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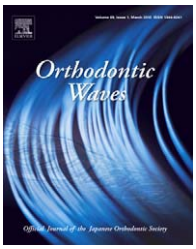

Research paper

Crown inclination measured by laser scanner

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ABSTRACT

We developed the computer measurement procedure to measure crown inclination of three-dimensional (3D) dental images scanned by laser scanner to reduce human error.

20 study models with normal occlusion were scanned by laser scanner. Crown inclinations of each tooth of scanned 3D dental images were measured according to Andrews' method. Results: The mean value measured by our method and that measured by manual procedure in the same sample did not detect significant differences. In the variances of the measurements, the results of measurement by our method were larger than that by manual procedure for almost all teeth.

Compared to other data, the results of our procedure tended to show large variances than that of other report with manual method. On the other hand, compared to non-manual procedure, the data and that of variances tended similar.

Our procedure could objectively measure inclinations with less prejudice and or human error of examiner. This procedure would be useful in research and in the clinic.

1. Introduction

Crown inclination (buccolingual inclination of the crown, crown torque) is one of Andrews' six keys to normal occlusion [1,2], and the critical factor for the prescription of pre-adjusted appliance. Several reports measured the inclination manually on study model [3–7]. Inclination is defined as the tangent angle on FA point. As manual procedure has difficulty to define tangent angle with the eye, it may lead to human error. With the recent advances in laser scanners and computers, it is now possible to scan the three-dimensional (3D) model shapes accurately [8,9]. Although several methods were described to reduce human error [10,11], little has been reported on measuring inclination with laser scanner and computer [12].

This study was conducted to develop the measurement procedure of inclination. The data that was measured by laser scanner, was compared with the data measured by manual procedure in the same sample, and also with the data with previous reports to evaluate the laser scanner system.

2. Materials

Orthodontic study models from approximately 1200 employees and students at Tokyo Dental College, which satisfied the following conditions were selected: (1) no history of orthodontic therapy; (2) no missing teeth, no tooth attrition and no restorations beyond inlays; (3) no temporomandibular disorder (TMD); (4) no abnormal mandibular morphology seen on cephalometric analysis; (5) no gingivitis or severe gingival recession; (6) favorable eruption; and (7) no abnormal tooth morphology. Furthermore, using Gottlieb's 10-item assessment method [13], 20 models [10 men and 10 women of an average age of 23.6 ± 1.99 years (mean ± S.D.)] with individual

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normal occlusion that satisfied at least eight items and did not require dental therapy were identified and used in this study.

3. Methods

3.1. *Preparation of 3D dental cast images*

The selected orthodontic study models were subjected to three-dimensional analysis using a laser scanning system (VMS-100F, UNISN, Osaka, Japan). In this system, a beam generated by a semiconductor laser (wavelength, 670 nm; output, 3 mW) is projected onto a target object as a slit beam by rotating a polygon mirror, and two CCD cameras (horizontal, 768 pixels; vertical, 494 pixels) are used to capture images by the light sectioning method. In this study, the measurement pitch was set at 0.2 mm in the vertical direction and 0.2 mm in the horizontal direction. The resulting 3D dental model images were processed using modeling software (SURFACER, Imageware Inc., USA) on a graphic workstation (Octane, Silicon Graphics Inc., USA) to prepare 3D images without blind areas. The inclination of each tooth was measured using the following methods:

3.2. *Measurement methods*

According to Andrews' method [3], measurements were taken as follows (Figs. 1 and 2):

(1) Occlusal plane

By matching upper and lower dentitions, the occlusal plane was defined by the following three points: the center of the maxillary and mandibular central incisor tegmentum as the anterior reference point and the center of the occlusal surface of the maxillary and mandibular right and left first molars as the posterior reference points.

(2) Sagittal plane

The sagittal plane of anterior teeth was the plane connecting the center of the incisal edge and the basal ridge, that of premolars was the plane connecting buccolingual cusps, and that of the molars was the plane connecting the center of the buccolingual mesiodistal cusps.

(3) Facial axis of clinical crown (FACC)

On the labial and buccal surface of each tooth, the FACC of anterior teeth was defined as the line connecting the center of the incisal edge and the center of the buccocervical region. The FACC of premolars was defined as the line connecting the buccal cusp and the center of buccocervical region, and that of molars was defined as the line connecting the buccocervical region and the midpoint between the mesiobuccal cusp and the distobuccal cusp.

(4) FA point

FA point was defined as the midpoint of FACC.

(5) FA tangent line

FACC was projected parallel to the sagittal plane onto the labial and buccal surface of each tooth, and a line tangential to the FA point was drawn to measure inclination.

(6) Projection of measured lines onto the sagittal plane of teeth

The occlusal plane and FA tangential lines were projected perpendicular to the sagittal plane of teeth.

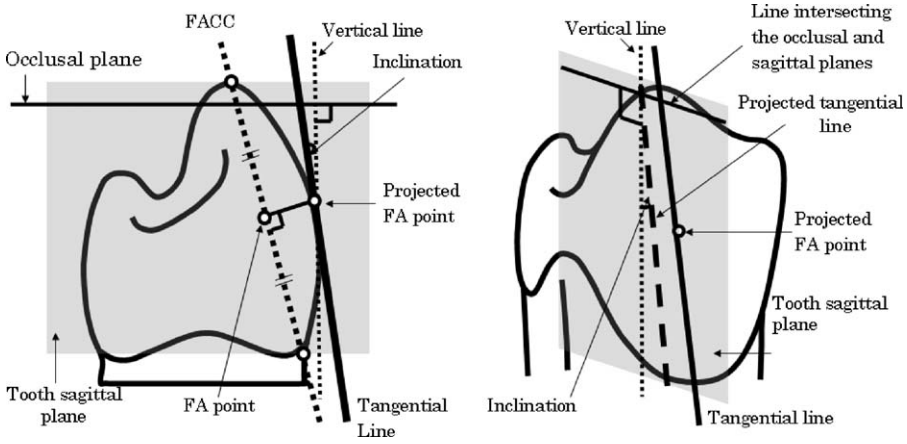

Fig. 1 – Crown inclination measurement methods. Measurements were taken as follows: (1) the sagittal plane of each tooth was the plane orthogonal to the occlusal plane: for anterior teeth, the plane connecting the center of the incisal edge and the basal ridge; for premolars, the plane connecting buccolingual cusps; and for molars, the plane connecting the center of the buccolingual mesiodistal cusps. (2) On the buccal surface of each tooth, FACC was drawn: for anterior teeth, the line connecting the center of the incisal edge and the center of the buccocervical region; for premolars, the line connecting the buccal cusp and the center of buccocervical region; and for molars, the line connecting the buccocervical region and the midpoint between the mesiobuccal cusp and the distobuccal cusp. Furthermore, FA point was defined as the midpoint of FACC. (3) On the buccal surface of each tooth, the FA point was orthogonally projected to draw a tangential line passing through the FA point.