A Comparison of Profilometer and AutoCAD Software Techniques in Evaluation of Implant Angulation In Vitro

Wirley Gonçalves Assunção, DDS, MSc, PhD[1]/Érica Alves Gomes, DDS, MSC[2]/
Lucas Fernando Tabata, DDS, MSc[2]/Humberto Gennari-Filho, DDS, MSc, PhD[3]

Purpose: *The aim of this study was to compare 2 different methods of assessment of implants at different inclinations (90 degrees and 65 degrees)—with a profilometer and AutoCAD software.* ***Materials and Methods:*** *Impressions (n = 5) of a metal matrix containing 2 implants, 1 at 90 degrees to the surface and 1 at 65 degrees to the surface, were obtained with square impression copings joined together with dental floss splinting covered with autopolymerizing acrylic resin, an open custom tray, and vinyl polysiloxane impression material. Measurement of the angles (in degrees) of the implant analogs were assessed by the same blinded operator with a profilometer and through analysis of digitized images by AutoCAD software. For each implant analog, 3 readings were performed with each method. The results were subjected to a nonparametric Kruskal-Wallis test, with* $P \leq .05$ *considered significant.* ***Results:*** *For implants perpendicular to the horizontal surface of the specimen (90 degrees), there were no significant differences between the mean measurements obtained with the profilometer (90.04 degrees) and AutoCAD (89.95 degrees;* $P = .9142$*). In the analyses of the angled implants at 65 degrees in relation to the horizontal surface of the specimen, significant differences were observed (*$P = .0472$*) between the mean readings with the profilometer (65.73 degrees) and AutoCAD (66.25 degrees).* ***Conclusions:*** *The degrees of accuracy of implant angulation recording vary among the techniques available and may vary depending on the angle of the implant. Further investigation is needed to determine the best test conditions and the best measuring technique for determination of the angle of the implant in vitro.* INT J ORAL MAXILLOFAC IMPLANTS 2008;23:618–622

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One of the most important factors for the success of an implant prosthesis is the accuracy of the impression procedure.[1,2] Knowledge of the positions of the implants is important for making the master cast and for casting a framework that fits passively to its supporting abutments,[3] without interference in the prosthesis-implant connection.[4,5]

[1]Associate Professor, Department of Dental Materials and Prosthodontics, São Paulo State University, Araçatuba Dental School, UNESP, São Paulo, Brazil.
[2]Postgraduate Student, Department of Dental Materials and Prosthodontics, São Paulo State University, Araçatuba Dental School, UNESP, São Paulo, Brazil.
[3]Chairman Professor, Department of Dental Materials and Prosthodontics, São Paulo State University, Araçatuba Dental School, UNESP, São Paulo, Brazil.

Correspondence to: Dr Wirley Gonçalves Assunção, Rua José Bonifácio, 1193 - Vila Mendonça, Araçatuba, São Paulo, SP 16015-050 BRAZIL. Fax: +55 18 3636 3245. E-mail: wirley@foa.unesp.br

The development of impression techniques to accurately record implant position has become more complicated and challenging. Several impression techniques have been suggested to achieve a master cast that will ensure the passive fit of a prosthesis on implants.[6,7] However, no single impression technique has emerged as the acknowledged gold standard. It is possible that the use of different evaluation methods (strain gauges,[8,9] photogrammetric,[10] and many others) for master cast accuracy has been responsible for the differences in results observed in studies with the same purpose.[8,9,11–18]

The profilometer is a manual measuring instrument that allows the measurement of angular and linear distances with good precision. This evaluation method has been used by many authors[6,7,11] for assessment of master cast accuracy.

The development of computer technology allowed the creation of a computer aided design (CAD), such as AutoCAD software, which is a graphic computer tool used to create and manipulate

Fig 1 Metal matrix with 1 implant at a 90-degree angle and the other at a 65-degree angle in relation to the surface.

Fig 2 Square impression copings splinted with dental floss and autopolymerizing acrylic resin.

technique designs and projects in architectural design, mechanics, civil engineering, and industrial projects. Recently, this software has been used in medicine[19–22] and dentistry[23–25] for model development as well as measurement of angles, areas,[26] thicknesses, and diameter.[27]

Medical studies[20–22] refer to the possible application of AutoCAD software to the measurement of angles. Pique-Vidal et al[19] compared measurements of large and small angles using a manual technique (goniometer) and a computerized program. They evaluated the degree of concordance between the 2 methods and determined the reliability of manual measurement. Values obtained with the 2 techniques were similar for large angles. However, regarding small angles, the results were significantly different. AutoCAD software showed more reliable results than the manual technique; the manual technique was found to underestimate the true values of the smaller angles.

Because of local anatomic limitations, many authors have been considering implant angulations that vary 30 degrees from the conventional 90-degree positioning in relation to the residual ridge.[28,29] When evaluating various implant angulations (90 degrees, 80 degrees, 75 degrees, and 65 degrees) with different impression transfer techniques and materials, Assunção et al[11] demonstrated that a more accurate impression was obtained when the implant was less angulated.

The purpose of this study was to compare 2 different methods of evaluation for master casts with 2 implants, 1 perpendicular to the surface (90 degrees) and the other with an angulation of 65 degrees, through the use of a profile projector (profilometer) and through digitized images assessed by AutoCAD software to see whether similar results would be obtained with these different methods.

MATERIALS AND METHODS

For this study, a 3.5 × 2.0 × 2.0-cm metal matrix block was fabricated using anodized aluminum. Two standard external hexagonal Brånemark System implants (3.75 × 10.0 mm; Conexao; Conexao Prosthesis Systems, São Paulo, Brazil) were affixed in this block, one at 90 degrees and one at 65 degrees in relation to the horizontal matrix surface (Fig 1). A 3-mm-thick wax spacer[30] was placed on the metal matrix around the square impression copings that had been screwed into the implants, allowing the impression material to be applied with a uniform thickness. Five custom open impression trays were fabricated this way using autopolymerizing acrylic resin (Jet; Classico Dental Products, Sao Paulo, Brazil) with a height of 45 mm, a width of 30 mm, a length of 45 mm, and a thickness of 3 mm. Four internal notches were used to guide tray positioning in a standardized way.

Five transfer impressions were carried out with heavy consistency vinyl polysiloxane impression materials (Imprint II; 3M Dental Products, St Paul, MN) and square impression copings that were joined together with dental floss scaffolding (Sanifil; Facilit Dental and Perfumary, Rio de Janeiro, Brazil) covered by autopolymerizing acrylic resin (Duralay; Reliance Dental, Worth, IL; Fig 2). A 5-kg metal block exerted a standardized pressure over each tray during the polymerization of the impression material. This was enough pressure to force excess material to flow out and to maintain a constant pressure throughout the working time.[11] After polymerization, the impression/matrix set was separated, and after 30 minutes, it was poured using a type V stone plaster (Durone; Dentsply Industry and Trade, Petropolis, RJ, Brazil). Through these procedures, 5 specimens were obtained. A single calibrated blinded examiner sequentially evaluated the possible

Fig 3 Nikon Profile projector and master cast specimen for readings.

Fig 4 View of graduated profilometer screen and angulation of a referential element in relation to the x axis.

shift in the implant-analog angulation for each specimen utilizing the 2 methods of evaluation (profilometer and AutoCAD).

Initially, the measurements were accomplished with a profilometer (Nikon, Tokyo, Japan). Previously, a metallic device used as a support for the specimens was designed and fabricated, and then centralized and cemented over the glass base of the profilometer support table. The impression transfer screws used as reference devices were screwed into the implant analog prior to the measurement. The profilometer, equipped with a circular screen with horizontal and vertical reference lines, has a movable table that allows the positioning of the object to be studied (Fig 3). A light source allows the projection of a magnified image of the object onto a screen in the form of a shadow so that the sharp edges of the projected silhouetted form become the reference points of measurement.[6]

Specimens with referential elements were placed and fitted to the metallic device. The lateral features of their images were then magnified and projected onto the circular screen of the profilometer. This screen was circumscribed by 2 circumferential protractors, one measuring to the nearest degree and the other to the nearest minute. By orienting both protractors to the Cartesian plane, the observer could have a reading to the nearest minute. After the readings, all values were standardized in degrees; in other words, the readings were performed to the nearest 0.017 degree.

The profilometer support table could be moved horizontally (sideways, forward, or backward) and vertically to focus on the angle formed between the referential elements connected to the implant analog of each specimen in relation to the horizontal surface. First, the support table was moved backward and forward until the surface of the specimen became parallel to the x axis (Fig 4). Then it was moved sideways to centralize the area to be assessed until the long axis of the referential elements become parallel to the y axis of the Cartesian plane. Next, readings provided by the y axis were recorded.

The angles measured on the reference metal matrix were equal to 330 degrees and 30 minutes and 305 degrees and 30 minutes, corresponding to 90 degrees and 65 degrees, respectively. The obtained data were turned into values corresponding to the usual angulations for each one of the implants (90 degrees and 65 degrees). For each implant, analog 3 readings were performed, totalizing 30 readings for the 5 specimens.

The same specimens were assessed by graphic computation using the AutoCAD 2000 software (AutoDesk, San Rafael, CA). Each specimen was digitalized in a scanner (Scan Jet 6100C; Hewlett Packard, Palo Alto, CA), where the bench top was perpendicular to the scanner table, and all images of the specimens were put into the scanner in the standardized position with the help of a metallic device fixed in the scanner glass table.

To determine the long axis of each implant analog, the impression transfer screw was screwed into the implant analog before the digitization process. Sequentially, the digitized images were exported to AutoCAD to carry out angular measurement of the implant analog in each situation (90 degrees and 65 degrees). For this purpose, 3 straight lines were created: 1 line in each lateral surface of the transfer screw in accordance with its inclination (90 and 65 degrees) and 1 line parallel to the bench top of the specimen. These 3 lines were used to establish reference points to carry out the measurements with the angular dimension toolbar of AutoCAD software (Fig 5). All angular measurements were made in degrees. Six readings for each specimen were made, for a total of 30 readings for the 5 specimens.

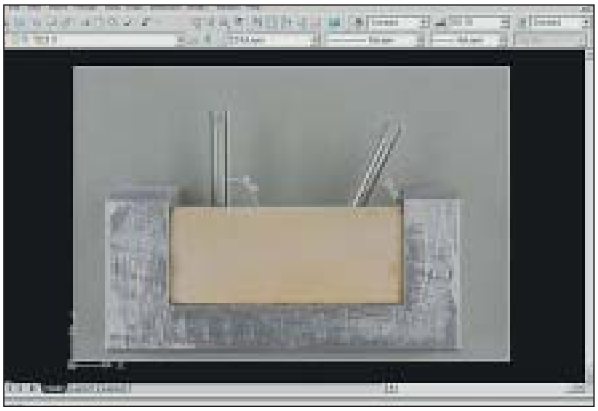

Fig 5 Measurement of implant analog angulation through the angular dimension toolbar of AutoCAD software.

Table 1 Mean ± SD Angle Measurements for the 2 Methods Used

Evaluation method	90 degrees	65 degrees
AutoCAD	89.95 ± 0.09[a]	66.25 ± 0.490[b]
Profilometer	90.04 ± 0.17[a]	65.73 ± 0.276[c]

Means are significantly different when followed by different letters (α =.05).

The data obtained after the readings were submitted to statistical analysis by nonparametric Kruskal-Wallis test ($P = .05$).

RESULTS

The obtained data showed that for the perpendicular implant (90 degrees) there was no statistically significant difference between the measurements made with the profilometer and those made with AutoCAD ($P = .9142$). For the implant at 65 degrees in relation to the specimen horizontal surface, there was a statistically significant difference ($P = .0472$) between the readings performed with these 2 methods (Table 1).

DISCUSSION

Considering that the aim of this study was not to compare implant transfer impression techniques, square impression copings joined together with a dental floss scaffolding covered by autopolymerizing acrylic resin were used. This is often considered a classic impression technique.[14–18] Thus, similar specimens were obtained to examine any difference between readings of the same specimens with different measurement systems.

The literature was reviewed to determine what angle measurement methods should be compared in the present study. Both classic methods and instruments used regularly, and more recent measurement devices, particularly those based on computerized technology, were considered. It was verified that in medicine, several studies[20–22] use AutoCAD software to measure angles, but that in dentistry, few studies have confirmed the reliability of AutoCAD software as an angle-measurement method. Pique-Vidal et al[19] compared measurement of large and small angles using a manual technique (profilometer) and a computerized program to assess the degree of concordance between the 2 methods. The authors observed that AutoCAD software showed more reliable results than a manual technique because the manual technique can underestimate the true values of the smaller angles. Iqbal et al[23,24] utilized the same program to measure angles pre- and postinstrumentation in endodontic radiographs; their findings demonstrate the degree of precision with which measurements can be obtained using AutoCAD.

In the present study, the profilometer[6,7,11] and AutoCAD software were compared to verify whether different analysis methods can provide different results for the same specimens. No statistically significant difference was observed between the 2 measurement methods for implant analogs placed at 90 degrees to the surface. However, a statistically significant difference was observed between the mean readings for angulated implant analogs (65 degrees).

Why this difference in the results? An important factor is the difference in sharpness of the image observed on the profilometer versus the computer screen. The digitized images are sharper and have more contrast, which makes reading them easier and improves the accuracy with which small differences can be distinguished. The AutoCAD readings were based on digitalized images and assessed by computer. However, the readings of the referential lines and markings were dependent on manual and visual criteria of the operator with both AutoCAD and the profilometer.

Based in the results obtained, it is important for researchers to be aware of the limitations of the method used for angle measurement, because significant differences were noted for the same specimen depending on the method used. Factors such as visual accuracy, fatigue, evaluation position, room illumination, clearness and contrast of the image, and the observer's stress can interfere with the results of this type of analysis.

CONCLUSIONS

Within the limitations of this study, it was concluded that

- Different methods of angle measurement can yield different results for the same angle.
- Some techniques may be more accurate than others in angle measurement, depending on the angle being measured.
- Further investigation is needed to reveal the best test conditions and the best measuring technique for determination of the angle of the implant in vitro.

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