Relationship between Blood HbA1c Level and Decayed Teeth in Patients with Type 2 Diabetes: A Cross-sectional Study

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Abstract

The purpose of this cross-sectional study was to determine whether there is an association between hemoglobin A1c (HbA1c) level and the presence or absence of decayed teeth in patients with type 2 diabetes mellitus. The patients and data on their age and sex, the presence or absence of dental claims, medical history of diabetes mellitus, and workplace dental examinations were obtained from a Japanese healthcare database available for epidemiological studies. The HbA1c levels were obtained from results of the Specific Health Checkups and Specific Health Guidance tests conducted by the Japanese Ministry of Health, Labour and Welfare. Data on a total of 1,897 patients were analyzed. Patients with poorly controlled diabetes (HbA1c ≥ 6.5, n = 779) had more decayed teeth than those in whom it was well controlled (HbA1c < 6.5, n = 1,118). Multiple logistic regression analysis with the presence or absence of decayed teeth as a dependent variable revealed a significant association between an HbA1c level of ≥ 8.0 and decayed teeth (odds ratio: 1.69; 95% confidence interval, 1.24–2.29), even after adjusting for dental attendance. This suggests that a poorly controlled blood HbA1c level is a risk factor for dental caries. More thorough oral hygiene instruction and education on preventive treatment for dental caries in patients with poorly controlled diabetes are needed.

Key words: Diabetes mellitus — Dental caries — Healthcare database — HbA1c

Introduction

The incidence of diabetes mellitus is increasing worldwide and is predicted to continue to rise. The results of patient survey conducted in 2014 by the Ministry of Health,
Labour and Welfare (MHLW) in Japan found that there were approximately 3 million patients with type 2 diabetes mellitus. Similar to predictions in other countries, the number of patients with diabetes is expected to increase substantially in the coming decades in Japan, making it a major health concern.

A strong association has been reported between the risk of diabetic complications and past hemoglobin A1c (HbA1c) levels. Additionally, intensive blood glucose control reportedly reduces the risk of microvascular complications. These reports underscore the importance of controlling HbA1c levels in patients with diabetes.

The universal health insurance system in Japan was established in 1961. Under this system, the Specific Health Checkups and Specific Health Guidance program was launched in 2008 by the MHLW. Under this program, insurers are obligated to offer an annual health checkup which includes blood chemistry to subscribers aged between 40 and 74 years. This means that data on HbA1c levels are available dating back to 2008.

A number of studies have reported that patients with diabetes received infrequent dental care. Dentate adults with diabetes mellitus were reported to be more likely to have received no dental care within the preceding 12 months than those without diabetes mellitus. The rates of reported dental attendance within the preceding 12 months were worse in patients with poorly controlled type 2 diabetes mellitus.

The relationship between diabetes mellitus and dental caries is controversial. Type 2 diabetes mellitus was found to be a risk factor for root caries, but not for coronal caries, in a study of 105 patients with type 2 diabetes mellitus and 103 without. On the other hand, diabetes mellitus had no effect on the prevalence of caries in another study of 25 patients with type 2 diabetes mellitus and 40 without. These reports used the number of decayed, missing, and filled teeth (DMFT) as an indicator of dental caries, however.

As patients with diabetes mellitus receive infrequent dental care, our hypothesis was that patients with poorly controlled type 2 diabetes mellitus would have more untreated teeth than those with controlled disease. Only decayed teeth were taken as an indicator of dental caries here, as filled and missing teeth indicate past experience of dental caries, and our focus was to be on the effect of infrequent dental care. Therefore, the purpose of this study was to investigate the potential relationship between HbA1c level and decayed teeth in patients with type 2 diabetes mellitus.

**Materials and Methods**

1. **Study design**

   This cross-sectional study used a Japanese healthcare database available for epidemiological studies (MinaCare Co. Ltd., Tokyo, Japan).

2. **Patients**

   MinaCare Co. Ltd. maintains a database of medical and dental claims from 3.5 million Japanese people and the results of the MHLW-SH program. Although not available in the MinaCare database, information on an individual’s HbA1c level can be obtained by searching that name in results from the MHLW-SH program. Those entered into the database comprise working individuals and their dependents, and represent a wide range of ages. Individuals involved in the primary industries such as agriculture, fishery, and forestry, however, are excluded from this database, together with those who are self-employed.

   According to data from the MHLW-SH program, the response rate to health examinations performed in 2013 was 47.6%. Here in the present study, data on HbA1c levels obtained as part of this program were used. The patient selection criteria are shown in Fig. 1. A total of 61,388 patients receiving workplace dental examinations in 2013 were selected from the MinaCare database. Of these, 39,672 patients were also retrievable in the results of the MHLW-SH program. Patients on whom the results of dental examinations
were unavailable (17,163) were excluded, as were those aged <40 and ≥60 years (1,531). A total of 1,897 patients with a diagnosis of type 2 diabetes mellitus as indicated on their medical claims were included in the final analysis. The protocol of this study was approved by the Ethics Committee of Tokyo Dental College (Approval number, 661).

3. Survey items

Data on age, sex, the presence or absence of dental claims, medical claims for type 2 diabetes mellitus, and workplace dental examinations, including number of present teeth and decayed teeth, were obtained from the MinaCare database. Dental attendance was taken to indicate the presence of a dental claim. Medical history of type 2 diabetes mellitus was obtained from conditions listed in these claims. The HbA1c levels were obtained from the MHLW-SH results.

The HbA1c levels were categorized into the following 3 groups: <6.5%, 6.5 to 7.9%, and ≥8.0%. The lower cutoff point was set at 6.5% based on the value of ≥6.5% used by the Japan Diabetes Society as a criterion for diabetes mellitus. The upper cutoff point was chosen because patients with HbA1c levels of ≥8.0% are reportedly at a high risk of complications. The number of present teeth was divided into the following 2 groups: <28 teeth and ≥28 teeth. The cutoff point was set at 28 teeth by the median. The age range was set according to the lower limit of that for the MHLW-SH (40 years) and the retirement age (60 years). Number of decayed teeth was categorized as present or absent.

4. Statistical analysis

Descriptive statistical analysis was performed to investigate the characteristics of the study population. Data on oral conditions in the MinaCare database were compared with those from the Survey of Dental Diseases conducted by the Japanese Ministry of Health, Labour and Welfare in 2011. Following this, the chi-square test was used to compare frequencies based on HbA1c levels.

Multiple logistic regression analysis was used to determine whether the HbA1c level was related to decayed teeth in patients with type 2 diabetes mellitus. The dependent variable was the presence or absence of decayed teeth. After adjusting for age, sex, number of present teeth, and dental attendance, the HbA1c value was entered into the multiple logistic regression as an independent variable. Multiple logistic regression was performed using the forced-entry method. Data were analyzed using the statistical package SPSS, version 22.0 (SPSS Japan, Inc., Tokyo, Japan), and a significance level of 0.05 was used.

Results

The mean number of decayed teeth was 0.9 ± 2.1, and the average number of present teeth was 27.3 ± 3.2. The results of a compari-
son of oral conditions between the MinaCare database and Survey of Dental Diseases (2011) based on age are shown in Table 1. The average number of present teeth according to the MinaCare database was greater than that recorded in the Survey of Dental Diseases in every age group. Similarly with the DMFT index, the Survey of Dental Diseases showed

Table 1  Comparison of oral conditions between MinaCare database and Survey of Dental Diseases (2011)

| Age     | MinaCare database | Survey of Dental Diseases (2011) |
|---------|-------------------|----------------------------------|
| The mean number of present teeth |
| 40–44   | 28.2              | 27.8                             |
| 45–49   | 27.9              | 27.1                             |
| 50–54   | 27.4              | 25.9                             |
| 55–59   | 26.6              | 24.4                             |
| DMFT Index |
| 40–44   | 15.0              | 12.7                             |
| 45–49   | 16.4              | 15.2                             |
| 50–54   | 16.9              | 16.2                             |
| 55–59   | 17.2              | 17.5                             |
| The mean number of decayed teeth per person |
| 40–44   | 0.8               | 1.0                              |
| 45–49   | 0.9               | 1.0                              |
| 50–54   | 0.8               | 0.8                              |
| 55–59   | 0.7               | 1.1                              |

Table 2  Characteristics of patients with type 2 diabetes (n = 1,897)

|                | n    | %    |
|----------------|------|------|
| Sex            |      |      |
| Male           | 1,793| 94.5 |
| Female         | 104  | 5.5  |
| Age            |      |      |
| 40–49          | 940  | 49.6 |
| 50–59          | 957  | 50.4 |
| Dental attendance |    |      |
| Yes            | 933  | 49.2 |
| No             | 964  | 50.8 |
| The number of present teeth |      |      |
| <28            | 743  | 39.2 |
| ≥28            | 1,154| 60.8 |
| HbA1c          |      |      |
| <6.5           | 1,118| 58.9 |
| 6.5–7.9        | 580  | 30.6 |
| ≥8.0           | 199  | 10.5 |
| Decayed teeth  |      |      |
| Absence        | 1,170| 61.7 |
| Presence       | 727  | 38.3 |
lower values, except for in the 55 to 59-year age group. The mean number of decayed teeth per person was similar in both groups.

The characteristics of patients with type 2 diabetes mellitus are shown in Table 2. Men occupied 94.5% of such patients. Patients aged 50 to 59 years, those without a record of dental attendance, those with ≥28 present teeth, an HbA1c level of <6.5, and without decayed teeth were dominant factors in the study population (50.4, 50.8, 60.8, 58.9%, and 61.7%, respectively).

Table 3 shows the distribution of each variable based on HbA1c level. Significant differences were found in age (p=0.032), dental attendance (p=0.001), and decayed teeth (p=0.001).

The results of multiple logistic regression with the presence or absence of decayed teeth as a dependent variable are presented in Table 4. Significant differences were observed in sex (odds ratio [OR]: 0.38; 95% confidence interval [CI]: 0.23–0.63), age (OR: 0.75; 95% CI: 0.62–0.91), and blood HbA1c level ≥8.0 (OR: 1.69; 95%CI: 1.24–2.29).

Discussion

The results of the present study revealed a relationship between HbA1c level and decayed teeth. Moreover, HbA1c level was associated with decayed teeth, even after adjusting for dental attendance. These results indicate a tendency for patients with poorly controlled type 2 diabetes mellitus to have decayed teeth, regardless of dental attendance.

All the data used in the present study were on health insurance subscribers in employment. This explains the dominance of men in the study population. The mean number of decayed teeth per person in the MinaCare database was approximately the same as that in the Survey of Dental Diseases. This means that it can be assumed that there is no major difference in decayed teeth between that reported in the MinaCare database and that in the Japanese population.

A number of studies have addressed the possibility of a relationship between type 2 diabetes mellitus and dental caries using DMFT as an indicator of dental caries. Few reports have discussed the relationship between type 2 diabetes mellitus and decayed teeth.
teeth, however. One study found that patients with diabetes mellitus had more decayed, missing, and filled surfaces, although no difference was noted with regard to the prevalence of decayed teeth. The results of the present study, however, revealed a significant difference in the association between HbA1c level and decayed teeth between patients with a value of ≥8.0 and those with a lower level.

Diabetes mellitus reportedly affects the characteristics of saliva. One study found that salivary flow rate, calcium, phosphate, and fluoride were significantly lower in patients with type 2 diabetes mellitus. Furthermore, patients with diabetes showed a significant reduction in salivary pH; and a negative correlation was also observed between a reduction in salivary pH and DMFT. Moreover, a suitable salivary pH and flow rate were found to be the main protective factors against dental caries in patients with diabetes. Taken together, this suggests an association between a change in the saliva and dental caries in patients with poorly controlled type 2 diabetes mellitus.

In addition, a relationship between tooth brushing and diabetes mellitus has been reported. One study found an association between a lower frequency of tooth brushing and a high prevalence of diabetes mellitus. Considering the relationship between tooth brushing and dental caries, patients with poorly controlled diabetes might have a greater number of decayed teeth owing to a low frequency of tooth brushing.

A lower frequency of dental attendance has been reported in patients with poorly controlled diabetes mellitus. The trend observed in the present study supports this earlier finding, with patients with poorly controlled type 2 diabetes mellitus less likely to have a record of dental attendance. The results of multiple logistic regression, however, showed a significant association between an HbA1c level of ≥8.0 and decayed teeth, even after adjusting for dental attendance. This suggests that patients with poorly controlled diabetes mellitus are at risk of dental caries, even if they have a record of dental attendance.

This study had several limitations. First, all the patients included were subscribers to the MinaCare database, so selection bias may have influenced the results. Additionally, almost all of the patients were men due to the nature of the database. This aspect may also have affected the results. Secondly, the dental

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Table 4  Results of multiple logistic regression analysis with presence or absence of decayed teeth as dependent variable (n = 1,897)

|                | OR   | 95% CI | p values |
|----------------|------|--------|----------|
| Sex            |      |        |          |
| Male           | 1    |        |          |
| Female         | 0.38 | 0.23–0.63 | <0.001  |
| Age            |      |        |          |
| 40–49          | 1    |        |          |
| 50–59          | 0.75 | 0.62–0.91 | 0.003   |
| The number of present teeth |      |        |          |
| <28            | 1    |        |          |
| ≥28            | 1.15 | 0.94–1.40 | 0.166   |
| Dental attendance |    |        |          |
| No             | 1    |        |          |
| Yes            | 0.85 | 0.71–1.03 | 0.098   |
| HbA1c          |      |        |          |
| <6.5           | 1    |        |          |
| 6.5–7.9        | 1.18 | 0.96–1.46 | 0.114   |
| ≥8.0           | 1.69 | 1.24–2.29 | 0.001   |
examinations were conducted by several dentists, which may have introduced inter-examiner errors. Thirdly, determination of the presence or absence of dental attendance was based on claims information. Hence, dental treatment performed at the patient’s own expense was not taken into consideration. Furthermore, confounding factors such as socioeconomic factors, sugar consumption, and the use of fluoride were not controlled. Finally, this study had a cross-sectional design; therefore, further research is required to demonstrate a causal relationship.

**Conclusion**

The results of the present study revealed a relationship between HbA1c level and decayed teeth. Our initial hypothesis was that patients with poorly controlled type 2 diabetes mellitus would have more untreated teeth than those with controlled disease. This was not supported by the results, however, which demonstrated a significant association between HbA1c level and decayed teeth in patients with poorly controlled diabetes mellitus, regardless of dental attendance. This suggests that a poorly controlled HbA1c level is a risk factor for dental caries. More thorough instruction in oral hygiene and education on preventive treatment for dental caries are needed in patients with poorly controlled diabetes. Additionally, desirable health behavior, including good eating habits and proper exercise, might be effective against both diabetes mellitus and dental caries.

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