Association Between Transmucosal Depth of Osseointegrated Implants and Malodor Production

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Purpose: *The aim of the present study was to test the association between transmucosal depth of 2-stage dental implants and malodor production.* ***Materials and Methods:*** *Fifty-nine 2-stage implants were tested in 14 patients. Measurements were conducted 3 to 4 weeks following second-stage surgery. Measurements included healing abutment malodor scored using a subjective scale, volatile sulfide compounds levels measured using a sulfide monitor (Halimeter), and microbial sampling for anaerobic growth and malodor production.* ***Results:*** *All the malodor-related parameters measured in this study were significantly associated with the transmucosal depth. A significant increase in severity was observed concomitant with the increase in transmucosal depth.* ***Conclusion:*** *Based upon the data from this study of 59 two-stage implants in 14 patients, it appears that transmucosal depth of 2-stage dental implants may be an important factor affecting the presence of anaerobic bacterial population and resulting malodor production within the implant-abutment interface.* (Case Series) INT J ORAL MAXILLOFAC IMPLANTS 2008;23:277–280

Key words: *bacteria, dental implants, malodor, transmucosal*

Oral malodor is often caused by bacteria.[1] The bacteria involved in this process are, for the most part, anaerobic proteolytic oral bacteria, such as *Porphyromonas gingivalis, Fusobacterium nucleatum,* and *Prevotella intermedia*.[2,3] These bacteria break down oral proteins into the amino acids that compose them, which are further metabolized to yield malodorous compounds such as hydrogen sulfide and methyl mercaptan (ie, volatile sulfide compounds).[4] These anaerobic micro-organisms are commonly found on the tongue dorsum[5] and in periodontal pockets.[6] However, various studies have demonstrated their presence in the microleakage occupying the internal compartment of the implant-abutment interface of 2-stage dental implant systems.[7,8] The presence of bacteria there has also been implicated as a cause for peri-implantitis and marginal bone loss.[7]

In view of this, it is hardly surprising that the opening of a healing abutment is often accompanied by foul smells. Clinical observations led the present authors to hypothesize that the depth of the implant-abutment microgap within the soft tissue is one of the major factors affecting the severity of this problem. Thus, the aim of the present study was to test the association between the transmucosal depth of 2-stage implant systems and malodor production.

MATERIALS AND METHODS

Experimental Protocol

Patients selected for this study were required to meet certain criteria. They were included only if they exhibited excellent periodontal health (ie, less then 10% bleeding on probing). Patients who were smokers or took antibiotics within a month prior to the study were excluded. Informed consent was obtained, and the experiment protocol was approved by and ethics committee in accordance with the Helsinki declaration and registered at the NIH-FDA protocol registration system (NCT00254839).

Patients were asked to refrain from eating or drinking for 2 hours prior to measurements. Measure-

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ments included subjective odor scores, volatile sulfide levels, and microbial sampling for viable counts and malodor production following anaerobic incubation. All measurements were conducted 3 to 4 weeks following second-stage surgery at the first removal of the healing abutment. Transmucosal depth was measured using a Nabers probe. Transmucosal depth was measured at 4 points, and the maximal depth was recorded.

Measurements

Organoleptic Measurements. The malodor emanating from the healing abutment was subjectively scored by a single observer using the following scale: 0 = no odor, 1 = barely noticeable odor, 2 = slight but clearly noticeable odor, 3 = moderate odor, 4 = strong odor, 5 = extremely foul odor.[9] The odor judge was given a verbal explanation of the malodor intensity scale and the opportunity to sniff a reference sample of n-butanol at a level 3 intensity.[10] Malodor was scored by sniffing the abutment immediately after uncovering it.

Volatile Sulfide Measurements. The healing abutments were placed into closed test tubes for 5 minutes prior to measuring headspace volatile sulfide compound levels in the test tubes. Volatile sulfide compound levels were measured using a portable sulfide monitor (Halimeter; Interscan, Chatsworth, CA).[11] The monitor was zeroed on ambient air, and the measurements were performed by the insertion of a 1/4-inch plastic straw approximately 2 cm into the test tube immediately after opening it.[12] Results were recorded as peak ppb sulfide equivalents.

Microbial Measurements. Sampling of the internal compartment of the implant-abutment interface was conducted using a sterile paper point (#40, SPI Dental Manufacturing, Inchon, Korea). The internal surface of the implant at the implant-abutment interface was circumferentially wiped with the paper point.[8] After sampling the paper points were placed into test tubes containing 2 mL of decarboxylase media and incubated at 37°C for 72 hours under anaerobic conditions.[11] Anaerobic conditions were obtained using an anaerobic jar and an AnaeroGen anaerobic kit (Oxoid, Hampshire, United Kingdom). Following incubation, malodor production in the test tubes was scored by a single observer using the aforementioned 0-to-5 scale. Volatile sulfide compound production was measured using a sulfide monitor, and viable counts were determined by plating 10 mL aliquots of tenfold serial dilutions in phosphate-buffered saline onto trypticase soy agar sheep blood agar plates (Hy-Labs, Rehovot, Israel). The plates were incubated at 37°C for 24 hours under anaerobic conditions.

Statistical Analysis

To compare the effect of transmucosal depth on the quantitative variables, analysis of variance was applied with post-hoc pairwise comparisons according to Dunnet and Scheffé. Kruskal-Wallis nonparametric analysis of variance was applied to compare the effect of transmucosal depth on the rank variables (subjective odor scores) as well as on the quantitative variables. For the rank variables the Mann-Whitney nonparametric test was applied for pairwise comparisons, using the Bonferroni correction for significance level. The Spearman nonparametric correlation coefficient was calculated to estimate the association between pairs of variables. All the tests applied were 2-tailed, and $P \leq .05$ was considered statistically significant.

RESULTS

The study population consisted of 14 patients (12 women and 2 men; mean age, 55.2 ± 9.3) treated at the Hebrew University–Hadassah School of Dental Medicine graduate program clinic in prosthodontics. Two patients were totally edentulous and the rest were partially edentulous. A total of 59 two-stage implants from different manufacturers, 41 of the Brånemark system (Nobel Biocare, Göteborg, Sweden) and 18 of the Centerpulse system (Centerpulse Dental, Carlsbad, CA), 44 maxillary and 15 mandibular, were distributed among the patient population. All the implants exhibited clinical and radiographic evidence of complete osseointegration without complications.

Both subjective odor scores and volatile sulfide compound levels emanating from the healing abutments of the 2-stage implant systems increased concomitantly with the increase in transmucosal depth (Figs 1 and 2). Malodor levels from the healing abutments with a transmucosal depth of 3 or 4 mm were significantly higher than those from the 1-mm ($P = .004$ and $P = .03$, respectively) or 2-mm groups ($P < .001$ and $P = .007$). VSC levels showed the same pattern; healing abutments with a transmucosal depth of 3 or 4 mm were associated with significantly higher sulfide monitor readings than those from the 1-mm ($P = .001$ and $P = .01$) and 2-mm groups ($P = .005$ and $P = .008$).

The anaerobic incubation of the microbial samples taken from the implant-abutment interface of the various implants resulted in an increase in malodor production ability and bacterial counts concomitant with the increase in transmucosal depth (Figs 3 and 4). Significant increases in malodor production ability were demonstrated between 1 mm and 2 mm of transmucosal depth ($P = .03$), and

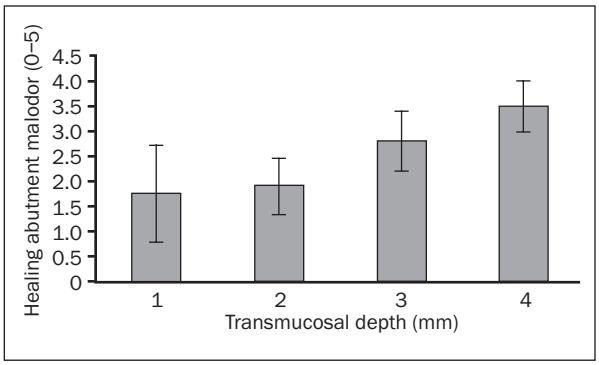

Fig 1 Mean results ± standard deviation of the malodor levels emanating from the healing abutments of the implants grouped according to their transmucosal depth. Malodor was scored by a single observer using a semi-integer scale of 0 to 5.

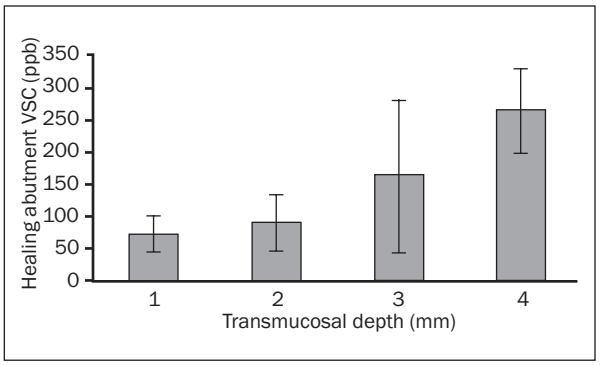

Fig 2 Mean results ± standard deviation of the volatile sulfide compound (VSC) levels emanating from the healing abutments of the implants grouped according to their transmucosal depth. VSC levels were measured using a sulfide monitor (Halimeter) and recorded as ppb sulfide equivalents.

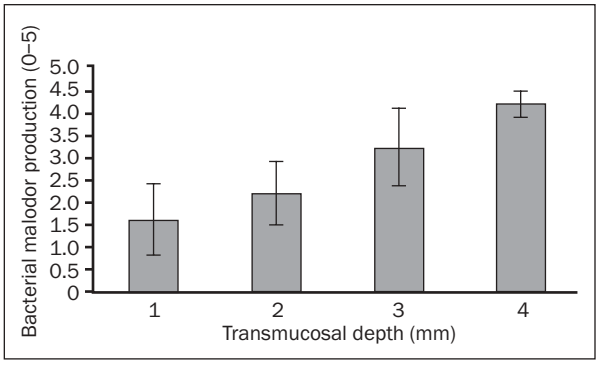

Fig 3 Mean results ± standard deviation of the malodor produced by the microbial samples taken from the implant-abutment interfaces of the implants following anaerobic incubation in decarboxylase media. Malodor was scored subjectively using a semi-integer scale of 0 to 5.

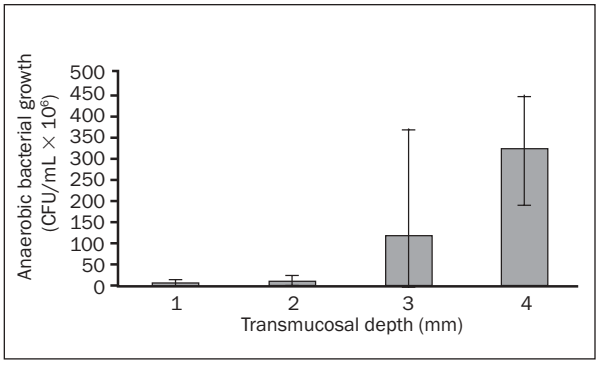

Fig 4 Mean results ± standard deviation of the anaerobic growth of the microbial samples taken from the implant-abutment interfaces of the implants. Microbial counts are described as CFU/mL ($\times 10^6$).

between 2 mm and 3 and 4 mm ($P = .001$, $P = .008$). Bacterial counts for 3 and 4 mm transmucosal depth were significantly higher then those for 1 mm ($P = .001$, $P = .01$) and 2 mm ($P = .001$, $P = .005$).

The level of association between the transmucosal depth and the various parameters was assessed by Spearman correlations (Table 1). All the parameters measured were significantly associated with the transmucosal depth, including healing abutment malodor and VSC production and bacterial counts and malodor production ability following anaerobic incubation, yielding r values ranging from 0.536 to 0.661.

Table 1 Spearman Correlation Coefficient Between Transmucosal Depth and Malodor-Related Parameters

Transmucosal depth	Healing abutment malodor*	Healing abutment VSC†	Bacterial malodor production*	Anaerobic bacterial growth‡
r	0.558	0.536	0.661	0.541
P	< .001	.001	.001	.001

*Measured subjectively on a scale of 0 to 5.
†Measured by a sulfide monitor in ppb sulfide equivalents. VSC = volatile sulfide compound.
‡CFU/mL.

DISCUSSION

In the present study, the hypothesis that transmucosal depth of 2-stage implant systems is related to malodor production was tested. Spearman correlations analysis showed that the transmucosal depth was significantly associated with both the malodor and volatile sulfide compounds emanating from the healing abutments, as well as the anaerobic growth and malodor-producing ability of the microbial samples taken from the implant-abutment interfaces of these implants. Furthermore, significantly higher malodor levels were measured in the implants with transmucosal depth of 3 and 4 mm as compared to 1 and 2 mm. These results indicate that the transmucosal depth of the implant-abutment interface is an important factor that affects the severity of the malodor emanating from 2-stage implant systems.

Anaerobic incubation of the microbial samples taken from the implant-abutment interface of implants with greater transmucosal depths (ie, 3 and 4 mm) resulted in significantly higher microbial counts and malodor production as compared to the shallower ones (ie, 1 and 2 mm). This suggests that the implant-abutment interfaces of implants with larger transmucosal depth harbor a larger proportion of anaerobic proteolytic bacteria of the kind implicated in oral malodor production and periodontal disease. The presence of periopathogenic bacteria has been previously demonstrated in the internal surfaces of 2-stage implant systems.[7] However, to the best of the authors' knowledge, the question of malodor production has not yet been addressed.

Given that the subjects in this study had excellent periodontal health, it is very likely that the main source for the anaerobic malodor-producing bacteria harbored in the implant-abutment interface originated from the tongue dorsum. Other researchers have demonstrated the importance of the anaerobic bacterial population of the tongue in oral malodor production.[5]

Although the methods used in this study did not enable the identification of these anaerobic bacteria, other studies employing molecular methods have shown them to include periopathogenic bacteria, such as *Fusobacterium nucleatum* and *Porphyromonas gingivalis*.[8] Given the implicated role of these bacteria in oral malodor production and periodontal disease, it is of clinical importance that the implant-abutment interface of 2-stage dental implants not function as a reservoir for these bacteria. Therefore, when possible, placing the implant-abutment interface no deeper then 2 mm could be a way to avoid this problem.

Whether or not this phenomenon contributes to the overall condition of oral malodor is not yet clear. However, leaky crowns and restorations and contaminated dentures have always been considered major risk factors in oral malodor production.[13] The contribution of implants, especially deeply seated 2-stage implants, to this condition warrants further investigation.

CONCLUSION

Based upon the data from this study of 59 two-stage implants in 14 patients, it appears that transmucosal depth of 2-stage dental implants may be an important factor affecting the presence of anaerobic bacterial population and resulting in malodor production within the implant-abutment interface.

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REFERENCES

1. Tonzetich J. Production and origin of oral malodor: A review of mechanisms and methods of analysis. J Periodontol 1977;48: 13–20.
2. Berg M, Fosdick LS. Studies in periodontal disease. II. Putrefactive organisms in the mouth. J Dent Res 1946;25:73–81.
3. McNamara TF, Alexander JF, Lee M. The role of microorganisms in the production of oral malodor. Oral Surg 1972;34:41–48.
4. Tonzetich J, McBride BC. Characterization of volatile sulphur production by pathogenic and non-pathogenic strains of oral Bacteroides. Arch Oral Biol 1981;26:963–969.
5. De Boever EH, Loeche WJ. Assessing the contribution of anaerobic microflora of the tongue to oral malodor. J Am Dent Assoc 1995:126:1384–1393.
6. Shiloah J, Patters MR. Repopulation of periodontal pockets by microbial pathogens in the absence of supportive therapy. J Periodontol 1996;67:130–139.
7. Quirynen M, van Steenberghe D. Bacterial colonization of the internal part of two-stage implants. Clin Oral Implants Res 1993;4:158–161.
8. Callan DP, Cobb CM, Williams KB. DNA probe identification of bacteria colonizing internal surfaces of the implant-abutment interface: A preliminary study. J Periodontol 2005;76:115–120.
9. Greenman J, Duffield J, Spencer P, et al. Study on the organoleptic intensity scale for measuring oral malodor. J Dent Res 2004; 83:81–85.
10. Nachnani S, Majerus G, Lenton P, Hodges J, Magallanes E. Effect of training on odor judges scoring intensity. Oral Dis 2005;11:40–44.
11. Rosenberg M, Kulkarni GV, Bosy A, McCulloch CAG. Reproducibility and sensitivity of oral malodor measurements with a portable sulphide monitor. J Dent Res 1991;70:1436–1440.
12. Goldberg S, Kozlovsky A, Rosenberg M. Association of diamines with oral malodor. In: Rosenberg M (ed). Bad Breath: Research Perspectives, ed 2. Tel Aviv: Ramot Publishing, 1997:71–85.
13. Rosenberg M. Clinical assessment of bad breath: Current concepts. J Am Dent Assoc 1996;127:475–482.