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Incidence of bacteremia after chewing, tooth brushing and scaling in individuals with periodontal inflammation

Lone Forner[1], Tove Larsen[2], Mogens Kilian[3] and Palle Holmstrup[4]

[1]Department of Periodontology, University of Copenhagen, Copenhagen, Denmark;
[2]Department of Oral Microbiology, University of Copenhagen, Copenhagen, Denmark;
[3]Institute of Medical Microbiology and Immunology, Aarhus University;
[4]Department of Periodontology, University of Copenhagen, Copenhagen, Denmark

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Abstract

Scientific rationale for study: Bacteremia occurs with various frequency after oral procedures. Periodontal disease may affect the incidence, magnitude, duration and bacterial spectrum of bacteremia.

Principle findings: The incidence and magnitude of bacteremia after scaling was significantly higher in periodontitis than in gingivitis patients and healthy control individuals. In periodontitis patients, the magnitude of bacteremia was associated with gingival index, plaque index and number of sites with bleeding on probing, but not with probing pocket depth measurements.

Practical implications: The prevention and treatment of periodontal diseases appear to be crucial for the prevention of bacteremia associated with oral procedures.

Key words: bacteremia; chewing; periodontitis; scaling; tooth brushing

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Bacteremia frequently occurs after dental treatment procedures such as extractions (Heimdahl et al. 1990, Roberts et al. 1997, Rajasuo et al. 2004), scaling (Conner et al. 1967, Heimdahl et al. 1990, Kinane et al. 2005), periodontal probing (Daly et al. 1997, 2001, Kinane et al. 2005), suture removal (King et al. 1988, Giglio et al. 1992), orthodontic treatment (Erverdi et al. 1999, Erverdi et al. 2001, Lucas et al. 2002a, b), restorative dentistry (Roberts et al. 1997) and non-surgical root canal treatment (Debelian et al. 1995, Savarrio et al. 2005). However, not only professional treatment, but also chewing (Cobe 1954, Guntheroth 1984) and oral hygiene procedures such as tooth brushing (Roberts et al. 1997, Bhanji et al. 2002, Kinane et al. 2005) and dental flossing (Lineberger & De Marco 1973) have been reported to give rise to bacteremia. Although most of such bacteremias are transient, it has long been recognized that oral bacteria may cause distant site infections (Duel et al. 1991, LaPorte &et al. 1999). There is currently significant interest in the possibility that bacteremia with oral bacteria also may play a role in the pathogenesis of atherosclerosis (Herzberg & McFarlane 1994). A meta-analysis of epidemiologic studies reveal an association between periodontal disease and cardiovascular disease (Janket et al. 2003) and several studies have demonstrated the presence of certain oral bacteria in atherosclerotic plaques and abdominal aortic anaeurysms, in particular species that have been implicated in the pathogenesis of periodontal disease (Haraszthy et al. 2000, Okuda et al. 2001, Taylor-Robinson et al. 2002, Kurihara et al. 2004, Fiehn et al. 2005). Signs of viable *Actinobacillus actinomycetemcomitans* and *Porphyromonas gingivalis* has recently been demonstrated in human atherosclerotic plaque material (Kozarov et al. 2005). While the focus has been mainly on dental surgical procedures as the cause of bacteremia, recent studies have suggested that everyday events such as chewing and tooth brushing contribute more significantly to the cumulative exposure of the vascular system to oral bacteria (Roberts 1999).

In previous studies of bacteremia blood culture methods of varying sensitivity have been used. It was the aim of the present study to determine the nature of bacteremia using the most sensitive blood culture method identified (Gill et al. 1984, Lucas et al. 2002a, b) in order to minimize the occurrence of false-negative blood cultures.

The majority of previous studies in this field have mainly focused on the impact on bacteremia of the procedures performed. Consequently, there is limited information regarding the impact on bacteremia of the periodontal condition. Thus, in the study reported here we tested the hypothesis that the risk of experiencing bacteremia after everyday oral procedures is associated with the

severity of periodontal inflammation because the ulcerated pocket epithelium may facilitate bacterial entrance into the circulation and because of the pronounced accumulation of bacteria in the region. We determined the incidence, magnitude, duration, and nature of bacteremia in individuals with periodontitis, gingivitis, and clinically healthy periodontium after chewing, tooth brushing and scaling.

Materials and Methods

Patient selection

Sixty systemically healthy individuals were recruited at The School of Dentistry, University of Copenhagen, Denmark. The regional ethical committee approved the study. All participants were informed about procedures and informed consent was obtained in writing.

Exclusion and inclusion criteria

The exclusion criteria were: antibiotic treatment within the latest 6 months, any other pharmacological treatment than oral contraceptives, systemic diseases and chronic infections other than periodontitis. Furthermore, patients with prosthetic heart valves, previous endocarditis, transplants, pregnant or lactating women, and individuals with pulpal or periapical infections were excluded. The participants were categorized into three groups (Table 1 shows patient data):

Table 1. Patient data

	Healthy	Gingivitis	Periodontitis
Age (years)			
Mean	30.4	28.15	43.75
Minimum	22	21	28
Maximum	63	36	63
Gender			
Men	11	10	5
Women	9	10	15
Smoking (number of persons)			
Smokers	8	11	11
Non-smokers	12	9	9
Time used for scaling (minutes)			
Mean	13.7	20.5	27.5
Minimum	9	11	25
Maximum	19	25	30
Number of teeth			
Mean	30	30	27
Minimum	27	28	21
Maximum	32	32	28
Gingival index			
Mean	0.06	1.66	1.66
Minimum	0.00	1.15	0.86
Maximum	0.30	2.10	2.18
Plaque Index			
Mean	0.10	1.01	1.12
Minimum	0.00	0.47	0.23
Maximum	0.40	2.06	2.29
Bleeding on probing (number of sites)			
Mean	3.15	99.9	94.4
Minimum	0	49	30
Maximum	12	192	168
Number of pockets > 5 mm			
Mean	0	0	47.2
Minimum	0	0	15
Maximum	0	0	111
Pocket sum score (mm)			
Mean	263	460.6	756.9
Minimum	174	321	464
Maximum	392	576	1083

(1) *Periodontitis*. Inclusion criterium: severe periodontitis, defined as at least 10 sites with probing pocket depth (PPD) > 5 mm. Eleven were diagnosed with aggressive periodontitis and nine with chronic periodontitis (Armitage 2000).
(2) *Gingivitis*. Inclusion criteria: distance between cemento-enamel junction (CEJ) and alveolar bone not evidently exceeding 2 mm on radiographs, PPD < 4 mm, and gingival index (GI) > 1.5 (Löe & Silness 1963).
(3) *Healthy periodontium*. Inclusion criteria: distance between CEJ and alveolar bone not evidently exceeding 2 mm on radiographs, PPD < 4 mm, and GI < 0.5 (Löe & Silness 1963).

Clinical examination

A thorough patient history was obtained regarding systemic health and intake of medication. Smoking habits were registered (number of cigarettes/day, years of smoking). Before inclusion, full-mouth periodontal registration was performed, including the following clinical variables: PPD, GI (Löe & Silness 1963), plaque index (PI) (Silness & Löe 1966), bleeding on probing (BOP), and clinical attachment level (CAL). All PPD measurements were added in order to estimate the area of the pocket epithelium, expressed as pocket sum score (PSS). Full-mouth radiographical examination was performed with periapical and bitewing radiographs. The clinical examination was performed at least 1 week before participation.

Experimental procedures

The three experimental procedures were: (1) Chewing on three pieces of chewing gum base performed for 10 min. (2). Supervised tooth brushing performed for 2 min. after a thorough instruction to ensure standardization among the participants. With the purpose of brushing each quadrant with same intensity and periods of time, the oral cavity was divided in eight areas consisting of the four quadrants' facial and lingual aspects. The participants were instructed to brush the teeth and attached gingiva of each area with circular movements for 15 s. A medium hardness toothbrush (Tandex 40, Tandex, Denmark) was used. The procedure was supervised by the investigator (L. F.). (3) Full-mouth scaling was for ethical reasons performed according to individual need by a combination of hand instruments and airscaler (Sonicflex, KaVo, Denmark). The time used for scaling was recorded. All participants were exposed to the three experimental procedures in the following order: chewing, tooth brushing, and scaling on separate days with at least

6 days in between. They were examined and treated by the same dentist (L. F.).

Blood sampling

After disinfection of the skin at the site of venipuncture with 0.5% chlorhexidine ethanol, an indwelling catheter was placed in the antecubital vein. The catheter was rinsed with sterile, isotonic saline after insertion and after obtaining each blood sample. The site of venipuncture was covered by a sterile pad to avoid contamination. Two mililitres of blood was discarded before drawing the blood for the bacteremia analysis in order to avoid addition of saline from the previous flush. Blood samples at baseline and at 0.5, 10, and 30 min. after each procedure were examined for bacteremia. Timing of blood sampling was chosen in accordance with a previous study demonstrating the highest incidence of bacteremia after 0.5 min. (Roberts et al. 1992). The 9 ml blood samples were collected in tubes containing 1.86 ml of 0.35% sodium polyanethol sulphonate (SPS).

Analysis for bacteremia

Detection of microorganisms in the blood samples was done by the lysis-filtration method (Heimdahl et al. 1990). Within 15 min. the blood samples were added to a lysing solution consisting of 190 ml 0.005% Triton X-100 (Sigma, Copenhagen, Denmark), 0.08% Na_2CO_3 and 3 ml streptokinase–streptodornase (Varidase, MEDA, Alleroed, Denmark) under anaerobic conditions. After 10 min., the liquid was vacuum filtered through a 0.45 µm pore-size cellulose acetate filter with a diameter size of 47 mm. Subsequently, the filters were transferred to tryptic soy agar (TSA, Oxoid, Greve, Denmark) plates and incubated anaerobically (80% N_2, 10% H_2, 10% CO_2) at 37°C for 10 days (Heimdahl et al. 1990).

Identification of bacteria

All colonies growing on the primary agar plate cultures were counted and transferred to a TSA plate. After 3–5 days, the isolates were described morphologically, Gram stained, tested for catalase activity, growth under aerobic conditions and in a CO_2-containing (7.5%) atmosphere.

Gram-positive, catalase-negative cocci were further identified based on colony morphology on mitis–salivarius agar (Difco, Broendby, Denmark), ability to hydrolyse arginine and esculine, and production of IgA1 protease (Kilian et al. 1989). Isolates that lacked the ability to hydrolyse arginine and esculine were assigned to species according to partial sequences of the *gdh* gene with reference to a comprehensive database of *gdh* sequences of type and reference strains of the species *Streptococcus mitis*, *Streptococcus oralis*, *Streptococcus infantis* and *Streptococcus pneumoniae*. Isolates hydrolysing arginine and/or esculine were identified by partial sequencing of the 16S ribosomal RNA gene and BLAST search using the database at www.ncbi.nlm.nih.gov/. Only close relationship to designated type strains was taken into account (M. Kilian, K. Poulsen and U. Skov, Sørensen, in preparation).

Gram-positive rods were checked for growth on Rogosa SL agar (Difco) (selective for *Lactobacillus* species) (Rogosa 1951). The identity of irregular Gram-positive rods showing branching was confirmed by APIZYM (bioMérieux, Herlev, Denmark) (Kilian 1978). Likewise, black-pigmented, Gram-negative coccoid rods were identified according to the APIZYM test system (Durmaz et al. 1995). Nine strains were unidentifiable in our laboratory because of lack of matching with biochemical tests. Further identification was performed in the reference laboratory at the Statens Serum Institute, which led to identification of six strains, while three remained unidentified.

Statistical analyses

A 5% level of significance was used in the statistical analyses. The analyses were performed using the statistical analysis system (SAS) for pc (SAS Institute 1987) SAS/STAT guide for personal computers, 6th edition, SAS Institute Inc., Cary, NC, USA). Differences in the incidences of bacteremia between groups were analysed by Fisher's exact test. Differences in magnitudes (CFU/ml) between groups were analysed by the Kruskal–Wallis test. Correlations between bacteremia and clinical variables were analysed by Spearman's correlation coefficients.

Results

Incidences of bacteremia

None of the 60 subjects were detectably bacteremic before the three experimental procedures. Following chewing four (20%) of the periodontitis patients were bacteremic whereas none of the periodontally healthy individuals or gingivitis patients showed evidence of bacteremia.

None of the periodontally healthy individuals or gingivitis patients was bacteremic after tooth brushing. However, one (5%) of the periodontitis patients was bacteremic immediately after tooth brushing. After 30 min., bacteremia was found in another patient from whom no bacteria were recovered in the blood samples collected at 0.5 or 10 min. after tooth brushing.

Bacteremia after scaling occurred in two (10%) of the healthy participants, in four (20%) of the gingivitis patients, and in 15 (75%) of the periodontitis patients. The magnitude decreased considerably within the 30 min.

Duration of bacteremia

Among the 29 bacteremic episodes after termination of chewing, tooth brushing or scaling, nine remained uncleared after 10 min. Seven of the nine episodes occurred after scaling, while the remaining two occurred after tooth brushing. After 30 min., bacteremia was detectable in four individuals. Among these four episodes, one occurred after chewing, one after tooth brushing and two after scaling. Incidences, magnitudes, and durations of bacteremia cases after each of the three experimental procedures are summarized in Table 2.

Identity of blood isolates

A total of 163 isolates were collected from 29 bacteremic episodes in 23 of the 60 participants. The isolates were from two healthy individuals, four gingivitis patients, and 17 periodontitis patients after chewing, tooth brushing or scaling. As shown in Table 3, the bacterial isolates included a range of *Streptococcus*, *Enterococcus*, *Actinomyces*, *Lactobacillus*, *Corynebacterium*, *Porphyromonas*, *Prevotella* and *Fusobacterium* species in addition to one isolate of *Candida*. The most predominant *Streptococcus* species were *S. mitis*, *S. oralis*, and *S. sanguis*. Five streptococcal isolates from three individuals remained unidentified because their characteristics did not fit any of the currently recognized species. Among the anaerobic Gram-negative rods *Prevotella intermedia* and *Fusobacterium nucleatum* were most frequently isolated. Sixteen of the

Table 2. Incidence, magnitude and duration of bacteremia after chewing, tooth brushing and scaling

	Healthy	Gingivitis	Periodontitis
Incidence, chewing			
Baseline	0	0	0
0.5 min.	0	0	4 in 20
10 min.	0	0	0
30 min.	0	0	1 in 20
Incidence, tooth brushing			
Baseline	0	0	0
0.5 min.	0	0	1 in 20
10 min.	0	0	2 in 20
30 min.	0	0	1 in 20
Incidence, scaling			
Baseline	0	0	0
0.5 min.	2 in 20	4 in 20	15 in 20
10 min.	1 in 20	0	7 in 20
30 min.	0	1 in 20	2 in 20
Mean magnitude in positive samples (CFU/ml) [range], chewing			
Baseline	0	0	0
0.5 min.	0	0	0.19 [0.11–0.22]
10 min.	0	0	0
30 min.	0	0	0.11
Mean magnitude in positive samples (CFU/ml) [range], tooth brushing			
Baseline	0	0	0
0.5 min.	0	0	0.11
10 min.	0	0	0.11 [0.11–0.11]
30 min.	0	0	0.11
Mean magnitude in positive samples (CFU/ml) [range], scaling			
Baseline	0	0	0
0.5 min.	0.61 [0.11–1.11]	0.44 [0.11–1.11]	0.78 [0.11–2.67]
10 min.	0.11	0	0.22 [0.11–0.67]
30 min.	0	0.11	0.11 [0.11–0.11]

CFU, colony forming units.

colonies that were detected on the primary agar plates remained unidentified because they failed to grow upon subcultivation. Another six isolates initially examined by Gram staining, catalase activity, and growth under aerobic conditions and in CO_2-containing atmosphere failed to grow after storage at $-80^{\circ}C$ and were only tentatively identified.

From blood collected from 15 individuals (65%) two to seven species were identified concurrently.

Contamination was observed in 15 out of a total of 720 filters used in the study (2%). Contamination did not appear as single colonies on the filters, but as growth corresponding to part of the circumference of the filter outline, and was consequently not considered to originate from the blood passed through the filter. The growth on these 15 filters was subcultured and tentatively identified as staphylococci by Gram staining, and a positive catalase test. Contamination was excluded from calculation of incidence of bacteremia.

Differences between groups

There were no statistically significant differences between any of the groups regarding the incidences or magnitudes of bacteremia after chewing or tooth brushing at any time following the experimental procedures.

After scaling, the incidences and magnitudes of bacteremia were significantly higher in the periodontitis group than in the gingivitis group ($p<0.001$) and the healthy control group ($p<0.001$). There was no significant difference in the incidences of bacteremia between the gingivitis group and the healthy individuals at 0.5 min. or between any of the groups at 10 or 30 min. after scaling.

Correlation between bacteremia in periodontitis patients and clinical variables

The magnitude of bacteremia (CFU/ml) immediately after scaling was moderately positively correlated with GI (correlation coefficient 0.53, $p<0.0001$), PI (correlation coefficient 0.41, $p=0.0117$) and number of sites with BOP (correlation coefficient 0.45, $p=0.0089$). No statistical association was detected between bacteremia and number of sites with PPD > 5 mm and PSS.

Influence of other factors

The magnitude of bacteremia was independent on age, gender, smoking, periodontal diagnosis (chronic or aggressive periodontitis), and time used for scaling.

Discussion

Because bacteremia is usually characterized by low concentrations of bacteria in the blood, the sensitivity of blood culture methods is crucial. The lysis-filtration method used in this study has shown increased sensitivity compared with BACTEC growth bottles (Gill et al. 1984, Lucas et al. 2002a, b). Detection of bacteria with lysis filtration is slower than with growth bottles, which makes it less feasible for clinical use. However, it is recommendable for research purposes, also because a quantitative estimate of the bacteria in the sample is obtainable by counting the number of colonies growing on the filter discs.

Recently, Kinane et al. (2005) published a study on bacteremia after periodontal procedures in this journal, in which, bacteremia was detected in 13% after scaling. Since the corresponding result of our study was 75%, this variation is considerable. Primarily, this may be explained by the different culture methods used for bacteremia detection. While in the present study, lysis-filtration was used, Kinane et al. used BACTEC bottles, which is associated with a significantly lower sensitivity (Gill et al. 1984, Lucas et al. 2002a, b). Other

Table 3. One hundred and sixty-three colonies were isolated from two periodontally healthy individuals, four gingivitis patients and 17 periodontitis patients after chewing, tooth brushing and scaling

	H: C/T/S			G: C/T/S			P: C/T/S		
	0.5 min. (CFU)	10 min. (CFU)	30 min. (CFU)	0.5 min. (CFU)	10 min. (CFU)	30 min. (CFU)	0.5 min. (CFU)	10 min. (CFU)	30 min. (CFU)
Streptococci (19)									
Streptococcus anginosus (1)						0/0/0	0/0/2		
Streptococcus australis (1)					0/0/1				
Streptococcus constellatus (1)							0/1/0		
Streptococcus crista (2)					1/0/6		1/0/0		
Streptococcus gordonii (2)					0/0/1	0/1/0			
Streptococcus infantis (1)					0/0/1				
Streptococcus mitis biovar 1 (5)					1/0/6	0/0/1	0/0/1		
Streptococcus oralis (5)					2/1/4				
Streptococcus parasanguis (2)					1/0/2		0/0/1		
Streptococcus salivarius (3)					0/0/1	0/0/2			
Streptococcus sanguis (6)	0/0/1	0/0/1		0/0/1			1/0/3		
Streptococcus vestibularis (1)					0/0/1				
Streptococcus spp. (6)			0/0/1			0/0/7	0/0/2		
Enterococci (1)									
Enterococcus faecalis (1)	0/0/10								
Gram-positive rods (5)									
Actinomyces naeslundii (1)		0/0/2							
Actinomyces spp. (1)						0/0/5			
Lactobacillus spp. (1)						0/0/1			
Corynebacterium spp. (2)		0/0/2			0/0/2				
Others (1)							0/0/2		
Gram-negative rods (16)									
Porphyromonas gingivalis (2)					0/0/8	0/0/1			
Prevotella intermedia (8)				0/0/1	0/0/24				
Prevotella buccae (1)						0/0/2			
Fusobacterium nucleatum (8)		0/0/8			0/0/10	0/0/1			
Others (2)							0/0/11		
Candida spp. (1)			0/0/1						
Unidentifiable (3)			0/0/1			0/0/8	0/0/7	0/1/0	
Total	0/011	0/0/1	0	0/0/16	0/0/0	0/0/0	6/1/106	0/2/16	1/1/2

H, healthy; G, gingivitis; P, periodontitis; C, chewing; T, tooth brushing; S, scaling.
Numbers in parentheses show the number of patients harbouring the strain.

explaining factors may be the duration of transportation to the laboratory and individual variation in patient characteristics. These factors may seem of minor importance, however, detection of bacteremia is highly sensitive to the treatment of the blood samples and variation may occur because of these factors. Furthermore, bacteremias vary greatly between patients, and none of the bacteremias in the present study were similar regarding magnitude or bacterial species, which may explain at least some of the variation between the two studies.

The oral microflora consists of more than 600 species half of which have not yet been cultured (Paster et al. 2001). Furthermore, as cultivable taxa of oral bacteria have a range of growth requirements no single isolation medium satisfies all. Although the isolates recovered in our study included a range of both facultatively and obligately anaerobic bacteria, some of which are notoriously fastidious, it is conceivable that they represent only a fraction of the microorganisms present in blood after chewing, tooth brushing, and scaling.

Previous studies have shown incidences of bacteremia from 0% to 78% (Berger et al. 1974, Bhanji et al. 2002). The incidences of bacteremia detected in the present study were low as compared with these findings. The substantial variation of the studies, reflects the different blood culture methods used and the differences in participant characteristics as well as in procedures performed. The present incidence of bacteremia in periodontitis patients was 75% immediately after scaling, the magnitude being within a range of 0.11 and 2.67 CFU/ml, which is in accordance with the results obtained by Heimdahl et al. (1990).

Patient characteristics such as periodontal diagnosis, age, gender, smoking and number of teeth might potentially influence the results. However, a statistical analysis showed that these characteristics did not influence the magnitude of bacteremia in the periodontitis group. Hence, we assume that these characteristics did not affect the incidences of bacteremia in any of the three groups.

The time used for scaling varied between groups as a consequence of the difference in treatment needs. Although the magnitude was independent of the time consumption in the periodontitis group, this may explain some of the differences in incidence between groups.

Comparison of the results for the three groups (Table 2) indicates that individuals with periodontitis have an increased risk of developing bacteremia during everyday events such as chewing and tooth brushing.

The blood isolates recovered from the different experimental groups reflect the complexity of the microflora of dental biofilms associated with health and various degrees of periodontal inflammation (Marsh & Martin 1992). In one healthy individual, only streptococci

were isolated from the blood, which is compatible with their predominance on tooth surfaces associated with gingival health. Blood from the other periodontally healthy individual, who developed transient bacteremia, yielded *Enterococcus faecalis*, which is not uncommonly found in the oral cavity (Marsh & Martin 1992). In the four bacteremic subjects belonging to the gingivitis group streptococci, Gram-positive rods, and *F. nucleatum* were the most commonly isolated in accordance with their relative proportions in that clinical condition. In the periodontitis group, the isolated bacteria represented a larger variety of species, reflecting the increased complexity of the microflora of the periodontal pocket. Although the majority of patients yielded growth of streptococci, obligately anaerobic Gram-negative rods like *P. intermedia, Prevotella buccae, F. nucleatum*, and *P. gingivalis* dominated.

Oral streptococci have long been recognized as the leading cause of subacute endocarditis in patients with predisposing conditions such as post-streptococcal rheumatic fever and severe atherosclerosis. The ability of some of these streptococci to aggregate platelets is a potential pathogenic factor in the development of endocarditis and formation of thrombi (Herzberg & Meyer 1996). More recently, a group of putative periodontal pathogens including *P. gingivalis, Tannerella (Bacteroides) forsythensis, P. intermedia*, and *A. actinomycetemcomitans* have attracted considerable attention because species-specific DNA sequences can be detected in a significant proportion of atherosclerotic plaques (Haraszthy et al. 2000, Okuda et al. 2001, Fiehn et al. 2005) and abdominal aortic aneurysms (Kurihara et al. 2004). The pathogenic significance of their presence is not known. However, several of these species including *P. gingivalis* and *P. intermedia* have the ability to invade cells and tissues in vitro (Dorn et al. 1999). *P. gingivalis* and *P. intermedia* were isolated from the blood of more than one third of the periodontitis patients in this study, suggesting that these patients may be at risk of cell or tissue invasion. Successful periodontal treatment is likely to be followed by a decrease in serum inflammatory mediators (D'Aiuto et al. 2005, Montebugnoli et al. 2005). Moreover, serum inflammatory mediators correlate with serum *P. gingivalis* titer (Dye et al. 2005).

While bacteremia is defined as the presence of bacteria in the blood, septicemia is bacteremia accompanied by clinical symptoms. Septicaemia is a life-threatening condition, resulting from an excessive production of cytokines in response to circulating bacteria. It is well known that bacteria from the oral cavity may give rise to septicemia, but whether the magnitudes of bacteremia detected in the present study is sufficient to elicit septicaemia for example in hematologic patients, remains unknown.

This study demonstrates that patients with periodontitis as compared with healthy individuals and gingivitis patients are at increased risk of experiencing bacteremia in association with scaling. Moreover, the study suggests an increased risk of bacteremia in periodontitis patients after chewing and tooth brushing, although this was not statistically significant.

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References

Armitage, G. C. (2000) Development of a classification system for periodontal diseases and conditions. *Northwest Dental* **79**, 31–35.

Becker, A. E., de Boer, O. J. & van Der Wal, A. C. (2001) The role of inflammation and infection in coronary artery disease. *Annual Review of Medicine* **52**, 289–297.

Berger, S. A., Weitzman, S., Edberg, S. C. & Casey, J. I. (1974) Bacteremia after the use of an oral irrigation device. *Annual International Medicine* **80**, 115–116.

Bhanji, S., Williams, B., Sheller, B., Elwood, T. & Mancl, L. (2002) Transient bacteremia induced by toothbrushing a comparison of the Sonicare toothbrush with a conventional toothbrush. *Pediatric Dental* **24**, 295–299.

Cobe, H. M. (1954) Transitory bacteremia. *Journal of Oral Surgery* **7**, 609–615.

Conner, H. D., Haberman, S., Collings, C. K. & Winford, T. E. (1967) Bacteremias following periodontal scaling in patients with healthy appearing gingiva. *Journal of Periodontology* **68**, 466–472.

D'Aiuto, F., Nibali, L., Parkar, M., Suvan, J. & Tonetti, M. S. (2005) Short-term effects of intensive periodontal therapy on serum inflammatory markers and cholesterol. *Journal of Dental Research* **84**, 269–273.

D'Aiuto, F., Parkar, M., Andreou, G., Brett, P. M., Ready, D. & Tonetti, M. S. (2004) Periodontitis and atherogenesis: causal association or simple coincidence? *Journal of Clinical Periodontology* **31**, 402–411.

Daly, C., Mitchell, D., Grossberg, D., Highfield, J. & Stewart, D. (1997) Bacteremia caused by periodontal probing. *Australian Dental Journal* **42**, 77–80.

Daly, C. G., Mitchell, D. H., Highfield, J. E., Grossberg, D. E. & Stewart, D. (2001) Bacteremia due to periodontal probing: a clinical and microbiological investigation. *Journal of Periodontology* **72**, 210–214.

Debelian, G. J., Olsen, I. & Tronstad, L. (1995) Bacteremia in conjunction with endodontic therapy. *Endodontics and Dental Traumatology 1995* **11**, 142–149.

Dorn, B. R., Dunn, W. A. Jr. & Progulske-Fox, A. (1999) Invasion of human coronary artery cells by periodontal pathogens. *Infection and Immunity* **67**, 5792–5798.

Duel, P., Siboni, K. & Jensen, T. G. (1991) Intracranial abscesses in Odense Hospital. Survey of bacteriology, epidemiology and treatment with antibiotics. *Danish Medical Bulletin* **38**, 407–410.

Durmaz, B., Jousimies-Somer, H. R. & Finegold, S. M. (1995) Enzymatic profiles of Prevotella, Porphyromonas, and Bacteroides species obtained with the API ZYM system and rosco diagnostic tablets. *Clinical Infectious Diseases* **20**, S192–S194.

Dye, B. A., Choudhary, K., Shea, S. & Papapanou, P. N. (2005) Serum antibodies to periodontal pathogens and markers of systemic inflammation. *Journal of Clinical Periodontology* **32**, 1189–1199.

Erverdi, N., Biren, S., Kadir, T. & Acar, A. (2000) Investigation of bacteremia following orthodontic debanding. *Angle Orthodontist* **70**, 11–14.

Erverdi, N., Kadir, T., Ozkan, H. & Acar, A. (1999) Investigation of bacteremia after orthodontic banding. *American Journal of Orthodontics Dentofacial Orthopedics* **116**, 687–690.

Fiehn, N-E., Larsen, T., Christiansen, N., Holmstrup, P. & Schroeder, T. V. (2005) Identification of periodontal pathogens in atherosclerotic vessels. *Journal of Periodontology* **76**, 731–736.

Giglio, J. A., Rowland, R. W., Dalton, H. P. & Laskin, D. M. (1992) Suture removal-induced bacteremia - a possible endocarditis risk. *Journal of American Dental Association* **123**, 65–66.

Gill, V. J., Zierdt, C. H., Wu, T. C., Stock, F., Pizzo, P. A. & MacLowry, J. D. (1984) Comparison of lysis-centrifugation with lysis filtration and a conventional unvented bottle for blood cultures. *Journal of Clinical Microbiology* **20**, 927–932.

Guntheroth, W. G. (1984) How important are dental procedures as a cause of infective endocarditis? *American Journal of Cardiology* **54**, 797–801.

Haraszthy, V. I., Zambon, J. J., Trevisan, M., Zeid, M. & Genco, R. J. (2000) Identification of pathogens in atheromatous plaques. *Journal of Periodontology* **71**, 1554–1560.

Heimdahl, A., Hall, G., Hedberg, M., Sandberg, H., Söder, P. O., Tuner, K. & Nord, C. E. (1990) Detection and quantification by lysis-filtration of bacteria after different oral surgical procedures. *Journal of Clinical Microbiology* **28**, 2205–2209.

Herzberg, M. C. & McFarlane, G. D. (1994) The platelet as an inflammatory cell in periodontal diseases: interactions with *Porphyromonas gingivalis*. Molecular pathogenesis of periodontal diseases. In: Genco, R (eds). pp. 247–255. American Society of Microbiology, Washington, DC.

Herzberg, M. C. & Meyer, M. W. (1996) Effects of oral flora on platelets: possible consequences in cardiovascular disease. *Journal of Periodontology* **67**, 1138–1142.

Janket, S. J., Baird, A. E., Chuang, S. K. & Jones, J. A. (2003) Meta-analysis of periodontal disease and risk of coronary heart disease and stroke. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* **95**, 559–569.

Kilian, M. (1978) Rapid identification of *Actinomycetaceae* and related bacteria. *Journal of Clinical Microbiology* **8**, 127–133.

Kilian, M., Mikkelsen, L. & Henrichsen, J. (1989) Taxonomic study of viridans streptococci: description of *Streptococcus gordonii* sp. Nov. and emended descriptions of *Streptococcus sanguis* (White and Niven 1946), *Streptococcus oralis* (Bridge and Sneath 1982), and *Streptococcus mitis* (Andrewes and Horder) 1906. *International Journal of Systematic Bacteriology* **39**, 471–484.

Kinane, D. F., Riggio, M. P., Walker, K. F., MacKenzie, D. & Shearer, B. (2005) Bacteraemia following periodontal procedures. *Journal of Clinical Periodontology* **32**, 713–718.

King, R. C., Crawford, J. J. & Small, E. W. (1988) Bacteremia following intraoral suture removal. *Oral Surgery Oral Medicine and Oral Pathology* **65**, 23–28.

Kozarov, E. V., Dorn, B. R., Shelburne, C. E., Dunn, W. A. Jr. & Progulske-Fox, A. (2005) Human atherosclerotic plaque contains viable invasive *Actinobacillus actinomycetemcomitans* and *Porphyromonas gingivalis*. *Arteriosclerosis Thrombosis and Vascular Biology* **25**, 17–18.

Kuramitsu, H. K., Qi, M., Kang, I. C. & Chen, W. (2001) Role for periodontal bacteria in cardiovascular diseases. *Annales Periodontology* **6**, 41–47.

Kurihara, N., Inoue, Y., Iwai, T., Umeda, M., Huang, Y. & Ishikawa, I. (2004) Detection and localization of periodontopathic bacteria in abdominal aortic aneurysms. *European Journal of Vascular and Endovascular Surgery* **28**, 553–558.

LaPorte, D. M., Waldman, B. J., Mont, M. A. & Hungerford, D. S. (1999) Infections associated with dental procedures in total hip arthroplasty. *Journal of Bone and Joint Surgery – British Volume* **81**, 56–59.

Löe, H. & Silness, J. (1963) Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontologica Scandinavica* **21**, 533–551.

Lineberger, L. T. & De Marco, T. J. (1973) Evaluation of transient bacteremia following routine periodontal procedures. *Journal of Periodontology* **44**, 757–762.

Lucas, V. S., Lytra, V., Hassan, T., Tatham, H., Wilson, M. & Roberts, G. J. (2002a) Comparison of lysis filtration and an automated blood culture system (BACTEC) for detection, quantification and identification of odontogenic bacteremia in children. *Journal of Clinical Microbiology* **40**, 3416–3420.

Lucas, V. S., Omar, J., Vieira, A. & Roberts, G. J. (2002b) The relationship between odontogenic bacteremia and orthodontic procedures. *European Journal of Orthodontics* **24**, 293–301.

Marsh, P. & Martin, M. (1992) *Oral Microbiology*, 3rd edition, pp. 11–17. London: Chapman & Hall.

Montebugnoli, L., Servidio, D., Miaton, R. A., Prati, C., Tricoci, P., Melloni, C. & Melandri, G. (2005) Periodontal health improves systemic inflammatory and haemostatic status in subjects with coronary heart disease. *Journal of Clinical Periodontology* **32**, 188–192.

Okuda, K., Ishihara, K., Nakagawa, T., Hirayama, A., Inayama, Y. & Okuda, K. (2001) Detection of *Treponema denticola* in atherosclerotic lesions. *Journal of Clinical Microbiology* **39**, 1114–1117.

Paster, B. J., Boches, S. K., Galvin, J. L. et al. (2001) Bacterial diversity in human subgingival plaque. *Journal of Bacteriology* **183**, 3770–3783.

Rajasuo, A., Perkki, K., Nyfors, S., Jousimies-Somer, H. & Meurman, J. H. (2004) Bacteremia following surgical dental extraction with an emphasis on anaerobic strains. *Journal of Dental Research* **83**, 170–174.

Roberts, G. J. (1999) Dentists are innocent! ''Everyday'' bacteremia is the real culpit: a review and assessment of the evidence that dental surgical procedures are a principal cause of bacterial endocarditis in children. *Pediatr Cardiology* **20**, 317–325.

Roberts, G. J., Gardner, P. & Simmons, N. A. (1992) Optimum sampling time for detection of dental bacteraemia in children. *International Journal of Cardiology* **35**, 311–315.

Roberts, G. J., Holzel, H. S., Sury, M. R., Simmons, N. A., Gardner, P. & Longhurst, P. (1997) Dental bacteremia in children. *Pediatric Cardiology* **18**, 24–27.

Rogosa, M., Mitchell, J. A. & Wiseman, R. F. (1951) A selective medium for the isolation and enumeration of oral lactobacilli. *Journal of Dental Research* **30**, 682–689.

Ross, R. (1999) Atherosclerosis - an inflammatory disease. *New England Journal of Medicine* **2**, 115–126.

Savarrio, L., MacKenzie, D., Riggio, M., Saunders, W. P. & Bagg, J. (2005) Detection of bacteraemias during non-surgical root canal treatment. *Journal of Dentistry* **33**, 293–303.

Silness, J. & Löe, H. (1966) Periodontal disease in pregnancy. 3. Response to local treatment. *Acta Odontologica Scandinavica* **24**, 747–759.

Taylor-Robinson, D., Aduse-Opoku, J., Sayed, P., Slaney, J. M., Thomas, B. J. & Curtis, M. A. (2002) Oro-dental bacteria in various atherosclerotic arteries. *European Journal of Clinical Microbiology & Infectious Diseases* **21**, 755–757.

Address:
Lone Forner
Department of Periodontology
University of Copenhagen
Noerre Allé, 20 Copenhagen N 2200
Denmark