Relations of Reference Planes for Orientation of the Prosthetic Plane

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Summary

During construction of dentures there is frequently a need for one or more reference planes. Various opinions have been expressed in literature on the mutual relations of reference planes used in prosthetic care of patients. On a sample of 60 cephalograms of patients with almost normal occlusion, seven variables were analysed. by roentgencephalometric method. The results of this study revealed the mean values of angles measured and their variability as well as their mutual correlation. Basic statistical parameters revealed significant variability of the occlusal plane inclination in the group of examinees with almost normal occlusion. The highest level of variability was found for the Camper's line - Occlusal line angle which indicates that the use of Camper's line to determine the occlusal plane is unreliable.

Key words: *referent planes, roentgencephalometry.*

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Introduction

The masticatory system is a functional unit composed of the teeth and their supporting structures, the jaws, the temporomandibular joints, the muscles involved directly or indirectly in mastication (including the muscles of the lips and tongue), and the vascular and nervous system supplying these tissues (1). The masticatory muscles are activated by both central and peripheral nervous system inputs and represent the active part of the system. The teeth and their supporting structures are the passive part. Functional and structural disturbances in any one of the components of the masticatory system may be reflected by functional or structural disorders in one or more of its components (2).

The basic motor functions of the stomatognathic system and its initial form, size and position are determined by genetic factors. Individual characteristics (intermaxillary relations, position of the teeth and appearance of the occlusal plane) are formed during growth and development, due to the functional stimulation of surrounding tissues and the influence of external factors. Thus, the individual form of occlusion is formed, which is characteristic for each individual (3,4).

Occlusion, ranging from occlusion with most serious anomalies to optimal occlusion, with constant variations between these two extremes, is the result of skeletal growth, dental development and neuromuscular activity (5).

The specifically formed occlusal complex becomes the foundation for normal basic functioning of the stomatognathic system, particularly the functions of mastication and articulation. During growth and development these functions adapt to the individual morphological type of occlusion (6). The basic course and direction of neuromuscular activity in the stomatognathic system, conditioned by inheritance and determined during life, are preserved even after loss of teeth, and can be restored by constructing dentures which faithfully reconstruct the original form of occlusion (7,8).

The articulator, a mechanical device which simulates movement of the jaw and mutual relations of the teeth during functioning, is essential for diagnostic and therapeutic procedures (9). Transfer of a plaster cast of the jaws into the articulator space, in the correct spatial relationships to the base of the skull, i.e. temporomandibular joints, is only possible by means of a Face-bow (10-23).

The basic transfer with the Face-bow is the transfer of reference planes of the head into the articulator system. The use of different reference planes does not change the centric relation of the plaster cast. However, non-centric relations change, which has an effect on the height and inclination of the cusps.

There is controversy in the literature about relations between referent lines (24-43).

The object of the investigation was to analyse the relations between the selected roentgencephalometric parameters, in order to identify those in which inclination of the occlusal plane can be evaluated more reliably during the reconstruction of its position in edentulous patients.

Material and methods

A sample of 60 latero-lateral cephalograms was selected from a collection of radiographs of examinees with almost normal occlusion. Selected radiographs were obtained of students from Zagreb and surrounding regions, according to the following criteria: 28 to 32 teeth in an acceptable arch form; Angle's Class I jaw relationship; no history of orthodontic treatment or trauma (Table 1).

Conventional roentgencephalometric tehnique was used to obtain radiographs for all examinees, and all radiographs were made in maximal intercuspation.

Definitions of roentgencephalometric points were designated as follows:

- Or - Orbitale - the lowest point of the left infraorbital margin;
- P - Porion - the midpoint on the upper edge of the external auditory meatus coincides with the superior border of the cephalometer's metal rod;
- ANS - Anterior nasal spine - the point on the lower contour of the anterior nasal spine where the vertical thickness is 3mm;
- PNS - Posterior nasal spine - the tip of the posterior nasal spine of the palatine bone;
- IS - Incision superius - the most forward incisal point of the most prominent maxillary central incisor;
- M - Molare - the tip of the distobucal cusp of the first upper molar;
- T1 - Anterior tangent point - the anterior tangent point of the lower border of the mandible; and
- T2 - Posterior tangent point - the posterior tangent point of the lower border of the mandible. (Figure 1)

Definition of the lines used in this investigation were as follows:

- FH - Frankfurt horizontal - the line traced from O to P;
- CL - Camper's line - the line connecting ANS and P;
- PL - Palatal line - the line connecting ANS and PNS;
- OL - Occlusal line - line traced between points IS and M; and
- ML- Mandibular line - the tangent line of the lower border of the mandible connecting points T1 and T2.

Variables (angles) defined with points and lines are:

OL-ML; CL-PL; FH-CL; FH-PL; PL-OL; FH-OL; and CL-OL (Figure 2).

All radiographs were cephalometrically traced. Points, lines and angles were traced on transparent foil and angles were measured. All measurements were performed by two examiners with a double-check method. There were no significant differences between the measurements of the two examiners on any variable. All angle measurements were recorded to an accuracy of 0.5 degrees. Results were statistically evaluated.

Results and discussion

Mean values of the investigated variables are shown in Table 2 with basic measures of variability (Table 2).

The occlusal line revealed its largest inclination towards the basal part of the mandible where the arithmetic mean value was 13.32 degrees. This angle value differs minimally compared to the findings of other studies (46, 47). The smallest inclination of the occlusal line was found in relation to Camper's line with a mean value of 5.37 degrees. Of all the investigated variables, the largest variability was found for the angle between Camper's and occlusal lanes with a standard deviation of 3.45 and coefficient of variability of 64.34%, while the smallest variability was found for the FH - CL variable (T = 1.99, cv = 11.95).

Statistical analysis indicated correlation levels, estimated indirectly the reliability of referent lines, and indicated the highest correlation between FH - CL and OL - ML variables (Table 3).

The measured value revealed divergence between Camper's line and the upper jaw base of 12.4 degrees with standard deviation of 2.4.

Mean value of the FH - CL angle in our approach amounted to 16.7 degrees with minimal variability, indicating the relative stability of their relations. Olsson and Posselt reported 17.1 degrees with a standard deviation of 2.8 degrees for the value of this angle in a Swedish population (37). For a Chinese population, Ow et al. reported a value of 19.2 degrees with standard deviation of 2.0 degrees (36). Hortono showed variations of this angle with values in various types of faces, ranging from 13 to 15.9 degrees (24). In the operating instruction manual for the Artex articulator system, Girbach Dental indicates a value of 10 - 15 degrees for the angle between the Frankfurt and Camper lines (48). The angle value obtained in this investigation differs considerably from the value indicated by Suvin (47). Although Suvin does not state by which method he obtained the result of 9.3 degrees, it is identical to the value of the angle between the Frankfurt and Occlusal lines in Augsburgers investigation of bimaxillary protraction (21). The value reported by Olsson and Posselt is almost identical to our finding and differs minimally from Hortono's finding (37,24).

The FH - PL angle demonstrated minimal values in this investigation, which indicates relative parallelism of the maxillary jaw base and the Frankfurt plane. Gonzales and Kingery found that the angle between the Frankfurt plane and that of maxillary ridges is 4.00 degrees (35).

In our investigation the PL - OL angle mean value was 7.58 degrees. Sinobod reported a value of 9.68 for the same angle, which differs slightly from our result (46). L'Estrange and Vig reported a value of 7.5 degrees for examinees with natural teeth, which is almost identical to the value in this investigation (40). Suvin reported a value of 15 degrees for this angle, without stating the method used (47).

The relation between the Frankfurt horizontal and occlusal line (FH - OL) in our study was estimated to be 11.42 degrees. Hortono and Augsburger reported statistically significant differences for the value of this angle in different face types (24,21). For the same angle, Dows reported an average value of 9.5 degrees, Mayne 7.4 degrees and Bushra 8.2 degrees, and Hughes (49) a value of 9.0 degrees, which is identical to the findings of Gonzales and Kingery (35). Olsson and Posselt reported 10.7 degrees and standard deviation of 0.5 degrees for this angle in a Swedish population (37). Ow at al. reported a value of 11.2 degrees with standard deviation of 4.5 degrees for a Chinese population (36). Celebic et al established that the angle between the Frankfurt plane and the occlusal plane was 9.42 degrees for natural dentition, and 8.53 degrees for artificial teeth (50). The value obtained in this investigation differs only slightly (0.528 degrees) from those obtained in Augsburger's investigation. Deviation from other studies can be explained by different definition of the occlusal plane and different methodological approaches. The wide distribution of the measured angles

ranging from 5 to 25 degrees, emphasize individual morphological variations, that are also confirmed by the variation coefficient (cv = 40.52).

For the OL - CL angle Augsburger found the mean value to be 3.2 degrees for mandibular retraction, 4.5 degrees for maxillary protraction and mandibular retraction, in his study which were not statistically significant, and 7.3 degrees for bimaxillary protraction and 7.9 degrees for mandibular protraction (21). However last two results are statistically significant. Hortono reported that the mean values of this angle amounted to 2.3 degrees for bimaxillary protraction and 3.6 degrees for maxillary protraction, 1.5 degrees for maxillary protraction and mandibular retraction, 0.0 degrees for mandibular retraction, 2.5 degrees for bimaxillary retraction, and 5.6 degrees for mandibular protraction (24). Karkazis at al. investigated the relation between occlusal and Camper's lines and found that the angle between these two lines varies depending upon the posterior referent point (porion, center of the external ear meatus, bottom edge of the external ear meatus (33). Abrahams and Carey reported a value of 9.66 degrees for the same angle (26). Karkazis and Polyzois reported an angle of 2.88 degrees(45), while Olsson and Posselt reported an angle of 6.7 degrees (37), Van Niekerk et al. noted correlation of the artificial occlusal plane and Camper's plane (32), although parallelism with Camper's line was not used to determine the artificial occlusal plane. The angle between the investigated planes in their investigation amounted to 2.45 degrees. Ow et al. reported a value of 8.3 degrees for a Chinese population (36). Stanišić determined that the angle ranged from 0.4 to 2.5 degrees (44), and Seifert et al. (51) reported a value of 3.58 degrees for this angle, measured on a random sample.

The value obtained in this investigation amounted to 5.37 degrees and corroborates the results of Karkasis et al. (33), Augsburger for mandibular retraction (21), Stanišić (44), Seifert et al.(51), and Hortono (24). Deviations compared to other results originate mostly from differences in the definition of the referent points. All values prove that Camper's and occlusal lines are not parallel. Determining the position of the prosthetic plane parallel to Camper's plane posteriorly in the usual manner is not reliable in all cases. This conclusion is also made because of the high coefficient of variation: 64.34%, which indicates expressive variations of the occlusal plane inclination, also found in the examinees with approximately ideal occlusion.

The high level of correlation between the variables OL - ML and FH - OL (0.92) was probably due to the variations in the front third of faces. In longer faces, both angles are proportionally increased and vice versa.

High level of correlation was also found between the angles of FH - Ol and CL - Ol (0.82), as well as CP-PL and FH-PL (0.70). This confirms relatively stable relation of the basic referent parameters of the Frankfurt horizontal line and Camper's line, which was previously found by the low variability of the angle they mutually form (T = 1.99, C.V. = 11.95). The completely insignificant correlation between variables PL - OL and OL - OL (0.051 = indicates the expressive variations of the occlusal plane in relation to basal regions of both jaws.

Conclusion

Because of variability of the occlusal plane inclination in the group of examinees with normal occlusion, orientation of the occlusal plane in the articulator space by using examinee parameters is not reliable in all cases. Positioning the occlusal plane in the articulator space parallel to the superior and inferior branch of the articulator when they are parallel to the Frankfurt plane, is erroneous. The present investigation has demonstrated that the occlusal plane is not parallel to the Frankfurt plane. Such a position of the occlusal plane will decrease the anteroposterior inclination of the upper model and can effect the position of the maxillary anterior teeth. The occlusal plane will be lowered in the posterior portion, which may harm not only the esthetics of the denture but also the chewing effect. In cases where resorption of the alveolar bone runs uniformly and for a short period of time, relative parallelism of the FH - PL planes could be used in prosthetic dentistry. Due to the significant variability of all parameters in this investigation, no one parameter could be chosen for orienting inclination of the occlusal plane in edentulous patients. Significant morphologic skeletal aberrations, which inevitably follow dentoalveolar and occlusal compensatory adaptations, support individual correction of inclination of the occlusal plane, using esthetic and phonetic criteria.