BMC Geriatrics

RESEARCH

Open Access

Analysis of the current status and influencing factors of oral frailty in elderly patients with type 2 diabetes mellitus in Taiyuan, China

Chun Tian[1*†], Na Li[2†], Ya Gao[2] and Yan Yan[2]

Abstract

Background This study aimed to investigate the current status of oral frailty in elderly patients with type 2 diabetes mellitus (T2DM) and analyze its influencing factors.

Methods We recruited 464 elderly T2DM patients from a tertiary hospital in Taiyuan, Shanxi Province (June-October 2024) using convenience sampling. General information questionnaire, Oral Frailty Index-8 (OFI-8), Fatigue, Resistance, Ambulation, Illness and Loss of weight Scale (FRAIL Scale), Oral Health Assessment Tool (OHAT), and Mini-Nutritional Assessment Short Form (MNA-SF) were used to collect data. Binary logistic regression analysis was performed to identify the factors influencing oral frailty.

Results The prevalence of oral frailty was 45.9% among the 464 elderly T2DM patients. Regression analysis identified the following influencing factors ($p < 0.05$): age, smoking history, weekly frequency of physical activity, duration of diabetes mellitus, polypharmacy, frailty, and oral health score.

Conclusions Oral frailty is highly prevalent in elderly T2DM patients. Clinical staff should screen this population for oral frailty early and develop a comprehensive, integrated oral health care program to prevent or delay its onset and progression.

Clinical trial number not applicable.

Keywords Oral frailty, Type 2 diabetes mellitus, Elderly, Influencing factors

Introduction

Oral frailty [1] refers to the natural reduction in the number of natural teeth, the deterioration of oral function, the decline in oral hygiene, and the decreased attention to oral health with increasing age, ultimately leading to eating dysfunction and overall physical and mental functional decline. As an effective predictor of adverse health outcomes such as falls, sarcopenia, cognitive impairment, and frailty [2–4], oral frailty holds significant public health importance. However, current research on oral frailty primarily focuses on the elderly, cancer patients, and maintenance hemodialysis patients, with insufficient screening studies on elderly patients with T2DM.

†Chun Tian and Na Li contributed equally to this article.

*Correspondence:
Chun Tian
2007tianchun@163.com
[1]Department of Stomatology, First Hospital of Shanxi Medical University, Taiyuan, Shanxi, China
[2]School of Nursing, Shanxi Medical University, Taiyuan, Shanxi, China

Research data indicates [5] that the incidence of chronic periodontitis among patients with T2DM is as high as 72.7 – 87.0%, and tooth loss due to periodontitis directly increases the risk of oral frailty [6]. Notably, oral frailty is a reversible state [7], and early diagnosis and intervention can effectively delay its progression. Therefore, this study focuses on elderly patients with T2DM, investigating the current status and influencing factors of oral frailty to provide a basis for early assessment, screening, and intervention strategies for healthcare professionals.

Methods

Participants

In this study, we surveyed elderly patients with T2DM who visited a tertiary general hospital in Taiyuan, Shanxi Province, between June and October 2024. The survey used a convenience sampling method to select participants. Inclusion criteria: (1) age ≥ 60 years; (2) fulfill the diagnostic criteria specified in the 2020 Guidelines for Prevention and Treatment of Type 2 Diabetes [8]; (3) diagnosed for ≥ 1 year; (4) voluntary participation. Exclusion criteria: (1) Patients who meet al.l the inclusion criteria but do not wish to continue the collaboration for any reason; (2) the presence of a certain degree of cognitive impairment; (3) suffering from salivary gland organic lesions or dry syndrome. Eventually, 464 elderly patients with T2DM were included in the study.

Survey instruments

1) General information questionnaire. This questionnaire captures essential demographics such as gender, age, Body Mass Index (BMI), education level, and place of residence. It further collects financial data, including family per capita monthly income. Additionally, it documents health behaviors (e.g., smoking and drinking history), sleep time per night, weekly frequency of physical activity, dietary preferences, and clinical variables: number of natural teeth, fasting blood glucose (FBG), duration of diabetes mellitus, family history of diabetes mellitus, history of chronic illnesses, polypharmacy (defined as the concurrent or sequential use of five or more medications over a certain period), and self-reported toothache (pain in teeth or periodontal structures).
2) Oral frailty (OFI-8 [9]). It is employed to evaluate oral frailty in elderly individuals with T2DM. The Cronbach's α coefficient for this scale is 0.949 [10]. The scale encompasses five dimensions: whether to wear a denture, swallowing ability, chewing function, oral health - related behaviors, and social participation. It includes eight sub - items, and the total score ranges from 0 to 11. A score of 4 or higher indicates the presence of oral frailty.
3) Frailty (FRAIL Scale [11]). The scale has a Cronbach's α coefficient of 0.826 [12] and covers five indicators: fatigue, increased resistance or decreased endurance, limited activity, the coexistence of multiple diseases, and weight loss. A patient meeting three or more of these criteria is classified as frailty.
4) Oral health score (OHAT [13]). The OHAT, boasting a Cronbach's α coefficient of 0.710 [14], evaluates eight aspects of oral health: lip condition, tongue health, gum status, saliva secretion, natural teeth, dentures, oral hygiene habits, and toothaches. Scores range from 0 to 16, with higher scores reflecting poorer oral health.
5) Nutritional status (MNA-SF [15]). The scale has a Cronbach's α coefficient of 0.711 [16]. It covers six key aspects: body mass index, weight fluctuation over the past three months, experience of stressful events or sudden illness, assessment of physical activity ability, mental - emotional state, and reduction in food intake over the past three months. The total score ranges from 0 to 14 points and is categorized into three grades: malnourishment (0–7), risk of malnourishment (8–11), and normal nutritional status (12–14).
6) Grip Strength: Before measurement, patients are instructed to stand upright with their arms hanging naturally at their sides. Using their dominant hand, they grip the dynamometer, and the measurement is repeated three times, with a one-minute rest between each attempt. The highest value obtained is recorded.
7) Calf Circumference: Before measurement, patients are asked to relax and bend their knees at a 90° angle. The widest part of the calf is then measured to determine its circumference.

Quality control method

Before the study commenced, all study personnel received uniform training to ensure they were proficient in the relevant skills. The training covered the OHAT, methods for assessing oral frailty, standardized measurement procedures for anthropometric indicators (e.g. BMI, grip strength, and calf circumference), and guidelines for collecting and recording FBG. The training was conducted by professional dentists and clinical researchers, and its effectiveness was verified through an assessment.

Additionally, the researchers used standardized instructions to explain study objectives, importance, questionnaire-completion steps, and testing process to the participants to ensure participant understanding and cooperation.

During data collection, the research team maintained strict protocol adherence with clearly defined roles: a dental nurse specialist was responsible for assessing oral frailty, conducting the OHAT, and counting the number of natural teeth; a graduate student measured BMI, grip strength, calf circumference, and FBG; and another team member administered remaining questionnaire components. All questionnaires were verified for completeness and collected immediately after completion.

Statistical analyses

The analysis of data was meticulously conducted utilizing SPSS 25.0 software. For the metrological data conforming to normal distribution, they were expressed using $\bar{x} \pm s$ and statistically analyzed using two independent samples t-test; the non-normally distributed metrological data were described using M (P25, P75) and analyzed by applying the Mann -Whitney U test; the count data and rank data were expressed by frequency (n) and rate (%), with statistical analysis being conducted using the χ^2 test. Variables exhibiting statistically significant differences, as identified through univariate analysis, were subsequently included in the Logistic regression model to delve into the influencing factors of oral frailty in elderly patients with T2DM. Differences were considered statistically significant when $p < 0.05$.

Results

General information and oral frailty of elderly T2DM patients

A total of 464 elderly T2DM patients were included in this study, including 213 (45.9%) patients with oral frailty and 251 (54.1%) patients without oral frailty. There were 108 males and 105 females in the oral frailty group; the average age was 68.99 years (median 68.0, interquartile spacing 63.0, 73.0); 114 males and 137 females in the non-oral frailty group; the average age was 64.22 years (median 63.0, interquartile spacing 61.0, 66.0). There was a significant difference between the two groups in terms of age, education level, number of natural teeth, grip strength, smoking history, weekly frequency of physical activity, dietary preferences, toothache, duration of diabetes mellitus, polypharmacy, frailty, oral health score and nutritional status ($p < 0.05$). There was no statistically significant difference in other factors. For a detailed breakdown of these findings, please refer to Table 1.

Multi-collinearity analysis

Before conducting Logistic regression analysis, the variables with statistically significant differences in the results of the above one-way analysis were analyzed for multicollinearity. According to the judgment criteria of "multicollinearity": tolerance < 0.10, Variance Inflation Factor (VIF) > 10.0 [17], it can be seen that there is no multicollinearity among the included variables, and can be directly entered into the Logistic regression analysis. The results are shown in Table 2.

Analysis of factors influencing oral frailty in elderly T2DM patients

Oral frailty was selected as the dependent variable and statistically significant variables were screened for inclusion in the regression equation by univariate analysis. The description of the independent variable assignment is shown in Table 3. Logistic regression analysis was used to analyze the data using the forward Logistic regression method. Age, smoking history, weekly frequency of physical activity, duration of diabetes mellitus, polypharmacy, frailty, and oral health scores were the influencing factors for the occurrence of oral weakening in elderly patients with T2DM ($p < 0.05$), as shown in Table 4. Hosmer-Lemeshow test showed $\chi^2 = 4.858$, $p = 0.773$ ($p > 0.05$),indicating a good model fit.

Predictive value of various factors for oral frailty among elderly patients with T2DM

The findings revealed that seven factors—age, smoking history, weekly frequency of physical activity, duration of diabetes mellitus, polypharmacy, frailty, and oral health scores—carried specific predictive weight regarding the incidence of oral frailty in elderly patients with T2DM. Notably, polypharmacy, age and duration of diabetes mellitus demonstrated notably higher predictive power for oral frailty. The Area Under the Curve (AUC) for polypharmacy as a predictor of oral frailty stood at 0.728 (95% CI: 0.681–0.776), while the AUC for age was 0.721 (95% CI: 0.673–0.768), and the AUC for duration of diabetes mellitus was 0.684 (95% CI: 0.635–0.732). The predictive values associated with the other factors are detailed in Table 5, and the Receiver Operating Characteristic Curve(ROC Curves) illustrating these predictions are presented in Fig. 1.

Discussion

The results of this study indicate that the prevalence of oral frailty among elderly patients with type 2 diabetes is 45.9%, which is similar to the results of the study by Zhong (45.4%) [18], but lower than the result of Ishii's survey targeting individuals aged over 75 (53.2%) [19]. This discrepancy may be associated with age stratification, as numerous studies have demonstrated that advanced age is a significant risk factor for oral frailty [7, 20]. With increasing age, there is a reduction in salivary secretion, exacerbation of gingival recession, and exposure of tooth roots [21], leading to a higher incidence of dental issues such as dental caries and periodontal diseases [22]. Future research should further validate the impact of age stratification on oral frailty and consider

Table 1 Comparative analysis of general information among elderly patients with T2DM

Item	Oral frailty (213)	Non-oral frailty (251)	χ^2/Z value	*P* value
Sex [number, %]			1.290	0.256
males	108(50.7)	114(45.4)		
females	105(49.3)	137(54.6)		
Age [year, M (P25, P75)]	68.0(63.0, 73.0)	63.0(61.0, 66.0)	8.216	**< 0.001***
BMI [kg/m^2, M (P25, P75)]	23.66(21.95, 25.77)	23.67(21.63, 26.55)	-0.364	0.716
Education level [number, %]			14.873	**0.002***
Primary school and below	67(31.5)	42(16.7)		
Junior high school	66(31.0)	84(33.5)		
High school or technical secondary school	32(15.0)	47(18.7)		
College degree or above	48(22.5)	78(31.1)		
Place of residence [number, %]			1.465	0.226
Town	95(44.6)	98(39.0)		
Rural area	118(55.4)	153(61.0)		
Family per capita monthly income [RMB, %]			3.884	0.143
<3000	106(49.8)	104(41.4)		
3000–10,000	103(48.4)	144(57.4)		
≥ 10,000	4(1.8)	3(1.2)		
Grip strength [kg, M (P25, P75)]	24.30(18.56, 32.19)	25.80(22.20, 31.90)	-2.338	**0.019***
Calf circumference [cm, M (P25, P75)]	34.00(33.00, 36.00)	34.00(33.00, 36.00)	-0.487	0.626
Number of natural teeth [number, %]			8.337	**0.004***
0	13(6.1)	3(1.2)		
≥ 1	200(93.9)	248(98.8)		
Toothache [number, %]			6.989	**0.008***
No	85(39.9)	131(52.2)		
Yes	128(60.1)	120(47.8)		
Smoking history [number, %]			34.094	**< 0.001***
No	121(56.8)	205(81.7)		
Yes	92(43.2)	46(18.3)		
Drinking history [number, %]			0.193	0.660
No	190(89.2)	227(90.4)		
Yes	23(10.8)	24(9.6)		
Sleep time per night [number, %]			1.690	0.194
≤ 6	185(86.9)	207(82.5)		
>6	28(13.1)	44(17.5)		
Weekly frequency of physical activity [number, %]			31.842	**< 0.001***
≤ 2	156(73.2)	119(47.4)		
>2	57(26.8)	132(52.6)		
Dietary preferences [number, %]			12.932	**0.002***
Mainly meat-based diet	85(39.9)	65(25.9)		
Mainly vegetarian diet	60(28.2)	70(27.9)		
Meat and vegetable combination diet	68(31.9)	116(46.2)		
Duration of diabetes mellitus [number, %]			53.452	**< 0.001***
1–7	30(14.1)	102(40.6)		
8–14	58(27.2)	77(30.7)		
≥ 15	125(58.7)	72(28.7)		
FBG [mmol/L, M (P25, P75)]	7.38(6.38, 8.60)	7.80(6.40, 8.60)	-0.878	0.380
Family history of diabetes mellitus [number, %]			1.745	0.186
No	130(61.0)	168(66.9)		
Yes	83(39.0)	83(33.1)		
Polypharmacy [number, %]			102.629	**< 0.001***
No	81(38.0)	210(83.7)		
Yes	132(62.0)	41(16.3)		
History of chronic illnesses [number, %]			1.604	0.265

Table 1 (continued)

Item	Oral frailty (213)	Non-oral frailty (251)	χ^2/Z value	*P* value
No	102(47.9)	135(53.8)		
Yes	111(52.1)	116(46.2)		
Frailty [number, %]			48.788	**< 0.001***
No	107(50.2)	203(80.9)		
Yes	106(49.8)	48(19.1)		
Oral health score [score, M (P25, P75)]	7.00(7.00, 9.00)	7.00(6.00, 8.00)	3.495	**< 0.001***
Nutritional status [number, %]			21.872	**< 0.001***
Normal nutritional status	61(28.6)	121(48.2)		
Risk of malnutrition	77(36.2)	80(31.9)		
Malnutrition	75(35.2)	50(19.9)		

Note: *: $p < 0.05$

Table 2 Multi-collinearity analysis

variables	tolerance	VIF
Grip strength	0.928	1.077
Oral health scores	0.931	1.074
Age	0.841	1.190
Education level	0.968	1.033
Number of natural teeth	0.963	1.038
Smoking history	0.958	1.044
Weekly frequency of physical activity	0.950	1.053
Dietary preferences	0.960	1.042
Duration of diabetes mellitus	0.896	1.116
Polypharmacy	0.876	1.142
Frailty	0.905	1.105
Toothache	0.944	1.060
Nutritional status	0.897	1.115

Table 3 Definitions and assignments of independent variables

Independent variables	Assignments
Education level	Primary school and below = 1; Junior high school = 2; High school or technical secondary school = 3; College degree or above = 4
Number of natural teeth	0 = 0; ≥1 = 1
Smoking history	No = 0; Yes = 1
Toothache	No = 0; Yes = 1
Weekly frequency of physical activity	≤2 = 0; >2 = 1
Dietary preferences	Mainly meat-based diet = 1; Mainly vegetarian diet = 2; Meat and vegetable combination diet = 3
Duration of diabetes mellitus	1–7 = 1; 8–14 = 2; ≥15 = 3
Polypharmacy	No = 0; Yes = 1
Frailty	No = 0; Yes = 1
Nutritional status	Normal nutritional status = 0; Risk of malnutrition = 1; Malnutrition = 2
Age Grip strength Oral health scores	substitution of original values

including a broader age range to enhance the generalizability of the findings.

In the analysis of risk factors, polypharmacy (OR = 11.038) was confirmed as a significant risk factor. Polypharmacy can lead to a reduction in saliva volume and a decrease in salivary flow rate [23], thereby inducing oral mucosal inflammation and gingival bleeding. Medical staff need to pay special attention to patients with a history of polypharmacy, adopt a multidisciplinary collaborative approach, and thoroughly evaluate factors such as the patients' physical condition, disease progression, hepatic and renal function, and potential drug interactions, in order to maximize the protection of patients' medication safety.

Smoking (OR = 4.478) has also been confirmed as significant risk factor for oral frailty. Nicotine in tobacco can significantly promote the activity of Streptococcus mutans, accelerating the formation of dental caries [24]. Long-term smoking can also lead to gingival bleeding, reduced tooth stability, and oral ulcers [25]. Therefore, smoking cessation intervention programmes need to be included in diabetes management, with efforts made to strengthen patients' awareness of smoking cessation through multiple channels (e.g., health lectures, online communities).

In terms of oral hygiene, our study revealed that poor oral health (OR = 1.226) significantly increases the risk of oral frailty. From a pathophysiological standpoint, osmotic diuresis induced by hyperglycemia can lead to dry mouth symptoms [26]. Furthermore, prolonged hyperglycemia not only exacerbates damage to oral soft and hard tissues, but also renders oral microvessels and cells more susceptible to microcirculation disorders, ultimately resulting in the frequent occurrence of oral diseases such as periodontitis and dental caries [27]. Poor oral hygiene practices (number of times of daily tooth brushing < 1 time) directly contribute to dental plaque accumulation, which subsequently leads to tooth loosening and even tooth loss [28]. In addition, studies have found that prolonged diabetes duration is associated with

Table 4 Comprehensive logistic regression on factors influencing oral frailty in elderly T2DM patients

Independent variables	Coefficient	Standard error	Wald value	*P* value	OR	95%CI
Age	0.132	0.027	23.935	< 0.001	1.141	1.082–1.202
Oral health scores	0.204	0.082	6.153	0.013	1.226	1.044–1.441
Smoking history (Yes)	1.499	0.296	25.734	< 0.001	4.478	2.509–7.991
Weekly frequency of physical activity (> 2)	-1.172	0.282	17.301	< 0.001	0.310	0.178–0.538
Duration of diabetes mellitus			21.565	< 0.001		
Duration of diabetes mellitus (8–14)	1.180	0.368	10.255	0.001	3.253	1.580–6.696
Duration of diabetes mellitus (≥ 15)	1.705	0.355	23.014	< 0.001	5.499	2.741–11.035
Polypharmacy (Yes)	2.401	0.304	62.397	< 0.001	11.038	6.083–20.028
Frailty (Yes)	1.321	0.292	20.451	< 0.001	3.746	2.113–6.640
Constant	-12.293	1.961	39.286	< 0.001	0	—

Note: OR = Odds Ratio; CI = Confidence interval

Table 5 The predictive value of various variables for oral frailty in elderly patients with T2DM

Item	Sensitivity	Specificity	AUC	95%CI
Age	0.484	0.884	0.721	0.673–0.768
Smoking history	0.432	0.817	0.624	0.573–0.676
Weekly frequency of physical activity	0.732	0.526	0.629	0.578–0.680
Duration of diabetes mellitus	0.587	0.713	0.684	0.635–0.732
Polypharmacy	0.62	0.837	0.728	0.681–0.776
Frailty	0.498	0.809	0.653	0.603–0.704
Oral health scores	0.756	0.438	0.592	0.540–0.644

an increased risk of oral frailty, which may be related to the frailty state due to long-term diabetes [29]. These findings underscore the importance of incorporating oral health assessments into the routine management of diabetic patients, with a particular focus on providing health education and conducting regular oral examinations for those with a longer disease duration.

In terms of protective factors, the weekly frequency of physical activity > 2 times (OR = 0.310) can reduce the risk of oral frailty. The reason may be that regular exercise among older adults often leads to richer social activities, providing more opportunities for the use of oral muscles. Additionally, physical exercise helps prevent and improve physical frailty, which is closely associated with the decline of oral function [30, 31]. Therefore, caregivers should design suitable exercise programs, such as walking, Tai Chi and other low-intensity activities, for elderly diabetic patients. Meanwhile, they should encourage these patients to participate in various social activities, as this not only improves overall health but also effectively maintains oral function.

All participants in this study were recruited from a tertiary hospital, indicating that the majority of patients were undergoing diabetes treatment. However, the median FBG level was approximately 7.5 mmol/L, suggesting that their blood glucose control was not satisfactory. Even for some patients with a diabetes duration exceeding 15 years, the status of blood glucose control had not been effectively improved. This highlights a critical issue: adverse behavioral factors may be associated with oral frailty and poor oral hygiene. The effective management of diabetes not only relies on pharmacological treatment but also requires patients' active participation in self - management, which encompasses blood glucose monitoring, a balanced diet, regular exercise, and good oral hygiene practices. Studies have demonstrated that dietary and exercise interventions can reduce glycated hemoglobin (HbA1c) levels, enhance insulin sensitivity, and effectively improve blood glucose control [32, 33]. Self-care behaviors also have a direct and significant impact on oral health. Research conducted by Sreenivasan indicates that poor oral hygiene habits, such as incorrect tooth - brushing techniques and failure to use dental floss, can lead to a substantial accumulation of dental plaque, thereby increasing the risk of oral frailty [34]. Oral frailty not only affects oral functions but is also associated with nutritional status, physical frailty, and cognitive decline. For elderly diabetic patients, due to impaired chewing function, they have difficulty in adequately masticating food, which subsequently impairs the intake and absorption of nutrients, resulting in physical frailty. Physical weakness further restricts patients' physical activity

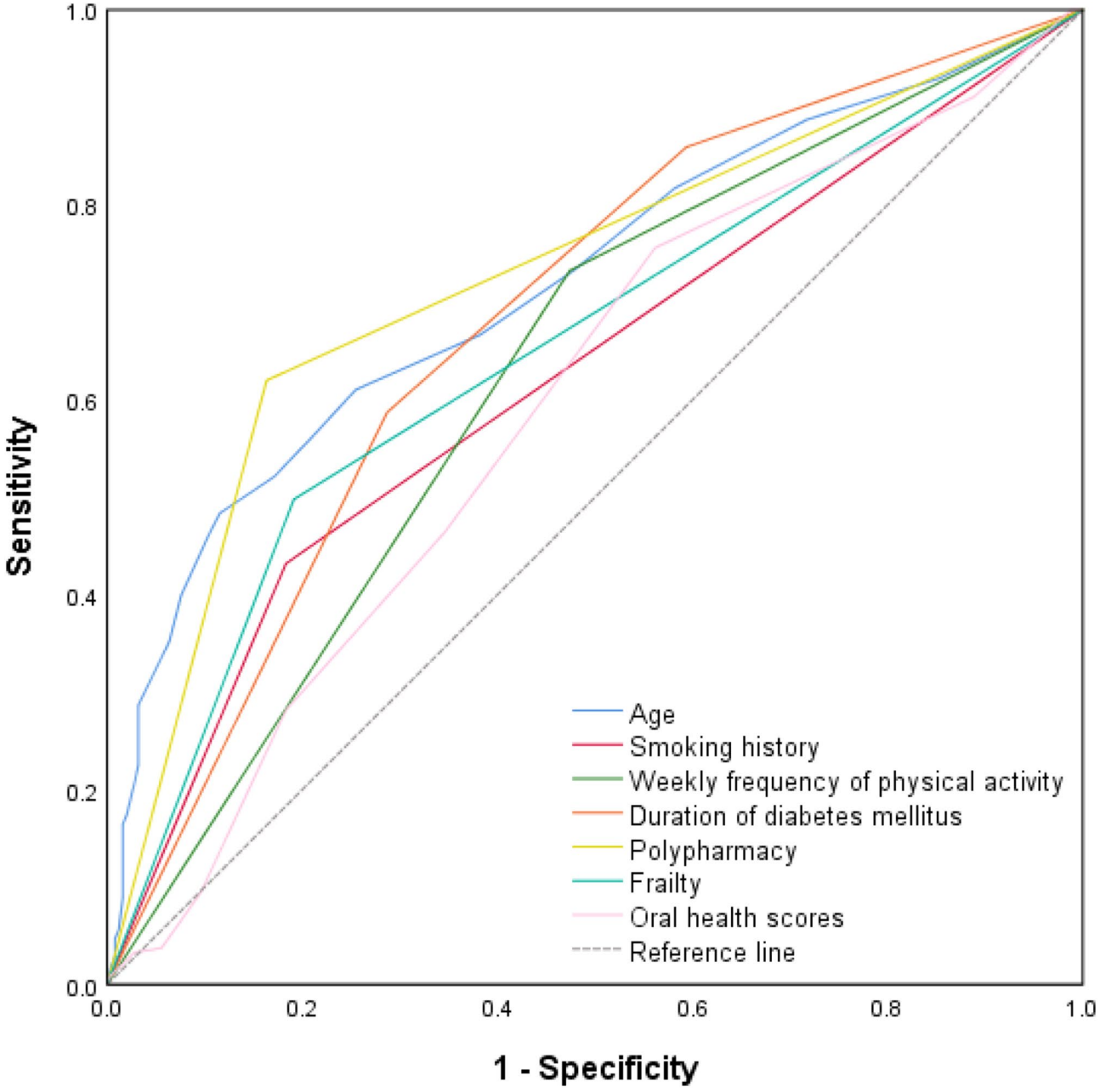

Fig. 1 ROC curve

capacity, creating a vicious cycle that exacerbates the challenge of blood glucose control [35, 36].

A systematic review reveals that effective oral health education can substantially enhance patients' awareness of the risks associated with oral diseases, boost their sense of self-efficacy, and motivate them to proactively adopt more proactive and scientific self-management behaviors [37]. Consequently, healthcare professionals should further strengthen oral health education for diabetic patients. By fully leveraging digital tools such as mobile health (mHealth), telemedicine, and artificial intelligence, they can extend the scope of education from hospitals to communities, thereby improving patients' adherence to self-management practices. This approach will ultimately enable the dual and effective management of both diabetes and oral health.

From the perspectives of clinical intervention and public health significance, given the high prevalence of oral frailty among elderly patients with T2DM, it is recommended to incorporate oral frailty assessment into routine evaluation items for inpatients. Through personalized oral hygiene guidance, exercise training, and

interventions in healthy lifestyles, we can prevent or delay oral frailty and improve the overall health status of patients. This approach aligns with the comprehensive diabetes management framework and will reduce the consumption of medical resources.

This study has several limitations. Firstly, the cross-sectional design limits the inference of causal relationships between oral frailty and related variables in elderly patients with T2DM. Longitudinal studies are needed in the future to clarify the associations between variables. Secondly, subjective assessments such as oral frailty and dry mouth may introduce bias. It is recommended to use objective indicators (such as salivary flow rate and Oral Diadochokinesis) to improve the reliability of the results. Thirdly, this study did not take into account periodontal-related indicators, psychological factors (such as anxiety and depression), and social factors (such as social support, economic status, and accessibility of oral healthcare services), all of which may have an impact on the condition of oral frailty. Additionally, this study used FBG instead of HbA1c to evaluate the effect of glycaemic control on oral frailty, while HbA1c can better reflect long-term glycaemic control levels. Lastly, the data were only collected from a single region. Future studies should expand the geographical coverage and incorporate data from multiple regions to improve the representativeness and external validity of the study results.

Conclusions

The study observed a relatively high prevalence of oral frailty among elderly patients with T2DM. This was primarily influenced by several factors, including age, number of dentures, smoking history, frequency of weekly physical activity, number of times of daily brushing, dry mouth, duration of diabetes mellitus, polypharmacy, frailty, and oral health scores. These findings underscore the importance of caregivers conducting regular, thorough assessments of elderly T2DM patients' oral health to identify those at risk of oral decline early on. Additionally, tailored and comprehensive oral health care strategies should be implemented for diverse patient groups to prevent or slow the progression of oral health deterioration, ultimately improving their overall oral health outcomes.

Abbreviations

T2DM	Type 2 diabetes mellitus
BMI	Body Mass Index
OFI-8	Oral Frailty Index-8
FRAIL Scale	Fatigue, Resistance, Ambulation, Illness and Loss of weight Scale
OHAT	Oral Health Assessment Tool
MNA-SF	Mini-Nutritional Assessment Short Form
FBG	Fasting blood glucose
VIF	Variance Inflation Factor
OR	Odds Ratio
CI	Confidence interval
AUC	Area Under the Curve
ROC Curve	Receiver Operating Characteristic Curve
HbA1c	Glycated hemoglobin

Acknowledgements

We are grateful to all the participants who took part in this study.

Author contributions

Chun Tian was responsible for the design of the study, data collection, statistical analysis, and the drafting of the manuscript. Na Li was in charge of the study design, data collection and organization, statistical analysis, and also contributed to the writing of the manuscript. Ya Gao focused on data organization and statistical analysis. Yan Yan was responsible for data collection. All authors have read and approved the manuscript.

Funding

This study was supported by grants from Scientific Research Special Topic on High-quality Development of the Great Health Industry in Shanxi Province (DJKZXKT2023181). The foundation provided funds for printing materials, but had no role in the design of the study, collection, analysis, interpretation of data and in writing the manuscript.

Data availability

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the Ethics Committee of the First Hospital of Shanxi Medical University (NO. KYLL-2024-149). Written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 27 November 2024 / Accepted: 16 May 2025
Published online: 07 June 2025

References

1. Watanabe Y, Okada K, Kondo M, et al. Oral health for achieving longevity. Geriatr Gerontol Int. 2020;20(6):526–38.
2. Yoshida M, Hiraoka A, Takeda C, et al. Oral hypofunction and its relation to frailty and sarcopenia in community-dwelling older people. Gerodontology. 2022;39(1):26–32.
3. Iwasaki M, Motokawa K, Watanabe Y, et al. Association between oral frailty and nutritional status among Community-Dwelling older adults: the Takashimadaira study. J Nutr Health Aging. 2020;24(9):1003–10.
4. Iwasaki M, Motokawa K, Watanabe Y, et al. Oral hypofunction and malnutrition among community-dwelling older adults: evidence from the Otassha study. Gerodontology. 2022;39(1):17–25.
5. He YY, Wang YD, Zhu GH. Influence of Zhibai Dihuang pills combined with basic periodontal treatment on clinical efficacy and inflammatory factors in patients with chronic periodontitis and type 2 diabetes. China J Conserv Dent. 2018;28(06):336–9.
6. Niu JH, Li C, Li R, et al. Study on the changes of subgingival microflora in patients with type 2 diabetes mellitus complicated with chronic periodontitis before and after periodontal treatment based on high-throughput sequencing technique. J Xinjiang Med Univ. 2021;44(04):453–7.
7. HU S, LI X. An analysis of influencing factors of oral frailty in the elderly in the community. BMC Oral Health. 2024;24(1):260.
8. Society C D. Guideline for the prevention and treatment of type 2 diabetes mellitus in China(2020 edition)(Part 1). Chin J Pract Intern Med. 2021;41(08):668–95.

9. Tanaka T, Hirano H, Ohara Y, et al. Oral frailty Index-8 in the risk assessment of new-onset oral frailty and functional disability among community-dwelling older adults. Arch Gerontol Geriatr. 2021;94:104340.
10. Chen ZM, Tan Y, Liang YJ, et al. Chinesization of the oral frailty Index-8 and its reliability and validity test. Chin Nurs Res. 2023;37(21):3808–12.
11. Abellan Van Kan G, Rolland Y, Bergman H, et al. The I.A.N.A task force on frailty assessment of older people in clinical practice [J]. J Nutr Health Aging. 2008;12(1):29–37.
12. Wei Y, Cao YP, Yang XL, et al. Frailty syndrome in hospitalized geriatric patients and its risk factors. Fudan Univ J Med Sci. 2018;45(04):496–502.
13. Chalmers JM, King P L, Spencer A J, et al. The oral health assessment tool–validity and reliability. Aust Dent J. 2005;50(3):191–9.
14. Wang JQ, Zhu SZ, Zhan Y, et al. Reliability and validity test of Chinese version of the oral health assessment tool. Chin J Mod Nurs. 2019;25(28):3607–10.
15. Kaiser M J, Bauer J M, Ramsch C, et al. Validation of the Mini nutritional assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Health Aging. 2009;13(9):782–8.
16. Zhang Y, Wang LX, Lv XH, et al. Application of mini nutritional assessment-short form in nutrition screening in elderly inpatients with chronic diseases. Chin J Mult Organ Dis Elder. 2019;18(2):107–11.
17. Kim JH. Multicollinearity and misleading statistical results. Korean J Anesthesiol. 2019;72(6):558–69.
18. Zhong L, Zhang H, Xu J, et al. Construction of nomogram prediction model for the risk of oral frailty in elderly patients with type 2diabetes mellitus. J Clin Med Pract. 2024;28(16):98–103.
19. Ishii M, Yamaguchi Y, Hamaya H, et al. Influence of oral health on frailty in patients with type 2 diabetes aged 75 years or older. BMC Geriatr. 2022;22(1):145.
20. Kugimiya Y, Watanabe Y, Ueda T, et al. Rate of oral frailty and oral hypofunction in rural community-dwelling older Japanese individuals. Gerodontology. 2020;37(4):342–52.
21. Wang L, Ju M, Wang T, et al. Oral frailty risk and its influencing factors in community-dwelling elderly population. J Nurs Sci. 2023;38(18):112–6.
22. Chapple I L, Bouchard P, Cagetti M G, et al. Interaction of lifestyle, behaviour or systemic diseases with dental caries and periodontal diseases: consensus report of group 2 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. J Clin Periodontol. 2017;44(Suppl 18):S39–51.
23. Soto AP, Meyer SL. Oral implications of polypharmacy in older adults. Clin Geriatr Med. 2023;39(2):273–93.
24. Fan Y, Cheng L. Smoking affects the oral microenvironment and its role in the progression of dental caries. Int J Stomatol. 2021;48(05):609–13.
25. Chaffee B W, Couch E T, Vora M V, et al. Oral and periodontal implications of tobacco and nicotine products. Periodontol 2000. 2021;87(1):241–53.
26. Zeng Q, Li N, Pan XF, et al. Clinical management and treatment of obesity in China. Lancet Diabetes Endocrinol. 2021;9(6):393–405.
27. Pan XF, Wang L. Epidemiology and determinants of obesity in China. Lancet Diabetes Endocrinol. 2021;9(6):373–92.
28. Tonetti MS, Jepsen S. Impact of the global burden of periodontal diseases on health, nutrition and wellbeing of mankind: A call for global action. J Clin Periodontol. 2017;44(5):456–62.
29. Gao TT, Chen TJ, Shi SR. Current status of debilitation in elderly diabetic population and its influencing factors. Chin J Mult Organ Dis Elder. 2024;23(02):114–7.
30. Komatsu R, Nagai K, Hasegawa Y et al. Association between physical frailty subdomains and oral frailty in Community-Dwelling older adults. Int J Environ Res Public Health. 2021;18(6).
31. Pan Q, Dai FM, Pan WY, et al. Recent developments in oral frailty in the elderly. Chin Gen Pract. 2022;25(36):4582–7.
32. Yonas W, Kahleova H, Znayenko-Miller T, et al. Lifestyle education online program in improving glucose control and other metabolic parameters. Int J Disease Reversal Prev. 2025;7(1):18.
33. Legaard G E, Feineis C S, Johansen M Y, et al. Effects of an exercise-based lifestyle intervention on systemic markers of oxidative stress and advanced glycation endproducts in persons with type 2 diabetes: secondary analysis of a randomised clinical trial. Free Radic Biol Med. 2022;188:328–36.
34. Sung K. The effect of oral environment and Self-care behavior on oral Health-related quality of life in the elderly with diabetes. J Korean Biol Nurs Sci. 2020;22(3):192–203.
35. Yu J, Ye A, Fei Y, et al. The association between oral frailty and HbA1c among older adults with T2DM: the chain mediating effect of nutritional status and physical frailty. Eur Geriatr Med. 2024;15(6):1891–8.
36. Madden K M, Feldman B. SY S, Frailty, body composition, and glycemic control in older adults with type 2 diabetes. Can J aging = La Revue Canadienne Du Vieillissement. 2024;1–6.
37. Petropoulou P, Kalemikerakis I. Dokoutsidou E, Oral health education in patients with diabetes: A systematic review. Healthc (Basel Switzerland), 2024; 12(9).

Publisher's note