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Effect of dental restoration with epoxy and bioceramic paste on periodontal tissue damage

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ABSTRACT

Objective: To study the effect of dental restoration with epoxy and bioceramic paste on periodontal tissue damage. **Methods:** Patients with pulpal and periapical diseases who received root canal therapy in our hospital between May 2013 and October 2016 were retrospectively analyzed, and according to the different root canal filling materials they used, they were divided into epoxy group and bioceramic group who used epoxy paste and bioceramic paste as root canal filling materials respectively. Before and after treatment, gingival crevicular fluid was collected respectively to determine the levels of inflammatory factors, oxidative stress products, cell apoptosis molecules and protease-related molecules. **Results:** 2 weeks after treatment, IL-1 β , IL-6, CRP, ROS, MDA, AOPP, Bcl-2, Bax, Cyt-C, caspase-3, Smac, EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 levels in gingival crevicular fluid of epoxy group were not significantly different from those before treatment; IL-1 β , IL-6, CRP, ROS, MDA, AOPP, Bax, Cyt-C, caspase-3, Smac, EMMPRIN, MMP-1 and MMP-2 levels in gingival crevicular fluid of bioceramic group were significantly higher than those before treatment while Bcl-2, TIMP-1 and TIMP-2 levels were significantly lower than those before treatment; IL-1 β , IL-6, CRP, ROS, MDA, AOPP, Bcl-2, Bax, Cyt-C, caspase-3, Smac, EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 levels in gingival crevicular fluid were significantly different between two groups of patients after treatment. **Conclusion:** Epoxy paste for dental restoration causes less damage to periodontal tissue than bioceramic paste.

1. Introduction

Dental pulp diseases and periapical disease are the common dental diseases, and root canal therapy is the first treatment. Root canal filling material has a significant influence on the effect of root canal treatment, and ideal root canal filling material not only has good stability and sealing ability so as to reduce the micro leakage after repair, but also has good biocompatibility and antibacterial function so as to reduce repair material damage to periodontal tissue[1,2]. Epoxy-based and bioceramic-based pastes are two common root canal filling materials for clinical root canal repair[3,4], but the differences in the biocompatibility and bacteriostasis of two materials were not clear. The differences in biological compatibility and bacteriostasis of root canal filling material is characterized by different damage to periodontal tissue, which will cause the changes in periodontal inflammation, oxidative stress, alveolar bone resorption and apoptosis. In the following study, the effect of dental restoration with epoxy and bioceramic paste on periodontal tissue damage was analyzed from the periodontal inflammation, oxidative stress, alveolar bone resorption, and cell apoptosis.

2. Research methods

2.1. Case origin

Patients with pulpal and periapical diseases who received root

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canal therapy in our hospital between May 2013 and October 2016 were selected as the cases of the study, and the inclusion criteria were: (1) conforming to the diagnosis of pulpal and periapical diseases; (2) conforming to the indications for root canal therapy, and using epoxy and bioceramic paste as filling materials; (3) all root canal treatment were done by the same group of doctors; (4) gingival crevicular fluid samples were collected before and after treatment; (5) with complete medical records. A total of 104 cases were selected, including 68 male cases and 36 female cases that were 42-64 years old.

2.2. Grouping methods

Case data of 104 patients were retrospectively analyzed, and according to the different root canal filling materials they used, they were divided into epoxy group and bioceramic group who used epoxy paste and bioceramic paste as root canal filling materials for root canal therapy respectively. Epoxy group (n=57) included 37 male cases and 20 female cases that were 44-63 years old; bioceramic group (n=47) included 31 male cases and 16 female cases that were 42-64 years old. The two groups of patients were not significantly different in general data (P>0.05).

2.3. Gingival crevicular fluid sample collection methods

Before treatment and 2 weeks after treatment, sterile filter paper method was used to collect the gingival crevicular fluid of two groups of patients: filter paper about 8 mm × 10 mm size was put in the periodontal pocket and taken out after 1 minute, and then another filter paper of 8 mm × 10 mm size was taken to repeat the above operation; the filter papers from two sampling were put in the EP tubes and kept in a -70 ℃ low-temperature refrigerator.

2.4. Gingival crevicular fluid index detection methods

The filter paper soaked in gingival crevicular fluid was taken out, added in protein lysis buffer, fully shaken and then centrifuged at 12 000 r/min and 4 ℃ for 10 min to separate supernatant, enzyme-linked immunosorbent assay kits were used to determine IL-1 β , IL-6, CRP, ROS, MDA, AOPP, Bcl-2, Bax, Cyt-C, caspase-3, Smac, EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 levels, BCA kits were used to determine total protein content, and then the IL-1 β , IL-6, CRP, ROS, MDA, AOPP, Bcl-2, Bax, Cyt-C, caspase-3, Smac, EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 levels per unit mass total protein were calculated.

2.5. Statistical methods

SPSS 17.0 software was used for statistical analysis, gingival crevicular fluid detection data were input and then analyzed by t test and $P<0.05$ was the standard of statistical significance in differences.

3. Results

3.1 Inflammatory factor levels in gingival crevicular fluid

Before treatment and 2 weeks after treatment, analysis of inflammatory factors IL-1 β , IL-6 and CRP levels in gingival crevicular fluid between two groups of patients was as follows: before treatment, IL-1 β , IL-6 and CRP levels in gingival crevicular fluid were not significantly different between two groups of patients (P>0.05); 2 weeks after treatment, IL-1 β , IL-6 and CRP levels in gingival crevicular fluid of epoxy group were not significantly different from those before treatment (P>0.05); IL-1 β , IL-6 and CRP levels in gingival crevicular fluid of bioceramic group were significantly higher than those before treatment (P<0.05); IL-1 β , IL-6 and CRP levels in gingival crevicular fluid were significantly different between two groups of patients after treatment (P<0.05).

3.2 Oxidative stress product levels in gingival crevicular fluid

Before treatment and 2 weeks after treatment, analysis of oxidative stress products ROS (U/mg), MDA (μmol/mg) and AOPP (ng/mg) levels in gingival crevicular fluid between two groups of patients was as follows: before treatment, ROS, MDA and AOPP levels in gingival crevicular fluid were not significantly different between two groups of patients (P>0.05); 2 weeks after treatment, ROS, MDA and AOPP levels in g ingival crevicular fluid of epoxy group were not significantly different from those before treatment (P>0.05); ROS, MDA and AOPP levels in gingival crevicular fluid

Table 1.

Comparison of inflammatory factor levels in gingival crevicular fluid between two groups of patients before and after treatment (ng/mg).

Groups	n	Time point	IL-1 β	IL-6	CRP
Epoxy group	57	Before treatment	3.51±0.64	1.25±0.17	5.41±0.84
		4 weeks after treatment	3.60±0.67[&]	1.32±0.18[&]	5.67±0.79[&]
Bioceramic group	47	Before treatment	3.56±0.69	1.30±0.16	5.50±0.72
		4 weeks after treatment	5.77±0.93[*]	2.04±0.35[*]	8.38±1.03[*]

[*]: compared within group before and after treatment, $P<0.05$; [&]: comparison between epoxy group and bioceramic group after treatment, $P<0.05$.

Table 2.

Comparison of oxidative stress products in gingival crevicular fluid between two groups of patients before and after treatment.

Groups	*n*	Time point	ROS	MDA	AOPP
Epoxy group	57	Before treatment	0.86±0.11	2.15±0.35	1.77±0.23
		4 weeks after treatment	0.89±0.12[&]	2.20±0.37[&]	1.82±0.24[&]
Bioceramic group	47	Before treatment	0.84±0.10	2.18±0.29	1.73±0.21
		4 weeks after treatment	1.35±0.19[*]	3.41±0.52[*]	2.31±0.36[*]

[*]: compared within group before and after treatment, $P<0.05$; [&]: comparison between epoxy group and bioceramic group after treatment, $P<0.05$.

Table 3.

Comparison of apoptosis molecules in gingival crevicular fluid between two groups of patients before and after treatment.

Groups	*n*	Time point	Bcl-2	Bax	Cyt-C	Caspase-3	Smac
Epoxy group	57	Before treatment	1.76±0.22	0.84±0.12	2.32±0.35	1.93±0.25	0.56±0.08
		4 weeks after treatment	1.80±0.23[&]	0.89±0.11[&]	2.40±0.37[&]	1.99±0.26[&]	0.58±0.07[&]
Bioceramic group	47	Before treatment	1.83±0.22	0.87±0.10	2.38±0.32	1.95±0.21	0.54±0.05
		4 weeks after treatment	1.02±0.15[*]	1.42±0.18[*]	3.94±0.61[*]	2.88±0.35[*]	0.93±0.10[*]

[*]: compared within group before and after treatment, $P<0.05$; [&]: comparison between epoxy group and bioceramic group after treatment, $P<0.05$.

Table 4.

Comparison of protease-related molecules in gingival crevicular fluid between two groups of patients before and after treatment (ng/mg).

Groups	*n*	Time point	EMMPRIN	MMP-1	MMP-2	TIMP-1	TIMP-2
Epoxy group	57	Before treatment	1.85±0.22	1.21±0.16	0.67±0.09	0.93±0.11	1.08±0.16
		4 weeks after treatment	1.91±0.24[&]	1.23±0.14[&]	0.70±0.08[&]	0.96±0.12[&]	1.10±0.14[&]
Bioceramic group	47	Before treatment	1.87±0.25	1.25±0.17	0.66±0.09	0.91±0.09	1.12±0.17
		4 weeks after treatment	3.02±0.52*	2.31±0.35[*]	1.15±0.17[*]	0.42±0.07[*]	0.42±0.06[*]

[*]: compared within group before and after treatment, $P<0.05$; [&]: comparison between epoxy group and bioceramic group after treatment, $P<0.05$.

of bioceramic group were significantly higher than those before treatment ($P<0.05$); ROS, MDA and AOPP levels in gingival crevicular fluid were significantly different between two groups of patients after treatment ($P<0.05$).

3.3 Apoptosis molecule levels in gingival crevicular fluid

Before treatment and 2 weeks after treatment, analysis of apoptosis molecules Bcl-2 (ng/mg), Bax (ng/mg), Cyt-C (U/mg), caspase-3 (ng/mg) and Smac (ng/mg) in gingival crevicular fluid between two groups of patients was as follows: before treatment, Bcl-2, Bax, Cyt-C, caspase-3 and Smac levels in gingival crevicular fluid were not significantly different between two groups of patients ($P>0.05$); 2 weeks after treatment, Bcl-2, Bax, Cyt-C, caspase-3 and Smac levels in gingival crevicular fluid of epoxy group were not significantly different from those before treatment ($P>0.05$); Bax, Cyt-C, caspase-3 and Smac levels in gingival crevicular fluid of bioceramic group were significantly higher than those before treatment while Bcl-2 level was significantly lower than that before treatment ($P<0.05$); Bcl-2, Bax, Cyt-C, caspase-3 and Smac levels in gingival crevicular fluid were significantly different between two groups of patients after treatment ($P<0.05$).

3.4 Protease-related molecule levels in gingival crevicular fluid

Before treatment and 2 weeks after treatment, analysis of protease-related molecules EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 in gingival crevicular fluid between two groups of patients was as follows: before treatment, EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 levels in gingival crevicular fluid were not significantly different between two groups of patients ($P>0.05$); 2 weeks after treatment, EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 levels in gingival crevicular fluid of epoxy group were not significantly different from those before treatment ($P>0.05$); EMMPRIN, MMP-1 and MMP-2 levels in gingival crevicular fluid of bioceramic group were significantly higher than those before treatment while TIMP-1 and TIMP-2 levels were significantly lower than those before treatment ($P<0.05$); EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 levels in gingival crevicular fluid were significantly different between two groups of patients after treatment ($P<0.05$).

4. Discussion

Epoxy and bioceramic paste are two clinical common root canal filling materials for root canal repair, and in order to clarify the damage of these two materials to periodontal tissue when they were used in root canal therapy, the periodontal inflammation was first analyzed in the study before and after treatment. Filling material damage to periodontal tissue will activate the local inflammatory response, increase the inflammatory cell infiltration as well as synthesize and secrete a variety of inflammatory factors. IL-1β and IL-6 are the important pro-inflammatory factors, they are secreted

by the neutrophils and mononuclear macrophages, and they can prompt inflammatory cell infiltration and accelerate inflammatory mediator secretion[5,6]; CRP is an important inflammatory mediator that is related to the degree of inflammatory reaction activation[7]. In the study, the analysis of inflammatory factor levels in gingival crevicular fluid before and after the treatment showed that IL-1 β , IL-6 and CRP levels in gingival crevicular fluid of epoxy group after treatment were not significantly different from those before treatment, and IL-1 β , IL-6 and CRP levels in gingival crevicular fluid of bioceramic group after treatment were significantly higher than those before treatment. This means that the epoxy paste for root canal therapy will not cause inflammation of periodontal tissue, and bioceramic paste for root canal therapy will activate the periodontal tissue inflammation, which reflects that epoxy paste damage to periodontal tissue after root canal therapy is weaker than that of bioceramic paste.

Filler material damage and stimulation to periodontal tissue will not only cause the activation of the inflammatory response, but can also cause the activation of oxidative stress reaction. Oxidative stress is mediated by the excessively generated reactive oxygen species, and the oxidation reaction of reactive oxygen species with lipid components and protein compositions in local tissue will cause the cellular structural and functional injury. MDA and AOPP are the oxidizing reaction products of lipid and protein with reactive oxygen species respectively, and they can reflect the activation of oxidative stress in the local tissue[8,9]. In the study, analysis of the oxidative stress product levels in gingival crevicular fluid before and after treatment showed that ROS, MDA and AOPP levels in gingival crevicular fluid of epoxy group after treatment were not significantly different from those before treatment, and ROS, MDA and AOPP levels in gingival crevicular fluid of bioceramic group after treatment were significantly higher than those before treatment. This means that the epoxy paste for root canal therapy will not cause oxidative stress reaction of periodontal tissue, and bioceramic paste for root canal therapy will activate the oxidative stress of periodontal tissue, which can further reflect that epoxy paste damage to periodontal tissue after root canal therapy is weaker than that of bioceramic paste.

Inflammation and oxidative stress activation in the periodontal tissue can promote cell apoptosis and cause tissue damage. Inflammatory mediators and oxidative stress products can act on local tissue to lead to changes in mitochondrial function and start the mitochondrial apoptosis, and Bax and Bcl-2 is a pair of molecules that regulate mitochondrial apoptosis[10]. Bax can form channel in the mitochondrial membrane and promote Cyt-C release from mitochondria into the cytoplasm, and the Bcl-2 can form heterodimer with Bax, inhibit Bax channel formation and reduce Cyt-C release into the cytoplasm. After entering into cytoplasm through mitochondria, Cyt-C can activate caspase-3 through a series of cascade amplification reactions and ultimately cause cell apoptosis[11,12]. Smac is a kind of apoptosis-related protein in the mitochondria that can increase the sensitivity of cells to apoptosis signal. In the study, the analysis of apoptosis molecule levels in gingival crevicular fluid before and after the treatment showed that Bcl-2, Bax, Cyt-C, caspase-3 and Smac levels in gingival crevicular fluid of epoxy group after treatment were not significantly different from those before treatment, and Bax, Cyt-C, caspase-3 and Smac levels in gingival crevicular fluid of bioceramic group after treatment were significantly higher than those before treatment while Bcl-2 level was significantly lower than that before treatment. This means that the epoxy paste for root canal therapy will not cause the cell apoptosis in periodontal tissue, and bioceramic paste for root canal therapy can activate the cell apoptosis in periodontal tissue.

The inflammation and oxidative stress of periodontal tissue will not only promote cell apoptosis, but can also cause alveolar bone resorption and lead to root canal loosening. Matrix metalloproteinases are the key molecules that cause matrix component degradation in alveolar bone, they are regulated by the inflammatory response in local tissue, and it has been confirmed that MMP1 and MMP2 are associated with the alveolar bone resorption in patients with periodontitis[13,14]. TIMP-1 and TIMP-2 are the inhibitors of MMPs molecules, and they can be combined with a variety of MMPs molecules and suppress their degradation effect on alveolar bone matrix[15,16]. EMMPRIN is MMPs-inducing factor in the immunoglobulin family, and it can enhance the function of MMPs and promote the expression of MMPs[17]. In the study, the analysis of protease-related molecule levels in gingival crevicular fluid before and after the treatment showed that EMMPRIN, MMP-1, MMP-2, TIMP-1 and TIMP-2 levels in gingival crevicular fluid of epoxy group after treamtent were not significantly different from those before treatment, and EMMPRIN, MMP-1 and MMP-2 levels in gingival crevicular fluid of bioceramic group after treatment were significantly higher than those before treatment while TIMP-1 and TIMP-2 levels were lower than those before treatment. This means that the epoxy paste for root canal therapy will not cause protease expression change or lead to alveolar bone resorption, and bioceramic paste for root canal therapy can enhance the function of proteases and increase the risk of alveolar bone resorption.

Based on above analysis of gingival crevicular fluid indexes, it is believed that the damage of epoxy paste for dental restorations to periodontal tissue is weaker than that of bioceramic paste; compared with bioceramic paste, epoxy paste can reduce the periodontal inflammation and oxidative stress as well as inhibit apoptosis and alveolar bone resorption.

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