Original Article

# Inconsistencies in the Differential Diagnosis of Open Bite

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**ABSTRACT**

**Objective:** To examine inconsistencies in the differential diagnosis of open bite.

**Materials and Methods:** Using visual judgments, a total of 77 anterior open-bite cases in the postpubertal growth period were grouped as either morphogenetic, functional, or combination. The same sample was also grouped as either hyperdivergent, normodivergent, or hypodivergent using mandibular-plane angle and conventional cephalometry. Kappa analysis was used to test the agreement between the 2 methods of evaluation, and $\chi^2$ tests were used to analyze the distribution of cephalometrically grouped hyperdivergent, normodivergent, and hypodivergent cases among the visually assessed morphogenetic, functional and combination groups and vice versa. A $\kappa$ score of 0.343 indicated a weak agreement between visual judgment and cephalometric methods of evaluation ($P < .001$).

**Results:** Despite the expectation that cases evaluated as hyperdivergent using cephalometry would be visually evaluated as morphogenetic, more than half of the cases assessed as hyperdivergent were in fact classified as functional.

**Conclusions:** These findings highlight the inadequacy of relying solely on cephalometric evaluation to classify open bite.

**KEY WORDS:** Differential; Diagnosis; Open bite

## INTRODUCTION

Orthodontists commonly agree with the sentiment, "Treatment of open bite is difficult, but relapse is easy," but the reasons behind this have not been sufficiently examined. The multifactorial nature of the etiology of open bite is largely responsible for the indecision surrounding its diagnosis and treatment. Conflicting systems of evaluation and classification often result in only partial and inadequate diagnosis, giving rise to problems during and after treatment.

Decades have past since Sassouni[1] suggested that the angle of the mandibular plane (MP) be used as the criterion for classifying open-bite cases as either "skeletal" or "dentoalveolar." Although the MP angle is still commonly accepted and in use today as an identifying factor in vertical facial morphology,[2–6] its accuracy in classifying open bite is debatable.[7–9] It is true that the MP angle increases in long-faced individuals; nevertheless, as stated by Fields and colleagues,[10] "not all long-faced patients have open-bite, not all open-bite patients are long faced."

Changes in the MP angle have been clinically and experimentally shown to occur as a result of environmental and functional factors.[11–14] Although an increased MP angle in such cases may justify their classification as hyperdivergent, they cannot reasonably be considered to be skeletal. Unfortunately, this misdiagnosis is not infrequent and leads to much confusion.

Cephalometric studies form the basis of our knowledge regarding normal and abnormal characteristics of the craniofacial structure. Cephalometry is routinely performed in orthodontic clinics because the procedure is simple and the results can be easily and quickly evaluated. Although the usefulness of cephalometry cannot be disregarded in the evaluation of treatment results and the followup of growth and development, the information provided by cephalometry is limited to morphologic and positional relations.

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Accepted: May 2007. Submitted: February 2007.

**Visual Judgment Criterion**

MORPHOGENETIC

| Long and narrow | **Symphsis** | Short and wide |
|---|---|---|
| *Prominent* | **Antegonial notch** | *Normal* |
| *Increased* | **Gonial angle** | *Decreased* |
| *Increased* | **Lower facial height** | *Decreased* |
| *Incompetent lips* | **Soft tissue profile** | *Competent lips* |
| *Yes / No* | **Nasopharyngeal airway deficiency** | *Yes* |
| *Yes / No* | **Mouth breathing** | *Yes* |

FUNCTIONAL

**Figure 1.** Visual judgment criterion, with sample cases.

**Table 1.** The κ Score Evaluation According to Landis and Koch[24]

| κ Score | Measure of Agreement |
|---|---|
| <0.00 | Poor |
| 0.00–0.20 | Slight |
| 0.21–0.40 | Fair |
| 0.41–0.60 | Moderate |
| 0.61–0.80 | Substantial |
| 0.81–1.00 | Almost perfect |

Because cephalometry is unable to provide adequate information about functional and environmental factors,[15] these factors are naturally overlooked in cephalometric studies. Because functional factors are frequently implicated in the etiology of open bite,[16–22] their neglect is probably the most notable reason for the complications in diagnosing open bite and designing an appropriate treatment plan as well as for the high incidence of relapse after treatment.

The aim of the current study was to examine the problem of conflicting evaluations of open bite in a group of postpubertal patients with open bite by comparing the differential diagnoses of open bite using visual as opposed to cephalometric methods.

## MATERIALS AND METHODS

The study population consisted of 77 young adults (17 young men, 60 young women) with anterior open bites (Mean: −2.23 mm ± 2.2; range −1 to −10 mm) whose pretreatment records were randomly selected from the orthodontic department archives.

Mean age of the subjects was 16.2 ± 2.5 years. All subjects were in their postpubertal growth period according to hand-wrist radiographs. None of the subjects had any syndromes or severe craniofacial deformities. Pretreatment records (lateral cephalograms, extraoral and intraoral photographs, hand-wrist films, and patient histories) were evaluated by 2 of the authors who have 30 and 15 years, respectively, of clinical experience in orthodontics as academicans. All of the cases (n = 77) were classified independently using visual and cephalometric methods.

### Visual Evaluation

The cephalograms and other pretreatment records (ie, extraoral and intraoral photographs and patient histories) were visually evaluated by two of the authors according to their clinical perceptions without reference to any cephalometric analysis.[23]

In this evaluation, differential diagnosis was based on criteria related to cranio-mandibular and mandibular morphology (ie, symphysis type, antegonial notch depth, gonial angle, lower facial height) and functional characteristics of the patients (ie, thumb-sucking history, tongue and lip posture, nasopharyngeal airway deficiency, and mouth breathing) (Figure 1). Accordingly, open-bite cases were visually classified as belonging to one of three groups: morphogenetic, functional, or combination. Cases that lacked a distinct character were classified as combination. Visual evaluation was conducted twice at 3-week intervals by the same researchers.

### Cephalometric Evaluation

The same study population was evaluated with cephalometrics and classified according to the mandibular plane angle (MP: GoGn-SN) as belonging to 1 of 3 groups: hyperdivergent (MP $\geq$ 38°), normovergent (32° $\leq$ MP $<$ 38°), or hypodivergent (MP $<$ 32°). Cephalometric evaluation was conducted twice at 3-week intervals using the PorDios (Purpose on request Digitizer input output system, Copenhagen, Denmark) orthodontic analysis software.

### Method Error

The κ coefficients were calculated to determine the reliability of visual evaluation.[24] A κ score of 0.812 indicated reliability between the first and second round of evaluations ($P < .001$) (Table 1). Intraclass correlation coefficients were calculated to determine the reliability of cephalometric evaluations, which was between 0.91 and 0.99, which indicates almost perfect agreement.

**Table 2.** Distribution of Visually and Cephalometrically Classified Open-Bite Cases

| Total Open-Bite Cases (n = 77) | | | |
|---|---|---|---|
| Visual Evaluation | | Cephalometric Evaluation | |
| | n (%) | | n (%) |
| Morphogenetic | 20 (26%) | Hyperdivergent | 48 (62.3%) |
| Functional | 46 (60%) | Normodivergent | 24 (31.2%) |
| Combination | 11 (14%) | Hypodivergent | 5 (6.5%) |

**Table 3.** The Agreement of Visual and Cephalometric Methods Examined Using the Kappa test[a]

| Visual Evaluation | Cephalometric Evaluation | | |
|---|---|---|---|
| | Hyperdivergent | Nonhyperdivergent | Total |
| Morphogenetic | 19 | 1 | 20 |
| Functional | 23 | 23 | 46 |
| Total | 42 | 24 | 66 |

[a] κ score: 0.343, $P < .001$.

## Statistical Analysis

The κ coefficients were calculated to determine the rates of agreement between visual and cephalometric evaluation, that is, correlation of morphogenetic with hyperdivergent and functional with nonhyperdivergent (normal and hypodivergent cases combined) cases. The distribution of visually assigned (morphogenetic, functional, combination) open-bite diagnoses was analyzed using $\chi^2$ tests among those assigned (hyperdivirgent, normodivergent, hypodivergent) as open-bite diagnoses with cephalometrics and vice versa.

## RESULTS

Table 2 shows the distribution of open-bite cases according to both visual and cephalometric evaluation. Of a total of 77 cases, 20 (26%) were grouped as morphogenetic, 46 (60%) as functional, and 11 (14%) as combination. Cephalometric evaluation of the same population grouped 48 (62.3%) as hyperdivergent, 24 (31.2%) as normodivergent, and 5 (6.5%) as hypodivergent.

Kappa analysis was conducted to examine the level of agreement between visual and cephalometric evaluation (Table 3). A κ score of 0.343 indicated a weak level of agreement between the 2 methods ($P < .001$).

Table 4 shows the results of $\chi^2$ tests analyzing the distribution of cases assigned using cephalometry and those assigned using visual assessment.

The actual distribution of hyperdivergent cases (n = 19) among the morphogenetic group (n = 20) was similar ($\chi^2 = 0.05$, not significant) to what would be expected, however, the actual distribution of normodivergent cases (n = 19) among the functional group (n = 46) varied significantly ($\chi^2 = 15.84$, $P < .01$) from expectations (Table 4). In the combination group, there were not any expectations about possible results. On the other hand, the actual distribution of functional cases (n = 19) among the normodivergent group (n = 24) was also similar ($\chi^2 = 1.04$) to expectations, but the actual distribution of morphogenetic cases (n = 19) among the hyperdivergent group (n = 48) varied significantly ($\chi^2 = 17.52$, $P < .01$) from expectations.

## DISCUSSION

Identifying the underlying cause(s) of open bite is essential for accurate diagnosis and precise treatment planning. The current study aimed to shed light on this subject by comparing the differential diagnoses of open-bite cases using 2 different methods: visual evaluation and conventional cephalometric method.

Open-bite cases were divided into morphogenetic, functional, and combination groups by visual evaluation and into hyperdivergent, normodivergent, and hypodivergent groups by cephalometric evaluation (Table 2). We expected that cases classified visually as morphogenetic would be classified as hyperdivergent using cephalometry and those classified visually as functional would be classified as non-hyperdivergent (normodivergent or hypodivergent) using cephalometry.

The majority of open-bite cases in this study were classified as functional (60%) by visual evaluation. At the same time, the majority (62%) were independently classified as hyperdivergent by cephalometric evaluation. However, the rate of morphogenetic open bites was rather low (26%). The finding of a low rate of morphogenetic open bites is not surprising when the dentoalveolar compensation mechanism[25–27] is taken into consideration.

**Table 4.** Distribution of Open-Bite Cases in Visually and Cephalometrically Determined Groups

| Open-Bite (n = 77) | | Cephalometric Evaluation: Hyperdivergent | Normodivergent | Hypodivergent | Total No. (%) |
|---|---|---|---|---|---|
| Visual evaluation | Morphogenetic | 19 | 1 | 0 | 20 (26%) |
| | Functional | 23 | 19 | 4 | 46 (60%) |
| | Combination | 6 | 4 | 1 | 11 (14%) |
| | Total | 48 (62.3%) | 24 (31.2%) | 5 (6.5%) | 77 |

Results of Kappa tests showed weak agreement between visual and cephalometric methods in the classification of open bite. Although hyperdivergent cases were expected to have also been evaluated as morphogenetic in nature, and nonhyperdivergent (normodivergent or hypodivergent) cases to be functional in nature, in actuality, 23 of hyperdivergent cases (n = 48) were evaluated as functional and 23 of functional cases (n = 46) were evaluated as hyperdivergent. Almost all cases classified as morphogenetic (n = 20) were also classified as hyperdivergent (n = 19), but of the 48 cases classified as hyperdivergent, only 19 were classified as morphogenetic. These findings indicate that while morphogenetic open bites may show a hyperdivergent pattern, hyperdivergency is not always morphogenetic in nature.

The distribution of hyperdivergent, normodivergent, and hypodivergent cases in the functional open-bite group was also different from what might be theoretically expected ($P < .01$) (Table 4). Whereas many more nonhyperdivergent cases were expected among the functional group, findings showed the distribution of hyperdivergent (23) and nonhyperdivergent cases (19 normodivergent, 4 hypodivergent) to be equal within the functional group. On the other hand, while morphogenetic cases were also evaluated as hyperdivergent in nature, functional cases were frequently deemed to be hyperdivergent as well. In fact, functional cases made up 60 percent of the overall study sample (n = 77), including both hyperdivergent and nonhyperdivergent open bites. This finding that the majority of open-bite cases were functional in origin is critical for the differential diagnosis and treatment planning of open bite.

The following scenarios may be suggested with regard to the development of open bites that would be in line with the results of the current study.

It was suggested that because of the effects of the dentoalveolar compensation mechanism, long-faced subjects demonstrate a narrow and elongated midsagittal projection of the basal and alveolar bone in the frontal part of the jaws.[26,28–30] Therefore, open bite is rarely seen in long-faced individuals.[27] However, in some instances, that is, mouth breathing,[31,32] enlarged tonsils,[33] oral habits,[34,35] or postural relationships of tongue and lips,[36,37] dento-alveolar growth fails to compensate for the vertical discrepancy, thus leading to a functional/environmental open bite in a person with a hyperdivergent facial pattern. Cephalometric analysis will classify such cases as skeletal open bite, in spite of the fact that the open bite in such cases, is, in fact, of functional origin. Such a scenario may account for 19 of the cases evaluated as both morphogenetic and hyperdivergent in the current study. Orthodontic treatment of such cases represents a significant challenge.

In some instances, the MP angle could be increased as a result of excessive tongue thrust accompanying increased oral respiration in a normodivergent facial pattern.[38–42] Accordingly, such a hyperdivergency is considered functional rather than morphogenetic. This kind of hyperdivergency is considered reversible because the MP angle can be decreased by eliminating causative factors during the early growth period.[12,43] However, if these cases are not treated early, the hyperdivergence will become permanent. The scenario of the 23 cases (functional/hyperdivergent) out of the total study sample (n = 77) is probably like this. These cases are (regarding MP angle) evaluated using cephalometry in the same category with hereditary skeletal open bites. This is another cause for the confusion in the differential diagnosis of open bites. Early intervention may prove to be advantageous in the treatment of such cases.

On the other hand, open bite can be observed in a normodivergent or even in a hypodivergent facial pattern. In such a condition, the causative factor could be thumb- or finger-sucking habits.[34,35] This kind of open bite would be correctly defined as a ''dentoalveolar'' open bite. In our findings, this accounted for 23 of 77 open-bite cases, which were visually evaluated as functional, but evaluated as normodivergent (n = 19) and hypodivergent (n = 4) using cephalometry.

Open-bite scenarios are not limited to those mentioned. In fact, each case has its own scenario that must be taken into consideration for precise treatment planning. Determining the specific etiology of open bite is difficult because of the interrelatedness of genetic, environmental, and functional factors. Furthermore, the intensity and duration of the causative dysfunction or acquired habit, as well as the growth period of the person in which it occurs, have an effect on the way in which open bite develops. Although functional factors (such as nasal restriction, abnormal functional patterns of the tongue, oral habits, abnormal swallowing patterns, and speech problems) often play a role in the etiology of open bite, they are just as often disregarded because of the inability of cephalometric analysis to measure functional and compensatory mechanisms. As a result, the use of cephalometric evaluation as the sole criteria for diagnosing open bite results in divergent classifications, inaccurate diagnoses, poor prognoses and a high incidence of relapse. The proper consideration of functional factors[44] as well as masticatory muscle functions[45,46] should lead to greater treatment success and improved stability.

## CONCLUSIONS

- Kappa analysis showed a weak correlation between cephalometric and visual classifications.

- Almost all open-bite cases visually evaluated as morphogenetic (n = 20) were evaluated as hyperdivergent (n = 19) using cephalometry. However, half of the open-bite cases visually evaluated as functional were evaluated as hyperdivergent (n = 23) and half as nonhyperdivergent (n = 23). Moreover, nearly half of the open-bite cases evaluated as hyperdivergent (n = 48) using cephalometry were visually evaluated as functional (n = 23), while functional cases accounted for equal numbers of hyperdivergent (n = 23) and nonhyperdivergent (n = 23) cases.
- Cephalometric evaluation alone is an inadequate tool for the differential diagnosis and classification of open-bite cases.

## ACKNOWLEDGMENTS

We thank Professor Fikret Gürbüz and Özgür Koskan (Ankara University, Faculty of Agriculture, Department of Biostatistics and Genetics) for their management of statistical procedures and Mrs Deborah Semel for grammatical correction of the manuscript.

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