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## ORIGINAL ARTICLE

# Prevalence of bacteraemia following third molar surgery

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**OBJECTIVE: To investigate the prevalence and aetiology of bacteraemia following third molar extractions (B-TME), analysing the factors affecting its development.**
**METHODS: The study group was formed of 100 patients undergoing third molar extractions under general anaesthesia. Peripheral venous blood samples were collected at baseline, 30 s after a mandibular third molar extraction and 15 min after completing the final extraction. Samples were inoculated into BACTEC aerobic and anaerobic blood culture bottles and were processed in the BacT/Alert. Subculture and further identification of the bacteria isolated was performed using conventional microbiological techniques.**
**RESULTS: The prevalence of bacteraemia following third molar surgery was 62% at 30 s after the first dental extraction and 67% at 15 min after finishing the final extraction. The bacteria most frequently identified in the positive blood cultures were *Streptococcus viridans* (87.9%).**
**CONCLUSION: In our series, the prevalence of B-TME at 30 s after a single third molar extraction was high, principally being of streptococcal aetiology, and was independent of the oral health status and the magnitude of the surgical procedure. Positive blood cultures persisted for at least 15 min after three to four dental extractions in a higher number of patients, questioning the supposedly transient nature of bacteraemia following dental extractions.**
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**Keywords:** focal infection; bacteraemia; dental extractions; third molar; *Streptococcus viridans*

## Introduction

A focal infection is 'a localized or general infection caused by the dissemination of microorganisms or toxic products from a focus of infection' (Easlick, 1951). Bacteraemia constitutes an essential step in the pathogenesis of some focal infections of oral origin such as bacterial endocarditis, prosthetic joint infections and brain abscesses (Gendron *et al*, 2000).

Okell and Elliott (1935) were the first to demonstrate the presence of bacteria in the bloodstream following dental extractions. Since then, numerous authors have studied the prevalence of bacteraemia associated with dental extractions (BDE) (Elliott and Dunbar, 1968; Peterson and Peacock, 1976; Shanson *et al*, 1978, 1985; Baltch *et al*, 1982; Coulter *et al*, 1990; Cannell *et al*, 1991; Hall *et al*, 1993; Roberts *et al*, 1998; Tomás *et al*, 2006). However, few papers have been published on the prevalence and aetiology of bacteraemia following third molar extractions (B-TME) (Josefsson *et al*, 1985; Otten *et al*, 1987; Heimdahl *et al*, 1990; Göker and Güvener, 1992; Okabe *et al*, 1995; Rajasuo *et al*, 2004a,b).

Furthermore, the influence of factors such as the anaesthetic technique used (general or local anaesthesia), the oral health status and the magnitude of the surgical procedure on the prevalence of B-TME has not been sufficiently investigated.

The aim of this study was to determine the prevalence and aetiology of bacteraemia following third molar extractions, analysing the factors affecting its development.

## Patients and methods

*Selection of the study group*

The study group was formed of patients who underwent extractions of third molars under general anaesthesia in the Valencia University General Hospital (Spain). The following exclusion criteria were applied: under 18 years of age, presence of positive blood cultures at baseline (before any manipulation), presence of signs of pericoronitis in the previous month, having received antibiotics in the previous month, the routine use of oral antiseptics, having any known risk factor for bacterial endocarditis, suffering any type of congenital or acquired immunodeficiency, and any other disease which could predispose to infections or bleeding. Applying these criteria, 100 patients were selected.

No preoperative antibiotics were prescribed and no special disinfection of the mouth was performed. The number of third molars extracted was ≤2 in 2% of patients, 3 in 19% and 4 in 79%.

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The project was approved by the Ethics Committee of the Valencia University General Hospital. Informed consent for participation in the study was obtained from the patients.

*Determination of the oral health status*
After recording the age and gender of each patient, a single GDP performed an intraoral examination gathering information on: plaque deposits (Silness and Löe oral hygiene index) (Silness and Löe, 1964), calculus deposits (oral calculus index) (Greene and Vermillion, 1960), the presence of gingival bleeding (gingival bleeding index) (Ainamo and Bay, 1975), depth of periodontal pockets in the Ramfjord teeth, and the presence of periapical lesions associated with the third molars (detected radiologically). The indication for the third molar extraction was also recorded, differentiating between history of pericoronitis reported by the patient and/or dentist (excluding those patients with some episode in the month prior to enrolment), and non-infective reasons. These records were performed 2 days prior to the surgical procedure.

*Magnitude of the surgical procedure*
The following variables on the magnitude of the surgical procedure were recorded: grade of inclusion, depth of impaction (Pell and Gregory classification) (Pell and Gregory, 1942), position in the mandible, level of insertion, relationship with the ascending ramus and the lower second molars (Pell and Gregory classification) (Pell and Gregory, 1942), number and type of roots, radiological relationship with the inferior dental nerve, and the time employed for osteotomy and/or tooth sectioning. The total time of the surgical procedure was also recorded.

*Collection of samples for blood culture*
To determine the prevalence of B-TME, peripheral venous blood samples were collected from each patient at baseline (before nasotracheal intubation and before local anaesthetic injection with articaine and adrenaline) and 30 s after the extraction of one mandibular third molar. A third sample of peripheral blood was taken at 15 min after finishing the final extraction in order to evaluate the duration of the bacteraemia. For blood culture collections, a large-bore (18–22 g) angiocath needle was placed in a vein in the antecubital fossa or dorsum of the hand, after cleansing the site in the usual manner with alcohol, followed by povidone-iodine. The angiocath needle and line were flushed with 3 ml of saline after drawing each blood sample, and 2 ml of blood was drawn and discarded immediately before each sample was taken. Each blood sample was divided equally between two bottles with aerobic and anaerobic culture media (BacT/Alert; BioMerieux, Durham NC, USA) and immediately transported to the laboratory. The collection, handling and transport of the blood samples for blood culture were performed according to the recommendations of the Spanish Society of Infectious Diseases and Clinical Microbiology (Loza Fernández de Bobadilla *et al*, 2003) and the methodology applied by numerous authors in studies on bacteraemia following dental procedures (Heimdahl *et al*, 1990; Roberts *et al*, 1998; Rajasuo *et al*, 2004a).

*Microbiological analysis of the blood cultures*
In the laboratory, a total of 302 blood culture bottles were processed in the BacT/Alert (BioMerieux). A Gram stain was performed on each positive blood culture. The positive blood cultures in the aerobic media were subcultured on blood agar and chocolate agar in an atmosphere of 5–10% $CO_2$, and on MacConkey agar under aerobic conditions. The same protocol was used for the positive blood cultures in the anaerobic media, with subculture on Schaedler agar and incubation in an anaerobic atmosphere. The bacteria isolated were identified using biochemical tests following the recommendations of the American Society for Microbiology (Murray *et al*, 1999). *Streptococcus viridans* were classified into five groups: *mitis*, *anginosus*, *salivarius*, *mutans* and *bovis*, applying the Ruoff criteria (Murray *et al*, 1999; Ruoff, 2002).

*Statistical analysis*
The results were analysed using the SPSS version 12.0 statistical package for Windows (SPSS Inc., Chicago, IL, USA). Student's *t*-test, Fisher's exact test and the chi-squared test were used to compare the distinct variables of the oral health status and magnitude of the surgical procedure between the patients presenting B-TME at 30 s and those with negative blood cultures. When the variables of the oral health status and magnitude of the surgical procedure showed a *P*-value $\leq 0.25$, a multivariate analysis using binary logistic regression was performed. The Student's *t*-test was used to compare the total time employed in the dental extractions between the patients presenting B-TME at 15 min and those with negative blood cultures.

## Results

*Characteristics of the study group*
The study group was made up of 43 (43%) male and 57 (57%) female patients, with a mean age of 25.2 ± 7.2 years (range 18–53 years). The results of the oral health status and the magnitude of the surgical procedure (related to the first third molar extraction performed) are shown in Table 1.

*Prevalence of B-TME and identification of the bacteria isolated*
The prevalence of bacteraemia was 62% at 30 s after completing the first extraction of a mandibular third molar and 67% at 15 min after finishing the final extraction. A total of 131 bacteria were isolated from third molar postextraction blood cultures: 115 (87.9%) were *Streptococcus viridans* (62 *S. viridans*, 39 *S. mitis* group, 8 *S. salivarius* group, 4 *S. anginosus* group and 2 *S. mutans* group), 6 (4.6%) *Neisseria* spp. (3 *N. subflava*, 1 *N. flava*, 1 *N. lactamica* and 1 *N. mucosa*), 2 (1.5%) *Staphylococcus* spp. (2 *S. aureus*), 2 (1.5%) *Corynebacterium* spp., 2 (1.5%) *Leuconostoc* spp., 2 (1.5%) *Rothia dentocariosa* and 2 (1.5%) other bacteria (1 *Acinetobacter iwoffii* and 1 *Moxarella catarrhalis*).

**Table 1** Oral health status and magnitude of the surgical procedure in the study group ($n = 100$ patients)

| | *Number of patients (%)* |
|---|---|
| Dental plaque[a] | |
| Grade 0 | 19 (19) |
| Grade 1 | 73 (73) |
| Grade 2 | 8 (8) |
| Mean ± SD | 1.41 ± 0.47 |
| Calculus[b] | |
| Grade 0 | 72 (72) |
| Grade 1 | 27 (27) |
| Grade 2 | 1 (1) |
| Mean ± SD | 0.73 ± 0.47 |
| Gingival bleeding[c] | |
| Mean ± SD | 35.73 ± 22.08 |
| Periodontal pockets[d] | |
| < 4 mm | 97 (97) |
| ≥ 4 mm | 3 (3) |
| Mean ± SD | 2.09 ± 0.83 |
| Periapical lesion | |
| No | 57 (57) |
| Yes | 43 (43) |
| Indication for the third molar extraction | |
| Pericoronitis | 40 (40) |
| Non-infective reasons | 60 (60) |
| Depth of impaction[e] | |
| Grade 1 | 16 (16) |
| Grade 2 | 49 (49) |
| Grade 3 | 35 (35) |
| Level of insertion | |
| ≤ 5 mm | 99 (99) |
| 6–10 mm | 1 (1) |
| Position of the third molar | |
| Horizontal | 24 (24) |
| No horizontal[f] | 76 (76) |
| Relationship with ascending ramus and with the lower second molars[e] | |
| Class I | 7 (7) |
| Class II | 66 (66) |
| Class III | 27 (27) |
| Relationship with the inferior dental nerve | |
| No contact | 16 (16) |
| Contact | 44 (44) |
| Superimposed | 40 (40) |
| Number and type of dental roots | |
| Sole or several amalgamated | 41 (41) |
| Two or more parallel or converging | 50 (50) |
| Two or more divergent or anomalous | 9 (9) |
| Practice of osteotomy | |
| No | 1 (1) |
| Yes | 99 (99) |
| Practice of tooth sectioning | |
| No | 34 (34) |
| Yes | 66 (66) |
| Time employed for osteotomy (s) | 212.27 ± 124.22 |
| Time employed for tooth sectioning (s) | 52.44 ± 57.35 |

Data on the magnitude of the surgical procedure were obtained in relation to the first mandibular third molar extraction.
[a]Silness and Löe oral hygiene index.
[b]Oral calculus index.
[c]Gingival bleeding index.
[d]Depth of periodontal pockets in the Ramfjord teeth.
[e]Pell and Gregory classification.
[f]Vertical, mesial and distal angulated third molars were included.

### *Factors related to the development of bacteraemia*

Of the patients with negative blood cultures at 30 s, 44.7% were male and 55.3% female with a mean age of 25.6 ± 7.4 years. Of the patients with positive blood cultures at 30 s, 41.9% were male and 58.1% female with a mean age of 24.9 ± 7.2 years. No statistically significant association was observed between age or gender and the prevalence of B-TME at 30 s after ending the dental extraction.

The results of the oral health status of the patients are shown in Table 2, grouped according to positive or negative blood cultures. None of the variables of oral health status (plaque and calculus deposits, presence of gingival bleeding, depth of periodontal pockets, presence of periapical lesions and the indication for the dental extraction) showed a statistically significant association with the prevalence of B-TME at 30 s after ending the dental extraction.

The results of the magnitude of the surgical procedure are shown in Table 3, grouping the patients according to positive or negative blood cultures. None of the variables of the magnitude of the surgical procedure (grade of inclusion, depth of impaction, position in the mandible, level of insertion, relationship with the ascending ramus and with the lower second molars, number and type of roots of the third molars extracted, radiological relationship to the inferior dental nerve, and the time employed for osteotomy or tooth sectioning) showed a statistically significant association with the prevalence of B-TME at 30 s after ending the extraction.

In the multivariate analysis, the variables 'periodontal pockets' and 'position of the third molar' were not significantly related to B-TME at 30 s after ending the extraction ($P = 0.260$ and 0.225 respectively).

**Table 2** Oral health status in the patients with NBC ($n = 38$) and PBC ($n = 62$)

| | *Patients with NBC* | *Patients with PBC* | *P*-value |
|---|---|---|---|
| Dental plaque[a] | | | |
| Grade 0 | 6 (15.8) | 11 (17.7) | 0.903 |
| Grade 1 | 29 (76.3) | 46 (74.2) | |
| Grade 2 | 3 (7.9) | 5 (8.1) | |
| Mean ± SD | 1.42 ± 0.49 | 1.41 ± 0.45 | |
| Calculus[b] | | | |
| Grade 0 | 25 (65.8) | 47 (75.8) | 0.329 |
| Grade 1 | 12 (31.6) | 15 (24.2) | |
| Grade 2 | 1 (2.6) | 0 (0.0) | |
| Mean ± SD | 0.79 ± 0.52 | 0.70 ± 0.43 | |
| Gingival bleeding[c] | | | |
| Mean ± SD | 37.21 ± 24.46 | 34.82 ± 20.64 | 0.601 |
| Periodontal pockets[d] | | | |
| < 4 mm | 38 (100.0) | 59 (95.2) | 0.154 |
| ≥ 4 mm | 0 (0.0) | 3 (4.8) | |
| Mean ± SD | 1.94 ± 0.73 | 2.19 ± 0.88 | |
| Periapical lesion[e] | | | |
| No | 23 (60.5) | 34 (54.8) | 0.678 |
| Yes | 15 (39.5) | 28 (45.2) | |
| Indication for the third molar extraction[e] | | | |
| History of pericoronitis | 18 (47.4) | 22 (35.5) | 0.295 |
| Non-infective reasons | 20 (52.6) | 40 (64.5) | |

Values within parenthesis are expressed as percentage. NBC, negative blood cultures; PBC, positive blood cultures.
[a]Silness and Löe oral hygiene index.
[b]Oral calculus index.
[c]Gingival bleeding index.
[d]Depth of periodontal pockets in the Ramfjord teeth.
[e]Data obtained in relation to the first mandibular third molar extraction.

**Table 3** Magnitude of surgical procedure in the patients with NBC ($n = 38$) and PBC ($n = 62$)

| | *Patients with NBC* | *Patients with PBC* | *P*-value |
|---|---|---|---|
| Depth of impaction[a] | | | |
| Grade 1 | 5 (13.2) | 11 (17.8) | 0.718 |
| Grade 2 | 22 (57.9) | 27 (43.5) | |
| Grade 3 | 11 (28.9) | 24 (38.7) | |
| Mean ± SD | 2.16 ± 0.63 | 2.21 ± 0.72 | |
| Level of insertion | | | |
| ≤5 mm | 38 (100.0) | 61 (98.4) | 1.000 |
| 6–10 mm | 0 (0.0) | 1 (1.6) | |
| Position of the third molar | | | |
| Horizontal | 32 (84.2) | 44 (71.0) | 0.154 |
| No horizontal[b] | 6 (15.8) | 18 (29.0) | |
| Relationship with ascending ramus and with the lower second molars[a] | | | |
| Class I | 2 (5.3) | 5 (8.1) | 0.603 |
| Class II | 25 (65.8) | 41 (66.1) | |
| Class III | 11 (28.9) | 16 (25.8) | |
| Mean ± SD | 2.24 ± 0.54 | 2.18 ± 0.55 | |
| Relationship with the inferior dental nerve | | | |
| No contact | 7 (18.4) | 9 (14.5) | 0.639 |
| Contact | 18 (47.4) | 26 (41.9) | |
| Superimposed | 13 (34.2) | 27 (43.6) | |
| Number and type of dental roots | | | |
| Sole or several amalgamated | 18 (47.4) | 23 (37.1) | 0.598 |
| Two or more parallel or converging | 17 (44.7) | 33 (53.2) | |
| Two or more divergent or anomalous | 3 (7.9) | 6 (9.7) | |
| Practice of osteotomy | | | |
| No | 37 (97.4) | 62 (100.0) | 0.380 |
| Yes | 1 (2.6) | 0 (0.0) | |
| Practice of tooth sectioning | | | |
| No | 12 (31.6) | 22 (35.5) | 0.828 |
| Yes | 26 (68.4) | 40 (64.5) | |
| Time employed for osteotomy (s) | 219.76 ± 139.93 | 207.68 ± 114.49 | 0.639 |
| Time employed for tooth sectioning (s) | 57.08 ± 63.40 | 49.60 ± 53.65 | 0.529 |

All data were obtained in relation to the first mandibular third molar extraction.
Values within parenthesis are expressed as percentage. NBC, negative blood cultures; PBC, positive blood cultures.
[a]Pell and Gregory classification.
[b]Vertical, mesial and distal angulated third molars were included.

The mean total time used to complete the extractions was 39.20 ± 13.78 min. No differences were found between the total time used to complete the extractions in patients with positive blood cultures at 15 min and those with negative blood cultures (39.88 ± 13.83 min and 37.82 ± 13.79 min respectively).

## Discussion

*Prevalence and aetiology of postextraction bacteraemia*

In our study, the presence of positive blood cultures at baseline was used as a criterion of exclusion. However, as found by numerous authors (Heimdahl *et al*, 1990; Okabe *et al*, 1995), this percentage was low (2%).

There are few reports on the prevalence of B-TME published in the literature. Furthermore, in all of these series, the B-TME rate was investigated in small study groups (≤25 patients). The prevalence of B-TME reported in the majority of the studies varies between 40% (Otten *et al*, 1987; Göker and Güvener, 1992; Rajasuo *et al*, 2004b) and 55% (Josefsson *et al*, 1985; Heimdahl *et al*, 1990). In the present series, the prevalence of B-TME was slightly higher (60%).

In the present series, all patients underwent third molar extractions under general anaesthesia. Baltch *et al* (1982) demonstrated that the practice of endotracheal intubation increased the prevalence of BDE. In contrast, Takai *et al* (2005) found similar percentages of positive postextraction blood cultures between patients treated under general anaesthesia and those treated using local anaesthesia (57.7% and 58.1% respectively). The prevalence of B-TME detected in the present series was similar to that reported in previous studies performed under local anaesthesia (Josefsson *et al*, 1985; Heimdahl *et al*, 1990).

Another difference observed in the methodological variables of the various series of B-TME is the time at which the blood samples were taken after the third molar extraction. Josefsson *et al* (1985), Heimdahl *et al* (1990) and Göker and Güvener (1992) performed the sampling during dental manipulation, Rajasuo *et al* (2004b) at 1 min and Otten *et al* (1987) at 3–5 min. In view of the findings reported by Roberts *et al* (1992) concerning the moment of highest incidence of BDE, the postextraction blood samples in our study were taken at 30 s after completing the first third molar extraction.

In 1997, the American Heart Association stated that bacteraemias of oral origin are of transient nature as they do not usually persist for more than 15 min after completion of the dental procedure (Dajani *et al*, 1997). Probably influenced by this premise, the prevalence of B-TME has been only determined for up to 10–15 min

after ending the surgical procedure in the majority of the studies. In the present series, we found positive blood cultures at 15 min in a higher percentage of patients than in previous series (25–40%) (Josefsson *et al*, 1985; Heimdahl *et al*, 1990; Rajasuo *et al*, 2004b). However, in those studies the persistence of B-TME (at 10–15 min) was evaluated after a single third molar extraction while in our series it was analysed after completing three to four third molar extractions (in all but two patients).

In two B-TME series recently published by Rajasuo *et al* (2004a,b), bacteraemia persisted for up to 30 min after a single third molar extraction in 10% and 12.5% of the patients respectively. Göker and Güvener (1992) investigated the duration of B-TME, detecting 28% of positive blood cultures at 1 h after the surgical procedure and 8% at 24 h. In consequence, some authors question the supposedly transient nature of B-TME (Rajasuo *et al*, 2004b).

According to some authors (Göker and Güvener, 1992), *S. viridans* were the bacteria most frequently isolated in third molar postextraction blood cultures. In contrast, 70% of the bacteria isolated were obligate anaerobes in other series on B-TME (Rajasuo *et al*, 2004b).

*Factors related to the prevalence of third molar postextraction bacteraemia*

*Age and gender*

Few authors have studied the influence of age on the prevalence of B-TME, probably because the study population in the majority of the series presented a narrow age range. Josefsson *et al* (1985) demonstrated that the frequency of positive third molar postextraction blood cultures did not vary significantly with the age of the patients. To our knowledge, there are no previous reports in the literature which analysed the influence of gender on the prevalence of B-TME. In the present series, neither age nor gender showed a statistically significant association with the prevalence of B-TME at 30 s after ending the dental manipulation.

*Oral health status*

Few authors have investigated the influence of the oral health status on the prevalence of B-TME, probably due to the good oral health status of the patients in most series (Göker and Güvener, 1992; Rajasuo *et al*, 2004a). In our series, we also found a low percentage of patients with high levels of dental plaque, calculus, gingival bleeding or periodontal pockets ≥4 mm.

Takai *et al* (2005), in a study on bacteraemia after various maxillofacial and oral surgical procedures (including third molar extractions), found no correlation between the prevalence of postmanipulation bacteraemia and the simplified oral hygiene index and gingival index scores. In the present series, the dental plaque or calculus levels and the presence of gingival bleeding showed no statistically significant association with the prevalence of B-TME at 30 s after completing the dental manipulation. However, Okabe *et al* (1995) and Takai *et al* (2005) detected a significantly higher prevalence of B-TME in teeth with signs of inflammation/infection (periodontitis, periapical infection and/or pericoronitis) than in infection-free teeth (88% *vs* 47% and 68% *vs* 23% respectively). On the basis of these findings, Takai *et al* (2005) suggested that the bacteria that could invade the bloodstream during the surgical procedure are present at higher concentrations around infected teeth than around infection-free teeth, and that the extraction of infected teeth would consequently increase the subsequent risk of bacteraemia. In the present series, neither the presence of periapical lesions nor previous pericoronitis showed a statistically significant association with the prevalence of B-TME at 30 s after completing the dental manipulation.

*Magnitude of the surgical procedure*

Heimdahl *et al* (1990) demonstrated that bacteraemia was not related to the extent of surgery, as a single conventional dental extraction produced a higher prevalence of bacteraemia than unerupted third molar surgery. For some authors, a possible explanation might be the rich bacterial flora present on the tooth surface and in the gingival sulcus in erupted teeth (Heimdahl *et al*, 1990; Rajasuo *et al*, 2004a). However, to our knowledge, in the literature there are no reports in which a comparison has been performed of the prevalence of B-TME after procedures on impacted teeth *vs* partially erupted teeth. The prevalence of B-TME in our series was similar after the extraction of impacted or partially erupted teeth.

Other authors have suggested that the frequency of bacteraemia following the extraction of erupted teeth might be due to the pumping movements used when the conventional dental extraction technique is employed (Heimdahl *et al*, 1990). Takai *et al* (2005) observed that the surgical technique of dental extraction did not influence bacteraemia as there was no statistical difference in the prevalence depending on whether or not the procedure involved the removal of bone. In our series, although the influence of the osteotomy on the prevalence of B-TME at 30 s was not analysed (because all but one of the patients underwent osteotomy), the duration of osteotomy, the practice of tooth sectioning and the time employed did not affect the percentage of positive postextraction blood cultures.

Okabe *et al* (1995) showed that the prevalence of BDE increased significantly with the number of teeth extracted, the duration of the surgical intervention and the volume of blood lost during the procedure. In contrast, although the influence of the number of third molars extracted on the prevalence of B-TME at 15 min was not analysed in our series (because all but two patients underwent three to four third molar extractions), the duration of the surgical intervention was similar in the patients with positive blood cultures at 15 min and in those with negative blood cultures. This result is in agreement with the findings of Josefsson *et al* (1985) who studied the influence of surgical time on the prevalence of B-TME, detecting no correlation between the two variables.

In conclusion, the prevalence of B-TME at 30 s, particularly of a streptococcal nature, was high after a single third molar extraction in our series, and was not related to the oral health status or to the magnitude of the surgical procedure. Positive blood cultures persisted for at least 15 min after three to four dental extractions in a higher number of patients, questioning the supposedly transient nature of bacteraemia following third molar extractions.

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