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Assessment of the interface between implant and abutments of five systems by scanning electronic microscopy

ABSTRACT

Aim The objective of this study was to assess, by Scanning Electronic Microscopy (SEM), the interface between the platforms of five implant systems and the conic abutments (I) gold ucla type (II) and multi-unit type (III).

Materials and methods The implant systems used and their respective abutments studied were: AS Technology Titanium Fix (I, II, III), Conexão (I, II, III), Neodent (I, II, III), Sterngold Implamed (I, II) and 3i Implant Innovation (I, II). The abutments were screwed to the implants with a 20 Ncm torque. For each sample, 6 points were selected for measurement, 3 on the right and 3 three on the left side: the most external point, the middle point and the most internal point at the interface formed between the implant platform and the abutment.

Results On the outer point there was a variation in measurement from 0 to 11.173 µm, on the middle point there was variation from 0 to 8.314 µm and in the internal point there was a variation from 0 to 15.267 µm. The smallest gaps for abutments I, II and III were obtained with Neodent (0.733 µm), Sterngold Implamed (0.513 µm) and Conexão (0.503 µm), respectively. The Neodent system showed statistically significant differences with the other systems analyzed in the right internal point ($p<0.05$), while on the left ones differences were not significant only with the the Conexão system ($p=0.168$); the latter showed statistically significant differences with the other systems except for the 3i system ($p=0.311$).

Conclusion It is concluded that the Neodent system differed from the other ones in the right and left internal points ($p<0.05$) except for the Conexão system ($p=0.168$), which also differed from the other ones, and the 3i system ($p=0.311$). Maladjustment values obtained are similar to those reported in the literature.

Keywords Implant, abutment, gap, peri-implant.

INTRODUCTION

Oral rehabilitation with dental implants requires clinical criteria based on performing the least traumatic surgery techniques, adequate surgical prosthetic planning, appropriate adaptation of the prosthesis on the implant, absence of movement on the abutment (1) on the one hand and on the other the patient's local and systemic health.

Jansen et al. (2) reported that microgaps between implants and abutments can act as niches for bacteria, enabling inflammatory reactions to occur in periimplant tissues. Adaptation of components both in the intra-system (same brand) and inter-system (different brands) situation can occur, but adaptation is safer when components of the same system are used (3).

Vidigal Jr. et al. (4) performed a study verifying the implant-abutment connection interface of five different types of titanium implants: Brånemark System™, Screw-vent, IMZ, TF and SR-Press. The latter presented a gap of 50 µm and the TF implant, a gap of up to 150 µm, which can help the accumulation of bacterial plaque in the oral environment.

Kano et al. (3) assessed the interfaces

Fig. 1 Three types of prosthetic components used: (a) conic (I), (b) gold ucla (II) and (c) mult unit (III).

between prosthetic components and implants using components of the same system and a combination of components of different systems: 3i, Lifecore, Conexão, Implamed, Nobelbiocare and Nápio. The results of the intra-system analysis were not statistically significant among the systems with regard to maladjustment (mean of 7.85 um), but the best fit in intra-system analysis was obtained by the Nobelbiocare systems (94.44%) and Implamed (90.27%) systems, followed by Lifecore (33.33%) and 3i (26.38%) systems. In inter-systems analysis, the authors suggested that not all the combinations can be considered compatible.
Gross et al. (5) demonstrated that microleakage can occur at the implant/abutment interface, causing a oral malodor and inflammation of the periimplant tissues. Increased torque on the screw from 10 Ncm to 20 Ncm significantly diminished microleakage in all systems.
Sartori and Franciscone (6) assessed the interface between gold intermediates and plastic cylinders. Initial analysis revealed interfaces with a mean gap of 5.7 µm (Nobelbiocare), 9.16 µm (3i), 10.49 µm (Conexão machined in gold), 17.82 µm (Carbontec in plastic) and 19.38 µm (Conexão in plastic). Measurements ranged from 5.8 to 20.4 µm in gold cylinders and from 23.10 µm to 141 µm in plastic cylinders.

Disadaptation between the base of the implant and the prosthetic abutment and the lack of passive fit can lead to fracture of the screw and to inadequate distribution of forces on the supporting bone tissue (7). Therefore, in the view of the importance of implant/abutment adaptation to eliminate retention of bacteria and reduce biomechanical strain on the screw, the purpose of this study was to assess by SEM, the existent interface (gap) between the platforms of five implant systems: AS Technology, Conexão, Neodent, Sterngold Implamed and 3i Implant Innovation and their respective abutments.

MATERIAL AND METHODS

In this study the following implant systems were used:

1) AS Technology, Implant Titanium fix;
2) Conexão Sistemas de Prótese, Implant Conexão;
3) Neodent Implante Osteointegrável, Implant Neodent;
4) Sterngold Implamed, Implant Implamed;
5) 3i Implant Innovations, Implant 3i.

Sample Selection

1) Implant: all implants were standard type, had machined surface, were 13 mm long and 3.75 mm wide, with a 4.1 mm prosthetic platform and external hexagon.

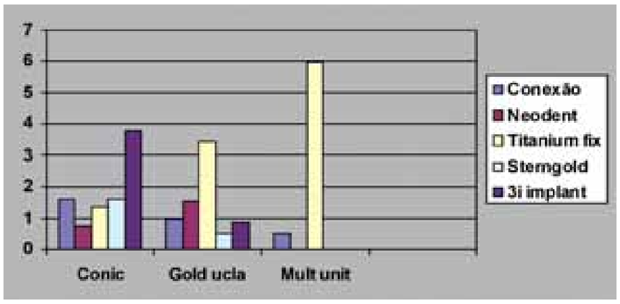

Fig. 2 Mean gap among implants systems and I, II and III abutment type.

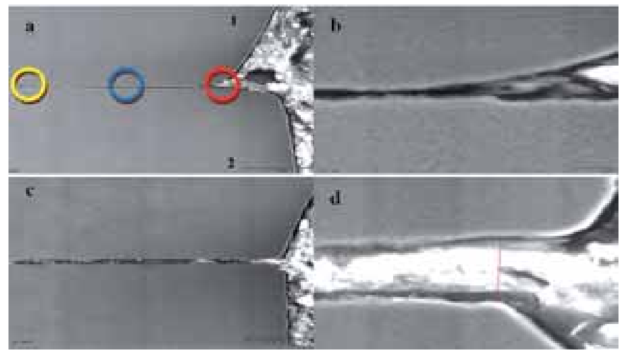

Fig. 3 Gap between implant/abutment I of the Neodent system, in the magnifications of 500X (a) and 5000X (b) and of the 3i systems in the magnifications of 500X (c) and 5000X (d). In the figure 3a the analyzed points are represented: the more outer point (red circle), the medium point (blue circle) and the more internal point (yellow circle) of the interface formed between the abutment (1) and the implant platform (2).

2) Prosthetic components: three types of prosthetic components were used: conic type (I), gold UCLA type (II) and mult unit type (III) (Fig. 1). The implant systems Conexão, Neodent and Titanium Fix have provided 6 implants: 2 implants connected with each abutment type (I, II, III). The implant systems Sterngold Implanted and 3i Implant Innovation provided 4 implants, namely 2 of type I and 2 of type II.

The abutments were screwed to the implants with a 20 Ncm torque, using a manual torquemeter.

Each group implant/abutment was embedded in bakelite with specific equipment (Embutidora metalográfica hidráulica manual, Panpress-30M, Pantec, Campinas, São Paulo, Brazil). After the embedding, samples were ground in longitudinal direction by using abrasive papers of different granulations (200 to 600). Polishing was performed with a 6 µm diamond powder granulation. Next, aluminum oxide paste was used for final polishing and removal of all remnants of grease and impurities; eventually, each sample was washed with alcohol and dried with a hair dryer.

After the entire cleaning procedure, the implant/abutment interface of the samples was analyzed by SEM. For each sample, 6 points, 3 on the right and 3 on the left side, were selected for measurement: the most external point, the middle point and the most internal point at the interface formed between the implant platform and the abutment at 3 points on the right and 3 on the left side.

To compare the results obtained, the Kruskal-Wallis non-parametric statistical test ($p<0.05$) was used.

RESULTS

The measurement of gaps in the abutment/implant interface for each sample varied from 0 to 15.267 µm (Table 1).

Considering the measured gaps in all the groups, in the outer point there was variation from 0 to 11.173 µm (mean: 4.77 µm), in the middle point the variation ranged from 0 to 8.314 µm (mean: 2.35 µm) and in the internal point the variation was from 0 to 15.267 µm (mean: 3.87 µm) (Fig. 2).

Considering implant/abutment adaptation, the Neodent system presented better results, followed by Titanium fix, Conexão, Sterngold Implamed and 3i Implant Innovation (Fig. 3). In type II abutment the

Implant Systems		Conexão		Neodent		Titanium Fix		Sterngold Implamed		3i Implant Innovation	
Abutments (Type)	Points	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
I	External	1.933	2.085	1.604	1.149	1.709	1.493	3.390	0.579	4.897	4.083
	Middle	2.635	1.298	0.595	0.252	1.271	0.157	0.422	0.256	3.589	4.187
	Internal	0.217	0.307	0	0	1.139	0.852	1.021	0.345	2.835	3.750
II	External	1.743	1.131	4.344	2.066	6.369	1.205	1.172	0.782	2.107	0.143
	Middle	0.289	0.102	0.297	0.181	2.914	3.808	0.157	0.016	0.253	0.085
	Internal	0.871	0.750	0	0	0.982	1.239	0.210	0.018	0.243	0.207
III	External	1.136	1.606	1.784	1.537	6.233	2.020	-	-	-	-
	Middle	0.374	0.358	0	0	2.224	0.070	-	-	-	-
	Internal	0	0	0	0	9.501	6.587	-	-	-	-

Tab.1 General Mean and Standard deviation (SD) (samples 1 and 2, right and left side) of the gaps obtained in the outer, medium and internal points to the different implant systems and abutment types analyzed.

smallest gap was found in the Sterngold Implamed system, followed by 3i Implant Innovation, Conexão, Neodent and Titanium fix systems. Type III abutment exhibited the smallest gap in Conexão system, followed by Neodent and Titanium fix.

Considering all the areas analyzed, 23 of them revealed gaps on the implants in relation to the abutments, 14 areas revealed gaps on the abutments, 9 areas presented deficient finishing on implants and 10 areas faulty abutment finishing. Figure 4 shows the graphic representation of these variations.

The gap values obtained for the different implant systems in the 3 points analyzed were statistically compared by the Kruskal-Wallis test ($p<0.05$) and a significant difference was recorded in the internal point on the right and the left side ($p=0.006$ and $p=0,003$ respectively), among the systems. In the multiple comparisons analysis, a statistically significant difference was found between Neodent system and the other systems, in the right internal point ($p<0.05$) (Fig. 5). Whereas for the left internal point a significant statistical difference was found between the Neodent and the other systems ($p<0.05$), except for Conexão ($p=0.168$); the latter significantly differed from all the other ones, except for the 3i system ($p=0.311$) (Fig. 6).

DISCUSSION

Gaps between implant platform the prosthetic abutment and lack of passive adaptation between the prosthesis and the abutments can alter the mechanical components, leading to abutment, screw and implant fracture. Furthermore, these gaps can lead to inadequate distribution of forces on the support bone, as well as bacterial penetration, gingival inflammation, and problems at the abutment/soft tissue interface (8).

In the present analysis, vertical gaps with variations from 0 to 15.267 µm were found between the abutment and the implant. Carvalho et al. (9) assessed the adaptation of Gold Ucla (3i) and Teflon Ucla (3i) abutments cast in commercially pure

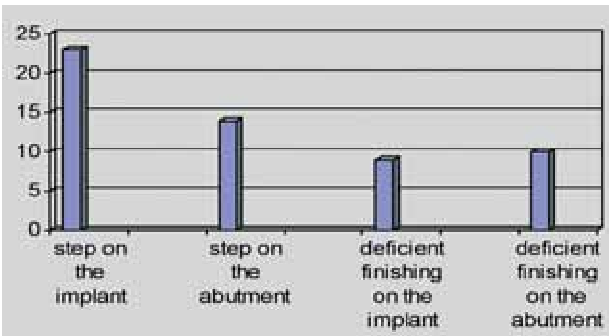

Fig. 4 Graphic representation of the variations in the samples (implant/abutment interface).

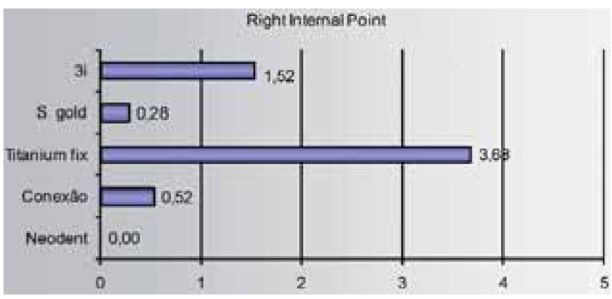

Fig. 5 Multiple comparisons analysis revealed a statistically significant difference between Neodent, in the right internal point, and the other systems ($p<0.05$).

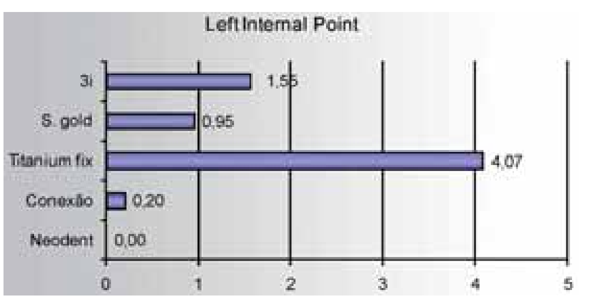

Fig. 6 Statistical difference between Neodent ($p<0.05$, in the left internal point, and the other systems, except for Conexão ($p=0.168$).

titanium (Ti cp) and nickel-chrome-titanium alloy (ni-Cr-Ti), Tilite. The authors analized 6 sides, after application of torques of 10 and 20 N.cm and they verified mean gaps of 7.517, 17.402 and 21.817 for Gold Ucla, Ucla abutments cast in Ni-Cr-Ti and Ucla cast in Ti cp, respectively, for torque of 20 Ncm.

In the present study the method for evaluation of the abutment/implant interface also consisted of analyzing 6 points and the mean gaps obtained were similar to those reported by Carvalho et al. (9), being a little smaller. However, a direct comparison of these results is not possible, since in the present study different prosthetic abutments, systems and methods of analysis were used.

Kano et al. (3), after an analysis on prosthetic component systems and implants, suggested that not all combinations can be considered compatible and that the best adjustment or adaptation was found between the prosthetic components and implant of the same manufacturer. The results obtained in this study revealed that even when using components and implants of the same manufacturer, gaps of 0 µm up to 15.267 µm can be found at the implant/abutment interface. These values are similar to those obtained in the studies of Sartori et al. (6) and Joly et al. (10). In these studies previously pointed out, the measurements were obtained of the external part of the interface between the abutment and the implant platform. However, in the present study, evaluations of abutment/implant interface were performed on the outer, middle and internal points in each side of the samples. Prosthetic maladjustement generates undesirable tensions, but the exact value capable to lead to clinical problems is still unknown (11).

Scarano et al. (12) report on 272 implants with screw or cement-retained abutments retrieved from humans for different causes during a 16-year period. In the implants with screw-retained abutments, a 60 µm microgap was present at the implant-abutment connection level. Besides, bacteria were often present in the microgaps between implant and abutment and in the internal portion of the implants.

In implants with cement-retained abutments, a 40 µm microgap was found at the level of the implant-abutment connection and all the internal voids were always completely filled by cement. No bacteria were observed in the internal portion of the implants or at the level of the microgap. The authors concluded that the size differences of the microgap between the two groups were statistically significant and that in screw-retained abutments the microgap can be a critical factor for bacteria colonization. The authors also verified that in these retrieved implants, the size of the microgap was markedly variable and much larger than that observed in vitro.

The gap values obtained in this study can favor bacterial infiltration at the implant/abutment interface and/or the prosthetic micromovement, which can lead to problems such as peri-implantitis and crestal bone remodeling. The precise mechanisms of bone loss around dental implants are poorly understood (13, 14). Broggini et al. (15) reported that the accumulation of bacteria in the peri-implant tissues promotes the activation of inflammatory cells with an increased formation of osteoclasts and subsequent bone resorption.

The mechanical importance of microgaps at the abutment/implant interface is related to a possible screw loosening and abutment fracture (16). Considering this problem, many manufacturers have attempted to improve the abutments and implant designs to achieve a more predictable method for tightening screws. Thus, in the past few years, cemented prostheses have been introduced that allow prosthetic crowns to be cemented directly onto the implant abutment, suggesting a higher potential of passive fit in the light of the fact that the cement space between retainer and abutment could compensate for minor prosthesis misfits (12).

The values of gaps obtained in this study can favor bacterial infiltration at the implant/abutment interface and/or the prosthetic micromovement which can lead to problems, such as periimplantitis and bone loss. Broggini et al. (13) reported that the accumulation of bacteria in the periimplant tissues promotes the activation of inflammatory cells with increase in the formation of osteoclasts and subsequent bone resorption. Furthermore, the presence of steps was verified in the implants and abutments analyzed, as well as differences in finishing quality at the edges of both the implants and the abutments. Therefore, in addition to the many factors that have to be considered for the success of osseointegration, it is of extreme importance that the materials used are of the best quality. Manufacturers must perform strict quality controls on their production, in order to supply the surgeons appropriate products. Moreover, the implantologist should take specific care when manipulating the components and inserting the prosthesis to minimize problems related to material limitations and consequent implant/abutment maladjustment and prevent bone loss, screw and prosthesis fractures or even fracture of the osseointegrated implant.

CONCLUSIONS

Considering the method used, it is possible to conclude the following.

1) According to the measurements obtained, the smallest gaps were found respectively in: a) type I abutments of Neodent system; b) type II abutments of Sterngold Implamed system; c) type III

abutments of Conexão system;

2) Neodent system differed from the other ones in the right and left internal point except for the Conexão system in the left internal point; this last one also differed form the other ones, with the exception of 3i system.
3) Maladjustment values obtained were similar to those reported in the literature and can generate undesirable mechanical and biological alterations. However, no clinically acceptable exact maladjustment values have yet been pointed out in the literature.

REFERENCES

1. Zarb GA, Zarb FL. Tissue integrated dental prostheses. Quintessence International 1985; 16: 39-42.
2. Jansen VK, Conrads G, Richter E. Microbial leakage and marginal fit of the implant/abutment interface. International Journal of Oral and Maxillofacial Implants 1997; 12:527-540.
3. Kano SC. Avaliação da adaptação da interface intermediário/cilindro de ouro e da compatibilidade de diferentes sistemas de implantes odontológicos: analise intra e entre sistemas. Dissertação (Mestrado) – Faculdade de Odontologia, Universidade de São Paulo. Bauru, 1998. 81f.
4. Vidigal GM Jr, Novaes AB Jr, Chevitarese O, de Avillez RR, Groisman M. Evaluation of the implant-connection interface using scanning electrón microscopy. Brazilian Dental Journal 1995; 6:17-23.
5. Gross M, Abramovich I, Wiess EI. Microleakage at the abutment-implant interface of osseointegrated implants: a comparative study. International Journal of Oral and Maxillofacial Implants. 1999; 14:94-100.
6. Sartori IAM, Franciscone CE. Análise comparativa da interface intermediário/cilindro protético. Revista Brasileira de Odontologia 2000;57:367-371.
7. Guimarães MP, Nishioka RS, Bottino MA. Analysis of implant/abutment marginal fitting. PGR-Pós-Grad. Rev. Fac. Odontol. São José dos Campos., v.4, n.2, p.12-19, Maio/Ago 2001.
8. Taylor TD. Prosthodontic problems and limitations associated with osseointegration Journal of Prosthetic Dentistry 1998; 79:74-78.
9. Carvalho MCA, Bondioli IR, Costa EMV, Nishioka RS, Bottino MA, Neisser MP. Avaliação microscopic entre a adaptação dos pilares Gold UCLA à plataforma do implante e UCLA de Teflon fundidos em titânio e liga de níquel-crômio-titânio. Estudo in vitro. BCI. 2002; 9:105-110.
10. Joly JC, Lima AFM. Characteristics of implant surface and implant-abutment gap in two-and one stage systems. Journal of Applied Oral Science 2003; 11:107-113.
11. Taylor TD, Agar JR. Twenty years of progress in implant prosthodontics. Journal of Prosthetic Dentistry 2002; 88:183-191.
12. Quirynem M, Bollen CM, Eyssen H, van Steenberghe D. Microbial penetration along the implant components of the Branemark system: an in vitro study. Clinical Oral Implants Research 1994;5:239-244.
13. Broggini N, Mcmanus LM, Hermann JS, Medina RU, Oates TW, Schenk RK, Buser D, Mellonig JT, Cochran DL. Persistent acute inflammation at the implant-abutment interface. Journal of Dental Research 2003; 82:232-236.
14. Misch CE. Early crestal bone loss etiology and its effect on treatment planning for implants. Postgraduate Dentistry1995; 2: 3-16.
15. Broggini N, Mcmanus LM, Hermann JS, Medina RU, Oates TW, Schenk RK, Buser D, Mellonig JT, Cochran DL. Persistent acute inflammation at the implant-abutment interface. Journal of Dental Research 2003; 82:232-236.
16. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JYK. Clinical complications with implants and implant prostheses. Journal of Prosthetic Dentistry 2003;90: 121-132.