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**Cross-Sectional Study**

# Oral Health Status and Gingival Inflammation in Moroccan Children and Adolescents with Type 1 Diabetes: A Matched Cross-Sectional Study

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## ABSTRACT

Type 1 diabetes has emerged as a significant public health issue in Morocco due to its incidence and widespread presence. The disease produces numerous consequences, including notable effects on oral conditions. This investigation aimed to examine how type 1 diabetes influences the oral health status of Moroccan children and to determine whether oral conditions affect glycemic regulation. This cross-sectional research enrolled 100 participants aged 3–17 years diagnosed with type 1 diabetes. The comparison group consisted of 100 non-diabetic children and adolescents in good general health, recruited from public schools and integrated into the national oral-health prevention initiative. They were matched with the diabetic group by number, age, and age category. Collected information included socio-demographic details, diabetes-related variables, and oral-health indicators. Clinical assessment covered oral status indices such as DMFT/dmft, plaque score, and gingival score. Chi-square was used for categorical data, the t-test for numerical variables, and ANOVA for comparisons across three groups. Linear regression identified determinants linked to dental caries, plaque levels, and gingival conditions. Participants had a mean age of 9.61 ± 2.65 years, with 48.5% being boys, ranging from 3 to 17 years. Every child showed at least one decayed tooth, but diabetic children had a higher mean DMFT/dmft (6.13 ± 3.26). Most oral indicators were poorer among those with type 1 diabetes. Significant differences between diabetic and non-diabetic groups were noted in calculus formation and inflammatory severity ($p = 0.001$ and $p = 0.022$, respectively). Gingival inflammation was markedly greater in children with uncontrolled diabetes ($p = 0.043$). Univariate regression revealed an association between plaque index and brushing habits ($p < 0.001$). Findings demonstrated that children with type 1 diabetes showed deterioration across multiple oral-health parameters. These observations highlight that diabetes, along with its degree of control, may play a meaningful role in shaping oral health outcomes.

**Keywords:** Oral health, Type 1 diabetes, Gingival inflammation, Children and adolescents, Morocco

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## Introduction

Diabetes is a long-term metabolic disorder defined by persistent hyperglycemia resulting from complete or partial insulin deficiency, influenced by both genetic predisposition and environmental triggers [1, 2]. Excess blood glucose, a hallmark of poorly managed diabetes, progressively damages various organ systems, especially cardiovascular and neural structures [3]. These effects also extend to the mouth, where chronic hyperglycemia contributes to complications such as dry mouth, reduced salivary protection, periodontal conditions, mucosal infections, sensory deficits, and eventual tooth loss—factors that substantially alter daily functioning and well-being [3, 4].

Over recent decades, many nations have documented an escalation in both new and existing diabetes cases [2]. In Morocco, the Ministry of Health reported an increase from 1.5 million diabetics in 2011 to over 2 million in 2023, alongside population growth from

around 32 million to approximately 37 million in the same period [5].

Worldwide, type 1 diabetes accounts for around 5%–10% of all cases, suggesting that 100,000–200,000 Moroccan residents may be affected [5]. National prevalence may now be approaching 15%, with complications such as cardiovascular disease, renal disorders, and blindness making diabetes a major public health threat [5].

With the rising burden of type 1 diabetes among younger age groups and the chronic complications that accompany it, evaluating its broader impact—particularly on oral health—has become essential. Although the oral repercussions of type 2 diabetes are well established, the interplay between type 1 diabetes and oral health, as well as the possible two-way relationship with glycemic control, requires further investigation.

This research seeks to examine how type 1 diabetes affects oral health in Moroccan children and to determine whether oral status influences metabolic control.

**Materials and Methods**

*Study population*

This cross-sectional work involved 100 children with type 1 diabetes attending the Young Diabetic House in Rabat, along with 100 healthy peers from public schools taking part in the national dental-prevention scheme.

Sampling followed a convenience approach over a six-month interval from December to June, during which 100 diabetic and 100 non-diabetic participants were enrolled.

Inclusion criteria:

- Children between 3–17 years of age.
- Participation permitted only when parents or guardians signed written informed consent.
- For the diabetic cohort, inclusion required a verified diagnosis of type 1 diabetes.
- For the comparison group, only children in good overall health, without disorders influencing oral conditions, were selected.

The assessment covered glycemic status, dental caries experience, gingival condition, and oral hygiene. Diabetes control was evaluated using HbA1c, caries experience via DMFT/dmft, gingival status through the Gingival Index (GI), and oral cleanliness using the Plaque Index (PI).

*Conduct of the investigation*

The study began after receiving authorization from the university dean and approval from the Institutional Review Board (CUMD/FIMD 003/20/24/Approval/20/24). Children and their parents were provided with a verbal explanation of the study aims, followed by the signing of informed consent forms prior to any clinical procedures.

The consent document invited families to participate in research examining how type 1 diabetes affects oral health. Participation was optional, data were anonymized, and confidentiality was strictly maintained. The study presented no foreseeable harm, and participants were free to discontinue whenever they wished.

*Collection of data and variables studied*

Two separate data-collection tools were prepared:

- One questionnaire for children with diabetes
- A second version for non-diabetic participants, identical except for the diabetes-related items

Each form consisted of two main components:

*The questionnaire:*

This section gathered several categories of variables:

• Sociodemographic, educational, and economic information:

- Age
- Sex
- Place of birth
- Child's school level: preschool, primary, secondary
- Father's educational level: none, primary, secondary, university
- Mother's educational level: none, primary, secondary, university

• General health information:

- Past medical issues
- Previous surgeries
- Known allergies
- Age at diabetes diagnosis
- Duration of diabetes (time since diagnosis)
- Daily number of insulin injections
- Mean HbA1c value:
- ▪ <7.5% (controlled)
- ▪ 7.5%–9.5% (uncontrolled)
- ▪ >9.5% (uncontrolled)
- Classification of diabetes control

• Oral hygiene habits:

- Age at which toothbrushing was initiated
- Brushing frequency (once, twice, three times daily, etc.)
- Brushing duration

• Oral-health-related information:
- Previous dental treatments
- Age at first visit to the dentist
- Parents' awareness of links between oral health and diabetes
- Most recent dental visit
- Reasons for seeking dental care
- Type of dental treatment received
- Reasons for avoiding dental care

• Dietary behavior:
- Balanced food intake (variety of nutrients, proteins, vitamins, etc.)
- Snacking patterns: how often and what types
- For diabetic participants: dietary habits before and after diagnosis

*Clinical examination:*
A full oral examination was performed for all children in both groups to document oral health status, including:
• Periodontal indicators:
▪ LOE and Silness plaque index [6]
▪ Gingival Index [6]
• Dental status:
▪ DMFT/dmft values for permanent and primary teeth
• Additional oral findings:
▪ Presence of calculus
▪ Condition of oral mucosa
▪ Identification of Molar Incisor Hypomineralization (MIH) [7]

*Data processing*
All statistical procedures were carried out using SPSS 20.0.0.
Numerical variables were summarized using averages with their standard deviations, while categorical information was reported as proportions and counts.
To examine relationships among the different parameters, the following analytical tools were applied:
- Chi-square for comparisons involving qualitative data.
- Student's t-test and ANOVA for evaluating differences in quantitative measures between two or more independent samples.
- Linear regression models to identify predictors influencing the DMFT/dmft index, plaque levels, and gingival status.
- A 5% threshold was adopted to determine statistical significance.

**Results and Discussion**

Children and adolescents assigned to the non-diabetic group met all eligibility requirements and showed no medical conditions or treatments likely to interfere with their oral status.
To better interpret risk indicators and oral findings, the total sample was subdivided into three developmental age brackets:
- 3–5 years
- >5 to 12 years
- >12 years

These divisions correspond to primary, mixed, and permanent dentition stages.

*Descriptive results*
*Sociodemographic overview*
Among children with diabetes, 53% were male and 47% were female, ranging from 3 to 17 years, with a mean age of $9.83 \pm 2.73$. In both the diabetic and comparison groups, the 6–12-year category was dominant, representing 76% of the sample **(Table 1).**

**Table 1.** Distribution of participants according to socio-demographic characteristics.

| Characteristic | Diabetic group (n = 100) | Non-diabetic group (n = 100) |
|---|---|---|
| Age (years), mean ± SD | 9.83 ± 2.73 | 9.39 ± 2.57 |
| Gender, n (%) | | |
| Female | 47 (47) | 56 (56) |
| Male | 53 (53) | 44 (44) |
| Age group, n (%) | | |
| 3–5 years | 2 (2) | 2 (2) |
| 6–12 years | 76 (76) | 76 (76) |
| >12 years | 22 (22) | 22 (22) |

*a: mean ± SD*
*b: n (%) *

*Age at diagnosis of diabetes*
A total of 58% of the diabetic group were diagnosed with diabetes before reaching 10 years of age.

*Glycemic control status*
Within the diabetic population, 22% had HbA1c <7.5%, and all individuals in this subgroup were categorized as having controlled diabetes.

*Analytic results*
*Oral-health comparison between groups*
Every participant in the study presented at least one decayed tooth. The mean DMFT/dmft score for diabetic children was $6.1 \pm 3.26$, while non-diabetic participants had a mean score of $5.85 \pm 3.58$, indicating high caries burden in both groups.
Plaque accumulation was more pronounced in children with diabetes ($0.97 \pm 0.28$) than in those without

(0.45 ± 0.30) **(Figure 1).** Gingival inflammation followed the same pattern, with diabetic children averaging 0.96 ± 0.34 compared to 0.58 ± 0.28 in the non-diabetic group **(Figure 2)**. These disparities, however, did not reach statistical significance (p = 0.05 and p = 0.55, respectively).

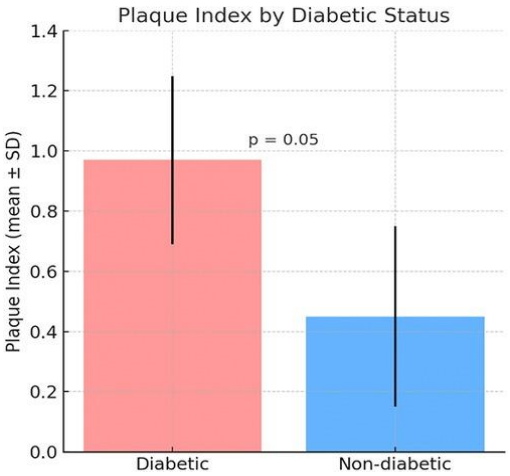


**Figure 1.** Mean Plaque Index for diabetic vs. non-diabetic children (mean ± SD).

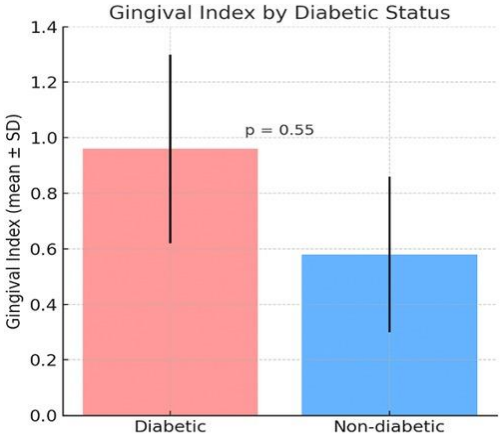


**Figure 2.** Mean Gingival Index for diabetic vs. non-diabetic children (mean ± SD).

Gingival inflammation affected 84% of both groups. Calculus was absent in 60% of diabetic participants and in 82% of children without diabetes.

A significant contrast between the two groups emerged regarding calculus accumulation and the degree of gingival inflammation, with p = 0.001 and p = 0.022**,** respectively **(Table 2).**

**Table 2.** Comparison of oral health between diabetic and non-diabetic groups.

| Variable | Diabetic group (n = 100) | Non-diabetic group (n = 100) | P-value |
|---|---|---|---|
| **DMFT/dmft index, mean ± SD** | 6.1 ± 3.26 | 5.85 ± 3.58 | 0.600 |
| **Plaque index, mean ± SD** | 0.97 ± 0.28 | 0.45 ± 0.30 | 0.050 |
| **Gingival index, mean ± SD** | 0.96 ± 0.34 | 0.58 ± 0.28 | 0.550 |
| **Calculus deposition, n (%)** | | | 0.001* |
| No calculus | 60 (42.3) | 82 (57.7) | |
| Mild deposit | 38 (67.9) | 18 (32.1) | |
| Abundant/very abundant | 2 (100) | 0 (0) | |
| **Degree of gingival inflammation, n (%)** | | | 0.022* |
| Mild inflammation | 45 (53.5) | 59 (70.2) | |
| Moderate inflammation | 37 (44.0) | 25 (29.8) | |
| Severe inflammation | 2 (2.4) | 0 (0) | |

Chi-square and Student's t.
a: n (%) ; + mean ± SD

Additionally, among diabetic children, HbA1c was significantly associated with calculus presence and inflammatory severity, with corresponding values of p < 0.001 and p = 0.01 **(Table 3)**.

**Table 3.** Correlation in diabetic group.

| Variable (within the diabetic group only) | Pearson's correlation coefficient (r) | P-value |
|---|---|---|
| HbA1c and DMFT/dmft index | −0.36 | 0.036 |
| HbA1c and plaque index | 1.13 | 0.050 |
| HbA1c and gingival index | 0.42 | 0.550 |
| HbA1c and calculus (tartar) deposit | −0.25 | <0.001* |
| HbA1c and degree of gingival inflammation | −0.19 | 0.010* |

*Comparison of oral health between controlled and uncontrolled diabetic groups*

Across nearly all examined oral health indicators, the two groups showed no meaningful statistical differences. The only exception was gingival inflammation**,** which appeared more marked in children with poorly controlled type 1 diabetes**,** reaching statistical significance (p = 0.043) **(Table 4).**

**Table 4.** Comparison of oral health between controlled and uncontrolled diabetic groups.

| Variable | Controlled diabetes (HbA1c ≤ 7.5%) (n = 22) | Uncontrolled diabetes (HbA1c > 7.5%) (n = 78) | P-value |
|---|---|---|---|
| **DMFT/dmft index, mean ± SD** | 5.77 ± 3.37 | 6.19 ± 3.24 | 0.590 |
| **Plaque index, mean ± SD** | 0.96 ± 0.27 | 0.97 ± 0.28 | 0.930 |
| **Gingival index, mean ± SD** | 0.92 ± 0.38 | 0.97 ± 0.33 | 0.560 |
| **Presence of gingival inflammation, n (%)** | | | 0.043* |
| Yes | 15 (68.2) | 69 (88.5) | |
| No | 7 (31.8) | 9 (11.5) | |
| **Calculus deposition, n (%)** | | | 0.420 |
| No calculus | 11 (50.0) | 49 (62.8) | |
| Mild deposit | 11 (50.0) | 27 (34.6) | |
| Very abundant deposit | 0 (0) | 2 (2.6) | |

Kh² and Student's t-test applied.
*Values shown as "mean ± SD".
aPresented as "n (%)".

When examining three subgroups**,** no significant variation in gingival inflammation was detected **(Table 5).**

**Table 5.** Influence of diabetes status on gingival inflammation.

| Variable | Controlled diabetes (HbA1c ≤ 7.5%) (n = 22) | Uncontrolled diabetes (HbA1c > 7.5%) (n = 78) | Non-diabetic group (n = 100) | P-value |
|---|---|---|---|---|
| **Gingival index, mean ± SD** | 0.92 ± 0.38 | 0.96 ± 0.33 | 0.58 ± 0.28* | 0.060 |

ANOVA used; data reported as "mean ± SD".



A linear regression model was used to explore links between the DMFT index**,** plaque index**,** gingival index, and several variables—diabetes control**,** sex**,** age, and brushing habits. In the univariate model, plaque index showed a significant association with tooth brushing ($p < 0.001$) **(Table 7)**. No additional significant relationships were noted **(Tables 6–8)**.

**Table 6.** Determinants of dental caries in the diabetic group.

| Variables | DMFT index | Univariate model | | | Multivariate model | | |
|---|---|---|---|---|---|---|---|
| | | β | 95% CI | p | β | 95% CI | p |
| **Glycemic control** | | | | | | | |
| Controlled vs. uncontrolled | | 0.022 | [−0.02, 0.06] | 0.31 | 0.022 | [−0.02, 0.068] | 0.34 |
| **Sex** | | | | | | | |
| Female vs. male | | −0.02 | [−0.06, 0.008] | 0.13 | −0.03 | [−0.07, 0.003] | 0.07 |
| **Age categories** | | | | | | | |
| 6–12 vs. 3–5 years | | −0.02 | [−0.15, 0.10] | 0.70 | −0.01 | [−0.14, 0.12] | 0.84 |
| >12 vs. 3–5 years | | −0.06 | [−0.19, 0.07] | 0.35 | −0.05 | [−0.19, 0.09] | 0.48 |
| **Toothbrushing habit** | | | | | | | |
| Yes vs. no | | 0.01 | [−0.03, 0.07] | 0.48 | 0.01 | [−0.03, 0.068] | 0.45 |

**Table 7.** Determinants of plaque index in the diabetic group.

| Factors | Plaque Index | Univariate Model | Multivariate Model |
|---|---|---|---|

| | | β | 95% CI | p-value | β | 95% CI | p-value |
|---|---|---|---|---|---|---|---|
| **Diabetes regulation** | | | | | | | |
| Yes vs. No | −0.044 | [−0.14, 0.13] | 0.94 | −0.008 | [−0.14, 0.12] | 0.90 | |
| **Sex** | | | | | | | |
| Female vs. Male | 0.02 | [−0.08, 0.14] | 0.36 | −0.23 | [−0.37, 0.08] | 0.002 | |
| **Age categories** | | | | | | | |
| 6–12 y vs. 3–5 y | −0.24 | [−0.64, 0.14] | 0.21 | −0.18 | [−0.57, 0.21] | 0.36 | |
| Up to 12 y vs. 3–5 y | −0.11 | [−0.5, 0.29] | 0.58 | −0.05 | [−0.45, 0.35] | 0.79 | |
| **Tooth-brushing habit** | | | | | | | |
| Yes vs. No | −0.24 | [−0.38, −0.10] | <0.001 | 0.23 | [−0.38, −0.08] | 0.002 | |

**Table 8.** Determinants of gingival index in the diabetic group.

| Variables | Gingival Index | Univariate Analysis | | | Multivariate Analysis | | |
|---|---|---|---|---|---|---|---|
| | | β | 95% CI | p-value | β | 95% CI | p-value |
| **Diabetes control** | | | | | | | |
| Controlled vs. uncontrolled | −0.041 | [−0.2, 0.12] | 0.61 | −0.04 | [−0.21, 0.12] | 0.59 | |
| **Sex** | | | | | | | |
| Female vs. Male | 0.03 | [−0.10, 0.17] | 0.60 | 0.066 | [−0.07, 0.20] | 0.34 | |
| **Age groups** | | | | | | | |
| 6–12 y vs. 3–5 y | −0.05 | [−0.54, 0.44] | 0.82 | 0.002 | [−0.49, 0.50] | 0.99 | |
| Up to 12 y vs. 3–5 y | 0.03 | [−0.46, 0.54] | 0.88 | 0.07 | [−0.44, 0.58] | 0.78 | |
| **Tooth brushing habit** | | | | | | | |
| Yes vs. No | −0.27 | [−0.45, −0.09] | 0.003 | −0.27 | [−0.46, −0.08] | 0.004 | |



*Diabetes and dental caries*

A comparison of the two study groups indicated that the mean DMFT/dmft scores were slightly higher in diabetic participants than in their non-diabetic peers—6.1 ± 3.26 versus 5.85 ± 3.58—though this difference was not statistically meaningful ($p = 0.6$).

Some previous studies echo this pattern, while others report contrasting outcomes. Several publications note significantly elevated DMFT/dmft scores in diabetic individuals ($p < 0.001$) [8, 9], suggesting that factors such as salivary glucose elevation, microbial imbalance, or weaker oral hygiene behaviors may heighten caries susceptibility.

Conversely, other researchers observed no significant gap between diabetic and non-diabetic groups [10].

A 2020 meta-analysis [11] also found higher average DMFT values among children with type 1 diabetes, but—similar to the present study—the difference lacked statistical significance. Differences in methodology, sample characteristics, and regional contexts may explain the divergent results across the literature.

People with uncontrolled diabetes frequently experience salivary quantity and quality alterations [12]. Increases in salivary glucose, calcium shifts, and lowered salivary pH create favorable conditions for cariogenic microorganisms, raising the likelihood of dental decay and oral infections [13].

Achieving stable glycemic control remains a central objective of diabetes management, as it lowers the risk of chronic complications and helps maintain quality of life [14].

In the current investigation, only 22% of participants had HbA1c values below 7.5%, the threshold for adequate control. Despite free access to insulin and routine follow-up, this unexpectedly low rate may reflect treatment fatigue or irregular adherence.

Children with elevated DMFT/dmft scores tended to fall into the uncontrolled diabetes category, although the association did not reach significance ($p = 0.59$).

A Japanese study [15] also reported that children who developed caries had higher HbA1c levels, indicating poor glycemic management, yet the distinction again lacked statistical significance. Consistent with these results, the meta-analysis [11] found no meaningful difference between controlled and uncontrolled type 1 diabetic groups.

In the regression model assessing the link between the DMFT index and diabetes control, together with sex,

age, and brushing habits, no meaningful statistical association was detected [16].

*Diabetes and the periodontium*

The connection between diabetes and periodontal conditions has long been noted in scientific literature. When diabetes is not well controlled, the likelihood of gingival or periodontal problems increases, as metabolic imbalance can alter periodontal tissues. Children with poorly regulated diabetes frequently show more intensely reddened, swollen, sometimes enlarged, and tender gingiva [13]. Disturbances in the oral microbiome further facilitate infectious processes, especially gingivitis.

In our study cohort, all periodontal parameters demonstrated some influence from diabetes:

- **Figure 1** reveals a higher Plaque Index in the diabetic group ($0.97 \pm 0.28$) compared to non-diabetic participants ($0.45 \pm 0.30$).
- **Figure 2** indicates a greater Gingival Index among diabetic children ($0.96 \pm 0.34$) than in non-diabetics ($0.58 \pm 0.28$).

Despite these elevations, the p-values were 0.05 for the Plaque Index and 0.55 for the Gingival Index, showing no statistically significant differences.

We also noted a high rate of gingival inflammation (84%) in both diabetic and non-diabetic children, though this comparison was statistically significant ($p = 0.022$). Diabetic participants also exhibited more calculus deposits ($p = 0.001$).

Similar findings were reported in earlier work examining periodontal disease prevalence among diabetics [17]. Even with adequate plaque control and frequent brushing, gingivitis appeared more pronounced in type 1 diabetic children than in non-diabetic controls [18].

Several studies further reinforce the theory that periodontitis arises more often in individuals with poorly controlled diabetes [19, 20].

In our data, periodontal indicators appeared least favorable in the uncontrolled diabetes subgroup: their gingival index, plaque index, and calculus levels were all higher than in the controlled group, though these differences did not reach statistical significance ($p = 0.56$, $p = 0.93$, $p = 0.42$).

Notably, HbA1c levels correlated with:

- calculus accumulation ($p < 0.001$)
- inflammatory severity ($p = 0.01$)

Gingivitis was identified in both groups, with a significant association ($p = 0.043$). Yet when comparing three categories—controlled diabetics, uncontrolled diabetics, and non-diabetics—no significant distinction in gingival inflammation emerged ($p = 0.06$). Examining plaque and gingival indices alongside diabetes control, age, gender, and brushing showed only one significant univariate link: plaque index and tooth brushing ($p < 0.001$); no other variable displayed a statistical relationship.

A meta-analysis published in *Clinical Periodontology* [21] argued that periodontitis significantly influences diabetes management, onset, and complications. Extensive epidemiologic evidence supports the role of periodontal disease in worsening problems associated with type 2 diabetes.

However, with respect to type 1 diabetes, the question remains: *Do individuals with type 1 diabetes exhibit poorer glycemic control when periodontal health is compromised?*

The joint consensus report from the International Diabetes Federation and the European Federation of Periodontology [22] emphasized a strong link between periodontal disease and diabetes. Their conclusions noted that inadequate glycemic regulation parallels deteriorating periodontal status, and that periodontal inflammation adds to insulin resistance and increases the risk of diabetes-related complications, including mortality. Periodontal treatment has been shown to lower HbA1c without safety concerns. Nonetheless, the report primarily focused on type 2 diabetes and did not specifically address type 1 diabetes, leaving uncertainty regarding its unique periodontal–glycemic interaction.



Because this evidence gap persists, the question of whether periodontitis is directly tied to poor glycemic control in type 1 diabetes remains unsettled. Numerous investigations have examined polymorphonuclear neutrophil (PMN) dysfunction in diabetic individuals, particularly given its impact on periodontal disease prevalence and severity [23]. Impaired PMN activity weakens host defense, heightening susceptibility to oral infections.

In type 2 diabetes especially, PMNs demonstrate compromised chemotaxis, phagocytosis, and microbial clearance, which promotes persistent pathogenic colonization and amplifies periodontal inflammation [23]. In healthy individuals, PMNs help regulate microbial load and resolve infections, but diabetes disrupts these protective functions, predisposing patients to gingivitis and periodontitis.

Periodontal inflammation—whether presenting as gingivitis or progressing to periodontitis—stimulates the release of numerous systemic inflammatory mediators. Molecules such as TNF-α, IL-1β, and IL-6 not only intensify the breakdown of periodontal structures but also contribute to reduced insulin

sensitivity. This creates a reinforcing cycle: inadequate glycemic regulation worsens periodontal disease, and the resulting inflammatory burden further disrupts glucose metabolism, making diabetes management substantially more challenging. Consequently, periodontal conditions represent not only a localized oral problem but also a contributor to diabetes-related systemic complications [24, 25].

Multiple investigations have shown that type 2 diabetes significantly increases susceptibility to both gingivitis and periodontitis, with disease severity tightly linked to poor metabolic control [25]. The likelihood of developing periodontitis has been reported to be three times higher in diabetic individuals than in the general population, emphasizing the importance of combined metabolic and oral health management.

The biological pathways connecting type 2 diabetes to oral diseases—especially periodontal pathology—are well established and mirror mechanisms seen in other long-term diabetic complications such as nephropathy and retinopathy:

- Chronic hyperglycemia and the oral milieu [26]: Persistent elevation of blood glucose disrupts the oral ecosystem by lowering salivary pH, creating acidic conditions that encourage proliferation of harmful microorganisms. Excess glucose also accumulates in saliva and gingival crevicular fluid, supplying abundant nutrients to oral pathogens. These alterations support the development of gingivitis and periodontitis. Furthermore, sustained hyperglycemia weakens innate protective functions within the oral cavity.
- Advanced Glycation End-products (AGEs) [27]: Hyperglycemia drives the formation of AGEs through reactions between excess glucose and tissue proteins or lipids. Their accumulation promotes inflammation. AGEs activate receptors known as RAGE, located on endothelial cells, macrophages, monocytes, and smooth muscle cells. This interaction triggers inflammatory cascades and upregulates cytokine release, thereby intensifying periodontal inflammation and disrupting blood glucose control.
- AGE-mediated effects on immune and vascular systems [27, 28]: Engagement of AGEs with RAGE increases vascular permeability and contributes to inflammatory cell infiltration into periodontal tissue, deepening soft-tissue damage and inflammatory burden.

These interconnected mechanisms demonstrate how hyperglycemia, AGEs, and altered host defenses collectively heighten periodontal risk in individuals with type 2 diabetes. Since the same processes underlie other chronic diabetic complications [26-28], maintaining proper glycemic control and managing periodontal disease are essential for improving overall health outcomes.

A limitation of this study is its cross-sectional design, which prevents the establishment of cause-and-effect relationships. Therefore, the associations observed between type 1 diabetes and oral health should be interpreted with caution. Longitudinal work is required to clarify directionality and underlying mechanisms.

## Conclusion

Compared with non-diabetic participants, our analysis clearly demonstrated that type 1 diabetes adversely affects oral health in children and adolescents. Every participant presented with at least one carious lesion, and the mean DMFT/dmft score was higher in the diabetic group ($6.13 \pm 3.26$). Most oral health indicators were poorer among patients with type 1 diabetes. The average plaque index in diabetic subjects was $0.97 \pm 0.28$, and 84% of individuals from both groups displayed gingival inflammation. Tartar was absent in 60% of diabetic children and 82% of non-diabetic controls. Significant differences between diabetic and non-diabetic subjects were observed in calculus accumulation and inflammatory severity, with $p = 0.001$ and $p = 0.022$, respectively.

In evaluating the influence of glycemic regulation on oral status, HbA1c values were associated with calculus formation and inflammatory severity, with $p < 0.001$ and $p = 0.01$. Gingival inflammation was significantly more marked in uncontrolled type 1 diabetic children **(**$p = 0.043$). Regression analysis indicated a significant univariate association between plaque index and tooth-brushing habits **(**$p < 0.001$).

Overall, the data show that children with type 1 diabetes exhibit a decline across several oral health measures, suggesting that both the condition itself and the level of glycemic management exert substantial influence on oral health.

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**Conflict of Interest:** None

**Financial Support:** None

**Ethics Statement:** The studies involving humans were approved by ethical committee of the college of health

sciences of International University of rabat. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

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