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ORIGINAL ARTICLE

Oral health in patients on haemodialysis for diabetic nephropathy and chronic glomerulonephritis

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Abstract
Objective The objective of this study was to clarify differences in oral health status between patients who needed haemodialysis (HD) owing to diabetic nephropathy (DN) and chronic glomerulonephritis (CGN).
Materials and methods Ninety-eight HD patients who were 50–70 years old were selected as the study subjects [DN group (29 subjects) and CGN group (69 subjects)] to compare with 106 control subjects (control group) not undergoing HD. All HD subjects underwent oral- and systemic-related examination just before HD therapy.
Results The mean number of teeth present in the DN group was significantly less than in the CGN and control groups. The mean percentage of sites with bleeding on probing in the DN group was greater than in the CGN and control groups. The mean salivary flow rate in the DN and CGN groups was significantly lower compared with the control group.
Conclusion The patients undergoing HD for DN were found to have fewer teeth and worse periodontal health compared with those undergoing HD for CGN and with the control subjects not undergoing HD. Furthermore, the dental and periodontal health of the patients undergoing HD for CGN was comparable to that of the controls.
Clinical relevance For effective measures of prevention and improvement of oral health in HD patients, clinicians should be aware of the differences in the characteristics of the oral health between patients undergoing HD for DN and CGN.

Keywords Haemodialysis · Oral health · Periodontal disease · Diabetic nephropathy · Chronic glomerulonephritis · Xerostomia

Introduction

The number of patients who need haemodialysis (HD) owing to chronic renal failure (CRF) has surpassed 280,000 people in Japan since 2008, a number presumed to increase progressively in the future. The most common reasons for

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CRF are diabetic nephropathy (DN), chronic glomerulonephritis (CGN), interstitial nephritis (including pyelonephritis), hypertension or vascular disease, hereditary or congenital disease and neoplasms [1, 2]. Although the most prevalent cause of CRF is CGN [1], DN is also a leading cause of end-stage renal disease; its prevalence and incidence vary greatly from country to country, being highest in the USA and Japan [3, 4].

Oral health is an essential and important factor for general health. CRF affects oral tissues and leads to gingival enlargement, xerostomia, alterations in salivary composition and flow rate, adverse effects related to drug therapy, mucosal lesions, oral malignancies, oral infections, dental anomalies and bone lesions. Consequently, the oral health status of HD patients is worsened as a result [1, 5–9]. However, there are also opposite opinions about the dental and periodontal health status of HD patients in the literature [10–15]. Furthermore, a recent study reported that there were some differences in oral manifestations between diabetic and non-diabetic uremic patients receiving HD [16], while the details of differences in oral health status between HD patients based on the diseases causing CRF have been unknown.

Thus, although there are many reports on the dental and periodontal deficiencies of HD patients, they have not been documented in a standardised manner, and conclusions about the oral health status of HD patients and about the influence of CRF and its causal diseases on oral status remain unclear. In this study, we hypothesised that there were specific differences in oral health characteristics between HD patients according to the disease causing their CRF. Our objective in this study was to clarify the differences in oral health status between HD patients with DN and those with CGN, the two main diseases causally linked to CRF.

Material and methods

Study design

This study was designed as a cross-sectional survey. The research is part of a project examining patients who are undergoing HD therapy. The survey was conducted according to the principles expressed in the Helsinki Declaration and was approved by the Human Investigations Committee of Kyushu Dental College. The details of the study protocol were explained to all participants, and written informed consent was obtained prior to participation. The study took place between May and July 2008.

Participants and examination

The participants in this survey were 219 Japanese patients (135 men and 84 women) who were randomly recruited from among all patients undergoing HD at the Kokura-Daiichi Hospital in Fukuoka, Japan. Their mean age was 65.2 years old [standard deviation (SD), 13.0]. All participants underwent oral and blood examinations and salivary flow tests just before a session of HD therapy and were surveyed using a questionnaire about living habits and xerostomia.

Oral examinations were performed by four dentists trained for inter-rater reliability. Tooth status was examined based on WHO criteria for all teeth using a dental mirror. The presence of periodontal probing depth more than 4 mm (PPD), clinical attachment loss more than 4 mm (CAL), and bleeding on probing (BOP) were measured using a periodontal probe at medial buccal and central buccal sites for each tooth. Wisdom teeth, tooth stumps, and root caps were excluded from the oral examination.

In the salivary flow test, stimulated whole saliva was spat into a sterilised plastic tube while chewing a tasteless piece of paraffin (1 g) for 5 min at a constant pace of 60 times/min, which was monitored with an electric metronome, and stimulated whole salivary flow rate per minute (mL/min) was estimated by measuring the volume of saliva collected in the tube.

The original English version of the Xerostomia Inventory (XI), which is composed of 11 xerostomia-related symptoms, was translated into Japanese, and the symptoms asked of the subjects were validated by a back-translation procedure. The response options to the 11 symptoms of the XI are ‘never’ (score 1), ‘hardly ever’ (score 2), ‘occasionally’ (score 3), ‘fairly often’ (score 4) or ‘very often’ (score 5). The XI represents a patient’s experience of the severity of xerostomia, providing a score between 11 and 55. In addition to the symptoms in the XI, other xerostomia-related symptoms including ‘I feel tongue pain’, ‘I have a bad taste when eating a meal’, ‘I have to drink water often’, ‘My mouth feels sticky’, ‘I feel that I have bad breath’ and ‘My voice feels hoarse’ were also asked with the same response options.

To focus on patients undergoing HD for DN and CGN in this study and compare with the data of control subjects (control group) obtained from another oral and systemic health survey for elderly residents, performed in 2005 in Fukuoka, Japan [17], the subjects were determined based on the inclusion criteria (including HD patients with either DN or CGN and age of 50–70 years). Of the participants, the diseases causing CRF and the need for HD were DN (59 patients), CGN (110 patients), hypertensive nephropathy (22 patients), polycystic kidney (6 patients), lupus nephritis (19 patients) and other reasons (3 patients). In this study, the 98 HD patients who were 50–70 years old were selected as the study subjects [DN group (29 subjects) and CGN group (69 subjects)], out of the participants whose cause of CRF was either DN or CGN. The control group was composed of

106 subjects who were randomly selected from the total of 393 participants in the health survey to adjust the sample size and the sex ratio to those in this study.

Statistical analyses

The symptoms related to xerostomia were classified into three classes [never (score: 1); hardly ever or occasionally (2); and fairly often or very often (3)] based on the response options to each symptom. The characteristics and the proportions of symptoms related to xerostomia were compared between the three groups (DN, CGN and control groups), and the statistical significance of the characteristics of the three groups was determined by chi-square analysis or one-way analysis of variance (ANOVA) with *post hoc* tests. Moreover, the oral-related characteristics of the three groups (current smoker, former smoker or never smoker) based on differences in smoking habits of the subjects in the DN group were analysed by ANOVA with post hoc tests.

All statistical analyses were performed using IBM SPSS Statistics version 19 (IBM Japan Inc., Tokyo).

Results

The mean age of the DN group, CGN group and control group was 60.5 (SD, 6.1) years old, 61.4 (5.0) years old and 62.9 (2.5) years old, respectively (Table 1). There was no significant difference in age between the three groups. The numbers of male subjects in the DN and CGN groups were greater than those of female, and there was no significant difference in proportion of male and female between the DN and CGN groups and the control group. The mean duration of HD in the CGN group was 17.1 (SD, 11.0) years, which was significantly longer than in the DN group [mean period, 9.5 (SD, 9.1) years] (unpaired t test: $p<0.05$). The proportion of smokers was significantly different among the three groups (chi-squared test: $p<0.05$), and the proportion of current smokers in the DN group was higher than in the CGN and control groups. Moreover, there were no significant differences in the proportions of subjects with conceptions of oral health and dental scaling and dental check experiences within 1 year between the three groups.

The mean body mass index was significantly lower in the DN and CGN groups than in the control group ($p<0.05$) (Table 2). The mean systolic blood pressure in the CGN group was significantly lower compared with the control group [Tukey's honestly significant difference (HSD) test: $p<0.05$]. The blood examination parameters that were significantly different between the DN and CGN groups and the control group are shown in Table 2. The means of serum creatinine, blood urea nitrogen and serum uric acid in the DN and CGN groups were significantly higher compared with the control group ($p<0.05$), while the means of serum total protein, glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, total cholesterol, high-density lipoprotein cholesterol and platelet blood count in the DN and CGN groups were significantly lower compared with the control group ($p<0.05$). The mean blood glucose was significantly higher in the DN group compared with the CGN and control groups ($p<0.05$), while the means of other parameters were not significantly different between the DN and CGN groups.

The mean number of teeth present in the DN and CGN groups was 17.9 (SD, 9.8) teeth and 24.1 (SD, 6.8) teeth, respectively, with that in the DN group significantly smaller than those in the CGN and control group [the latter was 25.3 (SD, 5.8) teeth] (Tukey HSD test, $p<0.05$; Table 3). The mean percentage of PPD (of more than 4 mm) in the DN and

Table 1 Basic data of the diabetic nephropathy (DN), chronic glomerulonephritis (CGN), and control groups

Parameters	DN group	CGN group	Control group
Number of subjects	29	69	106
Age (mean±SD)	60.5±6.1	61.4±5.0	62.9±2.5
Male/female [number (%)]	23(79.3)/6(20.7)	43(62.3)/26(37.7)	69(65.1)/37(34.9)
Duration of haemodialysis (mean years±SD)	9.5±9.1*	17.1±11.0	
Smoking habit**			
Current smokers [number (%)]	10 (34.5)	9 (13.6)	14 (13.2)
Former smokers [number (%)]	12 (41.4)	29 (43.9)	36 (34.0)
Never smokers [number (%)]	7 (24.1)	31 (52.5)	56 (52.8)
Subjects with conceptions of oral health [number (%)]	17 (58.6)	40 (57.9)	72 (67.9)
Dental scaling experience within 1 year [number (%)]	14 (48.3)	34 (49.3)	58 (54.7)
Dental check experience within 1 year [number (%)]	18 (62.1)	38 (55.1)	56 (52.8)

DN group HD subjects whose causal disease is diabetic nephropathy; *CGN group* HD subjects whose causal disease is chronic glomerulonephritis; *control group* subjects who participated in an oral and systemic health survey performed in 2005 in Fukuoka Prefecture, Japan

*$p<0.05$, unpaired t test; **$p<0.05$, chi-square test

Table 2 Systemic characteristics of the diabetic nephropathy (DN), chronic glomerulonephritis (CGN), and control groups (mean±SD)

Parameters	DN group	CGN group	Control group
Body mass index	20.9±3.0*	20.7±2.2*	24.4±3.1
Systolic blood pressure	138.7±14.3	135.4±12.6*	147.2±19.5
Diastolic blood pressure	74.6±11.2*	77.8±9.0*	82.1±10.2
Blood examination			
Serum creatinine (mg/dL)	10.8±2.0*	12.7±2.3***	0.7±0.2
Blood urea nitrogen (mg/dL)	68.8±16.9*	74.3±14.2*	17.8±4.1
Serum total protein (g/dL)	6.6±0.4*	6.6±0.4*	7.3±0.4
GOT (IU/L)	15.6±7.1*	14.0±8.0*	27.5±14.1
GPT (IU/L)	11.9±6.8*	11.6±6.2*	26.5±21.6
Total cholesterol (mg/dL)	165.4±44.1*	164.6±34.3*	211.9±32.6
HDL cholesterol (mg/dL)	38.2±14.3*	47.1±14.0*	57.8±14.8
Serum uric acid (mg/dL)	8.2±1.3*	8.1±1.2*	5.5±1.4
Blood glucose (mg/dL)	142.4±53.9**	116.8±34.8	109.3±34.8
Platelet blood count ($\times 10^4/\mu L$)	17.5±5.8*	16.1±5.3*	21.4±5.1

DN group HD subjects whose causal disease is diabetic nephropathy; *CGN group* HD subjects whose causal disease is chronic glomerulonephritis; *control group* subjects who participated in an oral and systemic health survey performed in 2005 in Fukuoka Prefecture, Japan; *GOT* glutamic oxaloacetic transaminase; *GPT* glutamic pyruvic transaminase; *HDL cholesterol* high-density lipoprotein cholesterol

*$p<0.05$, Tukey HSD test, vs. control group; **$p<0.05$, Tukey HSD test, vs. CGN and control groups; ***$p<0.05$, Tukey HSD test vs. DN and control groups

CGN groups was 5.9 (8.8) % and 3.4 (9.4) %, respectively, with that in the CGN group significantly less than that in the control group [PPD, 9.9 (16.9) %] ($p<0.05$). Furthermore, the mean percentage of BOP in the DN group [BOP, 13.3 (22.2)] was greater than in the CGN and control groups [8.2 (15.9) % and 8.2 (9.3) %, respectively] and significantly greater than in the control group ($p<0.05$). Although there were no significant differences in percentages of CAL (of more than 4 mm) between the three groups, that in the DN group [CAL: 28.3 (27.7) %] was greater than those in the CGN and control groups [21.3 (24.0) % and 21.5 (22.8) %, respectively]. The mean of salivary flow rate in the DN and CGN groups [0.7 (0.5) mL/min and 0.9 (0.7) mL/min] was significantly lower compared with that in the control group [1.2 (0.7) mL/min] ($p<0.05$). Moreover, the mean total score of xerostomia (XI) was significantly greater in the DN and CGN groups [22.2 (7.4) and 20.6 (5.9), respectively] than that in the control group [16.4 (3.9)]. Although the data related to oral mucosa lesions were not shown in Table 3, buccal mucosal blister, white spots on the palate and gingival mass were found in one subject of the DN group and two subjects of the CGN group, respectively. Furthermore, the mean number of present teeth in current smokers of the DN group was significantly smaller than in never smokers of the DN group ($p<0.05$), while there were no significant differences in other oral health-related parameters based on differences in smoking habits in the DN group (Table 4).

Among the xerostomia-related symptoms, the symptoms for which there was a significant difference in proportion of the response options between the DN and CGN groups and the control group were 'My mouth feels dry' (chi-square test, $p<0.001$), 'I have difficulty in eating dry foods' ($p<0.01$), 'My mouth feels sticky' ($p<0.01$), 'My eyes feel dry' ($p<0.001$) and 'My voice feels hoarse' ($p<0.01$), with these symptoms reported more frequently in the DN and CGN groups compared with the control group.

Discussion

Several previous reports suggested that HD treatment might cause oral changes, complications and alterations in salivary

Table 3 Oral-related characteristics of the diabetic nephropathy (DN), chronic glomerulonephritis (CGN), and control groups (mean±SD)

Parameters	DN group	CGN group	Control group
Number of teeth present	17.9±9.8**	24.1±6.8	25.3±5.8
Percentage of teeth with decay or filling (%)	64.6±26.7	46.4±25.0	49.2±23.3
Percentage of sites with probing pocket depth ≥4 mm (%)	5.9±8.8	3.4±9.4*	9.9±16.9
Percentage of sites with clinical attachment loss ≥4 mm (%)	28.3±27.7	21.3±24.0	21.5±22.8
Percentage of sites with bleeding on probing (%)	13.3±22.2*	8.2±15.9	8.2±9.3
Salivary flow rate (mL/min)	0.7±0.5*	0.9±0.7*	1.2±0.7
Total score of xerostomia (XI)	22.2±7.4*	20.6±5.9*	16.4±3.9

DN group HD subjects whose causal disease is diabetic nephropathy; *CGN group* HD subjects whose causal disease is chronic glomerulonephritis; *control group* subjects who participated in an oral and systemic health survey performed in 2005 in Fukuoka Prefecture, Japan; *salivary flow rate*, flow rate of total saliva stimulated by chewing gum for 5 min

*$p<0.05$, Tukey HSD test, vs. control; **$p<0.05$, Tukey HSD test, vs. CGN and control groups

Table 4 Comparison of oral-related characteristics based on differences in smoking habits in the diabetic nephropathy (DN) group (mean±SD)

Parameters	Current smokers (n=10)	Former smokers (n=12)	Never smokers (n=7)
Number of teeth present	12.3±10.0*	19.2±9.5	23.7±6.4
Percentage of teeth with decay or filling (%)	60.6±29.8	70.1±22.4	61.2±31.4
Percentage of sites with probing pocket depth ≥4 mm (%)	5.5±7.2	8.1±11.4	2.8±5.4
Percentage of sites with clinical attachment loss ≥4 mm (%)	37.4±32.7	31.7±27.1	11.3±13.7
Percentage of sites with bleeding on probing (%)	24.2±33.3	9.3±12.6	5.4±10.6
Salivary flow rate (mL/min)	1.0±0.6	0.6±0.4	0.5±0.4
Total score of xerostomia (XI)	22.6±10.7	23.1±5.6	19.7±3.3

Prefecture, Japan

Salivary flow rate flow rate of total saliva stimulated by chewing gum for 5 min

*p<0.05, Tukey HSD test, vs. CGN and control groups

composition and flow rate [5, 18, 19]. Other studies evaluating periodontal and gingival diseases in HD patients have reported that these were prevalent in these populations [7, 20, 21]. Conversely, several studies have reported that the dental and periodontal health status of HD patients was comparable with healthy controls [13–15]. Thus, although many studies have reported on the dental and periodontal findings in HD patients, there has been no definitive conclusion about the oral health of HD patients. This may be for the reason that there have been few studies that have reported differences in oral health status according to the causal diseases of CRF in HD patients, such as this report on oral and dental manifestation in diabetic patients undergoing HD [16]. The present study focused on HD patients with DN and CGN, the major causes of CRF and on the oral and systemic factors of patients in these two groups compared with a control group where the mean age and the sex ratio were comparable to those in both the DN and CGN groups. Therefore, the oral-related characteristics of patients undergoing HD for CGN and DN in this study represent new knowledge to enhance current understandings of HD patient oral health.

Of the systemic characteristics investigated in this study, the high levels of serum creatinine and blood urea nitrogen in the DN and CGN groups reflect CRF, while the high levels of blood glucose in the DN group reflect diabetes mellitus (DM). The mean levels of all the systemic parameters except for serum creatinine, blood urea nitrogen and serum uric acid in the DN and CGN groups and blood glucose in the DN group were within normal limits, although HD patients of both the DN and CGN groups had common differences with the control group. Therefore, the systemic conditions of the DN and CGN groups were relatively controlled with HD despite their CRF.

The present study found that HD patients in the DN group had poorer oral health compared with the CGN and control groups since they had fewer teeth and greater percentages of CAL and BOP. Moreover, the xerostomia in the DN groups tended to be worse compared with that in the CGN group. DM is generally thought to carry a greater risk for developing periodontitis [22] and for influencing various deteriorations of oral health such as severity of periodontitis, tooth loss and xerostomia [23–25]. Therefore, the increase in missing teeth, sites of CAL and BOP and xerostomia in the DN group may reflect the oral health status of patients with DM before the onset of CRF. On the other hand, we analysed the differences in oral-related characteristics based on the smoking habits of the DN group because the proportion of current smokers in the DN group was higher compared with those in other groups. Smoking is a major risk factor for periodontitis [26, 27], and its effect is related to tooth loss [28]. Additionally, recent studies have indicated that smoking was associated with the development of type 2 DM [29, 30]. In this study, the increase in missing teeth in the DN group also seemed to be influenced by smoking, while there was no statistically significant difference in periodontal health status between current smokers and others in the DN group. Accordingly, the daily smoking habit may directly and indirectly influence the oral health status of patients undergoing HD for DN through deteriorations of periodontal health and DM.

The prevalence of PPD (>4 mm) in HD patients was reported in a previous study as reflecting healthy periodontal status in spite of a tendency to worsened periodontal health status in HD patients compared with the control group in the case of other indicators such as BOP [15]. Other studies have suggested that medication taken by HD patients, such as anticoagulant therapy, could produce increased BOP and thus might not directly reflect the level of inflammation of this group of patients [11, 14]. The present study showed that the percentage of PPD (>4 mm) in the CGN group was significantly lower than that in the control group, while other dental and periodontal factors including BOP did not significantly differ from those in the control groups. Therefore, the oral health of HD patients in the CGN group seemed comparable to that in the control group except for the symptoms related to xerostomia.

This study showed that a greater proportion of HD patients, especially in the DN group, was found to experience some symptoms related to xerostomia in addition to a tendency to have decreased salivary flow rates. The salivary secretory function is essential for normal oral function and health status, and its reduction is linked to impairments in various oral functions reflected by xerostomia-related symptoms [31, 32], although other reports have suggested that salivary secretory function is not always related to symptoms of xerostomia [33].

The present study does not explain the differences in oral status of HD patients between the DN and CGN groups because this study was designed as a cross-sectional survey. Oral health is influenced by various factors such as health behaviour; social, economic and environmental states; and mental and systemic health. In this study, there were no differences in the factors of health behaviour, such as conceptions of oral health and dental scaling and check-up experiences, among the DN, CGN and the control groups at the point of the survey (although we did not investigate the details of health behaviour during the previous decade or so). Although the mean duration of HD in the CGN group was shown to be significantly longer compared with the DN group, the relationship between the differences in HD duration and oral health remains unclear, which is a limitation of the present study. The risk factors for the deterioration in oral health of patients undergoing HD maintenance due to DN and CGN need to be elucidated by further studies.

In conclusion, the present study described the characteristics of the oral health of patients undergoing HD for DN and CGN. The HD patients with DN were found to have fewer teeth and worse symptoms of periodontal health and xerostomia compared with those with CGN and with the control subjects not undergoing HD. Furthermore, the oral health of the HD patients with CGN was similar to that of the control subjects except for the symptoms related to xerostomia. Clinicians should recognise the differences in oral health between patients undergoing HD for DN and CGN to implement the most effective measures of monitoring and treatment for prevention, improvement and maintenance of oral health for these patients, especially those with DN.

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

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