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THE RELATIONS BETWEEN CRANIOFACIAL MORPHOLOGY AND DENTAL AESTHETIC INDEX(DAI)

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Multiple features of occlusion have been combined by epidemiologists in attempts to objectively to determine malocclusion severity and treatment priority. Jenny et al were developed DAI(Dental Aesthetic Index), which is an orthodontic index based on socially defined aesthetic standards.

This study aimed to evaluate association between 10 occlusal components of DAI and individual measures of skeletal morphology by use of univariate and multivariate analysis. In addition the relationship between a Dental Aesthetic Index score and skeletal morphology was evaluated.

The data for this study were obtained from cephalometric radiographs and dental casts of 182 Korean patients(79 men, 103 women) with permanent dentition who had been accepted for the orthodontic treatment at Department of Orthodontics, Chonbuk National University.

The results are as follows: 1. Several occlusal components of DAI(missing, crowding and spacing in the incisal segment, diastema, largest anterior irregularity on upper and lower arch) were not associated with individual measures of craniofacial morphology. 2. Sagittal occlusal components of DAI were associated with anteroposterior skeletal measures. 3. The relation between vertical occlusal components of DAI and vertical skeletal measures was low magnitude. 4. A Dental Aesthetic Index, which is based on several aspects of occlusion, did not identify craniofacial morphology.

We can conclude that combination of certain occlusal components of the DAI may be related with specific skeletal morphology; but, this concept could not be accepted generally.

Key Words : Dental Aesthetic Index, Malocclusion severity Index, Craniofacial morphology

For many years both the Fédération Dentaire Internationale(FDI) and the World Health Organization(WHO) have been searching for an objective method for assessing treatment needs and priorities for socially handicapping dentofacial anomalies, including malocclusion.

There are several methods that may be used to evaluate, describe, or classify occlusion. Probably the most commonly used is the Angle system of classification[1]. Other methods, such as Down's analysis, attempt to describe dental and skeletal structures quantitative using the lateral cephalograms[2]. Another quantitative method for describing the occlusal status of a person is the malocclusion index. Several frequently-referenced indices were followings: TPI(Treatment Priority Index)[3], OI(Occlusal Index)[4], PAR(Peer Assessment Rating Index)[5], HLD(Handicapping Labio-lingual Index)[6], Handicapping Malocclusion Index[7], IOTN(Index of Orthodontic Treatment Need)[8], SASOC (Social Acceptability Scale of Occlusal Conditions)[9].

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All are based on specifying the magnitude of deviation from normal occlusion. Several such indices may be used to rank occlusions quantitatively according to their severity within a population. Futhermore, they state that this would permit an objective method for establishing treatment priority of a patient. This is important for the dispersement of insurance or governmental funds for orthodontic treatment.

The importance of psychosocial as well as physical factors in assessing malocclusion was highlighted in the 1970s in a series of conferences in the USA and Internationally[10-12]. Also social psychologists have confirmed the importance of physical attractiveness on the socialization process. Current social science research indicates that unacceptable dental appearance, including visible dental characteristics that deviate greatly from the norm, are phenomena that may stigmatize, impede career advancement and peer group acceptance encourage negative stereotyping, and have a profoundly negative effect on self concept[13-16]. There was believed to be a salient need for the development of an malocclusion index containing psychosocial as well as clinical criteria.

In response to the demand for an malocclusion index that includes psychosocial criteria in assessing need for orthodontic care and for use in epidemiological surveys, Jenny et al.[17] developed the Dental Aesthetic Index that integrated the psychosocial and physical elements of malocclusion.

The Dental Aesthetic Index(DAI) is an orthodontic index based on socially defined aesthetic standards[17]. The development of the DAI is employed the publics ratings of the aesthetics of 200 photographs, each showing a full face view and both right and left profile views of model, representing the wide range of occlusal conditions found in a population of half a million people. The rating were linked by factor analysis and stepwise regression procedures to the occlusal trait measurements that were available for each of the 200 occlusal configurations. The resulting regression equation calls for ten measured components(intraoral measurements of occlusal traits) to be multiplied by their regression coefficients(weight) and the addition of products plus a constant to give a DAI score. The resulting DAI score can be placed in one of four severity categories to determine the relative need for orthodontic treatment[18]. The DAI is particularly sensitive to occlusal conditions that have the potential for causing psychological or social dysfunction. Although the DAI is particularly sensitive to occlusal conditions that have the potential for causing psychological or social dysfunction, it also predicts the clinical judgements of orthodontists in separating handicapping from nonhandicapping malocclusion[19].

Therefore the DAI, based on esthetic of face and dentition, would be more valuable if it were associated with craniofacial morphology, since there is some evidence that orthodontic patients seek care because of facial dysmorphology[20]. Thus screening the need for treatment, comprehensive evaluation of malocclusion would be facilitated, if the DAI were associated with craniofacial morphology.

This study investigated the relation between 10 occlusal components of the DAI and individual measures of skeletal morphology to determine whether the association between the DAI and craniofacial morphology was existed. In addition the relationship between the DAI score(a composite of occlusal features) and skeletal morphology was investigated.

MATERIALS AND METHODS

Subjects

The data for this study were obtained from pretreatment lateral cephalograms and dental casts of the adult patients who had been accepted for orthodontic treatment at Department of Orthodontics, School of dentistry, Chonbuk National University. There were 79 men(mean age: 17.0 years) and 103 women(mean age: 17.1 years). The subjects used in this study were chosen to provide a random sampling of various malocclusion.

All subjects met the following criteria:

1. All primary teeth were absent.
2. All subjects have permanent dentition stage. The second molars were in various stage of eruption.

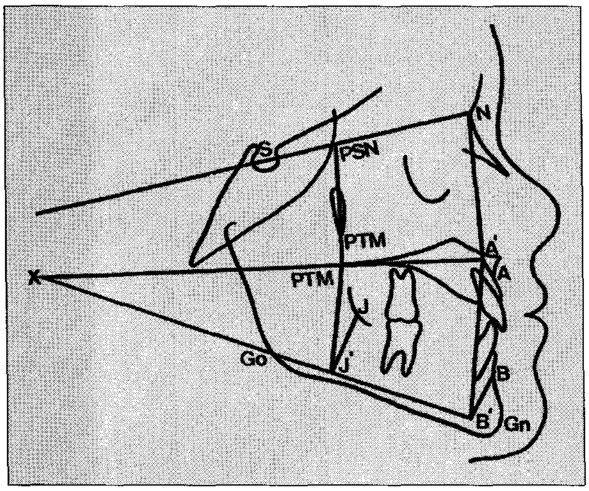

Fig. 1. Various landmarks used in this study

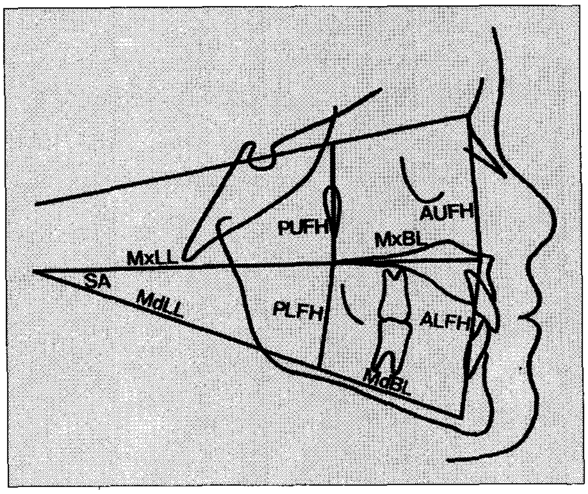

Fig. 2. Various lines and angular measurements used in this study

3. No gross caries that could interrupt the occlusion were present.
4. No parafunctional habits, such as tongue thrusting, thumb sucking, or lip biting, were noted either in the initial orthodontic record or at any time during orthodontic treatment.
5. No other obvious influences to normal occlusal or craniofacial development were noted in the orthodontic record.

Skeletal morphology assessment

The lateral cephalograms were traced by one investigator(C.Y.S). Tracing method of lateral cephalograms according to the standard method developed by DiPaolo [21]. A digital caliper with sharpened beaks was used to measure the skeletal structure on lateral cephalograms.

All direct linear measures were used to calculate ratios that express the proportional relationship between various segments of the facial complex.

The following landmarks were used in this study(Fig 1).

1. Point J: The deepest point of the curvature formed at the anterior portion of the ramus and corpus(the posterior limit of the mandibular base)
2. Point X: The intersect of the mandibular plane (Go-Gn) and the palatal plane(ANS-PNS)
3. Point A′: The perpendicular projection of point A onto the palatal plane
4. Point PTM′: The perpendicular projection of point PTM onto the palatal plane
5. Point B′: The perpendicular projection of point B onto the mandibular plane
6. Point J′: The perpendicular projection of point J onto the mandibular plane
7. Point PSN: The intersect of the S-N plane and the line perpendicular to the palatal plane through point PTM′(the posterior superior limit of the nasomaxillary complex)

The following measurements were used for analysis of skeletal morphology in this study(Fig 2).

1. Maxillary base length(MxBL): Distance from point PTM′ to point A′
2. Mandibular base length(MdBL): Distance from point J′ to point B′
3. Maxillary posterior leg length(MxLL): Distance from point X to point PTM′
4. Mandibular posterior leg length(MdBL): Distance from point X to point J′
5. Anterior upper facial height(AUFH): Distance from point N to point A′
6. Anterior lower facial height(ALFH): Distance from point A′ to point B′
7. Posterior upper facial height(PUFH): Distance from

Table Ⅰ. Components and weights of the Dental Aesthetic Index

Components	Symbol	Weight
Constant		13
Missing Incisors, canines, and premolars teeth - No.	MS	5.76
Crowding in the incisal segments	CR	1.15
0 : no, 1 : 1 segment crowded, 2 : 2 segments crowded		
Spacing in the incisal segments	SP	1.31
0 : no, 1 : 1 segment spaced, 2 : 2 segments spaced		
Midline diastema - in mm	DS	3.13
Largest anterior irregularity, maxilla - in mm	MxI	1.34
Largest anterior irregularity, mandible - in mm	MdI	0.75
Anterior maxillary overjet - in mm	MxO	1.62
Anterior mandibular overjet - in mm	MdO	3.68
Vertical anterior open bite - in mm	AOB	3.69
A-P molar relationships	APM	2.69
0 : normal, 1 : 1/2 cusp either mesial or distal, 2 : one full cusp or more		
Total		DAI score

point PSN to point PTM′

8. Posterior lower facial height(PLFH): Distance from point PTM′ to point J′
9. Angle of facial convexity(AFC): Angle formed by N-A′ and A′-B′
10. Sagittal angle: Angle formed by the mandibular plane and the palatal plane
11. Mandibular plane angle(MPA): Angle formed by the mandibular plane and the S-N plane
12. Average lower facial height(AvLFH): (ALFH+ PLFH)/2
13. Maxillary total sagittal length(MxSL): MxLL + MxBL
14. Mandibular total sagittal length(MdSL): MdLL + MdBL

DAI assessment

Score for each of the DAI components were determined by direct measurement from dental casts. Regression coefficients were used as relative weights for each of the 10 components of the DAI. The multiplication of each of these scores by the weighting factor(regression coefficient); the summation of their products and the addition of a constant number to the total. The resulting sum was the total DAI scores(Table Ⅰ).

Reliability

Fifteen sets of lateral cephalograms and dental cast were selected at random to provide data to assess intratester reliability. The second measures were taken after 3 weeks from the first measures. The results of repeated measures tests on each of the individual raw skeletal and DAI measures indicated that these measures were reliably obtained($p<0.05$).

Statistical analysis

The following statistical analysis were performed with SPSS/PC+ statistics program. The first step was to inspect the correlations among individual occlusal

Table II. Simple correlations between skeletal measures and occlusal components of the DAI

Variables	MS	CR	SP	DS	MxI	MdI	MxO	MdO	AOB	APM	DAI
MdBL/MxBL	0.00	-0.07	0.00	-0.00	-0.09	-0.17	-0.46*	0.49*	0.18	0.23*	0.18
MdLL/MxLL	-0.05	0.06	-0.03	0.01	-0.06	-0.04	-0.25*	0.36*	0.00	0.26*	0.14
MdSL/MxSL	-0.03	0.03	-0.04	-0.01	-0.07	-0.11	-0.44*	0.46*	0.11	0.28*	0.14
AvLFH/MxBL	0.08	0.01	-0.11	-0.02	-0.08	0.08	-0.15	0.08	0.16	0.12	0.08
AvLFH/MdBL	0.06	0.01	-0.07	-0.00	0.06	0.25*	0.26*	-0.32*	0.00	0.07	0.03
ALFH/AUFH	-0.12	0.00	-0.00	0.05	0.14	0.05	0.02	0.00	0.26*	-0.01	0.10
ALFH/PLFH	0.02	0.00	-0.02	0.03	0.03	0.01	-0.08	0.03	0.14	0.00	0.05
AUFH/PUFH	-0.06	0.03	-0.03	-0.04	0.03	0.08	-0.06	0.10	-0.02	-0.03	0.01
MPA	0.10	0.13	-0.14	-0.08	0.07	0.12	0.03	0.07	0.19*	-0.03	0.07
AFC	0.02	-0.00	-0.02	0.00	-0.16	-0.12	-0.38*	0.54*	-0.01	0.36*	0.11
SA	0.09	0.09	-0.10	-0.05	0.12	0.07	0.04	-0.15	0.23*	-0.06	0.04

*Statistically significant($p < 0.01$)

characteristics of the DAI and skeletal measures. Pearson product-moment correlation coefficients($p<0.01$) were calculated.

In the second step, the stepwise regression procedure was used to determine whether combinations of occlusal characteristics of the DAI explained more variance in any single skeletal measure than did single characteristics, and to determine whether combinations of skeletal characteristics explained more variance in any single occlusal characteristics of the DAI than did single characteristics.

RESULTS

Simple correlation between occlusal components of the DAI and skeletal measures(Table II).

The correlations between occlusal components of the DAI and skeletal measures ranged from 0.00 to 0.54. The highest correlation was found between the angle of facial convexity(AFC) and the MdO($r=0.54$, $p<0.01$). The MxO, the MdO and the APM of the DAI components were correlated with the MdBL/MxBL, the MdLL/MxLL, the MdSL/MxSL and the AFC of skeletal variables($p<0.01$). The AOB of the DAI components was correlated with the ALFH/AUFH and the SA of skeletal variables($p<0.01$). However, the number of missing teeth(MS), the crowding in the incisal segments(CR), the spacing in the incisal segments(SP), the anterior maxillary irregularity(MxI), and the anterior mandibular irregularity(MdI) were poorly correlated with various skeletal measures($p<0.01$).

Stepwise multiple regression: Ten occlusal components of the DAI and skeletal measures (Table III, IV).

Multiple R and R^2 values were calculated with stepwise multiple regression to assess whether combinations of occlusal components of the DAI explained more variance in any single skeletal variable than did single measures. These values are presented in Table III. Two or more independent variables entered the regression equation to produce an increase over simple correlation values in the explained variance of the dependent variable in 7 of the 11 stepwise multiple regression calculations. The multiple R values of these seven regressions ranged from 0.08 to 0.37.

Multiple R and R^2 values were calculated with stepwise multiple regression to assess whether combinati

Table III. Stepwise multiple regression between single skeletal variables and multiple occlusal components of the DAI

Dependent variables	Independent variables	Multiple R	R^2	Standard error	Overall F
MdBL/MxBL	MdO, MxO, AOB	0.61	0.37	0.08	26.95**
MdLL/MxLL	MdO	0.36	0.13	0.04	27.24**
MdSL/MxSL	MdO, MxO	0.53	0.28	0.05	36.38**
AvLFH/MxBL	AOB, MxO	0.22	0.05	0.13	4.79**
AvLFH/MdBL	MdO, MdI	0.43	0.18	0.13	20.32**
ALFH/AUFH	AOB, MxO	0.29	0.08	0.10	8.82**
ALFH/PLFH	None	·	·	·	·
AUFH/PUFH	None	·	·	·	·
MPA	AOB	0.19	0.03	0.85	6.84*
AFC	MdO, MxO, APM, MdI	0.60	0.36	6.76	25.47**
SA	AOB, MdO	0.28	0.08	5.67	8.04**

*Statistically significant($p < 0.01$)
**Statistically significant($p < 0.001$)

Table IV. Stepwise multiple regression between single occlusal component of the DAI and multiple skeletal variables

Dependent variables	Independent variables	Multiple R	R^2	Standard error	Overall F
MS	None	·	·	·	·
CR	None	·	·	·	·
SP	None	·	·	·	·
DS	None	·	·	·	·
MxI	None	·	·	·	·
MdI	AvLFH/MdBL	0.25	0.06	0.83	12.15**
MxO	MdBL/MxBL, MdLL/MxLL	0.52	0.27	4.85	33.49**
MdO	AFC, MdBL/MxBL, MdLL/MxLL	0.65	0.42	5.59	43.73**
AOB	ALFH/AUFH, SA	0.30	0.09	3.68	9.03**
APM	AFC, MdLL/MxLL	0.40	0.16	1.92	17.47**
DAI score	None	·	·	·	·

*Statistically significant($p < 0.01$)
**Statistically significant($p < 0.001$)

ons of skeletal measures explained more variance in any single variable of the DAI components than single measures. These values are presented in Table IV. Two or more independent variables entered the regression equation to produce an increase over simpe correlation values in the explained variance of the dependent vari able in 4 of the 11 step wise multiple regression calculations. The multiple R values of these seven regressions ranged from 0.09 to 0.42.

In the stepwise multiple regression between single skeletal variable and multiple occlusal components of the DAI, the total DAI score not entered the prediction formula for all skeletal measures. And any sets of skeletal features was not found to predict the total DAI score.

DISCUSSION

Occlusions vary from optimal to severe malocclusion, and are the expression of bone growth, dental development, and neuromuscular maturation[22]. Thus the concept that definitive relationships exist between a single characteristic of occlusion(anterior open and deep bite[23-27], mandibular anterior crowding and maxillary anterior crowding[28-30], malocclusion according to Angle's classification[31-39] etc.) and craniofacial morphology, is well known to orthodontists. However, the concept of occlusion is not based on simple component but rather on several aspects of occlusion; crowding, spacing, overjet, overbite, molar relationship. In addition it has been suggested that a malocclusion is the sum of individual deviations of several occlusal component[40-42]. Therefore the relationship between occlusion and craniofacial morphology might be better analyzed by examining multiple components of both occlusion and craniofacial morphology. Thus this study investigated the relationship between occlusal components of the DAI and individual craniofacial measures, and between the total DAI score base on multiple aspects of occlusion and craniofacial measures with univariate and multivariate analyses.

The statistically significant association was found between the anteroposterior skeletal measures(MdBL/MxBL, MdLL/MxLL, MdSL/MxSL) and the sagittal occlusal components(MxO, MdO, APM) of the DAI ($r=0.25\sim0.49$). The strongest association was found between the MdBL/MxBL and sagittal occlusal components of the DAI($r=0.49$, $p<0.001$). This association suggested that the mandibular base length excess or the maxillary base length deficiency was related with an Angle class Ⅲ molar relation and tendency toward reverse overjet, and vice versa. Similar findings of a relation between anteroposterior skeletal measures and sagittal occlusal components have been reported by Keeling et al[43], Meyers[44], Solow[45], Björk[46].

A combined sagittal occlusion variables(MdO, MxO) of the DAI was found to explain the greatest percents of the variance in anteroposterior skeletal measures (MdBL/MxBL) in this study(r^2=37%). This results were agreed with the finding of Meyers[44]. Also, combined skeletal measures were found to explain a greater percent of the variation in mandibular overjet of the DAI(r^2=42%) than did single measures; statistically significant association between the MdO and a combined skeletal variables heavily weighted by the AFC, the MdBL/MxBL, and the MdLL/MxLL. The statistically significant association was found between the AFC and single sagittal occlusal components(MxO, MdO, APM). In addition, a combined occlusal features was found to explain a greater percent of variation in AFC(r^2=36%) than did single component.

Associations between vertical skeletal variables and vertical occlusal components of the DAI was relatively weak($r=0.19\sim0.26$). But, a higher correlation was found between the ALFH/AUFH and the AOB. It showed that open bite tendency was more related to the ALFH increase than to the AUFH. These findings are consistent with the report of Solow[45] where the ALFH was found to explain a greater percent of variance in overbite than either the mandibular plane angle or the palatal plane angle. Also Meyers[44] have reported that skeletal factors are less significant in the case of a vertical malocclusion than in the case of an anteroposterior malocclusion.

In this study the MdI was weakly correlated with only AvLFH/MdBL. This was in contrast to the conclusion of Leighton and Hunter[30] and Sakuda and associates[29] that "lower incisor crowded case are more likely to have larger Frankfort-mandibular plane angle and occlusal plane angle and to have shorter posterior facial height and mandibular body". In this study, the MdI in the DAI was largest mandibular anterior irregularity, but in previous studies evaluation of crowding/spacing was determined by arch length discrepancy.

Dermaut et al[47] reported that most of patients with hypodontia had not different from Class I skeletal relationship, indicating no influence of the agenesis on skeletal pattern. Roald et al[48] reported that changes in craniofacial structure in missing group were about the same as in group without missing permanent teeth. In this study, there was no statistically significant between each of skeletal structure and the number of missing teeth.

It was interesting that molar relation, overjet, and overbite had higher correlations with individual skeletal measures than did the total DAI score, which was derived from those components. The total DAI score was not correlated with any skeletal variables. In the stepwise multiple regression for eleven dependent skeletal variables and for eleven dependent variables of the DAI, the total DAI score did not enter the prediction formula for all skeletal measures, and any sets of skeletal measures were not found to predict total DAI score. These shows that no classification scheme fully represents either occlusal or skeletal variability. Therefore screening the need for treatment and comprehensive evaluation of malocclusion should be based on, not depend on only one index, occlusal characteristics and skeletal morphology of the individual patient.

CONCLUSIONS

This study have evaluated the relation between for occlusal components of the DAI and eleven skeletal measures, and betwen the total DAI score(a composite of occlusal components) and skeletal morphology. Our results supported the following conclusions:

1. Several occlusal components of the DAI(missing, crowding and spacing in the incisal segment, diastema, largest anterior irregularity on upper and lower arch), individually and in combination, were not associated with individual measures of craniofacial morphology.
2. Sagittal occlusal components of the DAI(maxillary overjet, mandibular overjet) were associated with anteroposterior skeletal measures(MdBL/ MxBL, MdLL/MxLL, MdSL/MxSL, AFC).
3. The relation between vertical occlusal components of the DAI and individual skeletal measures was low magnitude association than relation between sagittal occlusal components of the DAI and skeletal morphology.
4. The total DAI score, which was based on several aspects of occlusion, did not identify craniofacial morphology.
5. Combination of certain occlusal components of the DAI may be related with specific skeletal morphology; but, this concept could not be accepted generally.

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국문초록

치열심미지수(DAI)와 악안면 형태와의 관계

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최용성 · 김은경 · 최현규 · 김정기

본 연구에서는 치열심미지수(DAI)의 10가지 교합적 요소와 악안면 형태와의 상호관계를 단변수와 다변수 통계처리 기법을 이용하여 조사하였다. 자료는 교정치료를 위해 내원한 영구치열을 가진 182명(남자 79명, 여자 103명)의 치료전 연구모형과 측모 두부규격방사선 사진으로부터 얻었다. 악안면 형태를 분석하기 위해서 DiPaolo의 사변형 분석 방법을 이용하였으며 치열심미지수의 10가지 교합적 요소는 Jenny, Cons 등에 의해 발표된 진단기준에 따라 각 항목을 측정하여 기록하였다. 또한 안모의 심미관계도 조사하여 다음과 같은 결론을 얻었다.

1. 치열심미지수의 구성요소중 결손치수, 절치부 총생도, 절치부 공극도, 정중이개량, 상악전치부 최대 변이량등 대부분의 구성요소가 악안면 형태와 상관관계를 보이지 않았다.
2. 치열심지지수의 구성요소중 상악전치부 수평피개량, 하악전치부 수평피개량, 전 · 후방 구치관계 등은 시상면적 악골관계를 나타내는 골격요소인 MdBL/MxDL, MdLL/MxLL, MdSL/MxSL들과 상관관계를 보였다.
3. 치열심미지수의 구성요소중 전치부 수직 개방교합량은 수직적 악골관계를 나타내는 ALFM/AUFH, MPA, SA등과 미약한 상관관계를 보였다.
4. 교합의 여러 측면을 기초로 한 치열심미지수는 악안면 형태와 무관하였다.
5. 교정치료 필요 유무의 선별 및 부정교합의 심도에 관한 포괄적인 평가에는 어느 특정 지수에 의존하기보다는 교합적 요소와 악안면 골격적 요소 모두에 기초를 두어야 할 것으로 사료된다.

주요 단어 : Dental Aesthetic Index, 부정교합의 심도, 악안면형태