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ORIGINAL ARTICLE

Computer-assisted flapless implant placement reduces the incidence of surgery-related bacteremia

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Abstract
Objective Bacteremia—the access of bacterium to the bloodstream—may yield life-threatening complications. The aim of this study was to compare the incidence, duration, and type of bacterium leading to bacteremia with relation to conventional and computer-assisted flapless implant surgery.
Material and methods A total of 377 implants were placed in 68 edentulous jaws using the conventional (conventional group) or a computer-assisted stereolithographic (SLA) template-guided surgery technique (flapless group). Bacteremia was monitored from pre- and postoperative blood samples.
Results The duration of the surgical intervention was significantly shorter in the flapless group (p=0.3510). Baseline samples were sterile. Following the 15th minute after the placement of the last implant, bacteria were present in 62 and 12 % of the patients in the conventional and flapless groups, respectively (p<0.0001; relative risk: 3.05). The differences in the incidence of the bacteremia detected at the baseline and 15 min after the last implant placement were statistically significant in the conventional group (p=0.0001). However, no such statistical significance was present in the flapless group. *Staphylocccus epidermidis*, *Bifidobacterium* spp., *Streptococcus viridans*, *Corynebacterium* spp., and *Streptococcus sanguinis* were the isolated bacterium.
Conclusions Irrespective of the utilized technique, bacteremia may occur upon the placement of four to eight implants to an edentulous jaw. The probability of bacteremia for the patients operated with the conventional technique is, however, 3.05 greater than those operated with the flapless technique.
Clinical relevance Flapless implant placement reduces the incidence of surgery-related bacteremia and, therefore, may be beneficial to patients at risk.

Keywords Bacteremia · Dental implant · Flapless surgery · Tomography · Computer assisted

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Introduction

Bacteremia can be defined as the presence of bacteria in the bloodstream [1]. Oral environment is inhabited by many different bacteria species harboring on teeth, tongue, gingiva, and the surrounding soft tissues, and upon any discontinuity on the highly vascularized mucosal integrity, bacteria easily transfer to the bloodstream and reach distant organs vulnerable to the adhesion of such bacteria. For most of the dental-related procedures, it is inevitable and could be related to various simple (i.e., tooth brushing and flossing) [2, 3] or invasive (i.e., extraction and dental implant surgery) procedures [4–7]. In healthy individuals, the bacterium in the bloodstream is rapidly terminated by the immune defense system [1]. However, in some particular group of compromised patients such as those with a prosthetic heart valve, specific congenital heart disease, or surgically constructed shunt/conduit, lethal complications may occur [8–10]. In such risky circumstances, antibiotic coverage is recommended [9, 10]. By their use, the bacterial growth at the localized site of colonization is inhibited, but there is no certainty that the development of an infection will be prevented and the prophylaxis will avail [11]. Besides, the risk of bacterial resistance, hypersensitivity reactions, and gastrointestinal side effects may outperform their benefits [7, 12, 13]. In general, antibiotic prophylaxis, constraining the duration and the invasiveness of the procedures as well as providing a high level of oral hygiene was recommended to decrease the risk of bacteremia [9, 14, 15].

With global awareness and demand for dental implants for the treatment of edentulism, an important portion of the elderly population has become at risk of developing a potential bacteremia complication [16, 17]. Up until now, the placement of implants was solely performed following the exposure of a mucoperiosteal flap extending beyond the margins of the edentulous crest [18]. With the help of recent advances in the radiographic imaging and computer-assisted stereolithographic (SLA) techniques, flapless insertion of multiple implants (four to eight implants) has become possible with an advantage of reduced surgical duration and postoperative morbidity—most probably as a result of no flap exposure [19, 20]. Since recent evidence suggests a significant incidence of bacteremia after conventional implant surgery, the use of the mentioned flapless technique may be of benefit for the patients at risk [6, 7].

Therefore, the aim of this study was to compare the incidence, duration, and type of bacterium leading to bacteremia with relation to conventional and computer-assisted flapless implant surgery. The characteristics of patients with and without bacteremia were also analyzed. A clinical study was conducted to test the following null hypothesis: the incidence, duration, and the involved bacterium in conventional and flapless implant surgery-related bacteremia techniques do not yield a statistically significant difference regarding the postoperative 15th and 30th minutes.

Materials and methods

This prospective observational study was approved by the ethical committee of Istanbul University (2008/3200-1844) and conducted according to the Helsinki Declaration of 1975 as revised in 2008. The study was also registered on the database of clinical trials website (NCT01027442). Results from a previous study [7] were referred to for the calculation of the sample size via dedicated software (nQuery Advisor, Statistical Solutions, Saugus, MA, USA). Accounting the reported bacteremia proportion of 23 %, an estimated minimum of 32 patients (per group) were calculated to detect a 30 % difference (70 % decrease of the bacteremia risk) between the groups at the level of α=0.05 and with a statistical power of 80 %. Possible dropouts (10 %) were also accounted for and a final total of 68 patients (34–35 patients per group) were targeted for the completion of the study.

Patients who applied to the Department of Oral Implantology, Faculty of Dentistry, Istanbul University between March 2008 and April 2011 for the treatment of edentulism were informed about the study, and consenting healthy volunteers with at least one edentulous jaw were included in the study. The following exclusion criteria were established: age under 18 years, pregnancy, heavy smoking (>10 cigarettes per day), systematic disease which may complicate implant surgery, immunodeficiency, systematic use of antibiotics within 3 months prior to the surgical intervention, routine use of oral antiseptics, presence of a prosthetic joint and/or a heart valve, odontogenic infection (periodontitis, periapical diseases, and pericoronitis), severe alveolar bone loss or atrophy, and any risk of bacteremia-related complication (infective endocarditis (IE), prosthetic joint, or heart valve infection). Patients with any remaining natural dentition in the antagonist jaw were also examined regarding the periodontal health. All remaining teeth were evaluated using the community periodontal index of treatment needs (CPITN) [21]. Any patients with a score of 3 or above (pathological pocket of 4–5 mm with or without bleeding and calculus) were excluded at the beginning of the study. Also, patients with the score of 2 (presence of calculus without a pathological pocket) went through an initial periodontal therapy consisting of a professional calculus removal and dental hygiene motivation 2 weeks before the implant surgery.

Allocation of the treatment groups

All patients were initially evaluated by panoramic x-rays and oral examination. According to a previously established criteria [22, 23], the eligibility of the patients for SLA surgical template-guided flapless implant surgery (flapless group) was decided according to the availability of sufficient bone thickness and attached mucosa. Using a bone caliper (Oraltronics, Bremen, Germany) under local anesthesia (Ultracain D-S forte, Sanofi-Aventis, İstanbul, Turkey), the thickness of the alveolar bone was measured in the incisor and premolar areas referring 4 mm apically from the top of the edentulous crest. Measurements were repeated in both segments of the edentate jaw and patients exhibiting sufficient bone thickness and attached mucosa width (≥5 mm) were deemed eligible for flapless implant surgery (flapless group). Patients, whose bone thickness and/or attached mucosa width were below 5 mm, were allocated to the conventional implant surgery technique (conventional group). The planning of implants in the conventional group was realized using the panoramic x-rays, intraoral photographs, and diagnostic plaster models.

For the patients in the flapless group, a barium sulfate scan prosthesis representing the final prosthetic outline was produced and checked in situ to confirm the correctness of the tooth setup, esthetic appearance, and phonetics. Then, the patient was forwarded for cone beam-computed topographic imaging (ILUMA, IMTEC Imaging, Ardmore, PA, USA). The resulting images were uploaded to a personal computer with the planning software (SimPlant Planner, Materialise Dental, Leuven, Belgium), and a total of 206 implants were planned by a clinician (V.A.) skilled in the SLA-assisted implant treatment sequence. The final data were saved and sent to the SLA guide production facility (Materialise Dental). Using the above-described classification criteria, a total of 68 patients were consecutively recruited until the aim of 34 patients per group was accomplished.

Implant surgery

All surgical procedures were carried out in a sterile surgical theater setup. All of the surgical armamentarium (except nonautoclavable materials) were encased and sealed by special sterilization packages and then sterilized using a B-Class medical autoclave. To prevent bias, no preoperative antibiotics, oral disinfectants, or sedative premedications were administered in any patients. Articaine hydrochloride with epinephrine (each 2-ml ampoule includes 80 mg articaine hydrochloride and 0.020 mg epinephrine; Ultracain D-S forte, Sanofi-Aventis, İstanbul, Turkey) was used for the infiltration anesthesia. Approximately 2 ml anesthetic solution was applied to each implant site in both groups.

The surgery in the conventional group was initiated by a midcrestal incision extending 5 mm distally to the posterior implant in each segment. A vertical releasing incision (usually one anterior–midline and/or two posterior oblique incisions) was used only when further visibility of alveolar bone was required. Osteotomy was performed according to the conventional implant surgery technique described by Branemark et al. [17] via a torque controlled surgical motor (W&H Dentalwerk Bürmoos GmbH, Austria) providing sterile saline irrigation of 15 ml/min. Upon completion of the osteotomy, a total of 166 two-piece titanium implants were placed either by the torque-controlled handpiece or with the manual ratchet of the implant system. To sustain standardization with the flapless group, gingival formers were fastened and the implants were left to transmucosal healing. Flap borders were repositioned and closed by interrupted 3.0 silk sutures (Dogsan Medical Supplies Industry, Trabzon, Turkey). The sutures were removed after 1 week.

The base material of the SLA guide is not durable to high temperatures. Therefore, the sterilization of the SLA guide was performed by immersing it into a povidone–iodine solution (Adekon, Ankara, Turkey) for 20 min, which was followed by rinsing under copious sterile saline solution. The SLA guide was positioned in the mouth, and to prevent undesired mobility of the SLA guide during instrumentation [21], the guide was rigidly fixated to the underlying alveolar bone by osteosynthesis screws via the previously planned holes. Using the special mucotome (SAFE trephine, Materialise Dental), the mucosae over the planned implant recipient areas were removed. Then, the osteotomy was completed using the special drill kit consisting of a 2-mm diameter pilot and 3.8-mm diameter final drill (SAFE Drills, Materialise Dental). The depth of the osteotomy was controlled by the physical stoppers on the drills. To clean debris and bone particles, the prepared osteotomy holes were irrigated by copious amounts of saline, and a total of 206 titanium dental implants were inserted through the SLA guide (Fig. 1). The osteosynthesis screws were detached and the SLA guide was removed from the mouth. In both groups, all implants were left to transmucosal healing by the fastening of the gingival healing screws.

The duration of the surgery, use of additional anesthetics, and per surgical complications were recorded in both groups. Since all patients had at least one edentulous jaw, the number of implants placed to each jaw was between four and eight. A total of 372 two-piece titanium dental implants consisting of 173 root form (XiVE, DENTSPLY Friadent, Mannheim, Germany) and 199 parallel-walled implants (SPI, Thommen Medical, Waldenburg, Switzerland) were uneventfully placed in both groups (Fig. 2). The diameters of the implants were between 3.4 and 4.5 mm and the lengths of the implants were between 8 and 15 mm. The distribution of implant brands among the patients was random; however, there were no combined use of brands in any patient.

Blood sampling

Intravenous blood samples were used for the detection of bacteremia via a dedicated bottle-based microbiologic analysis system (BACTEC, BD Diagnostic Systems, Sparks, MD, USA). In order to prevent any skin contamination, the skin was initially wiped with a 70 % isopropyl alcohol (ADR, Advanced Diagnostic & Research, Istanbul Turkey) and povidone–iodine (Adekon), respectively. Blood samples (each of 10 ml) were taken from the antecubital vein by a disposable syringe (Ayset Saglik Ltd., İstanbul, Turkey). To avoid contamination, the covers of the blood culture tubes were also wiped clean by 70 % isopropyl alcohol. To ensure the absence of any bacteremia prior to the surgery, a baseline sample was obtained just before the anesthetic injection. Following 15 and 30 min after the placement of the last implant, two postoperative samples were also taken. This timing was intentionally scheduled to account for the time required for flap closure and suturing in the conventional group and the removal of the SLA guide (after the

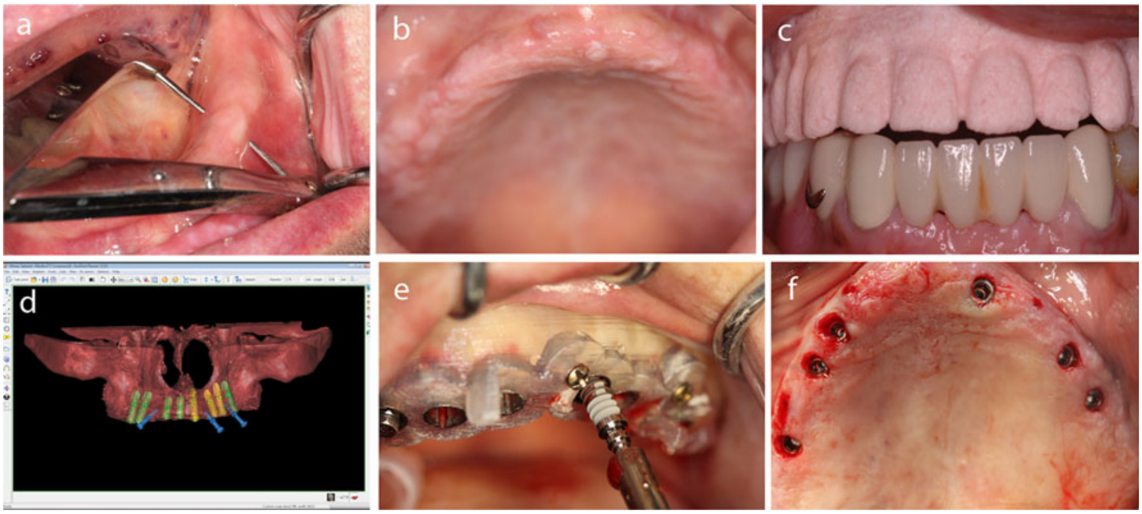

Fig. 1 Patient selection and treatment sequence in the flapless group: **a** alveolar bone thickness was measured using a bone caliper. **b** Patients revealing sufficient bone and attached mucosa width (≥5 mm) were deemed eligible for flapless implant surgery using mucosa-supported SLA guides. **c** A radio-opaque scan prosthesis was prepared and tried in situ in terms of satisfying esthetic, functional, and phonetic requirements. **d** The acquired CBCT data were used for virtual implant planning via dedicated software. **e** Implants were installed by the help of a special implant mount and the guiding cylinders on the SLA guide. **f** Clinical view of the maxilla after flapless implant surgery

detachment of the osteosynthesis screws) in the flapless group. A total of three punctures were performed in each patient, and all blood samples were immediately inoculated into the BACTEC bottles including aerobic and anaerobic culture media.

Microbiological analysis

All microbiological analyses were conducted at the laboratory of the Department of Microbiology and Clinical Microbiology, Faculty of Medicine, Istanbul University in accordance of the

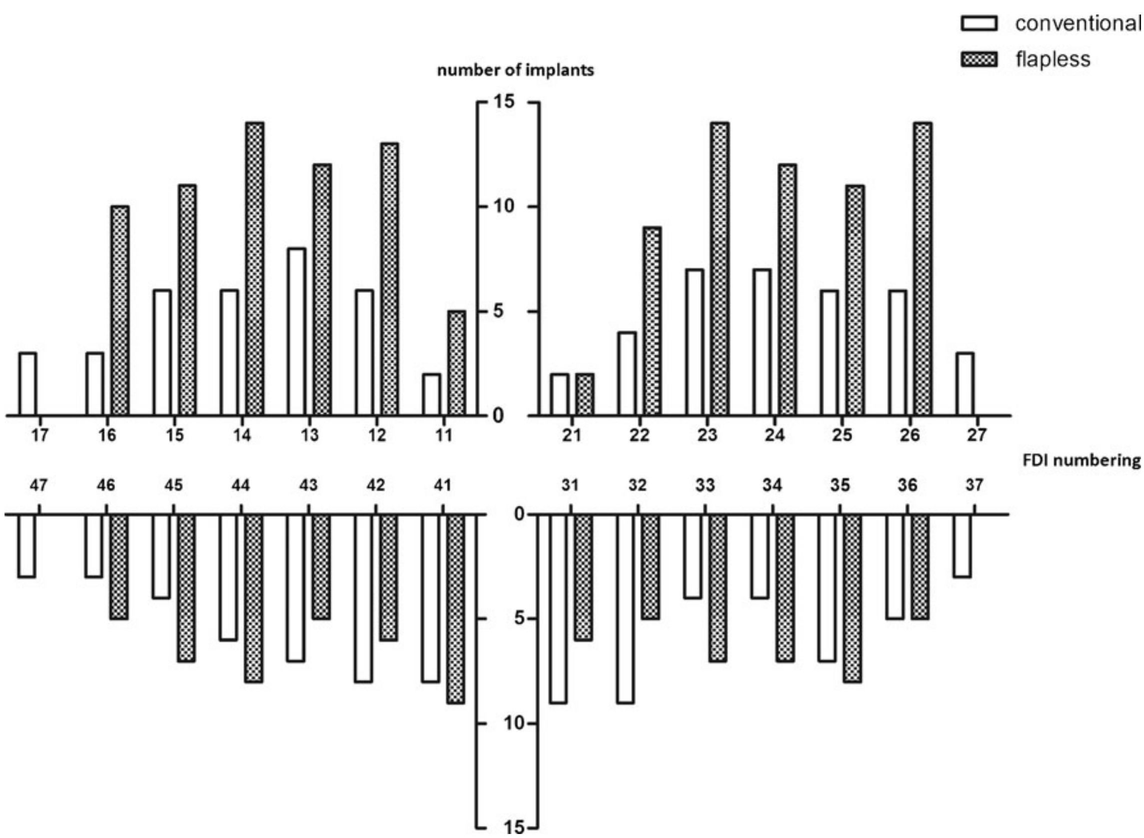

Fig. 2 Distribution and the number of placed implants in the conventional and flapless groups

protocol enrolled in a previous study [7]. The blood culture bottles were incubated and monitored for the presence of microorganisms for 14 days in a special automated system (BACTEC 9120 BD Diagnostic Systems, Sparks, MD, USA). A gram stain was performed for each positive culture that was removed from the blood culture system. For the aerobic bottle, the positive blood cultures were subcultured on sheep blood agar (bioMerieux, Marcy l'Etoile, France) and chocolate agar (bioMerieux) plates in an atmosphere of 5–10 % CO_2. For the anaerobic bottle, the same protocol was used, but the sample was subcultured on Schaedler agar (Oxoid, Hampshire, UK) and incubated in an anaerobic atmosphere using Gaspak pockets (Oxoid). The isolated bacteria were identified using conventional methods, including colonial morphology, gram stain appearance, and catalase and oxidase reactions. An automatic identification system (VITEK, bioMerieux) was also used for bacterial identification.

Statistical analysis

D'Agostino and Pearson omnibus normality test was used to verify the normality of the data distribution. Data sets revealing normal distribution, age, sex, surgery duration, and number of implants each patient received were analyzed by the *t* test. Remaining parameters were analyzed by the Mann–Whitney *U* test. The similarity of the groups regarding the patient characteristics (age, gender, and presence of teeth in the antagonist jaw), duration of the surgery, and number of implants placed in the surgical session were analyzed by the *t* test and Fisher's exact test. The incidence of the bacteremia in the conventional and flapless groups was compared by the Fisher's exact test at the consecutive three blood samples (baseline and 15 and 30 min after the placement of the last implant). Within the groups, McNemar's test (adjusted p=0.025) was used to compare the prevalence of bacteremia detected at baseline with that of following the placement of implants. All tests were performed on a statistical software package (GraphPad Prism, San Diego, CA, USA) and any *P* value below 0.05 was accepted as statistically significant.

Results

All surgeries were completed uneventfully, and there was no need for additional local anesthesia in any patients. Following the completion of the surgery in the conventional group, two female patients exhibited anxiety and left the operatory without donating blood, and two female patients experienced syncope. Also, at the end of the intervention, one male patient in the conventional group conceded to having consumed antibiotics. The corresponding data of these five patients were excluded from the study. Finally, the clinical data of 63 patients (29 in conventional and in 34 flapless groups) who had been treated by 346 implants (140 in control and 206 in flapless groups) were included in the analysis. One week after the surgery, all patients were reexamined in terms of any clinical or subclinical sign of an infection. Healing was uneventful in all patients, and no adverse outcomes were observed.

The conventional and flapless groups had similar patient age (48.81, SD 11.22 and 53.21, SD 9.11 years; t=1.032, p=0.209), gender (14 females, 15 males and 16 females, 18 males; p=0.611; (adjusted p=0.025)), presence of dentation in the antagonist jaw (10 (34.48 %) and 14 (41.17 %); p=0.211; (adjusted p=0.025)), and the number of implants placed in each surgical session (5.1, SD 0.66 and 6.1, SD 1.54 implants in conventional and flapless groups, respectively; t=1.1242, p=0.26). Mean surgery duration was 63.06 (range 21–110, SD 24.05) min and 32.97 (range 14–61, SD 11.95) min in conventional and flapless groups, respectively. The distribution of the time data was normal (K^2=3,814, p=0.1485 and K^2=2,094, p=0.3510 in conventional and flapless groups, respectively) and the differences of the surgery duration between the groups was statistically significant (t=5.900, p<0.0001) (Table 1; Fig. 3).

A total of 378 aerobic and anaerobic blood culture bottles taken from 63 patients at three consecutive time intervals (baseline, and 15 and 30 min after the placement of the last implant) was successfully processed. In the beginning of the surgical intervention (baseline), no bacterium was isolated in any groups. However, 15 min after the placement of the last implant, bacteremia was detected in 18 (62 %) and four (12 %) patients in the conventional and flapless groups, respectively. After 30 min, one patient of each group (3 %) demonstrated the same bacteria that had also been present in the previous sample.

The differences in the incidence of the bacteremia detected at the baseline and 15 min after the last implant placement were statistically significant in the conventional group (p=0.0001). However, no statistically significant difference was found in the flapless group (p=0.1336). The difference of bacteremia in the blood samples taken 15 min after the surgery was statistically significant between the two groups (p<0.0001; relative risk, 3.05;

Table 1 Descriptive statistics of surgery duration (in minutes) in conventional and flapless groups

	Conventional (min)	Flapless (min)
Mean (SD)	63.06 (24.05)	32.97 (11.95)
Min–max	21–110	14–61
95 % CI	54.67–71.45	28.80–37.14

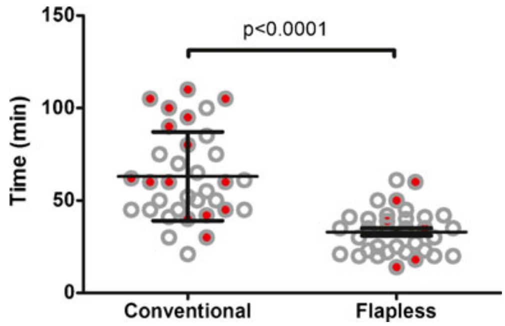

Fig. 3 Scatter plots of the surgery duration (in minutes) in conventional and flapless groups (*horizontal lines* depict mean values and the SD). *Red color* represents the patient bacteremia detected

95 % CI of relative risk, 1.772–5.247; odds ratio, 12.27; 95 % CI of odds ratio, 3.394–44.37) (Fig. 4).

In the flapless group, no statistically significant differences were found between the characteristics of the patients with or without bacteremia at 15 min after the placement of the last implant (adjusted $p=0.025$). However, in the conventional group, mean surgery duration of the patients with bacteremia (61.22 min, SD 14.45) was significantly higher than those of patients without bacteremia (41.2 min, SD 11.13) ($p=0.017$) (adjusted $p=0.025$). No statistically significant differences were found between the rest of the patients' variables detected with bacteremia.

In the conventional group, the differences in the percentage of bacteremia detected at the 15th and 30th minute were also statistically significant ($p=0.0016$) (adjusted $p=0.025$). However, no statistically significant difference was found in the flapless group ($p=0.2482$) (adjusted $p=0.025$).

Five bacteria species were isolated (Table 2). In both groups, *Staphylocccus epidermidis* was the most frequently isolated bacteria (31 and 8.8 % in the conventional and flapless groups, respectively). *S. epidermidis* and *Streptococcus viridans* were the common bacteria that were isolated in both of the groups. In addition, *Bifidobacterium* spp. (13.8 %), *Corynebacterium* spp. (10.3 %), and *Streptococcus sanguinis* (3.4 %) were isolated in the conventional group. The *S. viridans* isolated in the conventional group (3.4 %) and *S. epidermidis* isolated in the flapless group (2.9 %) at the

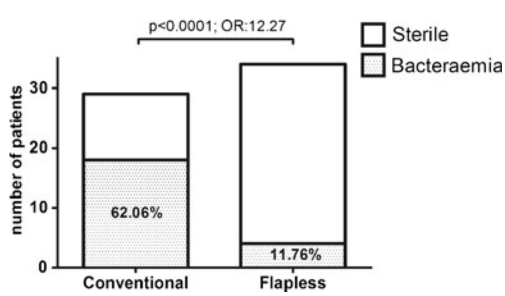

Fig. 4 Bar graph of bacteremia detected 15 min after the placement of the last implant

15th minute were also found remaining in the bloodstream after 30 min following the placement of the last implant..

Discussion

This study investigated the prevalence of bacteremia and involved bacteria after implant surgery utilizing the conventional or a computer-assisted flapless technique. Patients with at least one edentulous jaw were recruited to prevent bias related to possible contamination from the neighboring teeth to the surgical area. Patients with any remaining periodontal unhealthy teeth in the opposing jaw (CPITN≥3) were also excluded. For the detection of bacteremia, a dedicated blood culturing system (BACTEC) was used, as already it comprises the most common technique used in the available literature [3, 6, 7, 24]. Similarity of the compared groups regarding age, gender, and number of received implants validated the reliability of the statistical outcome.

In the dental literature, varying rates of bacteremia were reported for different dental procedures such as extraction (13–64 %) [5, 25], mucoperiosteal flap elevation (21–74 %) [26], osteosynthesis screw removal (20–50 %) [5, 27], and periodontal scaling and root planning (26–88 %) [1, 28]. Despite its widespread clinical use, dental implant surgery-related bacteremia has been the focus of a limited number of studies. A previous study utilizing the conventional technique where a total of 30 partially edentulous patients were treated by one or two implants within a mean duration of 30 min resulted with a 23 % rate of bacteremia after 30 min following the placement of the last implant [7]. In another study by Pineiro et al. [6], 30 patients were treated by a means of "4.7±1.53" implants caused bacteremia rates of 6.7 and 3.3 % after the 30th second and 15th minute of the implant placement, respectively. Given the present study design, the highest bacteremia rate of 62 % was encountered in the conventional group following 15 min after the placement of the last implant. This was most probably due to the need of a larger flap elevation, higher number of implants inserted, and longer surgical duration, as expected in a totally edentulous jaw being treated for an implant-supported fixed prosthesis. Consequently, the patients in the conventional group may have been subjected to a higher surgical trauma, increasing the chance of bacteremia. The use of a noninvasive, fast, flapless insertion protocol significantly reduced the prevalence of bacteremia but was not able to eliminate it completely. The probability of bacterial access to the bloodstream may be related to various factors such as the surface area and the duration of the flap exposure, the number of osteotomies prepared in the dental alveolus, and patient-related factors such as the status of the periodontium and systemic health [6, 26]. Therefore, comparison of the present findings with others is difficult,

Table 2 Bacterium detected in the iv samples taken 15 and 30 min after the placement of the last implant

Isolated bacterium	Conventional group (n=29)		Flapless group (n=34)	
	After 15 min	After 30 min	After 15 min	After 30 min
Staphylocccus epidermidis	9 (31 %)	0	3 (8.82 %)	1 (2.9 %)
Bifidobacteria	4 (13.8 %)	0	0	0
Corynebacteria	3 (10.3 %)	0	0	0
Streptococcus viridans	1 (3.4 %)	1 (3.4 %)	1 (2.9 %)	0
Streptococcus sanguinis	1 (3.4 %)	0	0	0

and discrepancies should be expected as a result of certain variables.

The periodontal status may be regarded as a source of bias in the analysis of dental bacteremia [26, 28]. Furthermore, the bacterial load of oral environment was shown to be differentiating between the partial and total edentulisms [29]. In this study, patients with poor periodontal health were excluded from the study and all of the potential periodontal risk factors were eliminated prior to the surgery. In addition, the presence of any natural dentition in the antagonist jaw was addressed in the statistical analysis that revealed no significance.

The method chosen for the analysis of bacteremia also seems to influence the outcome. The presently utilized culturing system provides a rapid and easy analysis of blood samples taken in the surgical theater, but when compared to the lysis filtration method, the sensitivity seems to be lower [28, 30]. However, utilization of the lysis filtration method is complicated, and detection is slower than BACTEC [28, 30, 31]. The very sensitive polymerize chain reaction technique can alternatively be used, but unfortunately, the dead and live bacteria are counted together and cannot be discriminated [1]. Therefore, the BACTEC system was chosen in this study to provide outcomes reproducible for the clinical practice.

According to the recommendation of the BSC and the RCP of London (British Cardiac Society Clinical Practice Committee and Royal College of physicians), a baseline blood sample is essential for the validity of any decision on the subsequent blood samples demonstrating bacteria [9]. Accordingly, preop blood samples were obtained from all of the patients, and all of them were found sterile. Oral-related bacteremia is also expected to be transitional within an hour. The relevant studies, therefore, obtained samples within a time frame of 30 s to 1 h after the intervention [1, 3, 4, 6]. Accordingly, to achieve a comparable outcome, postoperative sampling was done by obtaining two samples with an interval of 15 min in between. Similar to those reported in previous studies, the incidence of bacteremia peaked right after the surgery (62.06 and 11.67 %) and was almost completely eliminated after 30 min (3.44 and 2.94 % in the conventional and flapless groups, respectively). In the flapless group, the prevalence of bacteremia was not statistically significant in any of the time intervals, whereas in the conventional group, the differences were extremely significant. Based on these results, it can be concluded that conventional implant surgery leads to significant bacteremia especially within the first 15 min of the surgery. The method used in the flapless group, however, did not yield a statistically significant bacteremia.

In the human oral environment, approximately 700 bacterial species were identified in which the viridans group predominates [32]. Among these bacteria, certain groups such as *Streptococci*, *Staphylococci*, *Enterococci*, and especially *Staphylococcus* spp., (particularly, *S. aureus*) are commonly known to adhere to nonbacterial thrombotic endocarditis and cause IE [33, 34]. Most of them are normal commensals of the gastrointestinal flora [35], normal skin, mucous membrane [36], or the upper respiratory tract [37]. They can also be isolated from the oral mucosa and the fit surface in complete denture wearers [38]. The saliva of the partial denture wearers may even contain such bacteria [39]. In the present study, the range of the isolated bacteria were similar to that found in previous studies and possibly, as a result of selecting healthy volunteers, no adverse consequences were encountered.

Due to the natural presence of some organisms (i.e., *Staphylococcus* spp.) on the skin, it can be difficult to distinguish between false-positive results (skin contamination) and a true bacteremia. In a previous study examining 207 children, up to 6 % of such positive blood cultures were attributed to skin contamination [40]. Despite the undertaken strict skin contamination measures in this study, the contamination might have occurred in this study. Hence, giving respect to the study of Roberts et al. [40], the overall bacteremia prevalence related to *S. epidermidis* could have been overestimated.

For indicating a bacteremia-related infection, the clinical relevance of any isolated bacterium should be evaluated in relation to the patient-specific conditions and postoperative consequences. In other words, the isolation of any aforementioned bacterium would not necessarily yield an infection, and in most of the instances, the relevant bacterium is destroyed by the immune defense system [41]. Such a decision should be based on sound clinical evidences of infection such as fever, dizziness, or prolonged pain [42]. This was also proven by the results of this study since most of the bacterium isolated after 15 min were seen eradicated within 30 min. Two patients with ongoing bacteremia were also examined for any signs of infection and revealed no clinical symptoms during the following week of surgery. Nevertheless, to avoid a life-threatening complication, AHA and BSAC recommend prophylaxis in all dental surgical procedures for patients at risk. Efficacy of an antibiotic regimen is compromised by the bacterial resistance and side effects. As an alternative, the CHX mouthwash could also be adjunctively used since its efficacy was demonstrated by some studies [6, 43]. The standard antibiotic prophylaxis is amoxicillin or clindamycin [9, 10]. Unfortunately, numerous studies showed different rates of antibiotic resistance [7, 44], which should be elucidated by further studies.

It should also be emphasized that the validity of statistical analyses is critically dependent on the employed sample size as it may yield a type I (or II) error due to lack of sufficient subjects (n). Unfortunately, neither a sample size nor a power calculation was mentioned in any of the related mentioned studies. Therefore, corresponding conclusions should be interpreted cautiously. Furthermore, after 30 min, the incidence of bacteremia seems to be very rare, and achieving a statistical significance is unlikely without a fairly large study population [45].

In this study, the placement of four to eight implants in an edentulous jaw yielded a transitional bacteremia. In general, the sterility rate of the samples obtained from the flapless group was higher than those from the conventional group, and this was attributed to the completion of the less invasive flapless surgery in a shorter time. According to the present findings, it can be concluded that, irrespective of the technique utilized, bacteremia may occur upon the placement of four to eight implants in an edentulous jaw. The probability of bacteremia for the patients operated with the conventional technique is, however, 3.05 greater than those operated with the flapless technique. Computer-assisted SLA template-guided flapless implant surgery, therefore, may be beneficial to patients at risk by decreasing the duration and the invasiveness of the surgery.

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Conflict of interest The authors declare that they have no conflict of interest.

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