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ORIGINAL ARTICLE

Glycemic control, periodontal disease, and tooth mobility in type 2 diabetes

Molek[1], Susiani Tarigan[2], Arifah Nur Amaliyah Nuari[3]

ABSTRACT

Diabetes mellitus, a growing global and national health crisis, is associated with various systemic complications, including often-overlooked oral health deterioration, particularly periodontal disease. While the general bidirectional link between diabetes and periodontal disease is established, research on the direct correlation between glycaemic control (HbA1c) and periodontal status or tooth mobility in specific regional contexts like Indonesia remains inconsistent. This study aimed to analyse this relationship in patients with Type 2 Diabetes Mellitus (T2DM) at Dr. Yuliddin Away Tapaktuan Hospital. An analytical survey with a cross-sectional design was conducted in September-October 2024 at RSUD dr. Yuliddin Away Tapaktuan. A convenience sample of 40 T2DM patients was selected from a population of 63. HbA1c level was the independent variable, while periodontal disease status and tooth mobility degree were the dependent variables. Data were collected via direct oral examination and patient medical records, and subsequently analysed to determine associations. The study cohort (n=40) was predominantly female (72.5%) and over 45 years old (85%). A significant majority (80.0%) exhibited uncontrolled HbA1c levels. Periodontal disease was highly prevalent, with 80.0% of patients having gingivitis. The bivariate analysis revealed a strong and statistically significant relationship between blood glucose control and periodontal disease severity ($p < 0.001$). Among patients with controlled HbA1c, 87.5% maintained healthy periodontal status, whereas 96.8% of those with uncontrolled HbA1c presented with gingivitis. Conversely, while all controlled HbA1c patients showed no tooth mobility (Degree 0), 21.9% of the uncontrolled group had some degree of mobility (Degree 1 or 2). However, this association between HbA1c control and tooth mobility was not statistically significant ($p = 0.910$). This study confirms a significant inverse relationship between optimal blood glucose control and the severity of periodontal disease in T2DM patients, particularly regarding gingivitis. Effective glycaemic management is therefore critical for promoting periodontal health. While a trend was observed, the relationship between HbA1c control and tooth mobility did not reach statistical significance, suggesting its multifactorial nature. These findings underscore the importance of integrating comprehensive diabetes management with oral healthcare to prevent and mitigate periodontal complications.

Keywords: type 2 diabetes mellitus, periodontal disease, glycemic control

Introduction

Diabetes mellitus is a chronic metabolic disease characterised by elevated blood glucose levels (hyperglycaemia) due to impaired insulin production or function. This condition has emerged as a global and national health crisis.[1,2] According to the International Diabetes Federation (IDF) in 2021, over 537 million adults worldwide live with diabetes, and this figure continues to rise. In Indonesia, diabetes ranks as the fifth

Affiliation
[1]Department of Dental Science, Universitas Prima Indonesia, Medan, Indonesia
[2]Undergraduate Program in Dentitry, Universitas Prima Indonesia, Medan, Indonesia

*Corespondence:
drg.molek@yahoo.com

leading health concern, with projections indicating 28.6 million affected individuals by 2045. The burden of this disease not only impacts individual health through various systemic complications, such as cardiovascular disease and stroke, but also incurs substantial social and economic consequences, necessitating effective prevention and management strategies.[3]

A significant, yet frequently overlooked, complication of diabetes mellitus is the deterioration of oral health, particularly periodontal disease. Diabetic patients with poorly controlled blood glucose are more susceptible to gum inflammation (gingivitis) and damage to the supporting tissues of the teeth (periodontitis).[4,5] Hyperglycaemic conditions can weaken the body's immune response, impair blood flow to the gingiva, and impede healing processes, all of which contribute to progressive periodontal tissue destruction. The relationship between these two conditions is bidirectional: diabetes increases the risk and severity of periodontitis, while active periodontal infection can complicate blood glucose control.[6,7]

Although the general association between diabetes and periodontal disease is well-established, research on the direct correlation between the level of glycaemic control and the severity of periodontal status and tooth mobility in Indonesia has yielded varied results. Some studies have identified a clear relationship, where good glycaemic control is directly proportional to better periodontal health.[8–11] However, other research indicates that many diabetic patients continue to experience severe periodontitis despite treatment, and not all studies have found a direct correlation between blood glucose levels and tooth mobility.[12,13] These inconsistent findings suggest the influence of other potential factors and highlight existing knowledge gaps that require addressing.

Given these inconsistent findings and the scarcity of specific data from certain regions, further research is imperative to clarify this relationship within a local context. Dr. Yuliddin Away Tapaktuan Hospital, a primary referral hospital in South Aceh Regency, is one such location lacking empirical data on this issue. Therefore, this study aims to specifically analyse the relationship between glycaemic control and periodontal disease status, as well as the degree of tooth mobility, in patients with type 2 diabetes mellitus at the aforementioned hospital. The findings from this research are expected to provide robust scientific evidence to support evidence-based clinical practice and serve as a foundation for developing integrated oral healthcare policies for diabetic patients at the local level.

Method

This study employed an analytical survey method with a cross-sectional design to investigate the association between blood glucose control, periodontal disease status, and the degree of tooth mobility. This approach allowed researchers to concurrently observe and collect data on the risk factor (glucose control) and its impact (periodontal conditions) at a single time point, without any intervention. The study was conducted at the Endocrine and Dental and Oral Polyclinics of RSUD dr. Yuliddin Away Tapaktuan, South Aceh, between September and October 2024, following ethical approval.

The study population comprised 63 patients with type 2 diabetes mellitus who had recently initiated treatment between June and August 2024. From this population, a sample of 40 individuals was selected using the Slovin's formula to ensure data representativeness. The sampling technique employed was non-probability sampling with a convenience sampling method, where participants were chosen based on their availability and accessibility to the researchers, provided they met the pre-defined criteria.

This study utilised two types of variables: independent (explanatory) and dependent (response) variables. The independent variable was HbA1c level, hypothesised to influence the dependent variables: periodontal disease status and degree of tooth mobility. HbA1c level was chosen as it reflects blood glucose control in diabetic patients, which directly impacts periodontal health and tooth stability. The instruments and materials used in this study included various medical devices for dental and oral examinations. These comprised examination sheets, a periodontal probe with a 0.5 mm ball-end tip, a number 4 mouth mirror, and a WHO periodontal probe for assessing gingival pocket depth with a black colour scale at 3.5–5.5 mm. Additionally, for hygiene and safety, protective equipment such as masks, a kidney dish, 70% alcohol, cotton wool, antiseptic solution, mouthwash, and gloves were used.

Data collection was conducted using two methods: primary and secondary. Primary data were obtained through direct examination of periodontal disease status and degree of tooth mobility using the periodontal probe. Secondary data were retrieved from patient medical records, including demographic and medical information such as age, gender, smoking habits, duration of type 2 diabetes mellitus, and HbA1c levels. The research procedure commenced with a screening process to select subjects who met the inclusion and

exclusion criteria. Once subjects were selected, the researcher provided an explanation of the study procedures and objectives. If subjects agreed to participate, they signed an informed consent form. Subsequently, personal data and laboratory test results were collected, followed by a physical oral examination to assess periodontal disease status and degree of tooth mobility. All collected data will be analysed to obtain results relevant to the study's objectives..

Results

Table 1 presents the characteristics of 40 patients with Type 2 Diabetes Mellitus (T2DM). The data highlights various demographic and health-related aspects of this patient group. The majority of the T2DM patients were over 45 years old, accounting for 34 individuals (85%). Only a smaller proportion, 6 patients (15%), were 45 years old or younger. In terms of gender, there was a significant imbalance, with females representing the vast majority of the study participants. Twenty-nine patients (72.5%) were female, while only 11 patients (27.5%) were male.

Most patients had been living with diabetes for a relatively shorter period, with 35 individuals (87.5%) having a duration of diabetes mellitus of 10 years or less. A smaller group of 5 patients (12.5%) had been diagnosed with diabetes for over 10 years. Regarding blood glucose control, a significant concern was observed. The vast majority of patients, 32 individuals (80.0%), had uncontrolled HbA1c levels, indicating poor blood glucose management. Only 8 patients (20.0%) had their blood glucose controlled..

Table 1. T2DM patient characteristics (n= 40)

Characteristic	n	%
Age (years)		
≤ 45	6	15,0
> 45	34	85,0
Gender		
Male	11	27,5
Female	29	72,5
Duration of Diabetes Mellitus		
≤ 10 years	35	87,5
> 10 years	5	12,5
Blood Glucose Control (HbA1c)		
Controlled	8	20,0
Uncontrolled	32	80,0
Periodontal Disease Severity Status		
Healthy	7	17,5
Gingivitis	32	80,0
Periodontitis	1	2,5
Tooth Mobilty Degree		
Degree 0	33	82,5
Degree 1	5	12,5
Degree 2	2	5,0
Degree 3	-	-

The table also provides insights into the periodontal health of these T2DM patients. A striking finding was the high prevalence of gingivitis, affecting 32 patients (80.0%). Only 7 patients (17.5%) were categorized as having healthy periodontal status, and a single patient (2.5%) presented with periodontitis. Finally, the degree of tooth mobility was assessed. Most patients, 33 individuals (82.5%), exhibited no tooth mobility (Degree 0). A smaller number showed some degree of mobility, with 5 patients (12.5%) having Degree 1 mobility and 2 patients (5.0%) having Degree 2 mobility. Notably, no patients presented with Degree 3 tooth mobility.

Table 2. Relationship of Blood Glucose Control (HbA1c) to Periodontal Disease Severity Status

Periodontal Disease Severity Status	Blood Glucose Control (HbA1c)		p
	Uncontrolled (n=32)	Controlled (n=8)	
Healthy	0 (0,0%)	7 (87,5%)	
Gingivitis	31 (96,8%)	1 (12,5%)	< 0,001
Periodontitis	1 (3,1%)	0 (0,0%)	

The data in Table 2 reveals a strong and statistically significant relationship between blood glucose control and periodontal health (p<0.001). Among individuals with controlled blood glucose (HbA1c), a vast majority, specifically 7 out of 8 individuals (87.5%), maintained healthy periodontal status. In stark contrast, no individuals with healthy gums were found in the "Uncontrolled" blood glucose group.

Conversely, individuals with uncontrolled blood glucose levels predominantly exhibited signs of periodontal disease. A substantial 31 out of 32 individuals (96.8%) with uncontrolled blood glucose presented with gingivitis, the early stage of periodontal disease characterized by inflammation of the gums. Only one individual (3.1%) in the uncontrolled group had periodontitis, a more advanced and destructive form of gum disease. The findings clearly indicate that controlled blood glucose is highly associated with healthy gums, while uncontrolled blood glucose is overwhelmingly linked to the presence of gingivitis. This suggests that maintaining good glycemic control is crucial for preventing or mitigating the severity of periodontal disease.

Table 3. Relationship of Blood Glucose Control (HbA1c) to Tooth Mobilty Degree

Tooth Mobilty Degree	Blood Glucose Control (HbA1c)		P
	Uncontrolled (n=32)	Controlled (n=8)	
Degree 0	25 (78,1%)	8 (100,0%)	0,910
Degree 1	5 (15,6%)	0 (0,0%)	
Degree 2	2 (6,3%)	0 (0,0%)	
Degree 3	0 (0,0%)	0 (0,0%)	

For individuals with controlled blood glucose, a significant finding is that all 8 participants (100%) exhibited Degree 0 tooth mobility (see Table 3). This suggests a strong association between good blood glucose control and stable teeth with no noticeable looseness. In contrast, the group with uncontrolled blood glucose presented a different picture. While a majority, 25 out of 32 participants (78.1%), still had Degree 0 tooth mobility, a notable proportion experienced some degree of looseness. Specifically, 5 participants (15.6%) had Degree 1 mobility, indicating slight movement, and 2 participants (6.3%) showed Degree 2 mobility, meaning moderate looseness. No participants in either group experienced Degree 3 mobility.

The p-value of > 0.05 indicates that, statistically, there isn't a significant difference in tooth mobility between the controlled and uncontrolled groups at the current sample size. While the table shows a trend where uncontrolled blood glucose is associated with higher degrees of tooth mobility, the study's statistical analysis suggests that this difference isn't strong enough to be considered statistically significant, possibly due to the relatively small sample size, especially in the controlled group. This means that while there appears to be a relationship, more research with a larger sample might be needed to confirm it definitively.

Discussion

This study reveals a significant association between suboptimal blood glucose control and increased periodontal disease severity in patients with type 2 diabetes mellitus (T2DM). Chronic hyperglycaemia in diabetic individuals can trigger an excessive inflammatory response, marked by an elevated release of pro-inflammatory cytokines such as IL-1β and TNF-α.[2] Elevated cytokine levels contribute to periodontal tissue destruction, leading to gingival inflammation that can progress to periodontitis if left unmanaged.[14] Furthermore, chronic hyperglycaemia leads to the accumulation of advanced glycation end products (AGEs). AGEs contribute to structural damage in collagen and extracellular matrix, which can impair periodontal tissues and compromise gingival integrity.[15,16] Consequently, periodontal tissues become more susceptible to infection, and the body's immune response to infection is also impaired, exacerbating the periodontal disease condition. This explanation provides insight into why patients with high HbA1c levels are more prone to gingival inflammation, which can develop into periodontitis if not promptly addressed.[17,18]

These findings align with research conducted by Kim et al.[19], who utilized Propensity Score Matching (PSM) to adjust for confounding factors in their analysis. Kim's study demonstrated a significant relationship between periodontitis and diabetes, with an odds ratio (OR) of 1.52 after PSM adjustment. These findings reinforce the evidence that poor blood glucose control contributes to an increased risk of periodontal disease in T2DM patients. This research also underscores the importance of proper blood glucose management for diabetic patients to prevent oral health complications, such as gingivitis and periodontitis.

However, the current study's findings regarding tooth mobility present a nuanced picture. While poor blood glucose control can exacerbate soft tissue inflammation, it did not demonstrate a direct impact on the degree of tooth mobility in T2DM patients within this study. Tooth mobility is a multifactorial condition,

not solely linked to glycaemic control. Factors such as a history of occlusal trauma, subgingival calculus accumulation, and the duration of pre-existing periodontal disease also play a role in influencing tooth stability.[20,21] This finding does not completely align with some previous studies that reported increased tooth mobility in diabetic patients with poor glycaemic control.[22,23]

The increased risk of periodontal disease with age can be attributed to several factors, including a decline in immune system function, which can worsen the body's response to infection and inflammation in gum tissues.[24,25] Additionally, other factors such as reduced saliva production, suboptimal oral hygiene, and hormonal changes in older age can contribute to periodontal tissue damage.[26] For diabetic patients, this condition is further complicated by chronic hyperglycaemia, which can heighten the risk of gingival inflammation and exacerbate periodontal tissue damage.[27,28] Therefore, these findings emphasize the importance of effective diabetes management, particularly in older individuals, to prevent oral health complications. Early prevention and appropriate treatment can help reduce the prevalence of periodontal disease in diabetic patients, especially in the more vulnerable elderly age group.[29,30]

Conversely, research conducted by Valentim et al.[31] in Brazil showed results that differ from other studies regarding the relationship between HbA1c levels and periodontitis in diabetic patients. This study found no significant association between HbA1c levels and the presence of periodontitis. These differing results are likely due to several factors influencing the studied population, such as demographic characteristics, lifestyle patterns, and the healthcare system and diabetes management approaches implemented in Brazil. Demographic characteristics like age, gender, and socio-economic status can influence the prevalence and severity of periodontal disease in diabetic patients. For instance, in countries with higher levels of education and health awareness, patients may be more informed and proactive regarding diabetes management and good oral hygiene. Meanwhile, lifestyle factors such as eating habits, dental hygiene, and smoking habits also play a crucial role in the development of periodontal disease. Additionally, differences in healthcare systems and diabetes management in Brazil might be a primary reason for this inconsistency. Improved diabetes management approaches, including more optimal blood glucose control through educational programs and routine monitoring, can reduce the risk of long-term complications, including periodontal disease. These factors indicate that while a relationship between HbA1c levels and periodontal disease may be found in some studies, the results can vary depending on the local context and the studied population. Therefore, it is essential to consider various factors that may influence research outcomes before drawing general conclusions.

It is important to interpret the findings of this study with caution due to several limitations. The cross-sectional design prevents the establishment of causality between blood glucose levels and the degree of tooth mobility. Furthermore, the limited number of participants and their recruitment from a single healthcare facility restrict the generalizability of these findings to a broader population. This study also did not account for several other important variables, such as smoking habits, oral hygiene practices, and duration of diabetes, all of which can influence a patient's periodontal condition. Therefore, further longitudinal studies are needed to assess changes in blood glucose control and periodontal health over time. A more rigorous approach to controlling for other variables is also crucial to gain a more comprehensive understanding of the impact of blood glucose levels on periodontal health in patients with diabetes mellitus.

Conclusion

This study provides valuable insights into the oral health status of patients with Type 2 Diabetes Mellitus. Our findings conclusively demonstrate a statistically significant inverse relationship between optimal blood glucose control (HbA1c) and the severity of periodontal disease, primarily manifesting as gingivitis. This strong association underscores that effective glycaemic management is paramount for preventing or mitigating periodontal inflammation and subsequent tissue damage in diabetic individuals. While an observable trend suggested increased tooth mobility in patients with poorer glycaemic control, this correlation did not achieve statistical significance within our sample. This highlights the complex, multifactorial nature of tooth mobility, which is influenced by factors beyond just blood glucose levels. Overall, the study reinforces the critical importance of integrating meticulous diabetes management into comprehensive oral healthcare strategies. These findings advocate for a proactive approach to glycaemic control as a cornerstone for maintaining optimal periodontal health and preventing severe oral complications in T2DM patients. Future research, ideally employing longitudinal designs with larger and more diverse

cohorts, is warranted to further elucidate causal relationships and the intricate interplay between systemic glycaemic control and various facets of periodontal health.

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