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Orientation of the occlusal plane in a Class I adult population

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Objective. To primarily evaluate whether Delaire's ideal occlusal plane is present in Class I occlusal relationship adults.

Study Design. Pretreatment lateral cephalometric radiographs from 30 orthodontically untreated Caucasian Class I malocclusion adults were obtained. The occlusal, mandibular, and maxillary planes were traced and compared with the ideal occlusal, mandibular, and maxillary planes according to Delaire.

Results. The average occlusal plane was 3.5° below the ideal plane. This divergence was more pronounced in males, and in patients presenting with a hypodivergent skeletal pattern. The maxillary plane displayed on average less than 0.5° of divergence to the ideal. The average mandibular plane showed a divergence of 3.3° below the ideal.

Conclusions. When aiming to obtain an ideal orientation of the occlusal plane postoperatively, one must keep in mind that in Class I occlusal relationship adults without any dentofacial disharmony, the occlusal plane is rarely coincident with the ideal plane. (Oral Surg Oral Med Oral Pathol Oral Radiol 2013;116:35-40)

The orientation of the occlusal plane is often a factor used by maxillofacial surgeons both in predicting optimal functional and esthetic results, and in predicting the stability of a certain operative procedure.¹⁻³ It is thought to be true that if the postoperative occlusal plane is not coincident with the 'ideal' occlusal plane, then the risk for postoperative surgical relapse is increased. For this reason, when performing preoperative surgical planning and perioperative surgical positioning of the jaws, one of the objectives may be to establish the position of the occlusal plane and the jaws in accordance with cephalometric treatment planning.^{4,5} This may involve the surgeon performing a rotation of the maxillomandibular complex⁶ in order to improve both facial balance and the occlusal plane angle which ultimately is thought to favor occlusal stability.

Delaire^{7,8} developed a cephalometric analysis, referred to as the architectural and structural craniofacial cephalometric analysis, and discussed its application in the treatment of cranio-maxillo-facial anomalies. This method is often used for orthognathic treatment planning.⁹⁻¹² Delaire proposed that the occlusal plane, stated to pass through the occlusal surfaces of the premolars, in an ideal situation was meant to pass through the inferior part of the skull (a point referred to as the mandibular-occipital point, Om, in the original analysis). Moreover, the occlusal plane, again in an ideal situation, was meant to meet with the maxillary and mandibular planes at this same point (Figure 1). This implies a balance between the

maxillary, mandibular, and occlusal planes in relation to the craniospinal articulation and the postero-inferior part of the skull.⁸

This proposition by Delaire is, to the best of our knowledge, based on his clinical experience and thus on empirical evidence. There is no clear or available scientific evidence, unless based on unpublished data, which substantiates his propositions.

If the notions of occlusal balance and facial harmony are put into practice and an ideal occlusal plane desired following orthognathic surgery, then one would expect that individuals with a Class I molar relationship and good occlusal interdigitation would present with an ideal occlusal plane. The primary objective of the present study was thus to evaluate whether the ideal occlusal plane, as proposed by Delaire, was present in a Class I occlusal relationship adult population. The secondary objective was to evaluate whether the ideal maxillary and mandibular planes, as proposed by Delaire, were present in a Class I occlusal relationship adult population.

MATERIALS AND METHODS

The design of the current study was in the form of a cross-sectional retrospective study. It was granted exemption by the author's institutional review board. Guidelines put forward by the Helsinki Declaration,

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Statement of Clinical Relevance

When aiming to obtain ideal occlusal plane orientation postoperatively, one must keep in mind that this is rarely coincident with Delaire's ideal occlusal plane, which should only be used as a guide in surgical planning, considering the large interindividual variation.

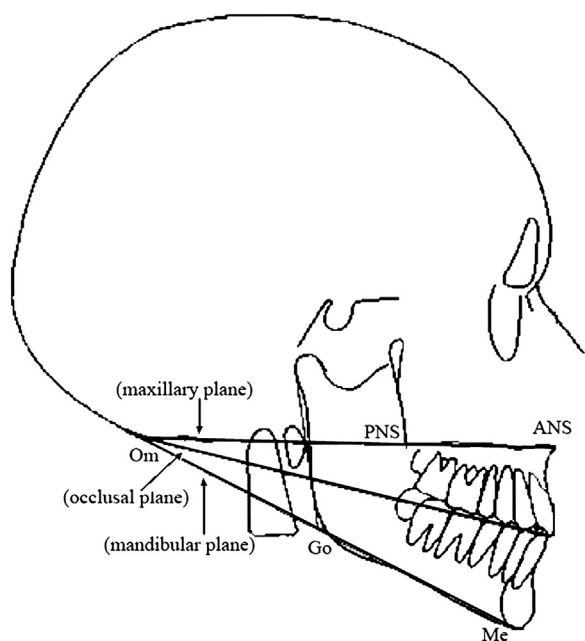


Fig. 1. Lateral cephalometric tracing, modified from Delaire (1978) showing the 3 planes traced. The maxillary plane is defined as a plane through the anterior nasal spine (ANS) and the posterior nasal spine (PNS). The occlusal plane is defined as a plane through the occlusal surfaces of the premolar teeth. The mandibular plane is defined as a plane through Menton (Me) and Gonion (Go). Also shown is the mandibular-occipital point (Om), through which all 3 aforementioned planes should pass according to Delaire.

wherever relevant, were adhered to. The sample of the current study was collected from the patient archives of our University clinic. The sample size was calculated based on an α -significance level of 0.05 and an 85% power to detect a difference from the constant (the ideal occlusal plane) of 2° , with a standard deviation of 3.5° (based on a previous pilot study). The power analysis showed that 30 patients were needed. The present sample therefore consisted of 30 Caucasian Class I occlusal relationship adult individuals, whose presenting complaint was anterior crowding, and who had a lateral cephalometric radiograph taken as part of the standard diagnostic records prior to orthodontic treatment. Fifteen male and 15 female subjects were chosen.

The inclusion and exclusion criteria were the following. Inclusion criteria: 18 years or older; bilateral Angle Class I molar relationships; complete dentition from first molar to first molar on both maxillary and mandibular arches; mild to moderate crowding without the need for extractions; overjet between 1 mm and 4 mm; over bite between 1 mm and 4 mm; no transverse discrepancies. Exclusion criteria: cleft lip and cleft palate patients; syndromic patients; patients with obvious facial asymmetry; patients with parafunctional habits; patients who had already undergone orthodontic

treatment; patients who had already undergone maxillofacial surgery; missing teeth (excluding third molars); posterior or anterior cross bite; open bite; exaggerated curve of Spee.

The mean age of the total patient sample was 30.0 years (standard deviation (SD) 11.1; range 18-61). Fifteen male patients had a mean age of 31.9 years (SD 12.6; range 18-61). Fifteen female patients had a mean age of 28.1 years (SD 9.5, range 18-49). There was no statistically significant difference between ages of males and females.

All cephalometric tracings were carried out by hand, by one of the investigators. On each of the pre-treatment lateral cephalometric radiographs, 3 planes were traced, namely the maxillary, mandibular, and occlusal planes (Figure 1). These were then compared with the ideal maxillary, mandibular, and occlusal planes respectively, as defined by Delaire.^{7,8} For each plane, the discrepancy between the actual plane and the ideal plane was measured, to the nearest 0.5° , a positive value indicating that the actual plane was above and a negative value below the ideal plane. The angle of the mandibular plane to the cranial base (Sella-Nasion plane to mandibular plane) and the intermaxillary angle (angle between the maxillary and mandibular planes) were also measured on each lateral cephalometric radiograph in order to establish correlations between these values and the divergence of the abovementioned planes to the ideal planes.

Statistical analyses were performed using the Statistical Package for Social Sciences version 17.0 for Windows (SPSS Inc., Chicago, IL, USA). Descriptive statistics were calculated for each plane (the discrepancy between the actual and ideal plane), namely means and SDs, and this was done for the whole patient sample, as well as for male and female patients separately. Divergence of the planes was compared between the male and female subjects using independent sample *t*-tests. Correlations were carried out using linear regression analysis. First, correlations between age and divergence of the planes were examined. Second, correlations between the Sella-Nasion (SN)-mandibular plane angle or the intermaxillary angle and occlusal plane divergence were examined. Multiple regression analyses were similarly carried out adding gender into the analysis.

An error of the method analysis was carried out in order to calculate the random error (RE) of the method, as described by Houston,¹³ by repeating the cephalometric tracings on 15 randomly selected lateral cephalometric radiographs from the patient sample, within a 3 week interval. Dahlberg's formula¹⁴ was used in order to calculate the error. In using Dahlberg's formula ($\sqrt{\Sigma d^2/2n}$), Σd^2 denotes the sum of the squared differences between pairs of recordings, while *n* denotes the

Table I. Divergence of the actual maxillary, occlusal, and mandibular planes to the ideal maxillary, occlusal, and mandibular planes respectively

Gender	Maxillary plane	Occlusal plane	Mandibular plane
Females			
Mean	−0.3	−2.1	−1.4
SD	2.7	2.4	3.4
Maximum	6	1	2.5
Minimum	−4	−6.5	−6.5
Males			
Mean	0.5	−4.9	−5.2
SD	2.4	3	3
Maximum	4	2.5	0
Minimum	−4.5	−9	−9
Total			
Mean	0.1	−3.5	−3.3
SD	2.6	3	3.7
Maximum	6	2.5	2.5
Minimum	−4.5	−9	−9

Means and distributions (SD, minimum and maximum values) of the results are represented. Values shown are in degrees.

number of duplicate measurements. The RE of the method was of 1.9° for the occlusal plane, 0.9° for the maxillary plane and 0.7° for the mandibular plane. Due to the RE of the method findings, a 2° tolerance value (as a cutoff range) was used in order to estimate the percentage of patients presenting with an actual occlusal plane with more than 2° divergence from the ideal. A similar analysis was carried out as regards the mandibular and maxillary planes, using a 1° tolerance value.

RESULTS

In the Class I subjects, the actual occlusal plane was coincident with the ideal occlusal plane in only 2 of the subjects (approximately 7%). However, 18 of 30 patients (60%) presented with a divergence of the actual occlusal plane above the tolerance value (ideal occlusal plane $\pm 2^\circ$). On average, the occlusal plane of the sample showed a divergence of 2.1° below the ideal occlusal plane. When looking at male and female individuals separately, more males than females presented with a divergence of the actual occlusal plane above the cutoff range (87% versus 33%). On average, the occlusal plane of the female subjects showed a smaller divergence of 2.1° below the ideal occlusal plane, compared with a divergence of 4.9° in male subjects ($P = .008$), (Table I and Figure 2).

The actual maxillary plane was on average closer to the ideal (0.1° above the ideal maxillary plane), with 18 of 30 patients (60%) presenting with a divergence of the actual maxillary plane above the tolerance value (ideal maxillary plane $\pm 1^\circ$). There were not any significant differences between the male and female individuals, with the average maxillary plane diverging 0.3° below

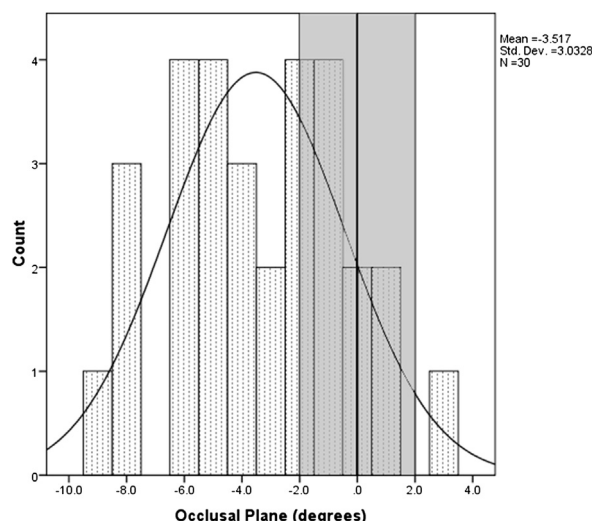


Fig. 2. Histogram showing the divergence of the actual occlusal plane to the ideal occlusal plane and the distribution of this divergence. The zero line represents the ideal occlusal plane. A normal distribution line is also drawn through the histogram representing the mean and standard deviations. The tolerance range (ideal plane $\pm 2^\circ$) is also represented by gray shading.

the ideal plane for females and 0.5° above the ideal plane for males. Likewise similar results were seen for males and females in the number of patients with a divergence of the actual to the ideal maxillary plane above the threshold, (Table I and Figure 3).

The actual mandibular plane showed a divergence of 3.3° below the ideal mandibular plane. Most patients ($25/30 = 83\%$) presented with a divergence of the actual mandibular plane above the tolerance value (ideal mandibular plane $\pm 1^\circ$). This was similar in the male ($13/15 = 87\%$) and female subjects ($12/15 = 80\%$). However, on average, the mandibular plane of the female subjects showed a smaller divergence (1.4°) below the ideal mandibular plane, as compared with the male subjects (5.2°) ($P = .003$), (Table I and Figure 4).

As regards correlations, age was not correlated with divergence of any of the measured planes to their ideal planes. The divergence of the occlusal plane was significantly correlated to the SN-mandibular plane angle when looking at the whole sample, in that patients with a more obtuse SN-mandibular plane angle present with an occlusal plane closer to the ideal plane (Figure 5). This association, however, may be linked to gender in that when performing a multiple regression analysis adding gender as a confounder, the significance of the correlation was more attributable to gender than the SN-mandibular plane angle. Moreover, when looking at males and females separately, significant correlations were not found. The intermaxillary angle showed no significant correlation with the divergence of the occlusal

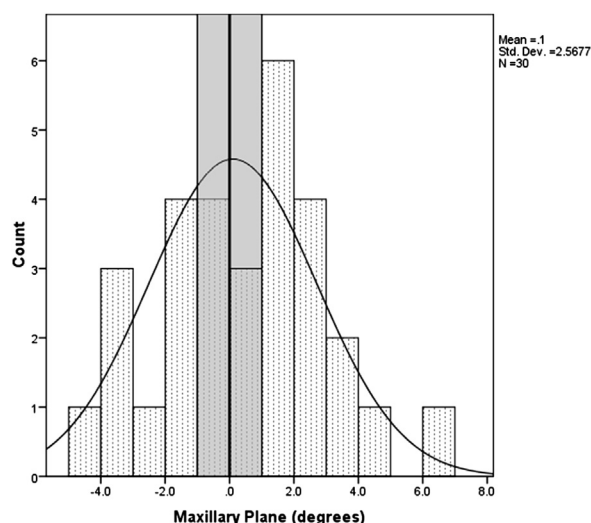


Fig. 3. Histogram showing the divergence of the actual maxillary plane to the ideal maxillary plane and the distribution of this divergence. The zero line represents the ideal maxillary plane. A normal distribution line is also drawn through the histogram representing the mean and standard deviations. The tolerance range (ideal plane $\pm 1^\circ$) is also represented by gray shading.

plane neither in the whole patient sample, nor when looking at males and females independently.

DISCUSSION

The ideal occlusal plane, as proposed by Delaire,^{7,8} was rarely coincident with the actual occlusal plane in the Class I malocclusion subjects examined in the present study. In fact, for the vast majority of subjects, the actual occlusal plane was below the ideal occlusal plane, this being more pronounced for males than for females. The orientation of the actual mandibular plane in relation to the ideal mandibular plane showed similar results, whereby in the vast majority of cases the actual plane was below the ideal plane. For the maxillary plane however, results show that the actual maxillary plane coincides with the ideal maxillary plane.

The divergence of the occlusal plane to the ideal plane, does not seem to be correlated to the age of the patient in our sample, despite the fact that secondary growth changes continue throughout adulthood, and postadolescent skeletal changes have been shown to occur, more so in the vertical dimension.¹⁵ Occlusal plane divergence, in our sample, was however correlated to the SN-mandibular plane angle, indicating that patients with a more hyperdivergent skeletal pattern display an occlusal plane which is closer to the ideal plane as proposed by Delaire. This may, however be related more to gender differences in that females have a more hyperdivergent skeletal jaw relationship than males.¹⁶

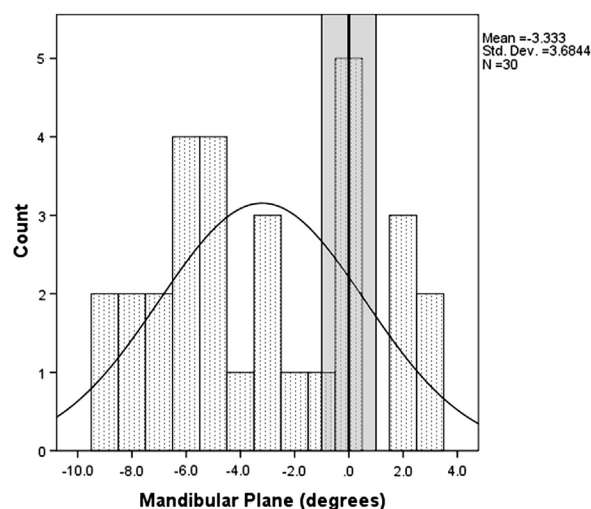


Fig. 4. Histogram showing the divergence of the actual mandibular plane to the ideal mandibular plane and the distribution of this divergence. The zero line represents the ideal mandibular plane. A normal distribution line is also drawn through the histogram representing the mean and standard deviations. The tolerance range (ideal plane $\pm 1^\circ$) is also represented by gray shading.

Surgical occlusal plane alteration was first reported by McCollum et al.¹⁷ with the goal of improving functional and esthetic results. This was further used by other authors such as Reyneke and Evans.¹⁸ A recent study shows that patients treated with occlusal plane manipulation (either a clockwise or counterclockwise rotation of the maxillomandibular complex) showed a comparable stability to those treated with conventional treatment planning, but not better stability.¹⁹ Chemello et al.³ and Rosen²⁰ also found stable results following rotation of the maxillomandibular complex. Studies looking into occlusal plane alteration mostly measure the occlusal plane in relation to the Frankfort horizontal or the constructed true horizontal plane, and not to the ideal occlusal plane of Delaire, which the current study was concerned with.

Limitations to the present sample may exist. First, all individuals were Caucasians, and hence results cannot be extrapolated to other populations, since non Caucasian populations have different cephalometric norms. Second, the present patient sample, even though individuals in a Class I occlusal relationship, does not represent individuals with an 'ideal' occlusion, since this was an orthodontic sample with crowding as the presenting complaint. Crowding, however, is not a static occlusal characteristic that defines a certain type of malocclusion, but rather a dynamic occlusal characteristic. Orthodontically untreated individuals show an increase in crowding with age.²¹ In addition, crowding may not be related to divergence of the occlusal plane since the occlusal

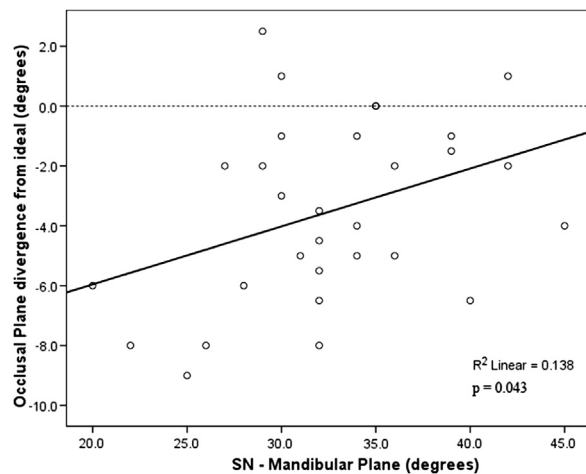


Fig. 5. Scatter plot showing the association between the SN-mandibular plane angle and the divergence of the occlusal plane to the ideal. The best fit line represents the correlation, and the zero line represents the ideal occlusal plane.

plane defined by Delaire^{7,8} passes through the occlusal surfaces of the premolars and is independent of the position of the incisors and canines. For these reasons, and due to the ethical restrictions in obtaining lateral cephalometric radiographs of orthodontically untreated individuals with an ideal occlusion, the present sample can be considered as suitable for the question under investigation.

The desire to obtain an orientation of the occlusal plane which is ideal, according to Delaire,^{7,8} needs perhaps to be re-examined. This theory should not be followed blindly but may be able to be used as a guide in surgical planning, considering the large error of the method as well as the interindividual variation. A tolerance of give or take 2° may be desired. The concept of the ideal occlusal plane should perhaps be applied more so to females and subjects with a hyperdivergent skeletal pattern, since in the present sample, Delaire's proposition seemed to hold true mostly for those subgroups. One must keep in mind however that perhaps gender differences in vertical skeletal morphology are responsible for these differences.

Further studies need to be carried out in order to determine norms for different populations. Likewise, studies are desired which examine the long-term stability of patients treated with orthodontic treatment and maxillofacial surgery, relating stability to the orientation of the occlusal plane defined by Delaire. One such study was found in the literature, that of Olivi et al.²² looking into the relapse of anterior open bite in a sample of 50 patients, which concludes that postoperative relapse was 7 times more frequent when the postoperative occlusal plane was tilted either posteriorly or anteriorly more than 3.75° in reference to the ideal occlusal plane. Immediate

postoperative lateral cephalometric radiographs were used, which may lead to results which are not very reliable however, as postoperative orthodontic treatment may also influence the orientation of the occlusal plane. In fact, many studies looking into surgical stability use immediate postoperative lateral cephalometric radiographs as the baseline in order to judge stability, but the occlusal plane is defined by dental landmarks and so can easily be influenced by postoperative orthodontic treatment.

The error of the method when locating the occlusal plane can be rather high. There is always an associated RE of the method when locating cephalometric points. The location of a plane, defined in a two-dimensional cephalometric situation as the junction between 2 points, adds to the overall error as 2 points need to be identified, each with its inherent error.²³ If the points which make up the plane are close together, the plane is more difficult to locate accurately, such as in the case of the occlusal plane.^{24,25} When identifying the occlusal plane, one must also overcome the obstacle of bilateral images which can lead to problems with the reproducibility of the occlusal plane.²⁶ Plane identification is difficult even under ideal conditions, which in the case of the occlusal plane can lead to variation in interpretation of the cant between different tracings of the same film as much as 3°. ²⁷ In the present study the error of the method for the occlusal plane was almost 2°. These were however patients with a Class I malocclusion and without any skeletal disharmony, asymmetry, or a deep curve of Spee. In patients with tooth overlap, dental restorations, missing teeth, malpositioned teeth, or a pronounced curve of Spee, further difficulties may be introduced in defining the occlusal plane.^{24,28,29} The correct location or representation of the occlusal plane can be problematic³⁰ and this must thus be taken into account when using the occlusal plane for surgical planning.

In conclusion, when aiming to obtain an ideal orientation of the occlusal plane postoperatively, one must keep in mind that in Class I occlusal relationship subjects without any dentofacial disharmony, the occlusal plane is rarely coincident with the ideal occlusal plane. On average, the actual occlusal plane is 3.5° below the ideal occlusal plane, as defined by Delaire, and this is more pronounced in males and in those with a hypodivergent skeletal pattern. Delaire's proposition seems to hold true mostly for females and subjects with a hyperdivergent skeletal pattern.

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