Effects of Dental Care on Glycaemic Control in Type 2 Diabetes

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Objective: *To investigate the effect of dental treatments on the glycaemic control of type 2 diabetes.*
Methods: *At baseline, 105 patients with poorly controlled type 2 diabetes (glycated haemoglobin $HbA_{1c} \geq 8\%$) were recruited. Dental treatments were provided and the subjects were reviewed at three-monthly intervals. At 12 months, 83 patients remained in the treatment group. Sixty type 2 diabetic patients who had not received any dental treatment during the past 12 months were recruited into the comparison group.*
Results: *The HbA_{1c} level of the treatment group subjects decreased from 9.0% at baseline to 8.1% at evaluation (paired t-test; $p < 0.001$). The reduction was higher than that in the comparison group over the same period, 0.9% versus 0.3% (t-test; $p < 0.01$). Analysis of covariance showed that receipt of dental care was related to a reduction in HbA_{1c} level ($p = 0.001$).*
Conclusion: *Provision of dental treatment and maintenance of good oral health contribute to an improvement in glycaemic control in patients with type 2 diabetes.*
Key words: *diabetes mellitus, dental treatment, Chinese, Hong Kong, clinical trial*

Evidence from recent clinical studies suggests that the relationship between diabetes mellitus and periodontal diseases is bidirectional[1,2]. The effects of diabetes on periodontal health have been well documented and characterised by increased susceptibility to oral infection and loss of periodontal attachment, especially in patients with poorly controlled diabetes[3]. The effects of dental treatment on glycaemic control in patients with diabetes have also been investigated. Some studies have demonstrated that dental treatment may reduce the glycated haemoglobin (HbA_{1c}) level or requirement of insulin[4–8], whereas some have failed to show such an effect[9–13]. However, most of these studies were cohort studies without a control group for comparison and had a small sample size. Owing to the above problems and the inconsistent results, a conclusion as to whether dental treatment can contribute to management of glycaemic control in patients with diabetes cannot be drawn[14,15].

The aim of this study was to investigate the effect of providing comprehensive dental care services on the glycaemic control of patients with type 2 diabetes who were receiving regular medical care.

Materials and Methods

This was a 12-month cohort study with intervention and comparison groups. Approval from the Ethics Committee of the University of Hong Kong was obtained prior to implementation. Participation in the study was voluntary and written informed consent was obtained.

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The study population was patients with type 2 diabetes who regularly attended a diabetes centre every 3 months in Hong Kong. In early 2002, patients' daysheets (from February to May) were screened. In total, 478 patients who satisfied the study inclusion and exclusion criteria were selected as the study patient pool. The patients' medical records numbers were input to a computer and a list of 200 patients was randomly drawn from the computer. These 200 patients were invited to attend a free dental examination which was conducted by one qualified practitioner (WSR). Dental panoramic and periapical radiographs were taken as necessary. Dentate patients with untreated active oral diseases were invited to participate in the study and they would receive free comprehensive dental treatment in a dental teaching hospital.

Subject inclusion criteria:
1. age 41–70 years;
2. $HbA_{1c} \geq 8.0\%$.

Subject exclusion criteria:
1. having life-threatening diseases such as cancer;
2. being affected by major complications of diabetes other than hypertension;
3. current smoker or ex-smoker.

Comprehensive dental treatment was provided to the study patients according to their individual oral health condition and treatment need. Treatments included oral hygiene instructions, topical fluoride applications, fillings, root canal treatment, crown, scaling, advanced periodontal treatment and tooth extraction. All treatments were completed within 3 months from the baseline examination.

After the active treatment phase, the patients were reviewed at 3, 6, and 9 months post-treatment, and maintenance care was provided. Oral hygiene instructions were reinforced at each visit. The evaluation examination was carried out at the 12-month review by the same practitioner as at the baseline. The attending physicians of the study patients in the diabetes centre were not informed which of their patients were involved in this study; hence, they provided the necessary medical care to all patients according to an established clinical protocol.

Ideally, to obtain a high level of evidence, a prospective randomised controlled trial design should be adopted in this study. However, it was thought that random allocation of patients who had active untreated oral diseases into a no-treatment group for 12 months could not be regarded as an ethical practice. Hence, a retrospective comparison group was used as an ethical alternative. Around the time of the evaluation examination of the treatment group patients (May to August 2003), patients in the study patient pool who had not been invited to have a free dental examination were approached. Each of the selected patients was interviewed over the telephone to check whether they had received any oral health care services during the past 12 months. Only dentate subjects who had not received any oral health care during the past 12 months were invited to receive a free oral examination.

Information on the study patients at baseline, including their age, gender, body mass index (BMI), duration of diagnosed diabetes mellitus and type of diabetic medication, was retrieved. Besides, the subject's glycated haemoglobin (HbA_{1c}) and fasting plasma glucose (FPG) levels, change in diabetic medication and use of insulin injection during the 12-month study period were retrieved.

The baseline time point of the treatment group subjects was the time when they had received all planned dental treatments. They were examined 12 months after the baseline in the evaluation. As for the comparison group subjects, their evaluation time point was the date of their oral examination, and the baseline was 12 months prior to the examination. The change in the HbA_{1c} or the FPG level of each subject was calculated by subtracting the level of HbA_{1c} or FPG at evaluation from that at baseline. In addition, the serial HbA_{1c} and FPG levels of the subjects in both groups over the 12-month study period were plotted and the area under the curve (AUC) was calculated using the trapezoidal method to provide an integral measure of HbA_{1c} and FPG levels during the study period.

The sample size required in this study was determined by using a 5% statistical significance level, a power of 80%, an anticipated reduction of 0.8% in HbA_{1c} levels, which was regarded as clinically significant by the physicians of the diabetes centre[8], and a standard deviation of 1.8%. The result showed that the number of subjects required in each group was 80.

Data were entered into a computer and analysed using the software SPSS 10.0 for Windows. The paired t-test was used to assess the significance of the changes in the level of HbA_{1c} and FPG within subjects in each group. Differences in the changes in HbA_{1c} and FPG levels and in the AUCs between the treatment and comparison groups were assessed by two-sample *t*-tests. Traditional analysis of covariance (ANCOVA) was performed with the changes in HbA_{1c} and FPG levels and with the AUCs of HbA_{1c} and FPG as the dependent variables. The independent variables were age, gender, education level, baseline HbA_{1c} or FPG level, baseline

Table 1 Selected demographic, medical, and dental status of the treatment and comparison group subjects at baseline

	Treatment group (n = 83)	Comparison group (n = 60)
Mean age in years	56.4 (7.4)	57.4 (6.6)
% male	50.6	41.7
Education level		
% with up to primary school education	39.7	50.0
% with secondary school education	50.6	40.0
% with post-secondary education	9.7	10.0
Mean BMI	25.7 (4.6)	25.9 (3.4)
Mean time of diagnosed diabetes (years)	12.0 (9.5)	11.7 (7.2)
Mean HbA_{1c} level (%)	9.0 (0.9)	9.1 (1.2)
Mean FPG level (mmol/l)	9.7 (2.8)	9.5 (3.3)
Diabetes medication		
% on oral hypoglycaemic agents only	69.9	66.7
% on insulin	30.1	33.3
Mean DMFT	11.2 (6.0)	13.2 (8.1)
Mean DT	0.8 (1.2)	1.2 (1.5)
Mean MT	8.3 (5.5)	10.6 (8.1)
Mean FT	2.1 (2.4)	1.4 (2.2)
% DMFT > 0	98.8	96.7
% with periapical lesion/retained root	44.6	50.0
% with highest CPI score		
0 or 1	0	1.7
2	16.8	13.6
3	44.6	61.0
4	38.6	23.7

Standard deviations in parentheses.

No statistically significant differences between the two groups in any of the parameters.

diabetes control method, duration of diagnosed diabetes, the number of teeth present in the mouth, the decayed, missing, or filled teeth (DMFT) score, the highest community periodontal index (CPI) score, having received dental treatments in the study period and change in BMI. The level of statistical significance for all tests was 0.05.

Results

At baseline, 153 patients were clinically examined and 105 of them with untreated active oral diseases satisfied the study inclusion criteria and were recruited into the treatment group. At evaluation, 83 subjects had completed all the planned dental treatments and had attended the follow-up and evaluation examinations. The subject drop out rate was 21% (22/105). All of the 83 subjects received scaling and periodontal treatment, 53% received tooth extraction, and 21% received root canal treatment. The demographic background, baseline diabetic status and oral health status of the subjects who remained in the study and those who dropped out were compared. No statistically significant differences were found between these two groups in any of the parameters.

In the recruitment of subjects for comparison at the evaluation, 134 patients satisfied the study inclusion criteria and they all came for a free oral examination. Only 60 dentate patients with untreated active oral diseases were recruited as the comparison group of the study. No statistically significant difference between the treatment and comparison group subjects was found

Table 2 Oral health status of the treatment group subjects (n = 83) at baseline and at the 12-month evaluation

	Baseline	Evaluation	*p*-value
% subjects with decayed teeth*	44.3	0	<0.001
Mean (SD) number of decayed teeth#	0.8 (1.2)	0	<0.001
% subjects with periapical lesion or retained root*	44.6	0	<0.001
Mean (SD) number of teeth with periapical lesion or retained root#	0.9 (1.4)	0	<0.001
			<0.001
Periodontal diseases**			
% subjects with healthy gums or gingivitis only	16.8	77.2	
% subjects with moderate disease (4–6 mm pocket)	44.6	20.4	
% subjects with advanced disease (>6 mm pocket)	38.6	2.4	

* Fischer's exact test.
\# Paired *t*-test.
** McNemar–Bowker test.

in any of the baseline demographic and medical parameters measured (Table 1).

At evaluation, the comparison group subjects had not received any oral health care services during the past 12 months. It was assumed that the oral health status of the comparison group subjects had not changed much during the past 12 months such that the status found at the evaluation examination would be similar to that found at baseline if a clinical examination had been conducted then. When comparing the baseline oral health status of the treatment group subjects with that of the comparison group subjects, no statistically significant difference was found in any of the clinical parameters (Table 1).

The oral health status of the treatment group subjects improved drastically after having received dental treatments and was maintained during the whole study period. At baseline, around half of the subjects had decayed teeth and 44.6% had periapical lesions or retained roots (Table 2). None of them had healthy gums and 38.6% had advanced periodontal diseases with deep (>6 mm) periodontal pockets, commonly presenting with suppuration or abscesses. At the 12-month evaluation, none of the subjects had any decayed teeth or periapical lesions. Most of them, 77.2%, had healthy gums or gingivitis only, while 2.4% still had residual deep periodontal pockets.

During the 12-month study period, the level of HbA_{1c} and FPG of the treatment group subjects decreased significantly from 9.0% to 8.1% (paired *t*-test, $p < 0.001$) and from 9.7 to 8.6 mmol/l (paired *t*-test, $p < 0.01$) respectively. In the comparison group, the changes in the HbA_{1c} level (from 9.1% to 8.8%) and the FPG level (from 9.5 to 9.0 mmol/l) were not statistically significant (paired *t*-test, $p > 0.05$).

The decrease in the HbA_{1c} level during the study period was greater in the treatment group subjects than in the comparison group subjects (0.9% versus 0.3%, $p = 0.01$) (Table 3). Moreover, the mean AUC of HbA_{1c} of the treatment group subjects was significantly lower than that of the comparison group (101 versus 106, $p < 0.01$). However, no significant differences in the change in FPG level and the mean AUC of FPG were found between the two groups. Furthermore, no statistically significant differences in the change in the mean BMI and the subjects' diabetic control medication during the study period were found between the two groups.

Variables that remained in the final ANCOVA model using the change in HbA_{1c} level as the dependent variable are shown in Table 4. It was found that the subject's baseline HbA_{1c} level was positively related to the change in HbA_{1c} ($p < 0.001$) and a higher level of HbA_{1c} at baseline would lead to a greater decrease in the level of HbA_{1c}. Subjects who were on insulin injection at baseline had less change in their HbA_{1c} level than those subjects on oral hypoglycaemic agents only ($p = 0.037$). Lastly, after accounting for the effects of the above factors, subjects who had received dental treatments in this study had a significantly greater reduction in HbA_{1c} level ($p = 0.001$) than those who had not.

Table 3 Changes in mean HbA_{1c}, mean FPG, mean AUC of HbA_{1c} and mean AUC of FPG during the study period in the two groups of subjects

	Treatment group (n = 83)	Comparison group (n = 60)	p-value
Change in mean HbA_{1c} *	0.9% (1.1)	0.3% (1.3)	0.010
Change in mean FPG (mmol/l)*	1.1 (3.0)	0.5 (2.7)	0.185
Mean AUC of HbA_{1c} *	101 (10.1)	106 (14.4)	0.009
Mean AUC of FPG*	106 (24.0)	111 (31.3)	0.233

Standard deviations in parentheses.
* Two-sample t-test.

Table 4 Results of the traditional ANCOVA using change in HbA_{1c} as the dependent variable (n = 143)

Independent variable	β	SE	p-value
Baseline HbA_{1c} level	0.62	0.09	<0.001
Baseline diabetes control method			
OHA*			
Insulin ± OHA	-0.44	0.21	0.037
Having received dental treatment			
No*			
Yes	0.61	0.18	0.001
(Constant)	-6.28	1.11	<0.001

F-value = 6.44, df = 142, p < 0.001.
* Reference category. OHA: oral hypoglycaemic agent.

Similar results were obtained in the ANCOVA using the AUC of HbA_{1c} as the dependent variable. A higher baseline HbA_{1c} level would lead to a greater AUC of HbA_{1c} during the study period ($p < 0.001$). Subjects who were on insulin at baseline also had a greater AUC than subjects who were on oral hypoglycaemic agents only ($p = 0.001$). Lastly, subjects who had received dental treatment in this study had a significantly smaller AUC of HbA_{1c} ($p = 0.01$) than those who had not. When the change in FPG level and the AUC of FPG were used as dependent variables in the ANCOVA, no independent variables remained in the final models.

Discussion

In this study, comprehensive dental treatment was provided to the treatment group subjects. The aim of the dental treatments was to eliminate all infections related to the hard and soft oral tissues. After the active treatments, the subjects were regularly reviewed and maintenance care was provided. Compared with the earlier studies on periodontal treatment and diabetic control[4,7,8,13], the oral health care service provided in this study was more comprehensive. None of the earlier studies carried out regular reviews and provided maintenance care after treatment. Studies have shown that maintenance care is essential in maintaining good periodontal health[16]. The regular dental visits in this study probably had assisted the subjects to maintain a relatively healthy oral health status throughout the study period and to prevent progression of periodontal diseases.

The drop-out rate of the treatment group subjects in this study was not high. The main reasons for with-

drawal from the study were refusal of dental treatments and being unable to find time to attend the multiple dental visits. Since no statistically significant differences in demographic background, baseline oral health status and the diabetic conditions were found between the subjects who dropped out and those who completed the study, there is no obvious bias due to subject drop-out.

In this study there was a significant reduction in the HbA_{1c} level among the patients who had received comprehensive dental treatment. This result is comparable to those found in other studies[7,8]. Moreover, there were statistically significant differences in the change in HbA_{1c} level and in the AUC of HbA_{1c} over the study period between the patients who had received dental treatment and those who had not. These findings provide evidence to support that provision of comprehensive dental treatment and regular maintenance care to patients with poorly controlled type 2 diabetes can help to improve their HbA_{1c} level. The positive effect of dental treatment on the improvement of glycaemic control was confirmed by ANCOVA when the effects of some possible confounding variables were accounted for.

The results of the ANCOVA further show that having received dental treatment had a positive effect on diabetic patients who were just on oral hypoglycaemic agents, as well as those who were on insulin and patients with different baseline HbA_{1c} levels within the range that was studied. This provides evidence to support that provision of dental treatments, as an adjunct to regular medical care, will have a beneficial effect on the glycaemic control of different types of patient with poorly controlled type 2 diabetes.

The possible reasons for a lack of statistical significance between the two study groups in the change in FPG level include inadequate sample size and the possibly more prominent effect of oral health care on post-prandial glucose levels rather than on the fasting levels.

In conclusion, the results of this 12-month study show that provision of comprehensive dental treatment to patients with poorly controlled type 2 diabetes as an adjunct to their medical treatment can help to improve their glycaemic condition. Thus, the provision of dental treatment should be considered as an integral part of a comprehensive health care service for people with type 2 diabetes.

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