*European Journal of Orthodontics* 24 (2002) 293–301 

# The relationship between odontogenic bacteraemia and orthodontic treatment procedures

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SUMMARY The purpose of this research was to estimate the prevalence and intensity of bacteraemia associated with orthodontic treatment procedures. The four procedures investigated were: an upper alginate impression, separator placement, band placement, and adjustment of an archwire on a fixed appliance. Eighty-one children undergoing general anaesthesia (GA) for dento-alveolar surgery related to their orthodontic treatment were randomly allocated to the impression or separator group. A further 61 children, receiving treatment in the Outpatient Department, were included and randomly allocated to the banding or archwire adjustment groups. A cannula was inserted into either the left or right antecubital fossa using an aseptic technique. A baseline 6 ml sample of blood was taken before treatment and a second 6 ml sample was taken 30 seconds after the procedure.

There was no significant difference in the number of positive blood cultures between baseline (nine, 23 per cent), and following an upper alginate impression (twelve, 31 per cent); between baseline (twelve, 27 per cent), and placement of a separator (fifteen, 36 per cent); between baseline (nine, 36 per cent), and fitting or placement of a band (eleven, 44 per cent); or between baseline (twelve, 33 per cent), and archwire adjustment (seven, 19.4 per cent). For the separator group only the mean total number of aerobic and anaerobic bacteria combined, isolated from the blood samples (cfu of bacteria per ml of blood), was significantly greater following the placement of a separator (2.2, SD 9.1), compared with baseline (0.9, SD 0.2; $P < 0.02$).

This investigation demonstrates that the only orthodontic treatment procedure that causes a significant bacteraemia is the placement of a separator.

## Introduction

Transient bacteraemia associated with extraction of teeth is believed to be an important cause of bacterial endocarditis (BE; Everett and Hirschmann, 1977). The current recommendations are that antibiotic prophylaxis should be given prior to extractions in patients at risk of developing BE (Federation Dentaire Internationale, 1987; Endocarditis Working Party, 1993; Dajani *et al.*, 1997). In addition, the guidelines of the Endocarditis Working Party (EWP) of the British Society of Antimicrobial Chemotherapy recommend antibiotic prophylaxis not only before extractions, but also prior to scaling and periodontal surgery. The guidelines from the American Heart Association (AHA) specify antibiotic prophylaxis for 'procedures associated with significant bleeding from hard and soft tissues'. This includes the placement of orthodontics bands but not brackets.

Bacteraemia following a variety of dento-manipulative procedures is well documented. These procedures include extraction of teeth (Burket and Burn, 1937; Coulter *et al.*, 1990; Roberts *et al.*, 1997), intra-ligamental local anaesthesia (Roberts *et al.*, 1998), placement of a rubber dam, matrix band, or wedge (Roberts *et al.*, 2000). Professional cleaning and polishing

of teeth causes bacteraemia (Everett and Hirschmann, 1977) and there is evidence that everyday self-care procedures such as tooth-brushing are associated with bacteraemia (Lucas and Roberts, 2000). There are also a number of orthodontic procedures, which are likely to cause a bacteraemia, for example, placement of separators and bands. In a survey of 1038 orthodontists eight cases of BE were diagnosed either during or immediately after procedures involving treatment with both fixed and removable appliances (Hobson and Clark, 1995). There is the possibility that the relationship between the orthodontic treatment and BE was coincidental rather than causal, as the evidence was not conclusive. Although the placement of full orthodontic bands increases the mean population of oral bacteria (Bloom and Brown, 1964), some workers have reported no bacteraemia following banding and debanding (Degling, 1972). Other investigators reported a prevalence of 10 and 7.5 per cent, respectively, of positive blood cultures following band placement (McLaughlin *et al*., 1996; Erverdi *et al*., 1999). Bacteraemia following orthodontic debanding and debonding have also been investigated and the prevalence was 6.6 per cent both pre- and post-operatively (Erverdi *et al*., 2000).

The most widely used method of detecting positive blood cultures in the UK and Europe is the broth culture. This provides quick, reliable identification of organisms and is now automated. The quantitative data obtained are the percentage prevalence of positive cultures (Roberts *et al*., 1992). The shortcoming of broth culture is the inability to provide information regarding the number of bacteria in the original blood sample. The technique of lysis filtration had been developed for clinical purposes (Hockett *et al*., 1977; Zierdt *et al*., 1982; Heimdahl *et al*., 1990) and not only estimates the prevalence of bacteraemia, but also the intensity in colony forming units per millilitre of blood. The main principle of lysis filtration is disruption of the red and white cell envelopes by proteolytic enzymes to prevent clogging of the filters. In addition, bacteria ingested by the neutrophils are released into the filtrate. The lysed blood sample is pulled through a sterile 0.45 μm pore filter by negative pressure and the bacteria are caught on the filter. The filters are inoculated onto Brain Heart Infusion agar (BHI), and any bacterial growth is recorded and identified. It is a sensitive method, which provides a significantly higher bacterial yield from blood than other techniques (Zierdt *et al*., 1982; Heimdahl *et al*., 1985; Washington and Ilstrup, 1986; Loesche *et al*., 1998). In addition, viable organisms released from neutrophils increase the yield to a more realistic level (Yagupsky and Nolte, 1990).

Lysis filtration has been shown to be successful in isolating organisms following dental extractions and other minor oral surgery procedures in adults (Heimdahl *et al*., 1990). There is little data on the intensity of bacteraemia and no data using lysis filtration following orthodontic treatment procedures.

The purpose of this work was to record the prevalence and intensity of bacteraemia following four orthodontic procedures. These were an upper alginate impression, placement of separators, placement or fitting of bands, and archwire adjustment on a fixed appliance. This is part of a large ongoing project investigating the prevalence of bacteraemia following extractions and a variety of conservative dental procedures and impression techniques.

## Subjects

Ethical approval was obtained from the Eastman Dental Hospital Research and Ethics Committee. Children and adolescents undergoing general anaesthesia (GA) for dento-alveolar surgery related to their orthodontic treatment, and adolescents and young adults undergoing treatment procedures in the Orthodontic Outpatient Department were recruited. Written consent was obtained from the parents and verbal consent from the subjects. Allocation to the study groups was made using a random number table.

## Methods

Indices were recorded for bacterial dental plaque and gingival inflammation (Franco *et al*., 1996) for the whole mouth. A separate score

was recorded for the teeth involved in the orthodontic procedure.

Four per cent amethocaine local anaesthetic paste was applied to both the left and right anticubital fossae of the children treated in the Outpatient Department. This remained in place for approximately 35 minutes to ensure adequate anaesthesia. For all the subjects the skin on either the left or the right antecubital fossa was prepared with 1 per cent povidone iodine solution. A 23 gauge Y CAN (Wallace, SIMS Portex, Hythe, Kent, UK) was inserted into a vein using aseptic technique. For the children undergoing GA the cannula was inserted following induction.

The first 0.5 ml of blood withdrawn through the cannula was discarded to void any skin contaminants. A further 6 ml sample of blood was withdrawn and inoculated into a sterile universal bottle containing 1.23 ml sodium polyanethol sulphonate (SPS) to prevent clotting. This was the baseline sample. The orthodontic procedure to be investigated was carried out immediately before any other treatment. For the children under GA this was either an upper alginate impression or the placement of a separator between either two lower molar teeth, or between a lower molar and premolar tooth. For the subjects in the Outpatient Department the procedure was either the fitting or placement of an orthodontic band, or adjustment of an archwire.

A second 6 ml sample of blood was withdrawn 30 seconds after the orthodontic procedure (Roberts *et al*., 1992) and similarly inoculated into SPS. The blood and SPS were added to the lysing solution containing 190 ml distilled water, 0.08 per cent $Na_2CO_3$, 0.005 per cent Triton X and 3 ml of a proprietary streptokinase–streptodornase compound (Varidase, Cyanamid, Gosport, Hampshire, UK) and incubated at 37ºC for 10 minutes. Two equal volumes of the solution were poured into a disposable, sterile filtration unit and drawn through a 0.45 μm pore filter by negative pressure of approximately 460 mm Hg. Each filter was inoculated onto BHI. One plate was incubated aerobically and the other anaerobically for 10 days. From day 3 each filter was checked daily for bacterial growth using a stereomicroscope.

*Control procedures*

For each batch of blood samples one blank filter was inoculated onto BHI and incubated aerobically, and a second blank filter was inoculated onto BHI and incubated anaerobically for a period of 10 days. Two blank plates of BHI were processed in the same manner.

*Identification of bacteria*

All bacteria were identified to genus level (Barrow and Feltham, 1993) except for the oral streptococci, which were identified to species level (Beighton *et al*., 1991).

*Outcome measures*

These were:

1. The prevalence of bacteraemia recorded as the number of positive blood cultures and expressed as the percentage prevalence.
2. The intensity of bacteraemia, recorded as the number of colony forming units of bacteria per millilitre of blood (cfu/ml).
3. The identity of the bacteria.

*Statistical analysis*

The data were tested for normality using the Shapiro–Wilks test (Altman, 1991) and found to be non-normal in distribution. Non-parametric statistical tests were used. The Chi square test was used for categorical data and the Wilcoxon Ranked Test for comparisons between baseline and post-procedure.

## Results

*Subjects*

From a total of 85 children undergoing dento-alveolar surgery, 81 were included in the study. Three subjects withdrew consent and one other had poor venous access. From a total of 120 children approached a further 61 were recruited from the Outpatient Department. Thirty-seven refused because of fear of injections, five others

were short of time, and a further 17 gave no reason for declining. The mean age of the whole group was 13.5 years (SD 2), range 9.2–17.9 years. There were 64 males and 78 females. The number of subjects in each treatment procedure group is shown in Table 1.

*Bacterial dental plaque*

The mean plaque score for the alginate impression group was 14.8 (SD 16.9), for the separator group 11.9 (SD 8.0), for the fit/placement of band 15.9 (SD 14.6), and for the archwire adjustment group 15.1 (SD 9.9) (Table 2).

*Gingival inflammation*

The mean gingivitis score for the groups was alginate impression 8.1 (SD 11.2), separator 6.5 (SD 6.1), fit/placement of band 13.3 (SD 11.5), and archwire adjustment group 7.7 (SD 5.7; Table 2).

*Prevalence of bacteraemia*

There was no significant difference in the number of positive blood cultures between baseline and the dentogingival manipulations (Table 3). There was no significant association between the mean plaque and gingivitis scores, and the number of positive blood cultures for any of the procedures.

**Table 1** Orthodontic treatment procedures.

| Treatment procedure | Number of subjects |
|---|---|
| Upper alginate impression | 39 |
| Separator | 42 |
| Fit/placement of band | 25 |
| Archwire adjustment | 36 |

**Table 3** Prevalence of bacteraemia: number of positive blood cultures.

| Group | *n* | Baseline | Post-procedure |
|---|---|---|---|
| Alginate impression | 39 | 9 (23%) | 12 (31%) |
| Separator | 42 | 12 (27%) | 15 (36%) |
| Fit/placement of band | 25 | 9 (36%) | 11 (44%) |
| Archwire adjustment | 36 | 12 (33%) | 7 (19.4%) |

*n* = number of subjects.
No significant difference in the percentage prevalence of positive blood cultures between baseline and post-procedure.

*Intensity of bacteraemia*

The mean total number of aerobic and anaerobic bacteria isolated from the blood samples (cfu of bacteria per ml of blood) was significantly greater following the placement of a separator ($P < 0.02$; Tables 4–6). There was no significant difference in the mean number or aerobic, anaerobic, or the combined total aerobic and anaerobic bacteria isolated from the blood samples between baseline and an upper alginate impression, between baseline and fitting or placement of a band, or between baseline and archwire adjustment (Tables 4–6).

*Identity of bacteria isolated*

The identity of the bacteria isolated from blood cultures were similar to those following dental

**Table 2** Bacterial dental plaque and gingivitis score.

| Group | | Plaque score | | | | Gingivitis score | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *n* | Mean | SD | Median | Min–Max | Mean | SD | Median | Min–Max |
| Alginate impression | 39 | 14.8 | 16.9 | 10.0 | 0–96 | 8.1 | 11.2 | 4.0 | 0–40 |
| Separator | 42 | 11.9 | 8.0 | 10.0 | 0–32 | 6.5 | 6.1 | 6.0 | 0–18 |
| Fit/placement of band | 25 | 15.9 | 14.6 | 14.0 | 0–45 | 13.3 | 11.5 | 10.0 | 0–40 |
| Archwire adjustment | 36 | 15.1 | 9.9 | 14.0 | 0–36 | 7.7 | 5.7 | 6.0 | 0–20 |

*n* = number of subjects. SD = standard deviation.

**Table 4** Intensity of bacteraemia: total combined aerobic and anaerobic bacteria (cfu per ml of blood).

| Group | *n* | Mean | SD | Median | Min–Max | Significance |
|---|---|---|---|---|---|---|
| Alginate impression | | | | | | |
| Baseline | 39 | 0.2 | 0.7 | 0 | 0–2.7 | |
| Post-procedure | | 0.3 | 0.6 | 0 | 0–3.5 | NS |
| Separator | | | | | | |
| Baseline | 42 | 0.9 | 0.2 | 0 | 0–0.7 | |
| Post-procedure | | 2.2 | 9.1 | 0 | 0–43.7 | $P < 0.02$ |
| Fit/placement of band | | | | | | |
| Baseline | 25 | 0.1 | 0.2 | 0 | 0–0.7 | |
| Post-procedure | | 0.3 | 0.6 | 0 | 0–2.8 | NS |
| Archwire adjustment | | | | | | |
| Baseline | 36 | 0.2 | 0.7 | 0 | 0–4 | |
| Post-procedure | | 0.04 | 0.1 | 0 | 0–0.5 | NS |

*n* = number of subjects. NS = not significant.

**Table 5** Intensity of bacteraemia: aerobic bacteria (cfu per ml of blood).

| Group | *n* | Mean | SD | Median | Min–Max | Significance |
|---|---|---|---|---|---|---|
| Alginate impression | | | | | | |
| Baseline | 39 | 0.1 | 0.4 | 0 | 0–1.7 | |
| Post-procedure | | 0.2 | 0.6 | 0 | 0–3.5 | NS |
| Separator | | | | | | |
| Baseline | 42 | 0.06 | 0.1 | 0 | 0–0.5 | |
| Post-procedure | | 0.8 | 3.4 | 0 | 0–19.3 | $P < 0.02$ |
| Fit/placement of band | | | | | | |
| Baseline | 25 | 0.03 | 0.08 | 0 | 0–0.3 | |
| Post-procedure | | 0.2 | 0.5 | 0 | 0–2.7 | NS |
| Archwire adjustment | | | | | | |
| Baseline | 36 | 0.07 | 0.3 | 0 | 0–1.8 | |
| Post-procedure | | 0.02 | 0.06 | 0 | 0–0.2 | NS |

*n* = number of subjects. NS = not significant.

**Table 6** Intensity of bacteraemia: anaerobic bacteria (cfu per ml of blood).

| Group | *n* | Mean | SD | Median | Min–Max | Significance |
|---|---|---|---|---|---|---|
| Alginate impression | | | | | | |
| Baseline | 39 | 0.1 | 0.4 | 0 | 0–2.2 | |
| Post-procedure | | 0.07 | 0.2 | 0 | 0–0.7 | NS |
| Separator | | | | | | |
| Baseline | 42 | 0.03 | 0.09 | 0 | 0–0.5 | |
| Post-procedure | | 1.4 | 6 | 0 | 0–30.7 | $P < 0.03$ |
| Fit/placement of band | | | | | | |
| Baseline | 25 | 0.07 | 0.2 | 0 | 0–0.7 | |
| Post-procedure | | 0.08 | 0.1 | 0 | 0–5.0 | NS |
| Archwire adjustment | | | | | | |
| Baseline | 36 | 0.09 | 0.4 | 0 | 0–2.2 | |
| Post-procedure | | 0.02 | 0.06 | 0 | 0–0.3 | NS |

*n* = number of subjects. NS = not significant.

operative procedures (Roberts *et al*., 1997, 1998). These included *S. gordonii*, *S. sanguis*, *S. salivarius*, *S. vestibularis*, and coagulase-negative staphylococci (Table 7). The bacteria isolated from the baseline group included *S. oralis*, *S. mitis*, and coagulase negative staphylococci (Table 7).

## Discussion

The purpose of this study was to investigate the prevalence and intensity of odontogenic bacteraemia following orthodontic treatment procedures. The four procedures included were: an upper alginate impression, placement of a separator, fitting, or placement of a band, and archwire adjustment. It is clearly important to determine which procedures in the provision of orthodontic care are likely to cause a bacteraemia so that an informed decision can be made regarding antibiotic prophylaxis for individuals at risk of BE.

There is limited data on orthodontic treatment and bacteraemia. Banding and debanding have been investigated and some workers have reported no incidence of bacteraemia (Degling, 1972). Other workers have reported a 10 per cent prevalence of positive blood cultures following band placement (McLaughlin *et al*., 1996). The post-operative blood sample was taken 60 seconds after the band was fully seated and cultured using a pour plate and a broth culture technique. Earlier work with broth cultures of this type demonstrated that the maximum bacteraemia occurred 30 seconds following the maximum dento-gingival manipulation (Silver *et al*., 1975). Different investigators have reported a prevalence of 7.5 per cent of positive blood cultures following band placement (Erverdi *et al*., 1999). However, in that investigation the post-operative blood sample was taken two minutes after cementation, by which time the maximum bacteraemia would have disappeared.

In the present study blood samples were taken before the orthodontic procedure, as a baseline, as this is important for determining the true post-procedure bacteraemia (Hockett *et al*., 1977). The proportion of culture-positive baseline samples was similar to other reports (Roberts *et al*., 1997) and is the 'background' bacteraemia that occurs following everyday procedures, for example, a dental examination (Roberts *et al*., 1997) or toothbrushing (Lucas and Roberts, 2000). Both the baseline and post-operative prevalence of bacteraemia was greater in the present investigation. One explanation for this

**Table 7** Bacterial species isolated from blood cultures: all groups.

| Species | Baseline | | Post-procedure | |
|---|---|---|---|---|
| | Aerobic (*n*) | Anaerobic (*n*) | Aerobic (*n*) | Anaerobic (*n*) |
| *S. mitis* | – | – | – | 2 |
| *S. oralis* | 1 | 1 | – | – |
| *S. salivarius* | – | – | 1 | – |
| *S. vestibularis* | – | – | – | 1 |
| *S. gordonii* | – | – | 1 | 1 |
| *S. sanguis* | – | – | 1 | 1 |
| Coagulase-negative staphylococci | 30 | 25 | 31 | 26 |
| *S. aureus* | 1 | – | 3 | 1 |
| *Micrococcus* spp. | 3 | 1 | 4 | 1 |
| Pediococcus | – | 1 | – | – |
| Propionebacterium | – | – | – | 1 |
| *Actinomycetes* spp. | – | 3 | 2 | 2 |
| *Corynebacterium* spp. | 1 | 5 | 2 | 1 |
| Stomatococcus | – | – | 3 | – |
| *Candida* spp. | 1 | – | – | – |
| *Lactobacilli* spp. | – | – | 1 | 1 |

*n* = number of blood samples bacterial species isolated from.

is the increased sensitivity of lysis filtration compared with conventional broth culture (Hockett *et al*., 1977; Heimdahl *et al*., 1985). An advantage of the lysis filtration system is that lysis of the phagocytes releases intracellular organisms that would otherwise not be detected.

There was a low intensity of bacteraemia at baseline for all procedures, which only increased significantly following insertion of a separator. A similar increase might also have been expected after banding and there are two reasons why this was not apparent. First, the space created by the separator facilitates the band placement. Despite the increase in plaque and gingival inflammation that may occur in the area of the separator, the band does not appear to force any accumulated bacteria into the gingival margin. In addition, there was no significant association between plaque and gingivitis and the prevalence of positive blood cultures.

The present recommendations of the EWP (1993) are the use of antibiotic prophylaxis for dental procedures likely to cause a bacteraemia, namely, extractions, scaling, and periodontal surgery. The AHA recommend antibiotic prophylaxis for all procedures that are likely to cause gingival bleeding and specifically include the initial placement of orthodontic bands, but not brackets (Dajani *et al*., 1997). In the UK, 67 per cent of orthodontists prescribe antibiotic prophylaxis for band placement and 56 per cent for band removal (Hobson and Clark, 1995) for patients at risk of developing BE. In the USA, 51 per cent of orthodontists consider it necessary to prescribe antibiotic prophylaxis for banding and 38 per cent for debanding (Gaidry *et al*., 1985). This investigation indicates that there is a small, but significant increase in the intensity of bacteraemia following placement of a separator, which does not occur following banding. Further exploration of the data revealed that there were two subjects with bacterial intensity of approximately 40 cfu per ml of blood after placement of a separator. The intensity for the other subjects was low in comparison, between 0.2 and 3.5 cfu per ml. Nevertheless, this demonstrates the high intensity of bacteraemia that can occur with separator placement. There is very little reliable data on the intensity of bacteraemia in humans. The existing data from animal studies indicate that the intensity of bacteraemia required to reliably cause BE is of the order of $1 \times 10^6$–$1 \times 10^8$ cfu/ml of blood (Bahn *et al*., 1978; Cremieux *et al.*, 1993). The available data for humans demonstrate the intensity of bacteraemia to vary from 1 cfu/ml of blood (Coulter *et al*., 1990) to 240 cfu/ml of blood (Roberts *et al*., 1987). In the present study, the intensity ranged from 0 to 44 cfu/ml of blood. There is no advice available from the national advisory bodies regarding the intensity of bacteraemia that 'causes' endocarditis.

The bacterial species isolated from the blood cultures included *S. gordonii*, *S. sanguis*, *S. salivarius*, *S. vestibularis*, and coagulase-negative staphylococci, all of which have been isolated from blood cultures following dental operative procedures (Roberts *et al*., 1997, 1998). They are also implicated in the aetiology of BE (Shanson, 1989; McCartney, 1992). Oral streptococci are the predominant species implicated in BE and account for between 60 per cent (Hogg, 1994) and 40 per cent (EWP, 1993) of cases. In this study, 9 per cent of post-procedure isolates were oral streptococci and 65 per cent were coagulase-negative staphylococci. Children undergoing active orthodontic treatment may have a higher oral carriage of coagulase-negative staphylococci compared with children who are not. Concurrent work investigating the bacterial load of blood discarded after placement of the cannula revealed that from 69 0.5 ml discard samples only three were culture positive. One cfu of coagulase-negative staphylococci was isolated from two of these. One cfu of vancomycin-resistant enterococcus was isolated from the third sample. This confirms that the aseptic technique used for the blood sampling was satisfactory.

## Conclusions

This work demonstrates that there is no difference in the prevalence of bacteraemia between the placement of separators and bands. However, some individuals have a greater intensity of bacteraemia following the placement of a separator compared with baseline. It would

be appropriate to investigate a much larger sample of children and adolescents from several orthodontic units using the same blood culture system. This would help to clarify the question of which, if any, procedures used in the provision of orthodontic treatment are a significant cause of dental bacteraemia that would require antibiotic prophylaxis in children and adolescents with predisposing cardiac lesions.

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