European Journal of Orthodontics 30 (2008) 269–273
doi:10.1093/ejo/cjm130

Overjet as a predictor of sagittal skeletal relationships

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SUMMARY Skeletal relationships in the sagittal plane do not always correspond with dental relationships. The aim of this study was to determine in which type of malocclusion the correlation between overjet and skeletal sagittal parameters assessed by lateral cephalogram analysis is the highest. The extent to which overjet can predict skeletal relationships in the sagittal plane was also assessed.

Eighty-three subjects fulfilled the inclusion criteria (40 males and 43 females, mean age 16.3 ± 4.3 years). Overjet was measured on study casts and sagittal skeletal relationships were analysed on lateral cephalograms. ANB angle, Wits appraisal, and convexity at point A were determined. Mean values and standard deviations of measured parameters were calculated for Class I, Class II division 1, and Class III malocclusion subjects. Correlation between overjet measured on study casts and sagittal skeletal parameters measured on lateral cephalogram was calculated. Overjet as a predictor of skeletal relationships was assessed by means of linear regression analysis.

A statistically significant positive correlation ($P < 0.01$) was found between the values of overjet and ANB ($r = 0.690$), overjet and Wits appraisal ($r = 0.750$), and overjet and convexity at point A ($r = 0.608$) when assessing the whole sample. When linear regression between overjet and cephalometric parameters was assessed separately in Class I, Class II division 1, and Class III malocclusion subjects, the percentage of variability was statistically significant in just four pairs.

The findings show that overjet is a good predictor of sagittal relationship only in subjects with a Class II division 1 malocclusion.

Introduction

Different diagnostic records are obtained to determine the optimal treatment plan. The diagnostic database includes patient's history, clinical examination, study cast analysis, cephalometric analysis, and facial photographs (Proffit and Ackerman, 2000).

Overjet is an important measure in study cast analysis. It is one of the parameters used to assess the sagittal relationship of the upper and lower dental arch. The cause of a large or small overjet could be skeletal, dental, or a combination of both.

In adolescents beyond the growth spurt, when deciding on surgical or orthodontic intervention, beside the facial profile, overjet is an important guideline. Generally when the overjet is greater than 10 mm, surgery is a more successful treatment option (Proffit *et al.*, 1992).

However, overjet is not always a reliable measure of the jaw relationship in the sagittal plane, especially in subjects with Class III malocclusions (Iwasaki *et al.*, 2002). For accurate determination of jaw relationship, cephalometric analysis is necessary because two malocclusions can appear alike when observing just study casts but careful cephalometric analysis can show that the basic problem is very different.

Skeletal relationships in the sagittal plane do not always correspond with dental relationships. The most frequent disagreement has been found in Class I dental relationships (Milacic and Markovic, 1983).

Radiographic analysis not only assists in the diagnosis of malocclusions but can also influence the treatment plan. It has been shown that especially when extractions are involved, cephalometric data significantly influence the course of treatment (Pae *et al.*, 2001).

Several cephalometric parameters are used to assess sagittal jaw relationships. The position of the jaws is usually defined relative to the cranial base, although this does not always offer accurate data for the anteroposterior relationships of the jaws (Jacobson, 1975, 1976; Tanaka *et al.*, 2006).

The position of the upper jaw is assessed with SNA and that of the lower jaw with SNB. ANB is most commonly used to measure jaw disharmony (Steiner, 1953, 1959; Jacobson, 1975; Hussels and Nanda, 1984; Oktay, 1991).

The reliability of ANB relative to the jaw relationships in the sagittal plane also depends on the inclination of the mandible with reference to the anterior cranial base, which is normally 32 degrees (SD = 5 degrees; Riedel, 1952). If this inclination is within the normal range, the jaw relationships are reflected in ANB. If the inclination of the mandible is out of normal range, ANB is not a reliable measure of the jaw relationships in the sagittal plane. In that case, it may be accordingly adjusted (Panagiotidis and Witt, 1977). The Wits appraisal may be used in order to obtain supplementary information. The latter is not an analysis *per se*, but merely a linear measurement, which assists in the interpretation of ANB and thus in the assessment of the relative jaw relationships in the sagittal plane (Jacobson, 1976).

The assessment of the anteroposterior relationships with Wits appraisal depends mainly on the accurate definition of the occlusal plane and its inclination (Rushton *et al.*, 1991).

Sagittal jaw relationships can also be assessed using Ricketts analysis of the convexity at point A. The convexity of the mid face is measured from point A to the facial plane (n–Pg; Jacobson, 1995).

The aim of this study was to determine in which type of malocclusion the correlation between overjet and skeletal sagittal parameters assessed on lateral cephalograms was the highest. The extent to which overjet can predict skeletal relationships in the sagittal plane was also determined.

Subjects and methods

Subjects

From a total sample of 650 randomly selected subjects referred to the Department of Orthodontics, Faculty of Medicine, University of Ljubljana, 30 patients with a Class I molar relationship, 27 with a Class II molar relationship (division 1 only), and 26 with a Class III molar relationship were selected. They had to fulfil the following inclusion criteria: permanent dentition, no absent or supernumerary teeth, no previous extraction of any tooth, or previous orthodontic treatment.

The study included 83 subjects [40 males and 43 females, mean age 16.3 years, standard deviation (SD) = 4.3 years] that fulfilled the inclusion criteria. Ethical approval was obtained from the Medical Ethics Committee of the Ministry of Health of Slovenia (reference 140/12/03).

Methods

Case histories were recorded and clinical examinations carried out to ensure that the subjects fulfilled the criteria.

The molar relationship was assessed according to the mesiobuccal cusp of the upper first permanent molar: Class I when the mesiobuccal cusp occluded in the buccal groove of the lower molar, Class II when the lower molars were positioned distally relative to the upper molars, and Class III when the lower molars were positioned mesially relative to the upper molars.

Overjet, defined as the horizontal overlap of the most prominent incisor, was measured on the study casts. The same ruler (042-751-00 Dentaurum, Ispringen, Germany) was used on all study casts to measure the largest horizontal distance between the upper and lower incisor. Intraexaminer reliability (repeatability) was assessed using the intraclass correlation coefficient (ICC; Ovsenik *et al.*, 2007). As almost perfect intraexaminer reliability (ICC = 0.90) was determined for measuring overjet, and the measurements were not repeated.

The lateral cephalograms were taken under standard conditions. The film–focus distance from the median plane of the patient's head was 150 cm, and the median plane–film distance 10 cm. The cephalograms were taken with the subjects standing and the head positioned in the cephalostat and orientated to the Frankfort horizontal plane with the teeth in maximum intercuspation. All measurements were made by the same person (S2) to minimize error. In a previous study (Drevenšek *et al.*, 2006), good reliability for all the parameters was found.

Sagittal skeletal relationships were analysed on the lateral cephalograms. ANB angle, Wits appraisal, and convexity at point A were determined. The cephalometric landmarks (Miyashita, 1996) and planes (Jacobson, 2006) used are shown in Figure 1.

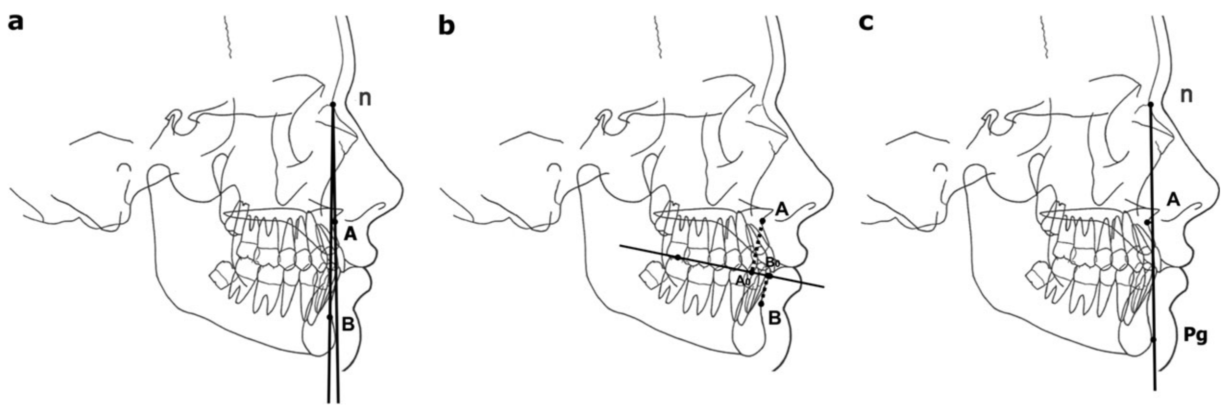

Figure 1 Point A (A)—the deepest point on the contour of the alveolar projection, between the spinal point and prosthion; nasion (N)—the point where the midsagittal plane intersects the most anterior point of the nasofrontal suture; point B (B)—the deepest midline point on the mandible between infradentale and pogonion; pogonion (pg)—the most anterior point on the symphisis of the mandible. ANB—angle formed by the intersection of lines from points A and B to point N (a). Wits appraisal—the distance between points AO and BO, which are the points of contact of a perpendicular line drawn from points A and B to the bisected occlusal plane (b). Bisected occlusal plane—a line joining the mesiobuccal cusp of the upper first molar at a point midway between the overlap of the upper and lower incisors (Jacobson, 1976; Thayer, 1990; Melsen and Baumrind, 1997). Convexity at point A—distance from point A perpendicular to the facial plane (n–Pg, c).

The data were statistically analysed. The mean values and SDs of study cast and lateral cephalometric parameters were calculated for Class I, Class II division 1, and Class III malocclusion subjects.

Correlation between overjet measured on the study casts and sagittal skeletal parameters measured on the lateral cephalogram was calculated. Linear regression analysis was used to assess overjet as a predictor of skeletal relationships. $P < 0.05$ was considered statistically significant.

All statistical analyses were performed using the Statistical Package for Social Sciences, Windows version 12 (SPSS Inc., Chicago, Illinois, USA).

Results

The mean values and SDs of overjet, ANB, Wits appraisal, and convexity at point A in the Class I, Class II, and Class III malocclusions are presented in Table 1.

A statistically significant positive correlation ($P < 0.01$) was found between overjet and ANB ($r = 0.690$), overjet and Wits appraisal ($r = 0.750$), and overjet and convexity at point A ($r = 0.608$) when assessing the whole sample.

Overjet was found to be a highly significant predictor of sagittal skeletal relationship ($P < 0.001$).

When linear regression between overjet value and cephalometric parameters was assessed separately in Class I, Class II division 1, and Class III malocclusion subjects, the percentage of variability was statistically significant in just four pairs (Table 2).

Discussion

Among the criteria required for diagnosis and treatment planning, the sagittal relationship between the maxilla and the mandible is critical (Tanaka *et al.*, 2006). Many parameters used to evaluate the intermaxillary relationship have been described (Jacobson, 1975, 1976; Rotberg *et al.*, 1980; Hussels and Nanda, 1984; Oktay, 1991).

The aim of this study was to determine whether any correlation exists between overjet value, as measured on study casts, and cephalometric parameters, which evaluate the craniofacial complex in the sagittal plane. Therefore, within individual classes of malocclusion according to Angle's classification, the average values of these parameters were calculated and their correlations tested. The extent to which overjet can predict skeletal relationships in the sagittal plane was assessed.

The subjects included in this study were referred for orthodontic consultation by their dentists. It proved to be very difficult to find orthodontic patients with Class III malocclusions, which would fulfil the selection criteria. Since treatment of Class III malocclusions has a high priority in Slovenia, this usually starts early in the period of the mixed or even in the primary dentition. Therefore, these patients rarely fulfil the criterion of no previous orthodontic therapy. Moreover, Class III is a relatively rare malocclusion: in 9-year-old children, being found in less than 1 per cent (Rejc-Novak, 1980). Some adult patients were excluded from the study due to prior extractions (although the teeth might have been extracted for periodontal, endodontic, or other reasons). Missing teeth can cause movement of the remaining adjacent and/or opposing teeth, which could have affected the measured dental parameters.

In spite of its shortcomings, Angle's method still remains the most popular tool for classification of malocclusion. Low level reliability for both inter- and intraexaminer Angle classification has been shown (Brin *et al.*, 1999). Extremely distal or mesial occlusions usually do not present a problem. However on the other hand, it is evident in Class I malocclusions (Katz, 1992a,b).

Factors that influence measurement of ANB include a number of sagittal and vertical parameters: facial prognathism, age, and the growth rotation of the jaws in relation to the cranial reference planes. The amount of rotation is greatly related to the facial pattern of the individual. The mean values are higher for dolichofacial in comparison with mesiofacial and brachyfacial facial types, but facial type does not have an influence on the correlation between parameters (Tanaka *et al.*, 2006).

For overjet and ANB, a positive correlation was expected, because they both directly or indirectly reflect the jaw relationships in the sagittal plane. Nevertheless, the ICC was relatively low ($r = 0.691$). This is probably due to the fact that overjet is influenced by inclinations of the upper and the lower incisors and ANB depends also on the anteroposterior position of nasion (Ferrazzini, 1976), on inclination of the SN line, on maxillary inclination, and on the vertical position of nasion (Jacobson, 1975; Bishara *et al.*, 1983). These are normal variations and should be considered when ANB is

Table 1 Mean values ± standard deviation for overjet, ANB angle, Wits appraisal, and convexity at point A in Class I, Class II, and Class III malocclusion subjects measured on lateral cephalograms.

	Overjet (mm)	ANB (°)	Wits (mm)	Convexity (mm)
Class I	3.8 ± 2.0	2.6 ± 2.7	−2.8 ± 3.3	1.4 ± 3.3
Class II division 1	6.0 ± 2.8	4.8 ± 1.8	1.2 ± 3.3	3.9 ± 2.4
Class III	0.0 ± 2.9	−1.4 ± 2.5	−10.3 ± 3.1	−2.5 ± 3.0

Table 2 Percentage of explained variability for ANB angle, Wits appraisal, and convexity at point A when predicted using overjet.

	ANB (%)	Wits (%)	Convexity (%)
Class I	20.3*	12.2	13.2*
Class II division 1	28.8**	43.1***	7.9
Class III	5.1	9.8	4.7

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

interpreted. In fact, any different horizontal or vertical position of point N and the location of points A and B in the vertical plane will influence the size of ANB and not the actual sagittal relationships of the jaws. The inclination of the occlusal plane also affects ANB, although the sagittal relationship remains constant (Hussels and Nanda, 1984).

Likewise, for overjet and Wits appraisal, both parameters also evaluate jaw relationships in the sagittal plane. In contrast to ANB, the line of reference for Wits appraisal is the occlusal plane, which is a dental parameter. Therefore, it is not surprising that the correlation coefficient value (r = 0.749) was higher when compared with the value for overjet and ANB (r = 0.691).

Thayer (1990) found a lower correlation between overjet and Wits appraisal (r = 0.574 using a the functional occlusal plane and r = 0.647 when using a bisected occlusal plane). Either occlusal plane can be used in the calculation of Wits appraisal. A bisected occlusal plane has higher reproducibility than the functional occlusal plane, but an error of 5 degrees may change the Wits appraisal by 3–6 mm, depending on the vertical dimensions of the face (Thayer, 1990). This might be the reason for the difference between correlation factors.

Convexity at point A is another parameter which evaluates jaw relationships in the sagittal plane. It is influenced by the position of the maxilla relative to the facial plane (n–Pg). Therefore, even Class I malocclusion subjects with a prominent chin can show a skeletal Class III relationship. However, those with a less prominent chin can demonstrate a skeletal Class II. This is probably why the ICC for overjet and convexity at point A was relatively low (r = 0.610).

With linear regression, with knowledge of one variable, a part of the natural variability of the other can be explained. In this case, knowing the overjet value, prediction of the values of ANB, Wits appraisal, and convexity at point A within a certain range can be made. However, overjet may only account for part of the variability of these parameters. Overjet is certainly not the only factor which should be taken into account when evaluating skeletal relationships in the sagittal plane. Since the lowest value (R^2 = 0.372) was for overjet and convexity at point A in this study, overjet was not a good predictor for convexity at point A.

Assessing the prediction ability of overjet within individual Classes of malocclusion, this finding demonstrates that in Class III subjects, knowing the overjet value, the values of ANB, Wits appraisal, and convexity at point A cannot be precisely predicted. Skeletal malocclusions can be hidden due to dental compensation and in such cases overjet measurement is not very informative. Furthermore, ANB and Wits appraisal values are influenced by rotations of the jaws and growth i.e. vertical or horizontal (Iwasaki *et al.*, 2002).

Cephalometric analyses have shown that even in subjects with a Class I molar relationship, Wits appraisal can be either positive or negative (Rotberg *et al.*, 1980). The present findings also show that overjet in Class I malocclusions cannot predict Wits value. In contrast in Class II malocclusions, overjet was a statistically significant predictor of skeletal relationships in the sagittal plane.

Conclusion

This study findings demonstrate that for Class I and Class III malocclusions overjet is not a good predictor of skeletal relationships in the sagittal plane. In Class II division1 malocclusion subjects, however, overjet is a statistically significant predictor. Knowledge of the overjet value permits a significant part of the variability of ANB angle, Wits appraisal, and convexity at point A to be explained. Still, there is a relatively wide interval variability, which cannot be explained by overjet alone. Probably, there are other important factors which were not included in this study and further research should be performed.

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Funding

University of Liubliana, Medical Faculty.

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