Oral health and dental behaviour of patients with left ventricular assist device: a cross-sectional study

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Abstract

Aims The aim of this cross-sectional study was the assessment of dental behaviour, oral health, as well as oral health-related quality of life of patients with left ventricular assist device (LVAD).

Methods and results Patients (128) with LVAD were recruited from the University Department for Cardiac Surgery at Heart Center, Leipzig, Germany. A healthy control group (HC, n = 113) was included. Dental behaviour was assessed with a standardized questionnaire, and to evaluate oral health-related quality of life, the German short form of oral health impact profile was applied. The presence of decayed, missing, and filled teeth; dental treatment need; periodontitis severity; and periodontal treatment need were assessed. These findings were correlated to disease-related and device-related factors. The minority of patients used aids for interdental hygiene (16.4%). For the LVAD patients, a German short form of oral health impact profile sum score of 4.96 ± 8.67 [0.5; 0–6] was assessed. The LVAD group suffered from more missing teeth (11.91 ± 9.13 vs. 3.70 ± 3.77; P < 0.01) than HC. More severe periodontitis was found in LVAD group (LVAD = 41.4% and HC = 27.4%; P < 0.01). Periodontal treatment need was high in both groups, without a significant difference (LVAD = 84.4% vs. HC = 86.7%; P = 0.71). LVAD therapy as bridge to transplantation was correlated with periodontal treatment need (odds ratio = 11.48 [1.27; 103.86]; P = 0.03). Further correlations between treatment need and disease specific factors were not detected.

Conclusions Patients with LVAD suffer from a high periodontal treatment need and a lack in oral behaviour. Interdisciplinary special care concepts appear recommendable to improve oral health in LVAD patients.

Keywords Dental care; Left ventricular assist device; Oral health; Dental behaviour

Introduction

For therapy of severe heart failure, left ventricular assist device (LVAD) has developed into a therapeutic strategy of high clinical relevance.1 Because of the increasing number of patients with a need for heart transplantation, of which about 30% need circulatory support with an LVAD system, an exponential growth of LVAD implantation was recorded during past years.1 Although this therapy option has revolutionized the treatment of severe heart failure, infectious complications, especially driveline infections are still a substantial risk.2 In this context, the long-term destination therapy with LVAD for patients has contributed to the increasing relevance of infectious complications.2

A potential source of infection constitutes the oral cavity; it is known that oral microbiota, especially in the case of periodontal inflammation can serve as a risk for systemic infections.3 It has been already demonstrated that oral bacterial DNA can be found in inflamed cardiac tissues.4 Additionally, an interlink between oral inflammation, especially...
periodontal infection and cardiovascular diseases has been repeatedly described.\(^5\)\(^,\)\(^6\)

Accordingly, sufficient dental management appears as an important measure for the prevention of infections in patients with severe heart diseases, especially for vulnerable patients with LVAD. In contrast, only one study is available regarding the dental management of patients with LVAD, which was solely focused on surgical management of these patients.\(^7\) Furthermore, a case report is available, highlighting the increasing relevance of dental management of patients with LVAD.\(^8\) Moreover, oral health of patients with severe heart disease undergoing cardiovascular surgery was reported as poor, leading to the necessity of improved interdisciplinary healthcare of these patients.\(^9\) In this context, special oral healthcare programs, which also focus on oral hygiene maintenance, seem recommendable for LVAD patients.\(^10\)

However, there is still no study available that examined the recent dental care situation of patients with LVAD. A previous study by this working group was able to demonstrate a high periodontal treatment need in patients with heart insufficiency and after heart transplantation.\(^11\) Moreover, it is still unclear whether oral diseases could be associated to driveline infections as a complication of high clinical relevance. In this regard, there is no clear recommendation given by any society.

Accordingly, the current study aimed in the comprehensive assessment of oral behaviour, dental and periodontal health, as well as oral health-related quality of life (OHRQoL) of patients with LVAD. Furthermore, potential associations to disease-related parameters should be examined. It was hypothesized that patients with LVAD suffer from an insufficient oral health status, what might be associated to the occurrence of driveline infections.

**Methods**

This study was designed as a cross-sectional study to assess the oral health/dental behaviour, oral health situation (dental and periodontal), as well as OHRQoL of patients with LVAD. Furthermore, a healthy control group (HC) was included for comparison of oral health status. The examination complies with the Declaration of Helsinki and has been reviewed and approved by the ethics committee of the Medical Faculty of University of Leipzig (number 414/16-ek). The participants included in the current study provided their written informed consent.

**Patients**

Patients under treatment with an LVAD, who attended the Department for Cardiac Surgery at the Heart Center Leipzig for routine follow-up appointment, were informed about the study and asked for their voluntary participation. A mean age of at least 18 years and the ability to provide informed consent were inclusion criteria for participation. The exclusion criteria were as follows:

1. Clinical examination impossible due to worse general health status;
2. Auto-immune diseases (e.g. rheumatoid arthritis);
3. Infectious diseases (hepatitis A, B, C, tuberculosis, and HIV); and
4. Pregnancy.

Furthermore, an HC containing patients without any cardiac diseases attending the Department of Cardiology, Endodontology and Periodontology, University of Leipzig, Germany, for their routine control appointment were included. The inclusion and exclusion criteria were equal for both groups. As general health and cardiological data, smoking habits (smoker, currently smoking; former smoker, smoking within 5 years before examination; and non-smoker, no smoking for at least 5 years), age, and gender as well as for LVAD group underlying heart diseases, comorbidities, and different disease-related/therapy-related parameters were collected from the medical records. The following disease-related parameters were evaluated: occurrence of driveline infection, ejection fraction, status on waiting list for heart transplantation, time since LVAD implantation in months, Interagency Registry for Mechanically Assisted Circulatory Support at LVAD implantation, LVAD intension [bridge to transplantation (BTT), destination therapy, bridge to decision, or bridge to recovery], and the urgency of LVAD implantation (emergency, urgent, or elective).

**Questionnaires**

For the assessment of dental behaviour of participants in LVAD group, different questions within a standardized questionnaire were applied. On the one hand, disease-specific parameters like a dental visit and rehabilitation before LVAD implantation and on the other hand, questions about the oral hygiene were asked.

To assess the OHRQoL, the German short version of oral health impact profile (OHIP G14) was applied.\(^12\)\(^,\)\(^13\) Thereby, 14 functional and psychosocial impacts, which participants have experienced in the previous month resulting from complaints with their teeth, mouth, or dentures, were evaluated. One out of five different answering possibilities were available: very often = ‘4’, fairly often = ‘3’, occasionally = ‘2’, hardly ever = ‘1’, and never = ‘0’. The sum score of OHIP G14 values, as well as the patterns of ‘oral function’ and ‘psychosocial impact’, ‘oral pain’, and ‘orofacial appearance’ were analysed.\(^14\)
Oral examination

The participants within the LVAD group were examined at the Department for Cardiac Surgery at Heart Center, Leipzig, once by three experienced and calibrated (kappa > 0.8) dentists under standardized conditions. According to the guidelines, to prevent infectious endocarditis, these participants received 2-g Amoxicillin as an antibiotic prophylaxis. The HC group was examined at the Department of Cariology, Endodontology and Periodontology, University of Leipzig, Germany.

Dental examination

The dental investigation contained of the assessment of the decayed-teeth (D-T), missing-teeth, and filled-teeth index in accordance to World Health Organization. The examination was performed visually with mirror and probe. Teeth with a carious lesion showing a cavitation of the tooth surface were allocated to the D-T component. Missing teeth, excluding third molars, were included in the missing-teeth component. Teeth with a filling or a crown were assigned to the filled-teeth component. If a patient suffered from at least one carious lesion deserving invasive dental intervention (D-T > 0), dental treatment need was evaluated.

Periodontal examination

Assessment of periodontal probing depth and clinical attachment loss was executed at six measurement points per tooth with a periodontal probe (PCP 15; Hu-Friedy, Chicago, IL, USA). According to American Academy of Periodontology/Centers for Disease Control, periodontitis was classified into no/mild and moderate or severe periodontitis. Periodontal treatment need was defined by the presence of periodontal probing depth ≥ 3.5 mm in at least two different sextants. The presence of dental and/or periodontal treatment need was summarized as overall dental treatment need.

Statistical analysis

The statistical analysis was performed with SPSS for Windows, version 24.0 (SPSS Inc., USA). After testing with Kolmogorov–Smirnov test, none of the metric variables were found to be normally distributed. Accordingly, Mann–Whitney U-test was applied as non-parametric test. Categorical data were analysed with $\chi^2$ or Fisher’s test, respectively. For multivariate analysis, a binary logistic regression with backward integration was used. For all applied analyses, a two-sided significance testing was used, whereby the significance level has been set at $P < 0.05$.

Results

Patients

For the LVAD group, 128 participants with a mean age of 59.56 ± 11.08 years were included, while the HC consisted of 113 patients with a mean age of 60.20 ± 7.64 years ($P = 0.57$). The majority of participants were male gender, whereby LVAD consisted of significantly less female patients than HC (9.4% vs. 32.7%; $P < 0.01$; Table 1). The causal underlying diseases, comorbidities, as well as disease-related parameters are presented in Table 1.

Questionnaires

A total of 60.3% of LVAD patients stated that they visited their dentist previous to LVAD implantation, and about half of participants (49.6%) stated that they had received a dental rehabilitation. The majority of participants in LVAD group performed oral hygiene with a manual toothbrush (78.1%), while only a small amount of patients used aids for interdental hygiene (16.4%; Table 2).

For the LVAD patients, an OHIP G14 sum score of 4.96 ± 8.67 [0.5; 0–6] was assessed. For the two major patterns oral function and psychosocial impact, values of 1.49 ± 3.20 [0; 0–1] and 2.52 ± 4.68 [0; 0–3] were found, respectively (Table 3).

Oral examination

Dental findings

While decayed-teeth, missing-teeth, and filled-teeth index and D-T values were comparable between LVAD and HC ($P > 0.05$), LVAD group suffered from more missing teeth (11.91 ± 9.13 vs. 3.70 ± 3.77; $P < 0.01$) and less filled teeth (6.65 ± 4.78 vs. 14.22 ± 4.9; $P < 0.01$) compared with HC (Table 4). The dental treatment need was comparable between groups ($P = 0.17$; Table 4).

Periodontal findings

The LVAD patients were found to show more severe periodontitis than the HC group ($P < 0.01$; Table 4). Periodontal treatment need was high in both groups, without a significant difference (84.4% vs. 86.7%; $P = 0.71$).

Association between oral health and disease-related/device-related parameters

Of the examined parameters, smoking habits showed an association to dental treatment need ($P < 0.01$), what could not be confirmed by multivariate analysis (odds ratio = 2.89 [0.84; 9.92]; $P = 0.09$; Tables 5 and 6). The LVAD intension (BTT, destination therapy, bridge to decision, or bridge to recovery) was found to be associated to the presence of periodontal treatment need ($P = 0.02$; Table 5). The logistic
regression analysis was able to confirm this for the differentiation between BTT vs. no BTT ([odds ratio = 11.48 [1.27; 103.86]; P = 0.03; *Table 6*]. Further correlations between dental or periodontal treatment need with disease-related parameters were not detected.

**Discussion**

**Summary of the main results**

While patients with LVAD showed more missing teeth than HC, a high periodontal treatment need was noticeable for both groups. The oral behaviour of LVAD patients showed several lacks; only half of patients received dental rehabilitation and less than one fifth performed interdental hygiene. The examined oral health parameters were only correlated to the BTT status in LVAD group.

**Comparison with published data**

At first it must be mentioned that this is the first study, which investigated the oral health and dental behaviour of patients with LVAD. Accordingly, a comparison of the results with international literature is limited. However, the study’s results can be interpreted considering findings of other groups of risk.
patients in dental practice. Regarding oral health conditions, the enlarged number of missing teeth in LVAD group seems plausible by different reasons; on the one hand, tooth loss is associated to the occurrence of heart diseases. On the other hand, the dental rehabilitation, which patients receive, might be mainly focused on tooth removal. This assumption would be supported by the higher amount of filled teeth in HC. This could be a dangerous strategy because surgical management, especially avoidance of bleeding events is a hazardous situation. Therefore, prevention-oriented concepts for dental maintenance should be favoured. The high prevalence of periodontal treatment need in both groups was the main finding within oral health findings of the current study. A high periodontal treatment need in the HC is in line with similar findings of the Fifth German Oral Health Study, a representative study of German general population. This seems to be the explanation why there is no difference between LVAD and HC group. A recent examination of patients undergoing cardiovascular surgery presented also a high periodontal treatment need for these patients, which was with 68.8% approximately lower than in the current study. A comparably high periodontal treatment need than in the current study was found in a previous cross-sectional study by this working group, investigating patients with heart insufficiency or heart transplantation. Furthermore, similarly high periodontal burden can be found in liver transplant candidates or patients after solid organ transplantation. Therefore, a sufficient therapeutic and preventive strategy seems mandatory to treat and avoid periodontal diseases in these patients. It remains unclear whether the treatment of dental and periodontal disease in patients with LVAD would impact their status of heart failure and its progression. It is known that periodontal inflammation is related to subclinical and clinical atherosclerotic vascular disease. Therefore, a negative effect of periodontal diseases on the progression of heart failure is conceivable, especially if coronary heart diseases are the underlying condition. Although an improvement of heart failure by dental and/or periodontal therapy would not be expectable, the progression and morbidity might be positively influenced. Accordingly, the sufficient oral care would be both a benefit for oral and systemic health of LVAD patients. However, based on the results of this current cross-sectional study, this remains speculative.

### Table 2: Results of the dental behaviour of left ventricular assist device patients

| Dental visit before LVAD [%] | 60.3% [76/128] |
| Dentists knowledge about underlying disease [%] | 49.6% [63/127] |
| Information about antibiotic prophylaxis [%] | 65.4% [83/127] |
| Information about relationship of oral general health [%] | 58.4% [73/125] |
| Oral hygiene: tooth brushing [%] | 51.6% [65/126] |
| Oral hygiene aids [%] | 71.9% [92/127] |
| Feel informed appropriately | 60.3% [76/128] |
| Last dental examination [%] | 65.4% [83/127] |
| Oral hygiene: tooth brushing [%] | 51.6% [65/126] |

LVAD, left ventricular assist device; OHIP G14, German short form of oral health impact profile.

### Table 3: Results of oral health-related quality of life in left ventricular assist device group

| OHIP G14 patterns/questions | LVAD |
|-----------------------------|------|
| Oral function               |      |
| Total oral function         | 1.49 ± 3.20 [0; 0–1] |
| Trouble pronouncing         | 0.38 ± 0.84 [0; 0–0] |
| Taste worsened              | 0.3 ± 0.73 [0; 0–0] |
| Interrupting meals          | 0.24 ± 0.70 [0; 0–0] |
| Uncomfortable to eat        | 0.34 ± 0.84 [0; 0–0] |
| Diet unsatisfactory         | 0.25 ± 0.75 [0; 0–0] |
| Psychosocial impact         |      |
| Total psychosocial impact   | 2.52 ± 4.68 [0; 0–3] |
| Life less satisfactory       | 0.44 ± 0.87 [0; 0–0] |
| Difficult to relax          | 0.34 ± 0.82 [0; 0–0] |
| Feeling of tension          | 0.29 ± 0.73 [0; 0–0] |
| Short tempered              | 0.3 ± 0.75 [0; 0–0] |
| Difficult to perform daily jobs | 0.42 ± 0.95 [0; 0–0] |
| Unable to function          | 0.37 ± 0.96 [0; 0–0] |
| Embarrassed                 | 0.38 ± 0.90 [0; 0–0] |
| Oral pain                   |      |
| Oral pain                   | 0.35 ± 0.73 [0; 0–0] |
| Orofacial appearance        |      |
| Sense of uncertainty with teeth | 0.61 ± 1.3 [0; 0–0] |
| OHIP G14 sum score          | 4.96 ± 8.67 [0.5; 0–6] |

LVAD, left ventricular assist device; OHIP G14, German short form of oral health impact profile.

Values are given as mean value ± standard deviation (median; 25th–75th percentile).
Especially considering the risk of infectious complications during LVAD therapy, this issue could be crucial for LVAD patients. The high periodontal treatment need of patients with LVAD in the current study underlines the presence of a lack in dental care of these patients. This is also in line with findings of dental behaviour. Forty percent of participants with LVAD did not visit the dentist before LVAD implantation, and only half of patients received a dental rehabilitation. This might support a lack of interdisciplinary collaboration, which has been concluded by a questionnaire-based survey before. Moreover, the lack in personal oral hygiene procedures, especially the usage of interdental cleaning devices, is conspicuous. This leads to the assumption of an insufficient information, sensibilization, and motivation for the importance of oral hygiene procedures and their importance for systemic health. Similar findings were also found in the previous study for patients with heart insufficiency and after heart transplantation as well as for liver transplant candidates or patients receiving cardiovascular surgery with a usage of interdental hygiene measures between 7% and 34%. In this context, the findings of OHRQoL might support the mentioned assumption of an insufficient sensibilization for oral health issues. For a healthy general population, OHIP G14 values between 0 and 4 are present as a reference for fully or partially dentate individuals. Accordingly, the OHRQoL of LVAD patients in the current study can at most

### Table 4 Oral health conditions and treatment need between groups (significance level, \( P < 0.05 \))

| Parameter | LVAD (\( n = 128 \)) | HC (\( n = 113 \)) | \( P \) value |
|-----------|---------------------|------------------|--------------|
| DMF-T (mv ± SD) | 19.09 ± 6.87 | 18.54 ± 5.54 | 0.35 |
| D-T (mv ± SD) | 0.53 ± 1.58 | 0.62 ± 1.21 | 0.14 |
| M-T (mv ± SD) | 11.91 ± 9.13 | 3.70 ± 3.77 | <0.01 |
| F-T (mv ± SD) | 6.65 ± 4.78 | 14.22 ± 4.9 | <0.01 |
| Periodontitis % \([n]\) | Moderate | No/mild | Severe |
| | 14.1% [18] | 44.5% [57] | 41.4% [53] |
| | 11.5% [13] | 61.1% [69] | 27.4% [31] |
| Dental treatment need % \([n]\) | 18.8% [24] | 26.5% [30] | 0.17 |
| Periodontal treatment need % \([n]\) | 84.4% [108] | 86.7% [98] | 0.71 |

D-T, number of decayed teeth; DMF-T, decayed-teeth, missing-teeth, and filled-teeth index; F-T, number of filled teeth; HC, healthy control; LVAD, left ventricular assist device; M-T, number of missing teeth; mv, mean value; SD, standard deviation. Significant values are highlighted in bold.

### Table 5 Association between the presence of specific parameters and treatment need in left ventricular assist device group (significance level, \( P < 0.05 \))

| Parameter | LVAD group | Periodontal treatment need |
|-----------|------------|----------------------------|
| Smoking | | | |
| Smoker | Yes | 40.9% | 73.5% | <0.01 | 12.6% | 17.6% | 0.34 |
| Former smoker | 13.6% | 19.4% | 20.4% | 67% | 76.5% | |
| Non-smoker | 45.5% | 7.1% | 42.6% | 41.2% | |
| Ejection fraction | | | |
| ≤ 12 months | 24.5 ± 9.4 | 23.1 ± 8.2 | 0.58 | 23.2 ± 8.7 | 24.3 ± 6.4 | 0.50 |
| 13–48 months | 34.8% | 27.4% | 0.43 | 29.4% | 0.09 |
| >48 months | 30.4% | 45.3% | 42.6% | 41.2% | |
| INTERMACS at implantation | | | |
| 1–3 | 57.1% | 47.4% | 46.5% | 64.7% | 0.20 |
| 4–5 | 42.9% | 52.6% | 53.5% | 35.3% | |
| LVAD intension | | | |
| BTT | 43.5% | 37.8% | 43.3% | 11.8% | 0.02 |
| Destination | 34.8% | 33.7% | 35.3% | |
| Decision | 21.7% | 26.5% | 22.1% | 47.1% | |
| Recovery | | | |
| 0% | 2% | 1% | 5.9% | |
| Urgency of LVAD implantation | | | |
| Emergency | 22.7% | 14.7% | 16% | 17.6% | 0.18 |
| Urgent | 59.1% | 71.6% | 67% | 82.4% | |
| Elective | 18.2% | 13.7% | 17% | 0% | |
| Waiting list | | | |
| Yes | 60.9% | 61.2% | 59.6% | 70.6% | 0.44 |
| No | 39.1% | 38.8% | 40.4% | 29.4% | |
| Driveline infection | | | |
| Yes | 31.8% | 24.5% | 27.2% | 17.6% | 0.56 |
| No | 68.2% | 75.5% | 72.8% | 82.4% | |
| Diabetes mellitus | | | |
| Yes | 43.5% | 46.9% | 44.2% | 58.8% | 0.30 |
| No | 56.5% | 53.1% | 55.8% | 41.2% | |
| Renal insufficiency | | | |
| Yes | 47.8% | 57.1% | 55.8% | 52.9% | 0.99 |
| No | 52.2% | 42.9% | 44.2% | 47.1% | |
| Obesity | | | |
| Yes | 39.1% | 39.8% | 38.5% | 47.1% | 0.60 |
| No | 60.9% | 60.2% | 61.5% | 52.9% | |

BTT, bridge to transplantation; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; LVAD, left ventricular assist device; mv, mean value; SD, standard deviation.
The occurrence of complications of LVAD is between driveline infections and treatment need. There are two The current study was not able to con

supports the assumption of an insufficient oral situation of LVAD patients. Between LVAD intension (BTT vs. no BTT) and periodontal treatment need. This finding is somewhat surprising, as patients with a BTT intension, which are awaiting heart transplantation, should have received a comprehensive dental rehabilitation and preventive care to reduce their risk for systemic complications. Accordingly, it can be assumed that there is either no sufficient rehabilitation at all or that periodontal treatment need is not addressed appropriately in patients with LVAD awaiting heart transplantation. However, there is no correlation to the status on waiting list, what rather argue against the presumption of enhanced lack in periodontal care of heart transplant candidates. Nevertheless, it could be hypothesized that sufficient dental and periodontal treatment in these patients might positively influence the course during and/or after transplantation by decreasing the risk of infectious complications. Although this is just speculative and cannot be proven by the study’s findings, this would be of high clinical importance, especially in patients with BTT status.

**Strengths and limitations**

This is the first clinical study that comprehensively assessed the dental behaviour, oral health situation (dental and periodontal), as well as OHRQoL of patients with LVAD. The complex and standardized assessment of the data is a clear strength of the examination. Also the inclusion of 128 patients with this special health condition is worth mentioning. One limitation is the design as cross-sectional study, which allows no strong causative conclusions, especially regarding the influence of oral health on disease-related parameters or infectious complications. For this, longitudinal data would be of interest to see whether the time on LVAD is related to oral disease and whether they would be related to, e.g. laboratory markers associated with heart failure. Moreover, the HC

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**Table 6 Binary logistic regression analysis of different general and heart disease-specific parameters regarding dental and periodontal treatment needs**

| Parameter | Dental treatment need | Periodontal treatment need |
|-----------|-----------------------|---------------------------|
| Age (≤62 vs. >62 years) | OR 1.24 (CI 0.93; 1.64) 0.07 1.36 (CI 0.18; 10.54) 0.77 | | |
| Gender | OR 2.89 (CI 0.84; 9.92) 0.09 2.46 (CI 0.52; 11.65) 0.26 | | |
| Smoking habits (non-smoker vs. former smoker/smoker) | OR 1.32 (CI 0.43; 4.04) 0.62 1.23 (CI 0.33; 4.54) 0.76 | | |
| Ejection fraction (≤23% vs. >23%) | OR 1.42 (CI 0.37; 5.48) 0.61 1.41 (CI 0.33; 6.06) 0.65 | | |
| Time with LVAD (≤12 months vs. > 12 months) | OR 0.59 (CI 0.16; 2.20) 0.43 1.83 (CI 0.42; 8.03) 0.42 | | |
| INTERMACS (1–3 vs. 4–5) | OR 1.49 (CI 0.29; 7.65) 0.64 11.48 (CI 1.27; 103.86) 0.03 | | |
| LVAD intension (BTT vs. no BTT) | OR 0.63 (CI 0.10; 3.87) 0.62 0.90 (CI 0.12; 4.21) 0.72 | | |
| Urgency of LVAD (elective vs. emergency/urgent) | OR 2.20 (CI 0.64; 7.49) 0.21 3.02 (CI 0.52; 17.63) 0.22 | | |
| Waiting list | OR 0.70 (CI 0.22; 2.20) 0.54 0.63 (CI 0.17; 2.30) 0.48 | | |
| Driveline infection | OR 1.09 (CI 0.30; 3.93) 0.89 4.17 (CI 0.98; 17.79) 0.08 | | |
| Diabetes mellitus | OR 1.66 (CI 0.47; 5.90) 0.43 0.58 (CI 0.14; 2.47) 0.46 | | |

BTT, bridge to transplantation; CI, confidence interval; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; LVAD, left ventricular assist device; OR, odds ratio. Significant results are highlighted in bold.
group was composed of patients regularly attending a dental clinic for control, what might be a bias. Heart diseases are related to periodontal inflammation. This could be a reason for the worse oral conditions in LVAD group compared with HC. To detect the sole effect of LVAD on oral health, a control group containing patients suffering from heart failure without LVAD might be recognized. This approach could be addressed in future research. In the HC patients, no OHRQoL was assessed, what limits the current analysis. However, reference values for healthy individuals are available that were used for interpretation. Also the significant difference in gender between LVAD and HC group must be considered. Furthermore, the cohort of LVAD patients is heterogeneous because of different underlying diseases, comorbidities, medications, or general health status. It is still unclear in what extent these factors are influential in oral health issues. In general, information about the complications after dental management like arrhythmias or bleeding complications are of high clinical relevance for dental care of these patients. The current study does not provide any information about this because these data were not assessed. This information should be evaluated in future studies. In addition, the relationship between periodontal and systemic inflammation might be addressed in future research. This could be of certain interest for patients with LVAD, although the effect of periodontitis on systemic parameters of inflammation in general is limited. Beside of these limitations, the current study provides new knowledge of clinical relevance for the care of LVAD patients.

Conclusions
Patients with LVAD suffer from a high periodontal treatment need, which is comparable with healthy controls. Furthermore, a lack in dental behaviour and nearly unaffected OHRQoL suggests deficits in information, sensibilization, and motivation for oral health issues in these patients. Although the influence of oral health on systemic disease-related and device-related parameters remains unclear, interdisciplinary special care concepts are recommendable to improve oral health in LVAD patients.

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Conflict of interest
None declared.

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References
1. Prinzting A, Herold U, Berkefeld A, Krane M, Lange R, Voss B. Left ventricular assist device-current state and perspectives. J Thorac Dis 2016; 8: E660–E666.
2. Leuck AM. Left ventricular assist device driveline infections: recent advances and future goals. J Thorac Dis 2015; 7: 2151–2157.
3. Kumar PS. Oral microbiota and systemic disease. Anaerobe 2013; 24: 90–93.
4. Ziebolz D, Jahn C, Pegel J, Semper-Pinnecke E, Mausberg RF, Waldmann-Beus hausen R, Schöndube FA, Danner BC. Periodontal bacteria DNA findings in human cardiac tissue—is there a link of periodontitis to heart valve disease? Int J Cardiol 2018; 251: 74–79.
5. Kebschull M, Demmer RT, Papapanou PN. “Gum bug, leave my heart alone!”—epidemiologic and mechanistic evidence linking periodontal infections and atherosclerosis. J Dent Res 2010; 89: 879–902.
6. Batry GD, Jung KJ, Mok Y, Lee SJ, Back JH, Lee S, Jee SH. Oral health and later coronary heart disease: cohort study of one million people. Eur J Prev Cardiol 2018; 25: 598–605.
7. Morimoto Y, Nakatani T, Yokoe C, Kudo C, Hanamoto H, Niwa H. Haemostatic management for oral surgery in patients supported with left ventricular assist device—a preliminary retrospective study. Br J Oral Maxillofac Surg 2015; 53: 991–995.
8. Findler M, Findler M, Rudis E. Dental treatment of a patient with an implanted left ventricular assist device: expanding the frontiers. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 111: e1–e4.
9. Kumar A, Rai A. Oral health status, health behaviour and treatment needs of patients undergoing cardiovascular surgery. Braz J Cardiovasc Surg 2018; 33: 151–154.
10. Javed F, Michelogiannakis D. Is oral health maintenance/promotion crucial in patients treated with the left ventricular assist device? Am J Med Sci 2019; 358(2): 168. https://doi.org/10.1016/j.amjms.2019.04.004
11. Slade GD, Spencer AJ. Development and evaluation of the oral health impact profile. Community Dent Health 1994; 11: 3–11.
12. John MT, Micheulis W, Riffar R. Reference values in oral health-related quality of life for the abbreviated version of the oral health impact profile. Swiss Dent J 2004; 114: 784–791.
13. John MT, Rener-Sitar K, Baba K, Čelebić A, Larsson P, Szabo G. Patterns of impaired oral health-related quality of life dimensions. J Oral Rehabil 2016; 43: 519–527.
14. Wilson W, Taubert KA, Gewitz M, Lockhart PB, Baddour LM, Levison M, Bolger A, Cabell CH, Takahashi M, Baltimore RS, Newburger JW, Strom BL, Tani LY, Gerber M, Bonow RO, Pallasch T, Shulman ST, Rowley AH, Burns JC, Ferriero P, Gardner T, Goff D, Durack DT, American Heart Association Rheumatic Fever, Endocarditis, and Kawasaki Disease Committee; American Heart Association Council on Cardiovascular Disease in the Young; American Heart

ESC Heart Failure 2020; 7: 1273–1281 DOI: 10.1002/ehf2.12636
Association Council on Clinical Cardiology; American Heart Association Council on Cardiovascular Surgery and Anesthesia; Quality of Care and Outcomes Research Interdisciplinary Working Group. Prevention of infective endocarditis: guidelines from the American Heart Association: a guideline from the American Society for Microbiology, the Infectious Diseases Society of America, and the American Heart Association: executive summary. J Am Coll Cardiol 2007; 49(10): 1519–54.

15. World Health Organization (WHO) Geneva: Oral Health Surveys 1997; Basic Methods. 4th Edition.

16. Eke PI, Page RC, Wei L, Thornton-Evans G, Genco RJ. Update of the case definition for special care programs. J Clin Periodontol 2012; 39: 1425–1449.

17. Diamanti-Kipioti A, Papapanou TN, Moraitaki-Zamitsai A, Lindhe J, Mitis F. Comparative estimation of periodontal conditions by means of different index systems. J Clin Periodontol 1993; 20: 656.

18. Meyle J, Jepsen S. The Periodontal Screening-Index (PSI). Parodontol 2000; 11: 17–21. [in German].

19. Jordan RA, Michaelis W. The fifth German Oral Health Study (DMS V). Institut der Deutschen Zahnärzte (Hrsg.); (IDZ Materialienreihe Band 35). Deutscher Zahnärzte-Verlag DAV, Köln 2016. [in German]

20. Schmalz G, Wendorff H, Marcinkowski A, Weinreich G, Teschler H, Haak R, Sommerweck U, Ziebolz D. Oral health related quality of life depending on oral health and specific factors in patients after lung transplantation. Clin Respir J 2018; 12: 731–737.

21. Kauffels A, Schmalz G, Kollmar O, Slotta JE, Weig M, Groß U, Bader O, Ziebolz D. Oral findings and dental behaviour before and after liver transplantation—a single-centre cross-sectional study. Int Dent J 2017; 67: 244–251.

22. Schmalz G, Hübischer AE, Angermann H, Schmidt J, Schmickler J, Legler TJ, Ziebolz D. High prevalence of periodontitis in blood donors and the possibility of questionnaire-based screening-results of a cross-sectional study. Transfus Med 2019; 29: 394–400.

23. Binner C, Wagner J, Schmalz G, Eisner M, Rast J, Kottmann T, Haak R, Oberbach A, Borger MA, Garbade J, Ziebolz D. Insufficient oral behaviour and the high need for periodontal treatment in patients with heart insufficiency and after heart transplantation: a need for special care programs? J Clin Med 2019; 8(10): 1668. https://doi.org/10.3390/jcm8101668

24. Schmalz G, Wendorff H, Berisha L, Meisel A, Widmer F, Marcinkowski A, Teschler H, Sommerweck U, Haak R, Kollmar O, Ziebolz D. Association between the time after transplantation and different immunosuppressive medications with dental and periodontal treatment need in patients after solid organ transplantation. Transpl Infect Dis 2018; 20: e12832.

25. Carinci F, Martinelli M, Contaldo M, Santoro R, Pezzetti F, Lauritano D, Candotto V, Mucchi D, Palmieri A, Tagliabue A, Tettamanti L. Focus on periodontal disease and development of endocarditis. J Biol Regul Homeost Agents 2018; 32: 143–147.

26. Ziebolz D, Reiss L, Schmalz G, Krause F, Haak R, Mausberg RF. Different views of dentists and general medical practitioners on dental care for patients with diabetes mellitus and coronary heart diseases: results of a questionnaire-based survey in a district of Germany. Int Dent J 2018; 68: 197–203.

27. Durham J, Fraser HM, McCracken GI, Stone KM, John MT, Preshaw PM. Impact of periodontitis on oral health-related quality of life. J Dent 2013; 41: 370–376.

28. Schmalz G, Dietl M, Vasko R, Müller GA, Rothermund L, Keller F, Ziebolz D, Rasche FM. Dialysis vintage time has the strongest correlation to psychosocial pattern of oral health-related quality of life—a multicentre cross-sectional study. Med Oral Patol Oral Cir Bucal 2018; 23: e698–e706.

29. Schmalz G, Meisel A, Kollmar O, Kauffels A, Slotta JE, Kottmann T, Haak R, Ziebolz D. Oral health-related quality of life depending on dental and periodontal health in different patients before and after liver transplantation. Clin Oral Investig 2018; 22: 2039–2045.

30. Emani S. Complications of durable left ventricular assist device therapy. Crit Care Clin 2018; 34: 465–477.

31. Rustemeyer J, Bremerich A. Necessity of surgical dental foci treatment prior to organ transplantation and heart valve replacement. Clin Oral Investig 2007; 11: 171–174.

32. Loos BG. Systemic markers of inflammation in periodontitis. J Periodontol 2005; 76: 2106–2115.