Comparison of Fit Accuracy between Procera Custom Abutments and Three Implant Systems

Tiago de Morais Alves da Cunha;* Roberto Paulo Correia de Araújo;† Paulo Vicente Barbosa da Rocha;‡ Rosa Maria Pazos Amoedo*

ABSTRACT

Background: Although increase of misfit has been reported when associating implant and abutment from different manufacturers, Procera® (Nobel Biocare™, Göteborg, Sweden) custom abutment has been universally used in clinical practice.

Purpose: The purpose of this investigation was to compare the vertical gap of zirconia Procera abutment associated with implants from the same manufacturer (Nobel Biocare) and two other implant systems.

Materials and Methods: Twenty-four zirconia Procera abutments were produced using computer-assisted design and manufacture (CAD/CAM) and paired with (1) eight MK Iii RP 4.1 × 10 mm implants (Nobel Biocare) – GNB group; (2) eight Try on, 4.1 × 10 mm implants (Sistema de Implantes, São Paulo, Brazil) – ES group; and (3) eight Master screw, 4.1 × 10 mm implants (Conexão Sistema de Prótese, São Paulo, Brazil) – EC group. A comparison of the vertical misfit at the implant-abutment interface was taken at six measuring sites on each sample using scanning electron microscopy with a magnification of 408×. One-way analysis of variance was used to test for differences, and Tukey's test was used for pairwise comparison of groups ($\alpha = 0.05$).

Results: Significant differences relative to average misfit were found when Procera abutments were associated with other implant manufacturers. The ES group and EC group did not differ significantly, but both demonstrated significantly larger average misfit than the GNB group ($p = .001$). The average misfit was 5.7 μm ± 0.39, 9.53 μm ± 0.52 and 10.62 μm ± 2.16, respectively, for groups GNB, ES, and EC.

Conclusion: The association of Procera zirconia abutment with other implant systems different from its manufacturer demonstrated significant alteration of vertical misfit at implant-abutment interface.

KEY WORDS: dental implants, implant-supported prosthesis, misfit, prosthodontic planning

INTRODUCTION

The Procera® ceramic abutment is an excellent choice in single implant restorations, due to its biocompatibility and better aesthetics, since it minimizes the gray color associated with metal components that is transmitted through the peri-implant tissues.[1,2] Based on computer-assisted design/computer-assisted manufacturing (CAD/CAM) technology, it also provides custom implant abutments, without casting procedures, reproducing body height, width, and taper of the abutment, as well as gingival margin height, width, and emergence profile.[2] These advantages would offer universal application for all Brånemark compatible implant systems, if an optimal fit could be obtained on the implant-abutment interface.

There are conflicting reports about misfit clinical effects. Some investigators have claimed a relation between clinical complications and poor fit of screw-retained implant prostheses. According to their findings, vertical and horizontal misfit applies loads to the

*Professor, Department of Prosthodontics, School of Dentistry, UNIME, Brazil; †associate professor, Department of Biochemistry, Federal University of Bahia, Brazil; ‡adjunct professor of prosthodontics, Federal University of Bahia, Brazil

Reprint requests: Professor Tiago de Morais Alves da Cunha, Antônio Carlos Magalhães, 3359, Ap 1104N, Salvador, BA, 41800-700, Brazil; e-mail: tiagoalvescunha@hotmail.com

DOI 10.1111/j.1708-8208.2010.00311.x

implant assemblies and the bone, being directly related to several mechanical complications, such as loosening or fracture of abutment and prosthetic screw, abutment fracture and complete loss of osseointegration in the most severe cases.[3–9] However, marginal integrity at the implant-abutment interface is important to reduce stress transfer to bone and screw joint, preventing movement at the deep implant-abutment interface that causes peri-implant tissues irritation, and possibly bone loss surrounding implants.[10–13] However, studies in animals reveal a positive bone response, with increased bone-to-metal contact at the tip of threads, in association with implants supporting misfitting frameworks.[14,15]

Another consequence is the microbial colonization inside the implants, where the microgap is related to bacterial leakage that might play an important role in the etiology of peri-implantitis.[16–19]

The Procera abutment is manufactured by Nobel Biocare™, Göteborg, Sweden) and, according to the manufacturer, aside from the Brånemark System® implants (Nobel Biocare), they are also suitable only for 3i® 3.75 (Implant Innovations, West Palm Beach, FL, USA), Lifecore® Biomedical Restore 3.75 (Lifecore Biomedical LLC, Chaska, MN, USA), Zimmer® Dental Taper-Lock 4.0 (Zimmer Dental Inc., Carlsbad, CA, USA), and Sterngold® Implamed® 3.75 (Sterngold Dental LLC, Attleboro, MA, USA).

Combination of abutments and implant systems from different manufacturers may lead to poor marginal fit, compared to an implant-abutment interface from the same manufacturer.[3]

Consequences of misfit have been discussed in a great number of studies;[20–28] however, little or no data have been published concerning association between Procera® ceramic abutments made from zirconia and other Brånemark compatible implant systems, even though it has been widely used as an universal abutment.[22]

The purpose of this study was to compare the vertical gap of zirconia Procera abutment associated with the Brånemark System implants and two other implant systems widely used in Brazil.

The null hypothesis was that Procera abutments associated with its respective implant manufacturer and with other implant systems, clearly not listed as recommended by manufacturer, would not imply significant changes with respect to marginal gap.

MATERIALS AND METHODS

Fabrication of Specimens

For this experiment, an abutment (Nobel Biocare) was secured in one external-hexagon implant analog and two vertical lines disposed 180° from each other were milled on lingual and buccal surfaces attempting to guide scanning electron microscopy (SEM) measurements.

The assembly was then positioned in the Procera scanner in order to obtain digitally scanned images. Based on the images processed, 24 zirconia abutments were produced identically in shape and placed in three groups of eight specimens each:(1) Nobel Biocare group (GNB) – MK III, RP 4.1 × 10 mm implants (2) Experimental group SIN (ES) – Try on, 4.1 × 10 mm implants (SIN-Sistema de Implantes, São Paulo, Brazil) (3) Experimental group Conexão (EC) – Master screw, 4.1 × 10 mm implants (Conexão Sistema de Prótese, São Paulo, Brazil).

Each implant and respective abutment formed one sample. Subsequently, each sample was placed in a rigid device to ensure stable fixation and tightened to 35 Ncm by a single examiner using a calibrated electronic torque controller with a precision of ±2% (W&H Dentalwerk, Burmoos, Austria).

SEM

The fit of all 24 samples was then measured by SEM with a spatial resolution of 5 nm (LEO 1430 VP, Oberkochen, Germany). Initially, each implant-abutment sample was inserted in the SEM source, with the reference vertical line on the outer surface of the abutment oriented toward the reader and the gap areas were measured in three points (left edge, central, right edge) with the aid of a digital imaging software and analyzer from the SEM apparatus. Subsequently, the samples were rotated 180° in order to show the other vertical reference line, and the same three measuring points were recorded. All measurements were made at a magnification of 408× at six predefined areas, resulting in a total of 48 measurements for each group. The mean value of the six measuring points was assumed as the gap width of each sample. Means and standard deviations were calculated for the vertical misfit in each of the three groups. Photomicrographs analysis also allowed observation of horizontal discrepancies between the external contours of abutment and implants.

TABLE 1 Descriptive Statistic for Vertical Misfit (μm)

Groups	*n*	Minimum	Maximum	Mean	SD	*p*
GNB	8	5.32	6.22	5.7	±0.39*	
ES	8	9.08	10.25	9.53	±0.52†	0.005
EC	8	8.93	13.6	10.62	±2.16†	0.001

Different symbols indicate statistical difference ($p < 0.05$). EC = Procera abutment associated with implants from Conexão. ES = Procera abutment associated with implants from SIN. GNB = Procera abutment associated with implants from Nobel Biocare.

Statistical Analysis

Statistical analysis was performed using SPSS (SPSS Inc., Chicago, IL, USA). Quantitative differences between the groups were assessed using analysis of variance (ANOVA). Tukey's test was used for pairwise comparison of groups. A significance level of $\alpha = 0.05$ was used for all comparisons. All statistical analysis were performed at the 95% confidence level.

RESULTS

The mean gap widths and standard deviations (SD) results for each group are presented in Table 1.

One-way ANOVA showed differences between the means of the groups ($p = .001$). Tukey's test revealed statistical significant differences between experimental groups (ES and EC) and GNB group, with smaller misfit values when implant and abutments were from the same manufacturer (GNB). The mean gap width for both experimental groups (ES and EC) were not significantly different; however, the ES group showed smaller mean values compared with the EC group.

The distribution of vertical misfit for each group is shown in Figure 1.

All GNB group specimens' photomicrographs were similar, showing a relatively smaller marginal gap size distributed uniformly within the six measuring points (Figure 2).

Samples of the ES showed greater amount of misfit at the central area compared to the left and right edges (Figure 3). Group EC demonstrated larger average vertical misfit (10.62 μm ± 2.16) distributed non-uniformly (Figure 4).

DISCUSSION

This study assessed changes at the implant-abutment interface when Procera ceramic abutments are associated with different implant manufacturers.

There are contradictory reports about the effects of implant-abutment interface gap space. Considering the lack of in vivo studies regarding bone response to misfit, no scientific support can be found for clinical belief that misfit alone contributes to clinical problems. Although the ideal level of accuracy of fit at the implant-abutment interface has yet to be determined, some authors claim that controlling the amount of misfit is important to prevent mechanical and biologic failures, as well as to maintain osseointegration.[12,19,21,23] In the absence of an ideal level of misfit, the recommendation is to choose implant-abutment combinations that have demonstrated acceptable fit in research investigations.

The current study findings are in accordance with other SEM evaluations using similar methodology. Jansen and colleagues[19] analyzed 13 different implant-abutment combinations and demonstrated that implant misfit averaged less than 10 μm in all systems. Piattelli and colleagues[21] showed mean misfit values ranging from 2 to 7 μm for the same implant system. A previous investigation, evaluating implant-abutment interface between Brånemark System implants and Procera

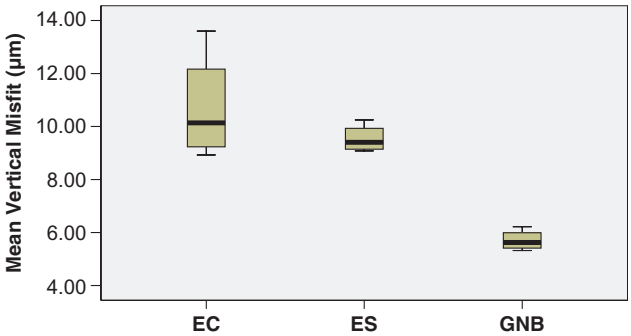

Figure 1 Box plot comparing misfit at implant-abutment interface for each group. EC = Procera abutment associated with implants from Conexão. ES = Procera abutment associated with implants from SIN. GNB = Procera abutment associated with implants from Nobel Biocare.

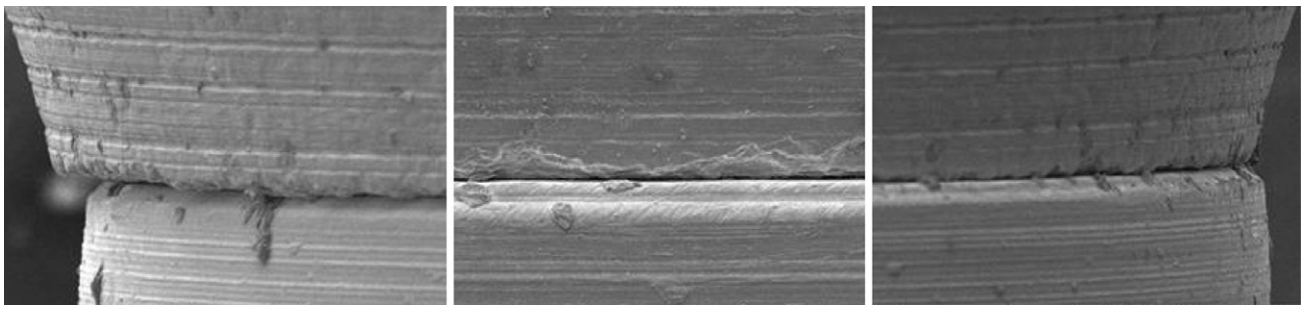

Figure 2 Photomicrographs from group GNB (implant manufactured by Nobel Biocare) showing microgap distributed uniformly among all measured sites. Note the absence of horizontal discrepancies.

abutments, demonstrated mean microgap measurements of 3.15 μm, 2.52 μm, and 3.19 μm for alumina, zirconia, and titanium abutments, respectively.[4]

In the present study, SEM examination revealed statistical significant differences between tested groups, regarding misfit at the implant-abutment interface. The GNB group showed smaller amounts of misfit distributed uniformly in all measured sites. The average vertical gap width was 5.7 μm ± 0.39.

Compared to the GNB group, the experimental groups ES and EC were significantly different, showing average misfit of 9.53 μm ± 0.52 and 10.62 μm ± 2.16, respectively. These findings are consistent with some studies that have assessed implant-abutment vertical misfit when implants and abutments from different manufacturers are associated.[3] It may be explained by differences in machining tolerances of implant systems.

The range of misfit reported in the current study is considered by many authors as clinically acceptable.[22–26] Although certain biologic tolerance for misfit may be present,[19,28] these investigations evaluated abutment-cylinder misfit in partial implant-supported

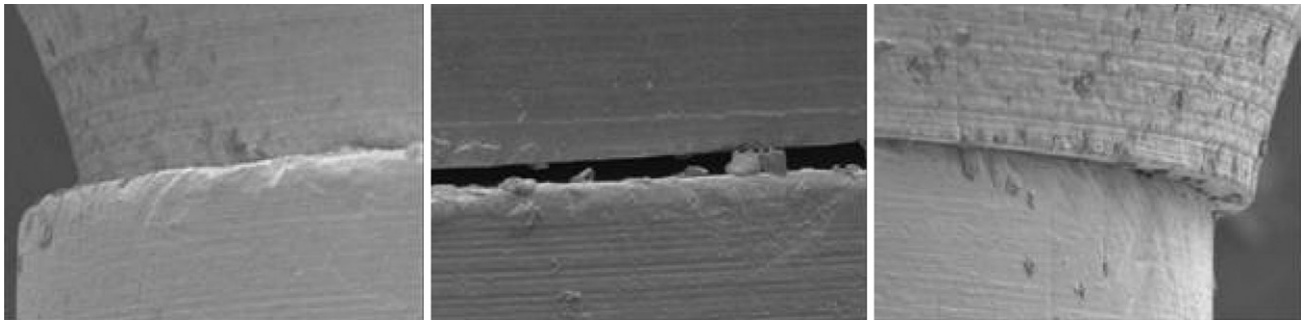

Figure 3 Photomicrographs from group ES (implant manufactured by SIN) showing a greater misfit in the central area compared to the left and right edges. Note the presence of horizontal overcontour and undercontour.

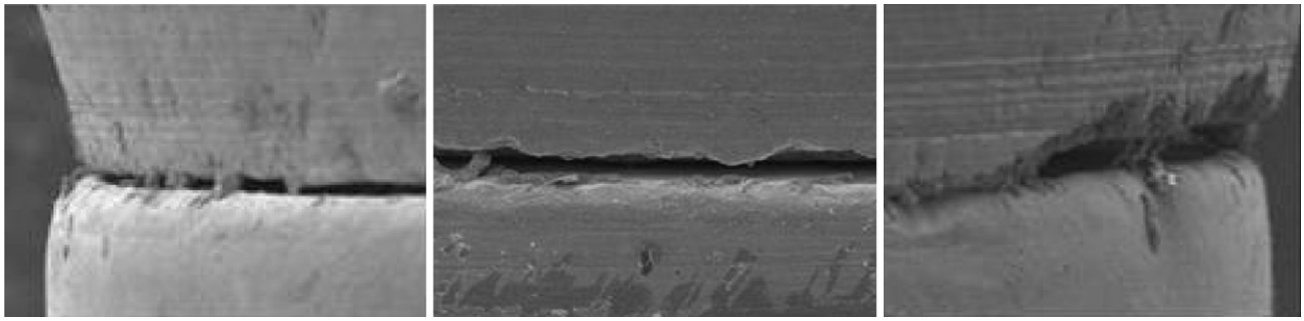

Figure 4 Photomicrographs from group EC (implant manufactured by Conexão) showing microgap at all measuring sites, distributed nonuniformly.

frameworks.[21–29] This observation is important because in case of multiple implants, stresses generated by occlusal forces can be well distributed within implants and, subsequently, between abutments and cylinders. It may explain the biologic tolerance to certain levels of misfit.

Consequences of misfit in single-tooth restorations using abutments designed to engage the implant directly, as Procera abutments have to be further investigated, because loads are applied directly to implant/bone interface. Assunção and colleagues[30] demonstrated, by means of finite element analysis, that different misfit patterns influences stress distribution of single implant-supported prosthesis. Changes in the implant system, position, bone classification, axis of loading, and loading condition also had influence on the biomechanical response of a single-unit implant-supported restoration.[31,32] However, considering external forces from function and the presence of microbial colonization, the amount of misfit may be considered as a contributing, but probably not significant, factor for complications and failures.[14]

In the ES group, all specimens showed horizontal discrepancies at both left and right edges, with a combination of overcontour and undercontour. It demonstrates that proper part alignment was not achieved. Photomicrographs also demonstrate a larger amount of misfit at the central area compared with the left and right edges. Although compatibility is claimed by this manufacturer for the Brånemark system implant, the evidence suggest that this assumption is inconsistent.

Studies evaluating implant-abutment misfit demonstrate different results because of differences in measurements using SEM analysis.[4] A limitation of the current study is that the microgap was measured around the outer perimeter of the implant-abutment interface and no information about inner regions were provided. However, this approach has been used in similar investigations, therefore justifying the methodology utilized.

In view of the benefits of the Procera ceramic custom abutments, more studies assessing interchangeability with implant systems that include rotational freedom, preload, and stress transfer will likely provide better information about Procera universality.

CONCLUSION

Within the limitations of this in vitro study, it was found that association of Procera zirconia abutment with other implant systems different from its manufacturer results in significant alteration of vertical misfit at implant-abutment interface.

ACKNOWLEDGMENT

This study was supported by The Brazilian Research Support Foundation of Bahia (FAPESB).

REFERENCES

1. Yildirim M, Edelhoff D, Hanisch O, Spiekermann H. Ceramic abutments – a new era in achieving optimal esthetics in implant dentistry. Int J Periodontics Restor Dent 2000; 20:81–91.
2. Kucey BKS, Fraser DC. The Procera abutment – The fifth generation abutment for dental implants. J Can Dent Association 2000; 66:445–449.
3. Byrne D, et al. The fit of cast and premachined implant abutments. J Prosthet Dent 1998; 80:184–192.
4. Yüzügüllü B, Avci M. The implant-abutment interface of Alumina and Zirconia abutments. Clin Implant Dent Relat Res 2008; 10:113–121.
5. Jemt T, Lekholm U, Gröndahl K. 3 year follow-up study of early single implant restorations ad modum Bränemark. Int J Periodontics Restorative Dent 1990; 10:340–349.
6. Jemt T, Lindén L, Lekholm U. Failures and complications in 127 consecutively placed fixed partial prosthesis supported by Bränemark implants: from prosthetic treatment to first annual checkup. Int J Oral Maxillofac Implants 1992; 7:40–44.
7. Becker W, Becker BE. Replacement of maxillary and mandibular molars with single endosseous implant restorations: a retrospective study. J Prosthet Dent 1995; 74:51–55.
8. Simon RL. Single implant-supported molar and premolar crowns: a ten year retrospective clinical report. J Prosthet Dent 2003; 517–521.
9. Coelho AL, Suzuki M, Dibart S, DaSilva N, Coelho PG. Cross-sectional analysis of the implant-abutment interface. J Oral Rehab 2006; 34:508–516.
10. Byrne D, Jacobs S, O'Connell B, Houston F, Claffey N. Preloads generated with repeated tightening in three types of screws used in dental implants assemblies. J Prosthodontics 2006; 15:164–171.
11. Gratton DG, Aquilino SA, Stanford CS. Micromotion and dynamic fatigue properties of dental implant-abutment interface. J Prosthet Dent 2001; 47–52.
12. Hermann JS, Schoolfield JD, Schenk RK, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged implants in the canine mandible. J Periodontol 2001; 72:1372–1383.
13. Jemt T, Book K. Prosthesis misfit and marginal bone loss in edentulous implant patients. Int J Oral Maxillofac Implants 1996; 11:620–625.

14. Jemt T, Lekholm U, Johansson CB. Bone response to implant-supported frameworks with differing degrees of misfit preload: in vivo study in rabbits. Clin Implant Dent Relat Res 2000; 2:129–137.
15. Carr A, Gerard D, Larsen P. The response of bone in primates around unloaded dental implants supporting prostheses with different level of misfit. J Prosthet Dent 1996; 76:500–509.
16. Quirynen M, Steenberghe D. Bacterial colonization of the internal part of two-stage implants: an in vivo study. Clin Oral Implant Res 1993; 4:158–161.
17. Quirynen M, Bollen CM, Eyssen H. Microbial penetration along the implant components of Bränemark system. Clin Oral Implant Res 1994; 5:239–244.
18. Covani U, Marconcini S, Crespi R, Barone A. Bacterial plaque colonization around dental implant surfaces. Implant Dent 2006; 15:298–304.
19. Jansen VK, Conrads G, Richter EJ. Microbial leakage and marginal fit of the implant-abutment interface. Int J Oral Maxillofac Implants 1997; 12:527–540.
20. Romanos G, Toh CG, Siar CH, et al. Peri-implant bone reactions to immediately loaded implants. An experimental study in monkeys. J Periodontol 2001; 72:506–511.
21. Piattelli A, Vrespa G, Petrone G, Iezzi G, Annibali S, Scarano A. Role of the microgap between implant and abutment: a retrospective histologic evaluation in monkeys. J Periodontol 2003; 74:346–352.
22. Lang LA, Sierraalta M, Hoffensperger M, Wang R. Evaluation of the precision of fit between the Procera custom abutment and various implant systems. Int J Oral Maxillofac Implants 2003; 18:652–658.
23. Isa ZM, Hobkirk JA. The effect of superstructure fit and loading on individual implant units: part I. The effects of tightening the gold screws and placement of superstructure with varying degrees of fit. Eur J Prosthodontic Rest Dent 1995; 3:247–253.
24. Kunavisarut C, Lang LA, Stoner BR, Felton DA. Finite element analysis on dental implant-supported prosthesis without passive fit. J Prosthodontics 2002; 11:30–40.
25. Markarian RA, Ueda C, Sendyk CL, Laganá DC, Souza RM. Stress distribution after installation of fixed frameworks with marginal gaps over angled and parallel implants: a photoelastic analysis. J Prosthodontics 2007; 16:117–122.
26. Millington ND, Leung T. Stress on an implant superstructure in relation to its accuracy of fit. J Dent Res 1992; 71:529–537.
27. Waskewicz GA, Ostrowski JS, Parks VJ. Photoelastic analysis of stress distribution transmitted from a fixed prosthesis attached of osseointegrated implants. Int J Oral Maxillofac Implants 1993; 8:19–31.
28. Hecker DM, Eckert SE, Choi YG. Cyclic loading of implant-supported prostheses: comparison of gaps at the prosthetic-abutment interface when cycled abutments are replaced with as-manufactured abutments. J Prosthet Dent 2006; 95:26–32.
29. Alkan I, Sertgöz A, Ekici B. Influence of occlusal forces on stress distribution in preloaded dental implant screws. J Prosthet Dent 2004; 91:319–325.
30. Assunção WG, Gomes EA, Barão VA, Delben JA, Tabata LF, de Souza EA. Effect of superstructure materials and misfit on stress distribution in a single implant-supported prosthesis: a finite element analysis. J Craniofac Surg 2010; 21:689–695.
31. Hsu ML, Chen FC, Kao HC, Cheng CK. Influence of off-axis loading of an anterior maxillary implant: a 3-dimensional finite element analysis. Int J Oral Maxillofac Implants 2007; 22:301–319.
32. Lin CL, Chang SH, Chang WJ, Kuo YC. Factorial analysis of variables influencing mechanical characteristics of a single tooth implant placed in the maxilla using finite element analysis and the statistics-based Taguchi method. Eur J Oral Sci 2007; 115:408–416.