"*In Vivo* Implant Micromovements Mesuring With 3D Digital Image Correlation (DIC)"

RODRIGUES, T.[1], MOREIRA, F.[1], NETO, A.[2], GUERRA, F.[1], NICOLAU, P.[1]

[1]Faculty of Medicine, University of Coimbra, Dentistry Area, Coimbra, Portugal
[2]Faculty of Science and Technology, University of Coimbra, Mechanical Engineering Department, Coimbra, Portugal

Address: DDM, MSc, Tânia Rodrigues, Coimbra, taniarodrigues.md@gmail.com

Introduction

Implant stability is one of the principal factors in the clinical success of implant therapy. Research has shown that one of the major causes of failures in osseointegration is excessive micro-movements, although to date, there is no clinical available method for measuring micro-movements.

Objectives

The primary objective of this study was to use a 3D DIC method for clinical full-field tridimensional surface micro-movements measurement of endosseous implants. Secondarily, this work aimed to understand the influence of different factors in the occurrence of micro-movements, particularly the change in the prosthetic abutments geometry (Standard [SD] and Platform-Switching [PS]).

Materials and Methods

In this study 32 endosseous implants (Camlog Biotechnologies®, Wimsheim, Germany) inserted in rehabilitated patients with two or more adjacent dental implants in the lower posterior jaw [Fig.1]. Implants were restored using single unit crowns over two different prosthetic abutments SD (N=18) and PS (N=14), were used [Fig. 2].

Clinical Report

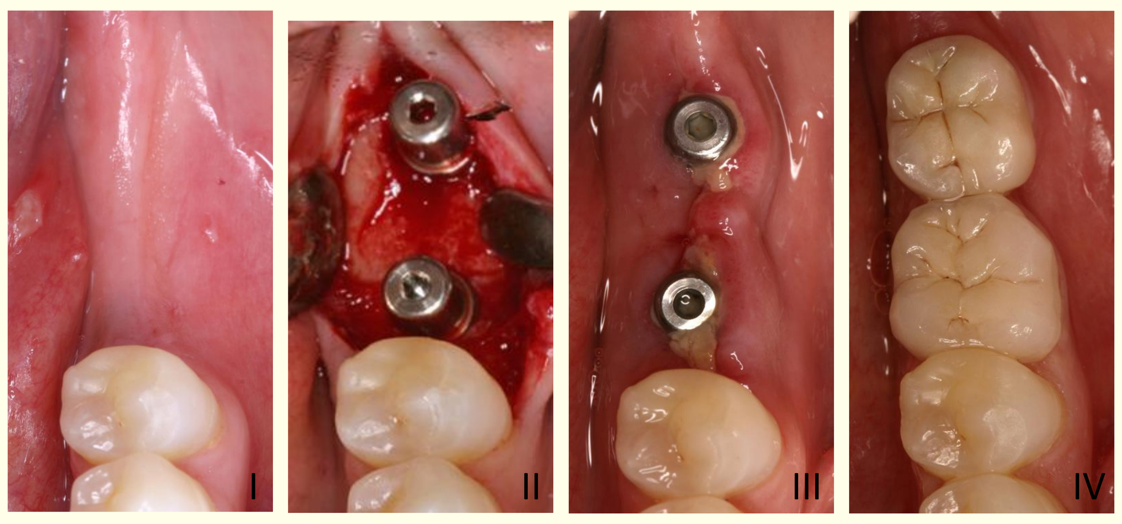


Fig 1. Oral photographs of a clinical case. I - Posterior edentulous lower jaw previous to implants placement. II - Implants placement and abutment randomization at the surgery day. In this clinical case, Platform-Switching (PS) abutment was raffled. III - One week post-surgical view. IV - One year after final rehabilitation with cemented fixed prosthesis.

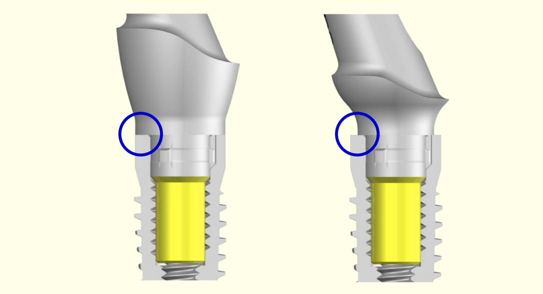


Fig 2. Standard (SD) and Platform-Switching (PS) prosthetic abutments used in this study (Camlog Biotechnologies®, Wimsheim, Germany).

Implant stability was also measured clinically in ISQ (Implant Stability Quotient) using the Osstell® ISQ (Osstell® ISQ Integration Diagnostic, Sweden) [Fig.5]. The results were statistically analyzed with the software IBM SPSS® Statistics 20.0 (SPSS Inc., Chicago, Illinois, USA).

Implant stability assessment

Fig 5. Osstell® ISQ (Osstell® ISQ Integration Diagnostic, Sweden) used in this study to assess implant stability, and diagram image of device functioning.

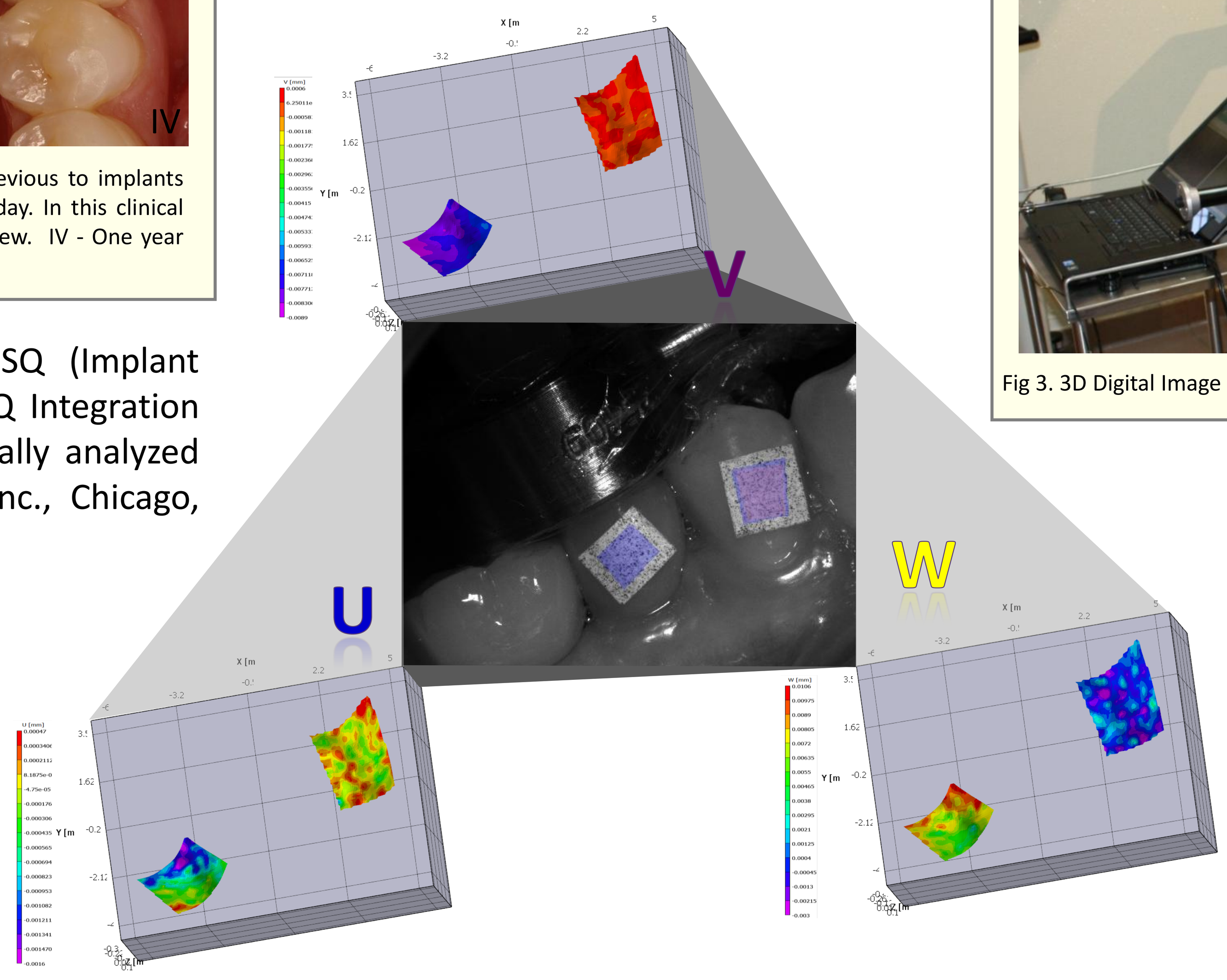


Fig 6. Maximum micro-movements measurements obtained by digital image correlation with Vic-3D 2010 (Correlated Solutions®, Columbia, USA) in the three space directions U, V and W (Mesio-Distal, Occlusal-Apical and Buccal-Lingual, respectively) for the one clinical case.

Micro-movement measurements were performed by 3D DIC with two high speed photographic cameras [Fig.3] (Point Grey GRAS-20S4M-C, PENTAX TV Lens 75mm, 1:2.8, with 1624x1224 resolution) and the video correlation system Vic-3D 2010 (Correlated Solutions®, Columbia, USA), after the application of a bite load of more than 30N, measured with a miniature compression loading cell (Applied Measurements Ltd., Berkshire, UK) and the system design software LabVIEW 2010 (National Instruments®, Texas, USA) [Fig.4].

DIC 3D Measurements *setting*

Fig 3. 3D Digital Image Correlation system *set up* (Correlated Solutions®, Columbia, USA).

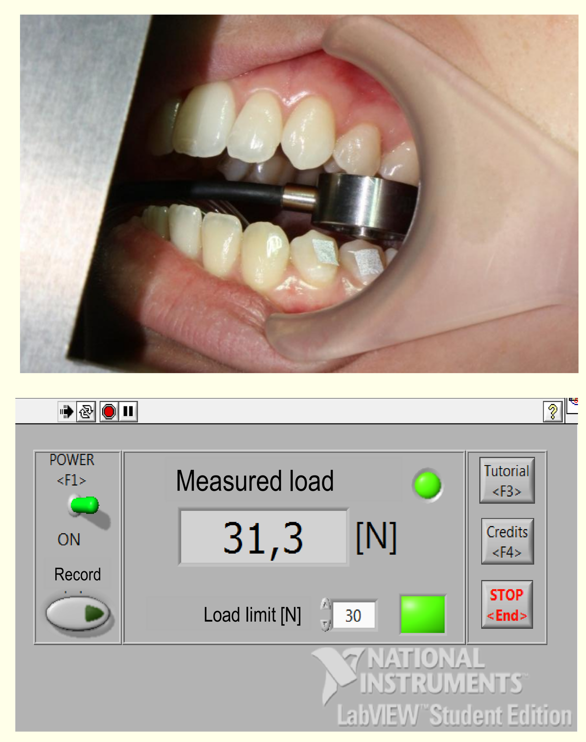


Fig 4. Stainless steel miniature compression load cell in position for images capture (Applied Measurements, Berkshire, UK) and correspondent Interface of the system design software LabVIEW 2010 (National Instruments®, Texas, USA) for measuring and recording the load bite application.

In order to measure micro-movements, the system required a heterogeneous pattern which was handmade with a airbrush Evolution Silverline (Harder & Steenbeck, Norderstedt, Germany) over a sticker paper and placed on the buccal side of both the crown over the implant and the neighboring natural tooth [Fig.6]. After images acquisition, micro-movements analysis was done with a post processing application from Vic-3D 2010, in order to remove the rigid body motion.

For each patient, a *stereo system* calibration was performed using a standardized calibration target sized 14,929mm, with a pitch of 1,780mm (9x9), before acquiring images.

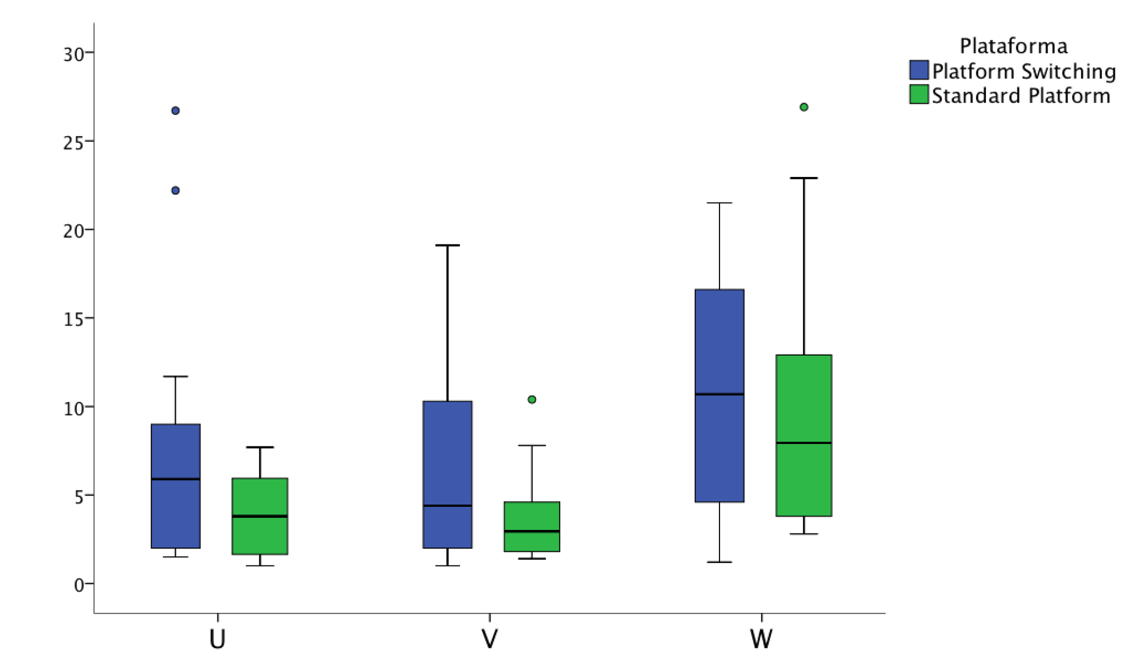
Results

The results obtained for maximum micro-movements values (μm) with digital image correlation in the three space directions U, V and W (Mesio-Distal, Occlusal-Apical and Buccal-Lingual, respectively) and the Resultant displacement (R) were:

Displacement	U	V	W	R
Mean ± pd	4,407 ± 2,834	4,286 ± 3,390	10,604 ± 6,825	12,804 ± 7,192

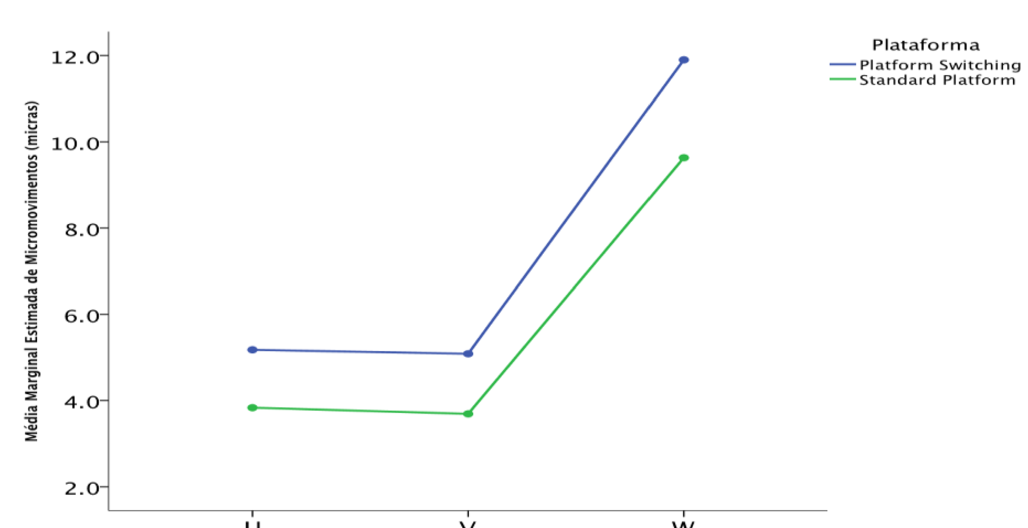
The results obtained seem to be correlated with the ISQ values indirectly measured by RFA (Resonance Frequency Analysis) with the Osstell® ISQ for each space direction considered (U and W). U: r(26)=-0,412, p=0,036; W: r(26)=-0,417, p=0,034. For direction V (Apical) results weren't compared because the Osstell ® ISQ doesn't work in this direction, which is a limitation of this method.

The results didn't show statistical significant differences between the two prosthetic platforms (Mann-Whitney test) for any direction analyzed [Graph. 1]. U:U=69,500;Z=-1,232;p=0,218; V:U=79,500;Z=-0,766;p=0,443; W:U=76,500;Z=-0,906;p=0,365.



Graph. 1. Maximum micro-movements values distribution in the directions U, V and W, for both groups of platforms PS and SD.

Within each platform, the paired sample analysis of the U, V and W values showed significant statistical differences between these three directions of displacement [Graph. 2]. The same analysis made for all implants, independently of the prosthetic abutment confirmed that motion in W direction ($X^2(2)=26{,}691$, $p<0{,}01$) is significant statistically higher than in the other directions.



Graph. 2. Marginal Mean Estimated of micro-movements for platforms PS and SD in the directions U, V and W.

Conclusions

Within the limitations of this study, 3D DIC method is capable to measure dental implants micro-movements, although not being a clinical system.

The results obtained show correlation with the RFA system, and Prosthetic abutment geometry did not influence the occurrence of micromovements.

Acknowledgments

Co-financed by the Foundation for Science and Technology via project PTDC/SAL-BEB/108658 and by F.E.D.E.R. via the «Programa Operacional Fatores de Competitividade» of QREN with COMPETE reference FCOMP-01-0124-FEDER-010961.

References

1. A randomized clinical study between immediate and early loading. *In:* Nicolau P (ed). *Immediate Loading of Endosseous Implants-Clinical and Biomechanical Evaluation*, 2007: pp 132-133.
2. Branemark PI, Hansson BO, Adell R, Breine U, Lindstrom J, Hallen O, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg* 1977;16:1-132.
3. Albrektsson T, Zarb GA. Current interpretations of the osseointegrated response: clinical significance. *Int J Prosthodont* 1993;6:95-105.
4. Brunski JB. Avoid pitfalls of overloading and micromotion of intraosseous implants. Dent *Implantol Update* 1993;4:77-81.
5. Kimura K, Fukase Y, Makino M, Masaki C, Nakamoto T, Hosokawa R. Preoperative assessment of treatment planning on minimization of micro-movement during healing period of immediate-loaded implants using X-ray CT data-based simulation. *J Oral Implantol* 2010.
6. Göllner M, Holst A, Berthold C, Schmitt J, Wichmann M, Holst S. Noncontact intraoral measurement of force-related tooth mobility. *Clin Oral Investig* 2009.
7. Goellner M, Schmitt J, Karl M, Wichmann M, Holst S. Photogrammetric measurement of initial tooth displacement under tensile force. *Med Eng Physics*;32:883-888.
8. Morita Y, Uchino M, Todo M, Qian L, Matsushita Y, Arakawa K, et al. Dental occlusal deformation analysis of porcine mandibular periodontium using digital image correlation method. *Interface Oral Health Science* 2009 2010:150-152.
9. Sutton MA, Orteu JJ, Schreider HW. *Image correlation for shape, motion and deformation measurments*, 2009.
10. Clelland NL, Seidt JD, Daroz LG, McGlumphy EA. Comparison of strains for splinted and nonsplinted implant prostheses using three-dimensional image correlation. *Int J Oral Maxillofac Implants*, 2010;25(5):953-9.
11. Tiossi R, Conrad HJ, Rodrigues RC, Heo YC, De Mattos MdaG, Fok AS, Ribeiro RF. A digital image correlation analysis on the influence of crown material in implant-supported prostheses on bone strain distribution. *J Prosthod Res* 2012;56:25-31.

camlogfoundation

5TH INTERNATIONAL CAMLOG CONGRESS
26TH – 28TH JUNE 2014, VALENCIA, SPAIN