximum values, and standard deviations were analyzed for all calculated values.

The 2-sample t-test was conducted to analyze the difference of values by gender. Since the 2-sample t-test showed no statistically significant difference by gender, 62 patients were divided into two groups according to the 4 premolars extraction during orthodontic treatment: extraction group(n=22; male 7, female 15) and non-extraction group(n=40; male 13, female 27). The 2-sample t-test was conducted to compare the values between the 2 groups. Since all difference values showed no statistically significant difference by extraction, the paired t-test was conducted to compare the tooth size between maxilla and mandible in the entire group.

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III. Results

Table II shows the means, standard deviations, maximum and minimum values of overall ratio, premolar ratio, premolar to molar ratio, lateral segment ratio, premolar difference, premolar to molar difference, and lateral segment difference in each group. Table II also shows the comparison of the mean values between the extraction group and the non-extraction group. Among the values, the values showing a statistically significant difference between the extraction group and the non-extraction group were overall ratio, premolar ratio, and premolar to molar ratio. The mean overall ratio was 89.91% in the extraction group and 91.22% in the non-extraction group. The mean premolar ratio was 104.11% in the extraction group and 102.39% in the non-extraction group. The mean premolar to molar ratio was 107.10% in the extraction group and 104.95% in the non-extraction group. All tooth size ratios except the lateral segment ratio showed statistically significant differences between groups, but all tooth size differences showed no statistically significant difference between the extraction and non-extraction groups.

Table III shows the mean and comparison of tooth size between maxilla and mandible in the entire group. The tooth size between maxilla and mandible was significantly different in all segmented groups. The mean values of premolar difference, premolar to molar difference, and lateral segment difference were 0.32mm, 1.25mm, and 0.22mm respectively.

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Table II. Mean and comparison of values between extraction and non-extraction group

	Extraction group (n=22)				Non-extraction group (n=40)				
	Mean	SD	Max	Min	Mean	SD	Max	Min	Significance
Overall ratio (%)	89.91	1.63	93.76	86.80	91.22	1.60	94.39	84.95	*
Premolar ratio (%)	104.11	3.82	112.52	92.96	102.39	3.57	110.66	89.97	*
Premolar to molar ratio (%)	107.10	2.14	111.94	102.96	104.95	2.53	110.58	97.45	*
Lateral segment ratio (%)	101.02	2.00	106.06	96.81	100.61	2.09	104.45	93.67	-
Premolar difference (mm)	0.29	0.28	0.88	-0.56	0.34	0.51	1.57	-1.46	-
Premolar to molar difference (mm)	1.28	0.38	2.14	-0.54	1.24	0.61	2.47	-0.65	-
Lateral segment difference (mm)	0.26	0.51	1.53	-0.82	0.19	0.69	1.52	-2.10	-

*, Significant (P<0.05)

Table III. Mean and comparison of tooth size between maxilla and mandible

	Entire group (n=62)						
	Maxilla		Mandible		Difference		
	Mean	SD	Mean	SD	Mean	SD	Significance
Premolar (mm)	12.05	0.31	12.37	0.31	0.32	0.44	*
Premolar to molar (mm)	22.74	0.32	24.00	0.32	1.25	0.54	*
Lateral segment (mm)	30.78	0.32	31.00	0.32	0.22	0.63	*

*, Significant (P<0.05)

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IV. Discussion

The conventional tooth size analysis helps to identify the potential tooth size discrepancy before tooth alignment [19, 21]. However, despite efforts to identify and correct tooth size discrepancy through the analysis, it is often difficult to achieve Class I molar and Class I canine key simultaneously in clinical practice [9, 15, 23]. This is because each tooth constituting the overall ratio may have a tooth size variation, and the ratio configuration can be changed through the extraction of premolars [24, 25]. Therefore, for an ideal lateral segment occlusion, this study was conducted to develop a more detailed tooth size analysis.

In this study, the mean overall ratio of the non-extraction group was 91.22%, which is consistent with the original value [21]. The mean overall ratio of the extraction group was 89.91%, and the difference between the two groups was statistically significant. This means that extractions of premolars reduce the overall ratio and it is consistent with the previous studies [26-29].

In the ratios of mandible to maxilla of each tooth group made by separating the lateral segment teeth, the mean values in the extraction group were higher than those in the non-extraction group. The premolar ratio and premolar to molar ratio showed significant differences between the extraction and non-extraction groups. In contrast to the overall ratio, the value increased after premolar extraction. Considering the reason, extraction of the first premolar is the most common during the extraction cases. In Koreans, the maxillary first premolar is generally larger than the second premolar, whereas the sizes of the mandibular first and second premolars are usually similar [30]. Accordingly, the ratio

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increased because the reduction due to extraction in the maxilla was greater than that in the mandible.

In the tooth size differences of each tooth group made by separating the lateral segment teeth, there were statistically significant differences between maxilla and mandible in all groups. But there were no statistically significant differences between the extraction and non-extraction groups. It means that the premolar size difference between maxilla and mandible needed for Class I molar and Class I canine key did not change by premolar extraction. So the mean difference values of the entire group will be useful to show the distance needed for ideal lateral segment occlusion.

Considering the ways to use the findings of this study, the ratio and difference values can be used in the selection of a tooth to be extracted [26, 29, 31, 32]. When the size of the first premolar and second premolar is greatly different, it is useful to extract a tooth that has more tooth size discrepancy. If it is unavoidable to preserve a tooth that has more tooth size discrepancy, interproximal reduction of the contralateral teeth or slight intentional rotation of the small tooth may be needed for ideal lateral segment occlusion.

This study excluded other factors affecting the overall occlusion, and just anteroposterior lateral segment occlusion was investigated. Since overjet, overbite, transverse width, tooth axis, and tooth rotation can affect the overall occlusion, various factors as well as the size of the tooth should be considered during orthodontic treatment [8].

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V. Conclusions

1. The premolar ratio of mandible to maxilla in the extraction group(104.11%) was statistically larger than that in the non-extraction group(102.39%).

2. The premolar difference of mandible to maxilla showed no statistical difference between the 2 groups. The size of mandibular premolars was larger than that of maxillary premolars (Mean 0.32mm, SD 0.44mm).

3. By using the ratios and differences of lateral segment teeth in this study along with the conventional methods to analyze tooth size discrepancy, it will be beneficial to achieve Class I molar and Class I canine key simultaneously.

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국문 초록

이상적인 측방 교합을 위한 치아 크기 관계

연세대학교 대학원 의학과

(지도교수: 이 정 섭)

양 정 웅

본 연구의 목적은 이상적인 측방 교합을 위하여 필요한 상악과 하악 측방치군의 치아 크기 관계를 연구하는 것이다.

교정치료 후 I 급 구치 및 견치 관계를 보이는 62 명의 환자를 대상으로 연구하였으며, 교정 치료 중 소구치 발치 여부를 기준으로 발치 군(22 명; 남성 7 명, 여성 15 명)과 비발치 군(40 명; 남성 13 명, 여성 27 명)으로 분류하였다. 교정치료 후 석고 모형에서 중절치부터 제 1 대구치까지 모든 치아의 크기를 계측하였고, 측방치군을 이루는 여러 조합의 치아 군을 대상으로 상악과 하악 사이의 크기 비율과 차이를 계산하고 통계적으로 분석하였다.

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연구 결과 상악에 대한 하악 소구치군의 크기 비율은 발치 군(104.11%)에서 비발치 군(102.39%)보다 더 컸다. 소구치군의 상하악간 크기 차이는 발치에 의해 유의미한 차이를 보이지 않았으며, 하악 소구치 군의 크기가 상악 소구치 군의 크기보다 평균 0.32mm 컸다.

기존의 치아 크기 부조화 분석 방법과 더불어 본 연구의 소구치군 및 측방치군의 크기 비율과 차이를 이용한다면 이상적인 측방 교합을 형성하는데 도움이 될 것이다.

핵심 되는 말: I 급 구치 관계, I 급 견치 관계, 측방 교합, 측방치군 치아 크기 관계, 치아 크기 부조화