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The prevalence of bacteraemia on removal of fixed orthodontic appliances

Donald J. Burden*, Wilson A. Coulter*, Chris D. Johnston*, Brian Mullally* and Mike Stevenson**
*School of Dentistry and **Department of Epidemiology and Public Health, Queen's University Belfast, UK

SUMMARY This study investigated the prevalence of bacteraemia on removal of fixed appliances. Venous blood samples were taken before and after debonding and debanding for 30 patients (mean age 17 years 8 months) who had worn fixed appliances for an average of 19 months. Before removal of the fixed appliances, bacteraemia was detected in one of the 30 subjects (3%) and in four subjects (13%) following removal of their fixed appliances. The 95 per cent confidence intervals for the prevalence of post-debanding bacteraemia were 3.8 and 30.7 per cent. No significant relationship was detected between the mean plaque scores ($t = -0.65$, $P = 0.52$) or the mean gingival scores ($t = 0.75$, $P = 0.46$) and the occurrence of bacteraemia. The prevalence of bacteraemia detected following debanding in this study is considerably lower than reported for dental procedures traditionally covered by antibiotic prophylaxis guidelines.

Introduction

Endocarditis is a life-threatening disease and although it is relatively uncommon, substantial morbidity and mortality can result from this infection despite advances in antimicrobial therapy (Burden *et al.*, 2001). Primary prevention of endocarditis is therefore very important (Dajani *et al.*, 1997). Traditionally, among all the orthodontic procedures, band fitting and removal have been considered to offer the greatest insult to the gingival margin, but recent work has suggested that the placing of orthodontic separators may also be a potential source of odontogenic bacteraemia (Lucas *et al.*, 2002). The first study to investigate the relationship between orthodontic treatment and endocarditis failed to detect any bacteraemia when fitting or removing orthodontic bands (Degling, 1972). However, recent investigations of bacteraemia on band fitting using more modern microbiological techniques have reported a relatively low prevalence of bacteraemia of 10 per cent or less (McLaughlin *et al.*, 1996; Erverdi *et al.*, 1999). The latest American guidelines have been modified to include the recommendation that antibiotic prophylaxis should be used for initial banding but not when removing bands (Dajani *et al.*, 1997). It could be argued that the prevalence of bacteraemia might be higher at band removal when the gingival tissues adjacent to the bands are often inflamed. Interestingly, Erverdi *et al.* (2000) found a slightly lower prevalence of bacteraemia at debanding than at band fitting (Erverdi *et al.*, 1999). However, patients with poor oral hygiene were specifically excluded from their debanding study. Therefore, the aim of the current study was to investigate the prevalence of bacteraemia on removal of fixed appliances among a representative sample of patients.

Subjects and methods

For the duration of the study, all patients completing fixed appliance treatment within Queen's University Orthodontic Department who had worn upper and lower fixed appliances (including bands on all four first molars) for at least 12 months were invited to participate. Patients with medical conditions or who were at risk from endocarditis or who had had surgical orthodontic treatment were excluded. Thirty subjects (22 females and eight males) were recruited. Previous research has shown that the prevalence of bacteraemia arising spontaneously is in the range of 1–4 per cent (Wilson *et al.*, 1975; Everett and Hirschmann, 1977; McLaughlin *et al.*, 1996). Using a predicted rise in bacteraemia of at least 30 per cent it was estimated that a sample size of 30 patients would allow the detection of statistically significant differences between pre- and post-operative bacteraemia (90 per cent power, 5 per cent significance level, two-tailed). In accordance with the terms of the ethical approval for this investigation, the procedure was explained in detail to each subject and written consent obtained. The mean age of the participants at debonding was 17 years 8 months with a range of 12 years 9 months to 35 years 11 months. All subjects had worn upper and lower fixed appliances including bands on all four first molars for an average of 19 months (range 12–31 months).

Immediately before the fixed appliances were removed, plaque scores were recorded for the upper and lower central incisors and for one premolar in each quadrant using the Bonded Bracket Index (Kilicoglu *et al.*, 1997). The gingival condition was assessed on all the first molars, second premolars, and central incisors using the Modified Gingival Index (Löe and Silness, 1963). Plaque and gingival scores were recorded using visual inspection only. A pre-operative blood sample was then taken from each of the subjects to act as a control, and to ensure that any post-operative bacteraemia discovered could be attributed to the debanding and debonding procedure. The left ante-cubital fossa was swabbed with alcohol and 15 ml of blood were drawn from a vein using a 21-gauge butterfly infusion needle (Abbot Ireland Ltd, Sligo, Ireland). The cannula was fitted with a three-way Luer valve (Nipro Medical Industries Ltd, Odate, Japan) enabling the blood withdrawal to be discontinued for a short period, and facilitating syringe replacement. When sufficient blood had been withdrawn the syringe was removed and a large bore sterile needle was fixed to the syringe to facilitate inoculation of the blood into culture bottles. To maintain the aseptic chain, the butyl rubber seal of each bottle was swabbed with alcohol.

Following this, the fixed appliances were removed by a single experienced orthodontist (DJB) using bracket and band removing pliers and retained band cement touching the gingival margins was quickly removed using a tungsten carbide bur. Thirty seconds later the withdrawal of 15 ml of blood was commenced using the established venous line (Lucas *et al.*, 2002). The tap-valve was re-opened and the blood drawn into a new sterile syringe avoiding contamination of any part of the venous line or syringe. The post-operative blood sample was inoculated into blood culture bottles as described above. All the samples were analysed in an accredited large regional hospital laboratory and handled by experienced and qualified laboratory staff. Standard measures were taken to avoid contamination and all micro-organisms of environmental origin were excluded from the analysis.

The pre- and post-operative blood samples were cultured using the following methods: (i) the pour plate method using 20 ml of fastidious anaerobic agar (Lab M Ltd, Salford, Lancashire, UK) supplemented with 5 per cent calf serum circulated with 1 ml of the subject's blood (Flow Laboratories Ltd, Harefield, UK) to give a quantitative count of bacteria. The pour plate method has many advantages in this type of study because an estimate of the number of colonies in a bacteraemia can be recorded and it is particularly good at isolating anaerobes (Coulter *et al.*, 1990). (ii) Bac T/Alert system (Organon Teknika Corp., Durham, North Carolina, USA), to give a qualitative aerobic and anaerobic culture based on a colourimetric detection system. This is the routine broth culture used in many laboratories in the UK. It is an automated validated system with high levels of sensitivity with separate broth media for anaerobes and aerobic bacteria. Five millilitres of blood were inoculated into each bottle and it served as a cross check with the pour plate method. Colonies from the pour plate were counted, subcultured and all those that conformed to the genus *Streptococcus* were speciated using the standard microbiological biochemical testing technique, API 20 STREP (API Lab Products Ltd, Basingstoke, Hampshire, UK). Although molecular techniques exist which allow further subgroup analysis of the oral streptococci detected, this was not the aim of this study. *Streptococcus viridans* (alpha-haemolytic streptococci) is the most common cause of endocarditis following dental or oral procedures (Dajani *et al.*, 1997). All other isolates were identified using standard microbiological techniques and the relevant API biochemical tests and species regarded as skin commensals were excluded (coagulase-negative staphylococci).

Results

Among the 30 cases, 25 yielded no detectable bacteraemia of oral origin either pre- or post-operatively. In total, five cases of bacteraemia were detected, four (13%) of these occurred among the post-operative blood samples, and one (3%) in a pre-operative sample only (Table 1). All of the post-operative bacteraemia were detected by the pour plate method. The single pre-operative bacteraemia and one of the post-operative bacteraemia were also detected by the BacT/Alert culturing system. The 95 per cent confidence intervals for the pre- and post-operative prevalence of bacteraemia are reported in Table 1. The upper 95 per cent confidence interval for the post-operative prevalence of bacteraemia was 30.7 per cent. The confidence intervals were estimated according to the Bayesian principle to give a one-sided fiducial limit of confidence concerning the true value.

Table 1 Positive blood culture results for the pre- and post-operative samples.

Blood sample	Pour plate	BacT/Alert	Total number of bacteraemia	Prevalence of bacteraemia (%)	95% confidence interval
Pre-operative (n = 30)	0	1*	1	3	0.1, 17.2
Post-operative (n = 30)	4	1†	4	13	3.8, 30.7

*Positive for the pre-operative sample only.
†Also positive for the post-operative pour plate method.

The number of bacteria isolated from the post-operative samples ranged from 2 to 7 colony forming units (cfu)/ml of blood (Table 2) and in one case included *Veillonella* and *Actinomyces* species. The mean plaque and mean gingival index scores recorded are reported in Table 3. The relationship between the mean plaque and gingival scores was examined using the independent samples *t*-test. These data were found to be normally distributed and therefore amenable to analysis using parametric statistics. No significant relationship was found between the mean plaque scores ($t = -0.65$, $P = 0.52$) or the mean gingival scores ($t = 0.75$, $P = 0.46$) and the occurrence of bacteraemia. Analysis of the mean gingival scores for the first molars only also showed no significant relationship with the occurrence of bacteraemia ($t = 1.04$, $P = 0.31$).

Discussion

This study focused on the prevalence of bacteraemia in the type of at-risk patient usually encountered by orthodontists. These patients usually have congenital heart defects and as a result are at risk from native valve endocarditis, which is almost exclusively streptococcal in origin. As a result, all skin commensals and CNS micro-organisms (coagulase-negative staphylococci) were excluded even though these can be implicated in non-native valve (prosthetic valve) endocarditis.

An extensive review of the literature only revealed three cases where endocarditis was reported to have developed during orthodontic treatment (Biancaniello and Romero, 1991; Hobson and Clark, 1993). The real possibility exists that in all these patients the relationship between the orthodontic treatment and endocarditis was coincidental rather than causal (Burden *et al.*, 2001).

The removal of fixed appliances involves a sequence of two procedures, which could conceivably cause a bacteraemia; bracket removal and band removal. In terms of the trauma caused to the gingival margin, orthodontic brackets are positioned supra-gingivally and their removal rarely causes gingival trauma. Continuous venous sampling during the removal of fixed appliances would allow analysis of the bacteraemia-inducing potential of each of these two procedures, but this was not permitted under the terms of the ethical approval for this study. To reduce the potential for bacteraemia remaining undetected, a strict clinical protocol was used by the experienced clinician who removed the fixed appliances in this investigation. The fixed appliances were removed as quickly as possible beginning with the orthodontic brackets, then the orthodontic bands, and finally any residual band cement extending into the gingival sulcus. Thirty seconds later the post-operative blood sample was collected. This approach ensured that the most traumatic procedure and therefore the most likely to precipitate a bacteraemia was completed at the end of the sequence just prior to the collection of the venous blood sample.

When deciding to prescribe antibiotics, the clinician must balance the potential side-effects such as anaphylaxis, allergy, gastrointestinal upset, and the emergence of resistant organisms against the risk of endocarditis developing (Seymour *et al.*, 2000). These often forgotten side-effects of antibiotics were also highlighted by Wahl (1994) who warned that clinicians who medicate at-risk patients for low-risk procedures are putting their patients at higher risk of morbidity. Indeed, when the technique of formal decision analysis was used to evaluate the risk of endocarditis in patients with mitral valve prolapse (without regurgitation) it was found that greater morbidity was likely to arise from the use of antibiotics (Bor and Himmelstein, 1984). Therefore, the key question is whether orthodontic procedures such as banding or debanding can be categorized as low-risk procedures where more morbidity is likely to arise from the use of antibiotics. Traditionally, expert committees such as the American Heart Association (AHA) and the British Society for Antimicrobial Chemotherapy (BSAC) have evaluated the scientific evidence and provided clinicians with advice on the use of antibiotic prophylaxis (Simmons *et al.*, 1993; Dajani *et al.*, 1997). The current BSAC guidelines do not include orthodontic procedures and only recommend the use of antibiotic prophylaxis in at-risk patients for dental extractions, scaling, and surgery involving the gingival tissues (Simmons *et al.*, 1993). Research has shown that these procedures are associated with a high prevalence of

Table 2 Micro-organisms isolated from the post-operative blood samples.

Subject	cfu/ml	Species
1	2	*Streptococcus sanguis* (1) *Streptococcus mitis* (1)
10	5	*Streptococcus sanguis* (1) *Streptococcus constellatus* (1) *Veillonella* (2) *Actinomyces* (1)
15	7	*Streptococcus mitis* (3) *Streptococcus sanguis* (4)
26	3	*Streptococcus* mutans (3)

cfu, colony forming units/ml of cultured blood.

Table 3 The mean plaque and gingival scores.

Post-operative bacteraemia	Mean plaque score	Mean gingival score	Mean gingival score (first molars only)
No ($n = 26$)	1.60	1.37	1.69
Yes ($n = 4$)	1.90	1.10	1.37

bacteraemia with the majority of patients (60–70%) experiencing a bacteraemia following extractions, scaling or gingival surgery (Coulter *et al.*, 1990; Lucarto *et al.*, 1992). The AHA guidelines were similar in not recommending the use of antibiotic prophylaxis for orthodontic procedures until 1997 when they were changed to include the recommendation that prophylaxis should be used for initial banding, but they do not make any recommendation regarding debanding (Dajani *et al.*, 1997). Interestingly, the two most recent studies that have investigated the occurrence of bacteraemia following initial banding found a relatively low prevalence of bacteraemia of 10 (McLaughlin *et al.*, 1996) and 7.5 per cent (Erverdi *et al.*, 1999).

The prevalence of bacteraemia found in this study when brackets and bands were removed at the end of orthodontic treatment was 13 per cent. This is higher than the bacteraemia prevalence of 6.5 per cent reported by Erverdi *et al.* (2000) when they investigated bacteraemia occurring at debanding. However, in the latter investigation, patients with poor oral hygiene were specifically excluded and it is contended that the present study, with no such exclusions, is more representative of patients at debonding. Intuitively it would be expected that after an average of 19 months of wearing orthodontic bands there would be a greater likelihood of bacteraemia than at initial banding. The present investigation confirmed this with bacteraemia occurring more frequently at debanding than has been reported at initial banding (McLaughlin *et al.*, 1996; Erverdi *et al.*, 1999).

It would be useful if the orthodontist could identify in advance those patients more likely to have a bacteraemia at debanding. However, visual inspection of the gingival condition or the amount of plaque accumulation was not found to be a useful predictor of the occurrence of bacteraemia, with no significant relationship detected between the mean gingival or plaque scores and bacteraemia. Even when the gingival scores for the banded first molars only were analysed, no significant relationship was detected.

Bacteraemia are common daily events even in healthy individuals (Guntheroth, 1984). Spontaneous bacteraemia of oral origin can arise from chewing or toothbrushing (Dajani *et al.*, 1997). The important question is whether orthodontic debanding increases the prevalence of bacteraemia beyond that normally found. Several studies have reported the prevalence of bacteraemia arising spontaneously to be in the region of 1–4 per cent (Wilson *et al.*, 1975; Everett and Hirschmann, 1977; McLaughlin *et al.*, 1996). The present study is in agreement with these previous reports, with only one patient (3%) found to have a bacteraemia of oral origin prior to removal of the fixed appliances. The prevalence of bacteraemia after removal of the brackets and bands in this study was 13 per cent, which is greater than one would expect to arise spontaneously. Although it appears clear that some patients experience bacteraemia as a result of removal of their fixed appliances, the question remains whether debanding should be classified as a low- or high-risk procedure in terms of the need for antibiotic prophylaxis. The prevalence of bacteraemia found at debanding in the present study is considerably lower than that following extractions, scaling or gingival surgery (60–70%). Examination of the upper 95 per cent confidence interval reveals that even when allowance is made for the power of the study, the prevalence of bacteraemia at debonding is unlikely to rise above 31 per cent. This is considerably lower than the procedures currently covered by the BSAC recommendations (extractions, scaling, and gingival surgery) and is similar to the 25 per cent prevalence of bacteraemia reported following toothbrushing in patients wearing fixed appliances (Schlein *et al.*, 1991).

At present there is little understanding of the relationship between the magnitude of a bacteraemia and the occurrence of bacterial endocarditis in humans. The magnitude of a bacteraemia is usually quantified in terms of cfu/ml. The magnitude of bacteraemia observed in humans after procedures such as dental extractions is generally of the order of 10–100 cfu/ml of blood sampled and is polymicrobial in composition, as also found in the present investigation (Everett and Hirschmann, 1977; Coulter *et al.*, 1990). By comparison, the magnitude of bacteraemia detected in the present study was relatively small, indicating that the bacteraemia were of low-grade intensity. However, animal studies have failed to find any direct relationship between the number of bacteria circulating in the blood after dental extractions and the incidence of bacterial endocarditis (Moreillon *et al.*, 1988). It has been postulated that the ability of the streptococcal strain to adhere to the sterile vegetations present on the damaged cardiac valves is more important in the pathogenesis of bacterial endocarditis than the actual magnitude of the bacteraemia (Moreillon *et al.*, 1988).

The final decision about whether antibiotic prophylaxis should be used in patients with cardiac lesions undergoing orthodontic procedures should quite properly remain within the domain of expert committees such as the BSAC and the AHA (Simmons *et al.*, 1993; Dajani *et al.*, 1997). However, the results of this study provide useful data to assist the expert committees in their deliberations. Due to the important implications it would also be preferable that further similar research is completed which also replicates the actual orthodontic clinical situation. Only then will clear and unambiguous advice emerge to remove the current often confusing and contradictory guidance available to orthodontists.

Address for correspondence

Donald J. Burden
Orthodontic Division
School of Dentistry
Queen's University, Belfast
Royal Victoria Hospital
Grosvenor Road
Belfast BT12 6BP
UK

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