Use of digital photography in the reconstruction of the occlusal plane orientation

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ABSTRACT

Aim This study evaluated whether the occlusal plane measurements on digital photographs were reliable for the reconstruction of occlusal plane.

Methods Forty-two subjects (25 female and 17 male subjects, aged 19 to 30 years) with all teeth and Angle Class I participated. Irreversible hydrocolloid impressions were made and the casts were poured in dental stone (ISO Type I) and finally mounted in the S.A.M. 2 “P”, articulator (S.A.M. Praezisiontechnik, GmbH, Munich, Germany) by a quick mount face-bow transfer. Lateral digital photographs were taken from a distance of 1.5 m in a natural head position with a subject in erect posture. A Fox plane was placed over the maxillary dental arch. A quick-mounting face-bow was positioned. The angles between the articulator horizontal plane and the occlusal plane (AHP-OP), as well as those between the face bow and the Fox plane (FB-FP) were measured, and the significance of the difference between the means was tested by the t-test (p<0.05).

Results The mean value of AHP-OP angle was 8.56 ± 3.1 degrees and the mean value of FB-FP angle was 8.80 ± 4.2 degrees. There was no significant difference between the male and the female subjects (p<0.05). There was no significant difference between AHP-OP and FB-FP angles (p<0.05).

Conclusion Measurements of occlusal plane inclination from digital photographs could be helpful in future prosthodontic reconstruction treatment.

Key words: occlusal plane, inclination, prosthodontic, digital photograph, Angle Class I
INTRODUCTION

Correct occlusal plane orientation in prosthodontic reconstructive treatments is one of the most important factors for the stability of the removable dentures and for the achievement of good esthetics, phonetic and masticatory function, as well as for the patient’s satisfaction (1-8).

A faulty orientation of occlusal plane will jeopardize the interaction between the tongue and the buccinator muscle. Where the occlusal plane is too high, the tongue cannot rest on the lingual cusps of the mandibular denture teeth and prevent its displacement. There is also a tendency for accumulation of the food in the buccal and lingual sulci (4). An occlusal plane that is too low could lead to the tongue and cheek biting (9). When the occlusal plane orientation is lost by complete or partial edentulism, it should be relocated correctly by means of a prosthodontic restoration. Over the last century, investigators have used various methods and advocated many anatomical landmarks to set a correct occlusal plane orientation and position to be able to set artificial denture teeth appropriately (1-5, 9-26).

A record of the occlusal plane orientation of an individual with natural teeth should be helpful in any reconstructive treatment. Therefore, the position of the occlusal plane in both, fixed and removable denture wearers could be as close as possible to the position which was previously occupied by the occlusal plane of the natural teeth. This also enables better denture stability and decreases patients’ adaptation to dentures (27-29).

Recent developments of digital photography and wide use of personal computers have made these techniques and equipment widely available. Photographic analysis of craniofacial characteristics has already been used in dentistry, mainly in orthodontics, and it is considered to be acceptably reproducible (30-35).

The aim of this study was to check the reliability of measurements on the digital photographs for possible reconstruction of occlusal plane in the future.

PATIENTS AND METHODS

Forty two subjects (25 female and 17 male subjects, aged between 19 and 30 years, average 24 years) were selected from dental students at the University of Zagreb, Croatia, according to the following eligibility criteria: complete natural dentition (except for occasionally missing third molars) and normal occlusion (bilateral Angle Class I molar and canine relation).

All subjects were well-informed and gave a written consent to participate in the study. The study was approved by the Institutional Ethics Committee.

Irreversible hydrocolloid impressions of the maxillary and mandibular jaw were made (Alginoplast fast set, Heraeus Kulzer, Hanau, Germany) and the casts were poured in dental stone (ISO Type I, Vel-Mix Stone, Kerr Italia S. p. A., Salerno, Italy). The casts were mounted in the S.A.M. 2 “P” articulator (S.A.M. Praezisiontechnik, GmbH, Munich, Germany) through a transfer with a quick-mounting face-bow.

Prior to measurement a transparent triangular plate was placed over the maxillary teeth, so that the contacts of cusps of the maxillary posterior teeth with a transparent triangular plate could be observed. Most often, the first posterior contact was between the triangular plate and the mesiopalatal cusp of the first molar. In 3 subjects the first posterior contact was between the triangular plate and the premolar palatal cusp.

The occlusal plane was defined on the cast of the maxillary jaw as the plane connecting the incisal edge of the maxillary central incisors and the mesiopalatal cusp of the left maxillary first molar (or the first cusp of the posterior teeth in contact with a transparent triangular plate placed over the maxillary teeth).

The following was measured: the vertical distance between the incisal edge of the maxillary central incisors and the mesiopalatal cusp of the left maxillary first molar (or the first cusp of the posterior teeth in contact with a transparent triangular plate placed over the maxillary teeth).

The following was measured: the vertical distance between the incisal edge of the maxillary central incisor and the articulator horizontal plane, the vertical distance between the mesiopalatal cusp of the first left maxillary molar (or the first cusp of the posterior teeth in contact
with a transparent triangular plate) and the articulator horizontal plane, as well as the horizontal distance between the incisal edge of the left maxillary central incisor and the mesiopalatal cusp of the first left molar (or the first cusp of the posterior teeth in contact with a transparent triangular plate).

Measurements were made with a calliper of 0.1 mm precision (MEBA, Zagreb, Croatia). Values obtained were transferred to a sheet of paper, calibrated in millimeters, and the lines were drawn. The occlusal plane was drawn and the angle (AHP-OP angle) between the horizontal line (representing articulator horizontal plane) (AHP) and the occlusal plane (OP) (representing the distance between the left maxillary central incisor and the first lateral cusp in contact with a transparent triangular plate, mostly mesiopalatal cusp of the first maxillary molar) was measured to the nearest 0.5 degree mark.

Lateral digital photographs of each subject were obtained in accordance with the following procedure: A quick-mounting face bow of the S.A.M. articulator was placed on the subject’s face; olives (plastic auriculare) were gently introduced into the meatus acousticus externus and the arch was fixed on the soft nasion. The Fox plane (Candulor AG, Wangen, Switzerland) was also placed in the mouth (Fig. 1). The subjects were standing barefoot on the ground in front of a mirror, with his/her feet slightly apart and divergent externally, and both arms hanging loosely. Following that, the subject was asked to look straight into the mirror (1.5 m x 0.5 m) at the reflection of his/her pupils and to assume a relaxed and normal erect posture of the head and shoulders. This is considered to be a natural head position (NHP) (22, 23). The mirror was positioned 1.5 m away, in front of the subject. All digital photographs were taken from a distance of 1.5 m with the subject standing, clenching the Fox plane and with the facial arch positioned.

Digital photographs were obtained by using a digital camera (Fuji Finepix A310, 3.1 Megapixel 3x Optical/2.9x Digital Zoom) on an adjustable tripod (Manfrotto Tripod Digi MN714-SHB) conveniently adjusted so that the camera was at the height of the subject’s ala-tragus line. The images were transferred by an USB cable to a personal computer in JPEG format.

The ISSA computer program was used for direct measurements on the screen (VAMS, Zagreb, Croatia): the grid-lines were drawn by superimposing the Fox plane (FP) and the face-bow plane (FB); and the angle between FP and FB planes was measured (FB-FP angle).

Statistical analysis included testing the normality of distribution by the one sample Kolmogorov-Smirnov test and descriptive statistics. The significance of the differences between males and females was assessed by the independent Student’s t test. The significance of the differences between the occlusal plane inclination measured in the articulator and on the digital photographs was tested by the Student’s t test for dependent samples. The significance was set at 95% probability level.

RESULTS

The data was distributed normally, as revealed by the one-way Kolmogorov-Smirnov test (p>0.05). Therefore, parametric tests were used for further statistic analysis. There was no significant difference between men and women (for AHP-OP angle: \( t = 0.81, \text{d.f.} = 40, p = 0.412 \); for FB-FP angle: \( t = 1.16, \text{d.f.} = 40, p = 0.23 \), as revealed by the independent Student’s t test.

Descriptive data (x ± SD) is shown in the Table 1.

There was no significant difference between the articulator AHP-OP angle (angle between the articulator horizontal plane and the maxillary

| Angle between the horizontal plane and the occlusal plane* |
|-----------------|-----------------|-----------------|
| Angle          | x               | SD              | No   |
| AHP-OP         | 8.56            | 3.1             | 42   |
| FB-FP          | 8.80            | 4.2             | 42   |

* AHP-OP, angle measured after mounting in the articulator; FB-FP, angle measured on digital photographs; x, mean; SD, standard deviation; No, number of measurements
DISCUSSION

One of the major problems in prosthodontics therapy is the lack of reproducible reference-structures for determining orientation and position of the occlusal plane. Not only did different authors use different landmarks and methods to establish the occlusal plane, but also the definition of the occlusal plane varied throughout the literature (1-5, 9-26). Although almost all textbooks on prosthodontics advocate the orientation of the occlusal plane parallel to the Camper’s line, many authors found significant differences between the orientation of the natural occlusal plane and the ala-tragus line (4,11,13,18,22,26,31). Another widely used landmark for the establishment of the artificial occlusal plane is the retromolar pad, although it was found out that orientation upon retromolar pad could place the occlusal plane a little too low posteriorly from the natural occlusal plane (3,20). Nissan (4) concluded that the cephalometric analysis alone cannot determine the location of the occlusal plane in edentulous patients and, consequently, he advocated that intraoral structures, which had been described by other authors should be considered (2,3,14). Bassi concluded that the cephalometric parameters do not correspond to the clinical positioning of the posterior teeth in a successful rehabilitation with complete denture (21).

Although many articles in the literature describe the establishment of the occlusal plane in completely or partially edentulous patients, none of the described methods seem to be completely satisfactory. Much of the controversy results from the small number of subjects examined, great variability of the location of anatomical structures and the lack of an agreement on the definition of the exact anatomical structures.

In order not to change proprioceptive regulatory mechanisms which ensure normal function of the cheek, tongue and other masticatory muscles, establishment of the occlusal plane should be reconstructed as close as possible to the position prior to the loss of teeth. Therefore, a record of the patient’s occlusal plane orientation would be helpful in a reconstructive therapy. Recent development of digital photography and wide use of personal computers and their low cost have made these techniques and equipment widely available.

Therefore, this study was made with the idea that general practitioners can easily obtain the profile digital photographs of their patients with a Fox plane in the mouth (representing the occlusal plane). Such photographs could be used for measurement of the occlusal plane inclination in a possible reconstructive treatment. Photographic evaluation of craniofacial characteristics has been already purposefully used in orthodontics and other fields of dentistry, and has showed to be acceptably reproducible in earlier studies (30-35).

The method of digital photography used in this study has already been standardized (8, 30-35) and has proved to be reproducible and reliable (26, 20-35), which is in agreement with the results of this study. We placed a Fox plane and a facial arch on the face of each subject in order to obtain objective data and information valuable for a clinical practice. Great advantage of digital photography in comparison with the cephalometric analysis is that it avoids exposition of subjects to potentially harmful radiation and it was therefore used in the present study.

The results of this study revealed no significant differences between genders (P>0.05) for the angle between the articulator horizontal plane and the occlusal plane (for both measurements), which is in agreement with other similar studies (3,13,17,19,30).

In order to test the accuracy of the inclina-
tion of the occlusal plane on digital photographs, the AHP-OP angle (between the articulator horizontal plane and occlusal plane) and FB-FP angle (face-bow-Fox plane on digital photographs) were measured, and the significance of the differences between them was tested by using the Student’s t test for dependent samples. The mean difference between the angles was only 0.242 degrees, which is of no clinical relevance. However, there was no significant difference between the angles measured on the articulator and on the digital photographs (Table 1 and Table 2). This study confirms the hypothesis that digital photographs are reliable for craniometric analysis. It also proves that digital photographs with a subject biting on the Fox plane could be helpful in any possible future reconstructive prosthodontics procedures where the occlusal plane must be re-established.

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Subject on the Figure 1 was well-informed and gave a written consent to publish photograph of his face in this journal.

Competing interests: none declared.

REFERENCES