

## ORIGINAL ARTICLE

# Dental care and oral health in solid organ transplant recipients: a single center cross-sectional study and survey of German transplant centers

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dental care, oral health, oral hygiene, solid organ transplantation.

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## Conflicts of Interest

The authors have declared no conflicts of interest.

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## Summary

Aim of this study was to collect information about oral health of patients before and after SOT as well as information about center-based recommendations for dental care. In a single center cross-sectional study, the oral situation of 20 patients before and 20 after SOT were examined including dental (DMF-T), periodontal (PSR<sup>®</sup>/PSI), and oral hygiene findings (modified QHI). In a second project, a survey among 50 transplant centers in Germany was questioned regarding their recommendations for dental care of SOT recipients. Patients before and after SOT showed similar quality of dental findings (DMF-T), but worse compared to the general population. In addition, most patients in both groups showed pronounced periodontal treatment need (PSR<sup>®</sup>/PSI score 3 or 4). Oral hygiene findings (modified QHI) after SOT were significantly worse than in patients on the waiting list ( $P = 0.032$ ). In a second project, the questionnaire was returned by 28 of 50 centers. Interpretation of data showed that 89% carry out a dental examination before SOT and 67% contacted the patients' dentists. After SOT, 83% of the transplant centers recommend antibiotic cover before dental measures. The results of our study revealed lacks in the dental care of SOT recipients. Consistent recommendations regarding the dental care of patients before and after SOT should be determined.

## Introduction

The oral cavity, with more than 700 different species of bacteria physiologically present, represents an important entry point for possible infections [1]. In addition to swallowing and aspiration, above all, the blood path and therefore associated bacteremia play a central role in infection. Even small injuries of the gingiva and/or the mucous membrane of the mouth can, depending on the level of oral infection, trigger bacteremia [2]. In the case of generalized inflammations, periodontal disease, and poor oral hygiene, bacteremia triggered by tooth brushing, as well as dental measures, is stronger and longer lasting than with healthy periodontal conditions and good

oral hygiene [2]. Bacteremia accompanying dental treatment is normally not problematical in healthy individuals, whereas in patients with modified immune response, reduced defense to infections, and subject to immunosuppression caused by the administration of drugs it should, however, be considered to be a potential cause of pathological processes ranging even to life-threatening conditions [3]. Therefore, in addition to patients with a damaged endocardium or who have undergone valve replacement (endocarditis risk), with severe or inadequately adjusted diabetes mellitus, and with rheumatic arthritis, as well as also those who have received an organ transplant, should be considered to be patients at risk in the dental practice. Consequently, in the case of patients

who are waiting for organ donation, early prophylaxis against infection, in the sense of a comprehensive dental treatment, should be strived for [4–6]. According to information provided by the ‘Deutsche Stiftung für Organtransplantation’ (German Foundation for Organ Transplantation), currently there are about 12 000 patients who are waiting for an organ [7].

In order, when possible, to avoid oral complications and the need for dental measures following solid organ transplantation (SOT), an extensive dental examination and the provision of information before a planned organ transplant is recommended [4]. In addition, antibiotic prophylaxis with dental treatment of those already having received an organ transplant appears to be necessary. However, the questions of which antibiotic, which dose rate, and for how long, as well as in which occasions, i.e. all or only invasive dental measures, should be carried out, have been the subject of much discussion [5,8]. Consistent (international) guidelines are not available [8]. In contrast, the importance attributed to good oral hygiene in the case of patients receiving an organ transplant is not disputed [9–11]. Which person, the medical specialist or the patients’ own dentist, is placed under an obligation to provide information to the patient, is also unclear. At the same time, in addition to the lack of guidelines, there appears to be a lack of awareness of oral hygiene and inadequate information on the part of patients, as well as a low level of knowledge on the part of physicians and dentists concerning poor oral hygiene and its systematic effects.

Several studies have drawn attention to inadequate oral hygiene behavior and clear deficits in oral health, both in relation to teeth as well as the periodontal situation, in those receiving an organ transplant [12–14]. Overall, however, the data available on this subject are insufficient.

In addition, the life-long immunosuppressive therapy following SOT has various unwanted oral effects, for example, changes to the mucous membranes brought about by drugs as well as systemically [15–17]. Fungal and herpes infections in the area of the gingiva and lips [18], as well as gingival overgrowth induced by different immunosuppressives, e.g. cyclosporine A, or potassium antagonists of the nifedipine type (e.g. following kidney SOT), have frequently been observed [15,19,20]. In addition to an interaction between preparations, metabolites, and gingival fibroblasts [21], here as well, oral hygiene and the periodontal condition play a decisive role in the level of manifestation of such gingival alterations [22]. The removal of hard and soft supra- and subgingival dental plaque and dental calculus, as well as efficient oral hygiene, is an important aspect in the therapy of gingival overgrowth induced by drugs [22].

Although the importance of dental care and oral health for recipients of SOT has been recognized there are no clear guidelines concerning the dental care of these patients. The aim of this study was, in the context of a single center cross-sectional study, to obtain information about dental care, oral hygiene behavior, and the oral health of patients before and after SOT (part I), in addition, on the basis of a survey of the largest transplant centers in Germany, to obtain information about the dental care given before and after SOT, as well as recommendations regarding antibiotic prophylaxis after SOT (part II). For part I the following hypothesis was formulated: The state of oral health in patients before and after SOT is good and the patients are well informed concerning oral hygiene measures. For part II it was hypothesized that consistent recommendations regarding dental care in SOT recipients as well as antibiotic prophylaxis in connection with dental measures after SOT are missing.

## Methods

By questioning and carrying out a dental investigation of patients before and after SOT in a single center cross-sectional study (part I), as well as surveying transplant centers (part II), it was intended to obtain information concerning dental care and oral hygiene behavior, as well as oral health of such patients. The clinical study was reviewed and approved by the ethics committee of the University Medical Center Goettingen, Germany (No. 43/9/07).

### Part I: Clinical study

#### *Patients*

The same number of patients before (preSOT group) and after heart, liver, or kidney SOT (postSOT group) attending the Department of General and Visceral Surgery of the University Medical Center Goettingen were included in the study.

*PreSOT group:* Patients who before being registered in the Eurotransplant waiting list and/or before a planned SOT in the Department of General and Visceral Surgery of the University Medical Center Goettingen were asked to freely participate in the study. Only patients with planned/imminent kidney, liver, and/or heart SOT were included. The following exclusion criteria were defined: patients below 18 years, the presence of an additional infectious disease (HIV or TBC infection), an addiction, and a seizure or nervous disorder.

*PostSOT group:* Organ transplanted patients (kidney, liver, and/or heart SOT) were asked to take part in the study in the context of a regular/routine subsequent appointment in the transplantation outpatients Depart-

ment of the University Medical Center Goettingen. The exclusion criteria were the same as for the preSOT group.

#### Patient questionnaire

Both groups of patients were asked to fill out a questionnaire regarding their general anamnesis; amongst other things, questions were asked about the following aspects: general illnesses, general medication, reason for the transplantation and, especially for postSOT, the date of the operation, type of SOT, as well as current immunosuppressive therapy. A special dental anamnesis investigated that whether providing information about the associations between oral health and SOT had been carried out and a dental check-up or comprehensive dental treatment preSOT had taken place (yes/no, when). In addition, the patients were asked about their oral hygiene behavior at home, as well as when they visit their dentist, i.e. regular dental check-ups or only in case of pain.

#### Dental examination

All subjects were examined once under standardized conditions by a skilled dentist (VH) in the dental clinic of the University Medical Center Goettingen. The dental examination included the inspection of the oral mucous membranes, dental findings, evaluation of the periodontal situation, and assessment of oral hygiene.

*Inspection of the oral mucous membranes:* at the beginning of the examination, the oral mucous membranes were examined visually. In addition to viral and fungal infections, existing gingival overgrowth was recorded.

*Dental findings (DMF-T) [23]:* the DMF-T was assessed visually with mirror and probe. Based on the number of decayed, missing, and filled teeth, the DMF-T index was determined: All teeth with a reasonable suspicion of/or definitely showing a cavity in the dentine layer were assigned to the D (decayed) component, filled and crowned teeth were evaluated component F (filled), missing teeth were assigned to the M (missing) component, i.e. the DMF-T generally reflects the caries experience of the person examined. In addition, the degree of caries restoration (%) was calculated: ratio of filled teeth (FT) to the carious (DT) plus filled teeth (FT) ( $FT / (DT + FT) \times 100$ ).

*Periodontal situation (PSR®/PSI) [24,25]:* the periodontal situation was evaluated with the periodontal screening index (PSR®/PSI). The examination was performed with a special probe (WHO probe; Morita, Kyoto/Japan) at six points per tooth. The evaluation covered PSR®/PSI score 0 (periodontally healthy), 1 (bleeding on probing, gingivitis), 2 (dental calculus), 3 (pocket depths up to 5.5 mm indicating moderate periodontitis) and 4 (pocket depth exceeding 5.5 mm indicating severe periodontitis), at

which PSR®/PSI score 3 and 4 means that a pronounced periodontal treatment need exists. For each sextant, the highest PSR®/PSI score was determined and the overall largest PSR®/PSI value established the periodontal situation [26].

*Oral hygiene (modified QHI) [27,28]:* the modified Quigley–Hein-Index evaluates oral hygiene by coloring dental plaque on the vestibular and oral tooth surfaces of the Ramfjord teeth (16, 21, 24, 26, 41, 44) with a plaque detector (erythrosine solution). The plaque extension at every index tooth orally and facially is graded on a scale from 0 to 5; values below 1 are considered as good oral hygiene.

## Part II: A survey of organ transplantation centers

For the survey, the largest transplant centers throughout Germany ( $n = 50$ ), determined primarily by the proportion of kidney and liver SOTs (information source: ‘Transplantation and Organ Donation’) were selected. The centers so selected were written to in the period from September to December 2006 and they were asked to fill out and return a questionnaire. The questionnaire covered the following aspects: dental examination and contact to the patients’ dentists (before and after SOT), antibiotic prophylaxis, and antibiotic recommendation in relation to dental treatment after SOT. Only those questionnaires that were returned by the end of December 2007 (i.e. within 12 months) were included in the evaluation.

#### Statistical analysis

The statistical evaluation was carried out using the statistics program STATISTICA (version 9.0, StatSoft GmbH, Hamburg, Germany). The parametric parameters were compared between the study groups with a normal distribution using the *t*-test and nonparametric parameters using the Mann–Whitney *U*-test. The categorical parameters were compared using the chi-square-test. The level of significance was set at 5%, i.e.  $P < 0.05$  was considered as being significant.

## Results

### Part I: Clinical study

#### Patients

In total, 40 patients  $n = 20$  in each of the two groups, were included in the study. The average age of the preSOT group was  $52.6 \pm 13.5$  years and that of the postSOT group  $53.9 \pm 13.8$  years. The majority was male (preSOT: 75%, postSOT: 50%; Table 1). In the preSOT group 55% were nonsmokers, in the postSOT group 90% (Table 1).

**Table 1.** Patients' characteristics.

|   |                       | PreSOT group (n = 20)  | PostSOT group (n = 20) | Significance level (P-value) |
|---|-----------------------|------------------------|------------------------|------------------------------|
| Gender (male) [n (%)]   |                       | 15 (75%)               | 10 (50%)               | 0.19                         |
| Age in years (mv ± SD, range)   |                       | 52.6 ± 13.5<br>(25–74) | 53.9 ± 13.8<br>(22–71) | 0.76                         |
| Smoking habits [n (%)]  | Smoker                | 9 (45%)                | 2 (10%)                | 0.06                         |
|   | Nonsmoker             | 11 (55%)               | 18 (90%)               |                              |
| Alcohol consumption [n (%)]   | Never                 | 14 (70%)               | 18 (90%)               | 0.25                         |
|   | Occasionally          | 5 (25%)                | 2 (10%)                |                              |
|   | Weekly                | 1 (5%)                 | 0 (0%)                 |                              |
| Transplanted organ [n (%)]  | Liver                 | 13 (65%)               | 14 (70%)               |                              |
|   | Kidney                | 6 (30%)                | 6 (30%)                |                              |
|   | Heart                 | 1 (5%)                 | 0 (0%)                 |                              |
| Causal underlying disease [n (%)]   | Carcinoma (liver)     | 5 (25%)                | 4 (20%)                |                              |
|   | Liver cirrhosis       | 7 (35%)                | 4 (20%)                |                              |
|   | Acute liver failure   | 0 (0%)                 | 3 (15%)                |                              |
|   | Renal insufficiency   | 5 (25%)                | 3 (15%)                |                              |
|   | Cardiac insufficiency | 1 (5%)                 | 0 (0%)                 |                              |
|   | Other causes          | 2 (10%)                | 6 (30%)                |                              |
| Waiting time for transplantation (preSOT)/time period following transplantation (postSOT) in months (mv ± SD) |                       | 62.4 ± 77.1            | 9.8 ± 8.4              |                              |
| Immunosuppressive medication (active ingredient) [n (%)]  | Cyclosporine,         |                        | 7 (35%)                |                              |
|   | Tacrolimus            |                        | 7 (35%)                |                              |
|   | Mycophenolate mofetil |                        | 16 (80%)               |                              |
|   | Sirolimus             |                        | 3 (15%)                |                              |
|   | Glucocorticosteroids  |                        | 15 (75%)               |                              |
| Antihypertensive medication [n (%)]   | Yes [Nifedipine]      | 15 (75%) [27%]         | 17 (85%) [18%]         | 0.68                         |
|   | No                    | 5 (25%)                | 3 (15%)                |                              |

preSOT group, before solid organ transplantation; postSOT group, after solid organ transplantation; mv, mean value; SD, standard deviation.

Most patients in the two groups were waiting for a liver SOT or had already had a liver SOT (preSOT: 65%, postSOT: 70%; Table 1). The following combinations of immunosuppressives were given: cyclosporine, mycophenolate-mofetil and glucocorticosteroid (30%), tacrolimus or sirolimus, mycophenolate-mofetil and glucocorticosteroid (35%), cyclosporine or sirolimus and mycophenolate-mofetil (15%) or a monotherapy with only one immunosuppressive (20%). Table 1 shows the distribution of planned and implemented transplantations, the causative underlying diseases, as well as the medication with anti-hypertensives and/or immunosuppressives (postSOT group).

#### Patient questionnaire

The results of the patient questionnaire concerning dental check-ups and oral hygiene behavior are given in Table 2. A total of 70% patients (n = 40) had been given no information about the links between oral health and SOT (preSOT: n = 14, postSOT: n = 14) up until the time of this study. The remaining 30% patients of both groups had been comprehensively informed: 18% of all patients

(n = 40) by their dentist (preSOT: n = 3, postSOT: n = 4) and 13% by the internist providing treatment (preSOT: n = 3, postSOT: n = 2). In the postSOT group, only 30% had comprehensive dental treatment before SOT. Only 20% of the postSOT patients had been informed about the possible appearance of gingival overgrowth in connection with immunosuppressive therapy.

#### Dental examination

*Inspection of the oral mucous membranes:* two patients (10%) in the postSOT group showed signs of gingival overgrowth. One patient (immunosuppression: cyclosporine, mycophenolate-mofetil and glucocorticoid) showed marked alterations of the interdental gingiva; the other patient (immunosuppression: glucocorticoid and sirolimus) showed only mild gingival changes of the interdental gingiva.

*Dental findings (DMF-T):* the comparison between preSOT and postSOT patients is shown in Table 3. The average DMF-T of the preSOT group was 18.1 ± 5.3 (DT: 2.9 ± 3.7, MT: 6.8 ± 6.3, FT: 8.5 ± 4.9) and that of the postSOT group 16.8 ± 8.3 (DT: 1.4 ± 1.9, MT: 7.0 ± 7.7,

**Table 2.** Results of the patients' questionnaire.

|  |                                 | PreSOT group<br>(n = 20) | PostSOT group<br>(n = 20) | Significance<br>level (P-value) |
|--|---------------------------------|--------------------------|---------------------------|---------------------------------|
| Regular contact with a dentist                   |                                 | 12 (60%)                 | 9 (45%)                   | 0.34                            |
| Last visit to a dentist                          | 0–3 months                      | 7 (35%)                  | 9 (45%)                   | 0.63                            |
|  | 6–12 months                     | 11 (55%)                 | 8 (40%)                   |                                 |
|  | >12 months                      | 2 (10%)                  | 3 (15%)                   |                                 |
| Reason for the visit to a dentist                | Control                         |                          |                           | 0.27                            |
|  | 1×/year                         | 8 (40%)                  | 12 (60%)                  |                                 |
|  | >1×/year                        | 11 (55%)                 | 6 (30%)                   |                                 |
|  | Complaints                      | 1 (5%)                   | 2 (10%)                   |                                 |
| Information/knowledge of oral health             |                                 | 6 (30%)                  | 6 (30%)                   | 0.84                            |
| Information/knowledge of gingival overgrowth     |                                 | No details               | 4 (20%)                   |                                 |
| Dental treatment before transplantation          |                                 | No details               | 6 (30%)                   |                                 |
| Interest in oral hygiene information/instruction |                                 | 19 (95%)                 | 13 (65%)                  | 0.018                           |
| Interest in oral hygiene                         |                                 | 19 (95%)                 | 19 (95%)                  | 0.57                            |
| Oral hygiene: tooth brushing                     | <1×/day                         | 1 (5%)                   | 3 (15%)                   | 0.54                            |
|  | 1–2×/day                        | 16 (80%)                 | 15 (75%)                  |                                 |
|  | 3×/day                          | 3 (15%)                  | 2 (10%)                   |                                 |
| Oral hygiene aids                                | Hand toothbrush                 | 17 (85%)                 | 15 (75%)                  | 0.68                            |
|  | Dental floss/inter-dental brush | 8 (40%)                  | 10 (50%)                  |                                 |
|  | Mouth rinse                     | 8 (40%)                  | 11 (55%)                  |                                 |

preSOT group, before solid organ transplantation; postSOT group, after solid organ transplantation, [n (%)].

**Table 3.** Comparison of the oral health parameters in both patient groups.

| Oral health parameters                       | PreSOT group (n = 20) | PostSOT group (n = 20) | Significance<br>level (P-value) |
|--|-----------------------|------------------------|---------------------------------|
| DMF-T (mv ± SD, range)                       | 18.1 ± 5.3 (6–28)     | 16.8 ± 8.3 (2–26)      | NS                              |
| DT (mv ± SD, range)                          | 2.9 ± 3.7 (0–16)      | 1.4 ± 1.9 (0–7)        | NS                              |
| MT (mv ± SD, range)                          | 6.8 ± 6.3 (0–24)      | 7.0 ± 7.7 (0–24)       | NS                              |
| FT (mv ± SD, range)                          | 8.5 ± 4.9 (0–15)      | 8.4 ± 5.7 (0–19)       | NS                              |
| Degree of caries restoration (median, range) | 80% (0–100%)          | 91% (0–100%)           | NS                              |
| Oral hygiene: QHI (mv ± SD, range)           | 1.89 ± 0.71 (1–4)     | 2.43 ± 0.73 (1–5)      | 0.03                            |

preSOT group, before solid organ transplantation; postSOT group, after solid organ transplantation; DMF-T, number of carious, missing and filled teeth (caries index); DT, carious teeth; MT, missing teeth; FT, filled teeth; QHI, Quigley–Hein Index; mv, mean value; SD, standard deviation; NS, not significant =  $P > 0.05$ .

FT:  $8.4 \pm 5.7$ ). A significant difference between the two groups could not be established ( $P = 0.57$ ). However, in the preSOT group, there were on average 1.5 more decayed teeth (DT); the number of missing (MT) and filled teeth (FT) were similar in both groups. Altogether in both groups, the caries experience was high. The degree of carious restoration in the postSOT group was higher (median: 91%) than in the preSOT group (median: 80%), but a significant difference could not be established ( $P = 0.37$ ).

**Periodontal situation (PSR<sup>®</sup>/PSI):** No patient of the two groups showed healthy periodontal conditions (score 0). One participant in the postSOT group showed only bleeding on probing (PSR<sup>®</sup>/PSI score 1), another patient

had a maximum PSR<sup>®</sup>/PSI score of 2. In the preSOT group, no patient showed a maximal PSR<sup>®</sup>/PSI score of only 1 or 2. PSR<sup>®</sup>/PSI score 3 or 4 were found in the preSOT group in eight (40%) and 11 patients (55%), respectively, and in the postSOT group in 10 (50%) and eight patients (40%), respectively. One participant in the preSOT group had no teeth (PSR<sup>®</sup>/PSI score X). In 95% of the preSOT and 90% of the postSOT, the PSR<sup>®</sup>/PSI was score 3 and 4, respectively, which corresponds to a moderately severe to severe periodontitis and therefore needs a marked periodontal treatment. The difference between the two groups was not significant ( $P > 0.05$ ) (Table 4).

**Oral hygiene (modified QHI):** The QHI in the preSOT group was on average  $1.89 \pm 0.76$ , in the postSOT group

**Table 4.** Comparison of periodontal findings (PSR<sup>®</sup>/PSI) in both patient groups.

|                                    |         | PreSOT group (n = 20)       |                          | PostSOT group (n = 20)      |                          | Significance level (p-value) |
|------------------------------------|---------|-----------------------------|--------------------------|-----------------------------|--------------------------|------------------------------|
|                                    |         | Number of patients (n = 20) | Number of sextants (120) | Number of patients (n = 20) | Number of sextants (120) |                              |
| PSR <sup>®</sup> /PSI max. [n (%)] | Score 0 | 0 (0%)                      | 0 (0%)                   | 0 (0%)                      | 0 (0%)                   | NS                           |
|                                    | Score 1 | 0 (0%)                      | 2 (2%)                   | 1 (5%)                      | 15 (12.5%)               |                              |
|                                    | Score 2 | 0 (0%)                      | 4 (3%)                   | 1 (5%)                      | 8 (7%)                   |                              |
|                                    | Score 3 | 8 (40%)                     | 71 (59%)                 | 10 (50%)                    | 60 (50%)                 |                              |
|                                    | Score 4 | 11 (55%)                    | 33 (28%)                 | 8 (40%)                     | 16 (13%)                 |                              |
|                                    | Score X | 1 (5%)                      | 10 (8%)                  | 0 (0%)                      | 21 (17.5%)               |                              |

preSOT group, before solid organ transplantation; postSOT group, after solid organ transplantation; PSR<sup>®</sup>/PSI, Periodontal Screening Index; X, toothless; NS, not significant =  $P > 0.05$ .

**Table 5.** Results of survey of the the transplant centers.

| Subjects of questions   |                               | Yes [n (%)]                     | No [n (%)] |
|---|-------------------------------|---------------------------------|------------|
| Dental examination and contact with the dentist (before and after SOT) (n = 28) | Dental examination before SOT | 25 (89%)                        | 3 (11%)    |
|   | Contact with the dentist      |                                 |            |
|   | Before the SOT                | 6 (21.5%)                       | 6 (21.5%)  |
|   | Before and after SOT          | 13 (46%)                        |            |
| Antibiotic prophylaxis with dental treatment after SOT                          | Before dental treatment       | No comment                      | 3 (11%)    |
|   |                               | Before all treatments           | 6 (21.5%)  |
|   |                               | Only with invasive treatments   | 9 (32%)    |
|   | Lifelong                      | AHA recommendation              | 6 (21.5%)  |
|   |                               | No comment                      | 2 (7%)     |
|   |                               | 1–2 years after transplantation | 19 (68%)   |
| Antibiotic recommendation   | No comment                    | 2 (7%)                          |            |
|   | Amoxicillin/Penicillin        | 10/3 (46%)                      |            |
|   | Clindamycin                   | 6 (21.5%)                       |            |
|   | Ampicillin                    | 5 (18%)                         |            |
|   | Cephalosporine                | 3 (11%)                         |            |
| Decision made by the dentist  | 2 (7%)                        |                                 |            |

The information relates to the questionnaires that were returned; n = 28 which corresponds to 100%; SOT, solid organ transplantation.

2.43 ± 0.73. In the postSOT group, the oral hygiene was worse than in the preSOT group; the difference between the two groups was significant ( $P = 0.03$ ; Table 3).

## Part II: Survey of the organ transplantation centers

Of the 50 questionnaires sent out, 28 were answered within 1 year, representing a return rate of 56%. The following information relates to the 28 questionnaires that were returned completed (=100%).

**Dental examination and contact with dentists:** 89% (n = 25) of the transplant centers carried out a systematic dental examination before SOT took place; 67% (n = 19) also contacted the patients' dentists (Table 5).

**Antibiotic prophylaxis:** 83% (n = 23) of the transplant centers recommend antibiotic cover before dental measures post SOT. With regard to the type of dental treat-

ment, only six transplant centers recommended antibiotic prophylaxis for all dental measures (Table 5).

**Antibiotic recommendation:** Amoxicillin (n = 10) or penicillin (n = 3) were the most frequently recommended antibiotics followed by clindamycin (n = 6) (Table 5).

## Discussion

The study presented here provides an overview of the dental care and level of information, as well as oral hygiene behavior and state of oral health of patients before and after SOT.

## Summary of the main results

Most of all surveyed patients had not been informed that there is an association between oral health and SOT. Only

in 30% of the postTx group, comprehensive dental treatment was carried out before SOT. With regard to oral health (prevalence of caries and periodontal condition), a high caries experience in the pre- and the postSOT group was observed. Nevertheless, most patients showed a marked periodontal treatment need. Regarding the oral hygiene situation (QHI), there was a significant worsened oral hygiene in the postSOT group than in the pre-SOT group.

The majority of transplantation centers that replied to the questionnaire carried out a dental examination before SOT and recommended antibiotic prophylaxis before dental measures after SOT. With regard to the type of dental measures (all measures or only surgical interventions) and the choice of antibiotic, no clear recommendations could be established.

### Comparison with existing literature

The importance of good oral hygiene and regular dental care should be made clear to those receiving a transplant [14]. Also, even though at present there are no evidence-based studies concerning the risk of odontogenic/periodontal infections in transplantation patients, it should be assumed that an increased risk of infection does exist [6]. However, the results of the clinical part of the study show a clear need for action in relation to patient information and in relation to the theme 'oral health and SOT' large deficits were found: 70% of patients had received no information regarding this. This is all the more noteworthy as most of the patients investigated behaved in a control-oriented manner with regard to visits to a dentist.

With regard to oral health, the occurrence of immunosuppressive-induced gingival overgrowth is of clinical relevance, above all with the administration of cyclosporine A [15]. In the study presented here, gingival overgrowth was only found in two patients. In one patient, immunosuppression occurred with cyclosporine A; additional antihypertensive therapy with a nifedipine calcium channel blocker may have increased the extent of gingival overgrowth [19,20,29,30]. The second patient received therapy with sirolimus. Although the new generation immunosuppressives should cause fewer unwanted oral side-effects [31], however, under sirolimus therapy as well, gingival alterations are possible [32].

In terms of the prevalence of caries and the periodontal situation of the patients investigated in the present study, a comparison of oral health with other investigations is only to a limited extent possible, as a majority of studies were carried out not on adults but on children and adolescents [12,33–35]. Only Guggenheimer *et al.* [14] carried out a similar investigation. In their study, 32% of patients who had undergone a liver SOT showed severe dental diseases, i.e. two or more carious teeth and two or more periodontal diseased teeth, and consequently had a significant need to receive dental treatment. Considering the results of the population-representative cross-sectional study DMS IV (the Fourth German Oral Health Study [36]), the dental findings (DMF-T) of the present study (preSOT:  $18.1 \pm 5.3$ ; postSOT:  $16.8 \pm 8.3$ ) are approximately between the DMF-T values of the age group 35–44 years (DMF-T = 14.5) and the age group 65–74 years (DMF-T = 22.1), see Table 6. Though, the number of decayed teeth (DT) in the present study (preSOT =  $2.9 \pm 3.7$ ; postSOT =  $1.4 \pm 1.9$ ) was higher than

**Table 6.** Dental findings (DMF-T) and periodontal findings (PSR<sup>®</sup>/PSI) of the the Fourth German Oral Health Study (DMS IV) and the present study.

| Oral finding                   | DMS IV                    |                          | Present study              |                             |
|--------------------------------|---------------------------|--------------------------|----------------------------|-----------------------------|
|                                | Age group:<br>35–44 years | Age group<br>65–74 years | PreSOT group<br>52.6 years | PostSOT group<br>53.9 years |
| DMF-T (mv $\pm$ SD)            | 14.5 $\pm$ 5.7            | 22.1 $\pm$ 5.9           | 18.1 $\pm$ 5.3             | 16.8 $\pm$ 8.3              |
| DT (mv)                        | 0.5                       | 0.3                      | 2.9                        | 1.4                         |
| MT (mv)                        | 2.4                       | 14.1                     | 6.8                        | 7.0                         |
| FT (mv)                        | 11.7                      | 7.7                      | 8.5                        | 8.4                         |
| PSR <sup>®</sup> /PSI max. (%) | Score 0                   | 0.5%                     | 1%                         | 0%                          |
|                                | Score 1                   | 12%                      | 4%                         | 0%                          |
|                                | Score 2                   | 14%                      | 7%                         | 0%                          |
|                                | Score 3                   | 53%                      | 48%                        | 40%                         |
|                                | Score 4                   | 20.5%                    | 40%                        | 55%                         |

preSOT group, before solid organ transplantation; postSOT group, following solid organ transplantation; DMF-T, number of carious, missing and filled teeth (caries index); DT, carious teeth; MT, missing teeth; FT, filled teeth; PSR<sup>®</sup>/PSI, Periodontal Screening Index; mv, mean value; SD, standard deviation.

in DMS IV [36], see Table 6. Even a still higher need for caries treatment in those having received an SOT was found by Gressmann *et al.* [13].

With regard to periodontal health, a large proportion of the patients investigated in the present study showed a marked need for periodontal treatment (PSR<sup>®</sup>/PSI 3 or 4): 95% (preSOT) or 90% (postSOT); healthy periodontal conditions (PSR<sup>®</sup>/PSI score 0) were seen in no patient. In a study conducted by Rustemeyer and Bremerich, periodontal therapy before SOT was needed in 64% of patients [37]. The findings regarding the periodontal situation in the present study demonstrating a high periodontal treatment need were similar to the findings in DMS IV [36], see Table 6.

Only in the case of oral hygiene (plaque index) there was a significant difference between the preSOT and the postSOT group. The more severe plaque accumulation in the postSOT patients could have been influenced by the immunosuppressive and/or antihypertensive medication, as these substances can have an adverse effect on saliva flow (Xerostomie) [38]. Also, postSOT, the importance of oral hygiene at home seems to have diminished in view of the overall health situation.

Therefore, the originally formulated hypothesis that the state of oral health in patients before and after SOT is good and these patients are well informed concerning oral hygiene measures, could not be confirmed.

The results of the survey of the transplantation centers reveal that there is uncertainty regarding recommendations for the dental treatment of patients before and after SOT, so that a consistent and generally valid therapy recommendation is lacking [4,6,39]. In addition, there are no scientifically based data available concerning antibiotic prophylaxis in the case of dental treatment of these patients [5,8]. However, the majority of authors are in agreement that, because of the life-long immunosuppression, antibiotic prophylaxis should be given before dental therapy takes place [4,5,39]. This view is supported by the results presented here: 89% of the transplant centers that responded to the questionnaire recommended antibiotic prophylaxis in the case of dental treatment. A concrete statement regarding which specific measures was not, however, made. Regarding therapy recommendations for antibiotic prophylaxis, most authors refer to the guidelines of the American Heart Association with reference to endocarditis prophylaxis [2,4,39]. Accordingly, the antibiotic of choice is amoxicillin or clindamycin as a substitute preparation in the case of a penicillin allergy [39]. In the questionnaire presented here, penicillin was also most frequently named.

Although comprehensive dental therapy before the planned SOT has been the subject of a controversial debate [40,41], there is predominantly an agreement that

the emphasis should not be placed on antibiotic prophylaxis following SOT, but instead the improvement or safeguarding of the oral health of the patient before SOT [2,4–6,14]. Accordingly, the recommendation is made to patients that prophylaxis against infection should begin before SOT; moreover, so bearing in mind that most patients have to wait a very long time for a suitable donor organ. Therefore, making contact with a dentist and comprehensive dental therapy before SOT should be considered to be an appropriate way to proceed and the elimination of all sources of infection should be strived for [4,6,37,39]. Thus, in a retrospective study, 80% of patients who did not undergo dental treatment had post-operative complications (infections, transplant rejection), but only 45.8% of patients who did undergo prior dental therapy [6]. Guggenheimer *et al.* [5] questioned American transplant centers about their dental protocols. A total of 80% physicians favored a dental examination before SOT; yet, in contrast, 20% indicated that they did not undertake a dental evaluation of candidates on the waiting list [5]. Forty-nine percent supported a dental check-up only for particular organ transplantations [5]. In the survey conducted here, indeed 89% of the transplant centers instigated a dental examination or treatment before SOT. Anyhow, at least two-thirds of the clinics made contact to the dentist before or after SOT. In contrast to this, the results of the clinical part of the investigation reported here showed that only in 30% of the postSOT patients dental treatment was carried out before SOT.

Therefore, the initially established hypothesis that consistent recommendations regarding dental care in SOT recipients as well as antibiotic prophylaxis in connection with dental measures after SOT are missing, could be confirmed.

### Implication for the practice

The results of this study underline the need for preparing binding guidelines for the dental care of those receiving an organ transplant (before and after SOT). The emphasis of these guidelines should be the improvement of or ensuring the oral health of patients. Given the current state of knowledge, it appears reasonable to administrate preventative antibiotic therapy to patients with solid organ transplants, based on known prophylaxis concepts. This procedure is justified as long as clinical studies do not demonstrate that it is ineffective or inappropriate [4]. In addition, comprehensive dental care with early information about the relationship between 'transplantation and oral health' is necessary. Optimal patient care can only be ensured when there is close interdisciplinary collaboration between dentists and physicians.



## Conclusion

The presented study shows that there are lacks in the dental care of patients before and after SOT. The worse oral hygiene status observed after SOT is viewed as an indication that, in the context SOT after-care, little importance is attributed to oral health. The preparation of binding guidelines is necessary. Then, in a preoperative stage, comprehensive dental treatment with the achievement of healthy oral conditions should be strived for and good oral hygiene should be ensured.

## Authorship

DZ: made substantial contributions to conception and design of the study and wrote the manuscript. VH: carried out the clinical examination and performed the statistical analysis. AG and AO: involved in revising it critically for important intellectual content and have given final approval of the version to be published. EH: conceived the study, participated in its design and coordination, interpretation of data and has been involved in drafting the manuscript. RM: head of the study and made some substantial contributions to its conception and design. All authors read and approved the final manuscript.

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