J Clin Periodontol 2007; 34: 148–155 doi: 10.1111/j.1600-051X.2006.01025.x

Journal of Clinical Periodontology

Effect of rinsing with povidone–iodine on bacteraemia due to scaling: a randomized-controlled trial

Martin Cherry[1,2], Christopher G. Daly[1], David Mitchell[3] and John Highfield[1]

[1]Discipline of Periodontics, Faculty of Dentistry, University of Sydney, Sydney, Australia; [2]Periodontics Unit, Westmead Centre for Oral Health, Westmead Hospital, Westmead, Australia; [3]Centre for Infectious Diseases and Microbiology, Institute of Clinical Pathology and Medical Research, Westmead Hospital, Westmead, Australia

Cherry M, Daly CG, Mitchell D, Highfield J. Effect of rinsing with povidone–iodine on bacteraemia due to scaling: a randomized-controlled trial. J Clin Periodontol 2007; 34: 148–155. doi: 10.1111/j.1600-051X.2006.01025.x.

Abstract

Aim: To investigate rinsing with povidone–iodine on bacteraemia caused by ultrasonic scaling.

Material and Methods: Sixty patients with gingivitis undertook a randomized, placebo-controlled trial in which 30 rinsed with 0.9% saline and 30 with 7.5% povidone–iodine for 2 min. before ultrasonic scaling of FDI teeth 31–35. Blood samples before and after 30 s and 2 min. of scaling were cultured by lysocentrifugation.

Results: Oral bacteraemia occurred in 33.3% of the saline group and 10% of the povidone–iodine group. Regression analysis showed that rinsing with povidone–iodine was approximately 80% more effective than rinsing with saline in reducing the occurrence of bacteraemia, with a statistically significant odds ratio (OR) of 0.189 (95% confidence intervals , OR = 0.043–0.827). There were 24 oral bacterial isolates in the saline group and 3 in the povidone–iodine group. Viridans streptococci comprised 11 of the isolates in the saline group and none in the povidone–iodine group. Bacteraemia magnitude was 0.1 colony-forming units /ml in the povidone–iodine subjects and 0.1–0.7 CFU/ml in the saline group.

Conclusions: Rinsing with 7.5% povidone–iodine reduced the incidence and magnitude of bacteraemia and eliminated viridans streptococci from such bacteraemia. Povidone–iodine rinsing may be helpful for ultrasonic scaling of gingivitis patients at risk of infective endocarditis.

Key words: bacteraemia; dental treatment; gingivitis; periodontal disease; periodontal treatment; povidone–iodine; scaling

Accepted for publication 12 October 2006

It is well established that transient bacteraemia can result from periodontal treatments such as scaling (Lockhart 2000). Bacteria that gain access to the bloodstream during such treatment are generally rapidly removed by the reticulo-endothelial system and do not cause disease in healthy individuals. However, in susceptible patients with acquired or congenital endocardial defects or cardiac prostheses, bacteraemia from dental treatment has been implicated in the development of infective endocarditis (Pallasch & Slots 1996, Moreillon & Que 2004).

For those patients considered to be in risk groups for infective endocarditis, pre-treatment administration of antibiotics is recommended to inactivate bacteria that gain access to the bloodstream during periodontal treatment (Dajani et al. 1997). However, antibiotic prophylaxis does not prevent infective endocarditis in all cases following dental treatment (Durack et al. 1983). It has therefore been suggested that prevention of infective endocarditis should not depend on antibiotic agents alone but that adjunctive methods, such as antiseptics applied topically to the gingival margin, should be used to reduce the numbers of viable microorganisms entering the bloodstream (Tzukert et al. 1986, Bender & Barkan 1989). The most recently published guidelines of the American Heart Association (AHA) recommend the use of topical antimicrobials such as povidone–iodine (POV–I) as an adjunct to systemic antibiotic cover to enhance the efficiency of current prophylactic measures (Dajani et al. 1997). Mouth rinsing is considered

Conflict of interest and source of funding statement

The authors declare that they have no conflict of interest.

This project was supported by a grant from the Dental Board of New South Wales.

preferable to subgingival irrigation as the latter has been shown to induce bacteraemia (Lofthus et al. 1991) and for this reason is not currently recommended by the AHA.

POV–I, which is used widely as a topically applied antiseptic, is an iodophore in which iodine is linked to povidone (polyvinylpyrrolidone), a dextran-like molecule (Fleischer & Reimer 1997). The povidone molecule, by virtue of its affinity for cell membranes, delivers diatomic free iodine directly to the bacterial cell surface (Zamora 1986) where it exerts its antibacterial effects (Schreier et al. 1997). POV–I appears to be active against all microorganisms, including Gram-positive and Gram-negative bacteria, spores, mycobacteria, fungi, viruses and protozoa (LeVeen et al. 1993). Although application of POV–I to the gingival margin has been reported to reduce the incidence of bacteraemia following gingivectomy (Randall & Brenman 1974) and tooth-extraction (Rahn et al. 1995), a review of the uses of POV–I in periodontal therapy recommended that it should not be used to reduce the incidence of bacteraemia caused by scaling (Greenstein 1999). The basis of this non-recommendation was the finding of Witzenberger et al. (1982) that rinsing and irrigation with POV–I did not reduce bacteraemia caused by scaling with curettes. However, the investigators did not use a negative control solution for rinsing and irrigation, nor did they identify the bacteria in positive blood cultures to a genus or species level to ensure they were of oral origin and not skin contaminants from the blood-sampling procedures.

Recent evidence has shown a lack of oral bacteraemia induced by chewing in patients with plaque-induced gingivitis (Murphy et al. 2006). Therefore, bacteraemia caused by dental treatments such as scaling in this group of patients may be of more importance as a causative factor in infective endocarditis and any measures to limit such bacteraemia would be helpful.

Given the shortcomings of the Witzenberger et al. (1982) study and the recommendations of the AHA concerning pre-treatment rinsing with POV–I (Dajani et al. 1997), the role of POV–I in reducing bacteraemia following scaling requires further evaluation. Therefore, this study was designed to investigate the effectiveness of pre-treatment rinsing with POV–I in patients with plaque-induced gingivitis who were undergoing ultrasonic scaling. The primary aim was to assess the effect of POV–I on the incidence of bacteraemia, with secondary aims to investigate the magnitude and microbial profile of such bacteraemia. A further aim of the study was to investigate whether patient or clinical parameters might be used to predict the occurrence of bacteraemia.

Material and Methods

Study design

The study was designed as a randomized, placebo-controlled clinical trial in which 30 patients would rinse with POV–I and another 30 with sterile saline (NaCl), before ultrasonic scaling. The study was approved by the Scientific, Human Ethics and Drug Committees of the Western Sydney Area Health Service and the Human Ethics Committee of the University of Sydney. Research was conducted in accordance with the World Medical Association Declaration of Helsinki (version VI, 2002 http://www.wma.net/e/policy/b3.htm). A detailed information sheet was provided for the volunteers and each signed a witnessed consent form.

Selection criteria

Sixty volunteers were sought from 331 patients on the periodontal waiting list of the Westmead Centre for Oral Health for whom clinical and radiographic records were available. For selection, patients were required to have plaque-induced gingivitis, as defined by the American Academy of Periodontology (Mariotti 1999), involving five adjacent teeth (FDI teeth 31–35). Potential subjects were telephoned consecutively and the experimental procedures and purposes of the study were explained. Their medical and dental histories were reviewed to assess inclusion and exclusion criteria and suitable patients were then invited to attend for the clinical procedure. Of the 331 patients available, 27 did not meet the inclusion criteria, 68 declined to participate and 176 could not be contacted.

Patients were excluded if they had any of the following: allergy to iodine, significant medical problems (e.g. diabetes), known infection with the human immunodeficiency virus, cardiac defects or other conditions requiring prophylactic antibiotic cover, pregnancy, having taken antibiotics in the last 3 months or currently taking corticosteroid or immunosuppressive medications or having received periodontal treatment within the previous 6 months. Patients were instructed not to brush for at least 30 min. before their appointment to avoid the possibility of any toothbrushing-induced bacteraemia (Sconyers et al. 1973).

Data recorded

Gender, age and smoking status (never; former; current) were recorded for each patient. Non-invasive clinical parameters (gingival inflammation and plaque) were recorded immediately before scaling while periodontal probing, which might cause bacteraemia (Daly et al. 2001), was performed after blood sampling.

Plaque was assessed on buccal and lingual surfaces using the plaque index (PI; Silness & Löe 1964). Gingival inflammation was assessed on buccal and lingual surfaces using a modified papilla, margin, attached gingiva index (mPMAI) (after Schour & Massler 1947) so that probing of the gingival margins could be avoided. The PMAI was modified by recording values in a way that facilitated statistical analysis, by adding a category for the absence of clinical inflammation (Table 1). Following recording of the non-invasive clinical parameters (PI, mPMAI), the patients were randomly allocated by the toss of a coin until 30 comprised

Table 1. Modification of the papilla, margin, attached gingiva index (m PMAI; Schour & Massler 1947). Values are shown

Extent of inflammation	PMAI value	Modified value
No visible signs of inflammation		0
Papillae only	P	1
Papillae and margins	M	2
Papillae, margins and attached gingiva	A	3

mPMAI, modified papilla, margin, attached gingiva index.

the experimental group and 30 the control group.

Experimental group treatment

Experimental group subjects rinsed with 10 ml of POV–I 7.5% v/v solution (Betadine® Sore Throat Gargle, Faulding Health Care, Virginia, Qld, Australia) for 1 min. and were then asked to expectorate. Following an interval of 30 s, the patients repeated the 1 min. rinse with a further 10 ml of the same solution. Immediately following the POV–I rinses and after the baseline blood sample was taken, an ultrasonic scaler (Siemens Siroson®, Bensheim, Germany) was used at maximum power and maximum water flow to clean the test teeth for a total of 2 min. All treatment was provided by the one operator (M. C.). Supragingival calculus was removed first. The scaler tip was then placed at the base of the sulcus at the disto-lingual of tooth 35 and the lingual surfaces cleaned to the mesial of 31. The side of the scaler tip was used to clean the toothsurfaces using horizontal strokes keeping the scaler tip at the base of the sulcus and the tip was tilted to reach the interproximal areas where a vertical lifting motion was used to remove any interproximal deposits. All the lingual surfaces were cleaned before moving to the disto-buccal aspect of 35. whereupon all the buccal surfaces were cleaned.

Any bleeding from the gingival margin provoked by scaling was recorded at six sites per tooth (mesio-buccal, mesio-lingual, mid-buccal, mid-lingual, disto-buccal, disto-lingual) and described as ''bleeding on scaling''. After the completion of blood sampling, probing depths and recession for the study teeth were recorded to the nearest millimetre using a Williams probe with Michigan markings (Premier Dental Products, Plymouth Meeting, PA, USA) at the same six sites for each tooth.

Control group treatment

The control group patients were asked to rinse with 10 ml of sterile 0.9% NaCl for 1 min. and were then allowed to expectorate. A 30-s respite was allowed before the NaCl rinse was repeated for a further 1 min. Ultrasonic scaling and measurement of the clinical parameters were then performed as for the experimental group.

Blood samples

Three blood samples (total of 30 ml) were obtained from each subject via an intra-venous cannula inserted into a vein in an antecubital fossa. Before cannulation, the skin overlying the vein was swabbed with sterile 70% isopropyl alcohol for 10 s and following insertion, a cannula dressing was placed to secure the cannula and to help prevent contamination of the wound (Opsite IV3,000™ 6 × 8.5 cm, Smith & Nephew, Hull, UK). Ten millilitres of blood was sampled as a baseline measurement immediately following rinsing with either NaCl or POV–I and before scaling commenced, to ensure the absence of a pre-existing bacteraemia. Ten millilitres of blood was sampled 30 s after scaling was commenced and a further 10 ml of blood was sampled at the completion of 2 min. of scaling.

Each blood sample was drawn using a sterile 10 ml eccentric tip syringe (Terumo®, Elkton, MD, USA) after connecting it to the intra-venous cannula. In order to prevent bacterial contamination of the cannula and valve, the intra-venous cannula was flushed with heparinized NaCl solution between samples (2 × 2.5 ml of 50 IU heparin sodium in 5 ml 0.9% NaCl, Astra Pharmaceuticals, North Ryde, NSW, Australia).

Culturing and identification

A lysocentrifugation tube (Oxoid Wampole Isolator10, Unipath Ltd, Basingstoke, UK) was inoculated with each blood sample immediately following collection and then centrifuged at room temperature for 10 min. at 5000 g. Following removal of the supernatant, the pellet containing the material to be cultured was re-suspended in the remaining liquid by vortexing for 20 s and equal amounts from each tube were then plated onto chocolate horse blood agar (CHBA), blood/haemin/vitamin K (BHV) and chromogenic agar (CHROMagar® Orientation, Chromagar Microbiology, Paris, France). Inoculation of cultures was performed in a Class II biosafety laminar flow cabinet to reduce the risk of contamination. The CHBA plates were incubated for 7 days at 35°C, 5% CO_2 in a CO_2 incubator; the Chromogenic agar plates were incubated for 7 days in ambient atmosphere at 37°C; and the BHV plates were incubated for 7 days in an anaerobic cabinet at 37°C, 10% CO_2, 80% N_2, 10% H_2. Any growth was subsequently subcultured and isolates identified to at least genus level using standard methods. All microbiological procedures were performed in the microbiology laboratory of the Centre for Infectious Diseases and Microbiology, Institute of Clinical Pathology and Medical Research, Westmead Hospital, which is a tertiary referral centre and an anaerobic reference laboratory.

Magnitude of bacteraemia

Each 10 ml blood sample was divided into thirds and plated onto three plates. The number of colonies on each plate represented the number in 3.3 ml of blood. For each patient, the total number of bacterial isolates was expressed as colony-forming units (CFU) per ml of blood.

Statistics

The null hypothesis was that rinsing with POV–I was no more effective than rinsing with NaCl in preventing the occurrence of bacteraemia due to ultrasonic scaling. We estimated that a 30% rate of bacteraemia in the control group was possible based on previous scaling-bacteraemia studies and we considered that a reduction in the incidence of bacteraemia to 10% would be clinically relevant. Based on these predictions at 80% power and a 95% confidence level, a sample size of 28 was required in each group. We therefore studied 30 patients in each group. The patient data were summarized using means and standard deviations for continuous variables and percentages in each category for categorical variables. The computer software utilized to create a spreadsheet for data entry and for statistical analysis of the results was SPSS v 8.0. The homogeneity of the POV–I and NaCl groups was tested using two sample *t*-tests for continuous variables (age, bleeding on scaling, probing depth and recession), the Mann–Whitney *U*-test for ordered categorical variables (PI, mPMAI) and χ^2 tests for categorical variables (gender, smoking status). All tests were two-sided and a significance of 5% or less was considered statistically significant throughout.

The primary outcome variable of the study was the presence or absence of a bacteraemia. Logistic regression

analysis was used to test for associations between this variable and the treatment (rinsing with POV–I or NaCl). It was also used to test whether clinical variables or patient data were predictive for bacteraemia. A stepwise elimination procedure was used to identify the best-fitting multivariate logistic regression model. ORs, together with their 95% confidence intervals (CI), were used to quantify the levels of association.

Results

Data for patient groups

The study population consisted of 60 subjects, 30 in the POV–I group (10 males, 20 females; mean age 45.9 years) and 30 in the NaCl group (seven males, 23 females; mean age 43.9 years), and all completed the study protocol. There were seven smokers in the POV–I group and four in the NaCl group. The age and clinical data for each group are shown in Table 2. No significant differences were found between the groups for age ($t = 0.38$, $p = 0.7$, 58 df, independent *t*-test), gender ($\chi^2 = 0.74$, $p = 0.4$, 1 df), smoking status ($\chi^2 = 1.00$, $p = 0.3$, 1 df), probing depth ($t = 0.03$, $p = 0.97$, 58 df, Independent *t*-test), recession ($t = -0.31$, $p = 0.8$, 58 df, Independent *t*-test), PI ($Z = 1.6$, $p = 0.1$, Mann–Whitney *U*-test) or mPMAI ($Z = 0.22$, $p = 0.8$, Mann–Whitney *U*-test). Bleeding on scaling was recorded as the percentage of sites that bled following scaling. Although a trend was observed for more bleeding on scaling in the POV–I group than the NaCl group, the difference was not significant ($t = -1.84$, $p = 0.07$, 58 df, Independent *t*-test). No adverse effects or side effects other than a bitter taste were reported by any of the POV–I group.

Table 2. Age and clinical data for groups rinsing with 7.5% povidone–iodine (POV–I) and for group rinsing with 0.8% saline (NaCl)

Variable	Mean (± SD)		*P*-value
	POV–I ($n = 30$)	NaCl ($n = 30$)	
Age (years)	45.9 (20.8)	43.9 (20.8)	0.7* (ITT)
Probing depth (mm)	2.2 (0.4)	2.2 (0.3)	0.97* (ITT)
Recession (mm)	0.6 (0.5)	0.5 (0.5)	0.8* (ITT)
MPMAI	1.2 (0.5)	1.3 (0.5)	0.8* (MWU)
Plaque index	1.1 (0.4)	1.3 (0.6)	0.1* (MWU)
Bleeding on scaling (%)	73.0 (17.7)	63.7 (21.2)	0.07* (ITT)

*Not significant at the 95% confidence level.
mPMAI, modified papilla, margin, attached gingiva index; ITT, independent *t*-test; MWU, Mann–Whitney *U*-test.

Table 3. Oral bacteria recovered from blood samples after 30 s and 2 min. of ultrasonic scaling in the control group ($n = 30$) who rinsed with NaCl before scaling

Patient	30 s	2 min.
N1		*Actinomyces naeslundii* (1)
N2		*Actinomyces odontolyticus* (1)
N3	*streptococcus milleri* (1) *viridans streptococcus* (1)	*Prevotella intermedia* (1) *viridans streptococcus* (2)
N4	*streptococcus milleri* (1) *viridans streptococcus* (1)	*Prevotella intermedia* (2) *milleri streptococcus* (5)
N5	*Prevotella intermedia* (1)	*Prevotella intermedia* (1)
N6	*Prevotella intermedia* (1)	
N7		*Porphyromonas gingivalis* (2)
N8		*Streptomyces* spp. (1)
N9		*viridans streptococcus* (1)
N10		Gram-positive coccus (1)*

*Unfortunately, the isolate (Gram-positive coccus) did not survive and could not be sub-cultured for further identification.
The numbers in brackets are the number of isolates recovered per 10 ml blood sample at each time point.

Bacteraemia

Bacterial isolates were recovered from the baseline blood samples of four subjects (three NaCl; one POV–I) and consisted of coagulase-negative staphylococci, one mixed colony of *Staphylococcus epidermidis*/*Corynebacterium* spp. and a yeast. These microorganisms were considered to be skin contaminants from the blood-sampling procedure (Cockerill et al. 1997). No microorganisms of oral origin were found in any of the baseline blood samples. Microorganisms of oral origin were found in blood samples of four subjects in the NaCl group and one in the POV–I group following 30 s of scaling and in nine of the NaCl group and in two of the POV–I group following 2 min. of scaling. Three subjects in the NaCl group exhibited positive cultures in both the 30-s and 2-min. blood samples but none did so in the POV–I group. Overall, a positive bacteraemia of oral origin was found in 33% of subjects in the NaCl group and in 10% in the POV–I group. Logistic regression analysis showed that the odds ratio for the occurrence of bacteraemia in the POV–I group relative to the NaCl control group was 0.189 ($p = 0.03$, 95% CI, OR = 0.043–0.827). Rinsing with POV–I before scaling was therefore approximately 80% more effective than NaCl in reducing the occurrence of bacteraemia. (OR $\approx$ 0.2).

Predictors of bacteraemia

Logistic regression was used to identify factors predictive for the occurrence of bacteraemia caused by scaling. Factors that were analysed included patient characteristics (age, gender and smoking status) and clinical parameters (PlI, mPMAI, probing depth, recession and bleeding on scaling). A stepwise elimination procedure was used to identify the best-fitting multivariate logistic regression model. Age was the only factor significantly predictive for the development of a post-scaling bacteraemia ($p = 0.05$, OR = 1.40, 95% CI, OR = 1.00–1.97). The OR for the recovery of a bacteraemia following scaling increased by 1.4 for every 10-year increase in age of the subjects. No other patient characteristics or clinical parameters were found to have a significant association with the occurrence of bacteraemia.

Microbiological findings

Table 3 shows the presumptive oral isolates recovered from the NaCl group. There were 24 isolates recovered from the NaCl group, five from the 30-s samples and 19 from the 2-min. samples. Viridans group streptococci comprised

Table 4. Presumptive oral bacteria recovered from blood samples after 30 s and 2 min. of ultrasonic scaling in the experimental group ($n = 30$) who rinsed with POV–I before scaling

Patient	30 s	2 min.
P1		*Enterobacteriaceae* spp. (1)
P2	*Enterobacteriaceae* spp. (1)	
P3		*Enterobacteriaceae* spp. (1)

The numbers in brackets are the number of isolates recovered per 10 ml blood sample at each time point.

11 of these 24 isolates (42.1%). *Prevotella intermedia* was identified in the 30-s samples from two patients and from the 2-min. samples in 3 patients. Only one patient had *P. intermedia* in both samples. *Porphyromonas gingivalis* was detected in one of the 2-min. samples. Only three presumptive oral isolates were recovered from the POV–I group: one at 30 s and two at 2 min (Table 4). No viridans group streptococci were identified in any of the POV–I group blood samples. One Gram-positive isolate in the NaCl group could not be identified. Two of the NaCl group subjects exhibited polymicrobial bacteraemia (growth of more than one microorganism from the blood sample) in both the 30-s and 2-min. samples. No polymicrobial growth was observed in the POV–I group.

In the post-scaling samples, 14 presumptive non-oral isolates were recovered from the NaCl group and 12 from the POV–I group. The predominant species among the contaminants were normal skin commensals such as Coagulase-negative staphylococci and *S. epidermidis*. Three colonies of yeasts were recovered including 2 *Oiccha monray* isolates from the POV–I group and one *Candida* spp. (non-albicans) isolate from the NaCl group. The recovery of non-oral microorganisms was evenly spread among the blood samples at all three time points.

Magnitude of bacteraemia

The three patients with positive samples in the POV–I group each demonstrated 0.1 CFU/ml of blood. In the NaCl group, the magnitude of bacteraemia ranged from 0.1 to 0.7 CFU/ml.

Discussion

This study found that rinsing with 7.5% POV–I for 2 min. before ultrasonic scaling significantly reduced the incidence of odontogenic bacteraemia in patients with plaque-induced gingivitis from 33% to 10%. Additionally, there was a trend for the magnitude of bacteraemia to be less in the POV–I group and there were no viridans streptococci or polymicrobial bacteraemia found in any of the positive POV–I blood samples.

The study was designed to ensure uniformity of treatment for both the experimental (POV–I) and control (NaCl) groups. Thus, the same teeth were scaled in each group for the same duration using the one ultrasonic unit with the same power and water flow settings for all patients. In addition, a standardized format of scaling was used for each patient using the same scaler tip. Although patients were randomly allocated to experimental or control groups, it was not possible to blind the operator to the use of POV–I as a 2-min. rinse left a brown–yellow film on the teeth and soft tissues. No control rinse could be identified that caused similar staining but did not contain iodine. Although there was a trend for more bleeding on scaling in the POV–I group, this difference was not significant, indicating that similar tissue trauma was experienced by both groups. Patients with plaque-induced gingivitis were selected for study since mouthrinse solutions do not penetrate into periodontal pockets (Pitcher et al. 1980) thus precluding the selection of patients with chronic periodontitis where POV–I would not be expected to access subgingival plaque before scaling. Subgingival irrigation with POV–I was not utilized as sulcular irrigation can cause bacteraemia in patients with gingivitis (Roman & App 1971) and periodontitis (Lofthus et al. 1991) and is therefore not recommended by the AHA (Dajani et al. 1997). Chlorhexidine was not used as a positive control as it has been shown to be inferior to POV–I in the prevention of bacteraemia caused by dental extractions (Rahn et al. 1995) and there is no evidence that establishes it as a gold standard antimicrobial rinse for the prevention of bacteraemia caused by scaling. Now that the effectiveness of POV–I in reducing bacteraemia caused by scaling in patients with plaque-induced gingivitis has been established, POV–I may be utilized as a positive control for assessment of the efficacy of other antimicrobial solutions including chlorhexidine, cetylpyridium chloride and phenolic compounds.

The incidence of odontogenic bacteraemia in the control group was 33%. Direct comparison of this finding with other scaling studies is difficult due to differences in periodontal disease status, types of instruments used, duration of instrumentation, study designs and bacterial culture techniques. Bacteraemia occurred in 50% of patients of undisclosed periodontal status who received ultrasonic scaling of a mandibular quadrant of six teeth for an undisclosed period of time (Reinhardt et al. 1982), while an incidence of 30% was reported after scaling and root planing of a single pocket $\geqslant$4 mm for 1 min. (Lofthus et al. 1991) although the type of instrument(s) used was not described. Lower incidences of bacteraemia have been reported for 2 min. of scaling and root planing with undisclosed instruments of a single pocket $\geqslant$4 mm (18.5%; Waki et al. 1990), for full-mouth ultrasonic scaling for an undisclosed duration in patients with untreated, moderate to severe periodontitis (13%; Kinane et al. 2005) and for full-mouth hand and sonic scaling for an undisclosed period of time in gingivitis patients (20%; Forner et al. 2006). A higher incidence has been reported for full-mouth hand and sonic scaling for an undisclosed period of time in patients with severe periodontitis (75%; Forner et al. 2006). The incidence of 33% in the present study is comparable with the 30–40% incidence of bacteraemia reported for other periodontal treatments such as subgingival irrigation of a single pocket $\geqslant$4 mm (Lofthus et al. 1991), subsonic scaling in children and adolescents (Roberts et al. 1997) and periodontal probing in chronic periodontitis patients (Daly et al. 1997, 2001).

The use of broth culture may have been more sensitive for Gram-negative anaerobe detection as compared with the lysis-centrifugation technique. However, one of the aims of our study was to investigate the magnitude of bacteraemia, which cannot be performed easily with broth culture, especially where mixed cultures may occur. There-

fore, we used lysis-centrifugation, which is considered to be the most sensitive quantitative culture technique for the recovery of bacteria in the blood stream (Lockhart 2000). Additionally, lysis-centrifugation has been shown to be more sensitive than other blood-culturing techniques, including broth cultures, in detecting bacteraemias of small magnitude (Henry et al. 1983, 1984). Given that the underlying issue in our study was prevention of infective endocarditis, a condition where oral Gram-positive streptococci are considered more important than oral Gram-negative anaerobes (Moreillon & Que 2004), we decided to accept a lower sensitivity of anaerobe detection for additional information on the more clinically relevant detection of Gram-positive streptococcal bacteraemia.

Pre-treatment rinsing with POV–I eliminated viridans streptococci from positive blood samples. Whereas 11 of 24 bacteria cultured from the control group blood samples following scaling were viridans streptococci, none were found in any of the blood samples from the POV–I group. POV–I has been found to be similarly effective in reducing the incidence of viridans streptococci in bacteraemias caused by the extraction of a single molar (10.0% incidence in the POV–I group, 32.5% incidence in the NaCl group; Rahn et al. 1995). Taken together, the findings of Rahn et al. (1995) and the present study suggest that POV–I is effective against viridans streptococci in dental plaque. If so, this could be of therapeutic value as viridans streptococci are commonly found pathogens in cases of native valve infective endocarditis and late-stage prosthetic valve endocarditis (Moreillon & Que 2004) and are considered to be important in the pathogenesis of infective endocarditis because of their ability to aggregate platelets (Herzberg & Meyer 1996). The apparent effectiveness of POV–I against supragingival plaque is suprising, given its biofilm structure, which confers resistance to antimicrobial agents such as mouthrinses (Marsh 2005). However, given the significant reduction in the incidence of bacteraemia observed in the present study, it would appear that rinsing for 2 min. with 7.5% POV–I may be effective in penetrating dental plaque biofilms and killing bacteria, including viridans streptococci. The Enterobacteriaceae spp. found in the positive cultures in the POV–I group were considered to be of oral origin as they are found in the mouth (Goldberg et al. 1997) and they are not common contaminants in blood-sampling procedures (Cockerill et al. 1997).

No correlation was found between bacteraemia and bleeding on scaling. This observation is at variance with the AHA antibiotic prophylaxis recommendations that identify dental procedures ''that may be associated with significant bleeding'' as risk procedures for causing bacteraemia. However, our findings are in agreement with those of Roberts (1999), who demonstrated that the presence of gingival bleeding with various dental and oral hygiene procedures did not constitute a predictive factor for bacteraemia of odontogenic origin. Although bleeding due to a dental procedure may or may not be predictive of a positive bacteraemia, it can only be assessed once the treatment has actually been performed. From a risk-assessment point of view, it is preferable to be able to identify individuals at risk of bacteraemia before treatment. No significant relationship was found between the degree of gingival inflammation and the occurrence of bacteraemia, thus confirming the findings of previous studies of ultrasonic scaling (Reinhardt et al. 1982) and hand scaling (Witzenberger et al. 1982). Similarly, no association was found between the amount of plaque and the occurrence of bacteraemia as has also been observed for hand scaling (Witzenberger et al. 1982). The only factor identified in our study as a significant predictor for bacteraemia was increasing age. In a study of bacteraemia caused by oral surgical procedures, older patients have also been found to be at increased risk of odontogenic bacteraemia (Okabe et al. 1995), suggesting a possible decreased ability to clear oral bacteria from the circulation in older individuals.

The magnitude of bacteraemia may be as important as the incidence of bacteraemia in causing infective endocarditis as a large inoculum of bacteria is required to produce infective endocarditis in experimental animals (Glauser & Francioli 1987). The magnitude of bacteraemia found in the positive samples ranged from 0.1 CFU/ml in the POV–I group to 0.1–0.7 CFU/ml in the NaCl group. This magnitude is comparable with the 0.11–1.11 CFU/ml range reported for full-mouth hand and sonic scaling in gingivitis patients (Forner et al. 2006) and the 0.0–1.0 CFU/ml range found for ultrasonic scaling of a quadrant of six teeth of undisclosed status (Reinhardt et al. 1982). Taken together, these ranges of CFUs/ml are less than have been found for extractions in adults (average 2.5 CFU/ml; Hockett et al. 1977), for extraction of single teeth in children (1–28 CFU/ml; Lucas et al. 2002) and for full-mouth scaling in severe periodontitis patients (0.11–2.67 CFU/ml; Forner et al. 2006).

Blood was sampled after 30 s and again after 2 min. of scaling with more isolates found at 2 min. than 30 s. Unfortunately, most scaling studies have not reported the duration of scaling and therefore there is no information available on the timeframe necessary to produce bacteraemia. Recently, Forner et al. (2006) reported that the peak incidence and magnitude of bacteraemia occurred 30 s after the completion of full-mouth scaling in gingivitis patients but the duration of the scaling was not disclosed. Our study showed that bacteraemia was present after only 30 s of scaling and it is possible that such bacteraemia could be cleared from the circulation by the time blood samples are obtained after the completion of full-mouth scaling. Roberts et al. (1992) have reported that the highest yield of bacteraemia occurs at 30 s after dental extractions. It is possible that the peak bacteraemia in our study may have occurred after more than 2 min. of scaling but this could not be verified. A study to investigate the time-dynamics of scaling-induced bacteraemia would require multiple blood samples to be taken during and after the completion of scaling.

Within the limitations of this study, it appears that pre-treatment rinsing with 7.5% POV–I in patients with plaque-induced gingivitis may reduce the incidence and magnitude of bacteraemia and also reduce the occurrence of viridans streptococci in bacteraemia caused by ultrasonic scaling. The findings of our study cannot be applied to periodontitis patients as mouth rinses cannot adequately penetrate periodontal pockets (Pitcher et al. 1980). Therefore, any potential use of antimicrobial solutions to reduce bacteraemia in patients with periodontitis requires further study. Use of POV–I rinsing should not replace antibiotic prophylaxis for patients in the defined risk groups for infective endocarditis, but

may be of clinical value as an adjunct to such prophylaxis.

Acknowledgements

The authors wish to acknowledge the advice and statistical assistance of Poppy Sindhusake of the Department of Community Medicine, University of Sydney, and Heather Gidding of the Institute of Clinical Pathology and Medical Research, Westmead Hospital, Westmead. The authors would also like to thank Sue Gordon from the anaerobe laboratory and the staff of the microbiology laboratory at Westmead Hospital ICPMR.

References

Bender, I. & Barkan, M. (1989) Dental bacteraemia and its relationship to bacterial endocarditis: preventive measures. *Compendium of Continuing Education in Dentistry* **10**, 472–482.

Cockerill, F., Hughes, J., Vetter, E., Mueller, R., Weaver, A., Ilstrup, D., Rosenblatt, J. & Wilson, W. (1997) Analysis of 281,797 consecutive blood cultures performed over an eight-year period: trends in microorganisms isolated and the value of anaerobic culture of blood. *Clinical and Infectious Diseases* **24**, 403–418.

Dajani, A., Taubert, K., Wilson, W., Bolger, A., Bayer, A., Ferrieri, P, Gewitz, M., Shulman, S., Nouri, S., Newburger, J., Hutto, C., Pallasch, T., Gage, T., Levison, M., Peter, G. & Zuccaro, G. (1997) Prevention of bacterial endocarditis: recommendations by the American Heart Association. *Journal of the American Dental Association* **128**, 1142–1151.

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

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

Durack, D., Kaplan, E. & Bisno, A. (1983) Apparent failures of endocarditis prophylaxis: analysis of 52 cases submitted to a national registry. *Journal of the American Medical Association* **250**, 2318–2322.

Fleischer, W. & Reimer, K. (1997) Povidone–iodine in antisepsis: state of the art. *Dermatology* **195**, 3–9.

Forner, L., Larsen, T., Kilian, M. & Holmstrup, P. (2006) Incidence of bacteremia after chewing, tooth brushing and scaling in individuals with periodontal inflammation. *Journal of Clinical Periodontology* **33**, 401–407.

Glauser, M. & Francioli, P. (1987) Relevance of animal models to the prophylaxis of Infective Endocarditis. *Journal of Antimicrobial Chemotherapy* **20**, 87–93.

Goldberg, S., Cardash, H., Browning, H., Sahly, H. & Rosenberg, M. (1997) Isolation of Enterobacteriaceae from the mouth and potential association with malodor. *Journal of Dental Research* **76**, 1770–1775.

Greenstein, G. (1999) Povidone–iodine's effects and role in the management of periodontal diseases: a review. *Journal of Periodontology* **70**, 1397–1405.

Henry, N., McLimans, C., Wright, A., Thompson, R., Wilson, W. & Washington, J. (1983) Microbiological and clinical evaluation of the isolator lysis-centrifugation blood culture tube. *Journal of Clinical Microbiology* **17**, 864–869.

Henry, N., Grewell, C., Van Grevenhof, P., Ilstrup, D. & Washington, J. (1984) Comparison of lysis-centrifugation with a biphasic blood culture medium for the recovery of aerobic and facultatively anaerobic bacteria. *Journal of Clinical Microbiology* **20**, 413–416.

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

Hockett, R., Loesche, W. & Sodeman, T. (1977) Bacteriemia in asymptomatic human subjects. *Archives of Oral Biology* **22**, 91–98.

Kinane, D., Riggio, M., Walker, K., MacKenzie, D. & Shearer, B. (2005) Bacteraemia following periodontal procedures. *Journal of Clinical Periodontology* **32**, 708–713.

LeVeen, H., LeVeen, R. & LeVeen, E. (1993) The mythology of povidone–iodine and the development of self-sterilizing plastics. *Surgery, Gynaecology, Obstetrics* **176**, 183–190.

Lockhart, P. (2000) The risk for endocarditis in dental practice. *Periodontology 2000* **23**, 127–135.

Lofthus, J., Waki, M., Jolkovsky, D., Otomo-Corgel, J., Newman, M., Flemmig, T. & Nachrani, S. (1991) Bacteraemia following subgingival irrigation and scaling and root planing. *Journal of Periodontology* **62**, 602–607.

Lucas, V., Lytra, V., Hassan, T., Tatham, H., Wilson, M. & Roberts, G. (2002) 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.

Mariotti, A. (1999) Dental plaque-induced gingival diseases. *Annals of Periodontology* **4**, 7–15.

Marsh, P. (2005) Dental plaque: biological significance of a biofilm and community life-style. *Journal of Clinical Periodontology* **32** (Suppl. 6), 7–15.

Moreillon, P. & Que, Y-A. (2004) Infective endocarditis. *Lancet* **363**, 139–149.

Murphy, A., Daly, C., Mitchell, D., Stewart, D. & Curtis, B. (2006) Chewing fails to induce oral bacteraemia in patients with periodontal disease. *Journal of Clinical Periodontology* **33**, 73–736.

Okabe, K., Nakagawa, K. & Yamamoto, E. (1995) Factors affecting the occurrence of bacteraemia associated with tooth extraction. *International Journal of Oral and Maxillofacial Surgery* **24**, 239–242.

Pallasch, T. & Slots, J. (1996) Antibiotic prophylaxis and the medically compromised patient. *Periodontology 2000* **10**, 107–138.

Pitcher, G., Newman, H. & Strahan, J. (1980) Access to subgingival plaque by disclosing agents using mouthrinsing and direct irrigation. *Journal of Clinical Periodontology* **7**, 300–308.

Rahn, R., Schneider, S., Diehl, O., Schafer, V. & Shah, P. (1995) Preventing post-treatment bacteremia: comparing topical povidone–iodine and chlorhexidine. *Journal of the American Dental Association* **126**, 1145–1148.

Randall, E. & Brenman, H. (1974) Local degerming with povidone–iodine I. Prior to dental prophylaxis. *Journal of Periodontology* **45**, 866–869.

Reinhardt, R., Bolton, R. & Hlava, G. (1982) Effect of non-sterile versus sterile water irrigation with ultrasonic scaling on postoperative bacteraemias. *Journal of Periodontology* **53**, 96–100.

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

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

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

Roman, A. & App, G. (1971) Bacteraemia, a result from oral irrigation in subjects with gingivitis. *Journal of Periodontology* **42**, 757–760.

Schour, I. & Massler, M. (1947) Gingival disease in post war Italy (1945). I. Prevalence of gingivitis in various age groups. *Journal of the American Dental Association* **35**, 475–482.

Schreier, H., Erdos, G. & Reimer, K. (1997) Molecular effects of povidone–iodine on relevant micro-organisms: an electron microscopic and biochemical study. *Dermatology* **195**, 111–116.

Sconyers, J., Crawford, J. & Moriarty, J. (1973) Relationship of bacteraemia to toothbrushing in patients with periodontitis. *Journal of the American Dental Association* **87**, 616–622.

Silness, J. & Löe, H. (1964) Periodontal disease in pregnancy. II. Correlation between oral hygiene and periodontal condition. *Acta Odontologica Scandinavica* **24**, 747–759.

Tzukert, A., Leviner, E., Benoliel, R. & Katz, J. (1986) Analysis of the American Heart Asso-

ciation's recommendations for the prevention of Infective Endocarditis. *Oral Surgery* **62**, 276–279.

Waki, M., Jolkovsky, D., Corgel, J., Lofthus, J., Nachani, S., Newman, M. & Flemig, T. (1990) Effects of subgingival irrigation on bacteremia following scaling and root planing. *Journal of Periodontology* **61**, 405–411.

Witzenberger, T., O'Leary, T. & Gillette, W. (1982) Effect of a local germicide on the occurrence of bacteraemia during subgingival scaling. *Journal of Periodontology* **53**, 172–179.

Zamora, J. (1986) Chemical and microbiologic characteristics and toxicity of povidone–iodine solutions. *American Journal of Surgery* **151**, 400–406.

Address:
C. G. Daly
Faculty of Dentistry
University of Sydney
2 Chalmers St
Surry Hills NSW 2010
Australia
E-mail: cdaly@dentistry.usyd.edu.au

Clinical Relevance

Scientific rationale: Bacteraemia due to scaling has been implicated as a possible causative factor for infective endocarditis in at-risk patients. Use of topical antiseptics such as POV–I has been suggested as an adjunct to antibiotic prophylaxis in such patients.

Principal findings: The incidence and magnitude of bacteraemia were reduced in gingivitis patients who rinsed with 7.5% POV–I before ultrasonic scaling. Although viridans streptococci (significant in infective endocarditis) comprised 11/24 isolates in the placebo group, none were present in the POV–I group.

Practical implications: Pre-treatment rinsing with POV–I may be helpful when scaling gingivitis patients in at-risk categories for infective endocarditis.