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Original Article

Clinical characteristics and factors associated with dentition defects in patients with diabetes mellitus and concomitant endodontic disease

Xuetao Deng, Min Min, Yuping Cai

Laboratory of Dental Biomaterials and Tissue Regeneration, Shanghai Xuhui District Stomatological Hospital, Shanghai 200032, China

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Abstract: Objective: This study focused on patients with endodontic disease (ED) and diabetes mellitus (DM), and analyzed the predisposing factors of dental defects, so as to provide a new reference for the management of dental complications in DM-related oral patients. Methods: In this regression analysis, we included 178 ED patients admitted to Shanghai Xuhui District Stomatological Hospital from January 2022 to June 2024, including 54 with ED alone (ED group) and 124 with ED concurrent with DM (ED+DM group). We collected the clinical data and laboratory indexes, periodontal indices, endodontic disease characteristics and laboratory findings (glycated hemoglobin [HbA1c], fasting plasma glucose [FPG]). We compared the differences in data between the DM group and ED+DM group, and further logistic regression analysis was used for the indicators with differences. Results: First, by univariate analysis, we found that compared with the ED group, the DM+ED group reported less intense spontaneous and nocturnal pain ($P<0.05$) but experienced prolonged pain from thermal stimuli ($P<0.05$). In addition, ED+DM patients also had a higher prevalence of root canal calcification and higher postoperative VAS score. ($P<0.05$). Independent risk factors for dentition defects identified through multivariate analysis were HbA1c, FPG, diabetes duration, and probing depth (PD) ≥4 mm ($P<0.05$). Conclusion: Poor blood glucose control, progression of periodontal inflammation, and different types of diabetes were independent influencing factors for dentition defects in the DM+ED group.

Keywords: Type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM), ED, dentition defects, glycemic control

Introduction

Diabetes mellitus (DM) is one of the most common chronic diseases worldwide [1, 2]. DM can cause a variety of organ diseases, among which oral disease is a very common one [3]. Hyperglycemia compromises oral environmental homeostasis through oxidative stress, immune cell dysfunction, and microvascular injury; on the one hand, weakened leukocyte chemotaxis and phagocytosis render the dental pulp more prone to infection [4]; on the other hand, abnormal collagen metabolism and accelerated bone absorption may lead to the weakening of alveolar bone support, creating conditions favorable for dentition defects [5]. Endodontic diseases (ED) and dentition defects have become key clinical concerns as they directly affect chewing function and the patient's overall well-being [6]. However, there are few studies on patients with DM concurrent with ED.

Currently, limited small-scale observational studies note that DM patients with ED often show subtle symptoms (e.g., mild spontaneous, atypical nocturnal pain) and present technical challenges such as calcified canals or overfilling risks during treatment [7]. However, the relationship of DM duration, glycemic control status (e.g., glycated hemoglobin [HbA1c]) [8-10], and periodontal complications is still unclear.

In this study, we investigated a correlation between DM and ED and dentition defects, so as to provide new reference and guidance for the overall prevention and control of DM-related oral complications. The insights facilitate the early detection of high-risk individuals by clarifying the specific manifestations of ED second-

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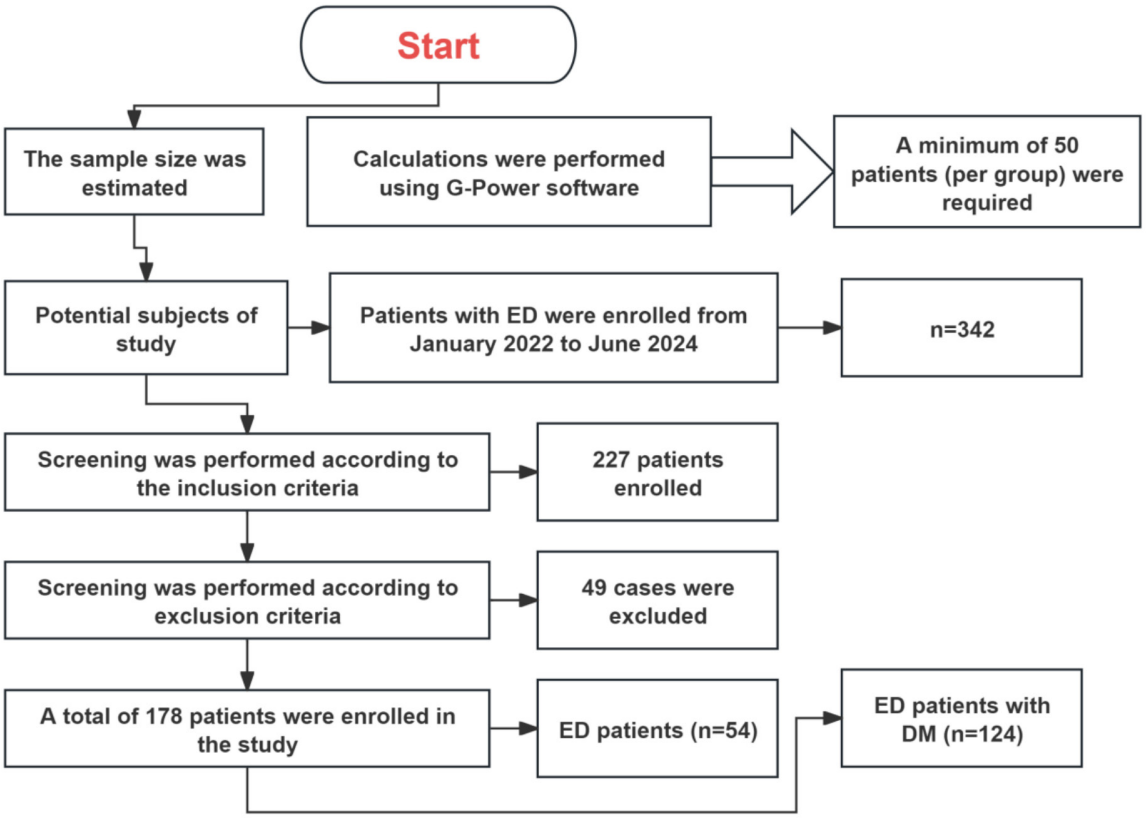

Figure 1. Screening process of study subjects. Note: ED: Endodontic Disease, DM: Diabetes Mellitus.

ary to DM, while also allowing for the optimization of root canal therapy plans. Additionally, they help elucidate how metabolic indicators predict dentition defects, providing an evidence-based rationale for tailored oral health intervention.

Materials and methods

Research participants

In this retrospective analysis, we included 178 ED patients who were diagnosed between January 2022 and June 2024, including 54 patients with ED alone (ED group) and 124 patients with DM and ED (ED+DM group). Based on previous studies [11], we presumed that key predictors of dentition defects (e.g., HbA1c, DM duration) had an effect size odds ratio (OR) of approximately 1.5-2.0. A power analysis performed with G*Power 3.1 (α=0.05, two-tailed; power =0.80) indicated a need for 50 participants per group. Accounting for a potential 10% loss to follow-up, we finalized the sample at 171 cases, which was sufficient for statistical analysis of the primary outcome (dentition defects). This study was approved by the Ethics Committee of Shanghai Xuhui District Stomatological Hospital, and the requirement for informed consent was waived given the retrospective approach. **Figure 1** illustrates the main flow of screening subjects for this study.

Patient selection criteria

Inclusion criteria: meeting the diagnostic guidelines for DM (fasting plasma glucose [FPG] ≥7.0 mmol/L, random plasma glucose ≥11.1 mmol/L, or HbA1c ≥6.5%) [12]; symptomatic pulpitis (spontaneous, nocturnal, or persistent thermal pain) or periapical periodontitis (pain on chewing/percussion or periapical radiolucency) [13], confirmed by oral examination and cone beam computed tomography (CBCT)/magnetic resonance imaging (MRI); ≥18 years old, with clear consciousness. Exclusion criteria: serious systemic diseases (e.g., malignancy, end-stage renal disease, blood system diseases); pregnant/lactating women; psychiatric conditions or cognitive impairment precluding cooperation; any endodontic treatment (root canal treatment, pulpotomy) or tooth extraction

within the preceding 3 months; maxillofacial trauma or post-tumor resection resulting in dentition defects.

Patient data collection

Baseline patient data retrieved included age, gender, body mass index (BMI), education level, and DM course. Periodontal data included modified plaque index (PLI), the simplified Oral Hygiene Index (OHI-S), full-mouth PD (mm), attachment loss (AL, mm), and the percentage of sites positive for bleeding on probing (BOP%). Endodontic presentations monitored spontaneous pain (no/mild/severe), nociceptive pain (no/yes), pain on thermal stimulation (none/transient/persistent), root canal calcification rate (percentage of calcified canals per total affected teeth %) detected by CBCT, and abnormal pulp chamber morphology (normal/constricted/obliterated). Laboratory indices encompassed FPG and HbA1c.

Treatment

All patients with dentition defects were treated by the same dentist in Shanghai Xuhui District Stomatological Hospital. Follow-ups were conducted regularly over one year, and the repair success rate was assessed at the last visit.

Quality control

Data were collected independently by two uniformly trained dentists. Measurements were conducted using standardized scales (e.g., PLI, OHI-S) and instruments (e.g., periodontal probes, CBCT machine). A double-entry protocol was implemented in EpiData 3.1.

Statistical methods

Data were processed by SPSS 30.0. The comparison of counted data [n(%)] employed the χ^2 test or Fisher's exact test. Measured data with a normal distribution were presented as ($\bar{x}\pm s$), with comparisons conducted using independent samples t-tests; the Mann-Whitney U test was used for non-parametric data shown as [M(P25, P75)]. To determine influencing factors, logistic regression analysis was applied. A $P<0.05$ indicated statistical significance.

Results

Clinical characteristics of ED in DM

Compared to the ED group, the DM+ED group reported less severe spontaneous and nocturnal pain ($P<0.05$), yet demonstrated prolonged pain duration in response to thermal stimuli ($P<0.05$). In addition, the DM+ED group also presented with higher root canal calcification and pulp chamber constriction rates, together with an increased complexity score for root canal treatment ($P<0.05$). Moreover, the DM+ED group showed higher VAS scores on postoperative day 7 ($P<0.05$), suggesting greater difficulties in controlling inflammation (**Table 1**).

Univariate predictors of dentition defects

After statistics, we found that 53 patients had dentition defects. These patients demonstrated notably elevated HbA1c and FPG levels, as well as a longer DM course, compared to participants without dentition defects ($P<0.05$). Findings from oral assessments indicated greater values for PD and OHI-S among patients with dentition defects ($P<0.05$) (**Table 2**).

Multivariate determinants of dentition defects

The single-factor indicators from the above analysis were assigned (**Table 3**), and a forward logistic regression (LR) analysis was performed with dentition defects as the independent variable. The output results indicated that OHI-S did not significantly influence dentition defects ($P>0.05$). However, HbA1c, DM duration, PD, and FPG were significant independent determinants of dentition defects among DM patients with concurrent ED ($P<0.05$). PD had the most significant effect (**Table 4**).

Risk prediction model for dentition defects

Subsequently, based on the results of the regression analysis, we established a risk prediction model for dentition defects (excluding OHI-S), and obtained the joint formula =-17.925+0.338×DM duration+1.511×HbA1c+0.173×FPG+PD×1.521. Through the ROC curve, it can be seen that the predictive efficacy of this model for dentition defects was 78.87% and 84.91% respectively (AUC=0.881, $P<0.001$), which has good clinical reference value (**Figure 2**).

Differential effects of DM types on ED and dentition defects

Further subgroup analysis showed a greater proportion of T1DM individuals reporting thermal sensitivity relative to their T2DM counterparts ($P<0.05$). This suggested a higher susceptibility to autonomic neuropathy and conse-

Table 1. Differences in clinical characteristics between the ED group and DM+ED group

Item	ED (n=54)	DM+ED (n=124)	Statistics values (t or χ^2)	*P* values
Age	65.76±5.21	65.81±6.01	0.050	0.960
Sex			0.199	0.656
male	35 (64.81)	76 (61.29)		
female	19 (35.19)	48 (38.71)		
Spontaneous pain			6.699	0.035
no	6 (11.11)	10 (8.06)		
mild	28 (51.85)	42 (33.87)		
severe	20 (37.04)	72 (58.06)		
Pain at night			4.223	0.040
no	18 (33.33)	62 (50.00)		
yes	36 (66.67)	62 (50.00)		
Cold and heat stimulation pain			8.181	0.017
no	12 (22.22)	10 (8.06)		
briefly	34 (62.96)	82 (66.13)		
continuous	8 (14.81)	32 (25.81)		
Root canal calcification			4.348	0.037
no	20 (37.04)	67 (54.03)		
yes	34 (62.96)	57 (45.97)		
Morphology of medullary cavity			6.070	0.048
normal	18 (33.33)	21 (16.94)		
coarctation	26 (48.15)	78 (62.90)		
closed	10 (18.52)	25 (20.16)		
Classification of Weine			6.156	0.013
I-II	34 (62.96)	53 (42.74)		
III-IV	20 (37.04)	71 (57.26)		
VAS				
Before surgery	6.20±2.15	6.48±2.12	0.808	0.420
7 days after surgery	3.13±1.24	3.94±1.64	3.252	0.001

Note: ED: Endodontic Disease, DM: Diabetes Mellitus, VAS: Visual Analogue Scale.

quent lowering of sensory thresholds in T1DM. Secondly, FPG in T2DM patients was higher than that of T1DM patients (P<0.05). This implied that sustained hyperglycemia in T2DM may exert more pronounced chronic detrimental effects on the alveolar bone (**Table 5**).

The effect of DM type on the prognosis progression of dentition defects

Finally, the dynamic changes in the prognostic dentition defects of the patients were counted. The results showed that different DM types had no effect on the success rate of denture restoration and the loss of new dentition defect (P>0.05). Regarding treatment response, the T1DM group demonstrated a greater rate of periapical radiolucency resolution one month after root canal treatment compared to the T2DM group (P<0.05). This difference may be attributed to the more intense inflammatory response, yet better metabolic regulation in T1DM (**Table 6**).

Discussion

We found that DM patients with concomitant ED displayed some specific manifestations, including occult symptoms (e.g., low scores for spontaneous and nocturnal pain, but prolonged duration of pain upon thermal stimuli) and complex root canal treatment (e.g., a high canal calcification incidence and notable post-operative pain). Multivariate analysis identified HbA1c, duration of DM, PD, and FPG as independent determinants for dentition defects. Analysis of disease type interactions further revealed that chronic hyperglycemia in T2DM was correlated

Table 2. Univariate analysis affecting dentition defects in DM+ED group

Item	No defect (n=53)	Defect (n=71)	Statistics values (t or χ^2)	*P* values
Age	65.30±4.96	66.18±6.69	0.807	0.421
Sex			0.306	0.580
male	31 (58.49)	45 (63.38)		
female	22 (41.51)	26 (36.62)		
Duration of DM (years)	8.13±1.87	8.85±1.95	2.047	0.043
HbA1c (%)	7.41±0.73	8.60±1.28	6.026	<0.001
FPG (mmol/L)	13.54±4.47	16.07±4.65	3.047	0.003
Types of DM			0.036	0.849
T1DM	5 (9.43)	7 (9.86)		
T2DM	48 (90.57)	64 (90.14)		
Level of education			0.218	0.897
primary school and below	16 (30.19)	20 (28.17)		
middle school	30 (56.60)	43 (60.56)		
university and above	7 (13.21)	8 (11.27)		
PD (mm)			9.210	0.002
<4	34 (64.15)	26 (36.62)		
≥4	19 (35.85)	45 (63.38)		
OHI-S	1.23±1.12	1.61±0.93	2.054	0.042
Smoking			0.196	0.658
no	24 (45.28)	35 (49.30)		
yes	29 (54.72)	36 (50.70)		
Drinking			0.456	0.514
no	15 (28.30)	24 (33.80)		
yes	38 (71.70)	47 (66.20)		

Note: ED: Endodontic Disease, DM: Diabetes Mellitus, T1DM: Type 1 Diabetes Mellitus, T2DM: Type 2 Diabetes Mellitus, HbA1c: Glycated Hemoglobin, FPG: Fasting Plasma Glucose, PD: Probing Depth, OHI-S: Simplified Oral Hygiene Index.

Table 3. Assignment table

Item	Assignment of value
Dentition defects	No defect =1, Defect =2
HbA1c, DM duration, FPG, OHI-S	Using raw data
PD	<4=1, ≥4=2

Note: HbA1c: Glycated Hemoglobin, FPG: Fasting Plasma Glucose, DM: Diabetes Mellitus, PD: Probing Depth, OHI-S: Simplified Oral Hygiene Index.

with exacerbated alveolar bone loss. Additionally, the results of subgroup analysis showed that long-term hyperglycemia caused more significant destruction of alveolar bone in T2DM patients, while the regression rate of a periapical shadow was higher in T1DM patients after treatment.

The conventional understanding posits DM peripheral neuropathy (DPN) as the core mechanism for paresthesia, characterized by oxidative stress-induced dorsal root ganglion (DRG) neuronal injury and diminished pain sensitivity [14, 15]. However, in this study, the increased thermal pain sensitivity in T1DM patients versus their T2DM counterparts implied a potentially more pivotal involvement of autonomic neuropathy. Literature has shown that metabolic dysregulation from β-cell destruction in T1DM readily causes an imbalance between the sympathetic and parasympathetic nervous systems, affecting pulp vasomotor function and pain signal transduction [16]. For T2DM, persistent insulin resistance is thought to promote central sensitization (e.g., via JNK/SAPK), which may partly offset peripheral nociceptive blunting [17]. Thus, differences in DM dental pain perception may be attributed to these divergent neuropathic pathways. According to Gao and colleagues, the extent of nerve damage increases with the duration of the disease [18]. Long-term high HbA1c levels are

Table 4. Multivariate analysis of factors affecting dentition defects in DM+ED group

Item	B	S.E	OR	95% CI	Wald χ^2	P
DM duration	0.343	1.136	1.409	1.079-1.839	6.335	0.012
HbA1c	1.478	0.301	4.383	2.431-7.903	24.136	<0.001
FPG	0.176	0.059	1.193	1.062-1.340	8.853	0.003
PD	1.509	0.508	4.522	1.670-12.243	8.186	0.003
OHI-S	0.191	0.248	1.210	0.744-1.969	0.590	0.442

Note: HbA1c: Glycated Hemoglobin, FPG: Fasting Plasma Glucose, DM: Diabetes Mellitus, PD: Probing Depth, OHI-S: Simplified Oral Hygiene Index, B: Regression Coefficient, SE: Standard Error, OR: Odds Ratio, CI: Confidence interval.

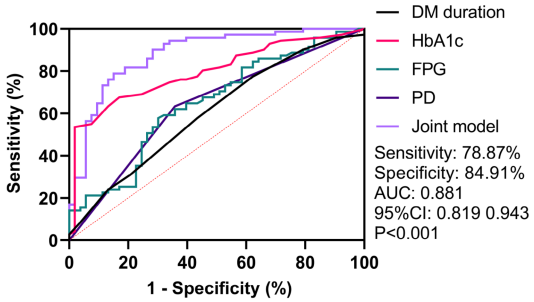

Figure 2. Establishing a risk prediction model based on the risk factors of dentition defects. The prediction sensitivity and specificity of this model for dentition defects were 78.87% and 84.91% respectively (AUC=0.881). Note: DM: Diabetes Mellitus, HbA1c: Glycated Hemoglobin, FPG: Fasting Plasma Glucose, PD: Probing Depth.

believed to significantly disrupt pulp sensory signaling. The subjective sensation of pulp pain is also subject to psychosocial modulation, such as pain catastrophizing tendencies [19, 20]. In DM individuals, concurrent multimorbidity may also divert attention from localized pain, possibly explaining why certain symptoms remain concealed.

Furthermore, we found higher root canal calcification rates and elevated postoperative VAS scores in DM patients with ED compared to non-DM patients, corroborating earlier work [21]. High glucose promotes diffuse calcification of the root canal wall through odontoblast mineralization mediated by the ERK/MAPK pathway [22], while repeated inflammation further induces osteoclast activation and aggravates periapical bone resorption, forming a vicious cycle [23]. Unlike previous studies [24], this study found a higher periapical radiolucency resolution rate in T1DM patients after root canal therapy. This difference may be due to differential inflammatory regulation between the two types of DM: T1DM's absolute insulin deficiency enables rapid clearance of IL-1β and other inflammatory cytokines [25], while T2DM's chronic hyperinsulinemia potentially amplifies inflammatory responses through NF-κB activation [26]. Thus, the DM type appears more influential on endodontic outcomes than glycemic levels alone. However, due to the small sample size of the T1DM group (n=12), the underlying mechanism needs to be verified by further basic and clinical studies with larger samples.

Subsequently, HbA1c, DM duration, PD, and FPG were shown by multivariate analysis to be independent determinants for dentition defects. We speculate that abnormal bone metabolism caused by the hyperglycemic state is the main factor contributing to this condition. Obesity-associated hyperleptinemia is common in T2DM, where leptin promotes alveolar bone loss vthrough the osteoclastic RANKL pathway activation [27]. In contrast, T1DM is characterized by insulin-deficient suppression of osteoblast activity, worsening the imbalance between bone resorption and formation [28]. Notably, PD≥4 mm had the most significant effect on dentition defects in this study, which could also be expected. PD depth directly reflects the periodontal health status [29, 30]. Not only that, but we have established a risk prediction model for dentition defect based on the risk model. The predictive sensitivity and specificity of this model for dentition defect in patients with DM combined with ED reached 78.87% and 84.91%, respectively, and it has good clinical reference value. At present, there is no effective method for predicting dentition defects in clinical practice [31]. This discovery also provides a new solution for the early assessment of dentition defect in the future. Clinically, by monitoring the course of DM, HbA1c, FPG, and PD in patients with DM combined with ED, the occurrence of dentition defect can be

Table 5. Effect of DM type on dentition defects

Item	T1DM (n=7)	T2DM (n=64)	Statistics values (t or χ^2 or Fisher's exact)	*P* values
Spontaneous pain			0.415	0.813
no	1 (14.29)	5 (7.81)		
mild	3 (42.86)	26 (40.63)		
severe	3 (42.86)	33 (51.56)		
Pain at night			-	0.697
no	3 (42.86)	35 (54.69)		
yes	4 (57.14)	29 (45.31)		
Cold and heat stimulation pain			7.323	0.026
no	0 (0.00)	7 (10.94)		
briefly	2 (28.57)	42 (65.63)		
continuous	5 (71.43)	15 (23.44)		
Root canal calcification			-	0.691
no	4 (57.14)	42 (65.63)		
yes	3 (42.86)	22 (34.38)		
Morphology of medullary cavity			0.139	0.933
normal	1 (14.29)	12 (18.75)		
coarctation	4 (57.14)	37 (57.81)		
closed	2 (28.57)	15 (23.44)		
Classification of Weine			-	>0.999
I-II	3 (42.86)	25 (39.06)		
III-IV	4 (57.14)	39 (60.94)		
Duration of DM (years)	8.00±2.38	8.94±1.90	1.209	0.231
HbA1c (%)	8.33±1.17	8.63±1.30	0.584	0.562
FPG (mmol/L)	22.96±1.45	15.32±4.24	4.715	<0.001
PD (mm)			9.210	0.002
<4	34 (64.15)	26 (36.62)		
≥4	19 (35.85)	45 (63.38)		
OHI-S	1.23±1.12	1.61±0.93	2.054	0.042

Note: DM: Diabetes Mellitus, T1DM: Type 1 Diabetes Mellitus, T2DM: Type 2 Diabetes Mellitus, HbA1c: Glycated Hemoglobin, FPG: Fasting Plasma Glucose, PD: Probing Depth, OHI-S: Simplified Oral Hygiene Index.

Table 6. Effect of DM type on prognosis of patients with dentition defect

Item	T1DM (n=7)	T2DM (n=64)	Fisher's exact	*P* values
The periapical shadow subsided			-	0.041
yes	6 (85.71)	1 (14.29)		
no	26 (40.63)	38 (59.38)		
Restoration of dentures			-	0.618
success	5 (71.43)	52 (81.25)		
failure	2 (28.57)	12 (18.75)		
New dentition defect			-	>0.999
no	6 (85.71)	52 (81.25)		
yes	1 (14.29)	12 (18.75)		

Note: T1DM: Type 1 Diabetes Mellitus, T2DM: Type 2 Diabetes Mellitus.

prevented as early as possible to ensure periodontal health. However, the clinical application effect of this model still needs to be verified and analyzed in large-base clinical cohorts.

Meanwhile, in the future, we can consider adding more clinical indicators to improve this risk model.

Therefore, when managing DM patients with ED, we recommend establishing a collaborative endocrine-dental follow-up mechanism. Treatment planning should be guided by achieving specific benchmarks for HbA1c, PD, and FPG prior to initiating endodontic therapy. However, this study still has the following limitations: (1) The retrospective design using historical records may have led to selection bias, warranting future prospective verification. (2) Another major limitation was the insufficient sample size of subgroups. Only 7 T1DM patients had dentition defects, and the imbalance between subgroups may reduce statistical power. Therefore, findings such as 'T1DM patients had more obvious cold and heat stimulation' and differences in periapical shadow resolution should be interpreted with extreme caution and cannot be generalized to the overall population. (3) Unexamined lifestyle confounders like smoking and diet may also have influenced the results. Further investigations should focus on overcoming these constraints. (4) Although the established risk prediction model exhibited good predictive efficacy, it lacked prospective verification. The clinical promotion and application of this model still need to be further confirmed by large-scale prospective studies.

Conclusion

HbA1c, FPG, duration of DM, and PD≥4 mm were independent risk factors for dentition defect. The risk prediction model based on these related factors showed good predictive efficacy for dentition defect, with a sensitivity of 78.87% and a specificity of 84.91% (AUC= 0.881), which may provide a reference tool for early identification of high-risk patients, though its clinical utility requires further verification through large-sample prospective research.

Disclosure of conflict of interest

None.

Address correspondence to: Xuetao Deng, Laboratory of Dental Biomaterials and Tissue Regeneration, Shanghai Xuhui District Stomatological Hospital, No. 500, Fenglin Road, Xuhui District, Shanghai 200032, China. Tel: +86-021-64037289; E-mail: xuetaodeng@163.com

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