The association between occlusal features and craniofacial structure

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ABSTRACT

Purpose: To investigate the relationship between craniofacial skeletal structure and occlusion.

Materials & Methods: Data were obtained from lateral cephalometric radiographs and study casts of 60 patients with various malocclusions, with the mean age of 13.3±1.5 years. Thirteen angular and 14 linear skeletal measures as well as 5 occlusal measures including; overjet, overbite, molar relation, maxillary and mandibular crowding were applied. Relations were examined by use of univariate and multivariate statistical methods.

Results: Simple correlation analysis between individual skeletal measures and individual occlusal characteristics showed that the strongest linear correlation exists between overbite and Pal-GoMe angle ($r=-0.451$, $P$-value $\leq 0.01$). Stepwise multiple regression was carried out for quantitative occlusal variables. The prediction formula for overjet had the highest multiple $R$ and $R^2$ values (multiple $R=0.654$, $R^2=0.428$), which shows that multiple skeletal features explained 43% of the variance in overjet.

Conclusion: Individually and in combination, skeletal measures were poorly associated with individual features of occlusion, so that variations in skeletal structure account for at most 43% of the variations in occlusion.

Keywords: Occlusion, Craniofacial structure, Association.

INTRODUCTION

Occlusion varies from optimal to severe malocclusion, with continuous variation between the two and reflect bone growth, dental development and neuromuscular maturation. The concept that definitive relationships exist between occlusion and craniofacial morphology is well known to orthodontists.¹⁻³ It has been argued that orthodontic diagnosis might be facilitated if the relationship between occlusion and craniofacial structure were better understood.¹ It is clear that teeth (cranial base, jaws, teeth) are related to each other.²⁻⁴ Numerous studies have examined the relationship between craniofacial morphology and a single characteristic of occlusion such as openbite,⁴⁻⁷ deep bite,⁸⁻⁹ mandibular anterior crowding¹⁰⁻¹² and Angle classification¹³⁻¹⁶ Others have examined the correlation between craniofacial structure and multiple features of occlusion.¹⁶⁻¹⁷ The results of these studies often are contradictory because of several problems inherent in examining the association between craniofacial structure and occlusion. Not only do most samples rarely include a typical assortment of occlusal variation, but the Angle classification schemes alone do not
best represent that variation.\(^{(1)}\) In addition, a malocclusion is the combination of several individual skeletal problems of which none may be remarkable in and of itself.\(^{(18,19)}\)

The purpose of this study was to examine the relationship between craniofacial skeletal structure and occlusion on a sample of occlusal variation with several angular and linear skeletal measures using univariate and multivariate statistical methods.

**MATERIALS & METHODS**

In this analytical study, the data were obtained from pretreatment lateral cephalometric radiographs and dental casts of children in early permanent dentition selected from the archive of Shahid Beheshti University Orthodontic department. There were 37 girls and 23 boys with ages ranged from 11 to 16 years. All subjects met the following criteria:

1. Presence of no primary tooth.
2. Presence of all permanent teeth except for the third molars. The second molars were in various stages of eruption.
3. No premature loss of primary teeth in the orthodontic records.
4. No tempromandibular joint abnormality, mandibular deviation or facial asymmetry.

The lateral cephalograms were traced by one investigator (ST). Landmarks were identified as described by Riolo and associates.\(^{(20)}\) 13 angular and 14 linear measures were selected to assess: cranial base flexure and length, maxillary horizontal and vertical positions and length, mandibular horizontal and vertical positions and length, anteroposterior and vertical maxillary-mandibular discrepancies.

All occlusal measurements were taken directly from the dental casts. Overbite, overjet and molar relationship were identified and measured as reported by Solow.\(^{(21)}\) Maxillary and mandibular crowdings were measured from one first molar to the other directly on dental casts.

The following statistical analysis were performed:

1. Pearson’s product-moment coefficient of correlation to assess the association, among skeletal measures, and between individual occlusal characteristics and skeletal measures.
2. Stepwise multiple regression to determine whether combinations of skeletal measures explained more variance in any single occlusal characteristic than did single measures. In this procedure a skeletal variable was entered and retained in the regression model at each step if it explained a significant amount of variance in occlusal variable at the \(P=0.05\) significance level. Addition of skeletal variables to the model was stopped when no other variable met the 0.05 significance level criterion and \(R\) reached to the maximum level.

**RESULTS**

The study sample consisted of 37 girls and 23 boys with the mean age of 13.3±1.5 years. The distribution of malocclusion in the sample was approximately similar to that in the Iranian population. Table 1 shows the mean, range and standard deviation of overjet, overbite, maxillary crowding and mandibular crowding and indicates that wide range of occlusal characteristics have been selected in order to strengthen external validity. Figure 1 shows the distribution of cases according to Angle classification.

**Table 1.** Mean, range and standard deviation of occlusal variables (mm).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overjet</td>
<td>3.41</td>
<td>2.5</td>
<td>10</td>
<td>0</td>
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<tr>
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<td>-4</td>
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<td>4.17</td>
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<td>Mand. Crowding</td>
<td>3.11</td>
<td>3.48</td>
<td>+13</td>
<td>-4</td>
</tr>
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</table>

The correlation among skeletal variables revealed several strong (\(r \geq 0.75, P \leq 0.05\)) associations, most of them reflecting redundancy or topographic relationship.

The significant linear correlation between...
individual occlusal features and individual skeletal measures ranged from 0.275 to -0.451 (Table 2).

![Fig 1. Histogram showing distribution of malocclusion in the sample.](image1)

Overjet showed significant correlation with several skeletal measures while the highest of these correlation were between overjet and A-N-B (r=0.377, P≤0.05) (Fig. 2).

The strongest correlation between overbite and skeletal structure was found between overbite and Pal-GoMe (r=-0.451, P≤0.05) (Fig. 3).

![Fig 2. Linear correlation between overjet and A-N-B angle (r=0.377).](image2)

Maxillary crowding showed significant correlation with N-Se (r=−0.302, P≤0.05) (Fig. 4) and ramus length, but it’s correlation with other skeletal measures were not statistically significant.

![Fig 3. Linear correlation between overbite and Pa-GoMe angle (r=-0.451).](image3)

The only significant correlation of mandibular crowding was found with ANS–Me/N-Me (r=−0.292, P≤0.05).

Multiple R and R² values were calculated with stepwise multiple regression to assess whether linear combinations of skeletal measures explained more variance in any single quantitative occlusal variable than did single measures. Unstandardized and standardized regression coefficients were also determined.

![Fig 4. Linear correlation between maxillary crowding and N-Se (r=0.302).](image4)
Table 2. Linear correlation between individual occlusal characteristics and individual skeletal measures.

<table>
<thead>
<tr>
<th>Skeletal</th>
<th>Occlusal</th>
<th>Mand. Crowding</th>
<th>Max. Crowding</th>
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<th>Overjet</th>
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<td>NS</td>
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<tr>
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<td>NS</td>
<td>NS</td>
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<tr>
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<td>NS</td>
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</table>

From occlusal variables, the highest multiple R and R² were related to overjet regression model (multiple R=0.654, R²=0.428, P≤0.05), which shows combination of 5 skeletal measures explained 43 percent of the variance in overjet. Overbite prediction formula showed that only 29 percent of the variance in overbite were explained by multiple skeletal measures.

The multiple R values of maxillary crowding and mandibular crowding were less than 0.5.

**DISCUSSION**

This study investigated the relationship between features of occlusion and craniofacial structure. The simple correlation analysis of overbite with skeletal measures showed that increase of overbite is accompanied with decrease of A.F.H (N-Me), A.L.F.H (ANS-Me), sum of posterior angles, SN-MeGo and Jarabak Index (P.F.H/A.F.H×100). Similar findings have been reported by Bjork(1947), Schud (1964), Solow(1966), Parlow(1972), Keeling(1989), Tsang(1997), and Meyers(1992). However our results showed that individual features of occlusion were poorly related to individual skeletal measures; the highest correlation (r=-0.451) explained only 20 percent (R²=0.20) of the variance between overbite and Pal-GoMe (basal angle). These values were lower than comparable values reported by Beckmann et al(1998)(9) (R²=0.31) but were nearly similar to the findings of Solow(1966), Keeling(1989), and Meyers(1992).

In multiple regression, when A-N-B entered the overbite prediction formula, raised r from 0.451 to multiple R=0.537; adding 9 per cent to explained variance. It was interesting that A-N-B, which is an anteroposterior skeletal measure, showed a considerable correlation with overbite, which is a vertical occlusal feature.

In anteroposterior relations, simple
correlation analysis showed that increase of overjet is associated with decrease of S-N-B, S-N-Pog and mandibular length and increase of N-Se. The strongest correlation was found between overjet and A-N-B angle ($r=0.377$) which indicated that only 14 per cent of the variance in overjet could be explained by A-N-B angle. These values are higher than comparable values reported by Solow (21), Bjork (1947) (22) and Keeling et al (1989) (17) ($R^2=0.09$) but are considerably lower than values reported by Meyers ($R^2=0.42$) (25). The higher values of shared variance reported by Meyers, may indicate that Dipaolo’s quadrilateral measures, which are consistent with Enlow’s counterpart principle and are used in Meyers’ study, better express the relations between variations in anteroposterior skeletal structure and variations in sagittal occlusion than other measures. Another reason for this difference, may be the variation in study sample.

The multiple regression between overjet and five skeletal measures, increased multiple R as high as 0.654. This indicated that up to 43 percent of the variance in overjet could be accounted for by the variance in skeletal measures. The interesting point was the relation of vertical skeletal measures such as Pn-Pal, SN-MeGo and Jarabak index, with overjet, a sagittal occlusal characteristic.

Although, the skeletal measures used in our study are different from Dipaolo’s quadrilateral measures used in Meyers’ study, the results of multiple regression analysis were similar (multiple $R^2=0.43$).

Mandibular crowding showed a significant correlation with ANS-Me/N-Me but it’s correlations with other skeletal measures such as Jarabak index and SN-MeGo were not significant. Similar findings have been reported by Meyers (1992) (25) and Eslamian (2003) (26) but Sakuda (1976) reported a significant correlation between mandibular crowding and Sn-MeGo (mandibular plane angle) and mandibular body length. (11)

Finally, it seems that, the reason of this low correlation between occlusion and skeletal structure, is the influence of other factors.

With the explosion of discoveries in developmental biology and genomics in the past decade, the direct relevance has affected the understanding of development, growth and adaptation of craniofacial skeletal tissue. It is essential to identify and understanding the role of key intrinsic and extrinsic factors that influence gene expression and cell growth during the development of the craniofacial complex. (27,28,29)

**CONCLUSION**

1. Individually, occlusal characteristics were poorly associated with individual measures of craniofacial morphology (14 per cent of the variance in overjet and 20 per cent of the variance in overbite could be explained by a single skeletal measure).

2. A linear combination of skeletal measures explained more variance in an occlusal variable (43 percent of the variance in overjet and 24 percent of the variance in overbite).

**Acknowledgement**

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**REFERENCES**


3. Angle EH: Malocclusion of the teeth. 7th Ed. Philadelphia: White Mfg Co. 1907;


