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ORIGINAL ARTICLE

Assessment of the oral health status of children with chronic kidney disease

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Abstract

Background There are various oral symptoms related to the disease and its management in individuals with chronic kidney disease (CKD). The aim of the study was to investigate the oral health status of children with different stages of CKD, kidney transplant recipients (KTR), and healthy children.

Methods A total of seventy-one children diagnosed with CKD and fifty-two healthy children were included in the study. Each patient was examined for dental caries by the decayed-missing-filled-teeth (DMFT/dmft) index and the International Caries Detection and Assessment System (ICDAS-II), developmental defects of enamel (DDE) by the DDE index, and oral hygiene by the debris (DI), calculus (CI), and simplified oral hygiene (OHI-S) indices.

Results The median number of DMFT/dmft was 1.00 (interquartile range (IQR):1.00–4.00) in children with stage 1–3 CKD, 0.00 (*IQR*: 0.00–2.50) in stage 4–5 children, 0.00 (*IQR*: 1.00–3.00) in KTR, and 8.00 (*IQR*: 1.00–13.00) in healthy children. According to ICDAS-II categories, the percentage of children with severe caries was 53.8% in healthy children, while it was 44.4% in KTR, 25.9% in stage 1–3, and 11.4% in stage 4–5 children. While the percentage of children with DDE was 88.8% in KTR, 80% in stage 4–5, and 66.7% in stage 1–3 children, this rate was 44.2% in healthy children. The highest mean OHI-S score was observed in stage 4–5 children (2.10 ± 1.08), followed by KTR (1.46 ± 1.19), stage 1–3 (1.27 ± 0.61), and healthy children (0.45 ± 0.44), respectively.

Conclusions Compared to healthy children, children with CKD had more debris accumulation, calculus formation, and more DDE but a lower severity of dental caries.

Keywords Chronic kidney disease · Oral health · Dental caries · Oral hygiene · Kidney transplantation · Developmental defects of enamel

Introduction

Chronic kidney disease (CKD) is defined as irreversible kidney damage that can progress to kidney failure [1]. CKD, which threatens to become a real epidemic due to its increasing incidence and prevalence in recent years, is a clinical syndrome characterized by a gradual decline in kidney function over time [2, 3]. The reported prevalence of pediatric CKD ranges from 15 to 74.7 per million of the age-related population worldwide [4].

Children and adolescents diagnosed with CKD have an average life expectancy of 38 years if treated with dialysis and 63 years if treated with kidney transplantation [5]. Given the increased survival times resulting from advances in the clinical management of kidney failure, various oral symptoms related to oral hygiene habits, nutritional and environmental factors, and disease and its treatment can be expected to be observed in patients with CKD [6]. These findings observed in patients with CKD include craniofacial growth distortions, bone fractures, and bone tumors secondary to severe hyperparathyroidism; inflammation of the soft

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tissues such as gingivitis and periodontitis due to increased debris and dental plaque accumulation and dental calculus formation; gingival hyperplasia secondary to medication therapy with cyclosporine and/or calcium channel blockers; halitosis caused by the hydrolysis of urea to ammonia; xerostomia due to hyposalivation; developmental defects of enamel (DDE) resulting from deterioration of calcification; tooth discoloration caused by DDE, dietary sources, and/or medication usage; and *Candida* infections and dysgeusia due to decreased salivary flow [6–13].

Considering the high prevalence of CKD in the population, dentists are highly likely to encounter patients with CKD. In addition, it is very important for medical professionals to be aware of the oral findings of CKD in the clinical management and follow-up periods. Poor oral health can lead to a negative impact on both quality of life and systemic health through complications such as poor aesthetics, pain, swelling, infection, and sepsis [14]. In addition, oral health is an important issue for medical professionals due to the fact that CKD is a progressive disease, and advanced-stage CKD patients are candidates for transplantation, and that oral health problems can cause various complications before and after transplantation, especially secondary infections. Also, given the fact that changes in mineral metabolism affect oral health, increasing awareness of the effects of CKD on oral diseases such as dental caries, DDE, debris accumulation, and calculus formation will increase the quality of life of these patients and the effectiveness of multidisciplinary diagnosis and treatment approaches. Therefore, the aim of the study was to investigate the oral health status of children at different stages of CKD, kidney transplant recipients (KTR), and a group of healthy children.

Methods

Ethical approval

This clinical and cross-sectional study was approved by the Marmara University School of Medicine Clinical Research Ethical Committee (with protocol number: 09.2021.290), and written informed consent forms were obtained from parents and/or caregivers. The study was conducted within the ethical principles of the Helsinki Declaration.

Study population

A total of seventy-one children between 4 and 17 years old, diagnosed with CKD and KTR under follow-up in the Pediatric Nephrology Clinic, Department of Pediatrics, Istanbul Pendik Education and Research Hospital, School of Medicine, Marmara University, were non-randomly selected to be included in the study. Fifty-two children between 4 and 17 years old who applied to the Pediatric Dentistry Clinic, Department of Pediatric Dentistry, School of Dentistry, Marmara University, in the same period, who did not have any systemic disease or did not use medication, were non-randomly selected to participate. CKD is classified into five stages according to the National Kidney Foundation guidelines [15]. According to these guidelines, glomerular filtration rate (GFR) $\geq$ 90 ml/min/1.73 m^2 is defined as stage 1, between 60 and 89 ml/min/1.73 m^2 as stage 2, 30–59 ml/min/1.73 m^2 as stage 3, 15–29 ml/min/1.73 m^2 as stage 4, and < 15 ml/min/1.73 m^2 as stage 5 CKD [15]. Estimated GFR is calculated from the patient's height and plasma creatinine using the original Schwartz formula [16] as follows: eGFR (mL/min/1.73 m^2) = k (height in cm)/serum creatinine in mol/L, where the constant k varies with age and sex ($k = 0.45$ for < 1 year old children, $k = 0.55$ for children from 1 to 12 years old, and $k = 0.55$ for females and $k = 0.7$ for males > 12 years old) [16]. For this study, we divided the patients into three subgroups: stage 1–3 CKD patients, stage 4–5 CKD patients [17, 18], and KTR. All patients in the KTR subgroup with stage 5 CKD before transplantation were selected from patients with at least a 6-month post-transplantation period.

Clinical data

The demographic and health-related information of patients, including age and sex, the stage of CKD, the presence of regular dental visits, and any other comorbid conditions, were recorded from the medical files and parents' replies. Comorbid conditions included diabetes, hypertension, hyperlipidemia, cardiovascular diseases (heart failure, left ventricular hypertrophy, ischemic heart disease, and peripheral vascular disease), smoking, obesity, and malnutrition [19, 20].

Patients' height and weight were measured with a standardized Health-O-Meter (HY-RGZ160 Weight & Height Measuring Scale, China), and the body mass index (BMI) was calculated by dividing body weight (kg) by height squared (m^2). In children, BMI varies with age; hence, BMI results are compared to age- and sex-specific benchmarks. For children and adolescents aged between 2 and 19, BMI was plotted on the sex-specific Centers for Disease Control and Prevention (CDC) growth chart to identify the BMI for age percentile [21]. Since none of the patients were classified as obese according to the BMI results, the patients were assigned to 3 groups: underweight, normal, and overweight.

Intraoral examination

Intraoral examination was performed by two different pediatric dentists. Ten patients were re-examined 1 week after the initial examination for calibration of the examiners.

Reproducible measurements and inter-examiner calibration were evaluated with the interclass correlation coefficient (ICC).

The visual diagnosis in the dental examination was conducted with a standard smooth-surface mouth mirror (#5), tactile inspection with a standard dental probe (PCP11), and periodontal examination with a standard periodontal probe with a milimeter scale (PCPUNC15).

Dental caries

Dental caries were assessed using two validated indices: the decayed-missing-filled-teeth (DMFT/dmft) index and the International Caries Detection and Assessment System (ICDAS-II) criteria. With the DMFT/dmft index, which is approved by the World Health Organization (WHO), the number of decayed (D/d), missing (M/m) due to caries, and filled (F/f) teeth is determined [22]. ICDAS-II criteria are used to evaluate the activity and severity of existing caries [23]. As a result of the evaluation made according to ICDAS-II criteria, children were divided into four groups: healthy, initial, moderate, and severe [24].

Developmental defects of enamel

The DDE index recommended by the Federation Dental International (FDI) [25] was used for the diagnosis and assessment of DDE. The presence of demarcated and diffuse opacities and hypoplasia was evaluated with visual and tactile intraoral examination. The individual was considered to have DDE in the presence of at least one tooth affected by DDE. According to the DDE index, teeth with extensive dental caries were excluded from evaluation [26].

Oral hygiene

The simplified oral hygiene index (OHI-S) was used in the evaluation of oral hygiene and the amount of dental plaque and dental calculus. This index, approved and recommended by the WHO, consists of two subindices [22]. These are the debris index (DI) and the calculus index (CI). For each individual, the number of debris and calculus codes on the reference teeth's buccal/vestibular and lingual/palatal surfaces is divided by the total number of teeth surfaces examined, and the individual's DI and CI scores are determined. The OHI-S score is obtained by the sum of the DI and CI scores. An increase in the OHI-S score means the worsening of the individual's oral hygiene status [27].

Statistical analyses

The Statistical Package for the Social Sciences (SPSS Version 20.0, IBM Corp., Chicago, IL, USA) was used for all statistical analyses. Categorical data are expressed as number and percentage, whereas numeric data are expressed as mean ± standard deviation (SD), minimum and maximum values, median, and first and third quartiles. The Shapiro–Wilk test was used to assess the normality assumption for the continuous variables.

Results

The inter-examiner agreements had an ICC value of 0.94 in the clinical examination based on DMFT/dmft, DDE, DI, CI, and OHI-S indices and ICDAS-II criteria. There was no statistically significant difference in the ICC value, which was found to be remarkably strong and reliable.

The mean age of the stage 1–3 patients ($n=27$) was 9.2 ± 3.4, the stage 4–5 patients ($n=35$) was 11 ± 2.5, the KTR ($n=9$) was 10.2 ± 2.4, and it was 9.8 ± 2.6 for the healthy children ($n=52$). The mean ages of the subgroups, general characteristics of age, sex, the presence of comorbid conditions, the presence of regular dental visits, and BMI of children with CKD, KTR, and healthy children are presented in Table 1. The duration of the patients in the KTR subgroup after transplantation was 9.4 ± 0.3 months ($min=6.0$, $max=12.0$ months).

Table 2 shows the medians, first and third quartiles, minimum and maximum values, and mean and standard deviation values of the DMFT/dmft, CI, DI, and OHI-S indices used for the assessment of oral health. While the

Table 1 Age, sex, presence of comorbid conditions and regular dental visits, and body mass index of different stages of chronic kidney disease (CKD), kidney transplant recipients (KTR), and healthy children

	Stage 1–3 ($n=27$)	Stage 4–5 ($n=35$)	KTR ($n=9$)	Healthy ($n=52$)
Age (mean ± SD)	9.2 ± 3.4	11 ± 2.5	10.2 ± 2.4	9.8 ± 2.6
Median (Q1–Q3)	9 (7–13)	12 (9–13)	10 (8–12.5)	9 (8–12)
Sex *n* (%)				
Male	16 (59.3)	16 (45.7)	6 (66.7)	30 (57.7)
Female	11 (40.7)	19 (54.3)	3 (33.3)	22 (42.3)
Presence of comorbid conditions *n* (%)				
No	18 (66.7)	27 (77.1)	9 (100)	52 (100)
Yes	9 (33.3)	8 (22.9)	0	0
Regular dental visits *n* (%)				
No	20 (74.1)	23 (65.7)	6 (66.7)	43 (82.7)
Yes	7 (25.9)	12 (34.3)	3 (33.3)	9 (17.3)
BMI *n* (%)				
Underweight	14 (51.9)	22 (62.9)	3 (33.3)	24 (46.2)
Normal	7 (25.9)	9 (25.7)	5 (55.6)	24 (46.2)
Overweight	6 (22.2)	4 (11.4)	1 (11.1)	4 (7.7)

n, number; *SD*, standard deviation; *min*, minimum; *max*, maximum; *KTR*, kidney transplant recipients; *BMI*, body mass index

Table 2 DMFT/dmft and debris, calculus, and simplified oral hygiene indices scores in different stages of chronic kidney disease (CKD), kidney transplant recipients (KTR), and healthy children

	Stage 1–3 ($n=27$)		Stage 4–5 ($n=35$)		KTR ($n=9$)		Healthy ($n=52$)	
	Median (Q1–Q3)	*Mean ± SD (min–max)*	*Median (Q1-Q3)*	*Mean ± SD (min–max)*	*Median (Q1-Q3)*	*Mean ± SD (min–max)*	*Median (Q1-Q3)*	*Mean ± SD (min–max)*
DMFT/dmft	1.00 (1.00–4.00)	(0.00–11.00)	0.00 (0.00–2.50)	(0.00–6.00)	0.00 (1.00–3.00)	(0.00–8.00)	8.00 (1.00–13.00)	(0.00–20.00)
DI	1.00 (0.00–4.00)	1.00 ± 0.47 (0.00–1.66)	1.33 (1.00–1.83)	1.36 ± 0.57 (0.00–2.33)	1.16 (0.17–1.33)	0.89 ± 0.64 (0.00–1.83)	0.33 (0.00–0.66)	0.43 ± 0.41 (0.00–1.66)
CI	0.16 (0.00–0.66)	0.27 ± 0.30 (0.00–0.83)	0.66 (0.16–1.33)	0.74 ± 0.61 (0.00–1.84)	0.33 (0.00–1.25)	0.57 ± 0.69 (0.00–1.66)	0.00 (0.00–0.00)	0.03 ± 0.08 (0.00–0.33)
OHI-S	0.16 (0.00–0.66)	1.27 ± 0.61 (0.00–2.16)	1.83 (1.33–3.00)	2.10 ± 1.08 (0.00–4.00)	1.16 (0.50–2.49)	1.46 ± 1.19 (0.00-–3.49)	0.33 (0.00–0.66)	0.45 ± 0.44 (0.00–1.66)

n, number; *min*, minimum; *max*, maximum; *Q*, quartile; *SD*, standard deviation; *KTR*, kidney transplant recipients; *DMFT/dmft*, decayed-missing-filled-teeth; *DI*, debris index; *CI*, calculus Index; *OHI-S*, simplified oral hygiene index

median value of the DMFT/dmft index was 1.00 in stage 1–3 patients ($min=0.00$, $max=11.00$), it was 0.00 in stage 4–5 patients ($min=0.00$, $max=6.00$), 0.00 in KTR ($min=0.00$, $max=8.00$), and 8.00 in healthy children ($min=0.00$, $max=20.00$). The mean DI score of patients with stage 1–3 CKD was 1.00 ± 0.47 (median = 1.00, $min=0.00$, $max=1.66$); it was 1.36 ± 0.57 (median = 1.33, $min=0.00$, $max=2.33$) in stage 4–5 patients, 0.89 ± 0.64 (median = 1.16, $min=0.00$, $max=1.83$) in KTR, and 0.43 ± 0.41 (median = 0.33, $min=0.00$, $max=1.66$) in healthy children. In the stage 1–3 subgroup, the mean CI score was 0.27 ± 0.30 (median = 0.16, $min=0.00$, $max=0.83$); it was 0.74 ± 0.61 (median = 0.66, $min=0.00$, $max=1.84$) in stage 4–5 patients, 0.57 ± 0.69 (median = 0.33, $min=0.00$, $max=1.66$) in KTR, and the healthy children had a mean CI score of 0.03 ± 0.08 (median = 0.00, $min=0.00$, $max=0.33$). When the OHI-S scores of the subgroups were examined, it was observed that while the mean score of children with stage 1–3 CKD was 1.27 ± 0.61 (median = 0.16, $min=0.00$, $max=2.16$), in stage 4–5, it was 2.10 ± 1.08 (median = 1.83, $min=0.00$, $max=4.00$), in KTR it was 1.46 ± 1.19 (median = 1.16, $min=0.00$, $max=3.49$), and in healthy children it was 0.45 ± 0.44 (median = 0.33, $min=0.00$, $max=1.66$). Figure 1 shows the interquartile range and minimum, maximum, and median values of DMFT/dmft, CI, DI, and OHI-S indices scores in stage 1–3, stage 4–5, KTR, and healthy subgroups.

The percentage distribution of participants according to ICDAS-II and DDE categories in all subgroups is shown in Fig. 2. According to ICDAS-II categories, healthy teeth were found in 42.9% of stage 4–5 patients, 33.3% of KTR, and 18.5% of stage 1–3 patients, with the lowest percentage of caries-free teeth in healthy children at 9.6%. According to the activity and severity of caries, 11.4% of stage 4–5 patients were in the severe group, while this rate was 25.9% in stage 1–3 patients, 44.4% in KTR, and 53.8% in healthy children. Hypoplasia was not observed in any of the children included in the study. For this reason, DDE categories were divided into three groups as diffuse and demarcated opacities and healthy. DDE were not observed in 33.3% of the patients in stage 1–3 CKD, patients with demarcated opacities constituted 59.3% of the group, and patients with diffuse opacities constituted 7.4% of the group. DDE were not observed in 20% of stage 4–5 patients, while demarcated opacities were observed in 62.9% and diffuse opacities in 17.1%. While the percentage of individuals with dentition without DDE in KTR was 11.1%, diffuse and demarcated opacities were observed in 44.4% and 44.4%, respectively. Dentition without DDE was observed in 55.8% of the children in the healthy group, diffuse opacities were observed in 1.9%, and demarcated opacities were observed in 42.3%.

Intraoral photographs taken from the participants included in the study are shown in Fig. 3. An 11-year-old patient in stage 4–5 CKD had an increase in debris and calculus accumulation and, consequently, an increase in DI, CI, and OHI-S indices scores (a), while no debris and calculus accumulation were observed in a healthy 11-year-old child (b). While no caries were observed in the teeth of a 6-year-old child in stage 1–3 CKD (c), cavitated and severe caries and a missing tooth due to caries were observed in the teeth of her healthy peer (d). A 9-year-old child in stage 4–5 CKD had DDE in the form of white/creamy demarcated opacity in the right upper permanent central incisor (e), while no DDE was observed in the healthy 9-year-old child (f).

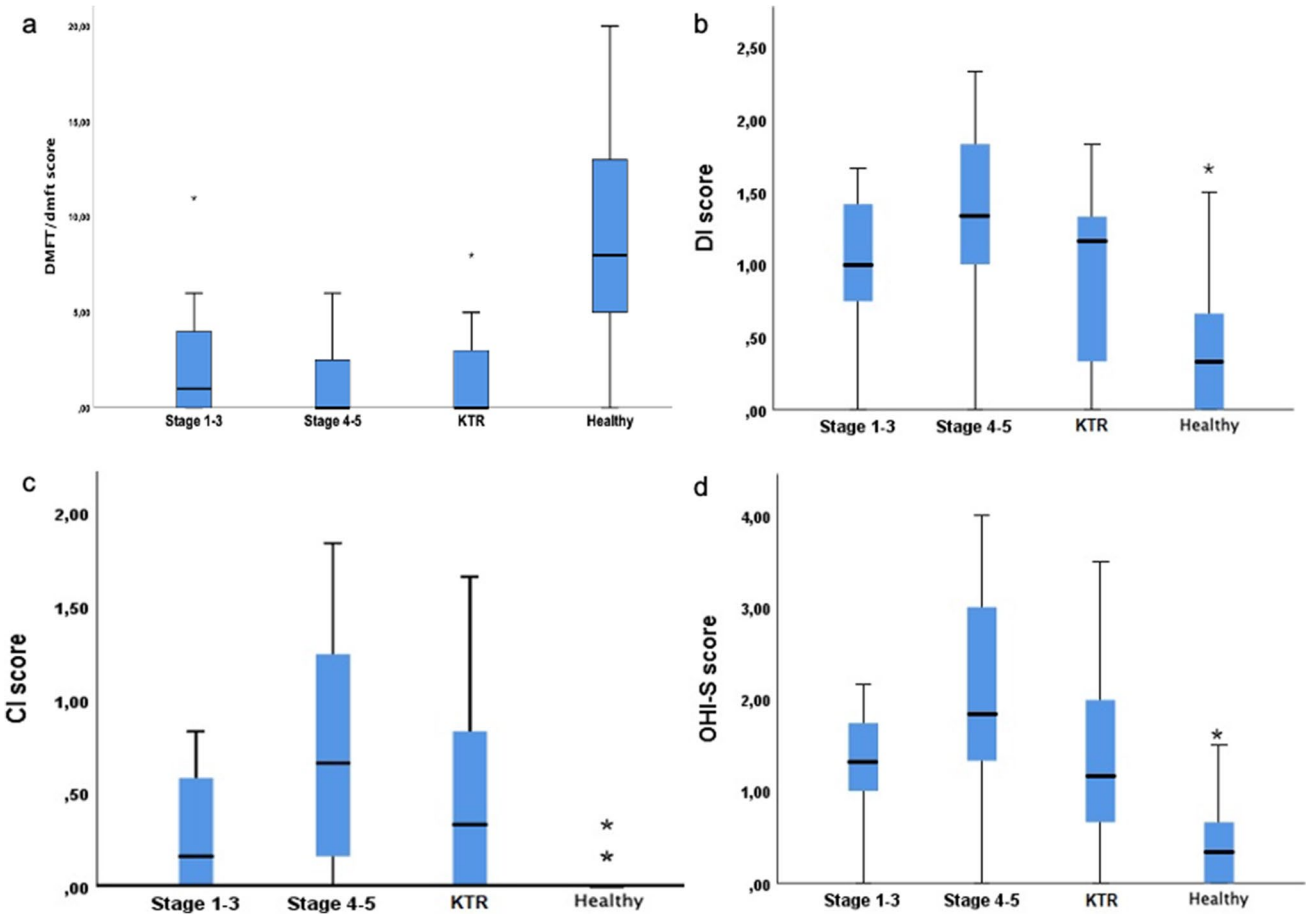

Fig. 1 Decayed-missing-filled-teeth (**a**), debris (**b**), calculus (**c**), and simplified oral hygiene (**d**) indices scores in children stage 1–3 chronic kidney disease, stage 4–5 chronic kidney disease, kidney transplant recipients, and healthy children. (The interquartile range is represented by the box, the greatest and lowest values are represented by the whiskers, the median is represented by the horizontal bold line in the box, and outliers are represented by asterisks. DMFT/dmft, decayed-missing-filled-teeth index; DI, debris index; CI, calculus index; OHI-S, simplified oral hygiene index; KTR, kidney transplant recipients)

Discussion

Children with CKD may have different findings and symptoms in soft and hard oral tissues compared to their healthy peers [6]. Although there are studies evaluating the oral health of patients with CKD in the scientific literature [9, 11, 28–35], to the best of our knowledge, there is no study that grouped children with CKD according to the stages of the disease and also included KTR and healthy children. Therefore, the results of this study should be carefully evaluated as they will help to improve the oral health of children with CKD at different stages. In addition, evaluation of oral health is of particular importance for immune suppressed KTR in terms of preventing systemic infections of dental origin.

Dental caries is a preventable and noncommunicable disease caused by a harmful change in the microbial community of dental biofilms toward an acid-tolerant and acid-producing microbiota with reduced levels of beneficial bacteria [36]. Although children and adolescents with CKD are expected to have more caries due to dry mouth, impaired oral hygiene, and nutritional habits, studies show that fewer caries are observed compared to their healthy peers [9, 28, 29], mostly due to the presence of a large amount of urea in the saliva of patients with CKD, which leads to its ability to neutralize plaque development and antibacterial characteristics [6, 9, 29, 31]. In the current study, it was found that the percentage, severity, and activity of dental caries were higher in healthy children than in stage 1–3 and 4–5 patients and KTR patients. In the studies of Andaloro et al. [9] and Ertuğrul et al. [28], it was found that DMFT scores in children with kidney failure were lower than controls. Although Pakpour et al. [33] reported statistically significantly more caries in hemodialysis patients, Andrade et al. [34] reported that hemodialysis patients had significantly fewer caries. The results of the study conducted by Silva et al. [35] showed that the prevalence of caries was significantly lower in CKD

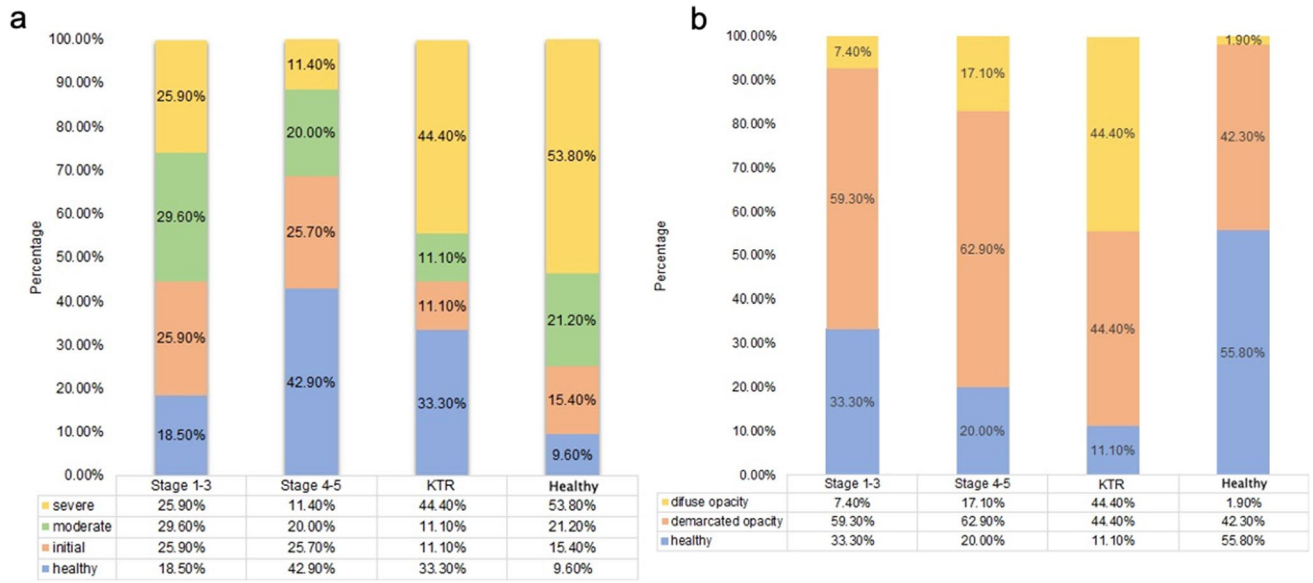

Fig. 2 International Caries Detection and Assessment System (ICDAS-II) (**a**) and developmental defects of enamel (DDE) (**b**) categories in children stage 1–3 chronic kidney disease, stage 4–5 chronic kidney disease, kidney transplant recipients, and healthy children. (KTR, kidney transplant recipients)

Fig. 3 (**a**) High OHI-S score due to extensive debris and calculus accumulation in an 11-year-old stage 4–5 CKD patient. (**b**) OHI-S score of zero due to the absence of debris and calculus accumulation in an 11-year-old healthy child. (**c**) Mandibular teeth of a 6-year-old stage 1–3 CKD patient without dental caries. (**d**) Mandibular teeth of a 6-year-old healthy child with cavitated and extensive caries and a missing tooth due to dental caries. (**e**) DDE observed as white-creamy demarcated opacity in the right upper permanent central incisor of a 9-year-old stage 4–5 CKD patient. (**f**) Teeth of a 9-year-old healthy child without DDE. (OHI-S, simplified oral hygiene index; DDE, developmental defects of enamel)

patients. In the study by Tadakamadla et al. [32], in which they evaluated the oral health status of adult CKD patients at different stages, the DMFT scores of the controls were found to be higher than those of patients with CKD at different stages.

Developmental defects of enamel are defined as quantitative or qualitative changes in the structure of enamel as a result of deterioration during enamel formation [29, 37]. DDE, which may present as demarcated or diffuse opacities and hypoplasia, is often associated with early chronic kidney failure [6, 10, 29]. Numerous metabolic or pathophysiological changes associated with CKD and its treatment have an effect on the formation, development, and calcification of teeth, and studies have reported that DDE is observed more in CKD patients than their healthy peers [9, 28, 29, 38, 39]. The etiology of DDE in patients with CKD has been suggested to result from the deterioration of calcification due to hypocalcemia, reduced serum 1,25-dihydroxycholecalciferol levels, and increased serum phosphate, parathormone, and fluoride levels [13]. In the current study, it was observed that the percentage of DDE in stage 1–3 and 4–5 patients and KTR was higher than healthy children. Similarly, in their studies, Al-Nowaiser et al. [40] and Caliento et al. [41] found the incidence of DDE in CKD patients was higher than in healthy individuals.

Dental calculus is formed as a result of the calcification of dental plaque accumulated on the tooth surface by means of minerals originating from the saliva and/or gingival crevicular fluid [42]. While the detorioration in oral hygiene causes plaque accumulation, the increase in plaque accumulation causes dental calculus formation. The reason why calculus formation is more common in children with CKD than their healthy peers is the increased salivary pH and high salivary urea and phosphate levels, which cause changes in mineral balance [30]. In this study, the mean OHI-S scores of the stage 1–3 and 4–5 patients and KTR were higher than the healthy children. In the study of Tadakamadla et al. [32], it was stated that the DI, CI, and OHI-S scores were significantly increased in the advanced stages of the disease. Similarly, Davidovich et al. [30] evaluated the formation of dental calculus in pre-dialysis, dialysis, and transplanted patients, and significantly, more calculus formation was found in patients with CKD, especially in dialysis patients, compared to the control group. According to the results of several studies on this subject, it has been reported that the oral hygiene scores in patients with CKD are significantly higher than those of healthy children [9, 33–35].

Studies show that saliva pH is more alkaline in patients with different stages of CKD than in KTR [43]. Therefore, the lower alkalinity of saliva can increase the risk of dental caries [43, 44]. In this study, it can be said that OHI-S scores are better in KTR than in stage 4–5 patients, since all dental procedures before transplantation are completed and oral hygiene rules are explained by physicians before and after transplantation.

Chronic kidney disease affects many situations that concern dental caries, DDE, oral hygiene, and plaque and dental calculus formation in a growing child. As the stage of the disease increases, the medications and the distribution of various determinants in body fluids are also affected by this situation. It has been confirmed by the study that children with advanced CKD have more debris and calculus and worse oral hygiene due to the significant effects of CKD and disease-related metabolic and systemic effects in the oral cavity.

The current research presents some limitations of a cross-sectional design, which may not represent all CKD patients and KTR. In addition, another important limitation is the relatively small sample size, and misbalance across all groups limits the ability to interpret the findings. Patients in stage 4–5 CKD at the time of the study may be in stage 1–3 for a long period, and this may affect the validity of the findings, especially since tooth development is completed at an early age. Since the formation of dental caries is affected by nutritional and oral hygiene habits, and socioeconomic background, the fact that these parameters were not evaluated in the study was another limitation. In addition, since interproximal caries may not be observed clinically, radiographs were not taken from the patients in the study, which is a limitation. The OHI-S index is a validated index that is widely used for the assessment of oral hygiene as well as the detection of debris and calculus status. On the other hand, considering that gingival and periodontal health may be worse in patients with CKD than healthy individuals, inflammation and bleeding were not evaluated in the study. The fact that healthy children may have various dental problems due to their application to the pediatric dentistry clinic may create a bias compared to a healthy sample group of the general population. In addition, it is not known how many teeth are affected by DDE in each child included in the study, making it difficult to interpret the severity of DDE and its impact on health. The strong aspects of the study are the use of valid, reliable, practical, and easy-to-use evaluation methods and criteria; being a multidisciplinary study; providing inter-rater reliability; and being a pioneering study that evaluated the oral health status of children at different stages of CKD, KTR, and healthy children together.

Considering the process of the disease and its effects on metabolism, the oral health status of patients with CKD and KTR should be considered a very important issue. The results of the study showed that the majority of patients with different stages of CKD and KTR did not attend regular dental visits. This situation demonstrates the importance of medical professionals referring their patients to the dentist. It is known that the quality of life related to health and oral health is low in patients with CKD, especially in advanced

stages [45]. While quality of life can be affected by oral health, the poor aesthetic appearance due to DDE, especially in the anterior teeth, also negatively affects quality of life [46]. At this point, improvements and preventive approaches in dental care, within a multidisciplinary team including dental, medical, and psychological staff, will improve the quality of life of individuals affected by CKD [35, 45, 47]. Therefore, we believe that there is a need for new and comprehensive studies that will evaluate different parameters with different indices in larger sample groups of patients with CKD.

Supplementary Information The online version contains a graphical abstract available at https://doi.org/10.1007/s00467-022-05590-6.

Author contribution Study conception and design: SB, AH, and KB. Acquisition of data: SB, KR, KDN, GS, and YN. Analysis and interpretation of data: SB and SD. Drafting of manuscript: SB. Critical revision: SB, SD, GS, YN, AH, and KB.

Declarations

Ethics approval The present study was approved by the Marmara University School of Medicine Clinical Research Ethical Committee (with protocol number: 09.2021.290). The study was carried out within the ethical principles of the Declaration of Helsinki.

Consent to participate Before starting the study, the patients' parents or caregivers were informed about the study and signed informed consent forms.

Conflict of interest The authors declare no competing interests.

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