Journal of Dental Sciences (2015) 10, 21–27

Available online at www.sciencedirect.com

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ORIGINAL ARTICLE

# A site-specific intraoperative measurement of bone-to-implant contact during implant insertion: A study on bovine ribs using a computerized implant motor

Giovanna Iezzi [a†], Antonella Filippone [b], Danilo Di Stefano [c†], Paolo Arosio [d], Adriano Piattelli [a], Antonio Scarano [a], Vittoria Perrotti [a*]

[a] *Department of Medical, Oral and Biotechnological Sciences, University of Chieti-Pescara, Chieti, Italy*
[b] *Department of Clinical Sciences and Bioimages, Section of Radiological Sciences, University of Chieti-Pescara, Chieti, Italy*
[c] *Private Practice, Milano, Italy*
[d] *Private Practice, Vimercate, Milano, Italy*

Received 7 July 2014; Final revision received 1 October 2014
Available online 27 January 2015

**KEYWORDS**
bone density;
bone-to-implant contact;
histomorphometry;
implant;
*in vitro* study;
insertion torque

**Abstract** *Background/purpose:* The aim of the current *in vitro* study was to determine if there was a correlation between the integrals (I) of the function cutting resistance/depth, obtained using a computerized implant motor, and the bone-to-implant contact (BIC) percentages of dental implants inserted in bovine ribs.
*Materials and methods:* Segments of bovine ribs were used, and a total of 21 perforations were performed. A total of 21 dental implants were inserted in the prepared bone sites. A computerized implant motor ("Torque Measuring Motor") was used to assess, before implant insertion, the values of the bone cutting resistance. The data of bone density obtained by the implant motor were statistically correlated with the BIC percentages.
*Results:* A significant positive linear correlation was found between the integrals measured by the implant motor and the BIC assessed by histomorphometry ($r = 0.78$, $n = 21$, $P < 0.0001$). Indeed, the increase of the integral values recorded by the reader matched with the increase of BIC percentages measured by histomorphometry. Pearson correlation coefficient for linear regression ($R^2$) between values assessed by the surgical motor and histomorphometry was 0.61 ($P < 0.0001$), indicating that 61% of the data points were aligned with the regression line.

* Corresponding author. Via dei Vestini 31, 66100 Chieti, Italy.
*E-mail address:* v.perrotti@unich.it (V. Perrotti).
† These two authors contributed equally to this work. GI for the histology and histomorphometry analysis, and DDS for the surgical procedure and the measurement readings.

http://dx.doi.org/10.1016/j.jds.2014.11.002

*Conclusion:* The instrument under testing seems to provide a reliable quantitative estimator, the integral, of the final BIC achieved at implant insertion, and therefore of the implant primary stability, and could represent a significant aid for a proper planning of rehabilitations with the use of dental implants.


## Introduction

Primary stability of a dental implant, i.e., the lack of mobility in the osseous site after the insertion of the implant, is strongly correlated with the quality of the receptor bone site.[1] In fact, it has been reported over many years in the dental literature that there is an increase of implant failures in bone sites characterized by low quality and quantity of bone.[2] Primary stability certainly plays a relevant role in obtaining a predictable result in the implant treatment.[1–3] Primary stability is strictly correlated to the mechanical relationship between the implant surface and the recipient bone, and this interlocking serves to avoid the occurrence of micromotions at the interface, which could have a deleterious effect on the peri-implant tissues.[3] Several factors contribute to achieving an optimal primary stability: implant design, thread design, macrogeometry and microgeometry of the implant, length, shape, surface features, quantity and quality of the bone receptor site, different techniques for the preparation of the bone site and for the placement of the implant (i.e., diameter of the drills used, depth of the preparation, tapping or not of the implant site), relative rigidity of the involved structures.[1,3–5]

One of the most important parameters to measure bone quality is to evaluate bone density, which is thought to be a predictor and main conditioner of primary stability.[5] An in-depth evaluation of the bone structure before implant insertion is necessary for planning e treatment.[5] The different bone densities of the portions of the jaws could play an important role in the planning, in the preparation of the bone implant site, and in the loading modalities of the implant (immediate, early, or delayed).[5] An improved knowledge of the bone density differences could help the clinicians to make a correct preoperative diagnosis and realize a treatment according to the necessities of each patient.[2,6] It has already been said that primary stability is the key to a successful outcome of the implant treatment and so its accurate prediction, before or during surgery, will play a valuable role.[7] There is then a need for a reliable and easy-to-use system to quantify, preoperatively, the bone quality, but, unfortunately, such technique or equipment does not exist. In a previous *in vitro* study from our laboratory, a significant positive linear correlation was found between the bone density measured by a computerized implant motor, and the bone density evaluated by histomorphometry.[8] The increase in the values of the bone density strongly correlated with the increase of the percentage of the bone trabeculae observed in the histological slides.[8] In a clinical set, moreover, the measuring system under testing allowed to distinguish different and clinically significant anatomical zones according to their different bone density.[9]

An evaluation of the bone density, in a site-specific way, seems then to be possible. Primary stability has been found to be a prerequisite for the osseointegration of dental implants and, in fact, in a study primary stable implants showed increasing percentages of bone-to-implant contact (BIC), whereas, on the contrary, an absence of osseointegration was reported for implants with no primary stability.[10] Higher values of BIC percentages have been reported to be strictly correlated to a better primary stability.[11] It was decided to determine, using the same computerized implant motor, whether a significant correlation existed between the integral values and the BIC of implants inserted *in vitro* into bovine ribs, under the hypothesis that implant insertion was a dynamic process, whose final result was the sum of the local modifications changing at the bone-implant interface whereas the implant screws deepened into the previously prepared bone site. BIC assessment through histomorphometry, however, was just a direct measurement of such interaction: its outcome being an estimate, from two-dimensional measurements, of the whole contact area between the implant and the bone tissue.

The goal of the current *in vitro* study was, therefore, to investigate if there was a relationship between the Integral of the resistance/depth function, obtained by the implant motor, and the BIC percentages of dental implants inserted into bovine ribs.

## Materials and methods

This *in vitro* study was performed at the Implant Retrieval Center of the Department of Medical, Oral and Biotechnological Sciences of the University of Chieti-Pescara, Chieti, Italy. Five segments of bovine ribs where it was possible to clearly define the cortical and the cancellous bone were used. The periosteum was removed from all bone segments, and the samples were regularized using a diamond saw (Precise 1 Automated, Assing, Rome, Italy).[12]

A total of 21 bone implant sites were performed. A computerized implant motor called "Torque Measuring Motor" (TMM2) (IDI Evolution, Concorezzo, Milano, Italy), was used for the intraoperative analysis of the density of the different osseous sites. The measurements were done using a special reading drill (Patented by IDI Evolution, Concorezzo, Milano, Italy), to assess, before implant insertion, the values of the bone cutting resistance.