

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

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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 Cariology, 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.¹⁵ 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.¹⁶ 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 valued.

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.¹⁷ Periodontal treatment need was defined by the presence of periodontal probing depth ≥ 3.5 mm in at least two different sextants.^{18,19} 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 χ^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

Table 1 Patient characteristics (significance level, $P < 0.05$)

		LVAD (n=128)	HC (n=113)	P value
Gender [female patients in % (n)]		9.4% [12]	32.7% [37]	<0.01
Age in years (mvSD)		59.5611.08	60.207.64	0.57
Smoking habits % [n]	Smoker	15% [19]	14.2% [16]	0.90
	Nonsmoker	64.6% [82]	67.3% [76]	
	Former smoker	20.5% [20]	18.6% [21]	
Underlying heart disease % [n]	DCM	53.9% [69]		
	ICM	42.2% [54]		
	Valvular insufficiency	53.1% [68]		
	Atrial fibrillation	39.1% [50]		
	Coronary heart disease	47.7% [61]		
Comorbidities % [n]	Hypertension	73.4% [94]		
	Diabetes mellitus	46.1% [59]		
	Renal insufficiency	55.5% [71]		
	Adipositas	41.4% [53]		
Driveline infection		24.2% [22]		
Ejection fraction		23.727.83		
On waiting list for HTx		38.8% [47]		
Time since LVAD implantation in months		31.6624.79		
INTERMACS at LVAD implantation	1	18.1% [21/116]		
	2	14.7% [17/116]		
	3	16.4% [19/116]		
	4	37.9% [44/116]		
	5	12.9% [15/116]		
LVAD intension	BTT	38.8% [47]		
	Destination	33.9% [41]		
	Decision	25.6% [22]		
	Recovery	1.7% [2]		
Urgency of LVAD implantation	Emergency	16.2% [19/117]		
	Urgent	69.2% [81/117]		
	elective	14.5% [17/117]		
Medication	ACE blocker	82% [105/128]		
	Calcium channel clocker	18.8% [24/128]		
	Anticoagulants	98.4% [126/128]		
	Antiplatelet medication	87.5% [112/128]		
	Immunosuppressive	2.3% [3/128]		
	Insulin	17.2% [22/128]		
	Oral antidiabetic drugs	24.2% [31/128]		
	Bisphosphonates	3.1% [4/128]		
Laboratory values	CRP (mg/dL)	15.68 ± 25.56		
	Creatinine (mol/L)	87.94 ± 126.58		
	Haemoglobin (mmol/L)	7.46 ± 1.56		
	Erythrocytes (10 ⁶ /L)	4.11 ± 0.81		
	Leucocytes (10 ³ /L)	7.71 ± 2.26		
	Platelet count (10 ³ /L)	219.61 ± 82.20		

ACE, angiotensin-converting-enzyme; BTT, bridge to transplantation; CRP, C-reactive protein; DCM, dilated cardiomyopathy; HC, healthy control; HTx, heart transplantation; ICM, ischaemic cardiomyopathy; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; LVAD, left ventricular assist device; mv, mean value; SD, standard deviation. Significant results are highlighted in bold.

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.

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.

Discussion

Summary of the main results

While patients with LVAD showed more missing teeth than HC, a high periodontal treatment need was noticeable for

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

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

		LVAD
Dental visit before LVAD % [n]		60.3% [76/128]
Dental rehabilitation before LVAD		49.6% [63/127]
Dentists knowledge about underlying disease % [n]		65.4% [83/127]
Information about antibiotic prophylaxis % [n]		58.4% [73/125]
Information about relationship of oral general health % [n]		51.6% [65/126]
Feel informed appropriately		71.9% [92/127]
Last dental examination % [n]	0–3 months	28.3% [36/127]
	3–12 months	63.6% [68/127]
	>12 months	18.1% [23/127]
Oral hygiene: tooth brushing % [n]	<1× per day	9.4% [12/127]
	1–2× per day	83.5% [106/127]
	>2× per day	7.1% [9/127]
Oral hygiene aids % [n]	Manual toothbrush	78.1% [100/128]
	Power toothbrush	25% [32/128]
	Dental floss/inter-dental brush	16.4% [21/128]
	Mouth rinse	48.4% [62/128]
	Fluoride gel	2.3% [3/128]

LVAD, left ventricular assist device.

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.⁶ 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.⁷ Therefore, prevention-oriented concepts for dental maintenance should be favoured.¹⁰ 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.²³ 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.⁹ 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.¹¹ Furthermore, similarly high periodontal burden can be found in liver transplant candidates or patients after solid organ transplantation.^{21,24} This seems potentially problematic because periodontal inflammation increases risk and extent of a systemic bacteraemia of oral origin, potentially leading to cardiovascular complications as well as infections like endocarditis.²⁵ Therefore, a sufficient therapeutic and preventive strategy seems mandatory to treat and avoid periodontal diseases in these patients.²⁵ 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.⁵ 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 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	
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).

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]	No/mild	14.1% [18]	11.5% [13]	<0.01
	Moderate	44.5% [57]	61.1% [69]	
	Severe	41.4% [53]	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.

Especially considering the risk of infectious complications during LVAD therapy,² 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 the 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.²⁶ 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%.^{9,11,21}

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.¹³ Accordingly, the OHRQoL of LVAD patients in the current study can at most

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					
		Dental treatment need			Periodontal treatment need		
		Yes	No	P value	Yes	No	P value
Smoking	Smoker	40.9%	73.5%	<0.01	12.6%	17.6%	0.34
	Former smoker	13.6%	19.4%		20.4%	5.9%	
	Non-smoker	45.5%	7.1%		67%	76.5%	
Ejection fraction		24.5 ± 9.4	23.1 ± 8.2	0.58	23.2 ± 8.7	24.3 ± 6.4	0.50
Time with LVAD in months	≤ 12 months	34.8%	27.4%	0.43	28.7%	29.4%	0.99
	13–48 months	30.4%	45.3%		42.6%	41.2%	
	>48 months	34.8%	27.4%		28.7%	29.4%	
INTERMACS at implantation	1–3	57.1%	47.4%	0.48	46.5%	64.7%	0.20
	4–5	42.9%	52.6%		53.5%	35.3%	
LVAD intension	BTT	43.5%	37.8%	0.85	43.3%	11.8%	0.02
	Destination	34.8%	33.7%		33.7%	35.3%	
	Decision	21.7%	26.5%		22.1%	47.1%	
Urgency of LVAD implantation	Recovery	0%	2%	0.51	1%	5.9%	0.18
	Emergency	22.7%	14.7%		16%	17.6%	
	Urgent	59.1%	71.6%		67%	82.4%	
Waiting list	Elective	18.2%	13.7%	0.99	17%	0%	0.44
	Yes	60.9%	61.2%		59.6%	70.6%	
	No	39.1%	38.8%		40.4%	29.4%	
Driveline infection	Yes	31.8%	24.5%	0.59	27.2%	17.6%	0.56
	No	68.2%	75.5%		72.8%	82.4%	
Diabetes mellitus	Yes	43.5%	46.9%	0.82	44.2%	58.8%	0.30
	No	56.5%	53.1%		55.8%	41.2%	
Renal insufficiency	Yes	47.8%	57.1%	0.49	55.8%	52.9%	0.99
	No	52.2%	42.9%		44.2%	47.1%	
Obesity	Yes	39.1%	39.8%	0.99	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.

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		
	OR	CI ₉₅	P value	OR	CI ₉₅	P value
Age (≤62 vs. >62 years)	1.24	[0.30; 5.14]	0.77	1.46	[0.31; 6.83]	0.63
Gender	3.88	[0]	0.99	1.36	[0.18; 10.54]	0.77
Smoking habits (non-smoker vs. former smoker/smoker)	2.89	[0.84; 9.92]	0.09	2.46	[0.52; 11.65]	0.26
Ejection fraction (≤23% vs. >23%)	1.32	[0.43; 4.04]	0.62	1.23	[0.33; 4.54]	0.76
Time with LVAD (≤12 months vs. > 12 months)	1.42	[0.37; 5.48]	0.61	1.41	[0.33; 6.06]	0.65
INTERMACS (1–3 vs. 4–5)	0.59	[0.16; 2.20]	0.43	1.83	[0.42; 8.03]	0.42
LVAD intension (BTT vs. no BTT)	1.49	[0.29; 7.65]	0.64	11.48	[1.27; 103.86]	0.03
Urgency of LVAD (elective vs. emergency/urgent)	0.63	[0.10; 3.87]	0.62	0	[0]	0.99
Waiting list	0.90	[0.19; 4.20]	0.90	0.72	[0.12; 4.21]	0.72
Driveline infection	2.20	[0.64; 7.49]	0.21	3.02	[0.52; 17.63]	0.22
Diabetes mellitus	0.70	[0.22; 2.20]	0.54	0.63	[0.17; 2.30]	0.48
Renal insufficiency	1.09	[0.30; 3.93]	0.89	4.17	[0.98; 17.79]	0.08
Obesity	1.66	[0.47; 5.90]	0.43	0.58	[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.

be interpreted as nearly unaffected. This is insofar worth mentioning as regularly periodontal burden affects OHRQoL.²⁷ Considering the high prevalence of periodontitis and periodontal treatment need in the LVAD patients within the current study, an impairment of OHRQoL would be expected. As already shown for patients undergoing haemodialysis as well as organ transplant recipients,^{20,28,29} the LVAD patients seem to estimate their oral health not as impaired, what is not in line with the clinical situation. This supports the assumption of an insufficient information, sensibilization, and motivation regarding the importance of oral health in these patients. Altogether, these findings suggest the necessity of interdisciplinary dental care concepts to improve the insufficient oral situation of LVAD patients.

To detect associations between dental or periodontal treatment need with disease-specific parameters, the current study examined several LVAD-specific issues like intension, urgency, and time since LVAD, as well as a potential listing on waiting list for transplantation or the occurrence of driveline infections. The occurrence of driveline infections is a problem of increasing clinical relevance, especially for patients treated with LVAD over a prolonged time period.² The current study was not able to confirm an association between driveline infections and treatment need. There are two major points that must be considered in this context: the occurrence of complications of LVAD is influenced by different patient-related factors.³⁰ Thereby, oral health might be only one out of several complex reasons or triggers for the occurrence of an infectious complication. Moreover, because of the overall high prevalence of periodontal disease and treatment need, the effect of this parameter is difficult to assess and still remains unclear. To examine the potential relationship between driveline infection and oral health, prospective examinations with additional assessment of microbiological parameters would be recommendable. The further analysis of disease-related parameters revealed only a correlation

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.³¹ 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

group was composed of patients regularly attending a dental clinic for control, what might be a bias. Heart diseases are related to periodontal inflammation.⁵ 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.¹³ 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.^{22,32} Beside of these limitations, the current study provides new knowledge of clinical relevance for the care of LVAD patients.

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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

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