A semi-automatic method for the marginal bone loss measurement in dental implants

E. Veronese¹, M. Veronese¹, S. Sivolella², A. Berto³, and E. Grisan¹
¹Department of Information Engineering, University of Padova, Italy
²Department of Oral Surgery, Institute of Clinical Dentistry, University of Padova, Italy

Introduction

BACKGROUND
One of the most used criteria for determining the success of dental implants is the evaluation of the peri-implant mesial and distal vertical marginal bone loss over the years [1]. The use of periapical radiography has become a standard in the follow up programs in implant dentistry and research. Since this measurement is commonly performed manually by experienced dental surgeons, it exhibits a considerable intra- and inter-operator variability. It follows that a robust and reproducible method is required.

AIM OF THE STUDY
In this study, we propose a semi-automatic computed-assisted approach to measure the mesial and distal bone loss around implants. In order to evaluate the robustness and reliability of the proposed method, results were compared with those provided by an expert operator. The reproducibility of measurements was tested in completion with the intraobserver variability.

Materials

Six patients were selected from a research study of Clinica Odontoiatrica of Padova University, with the proper indication for undergoing rehabilitation with endosseous implants (Nanotite TM Biomet 3®). Patients signed an informed consent form prior to participation. Images were obtained as part of a standardized follow-up of 21 implants in 6 patients, with conventional periapical radiographs. All the images were acquired with digital radiography scanners (SidexisTM, Sirona Dental Systems GmbH, Bensheim,DEU; HP scanjet NB420®, Hewlett-PackardTM, Palo Alto, CA, USA) by using a Rinn position system (Dentsply, York, PA, USA). A non-compressed file format (TIFF-Tagged Image File format) was used for data storage.

Methods

THE ALGORITHM
1. Two reference points manually inserted (Fig. 1), from which screw’s vertical axis is estimated.
2. For each line perpendicular to the axis, the points of steepest gray level variation on the left and on the right of the axis are evaluated (Fig. 2). These points are used as initialization of an Active Contours (AC) algorithm.
3. AC evolution: driven by both a dynamic inflation force and a static gradient-based force.

The static force was designed using the Vector Field Convolution (VFC) method [2]

\[ E_s = \frac{1}{2} \int_0^1 \left( \| \nabla v(s) \|^2 + \beta \| \nabla^2 v(s) \|^2 \right) + E_w(v(s), f(I)) \, ds \]

\[ v(s) = (x(s), y(s)) \]

4. At the end of the evolution the screw is segmented (Fig. 4).
5. Coupling the manual inserted point and the estimated screw: estimation of an intensity threshold.
6. Final marginal bone loss estimation

Results

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>Marginal Bone Loss Estimation [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expert grader</td>
</tr>
<tr>
<td></td>
<td>Result 1</td>
</tr>
<tr>
<td>Mesial side</td>
<td>mean 0.93</td>
</tr>
<tr>
<td>Distal side</td>
<td>mean 0.96</td>
</tr>
</tbody>
</table>

Marginal Bone Loss estimates performed by expert rater and by the computer assisted method

<table>
<thead>
<tr>
<th>TABLE II</th>
<th>Relative error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Expert grader</td>
</tr>
<tr>
<td>Mesial side</td>
<td>mean 7.02</td>
</tr>
<tr>
<td>Distal side</td>
<td>mean 53.61</td>
</tr>
</tbody>
</table>

Repeatability of the methods. Relative errors are obtained as the relative differences between the first and second set of measures provided by the human operator (third column) and our technique (fourth column).

Conclusions

The measurements provided by manual and semi-automatic methods are well correlated (r²: 0.85) thus suggesting the reliability of our technique. The proposed method might represent a valuable alternative to manually performed measurements: it avoids human variability while improving time efficiency.

References


Contact Information: Elisa Veronese, PhD
via Greadenigo 6/B Padova Italy
elisa.veronese@dei.unipd.it
Phone: +39 049 827 7758