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Original Article

The effects of basic periodontal treatment combined with Huangqin collutory on the oxidative stress products and inflammatory markers of diabetes in diabetic periodontitis patients

Qiaoyan Huang[1], Xiaoyan Dong[1], Jingyi Tan[2]

[1]*Department of Urology, Fuyang District Chinese Medicine Hospital of Hangzhou, Hangzhou 311400, Zhejiang, China;* [2]*Department of Oral Medicine, The Second Affiliated Hospital of Zhejiang University, Zhejiang, China*

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Abstract: Objective: Diabetes mellitus with periodontitis serious impacts patients' lives, so the main purpose of this study is to analyze the effects of basic periodontal treatment combined with Huangqin collutory on the oxidative stress products and inflammatory markers of diabetes with periodontitis. Methods: A total of 97 diabetes patients with periodontitis were retrospectively analyzed and divided into a control group (the CG, n = 48) adopting basic periodontal treatment and an observation group (the OG, n = 49) adopting basic periodontal treatment and Huangqin collutory so as to compare the efficacy of the two groups. Results: The results showed that the total effective rate, the symptom integrals, PLI, TM, PD, SBI and MDA were lower in the OG, and GHS-Px, SOD, IL-10, IL-8, IL-6 in the OG and the recurrence rate were superior to the CG. Conclusion: Therefore, the combination of basic periodontal treatment and Huangqin collutory can improve the clinical efficacy in diabetes patients with periodontitis.

Keywords: Diabetes, periodontitis, basic periodontal treatment, Huangqin collutory, oxidative stress products, inflammatory markers

Introduction

Diabetes is a chronic metabolic disease with a high clinical incidence. Alongside the changes in our daily lives and diets, the number of diabetes patients is rising in China [1]. Studies have revealed that the development of periodontosis is in close relation with diabetes as one of its common complications [2, 3]. The findings include not only the relationship between diabetic periodontitis and periodontal dysbacteriosis as well as abnormal glucose metabolism, but also the important roles of oxidative stress and the inflammation of the gingival sulcus in the development and progression of the disease [4, 5]. Therefore, inhibiting the oxidative stress and inflammation of the gingival sulcus is a new target for the clinical treatment of diabetes with periodontitis [6].

As the first stage of treating periodontosis, basic periodontal treatment employs scaling and oral prophylaxis to remove bacterial plaque and dental tophi. The main purpose is to eliminate periodontitis and restore periodontal health [7]. However, the effects of basic periodontal treatment when applied alone shall be further enhanced. Traditional Chinese medicine emphasizes the wholeness and treatment according to syndrome differentiation [8, 9]. With the increasingly in-depth studies of TCM in recent years, TCM therapies are also extensively applied in the treatment of diabetic periodontitis [10]. Huangqin collutory is a common TCM solution made mainly from *Scutellaria baicalensis*. In order to improve the treatment effects of diabetic periodontitis, improve periodontal health, reduce oxidative stress and inflammation in the gingival crevicular fluid as well as the recurrence rate, this study combined basic periodontal treatment with Huangqin collutory to treat diabetes patients with periodontitis, in order to determine the ideal clinical effects.

Materials and methods

Grouping method and inclusion and exclusion criteria

97 diabetes patients with periodontitis were retrospectively analyzed and divided into the CG (n = 48, basic periodontal treatment) and the OG (n = 49, basic periodontal treatment + Huangqin collutory). (1) Inclusion criteria: patients who signed the informed consent, patients who met the diagnostic criteria for type 2 diabetes in the *Chinese Guidance on the Prevention and Treatment of Type 2 Diabetes* [11], patients with changes such as alveolar resorption based on x-ray images, and patients with no drug-related contradictions. (2) Exclusion criteria: patients with severe conscious disturbances or mental disorders, patients who were lactating or pregnant, patients with severe infectious diseases, patients who had undergone periodontal treatment in the past year, patients with type 1 diabetes, patients with an allergic constitution, and patients who withdrew during the study.

This study was approved by the Ethics Committee of the Fuyang District Chinese Medicine Hospital of Hangzhou.

Treatment methods in the two groups

After their hospitalization, all the patients received basic diabetes treatment, including subcutaneous injections of insulin and the oral administration of deltamine to keep their HbA1c under 70% and their fasting blood glucose level under 6.1 mmol/L.

For patients in the CG, basic periodontal treatment was provided, such as reinforced education on preventing and treating periodontosis, subgingival scaling and supragingival cleansing with an ultrasound tooth cleaner, root planning and the adjustment of dental articulation. Diseased teeth which could not be preserved were removed, as were defective prostheses; periodontal pockets were alternatively rinsed with normal saline and 3% hydrogen peroxide. The treatment continued for 3 months.

Following the same regimen, the patients in the OG were additionally treated with Huangqin collutory prepared according to following steps: 100 mg of *Scutellaria baicalensis* was soaked in 500 ml of white vinegar, and the solution was then filtered to obtain 30 ml of filtrate, into which, 60 ml of distilled water was added to prepare the Huangqin collutory. After each meal, the patients were required to gargle with 15 ml of Huangqin collutory for 3 min and then with clean water. The procedure was to be repeated 3 times each day for 3 months.

Observation indices

Efficacy evaluation criteria: markedly effective: a decrease in the periodontal probing index ≥ 2 mm, the complete elimination of gingival hemorrhages, redness, and swelling and no exudate; effective: a decrease in the periodontal probing index ≥ 1 mm, significant alleviation of gingival hemorrhages, redness, and swelling; invalid: no decrease in the periodontal probing index or no changes in the gingival hemorrhages, redness, or swelling [12]. TER = Effective Rate + Markedly Effective Rate.

ICS: according to the *Guiding Principles of Clinical Research on New Chinese Medicine*, ozostomia, purulent discharges from periodontal pockets, mastication inability, periodontal pocket ulcers, gingival hemorrhages as well as the swelling and aching of gingiva were quantified based on their severity before and after the treatment, specifically 0 for nil, 1 for mild, 2 for moderate, and 3 for severe [13].

Periodontal indices: changes in the plaque index (PLI), tooth looseness (TM), periodontal pocket probe depth (PD), and the sulcus bleeding index (SBI) were measured before and after the treatment [14].

Oxidative stress products and inflammatory markers: before and after the treatment, all patients had to gargle with clean water. As the tooth surface was dried, a moisture-absorption paper was placed and retained in the gingival sulcus for 30 s to collect the gingival crevicular fluid with its tip, and then it was transferred to an EP tube, centrifuged for 10 min to harvest the eluent which was stored in a freezer at -70°C. The oxidative stress products were measured using different methods, such as malondialdehyde (MAD) by TBA, glutathione peroxidase (GSH-Px) by colorimetry, and superoxide dismutase (SOD) by xanthine oxidase. The inflammatory markers, including interleukin-10 (IL-10), interleukin-8 (IL-8), and interleukin-6 (IL-6), were tested using the ELISA-sandwich technique in strict accordance with the instructions.

Table 1. Comparison of the general clinical data [n (%)]/($\bar{x}$ ± s)

Characteristic		OG (n = 49)	CG (n = 48)	t/X^2	*P*
Gender (n)	Male	30 (61.22)	32 (66.67)	0.311	0.577
	Female	19 (38.78)	16 (33.33)		
Age (y)		61.25±3.18	61.23±3.15	0.031	0.975
Course of diabetes (y)		4.89±0.55	4.95±0.52	0.552	0.582
Severity (n)					
Mild		12 (24.49)	10 (20.83)	0.158	0.885
Moderate		28 (57.14)	26 (54.17)		
Severe		9 (18.37)	12 (25.00)		

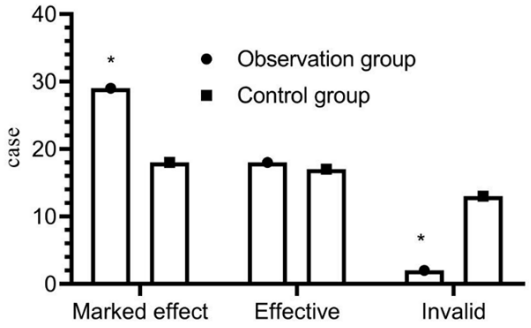

Figure 1. Comparison of therapeutic effects in the two groups. There were 29 markedly effective patients in the OG and more than 18 in the CG ($P < 0.05$); there were 18 effective patients in the OG and 17 in the CG, showing no significant difference ($P > 0.05$); there were 2 invalid patients in the OG, fewer than 13 in the CG ($P < 0.05$). * indicates $P < 0.05$ when compared with the CG.

The test kits were sourced from Beijing Jingmei Biology Co., Ltd.

Recurrence: all the patients were followed up for 6 months, and their recurrence rates were compared.

Statistical analysis

The statistical analysis was performed using SPSS 22.0. In the case of numerical data expressed as the mean ± standard deviation, comparison studies were carried out using T tests for data which were normally distributed and Mann-Whitney U tests for data which were not normally distributed. In the case of nominal data expressed as [n (%)], comparison studies were carried out using X^2 tests for the intergroup comparisons. For all the statistical comparisons, significance was defined as $P < 0.05$.

Results

Comparison of the general clinical data

Significant differences were not found between the two groups in terms of gender, age, or the course and severity of the disease ($P > 0.05$) (**Table 1**).

Comparison of the therapeutic efficacy

After the treatment, the number of markedly effective, effective, and invalid cases were 29, 18, and 2 in the OG, resulting in a TER of 95.92%, and 18, 17, and 13 in the CG, with a TER of 72.92% ($P < 0.05$) (**Figure 1**).

Intergroup comparison of ICS

For the ozostomia, purulent discharges from periodontal pockets, mastication inability, periodontal pocket ulcers, gingival hemorrhages as well as swelling and aching of gingiva, the integrals were (2.02±0.25), (2.01±0.23), (2.11±0.18), (2.13±0.15), (2.19±0.12) and (2.21±0.13) in the OG, and (2.05±0.23), (2.03±0.21), (2.13±0.15), (2.16±0.13), (2.20±0.11), and (2.25±0.11) in the CG (P>0.05) (**Figure 2**) before the treatment.

After the treatment, those integrals were reduced to (0.32±0.05), (0.21±0.02), (0.23±0.01), (0.26±0.02), (0.25±0.01) and (0.28±0.01) in the OG, and (1.06±0.15), (1.03±0.13), (1.05±0.12), (1.25±0.28), (1.18±0.16) and (1.13±0.12) in the CG (P < 0.05) (**Figure 3**).

Comparison of the periodontal indices

The two groups demonstrated no significant differences in PLI, TM, PD and SBI before the treatment ($P > 0.05$). After the treatment, a

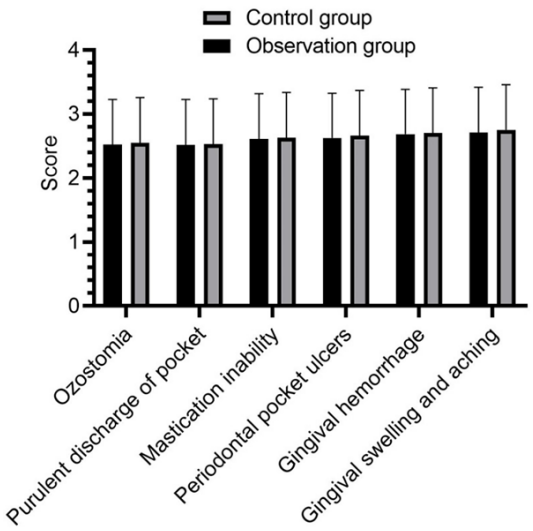

Figure 2. Comparison of the clinical symptom integrals before the treatment. There were no significant differences in terms of the integrals of ozostomia, purulent discharge of periodontal pockets, mastication inability, periodontal pocket ulcers, gingival hemorrhages or swelling and aching of the gingiva before treatment ($P > 0.05$).

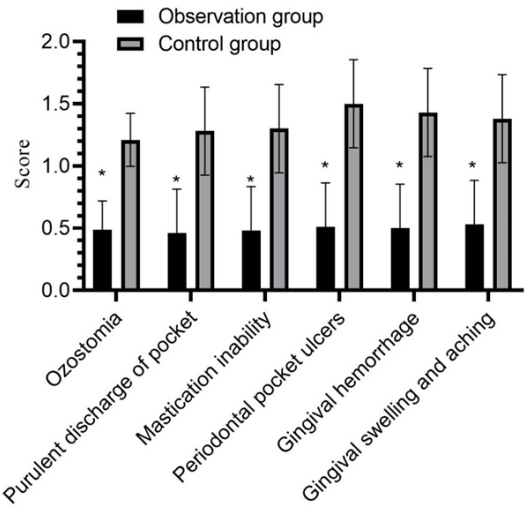

Figure 3. Comparison of the clinical symptom integrals after the treatment. After the treatment, the integrals of ozostomia, purulent discharge of pocket, mastication inability, periodontal pocket ulcers, gingival hemorrhages, and swelling and aching of gingiva in the OG were lower than they were in the CG ($P < 0.05$). * indicates $P < 0.05$ when compared with the CG.

reduction was observed in all ($P < 0.05$), and the values in the OG were lower as compared with the CG ($P < 0.05$) (**Table 2**).

Intergroup comparison of the oxidative stress product levels

The two groups were not statistically different in MDA, GSH-Px, or SOD before the treatment ($P > 0.05$), and the experienced a reduction in MDA and a rise in GSH-Px and SOD after the treatment ($P < 0.05$). Compared with the CG, the OG had lower MDA and higher GSH-Px and SOD ($P < 0.05$) (**Table 3**).

Comparison of the inflammatory indices

The IL-10, IL-8, and IL-6 were (36.18±2.52) pg/ml, (57.89±5.12) pg/ml and (82.56±8.12) pg/ml in the OG, and (36.22±2.50) pg/ml, (57.92±5.09) pg/ml and (82.58±8.09) pg/ml in the CG before the treatment. After the treatment, the indices changed to (62.15±5.58) pg/ml, (20.15±1.22) pg/ml, and (32.12±2.28) pg/ml in the OG, (50.08±5.16) pg/ml, (35.16±2.28) pg/ml and (45.58±3.29) pg/ml in the CG ($P < 0.05$) (**Figure 4**).

Comparison of the reoccurrence rates

All the patients complied with the 6-month follow-up. The reoccurrence rate was 4.08% (2/49) in the OG and 22.92% (11/48) in the CG ($P < 0.05$) (**Table 4**).

Discussion

Clinically, diabetes is one of the hazards of periodontosis and periodontosis is one of the common complications of diabetes [15]. Studies have revealed that periodontitis develops in 35% to 60% of diabetes patients with a course of 5 years or longer. However, so far, the specific onset mechanism of diabetes with periodontitis is still unclear, but the important role of the oxidative stress reaction and local periodontal inflammation in the development of the disease has been established [16]. IL-19 is a common anti-inflammatory cell secreted by leukomonocytes and IL-8 and IL-6 are proinflammatory cytokines from plymphomonocytes [17]. Generally, the two factors are in antagonism and dynamic balance [18]. The abnormal metabolism of diabetes patients results in the activation of NF-κB, a transcription factor, and consequently, a reduction in IL-10 and a rise in IL-8 and IL-6, which induces the inflammatory reaction and worsens the damage to the extraperiodontal matrix and the periodontal tissue, leading to alveolar resorption and tooth looseness [19]. Also, oxidative stress is an important pathological link in diabetes with periodontosis. Generally speaking, our body is under a

Table 2. Comparison of the periodontal indices ($\bar{x} \pm s$)

Group	PLI (%)		TM (mm)		PD (mm)		SBI (%)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
CG (n = 48)	2.78±0.42	1.95±0.35$^{\#}$	1.58±0.31	1.15±0.29$^{\#}$	6.45±0.52	4.36±0.48$^{\#}$	2.68±0.56	1.98±0.32$^{\#}$
OG (n = 49)	2.79±0.41	1.32±0.32$^{\#,*}$	1.61±0.29	0.75±0.18$^{\#,*}$	6.48±0.49	3.12±0.15$^{\#,*}$	2.72±0.52	1.22±0.28$^{\#,*}$
t	0.118	9.255	0.492	8.180	0.292	17.246	0.365	12.456
P	0.906	0.000	0.624	0.000	0.771	0.000	0.716	0.000

Note: $^{\#}P < 0.05$ vs conditions before the treatment; $^{*}P < 0.05$ vs CG.

Table 3. Comparison of the oxidative stress product levels ($\bar{x} \pm s$)

Group	MDA (nmol/ml)		GSH-Px (IU/L)		SOD (IU/ml)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
CG (n = 48)	6.35±0.85	4.48±0.52$^{\#}$	112.58±5.63	135.69±5.89$^{\#}$	72.15±5.26	92.56±6.08$^{\#}$
OG (n = 49)	6.38±0.82	3.32±0.22$^{\#,*}$	112.62±5.61	162.25±8.68$^{\#,*}$	72.18±5.22	112.58±6.19$^{\#,*}$
t	0.177	14.359	0.035	17.640	0.028	16.067
P	0.860	0.000	0.972	0.000	0.978	0.000

Note: $^{\#}P < 0.05$ vs conditions before the treatment; $^{*}P < 0.05$ vs CG.

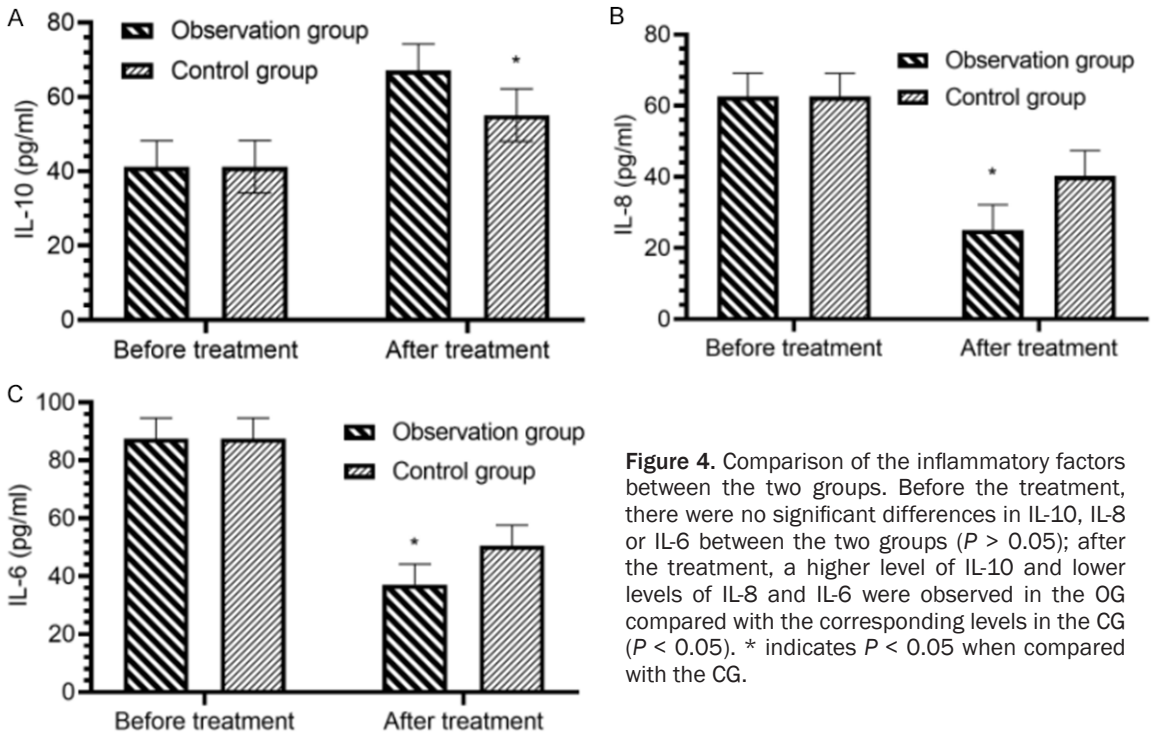

Figure 4. Comparison of the inflammatory factors between the two groups. Before the treatment, there were no significant differences in IL-10, IL-8 or IL-6 between the two groups ($P > 0.05$); after the treatment, a higher level of IL-10 and lower levels of IL-8 and IL-6 were observed in the OG compared with the corresponding levels in the CG ($P < 0.05$). * indicates $P < 0.05$ when compared with the CG.

dynamic balance between oxidation and antioxidation. GSH-Px and SOD are antioxidases enhancing the elimination of oxygen free radicals [20]. MDA is not only an important metabolin of oxidative stress, but it is also an important biochemical indicator for evaluating lipid peroxidation damage [21, 22]. With insulin resistance and hyperglycemia, diabetes patients are prone to oxidative stress. Therefore, the MDA level is heightened, and the activities of GSH-Px and SOD are reduced. A large number of oxygen free radicals accumulate locally to damage the small vessels in the gingival tissue, raise the periodontal susceptibility, and in the meantime compromise the local periodontal immunity, providing conditions for the inva-

Table 4. Comparison of the recurrence rates [n (%)]

Group	n	Recurrence rate
CG	48	11 (22.92)
OG	49	2 (4.08)*
X^2		7.412
P		0.006

Note: *$P < 0.05$ vs CG.

sion of anaerobia and toxins [23]. Furthermore, the large number of oxygen free radicals will activate the osteoclasts to cause damage to the periodontal and bone tissues, inhibit the activities of fibroblasts and osteoblasts, blocking the process of periodontal tissue repair [24]. Henceforth, the oxidative stress and inflammatory reactions in the gingival crevicular fluid of diabetes patients with periodontitis shall be rationally adjusted to improve the local periodontal microenvironment as a key point in the clinical treatment of diabetes with periodontitis.

Being a fundamental therapy of periodontitis, basic periodontal treatment includes measures such as enhanced health education with patients for knowledge related to the disease, treatment of the root surface and gingivae, periodontal pocket rinsing, and antibiotics. Though these measures have certain effects, the results of a simple therapy is further improved [25]. Therefore, this study combined basic periodontal treatment with Huangqin collutory to treat patients. The results indicated that the TER of the OG was higher, the ICS, reoccurrence rate, PLI, TM, PD and SBI were lower than the CG's ($P < 0.05$), indicating that the combination can improve the clinical efficacy, syndromes, and periodontal conditions of diabetes patients with periodontitis. According to the results, the MDA, IL-8, and IL-6 were lower, and the GSH-Px, SOD, and IL-10 were higher in the OG compared with the CG ($P < 0.05$), which further supports the effectiveness of TCM and Western medicine in combination. The possible mechanism of improved effects in diabetes patients with periodontitis is thought to be the effective regulation of the oxidative stress product levels and the inflammatory markers in the gingival crevicular fluid. The reason lies in the major active ingredient of Huangqin collutory, *Scutellaria baicalensis*, which can purge the pathogenic fire and eliminate the damp-heat out of the body. Containing flavonoids (baicalin and baicalein), *Scutellaria baicalensis* has the effects of resisting immune reaction, detoxifying, promoting bilification, gall bladder emptying and urinating, clearing heat, inhibiting bacteria, anti-hypertension, anti-inflammation, and enhancing immunization. While suppressing the expression of the inflammatory factors, baicalin promotes the proliferation of fibroblasts and the synthesis of total proteins in periodontal ligament cells, so as to improve the periodontal conditions. In addition, baicalin also inhibits the apoptosis of gingival epithelial cells induced by oxidative stress, which are thought to be related to the blockage of the Akt-GSK3β signaling pathway and the elimination of oxygen free radicals. Saygin [26] et al. found that *Scutellaria baicalensis* is a promoter of the proliferative activity of periodontal ligament cells, an inhibitor of IL-6 and TNF-α expressions in the local periodontal tissue, and a booster of periodontal tissue regeneration.

In conclusion, the combination of basic periodontal treatment and Huangqin collutory can improve the clinical efficacy, syndromes, and periodontal conditions of diabetes patients with periodontitis through the possible mechanism of effectively regulating the levels of the oxidative stress products and inflammatory markers in the gingival crevicular fluid.

However, the study included a limited number of subjects, such that its results are not representative enough. Future studies will be more inclusive, long-term, and large-scale.

Disclosure of conflict of interest

None.

Address correspondence to: Qiaoyan Huang, Department of Stomatology, Fuyang District Chinese Medicine Hospital of Hangzhou, No. 2-4, Guihua Road, Fuyang District, Hangzhou 311400, Zhejiang, China. Tel: +86-13706810954; E-mail: qt3ygp@163.com

References

[1] Wojciechowska J, Krajewski W, Bolanowski M, Krecicki T and Zatonski T. Diabetes and cancer: a review of current knowledge. Exp Clin Endocrinol Diabetes 2016; 124: 263-275.

[2] Palumbo C, Nicolaci N, La Manna AA, Branek N and Pissano MN. Association between central diabetes insipidus and type 2 diabetes mellitus. Medicina (B Aires) 2018; 78: 127-130.

[3] Agashe S and Petak S. Cardiac autonomic neuropathy in diabetes mellitus. Methodist Debakey Cardiovasc J 2018; 14: 251-256.
[4] Adams NC, Farrell TP, O'Shea A, O'Hare A, Thornton J, Power S, Brennan P and Looby S. Neuroimaging of central diabetes insipidus-when, how and findings. Neuroradiology 2018; 60: 995-1012.
[5] Gandhi J, Dagur G, Warren K, Smith NL and Khan SA. Genitourinary complications of diabetes mellitus: an overview of pathogenesis, evaluation, and management. Curr Diabetes Rev 2017; 13: 498-518.
[6] Fenske W, Refardt J, Chifu I, Schnyder I, Winzeler B, Drummond J, Ribeiro-Oliveira A Jr, Drescher T, Bilz S, Vogt DR, Malzahn U, Kroiss M, Christ E, Henzen C, Fischli S, Tonjes A, Mueller B, Schopohl J, Flitsch J, Brabant G, Fassnacht M and Christ-Crain M. A Copeptin-based approach in the diagnosis of diabetes insipidus. N Engl J Med 2018; 379: 428-439.
[7] Nascimento GG, Leite FRM, Vestergaard P, Scheutz F and Lopez R. Does diabetes increase the risk of periodontitis? A systematic review and meta-regression analysis of longitudinal prospective studies. Acta Diabetol 2018; 55: 653-667.
[8] Graziani F, Karapetsa D, Alonso B and Herrera D. Nonsurgical and surgical treatment of periodontitis: how many options for one disease? Periodontol 2000 2017; 75: 152-188.
[9] Van der Velden U. What exactly distinguishes aggressive from chronic periodontitis: is it mainly a difference in the degree of bacterial invasiveness? Periodontol 2000 2017; 75: 24-44.
[10] da Costa LFNP, Amaral CDSF, Barbirato DDS, Leão ATT and Fogacci MF. Chlorhexidine mouthwash as an adjunct to mechanical therapy in chronic periodontitis: a meta-analysis. J Am Dent Assoc 2017; 148: 308-318.
[11] Romandini M, Lafori A, Romandini P, Baima G and Cordaro M. Periodontitis and platelet count: a new potential link with cardiovascular and other systemic inflammatory diseases. J Clin Periodontol 2018; 45: 1299-1310.
[12] Kumar S. Evidence-based update on diagnosis and management of gingivitis and periodontitis. Dent Clin North Am 2019; 63: 69-81.
[13] Kim OS, Shin MH, Kweon SS, Lee YH, Kim OJ, Kim YJ and Chung HJ. The severity of periodontitis and metabolic syndrome in Korean population: The Dong-gu study. J Periodontal Res 2018; 53: 362-368.
[14] Invernici MM, Salvador SL, Silva PHF, Soares MSM, Casarin R, Palioto DB, Souza SLS, Taba M Jr, Novaes AB Jr, Furlaneto FAC and Messora MR. Effects of Bifidobacterium probiotic on the treatment of chronic periodontitis: a randomized clinical trial. J Clin Periodontol 2018; 45: 1198-1210.
[15] Harrois A and Anstey JR. Diabetes insipidus and syndrome of inappropriate antidiuretic hormone in critically ill patients. Crit Care Clin 2019; 35: 187-200.
[16] Nascimento GG, Gastal MT, Leite FRM, Quevedo LA, Peres KG, Peres MA, Horta BL, Barros FC and Demarco FF. Is there an association between depression and periodontitis? A birth cohort study. J Clin Periodontol 2019; 46: 31-39.
[17] Feng L, Qi Q, Wang P, Chen H, Chen Z, Meng Z and Liu L. Serum levels of IL-6, IL-8, and IL-10 are indicators of prognosis in pancreatic cancer. J Int Med Res 2018; 46: 5228-5236.
[18] Junga A, Pilmane M, Abola Z and Volrats O. Interleukin (IL)-1, 4, 6, 7, 8, 10 appearance in congenital intra-abdominal adhesions in children under 1 year of age. Appl Immunohistochem Mol Morphol 2018; 26: 664-669.
[19] Ramis IB, Vianna JS, Goncalves CV, von Groll A, Dellagostin OA and da Silva PEA. Polymorphisms of the IL-6, IL-8 and IL-10 genes and the risk of gastric pathology in patients infected with Helicobacter pylori. J Microbiol Immunol Infect 2017; 50: 153-159.
[20] Qin F, Pan X, Yang J, Li S, Shao L, Zhang X, Liu B and Li J. Dietary iodine affected the GSH-Px to regulate the thyroid hormones in thyroid gland of Rex Rabbits. Biol Trace Elem Res 2018; 181: 251-257.
[21] Goc Z, Szaroma W, Kapusta E and Dziubek K. Protective effects of melatonin on the activity of SOD, CAT, GSH-Px and GSH content in organs of mice after administration of SNP. Chin J Physiol 2017; 60: 1-10.
[22] Zhang J, Gao J, Guo G, Li S, Zhan G, Xie Z, Yang C and Luo A. Anesthesia and surgery induce delirium-like behavior in susceptible mice: the role of oxidative stress. Am J Transl Res 2018; 10: 2435-2444.
[23] Surai PF and Kochish II. Nutritional modulation of the antioxidant capacities in poultry: the case of selenium. Poult Sci 2019; 98: 4231-4239.
[24] Fan Y, Xiong W, Li J, Hu A, He Z, Zhang J, Zhou G and Yin Q. Mechanism of TangGanJian on nonalcoholic fatty liver disease with type 2 diabetes mellitus. Pharm Biol 2018; 56: 567-572.
[25] Lin X, Bai D, Wei Z, Zhang Y, Huang Y, Deng H and Huang X. Curcumin attenuates oxidative stress in RAW264.7 cells by increasing the activity of antioxidant enzymes and activating the Nrf2-Keap1 pathway. PLoS One 2019; 14: e0216711.
[26] Saygin B, Esrefoglu M, Bayindir N, Tok OE, Selek S, Bulut H, Ozer OF, Ozturk A, Yilmaz O and Meydan S. Protection with thymoquinone against formaldehyde-induced neurotoxicity in the rats. Bratisl Lek Listy 2018; 119: 726-730.